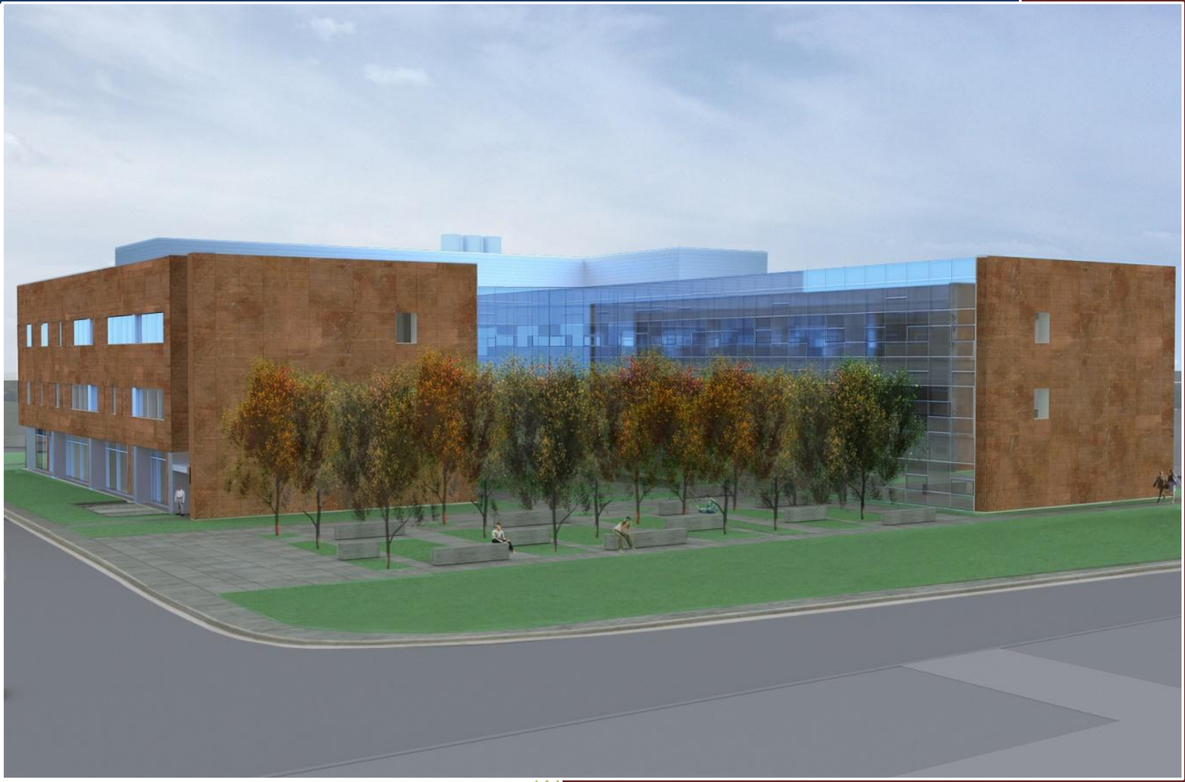
Nassau Community College Life Sciences Building

Garden City, NY

Technical Report Two

Building and Central Plant Load and Energy Analysis



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Executive Summary

In the past, the design mechanical engineer has been responsible for developing a design heating and cooling loads in order to properly size and design an HVAC system. As the industry is growing, it is becoming more popular for the mechanical engineer to also perform an energy analysis of the building under design. Organizations like LEED give points towards USGBC certification for submitting an energy analysis of the proposed building. These energy analyses allow for the prediction of energy consumption as well as the cost of energy per year, which is advantageous from a building owner standpoint. Energy models have also began to play a role in the design phase of a building with communication between architects and engineers. Energy models allow the architects to change building components mid-design in order to provide a more energy efficient building.

Many programs have been developed for building load and energy modeling. Trane TRACE 700 was used for this report along with information provided by the Life Sciences Building mechanical design engineer from Cannon Design and the energy model created by WSP Flack + Kurtz. Information from the construction documents was used to create a heating and cooling load and energy model. Electrical energy rates were determined from the Long Island Power Authority (LIPA) and the high temperature hot water and chilled water rates were assumed from the WSP Flack + Kurtz report. The calculated energy model created was compared to the designed energy model developed by WSP Flack + Kurtz.

An entire energy model was created for the Life Sciences Building and it was determined that the building consumes a total of 135.2 MBtu/ft^2-year of electricity, chilled water and high temperature hot water combined. This calculated energy consumption is 62.3% less than the designed energy consumption determined by WSP Flack + Kurtz. However, compared with ASHRAE and CBECS, a typical education building uses 71.0 and 83.1 MBtu/ft^2-year respectively. The calculated energy consumption is 190% greater than typical ASHRAE educational building and 163% greater than the average educational building according to CBECS. With the utility rates provided, the Life Sciences Building is calculated to spend $3.33 per square foot or $241,000 per year.

Building Overview

The Nassau Community College Life Sciences Building will house the expanding Chemistry Department and rising Nursing Department. The building will be a cluster of general lecture halls, computer labs, inorganic and organic laboratories, practical skills nursing rooms and faculty offices. The Life Science Building is a "U-shape" where the courtyard façade is a floor-to-floor glass curtain wall system. Faculty offices on all three floors are facing the courtyard and can have periods of high heat transfer through the curtain wall. The classrooms, lecture halls and laboratories, are located along the opposite exterior perimeter. The façade is composed of copper rain screen panels and long strips of glazing. There may also be periods of high heat transfer through this façade, but it was designed for a high aesthetic appeal rather than thermal function.

The design of the Life Sciences Building was highly influenced by the occupants, both students and faculty, as well as its use. It was designed to easily connect to the greater campus with spaces to accommodate the overall student population, not just the Chemistry and Nursing Departments. Furthermore, function played a role in the design because of the hazardous chemical storage and waste spaces that need to be guarded under restricted access but readily available to the classrooms for learning.

Mechanical System Overview

The Life Sciences Building receives conditioned air from three air handlers located in the Penthouse. One of the air handlers is a 100 percent outdoor air unit due to the nature of the chemistry laboratories that it serves. The supply air to the laboratory spaces is exhausted through a laboratory exhaust system. Three large exhaust fans operate as one unit, which pulls contaminated air from the laboratory fume hoods. Because this air handler is a 100 percent outdoor air unit, a heat recovery run-around loop transfers sensible heat from the exhaust fans to the air handler to either pre-heat or pre-cool the incoming outdoor air. All three air handlers are part of a variable air volume (VAV) system with terminal reheat coils.

The Life Sciences Building as well as the Nassau Community College campus is served by a campus-wide high temperature hot water and chilled water system. The high temperature hot water creates building hot water through several heat exchangers for the perimeter radiation, fan coils, cabinet unit heaters and air handler pre-heat coils. The 100 percent outdoor air unit's pre-heat coil uses a glycol system, which is heated via heat exchanger by the high temperature hot water system. A primary/secondary system is utilized with the chilled water and high temperature hot water systems. Booster pumps have been designed for the chilled water system in the event that there is a decrease in pressure in the primary line. The majority of the heat exchangers and pumps are located along with the service entrance in the basement mechanical equipment room.

The Central Utility Plant that serves Nassau Community College is operated by Nassau Energy Corporation and is comprised of a cogeneration and chiller plant. This 60 MW cogeneration facility produces 250 psig steam, 270°F high temperature hot water and 42°F chilled water that are distributed to various surrounding facilities such as Nassau University Medical Center (NUMC), Nassau Veterans Memorial Coliseum and Long Island Marriott Hotel. Figure 1 below is a diagram provided by Parsons Brinckerhoff's report that shows the location of the Central Utility Plant in red as well as the steam loads in blue stars and the high temperature hot water loads in yellow stars. Nassau Community College is denoted by the dotted yellow circle. Nassau Community College uses 50.6% of the high temperature hot water and chilled water produced by the Central Utility Plant compared to all buildings tapped into the high temperature hot water service.

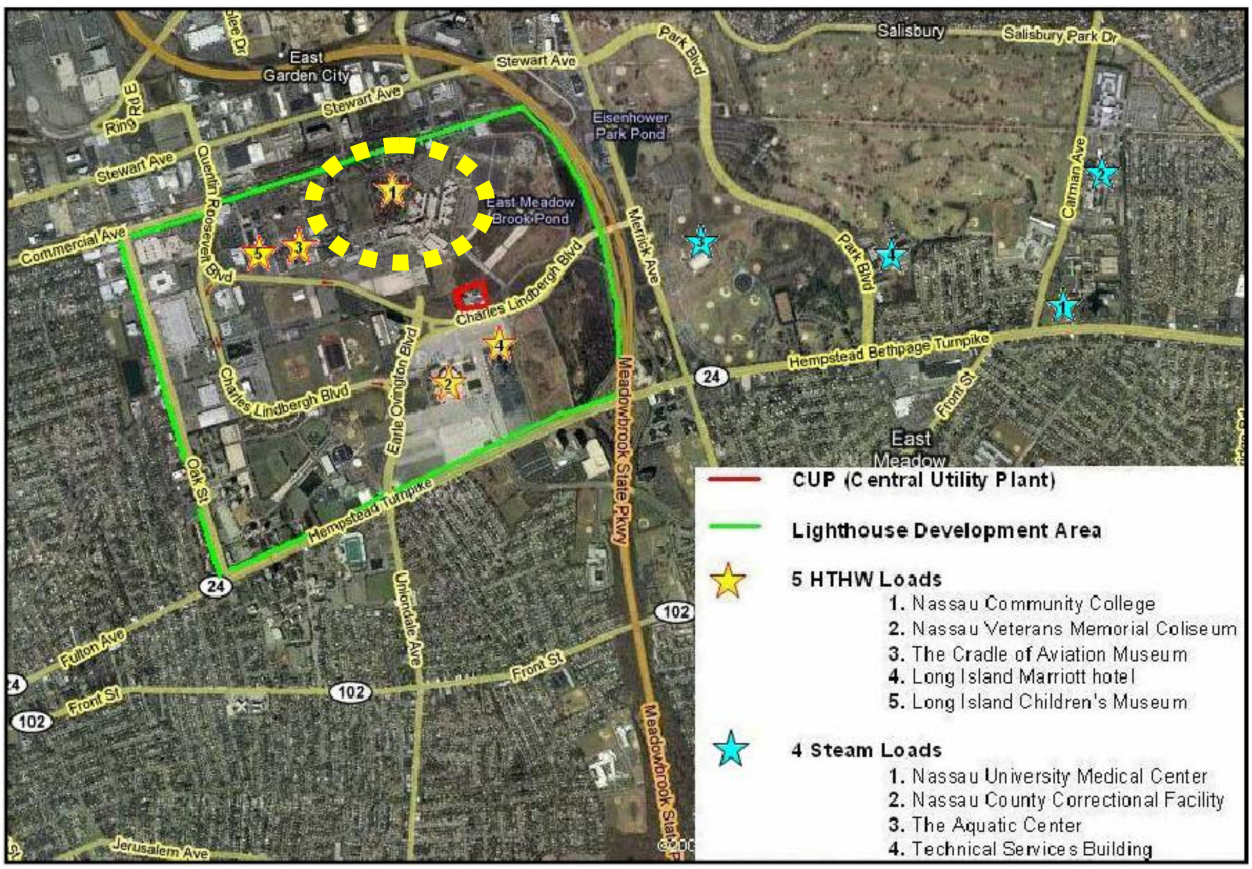

Figure 1 - Location of Central Utility Plan (Red) and NCC (Yellow)

System Design Load Estimation

To evaluate the heating, cooling loads and energy consumption of the Nassau Community College Life Sciences Building, Trane TRACE 700 was used along with Autodesk Revit Architecture. Revit was used to create a 3-dimensional model of the Life Sciences Building, which was exported as a gbxml file. The gbxml allows for the translation of geometries from the model to TRACE. TRACE was then used to develop an 8,760 hour energy analysis of the building's performance as well as to determine the design heating and cooling loads. Typical room templates and their specified assumptions used for this analysis are shown in Appendix A.

Block Load Assumptions

The information needed to develop the 3-dimensional model of the Life Sciences Building was taken directly from the construction documents as well as relative reports and specifications that provided appropriate engineering data such as assembly heat transfer coefficients, equipment characteristics and room areas.

Occupancy Assumptions

The number of occupants per space for the Life Science Building was determined by the design documents and the prescribed number of people designated by the architect. Occupancy densities were not used for estimation; rather exact, known values were used.

Ventilation Assumptions

Nassau Community College Life Sciences Building is located in Long Island, NY and falls under the jurisdiction of the New York State Mechanical Code of 2007. Table 403.3 in Chapter 4 provides minimum required outdoor air ventilation rates for specific occupancy classifications, similar to that of Table 6-1 in ASHRAE Standard 62.1-2007. These ventilation rates were used for determining the prescribed ventilation airflow in the design documents and were therefore used in this load and energy analysis.

Lighting and Equipment Electrical Load Assumptions

The lighting and equipment electrical loads for the Life Sciences Building were assumed on a Watts per square foot basis. A summary of these loads are shown in Table 1 below. The lighting power densities were largely taken from ASHRAE Standard 90.1-2007, Table 9.6.1 where the assumptions were not provided by the mechanical or electrical engineers. A lighting fixture schedule was available for this analysis but there were a large number of different fixtures used throughout the building. For simplicity and time management, lighting power densities were used. For a more accurate energy analysis, an exact count of power per square foot can be calculated.

Equipment electrical loads were regarded in the same manner as lighting loads and recorded on a Watts per square foot basis. The equipment power density varied greatly from space to space. The main electrical room in the basement, with two unit substations, was assumed at a high of 20 Watts per square foot, which was provided by the engineer. The smaller electrical and telecommunication rooms found on each floor were estimated at about 2 Watts per square foot. This range of equipment power densities was used for the mechanical equipment rooms and electrical rooms that fell between these two extremes. In spaces such as the classrooms and offices, internal loads were assumed more precisely with one computer workstation per person per office and one computer per teaching classroom.

Room Type	Lighting Load (W/SF)	Miscellaneous Load (W/SF)	Occupancy (# of People)	Ventilation Rate (CFM/Person)
Office	1.1	350 W	1	20
36-Person Classroom	1.4	350 W	36	15
Conference	1.3	1	12	20
Corridor	0.5	0	0	0.05 CFM/SF
Electrical	1.5	20	0	0.06 CFM/SF
Mechanical	1.5	20	0	0.06 CFM/SF

Table 1 - Internal Lighting and Equipment Loads

Exterior Wall Construction

The exterior wall of the Life Sciences Building is a curtain wall system comprised of copper rain screen panels and clear, low-e, insulated glass. The copper rain screen panels were treated as one continuous façade for the purpose of this analysis. The heat transfer coefficients and solar heat gain coefficients used for this energy analysis were the values provided by the architect. A summary of the overall heat transfer coefficients and solar heat gain coefficients can be found in Table 2.

Assembly	U-Value	R-Value	SHGC
Copper Rain Screen Panels	U-0.04678	R-21.4	-
Fenestration	U-0.28	-	SHGC-0.27

Table 2 - Exterior Construction Components

Weather Data

The weather data from the ASHRAE Handbook of Fundamentals for the New York City, JFK International Airport station was used in this load and energy analysis due to its similarity in weather conditions to Garden City, NY, which is located 15 miles to the east. Table 3 below provides a summary of the heating and cooling weather design conditions. The actual weather sheet provided by ASHRAE can be viewed in Appendix B.

Season	Indoor Design (°F)	Outdoor DB (°F)	Outdoor WB (°F)
Summer (0.4%)	75	89.7	73.5
Winter (99.6%)	72	12.8	-

Table 3 - ASHRAE Weather Data - New York, NY

Schedules

The Life Sciences Building is centrally located on Nassau Community College's campus and was designed to be a central meeting space for its students. The building is open 24 hours a day, 7 days a week and is assumed to be fully utilized during the fall, spring and summer semesters. The basement is where the hazardous chemical storage is located and is therefore locked to all unauthorized personnel. Main circulation spaces such as the corridors and lobbies will be scheduled to be conditioned all the time. Office spaces are scheduled for an 8 am to 5 pm work day with an hour before and after the occupied period for the system to throttle up and down. The lighting and the equipment loads in the offices follow the same schedule without the startup and turndown time.

Classrooms, including the chemistry laboratories, computer labs and general classrooms operate with a schedule similar to that of the offices. One hundred percent operation runs between the hours of 8 am and 12 pm and 1 pm and 5 pm. Two hours before and one hour after the periods of full operation is a startup and turndown time for the system. The hour between 12 and 1 pm permits the system to throttle back a little with the assumption that the majority of the occupants have gone to lunch.

These are the two main schedules that control the operation of the building for this load and energy analysis. The schedules provide reasonable assumptions as to the operation of the building in terms of occupants, lighting and electrical power densities, which allow for the reduction in fan power as well as coil load allowing for a decrease in energy costs.

Calculated Load vs. Design Load Analysis

Engineering check values for the designed Life Sciences Building were not provided by the mechanical engineer, nor were they provided by the outside consultant WSP Flack + Kurtz who developed a preliminary energy model using the U.S. Department of Energy's eQuest v3.6 building simulation software. Therefore, the calculated cooling and heating loads were compared to the ASHRAE 1997 Pocket Guide in Table 4.

Air Handler Zone	Cooling (ft^2/ton)	Heating (Btu/h-ft^2)	Supply Air (CFM/ft^2)
East AHU	294.1	29.76	1.35
West AHU	245.9	28.55	1.44
Lab AHU	208.7	34.84	1.25
ASHRAE Guide	185	-	1.60

Table 4 - Design Load Engineering Checks

The consultant recorded results from their energy analysis of the Life Sciences Building in the units of MBtu per square foot per year, where one MBtu equals 1,000 Btu's for each of the purchased utilities; electricity, high temperature hot water and chilled water. The results are compared in Table 5.

Analysis	Life Sciences Building Energy Usage (MBtu/ft^2-yr)			
	Electricity	Purchased Hot Water	Purchased Chilled Water	Total Building
Calculated Values	96.5	10.6	28.1	135.2
Designed Values	40.6	50.0[1]	46.0	136.6

Table 5 - Calculated and Designed Energy Consumption

There are several justifications that can account for the differences between the calculated and designed energy usage values. The designed energy model was created using assembly heat transfer coefficients and solar heat gain coefficients from ASHRAE Standard 90.1-2004 rather than the actual coefficients provided by the architect. In certain cases, ASHRAE Standard 90.1-2004 is more stringent than the design. In the case of the Life Sciences Building, the exterior U-Value is 62% less than the assumed U-Value, the fenestration U-Value us 51% less than the assumed value and the solar heat gain coefficient is 31% less than the assumed value. The large differences in these coefficients can account for a higher building heat gain, which leads to larger energy consumptions in the calculated than the designed analysis. A summary of the actual and designed overall heat transfer coefficients and solar heat gain values can be found in Table 6.

Assembly	Actual		Designed	
	U-Value	SHGC	U-Value	SHGC
Exterior Wall	U-0.04678	-	U-0.124	-
Fenestration	U-0.28	SHGC-0.27	U-0.57	SHGC-0.39

Table 6 - Actual and Assumed U-Values and SHGC

Operation schedules were utilized in the calculated analysis aiding in the reduction of energy consumption during unoccupied hours. The designed energy analysis did not incorporate equipment and lighting schedules into the system. However, night setback temperatures and occupancy schedules were used. The reduction in lighting and electrical equipment power densities in spaces such as the offices and computer labs can allow for increased energy consumption during unoccupied periods. These schedule differences can also account for the differences between the calculated and designed energy consumptions.

The designed energy analysis used a lighting power density on a whole building spectrum, 1.2 Watts per square foot. The value was taken from Table 9.5.1 in ASHRAE Standard 90.1-2004. The calculated analysis used lighting power densities on a space by space method, which range from 0.5 to 1.5 Watts per square foot depending on the type of space. Furthermore, the designed energy analysis used a miscellaneous load of 4 Watts per square foot in the laboratory spaces rather than the 2 Watts per square foot used in the calculated analysis. 2 Watts per

[1] The designed energy and load analysis used purchased campus steam as the heating utility.

square foot was provided by the mechanical engineer. However, miscellaneous loads assumed in the computer labs and nursing skill labs were higher in the calculated analysis than the designed analysis. These differences in lighting and equipment power densities also contribute to the difference between the designed energy and the calculated energy usages.

The purchased high temperature hot water consumption is the single utility that has the largest difference. This is due to the heating utilities that were assumed. The design load and energy analysis assumed steam to convert hot water for the building use when, in reality, the Life Sciences Building is served by a campus high temperature hot water system.

According to ASHRAE, a typical educational building uses 71.0 MBtu/ft^2-year of total energy. The calculated energy analysis concluded a total of 135.2 MBtu/ft^2-year, which is 190% larger than the typical ASHRAE educational building. The designed energy analysis found a total of 136.6 MBtu/ft^2-year, which is nearly twice the value for a typical educational building. The designed energy analysis is 1% larger than the calculated, which is a much closer margin than when compared to the typical ASHRAE educational building. The differences between the calculated and designed model and the ASHRAE educational building can be attributed to the Life Sciences Building being a laboratory facility. The requirements of fume hoods and high equipment loads cause the electrical consumption to be significantly larger than an educational building that consists of simply classrooms and lecture halls.

The similarity between the calculated and designed energy consumptions provide a reasonable idea as to the expected energy consumption of the Life Sciences Building. Furthermore, the large margin between the ASHRAE typical educational building and the projected energy consumptions provide opportunities for a redesign that reduces the building’s overall energy consumption.

System Energy Consumption and Cost

Trane TRACE 700 was also used to calculate a full year energy simulation of the Life Sciences Building. The cooling and heating equipment are supplied from a campus chilled water and high temperature hot water system. Electricity is also supplied from the same Central Utility Plant (CUP) that produces the high temperature hot water and chilled water.

System Energy Consumption

While the purchased chilled water appears to be the category with the highest energy, the chilled water system only contributes 20.8% of the overall building energy. The electrical consumers are the source that uses the most energy at 62.3% of the total Life Sciences Building's yearly energy consumption. Over one half of the building's yearly energy consumption us due to the receptacle loads throughout the building, which incorporates the chemical laboratories and nursing skill teaching laboratories, which were estimated at a high electrical equipment power density. The receptacle loads also include the office equipment and computer labs. The energy used for heating is at a measly 7.8% of the total building energy, which can be attributed to the use of high temperature hot water through heating coils in two of the three air handling units as well as a heat recovery run-around loop utilized in the 100% outdoor air unit. A summary of the Life Sciences Building's yearly energy consumption can be viewed in Table 7.

	Electrical Consumption (kWh/year)	Purchased Hot Water (MBtu/year)	Purchased Chilled Water (MBtu/year)	Total Building Energy (%)
Heating System				
Primary Heating	-	767,179	-	7.8%
Cooling System				
Primary Cooling	-	-	2,034,749	20.8%
Auxiliary				
Supply Fans	194,245	-	-	6.8%
Pumps	9,564	-	-	0.3%
Lighting	261,623	-	-	9.1%
Receptacles	1,581,672	-	-	55.2%

Table 7 - System Energy Consumption Breakdown

Building Energy Costs

The utility rates that the Life Sciences Building is charged for high temperature hot water, chilled water and electricity are displayed in Table 8, Table 9 and Table 10. According to the Long Island Power Authority (LIPA), the electrical rates for demand and consumption are not affected by on and off peak hours. Rather they are dependent on the time of year that the electricity is being used. The purchased high temperature hot water and purchased chilled water rates remain the same throughout the year. All three of these utilities are produced by the same central utility cogeneration plant operated by the Nassau Energy Corporation. The Nassau Energy Corporation sells electricity to LIPA and the high temperature hot water directly to the end user.

Utility	June – September	October - May
Electrical Consumption	$0.053/kWh	$0.0381/kWh
Electrical Demand	$9.33/kW	$8.25/kW

Table 8 - Electrical Consumption and Demand Rates

Utility	January - December
Purchased High Temperature Hot Water	$12/Therm

Table 9 - Purchased High Temperature Hot Water Rate

Utility	January – December
Purchased Chilled Water	$1.25/Therm

Table 10 - Purchased Chilled Water Rate

The rates in Table 8, Table 9 and Table 10 were used in the calculated energy analysis by created schedules for each of the utility costs. The utility costs were used in the computerized energy analysis in order to develop the total monthly energy consumption for an entire year broken down by individual energy source. The monthly utility cost for a full year for the Life Sciences Building can be viewed in Figure 2.

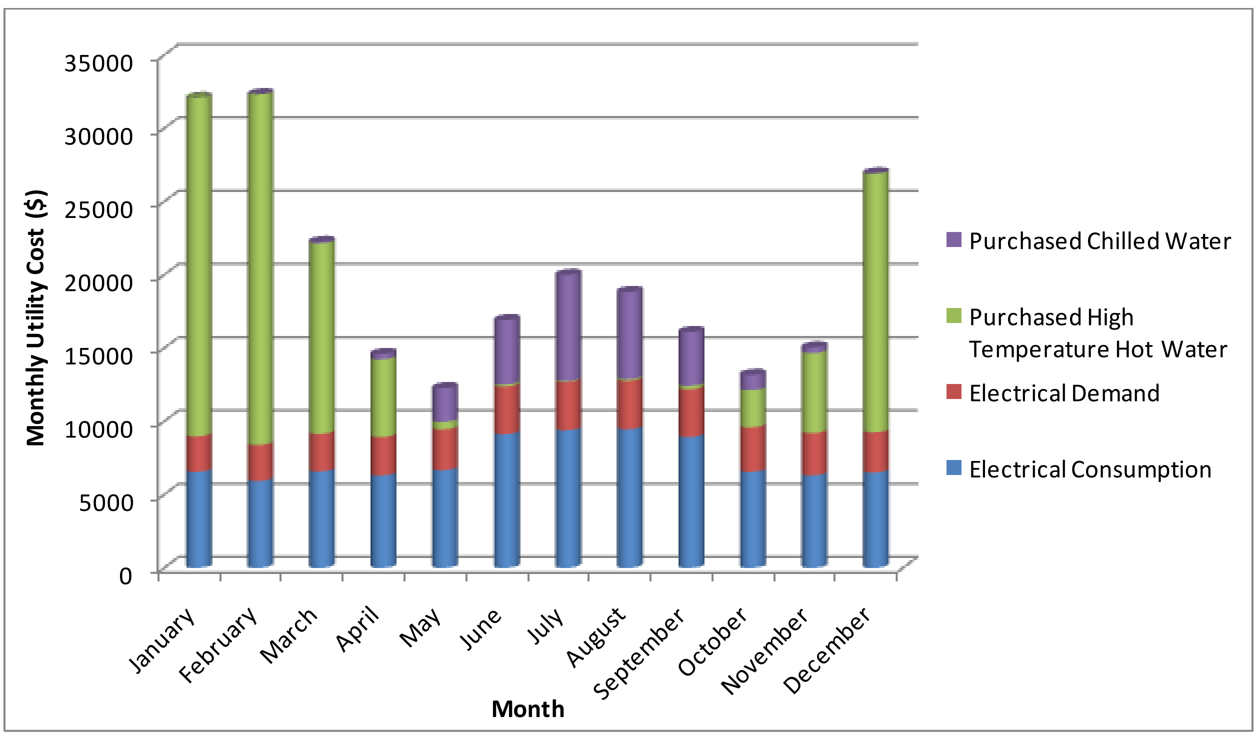

Figure 2 - Monthly Utility Cost

As expected, electrical usage peaks during the summer along with chilled water due to the requirement to cool the building and the high airflows needed to do so. As mentioned earlier, the Life Sciences Building is assumed to operate fully during the fall, spring and summer semesters. If the college were to not offer chemistry courses that require the laboratories during the summer, the peak electrical consumption and chilled water would decrease.

The high temperature hot water peaks during the winter, mostly due to the high volume of glass present on the exterior. The electrical consumption is not as high due to the decrease in supply airflow. The Life Sciences Building has a perimeter radiation system to aide in space heating during the winter months.

The total utility cost for an entire year was calculated at $240,528 with the highest month being February at $32,327. Purchased hot water is the most expensive utility per unit and therefore is most costly. With a yearly cost of about $241,000, the utility cost per area equates to $3.33/ft^2.

According to the 2003 Commercial Buildings Energy Consumption Survey (CBECS) under the Energy Information Administration (EIA), an average educational facility consumes 83.1 MBH/ft^2. This average energy consumption is 163% of the calculated 135.2 MBH/ft^2 as shown in Table 5 earlier in this report. Unfortunately, the survey does not have conclusive results as to the cost per square foot for a campus cooling system. Therefore, the incomplete data cannot be compared to the calculated $3.33/ft^2. While $3.33/ft^2 is much above the typical industry values around $2 to $3 per square foot, it is evident that the prices for the high temperature hot water and chilled may not be correct. The prices for high temperature hot water and chilled water were the assumed values provided by WSP Flack + Kurtz. More accurate utility rates were unavailable from Nassau Energy Corporation when contacted. The high energy costs per square foot can also be attributed to the high electrical consumption of the Life Sciences Building.

System Emission Rates

The pollution rate due to the amount of energy consumed by the Life Sciences Building is measured against the six criteria pollutants determined by the U.S. Environmental Protection Agency (EPA), which are: nitrogen dioxide (NO_2), ozone, sulfur dioxide (SO_2), particulate matter (PM), carbon monoxide (CO) and lead. The Life Sciences Building does not perform onsite combustion for a heating source. Rather, all of the utilities are provided by a nearby cogeneration facility operated by the Nassau Energy Corporation.

Central Utility Plant

The Central Utility Plant (CUP) contains a 42 MW natural gas-fired turbine coupled with a heat recovery steam generator. The steam generator produces both 270°F hot water and 1,250 psig steam. The 1,250 psig steam proceeds through a backpressure steam turbine, which knocks the pressure down to 200 psig and produces about 17 MW of electricity. Both the 270°F hot water and 200 psig steam are distributed to their respective buildings; Nassau Community College receives 270°F hot water.

The 200 psig steam and 270°F hot water are routed to a chiller plant located at the same facility. The chiller plant contains three 3,000 ton, steam turbine-driven chillers and one 1,200 ton absorber, which uses the 270°F hot water for the generator. The chilled water is produced and routed to all the buildings served by the high temperature hot water loads. The chilled water is also used to cool the gas turbine. Figure 3 is a schematic illustration of the CUP provided by Parsons Brinckerhoff.

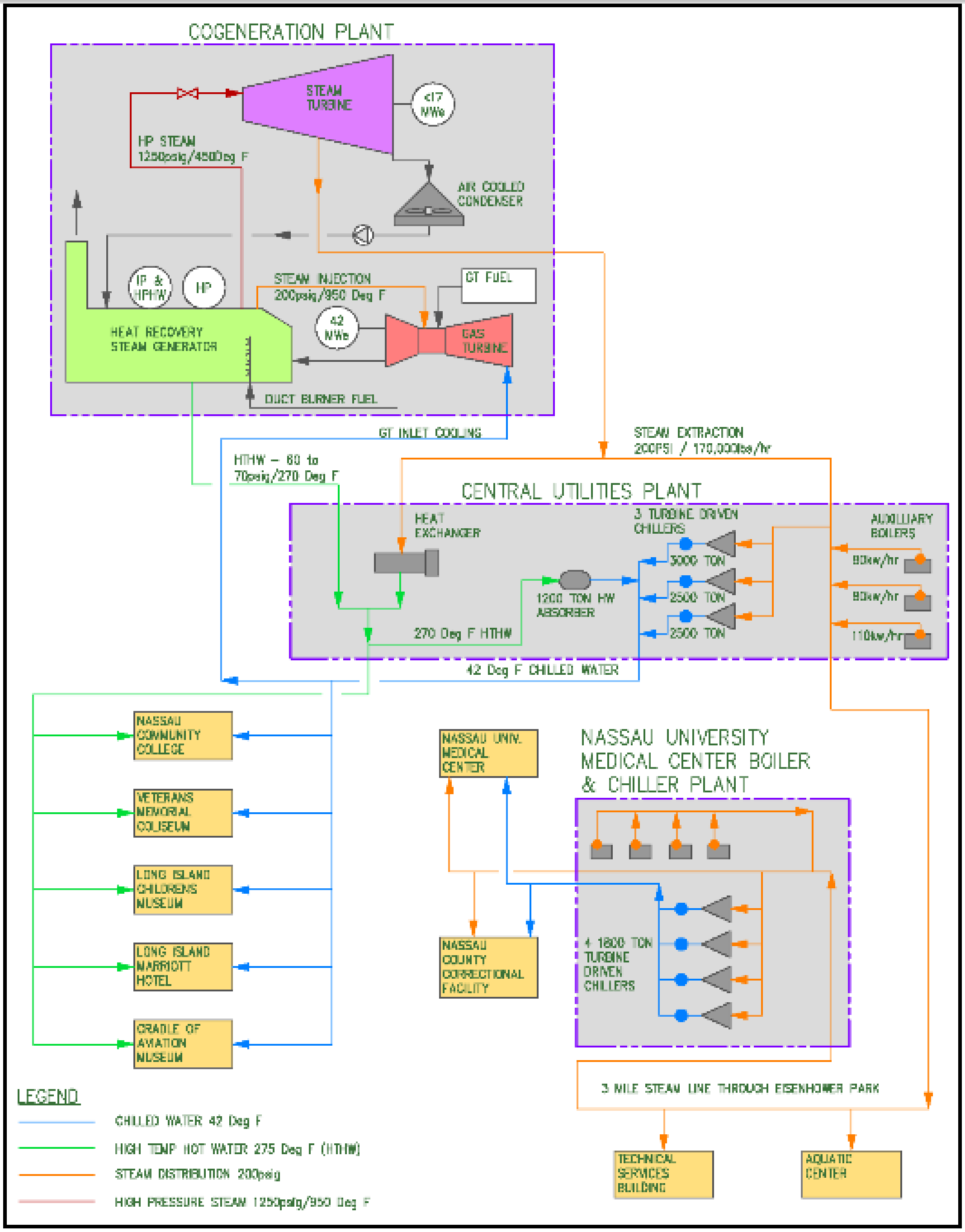

Figure 3 - Schematic of the Central Utility Plant

Emissions

The National Renewable Energy Laboratory (NREL) divides the United States into three main grids based how the energy within each specific grid is produced. Long Island is located in the Eastern Interconnection grid, which can be seen in Figure 4.

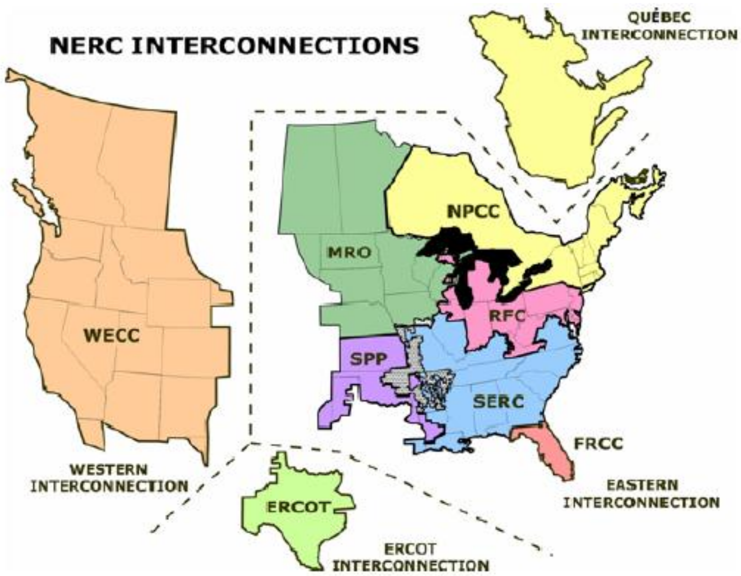

Figure 4 - NERC North American Electrical Grid Interconnections

The Eastern Interconnection grid is defined by having the majority of its electricity produced by coal, both bituminous and subbituminous. Natural gas, used in Nassau County's cogeneration plant, is the third largest fuel for combustion in the Eastern Interconnection grid. A breakdown of the fuel mixtures for each interconnection grid can be viewed in Figure 5.

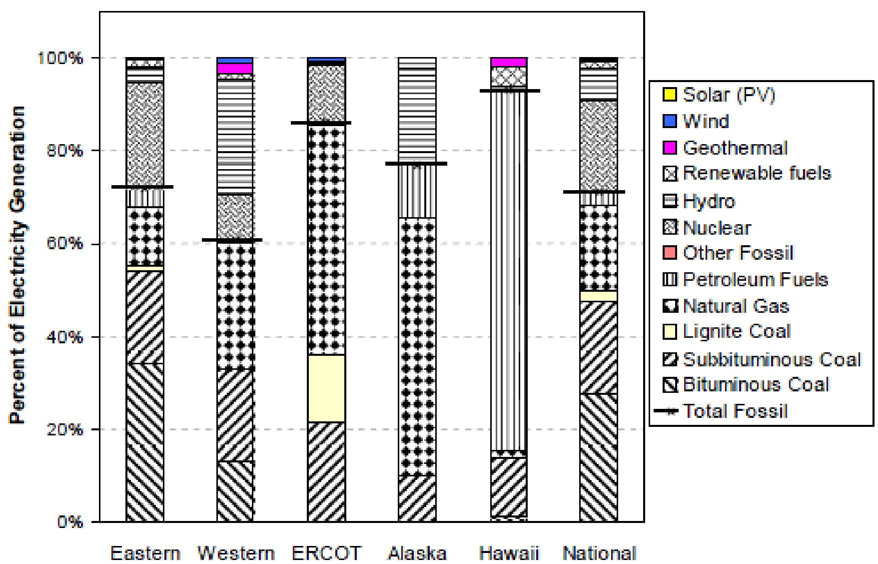

Figure 5 - Electricity Generation Fuel Mix

Each interconnection grid, based on their primary fuels used for combustion, has a series of factors that can be used to calculate the total pollutant emission in pounds of each particular pollutant. The Life Sciences Building uses about 2.05 million kWh of electricity per year. Table

11 provides a summary of the about of mass of pollutant is released into the atmosphere per year as a result of the electricity used by the Life Sciences Building.

NREL Pollutant	Eastern Interconnection Grid (lbm Pollutant/kwh)	Life Sciences Building Electricity (kWh/year)	Mass of Pollutant Emitted (lbm/year)
CO_{2e}	1.74	2,047,104	3.56×10^{6}
CO_2	1.64	2,047,104	3.36×10^{6}
CH_4	3.59×10^{-3}	2,047,104	7.35×10^{3}
N_2O	3.87×10^{-5}	2,047,104	7.92
NO_x	3.00×10^{-3}	2,047,104	6.14×10^{3}
SO_x	8.57×10^{-3}	2,047,104	1.75×10^{4}
CO	8.54×10^{-4}	2,047,104	1.75×10^{3}
TNMOC	7.26×10^{-5}	2,047,104	149
Lead	1.39×10^{-7}	2,047,104	2.85
Mercury	3.36×10^{-8}	2,047,104	0.0688
PM10	9.26×10^{-5}	2,047,104	190
Solid Waste	0.205	2,047,104	4.20×10^{5}

Table 11 - Mass of Pollutant Emitted per kWh of Electricity per Year

Unfortunately, NREL does not provide factors, like those in Table 11, for campus hot and chilled water systems. As mentioned in the CUP description, a 42 MW natural gas turbine and a heat recovery steam generator provide steam and high temperature hot water to the served facilities. Nassau Community College contributes, as a whole, 50.6% of the overall high temperature hot water and chilled water consumption from the CUP. However, it is unclear how much of the total college consumption will be used by the Life Sciences Building. Table 12 provides a summary of the emissions from the gas turbine found in the CUP, which is the main source of combustion in the plant. It was assumed that the turbine runs at full load for the entire year and has an efficiency of 49%, determined from GE's website.

NREL Pollutant	Natural Gas Emission Factor for Small Turbine (lbm Pollutant/mcf)	Turbine Natural Gas (mmcf/year)	Mass of Pollutant Emitted (lbm/year)
CO_{2e}	125	1,225	1.53×10^{8}
CO_2	122	1,225	1.49×10^{8}
CH_4	526	1,225	6.44×10^{8}
N_2O	4.54×10^{-3}	1,225	5.56×10^{3}
NO_x	0.351	1,225	4.30×10^{5}
SO_x	6.32×10^{-4}	1,225	774
CO	0.175	1,225	2.14×10^{5}
TNMOC	2.06×10^{-3}	1,225	2.52×10^{3}
Lead	5.00×10^{-7}	1,225	0.613
Mercury	2.60×10^{-7}	1,225	0.319
PM10	0.0264	1,225	3.23×10^{4}

Table 12 - Mass of Pollutant Emitted per mmcf of Natural Gas per Year

The GE turbine, upgraded in 1997, contains a continuous emissions monitoring system (CEMS) on the exhaust stack. Furthermore, a steam injection system was installed, which reduces NO_x emissions that escaped from the combustion system. Steam is injected into the compressor discharge, reducing flame temperature leading to a decrease in harmful NO_x releases to the atmosphere.

There are a total of 47 buildings on the Nassau Community College campus. If a general assumption is made that each building consumes the same amount of energy per year as the Life Sciences Building, then the campus as a whole uses a total of approximately 4,850 MMBtu of energy per year. This value includes all three utilities: electricity, high temperature hot water and chilled water.

At the CUP, it is known that Nassau Community College uses 50.6% of the total thermal energy produced. Therefore, the assumption could be made stating that Nassau Community College contributes to about 50% of the emissions released by the gas turbine. Furthermore, the Life Sciences Building contributes 2.1% to the overall campus energy consumption assuming that the energy is split equally amongst all buildings on campus. Table 13 summarizes how much mass of each pollutant would be emitted if the Life Sciences Building contributed to 2.1% of the college's emissions.

NREL Pollutant	Mass of Pollutant Emitted (lbm/year)
CO_{2e}	1.61×10^6
CO_2	1.56×10^6
CH_4	6.76×10^6
N_2O	58.4
NO_x	4.52×10^3
SO_x	7.81
CO	2.25×10^3
TNMOC	26.5
Lead	6.44×10^{-3}
Mercury	3.35×10^{-3}
PM10	339

Table 13 - Emissions Due to the Life Sciences Building

The results shown in Table 13 are estimates based on rough assumptions. The emissions include the three main utilities produced by the gas turbine in the Central Utility Plant. A more accurate representation of the emissions due to the Life Sciences Building can be made with more information about the high temperature hot water and chilled water volumetric flow rates consumed by Nassau Community College as well as the total volumetric flow rate produced by the heat recovery steam generator in the CUP.

The heat recovery steam generator produces both 1,250 psig steam and 270°F water from the gas turbine exhaust. The Parsons Brinckerhoff analysis of the Central Utility Plant does not specify the design or actual mass flow rates for either fluid. Therefore, it impossible to develop an actual relationship between the thermal energy consumed by Nassau Community College compared to the total amount of high temperature hot water created. If more information about the heat recovery steam generator is found, then a more proper relationship between thermal energy and the life sciences building can be analyzed and a more accurate emissions release can be calculated.

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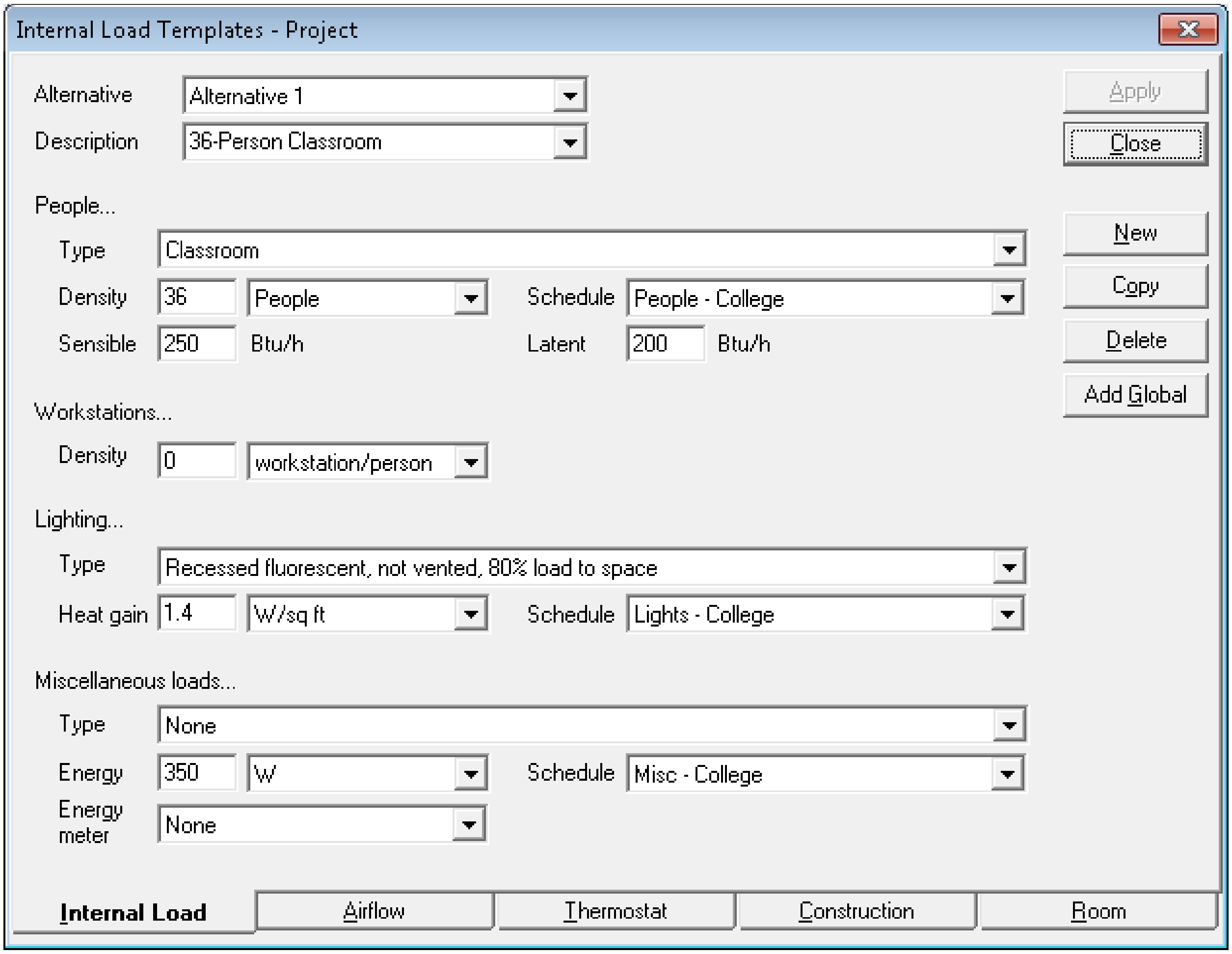
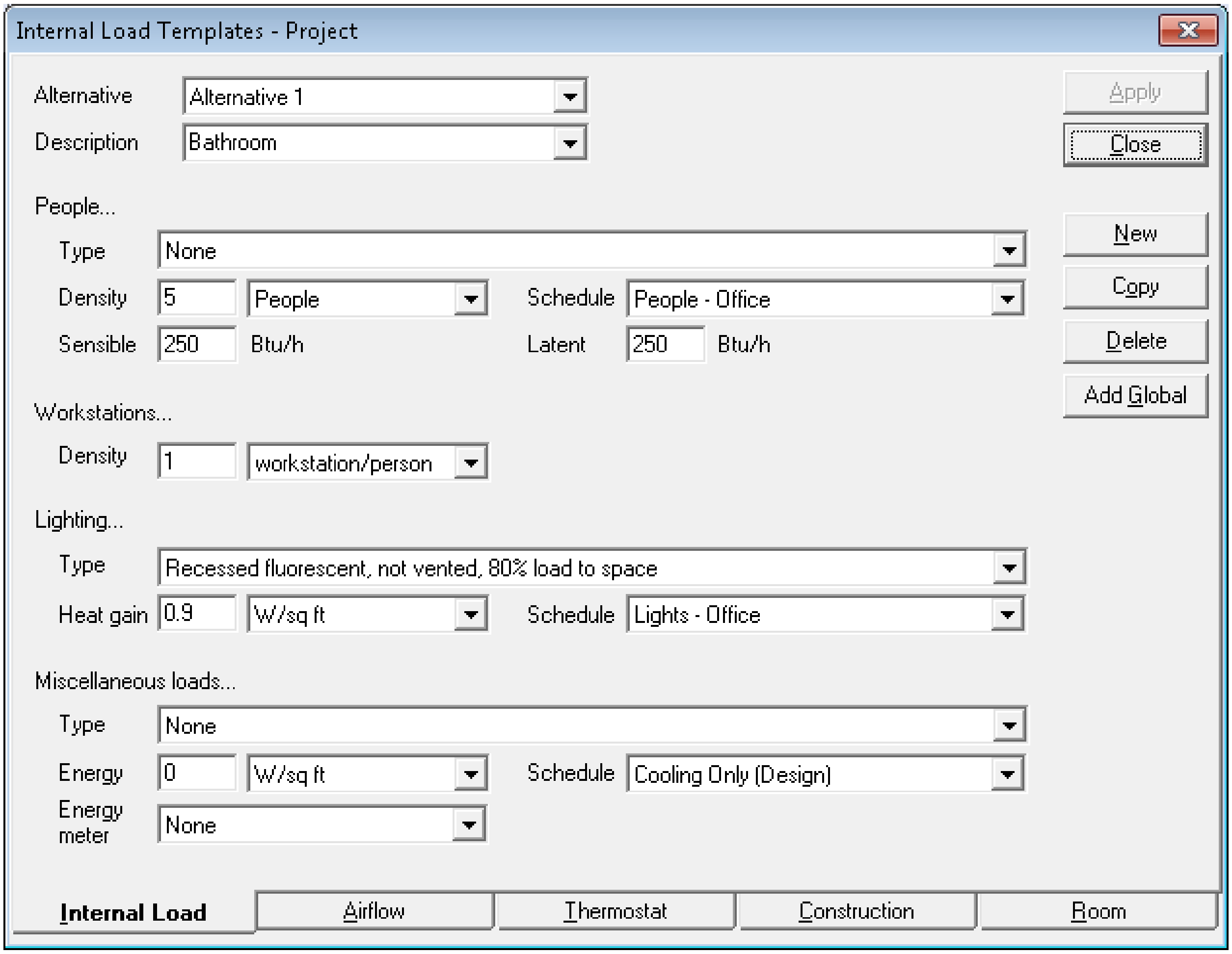
Appendix A – Typical Trane TRACE 700 Templates

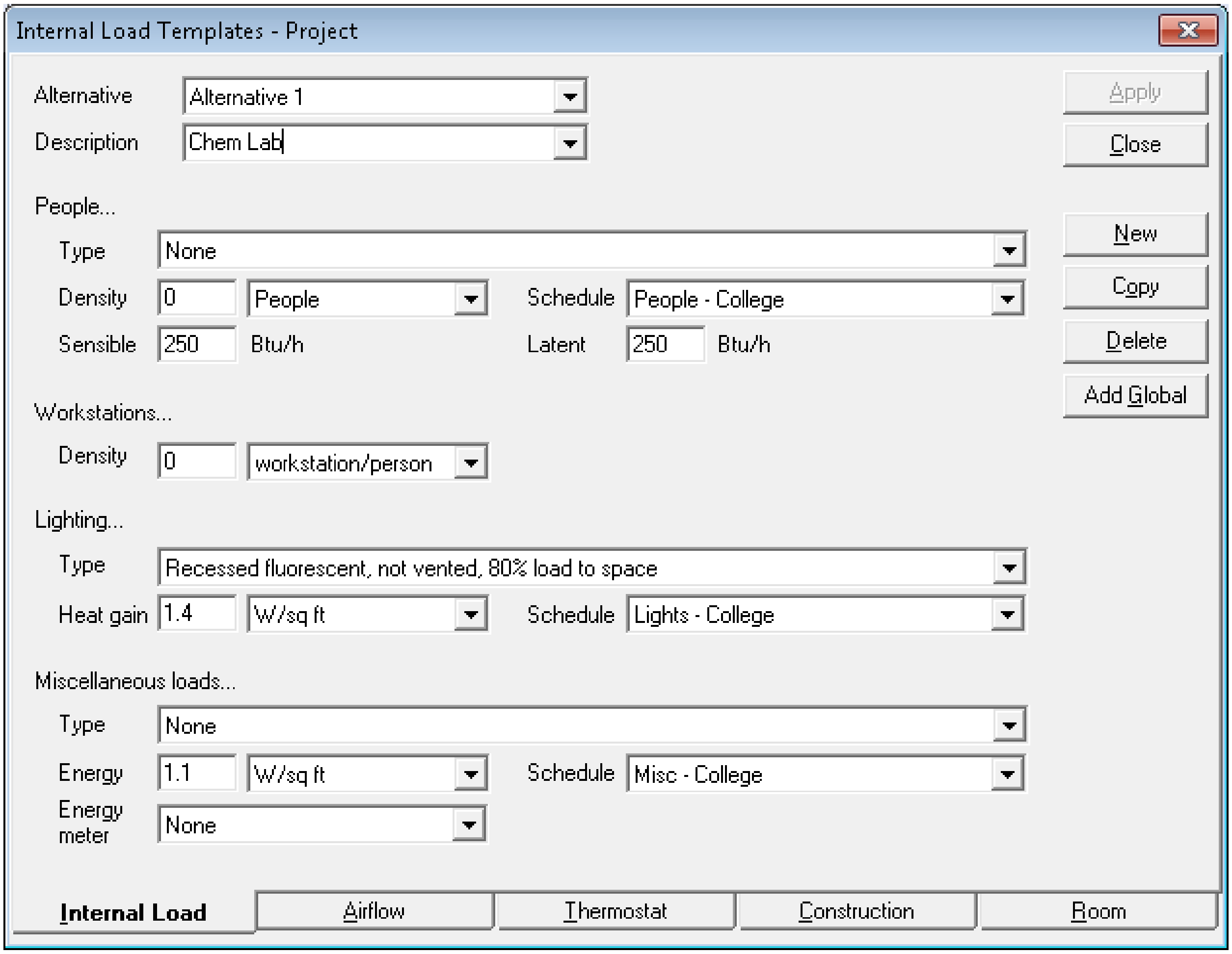
Typical 36-Person Classroom Internal Load Template



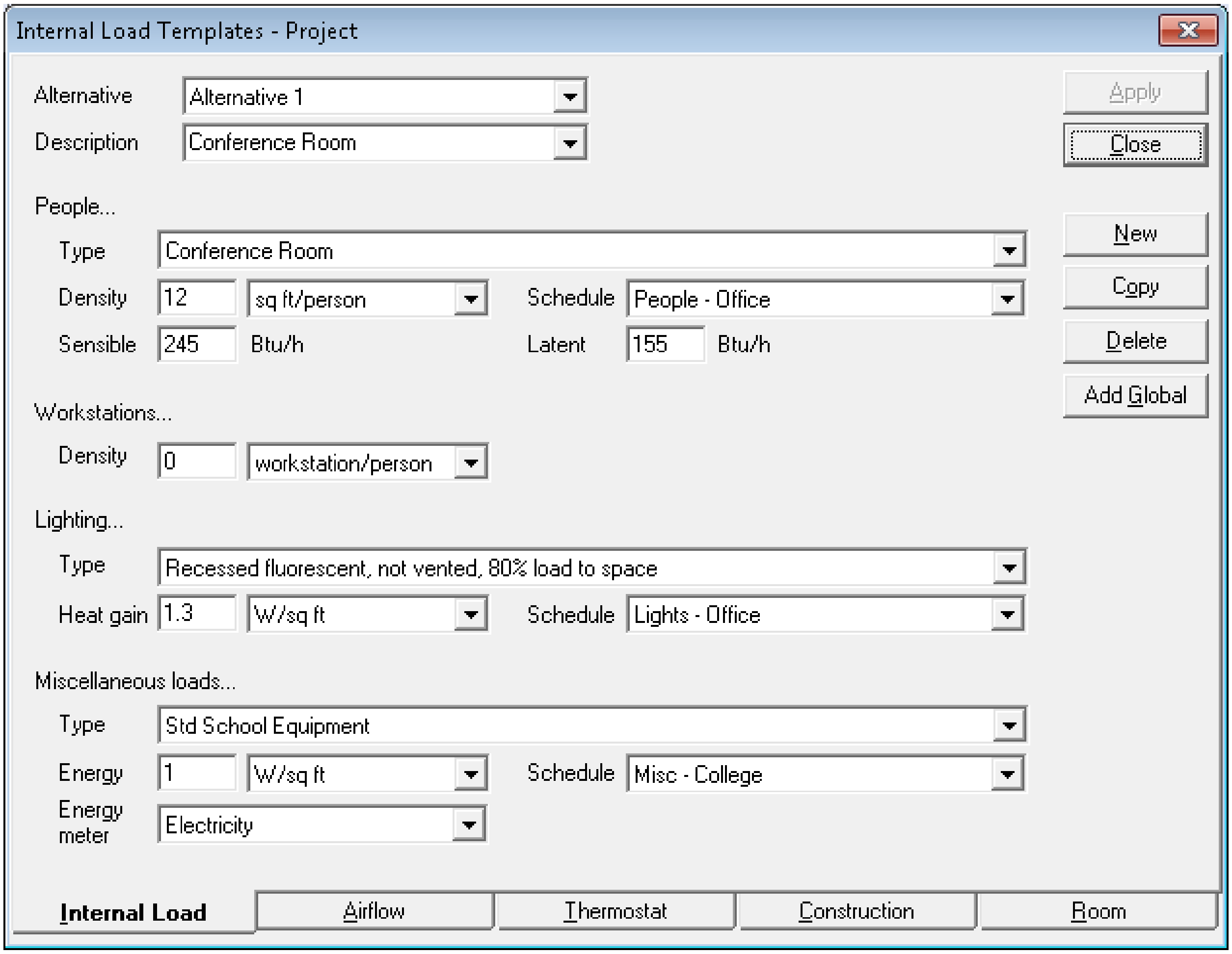
Typical Bathroom Internal Load Template



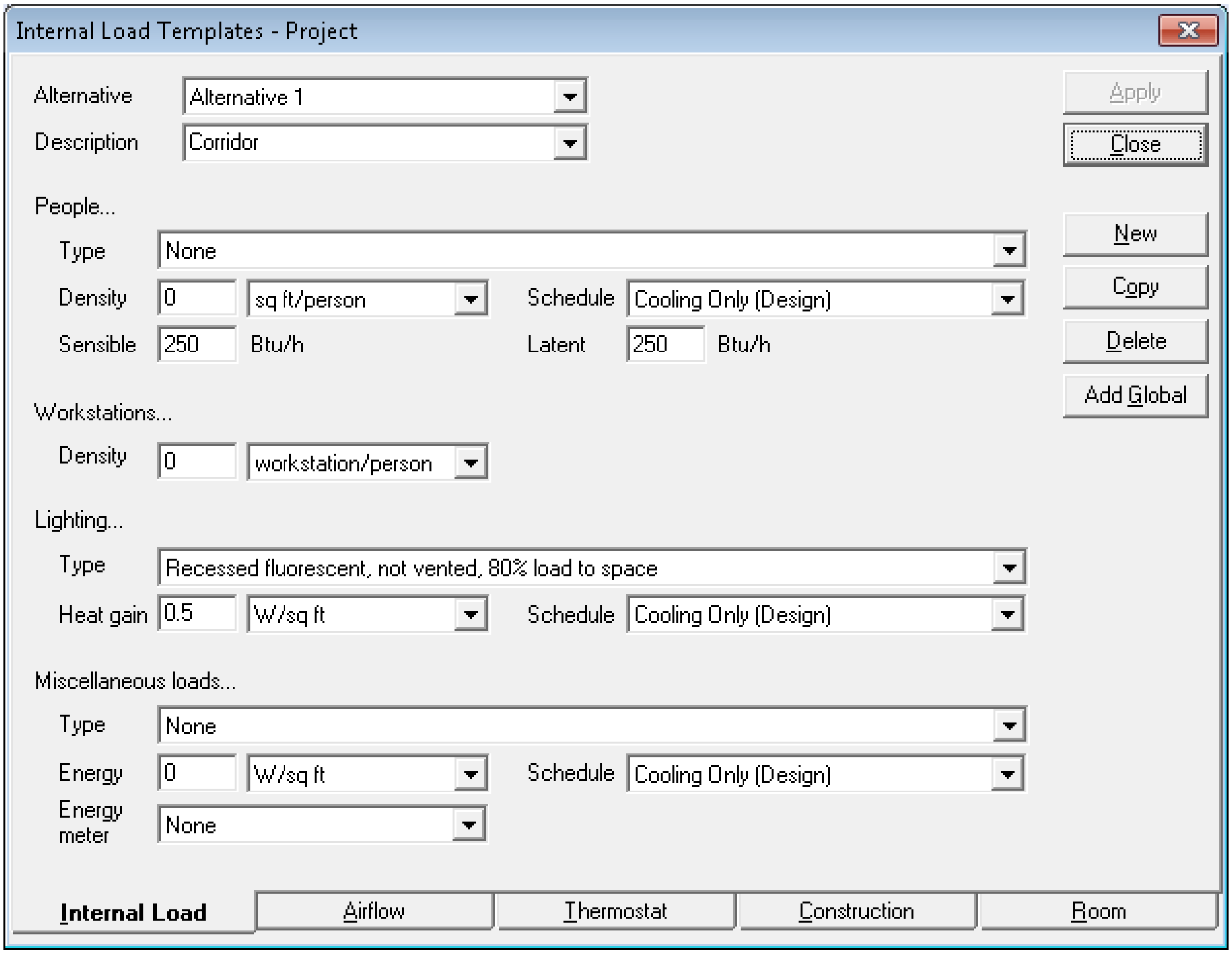
Typical Chemistry Laboratory Internal Load Template



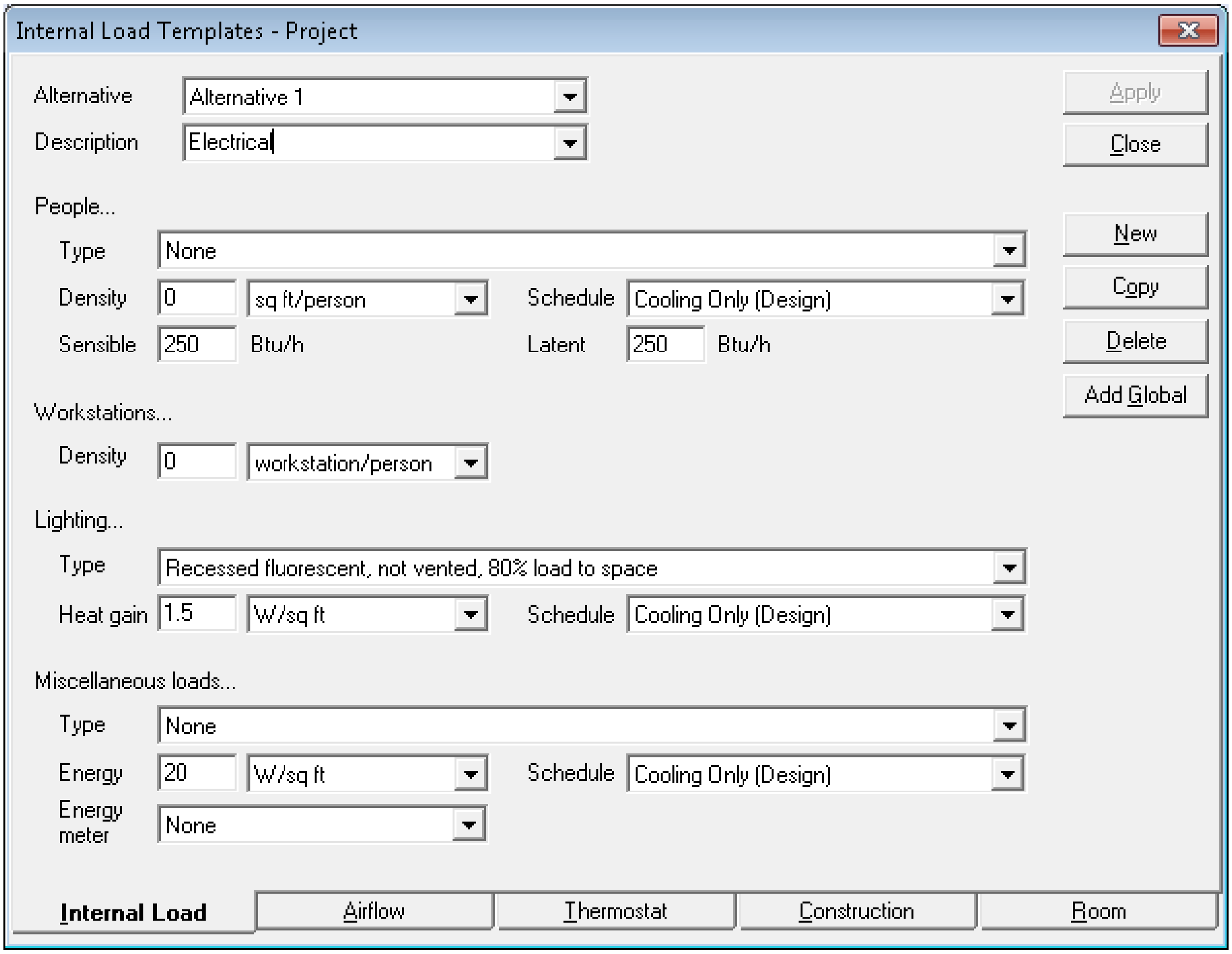
Typical Conference Room Internal Load Template



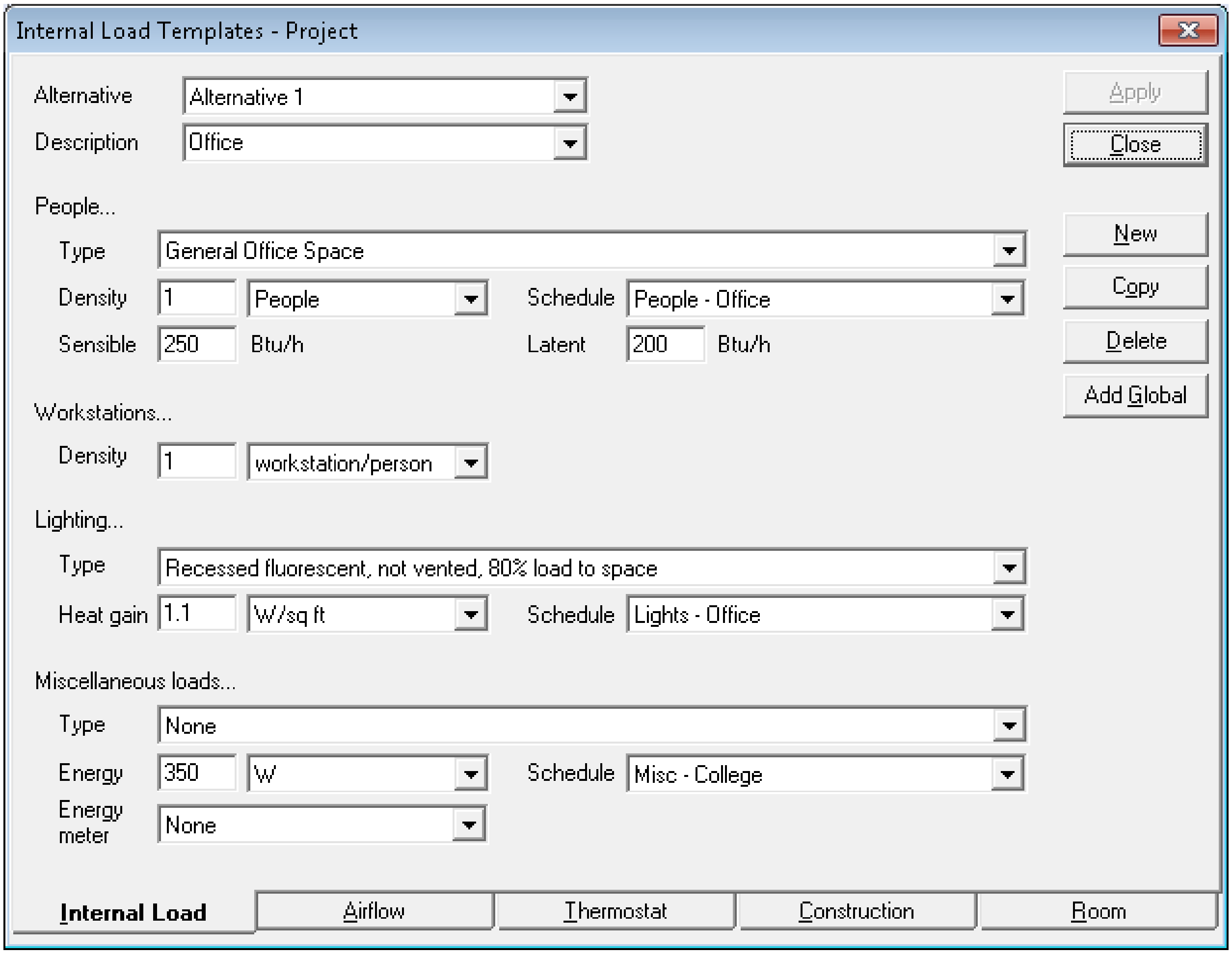
Typical Corridor Internal Load Template



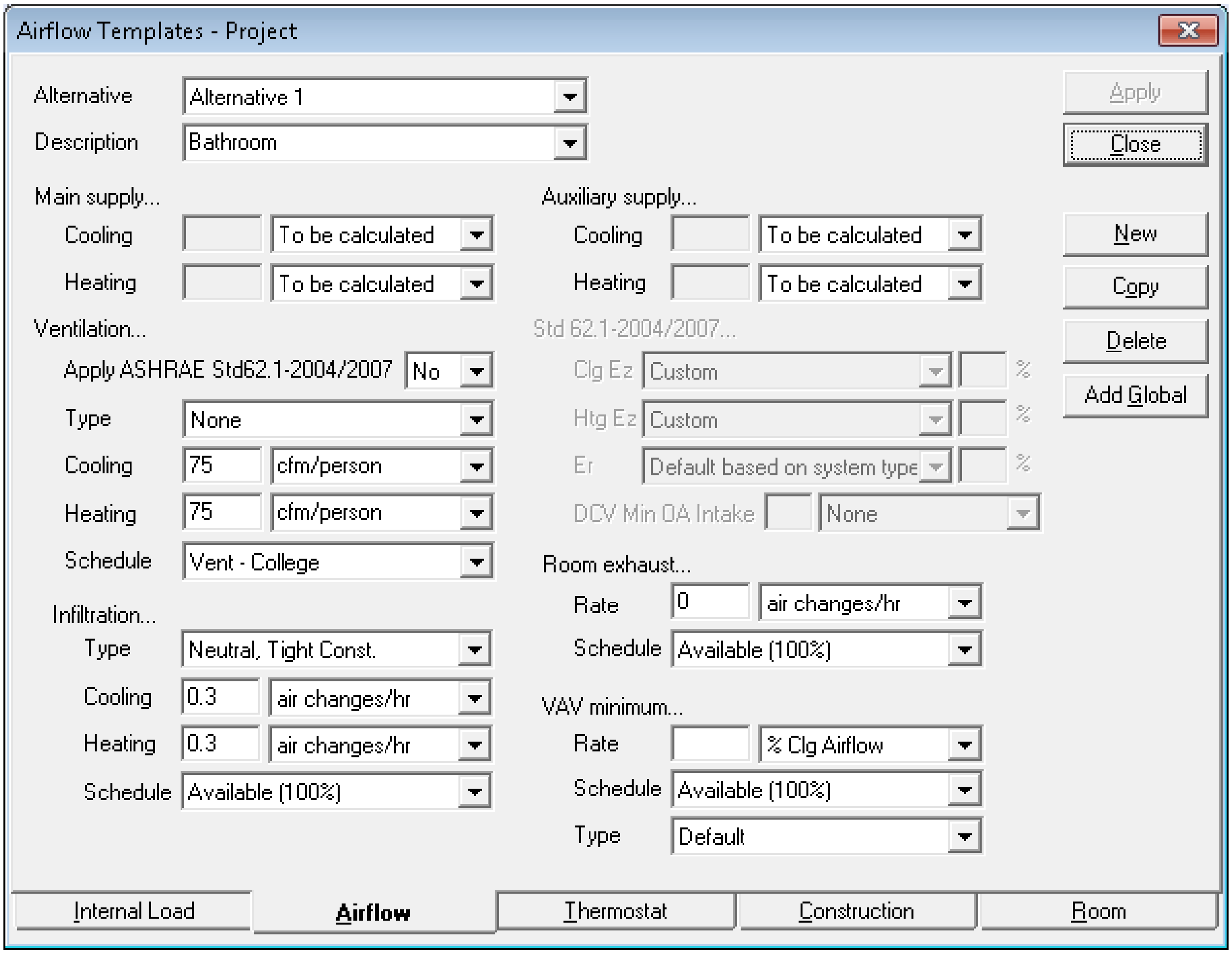
Typical Electrical Room Internal Load Template



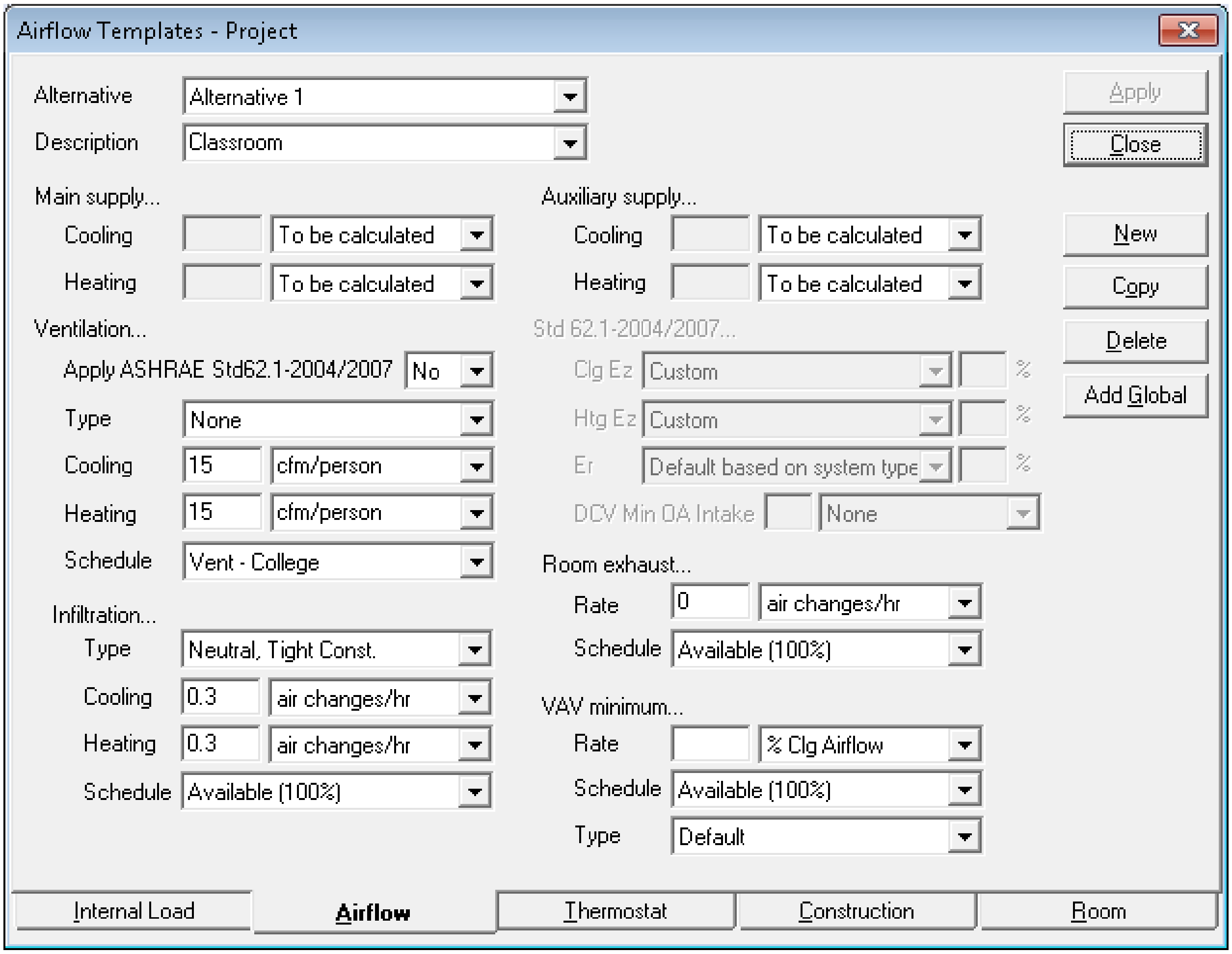
Typical Office Internal Load Template



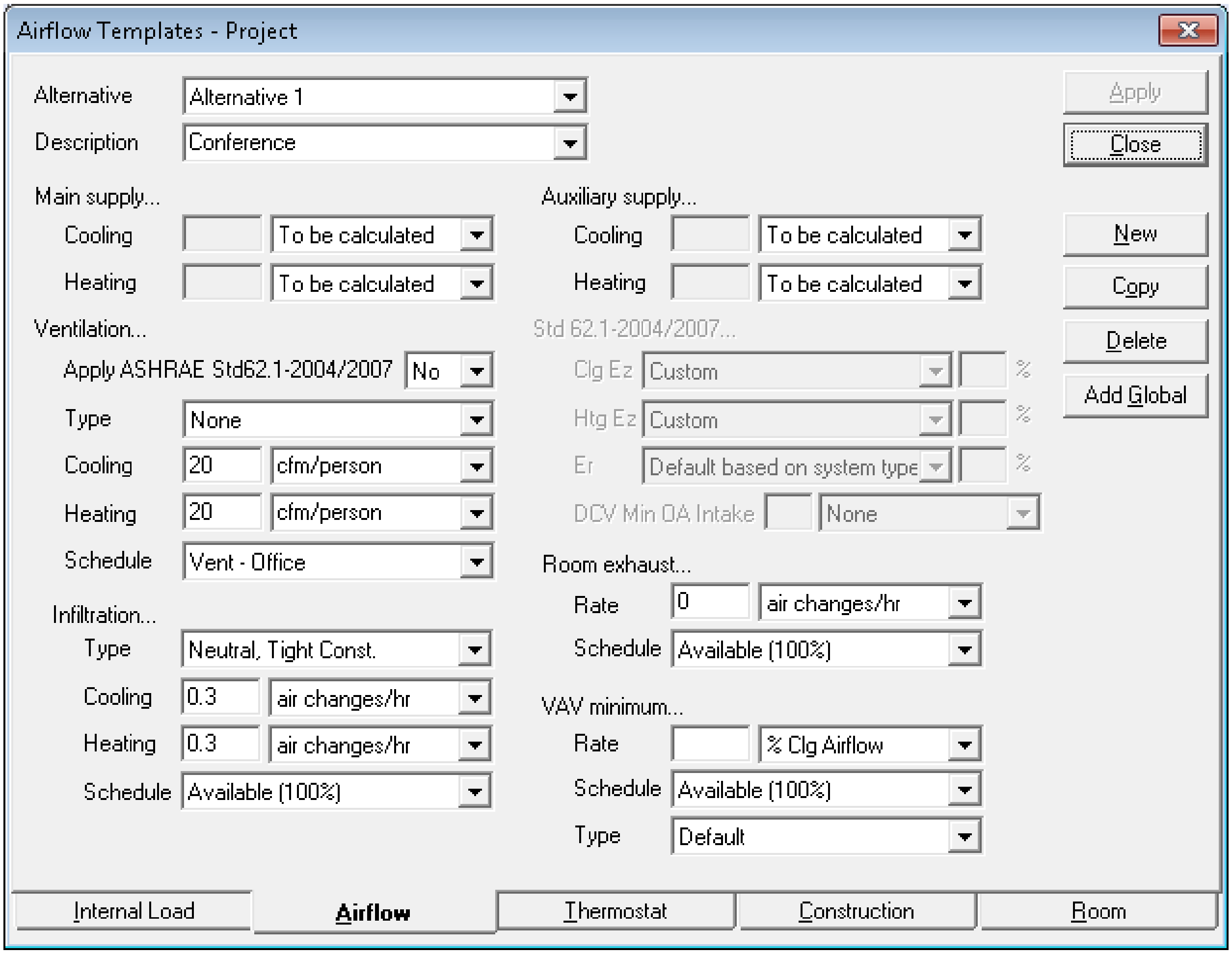
Typical Bathroom Airflow Template



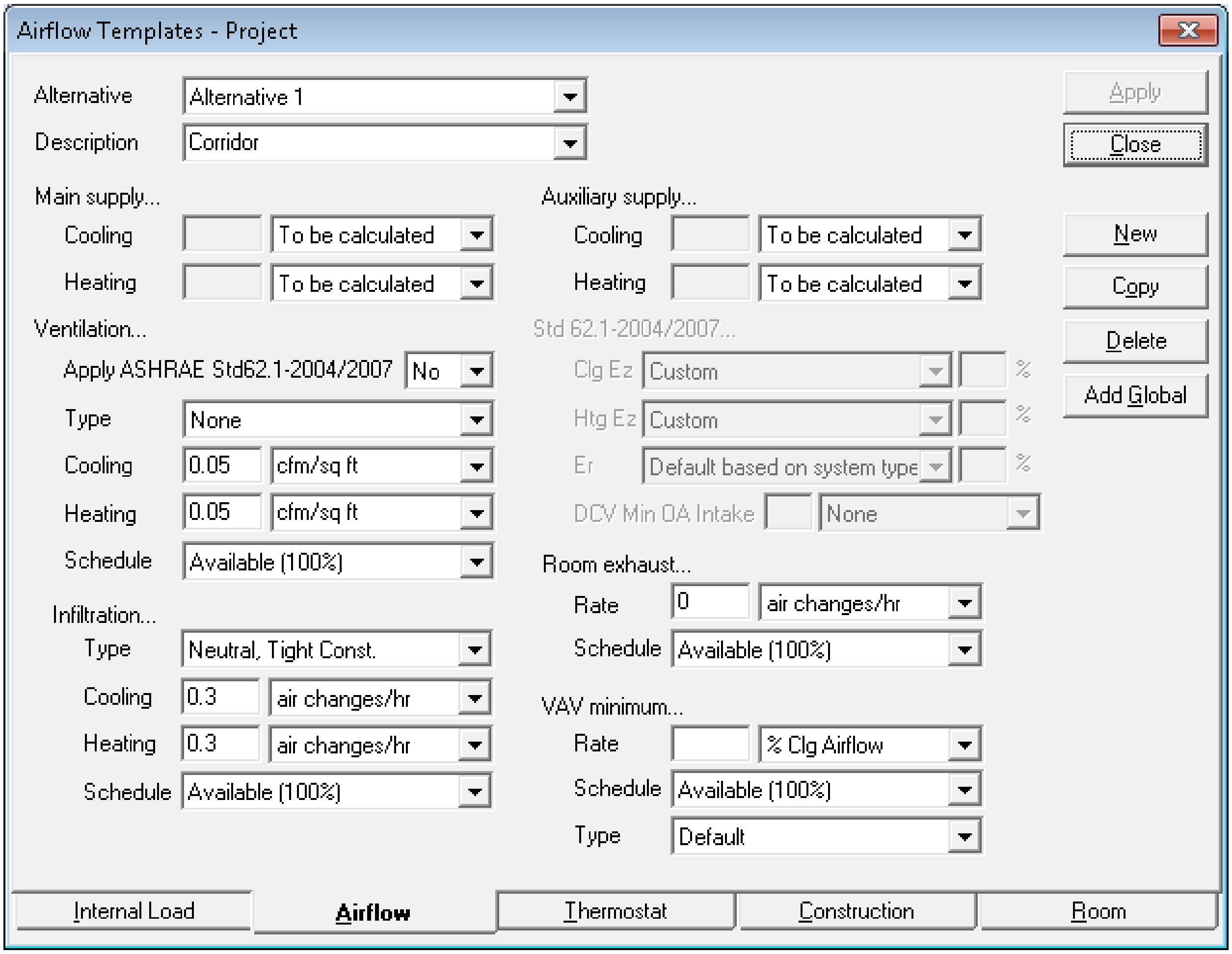
Typical Classroom Airflow Template



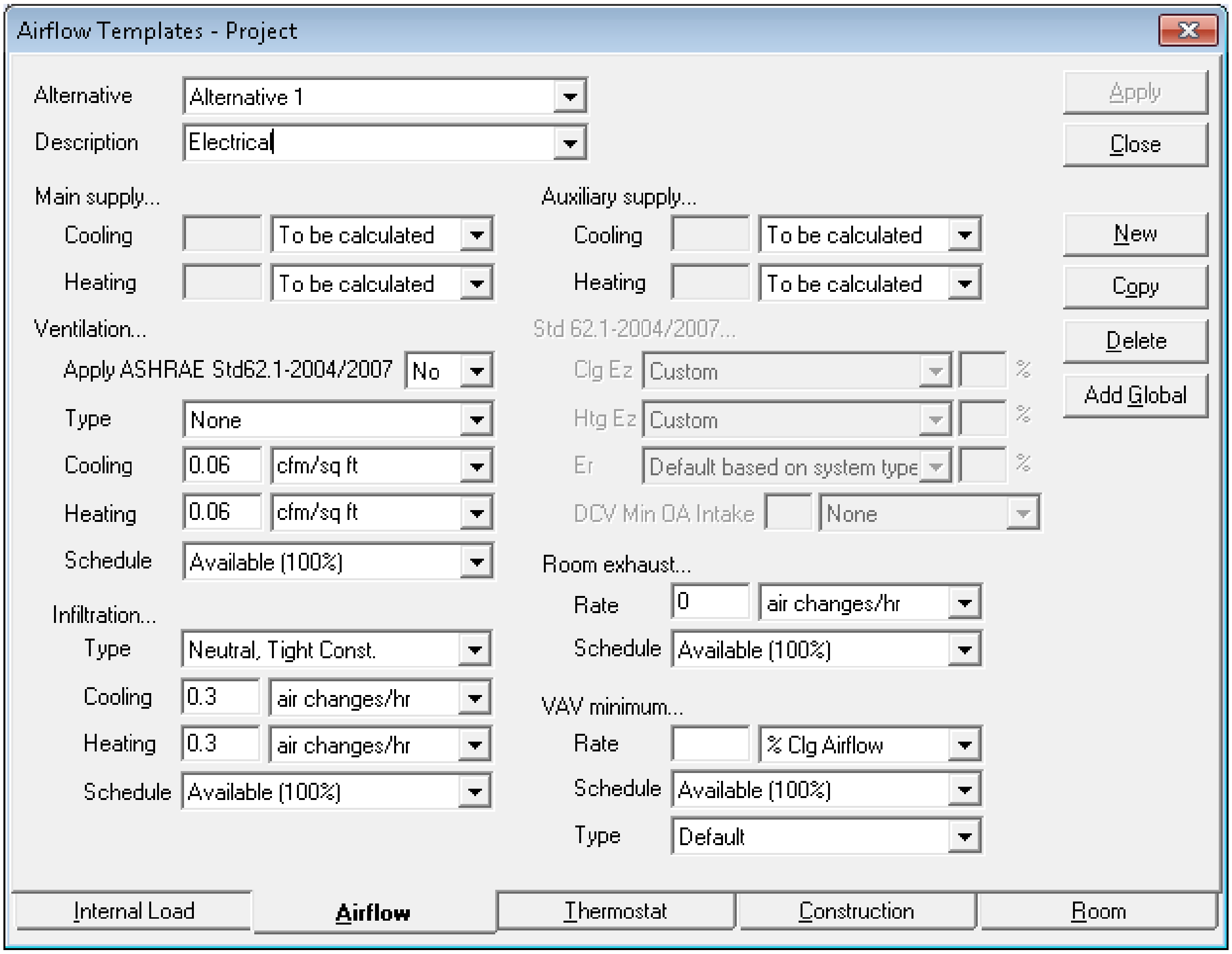
Typical Conference Room Airflow Template



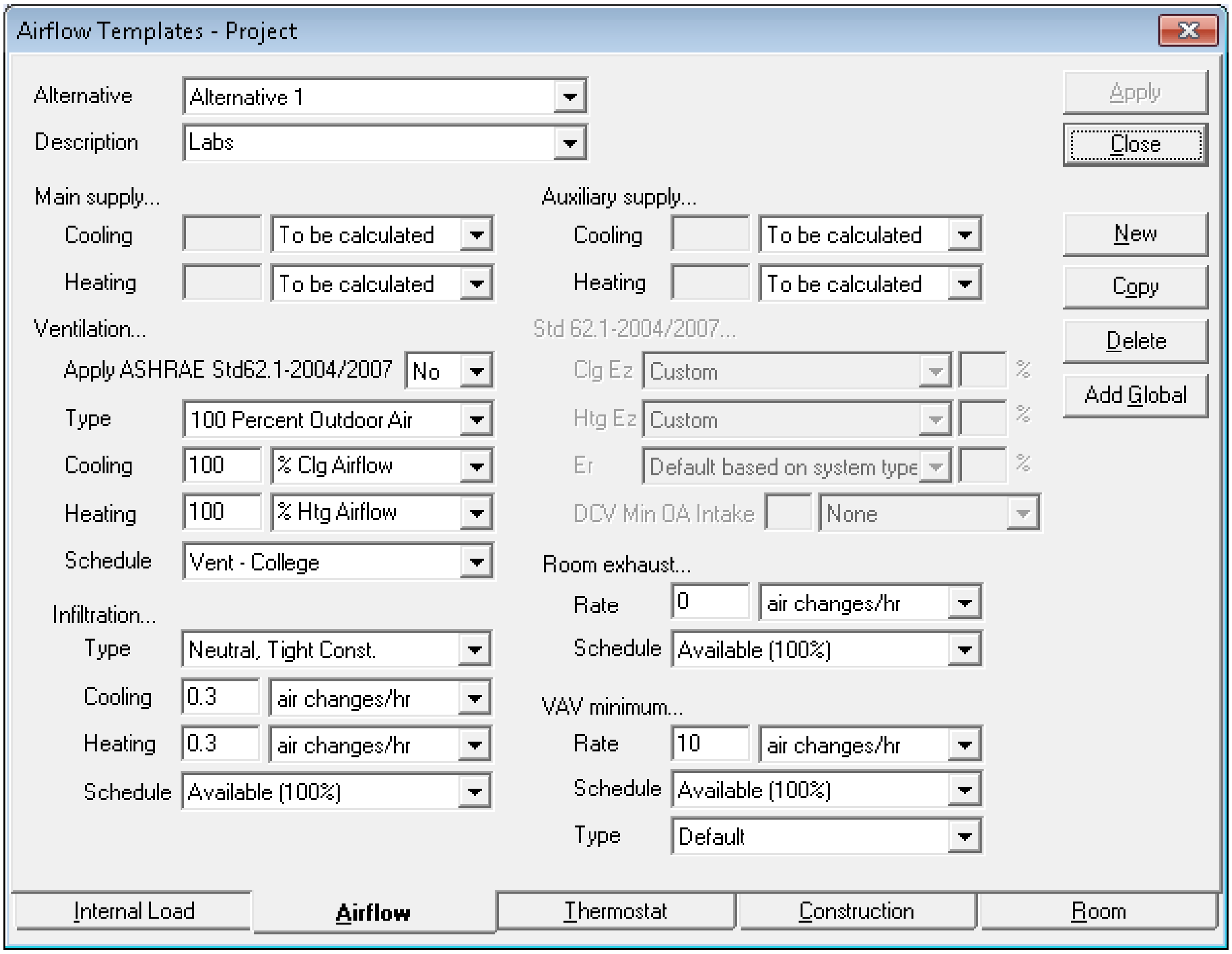
Typical Corridor Airflow Template



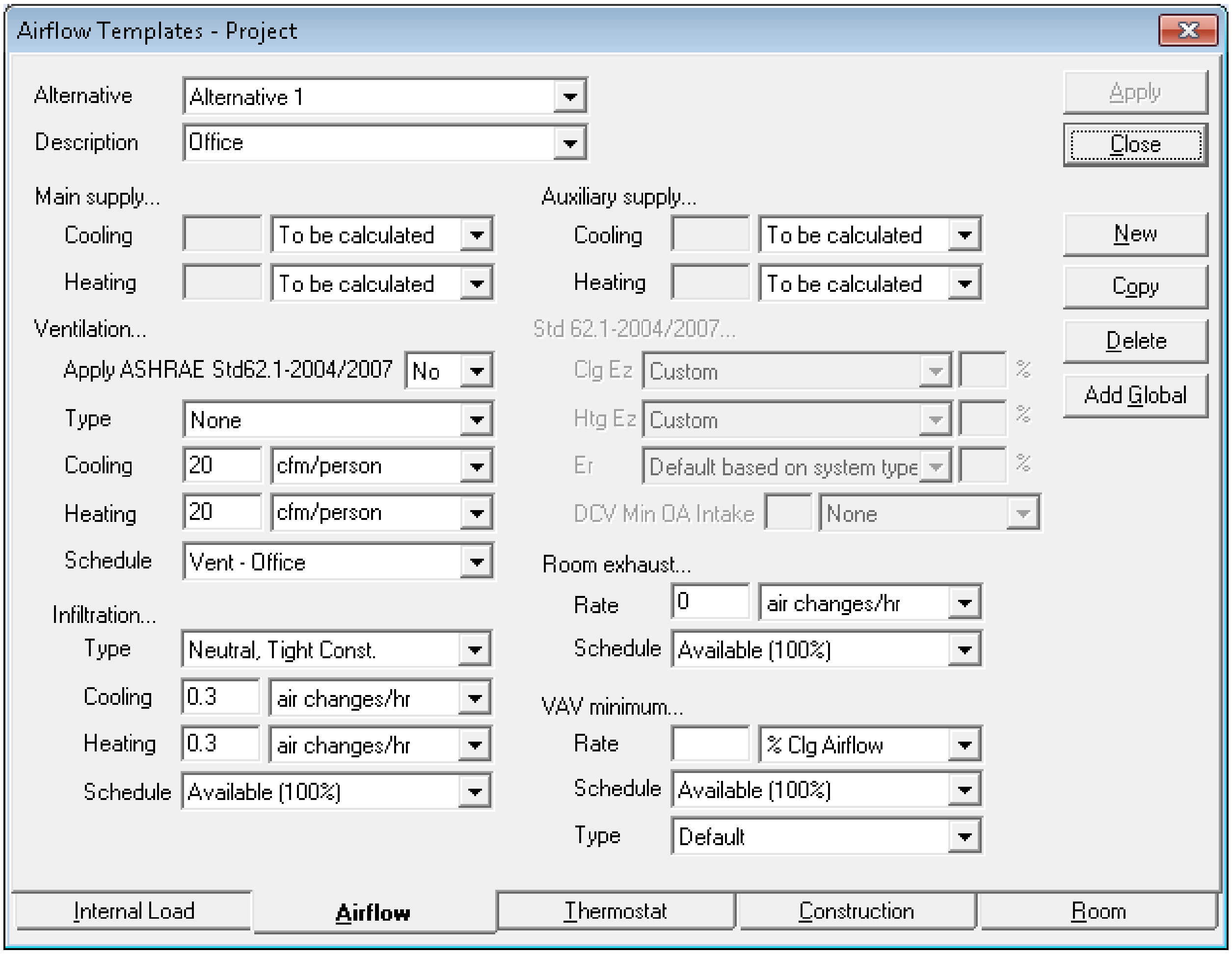
Typical Electrical Room Airflow Template



Typical Chemistry Laboratory Airflow Template



Typical Office Airflow Template



Appendix B – ASHRAE Weather Data

2009 ASHRAE Handbook - Fundamentals (IP) © 2009 ASHRAE, Inc.

NEW YORK J F KENNEDY INT'L AR, NY, USA

WMO#: 744860

Lat: 40.66N Long: 73.80W Elev: 23 StdP: 14.68 Time Zone: -5.00 (NAE) Period: 82-06 WBAN: 94789

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	12.8	17.2	-5.4	4.1	16.0	-1.6	5.1	20.2	31.7	26.2	28.8	27.4	16.7	320

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
7	13.4	89.7	73.5	86.5	72.2	83.7	71.4	77.0	84.3	75.8	81.9	74.6	80.2	12.6	230

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	
74.9	130.8	80.5	73.7	125.7	79.0	72.7	121.2	77.9	40.2	84.4	39.1	82.5	38.0	79.7	769

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
27.3	24.6	21.4	82.4	7.3	96.1	5.2	3.0	3.6	98.2	0.5	100.0	-2.4	101.7	-6.3	103.8

Monthly Climatic Design Conditions

			Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperatures, Degree-Days and Degree-Hours	Tavg		54.5	33.0	35.1	41.5	50.9	60.3	70.0	75.6	74.8	68.0	57.1	47.7	38.2
	Sd			9.27	7.90	7.73	6.54	6.24	5.92	4.84	4.79	6.03	6.88	7.37	8.67
	HDD50		1813	529	419	281	63	1	0	0	0	0	15	128	377
	HDD65		4828	993	837	729	424	174	21	0	1	37	261	519	832
	CDD50		3439	1	2	17	91	322	601	792	769	541	234	59	10
	CDD65		978	0	0	0	2	30	172	327	305	128	14	0	0
	CDH74		6064	0	0	3	22	193	963	2329	1962	554	38	0	0
	CDH80		1636	0	0	0	4	54	275	707	484	107	5	0	0
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB		55.5	59.2	69.0	77.1	86.5	91.9	95.5	92.6	88.5	79.0	68.2	62.5
		MCWB		51.5	48.0	55.0	60.7	69.1	73.4	76.6	75.0	73.4	66.6	60.7	56.0
	2%	DB		52.0	52.5	60.0	69.6	79.2	87.1	90.2	88.0	82.7	73.4	63.7	56.9
		MCWB		49.1	45.8	50.1	56.3	65.6	71.5	73.6	73.7	70.2	65.5	58.4	52.6
	5%	DB		48.4	49.0	55.4	64.7	74.2	82.7	86.8	84.9	79.5	70.3	61.2	53.2
		MCWB		44.9	44.0	47.4	53.1	63.1	69.3	72.3	72.7	69.4	63.9	57.2	50.1
	10%	DB		45.2	46.2	51.9	60.7	70.4	79.3	83.7	82.3	76.9	67.6	58.8	50.2
		MCWB		41.5	41.9	45.9	51.2	60.8	68.2	71.6	71.7	68.6	61.7	55.1	46.4
Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures	0.4%	WB		53.4	52.2	57.9	63.2	71.6	76.4	79.1	78.6	76.6	70.6	63.9	58.4
		MCDB		54.7	54.6	65.2	72.2	81.7	86.8	89.7	87.3	84.2	74.0	65.9	60.8
	2%	WB		50.0	47.9	52.5	59.0	68.1	74.2	77.2	77.0	74.4	68.4	60.6	54.0
		MCDB		51.3	50.6	56.7	65.9	76.1	82.5	84.9	83.4	78.9	71.7	62.3	55.8
	5%	WB		45.8	45.4	49.9	56.0	65.4	72.3	75.9	75.7	72.8	65.8	58.3	51.0
		MCDB		48.0	48.0	54.0	61.6	72.0	79.1	82.5	81.0	76.3	69.2	60.4	52.9
	10%	WB		42.0	42.5	47.1	53.4	62.9	70.6	74.5	74.7	71.1	63.2	55.9	47.2
		MCDB		44.6	45.7	50.8	57.7	68.1	76.4	80.6	79.6	74.7	66.4	58.3	49.6
Mean Daily Temperature Range		MDBR		12.0	12.7	13.8	14.4	14.4	14.1	13.4	12.9	13.5	13.7	12.7	11.7
	5% DB	MCDBR		14.6	15.7	18.6	20.6	20.8	19.3	16.9	15.1	15.2	15.6	14.4	14.6
		MCWBR		12.7	12.2	11.9	11.2	10.3	8.9	7.6	7.6	7.9	10.2	12.1	13.3
	5% WB	MCDBR		14.4	14.7	17.4	17.5	19.0	16.6	14.3	12.8	12.6	13.5	13.2	13.8
		MCWBR		14.1	13.5	13.2	11.3	10.7	8.9	7.1	7.0	8.2	10.4	13.0	14.5
Clear Sky Solar Irradiance	taub			0.331	0.362	0.401	0.439	0.476	0.534	0.541	0.527	0.418	0.379	0.357	0.328
	taud			2.299	2.147	2.038	1.955	1.890	1.786	1.800	1.822	2.170	2.231	2.246	2.353
	Ebn,noon			259	265	267	265	257	242	238	237	239	257	245	250
	Edh,noon			32	41	49	57	62	69	67	64	43	37	33	29

CDDn	Cooling degree-days base n°F, °F-day	Lat	Latitude, °	Period	Years used to calculate the design conditions
CDHn	Cooling degree-hours base n°F, °F-hour	Long	Longitude, °	Sd	Standard deviation of daily average temperature, °F
DB	Dry bulb temperature, °F	MCDB	Mean coincident dry bulb temperature, °F	StdP	Standard pressure at station elevation, psi
DP	Dew point temperature, °F	MCDBR	Mean coincident dry bulb temp. range, °F	taub	Clear sky optical depth for beam irradiance
Ebn,noon	} Clear sky beam normal and diffuse hori-	MCDP	Mean coincident dew point temperature, °F	taud	Clear sky optical depth for diffuse irradiance
Edh,noon	} zontal irradiances at solar noon, Btu/h/ft2	MCWB	Mean coincident wet bulb temperature, °F	Tavg	Average temperature, °F
Elev	Elevation, ft	MCWBR	Mean coincident wet bulb temp. range, °F	Time Zone	Hours ahead or behind UTC, and time zone code
Enth	Enthalpy, Btu/lb	MCWS	Mean coincident wind speed, mph	WB	Wet bulb temperature, °F
HDDn	Heating degree-days base n°F, °F-day	MDBR	Mean dry bulb temp. range, °F	WBAN	Weather Bureau Army Navy number
Hours 8/4 & 55/69	Number of hours between 8 a.m. and 4 p.m with DB between 55 and 69 °F	PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East	WMO#	World Meteorological Organization number
HR	Humidity ratio, grains of moisture per lb of dry air			WS	Wind speed, mph