ENVIROCENTER PHASE II

JESSUP, MARYLAND

TECHNICAL REPORT 2

BUILDLING LOAD AND ENERGY ANALYSIS

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SUBMITTED

OCTOBER 19TH 2011

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EXECUTIVE SUMMARY

The Envirocenter Phase II is a new 24,000 square foot spec office building to be built in Jessup Maryland. This office building was built with the intent of creating as environmentally friendly an office space as possible targeted toward tenants whose business strive to minimize their environmental impact.

This report is a calculation of loads and energy consumption by a block analysis of the Envirocenter Phase II. Trane's program Trace 700 was used to perform the calculations contained here using information provided by ASHRAE and JDB Engineering along with ASG Architects. The various sustainability and energy saving features of the Envirocenter Phase II made modeling it with Trace 700 a unique challenge.

After the Trace 700 calculations were completed, the peak cooling load significantly greater than the design peak load determined by JDB Engineering (by close to 100%). Additionally, my Trace 700 calculated a peak heating load that was approximately 24% greater than the design peak load. These discrepancies are likely due to the exotic nature of some of the EPCII's system elements. Specifically, the earth tubes used to passively precondition the air are unsupported by Trace 700. These tubes are stated by the design documents to reduce peak summer air temperatures by as much as 20°F, and increase winter air temperatures by as much as 24°F before being mechanically conditioned.

Upon looking at the ECPII's energy consumption, it can be seen that it uses a bit over 200,000 kWh annually. This is for all HVAC, lighting and receptacles. The ECPII is both heated and cooled by two electrically powered reversible ground source heat pumps. As such, all of the costs and emissions associated with operating the HVAC systems are from electricity.

INTRODUCTION

The Envirocenter Phase II is a new building being built in Jessup Maryland by Environmental Design and Resource Center LLC. It is a spec office building and will provide office space for tenants along with break/lounge areas and one of its more distinguishing features – a large sloping glass atrium which will act as a greenhouse for a fruit and vegetable garden inside of the building. This south-facing glass curtain wall will have high solar heat gain. This solar gain will create a natural “stack effect” in the atrium, causing air to flow up and out of operable windows at the top of the atrium, while simultaneously pulling air through the office spaces lining the atrium creating natural ventilation.

New construction will also tie into an existing building – Envirocenter Phase I – to allow occupants to travel back and forth between the two without leaving conditioned space.

MECHANICAL SYSTEM SUMMARY

AIRSIDE

Envirocenter Phase II has a VAV cooling system, with one air handler inside of the mechanical room on the first floor. Outdoor air comes in through a gravity vent off next to the parking lot and is then naturally pretreated as it flows through a series of earth tubes before reaching the air handler. It then either mixes with return air if the economizer is not running before being taken into the air handler. The air then travels through another bank of earth tubes before reaching a cooling coil and then heading off toward the zone VAV units. In economizer mode, the second trip through the earth tubes is skipped and after mixing with return air, travels directly from the air handler to the VAV boxes.

In heating mode, the air travels through both banks of earth tubes to preheat the air before reaching the VAV boxes. After that, the air is heated to its design temperature by the reheat coils in the VAV box.

WATERSIDE

Hot and chilled water for use in the cooling and reheat coils is provided by two reversible ground source heat pumps in the mechanical room – 119 MBH Cooling, 121 MBH Heating. Chilled water will flow into a cooling coil for cooling air. In the heating season, hot water will flow into radiant slabs under each of the office spaces, and into a mass wall which separates the offices from the atrium. This wall will serve a dual purpose of supplementing the heat going into the offices provided by the radiant floor as well as adding heat to the atrium area.

SYSTEM DESIGN LOAD ESTIMATION

In order to estimate the loads for the ECPII, a model was constructed using Trace 700, along with a 3-dimensional model in Autodesk Revit. Revit was used to determine various geometries of the building which could then be used in Trace to model the building.

BLOCK LOAD ASSUMPTIONS

The data used in the creation of the model were all obtained from the construction documents, and the Revit model used during the design process. These provided all necessary engineering data, room dimensions, equipment information etc. used in this energy model.

WEATHER INFORMATION

The ECPII is located in Jessup, Maryland which is very close to Baltimore, MD. ASHRAE weather data for that location can be found in Table-1 below.

ASHRAE WEATHER DATA		
SEASON	DESIGN DB	DESIGN WB
WINTER (99.6%)	12.3	-
SUMMER (0.4%)	93.6	75

Table -1

The engineer specified design set points for the spaces in the building. Because the spaces served by this buildings HVAC system are all office spaces, they all have the same set points: 78°F DB in the summer, 68°F DB in the winter, both with 60% relative humidity.

LIGHTING AND EQUIPMENT LOADS

The lighting and equipment loads used were done based on watts per square foot. Lighting loads were calculated based on the space by space method, with a level of 2.04 W/sf. Because the ECPII is a spec office building, exact equipment loads are unknown, so a generic assumption of 0.5 W/SF allowance for various office equipment was used.

OCCUPANCY LOADS

Not knowing exactly how many people are going to be in the EPCII at any given time because it is a spec office building, required that a general allowance for various people be applied to the spaces. A density of 143 SF per person was assumed, with each person providing a sensible load of 250 BTU/h and a latent load of 200BTU/h.

SCHEDULES

As an office building, the ECPII runs on a fairly predictable schedule. Minimum ventilation is provided 100% of the time, but lights, and equipment were assumed to run on a fairly simple schedule shown in Table-2 below:

OCCUPANCY SCHEDULE		
START TIME	END TIME	PERCENT
0:00	6:00	0
6:00	7:00	10
7:00	8:00	50
8:00	17:00	100
17:00	18:00	50
18:00	19:00	10
19:00	0:00	0

Table-2

RESULTS

RESULTS				
SYSTEM	SF/TON	BTUH/SF	SUPPLY CFM/SF	OA CFM/SF
VAV COOLING	294.09	40.8	1.43	0.59
REFERENCE	351.91	34.1	-	-

Table-3

The amount of cooling required by the ECPII is fairly low compared to a “typical” office building. This is partly due to the lack less conservative space set points used in the design, and also due to energy saving features like well insulated walls, and low-E argon filled glazing. The addition of earth tubes, which were not included in this model because Trace didn’t support them, would lower these values even more. This makes sense, as the ECPII’s goal is to be as energy efficient and sustainable as possible.

ENERGY ANALYSIS

For consistency, all of the same assumptions, internal and external loads, and schedules were used in this energy analysis as in the previous load analysis.

SYSTEMS

The system looked at in this analysis is the VAV cooling system served by the air handler AHU-1. The energy associated with fans from this AHU are included in this analysis.

PLANTS

The chilled and hot water are both provided by two reversible, water-to-water ground source heat pumps.

FUEL COSTS

The following fuel costs were obtained from Baltimore Gas and Electric, a local electric company. As the plants analyzed in this report use only electricity – both hot and chilled water are provided by electrically driven heat pumps – the following costs in Table-4 were used:

ELECTRICITY COSTS	
TIME	$/kWh
ON-PEAK	0.11351
OFF-PEAK	0.06033

Table-4

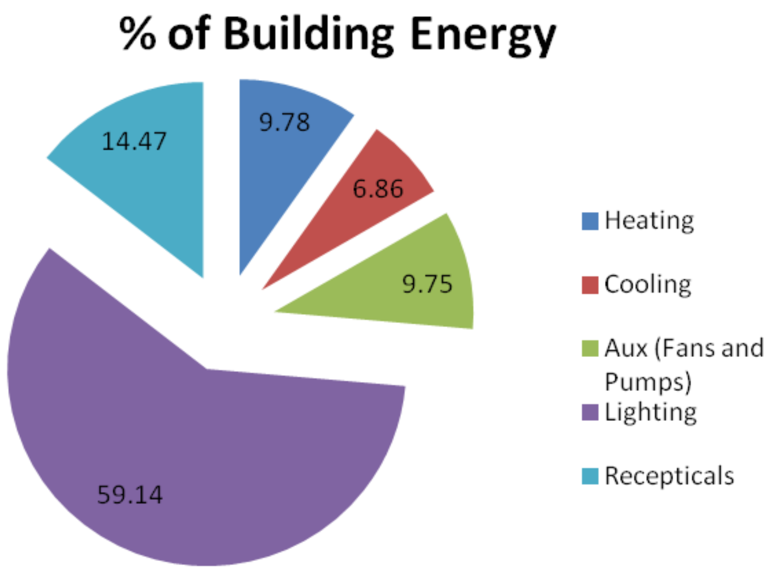
RESULTS

The results found in Table-5 were obtained from Trace using the same model from the load calculations and the energy costs noted in Table-4.

ELECTRICITY CONSUMED	
KWh/yr	$/yr
208,157	19,233

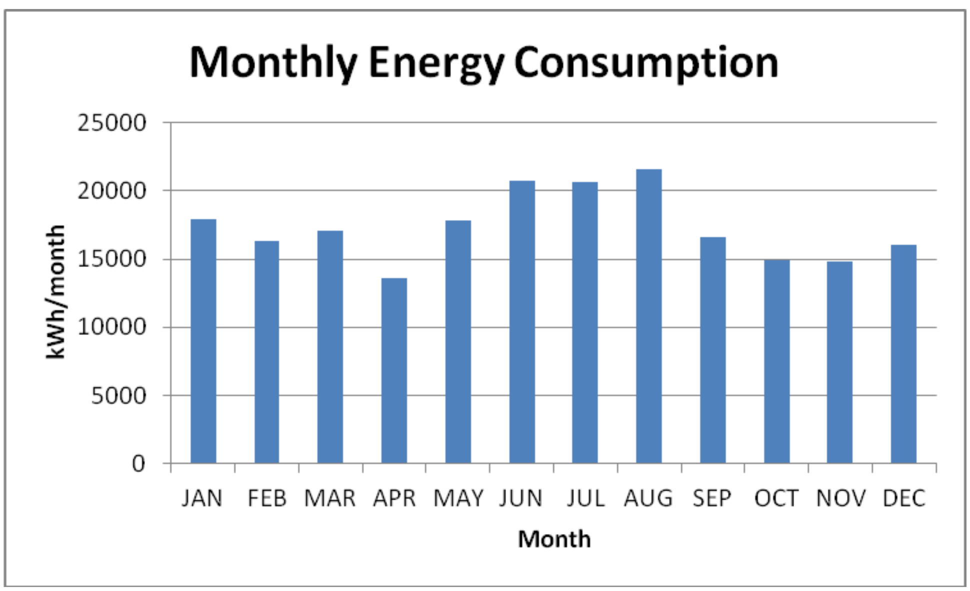
Table-5

Trace broke this total Electricity consumption down into fractions for each end use. These values can be seen in Graph-1 below.



Graph-1

Electricity consumption was also measured by this Trace simulation on a month to month basis, showing a cross section of a typical year. This can be seen below in Graph-2.



Graph-2

Because it is used in both heating and cooling, electricity use can be seen to be roughly constant throughout the year, with some dips in the Spring and Autumn months. This is likely because those are the times of year that an economizer is most likely to help reduce loads.

The total cost per square foot was also calculated by Trace, to be $0.82/SF-year. This is a very low number, likely due to the lack of natural gas needed by the HVAC system in the EPCII.

EMISSIONS

Because the ECPII's HVAC system isn't actually performing any combustion, the only emissions of interest are those created by the provided electricity.

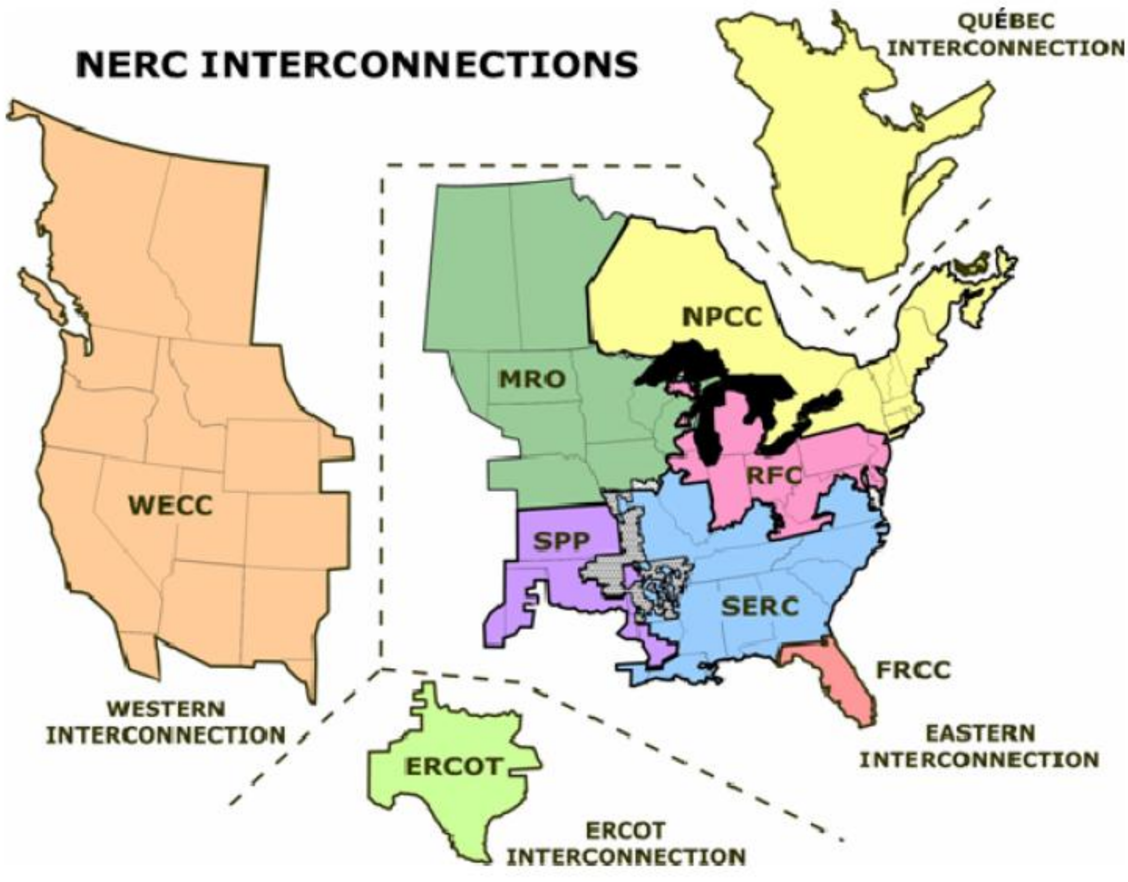
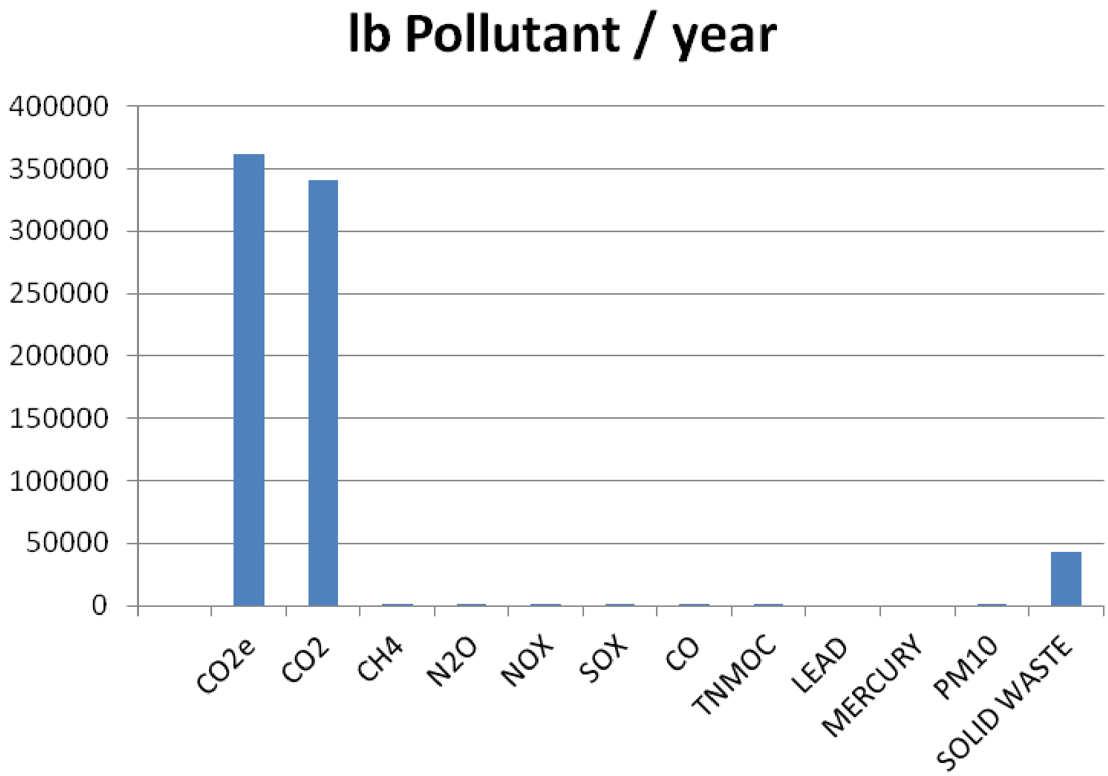


Figure-1

Shown above in Figure-1, is a map of North America's electrical grid interconnections. The EPCII is located within the RFC, in the Easter Interconnection. The emissions per kWh associated with the Eastern Interconnection can be found below in Table-6 and Graph-3 along with the calculations for the emissions for with the ECPII is responsible.

POLLUTANT EMISSIONS/kWh			
Pollutant	lb / kWh	kWh/year	lb Pollutant / year
CO2e	1.74E+00	208,157	3.62E+05
CO2	1.64E+00	208,157	3.41E+05
CH4	3.59E-03	208,157	7.47E+02
N2O	3.87E-05	208,157	8.06E+00
NOX	3.00E-03	208,157	6.24E+02
SOX	8.57E-03	208,157	1.78E+03
CO	8.54E-04	208,157	1.78E+02
TNMOC	7.26E-05	208,157	1.51E+01
LEAD	1.39E-07	208,157	2.89E-02
MERCURY	3.36E-08	208,157	6.99E-03
PM10	9.26E-05	208,157	1.93E+01
SOLID WASTE	2.05E-01	208,157	4.27E+04

Table-6



Graph-3

CONCLUSIONS

The Envirocenter Phase II is a unique building which makes modeling its loads and energy consumption something of a challenge. Because electricity is the only thing running the HVAC system, its usage is highly dependent upon weather conditions – primarily those responsible for triggering the economizer cycle. Ultimately, the accuracy of the results will rely on the quality of the assumptions. The assumptions made with this model were chosen so as to build a model as close as possible to the original design. However, in spite of this, some values were off due to simplifications and estimations. Going into the future it will be important to refine this model as much as possible.

REFERENCES

ASHRAE Standard 62.1-2007

ASHRAE Standard 90.1-2007

ASHRAE Handbook of Fundementals–2009

ENVIROCENTER PHASE II CONSTRUCTION DOCUMENTS: ASG ARCHITECTS, JDB ENGINEERING

BALTIMORE GAS AND ELECTRIC COMPANY, STANDARD OFFER SERVICE RATES TABLE

SOURCE ENERGY AND EMISSION FACTORS FOR ENERGY USE IN BUILDINGS, 2007: DERU & TORCELLINI

APPENDIX A

TRACE 700 SCREEN SHOTS

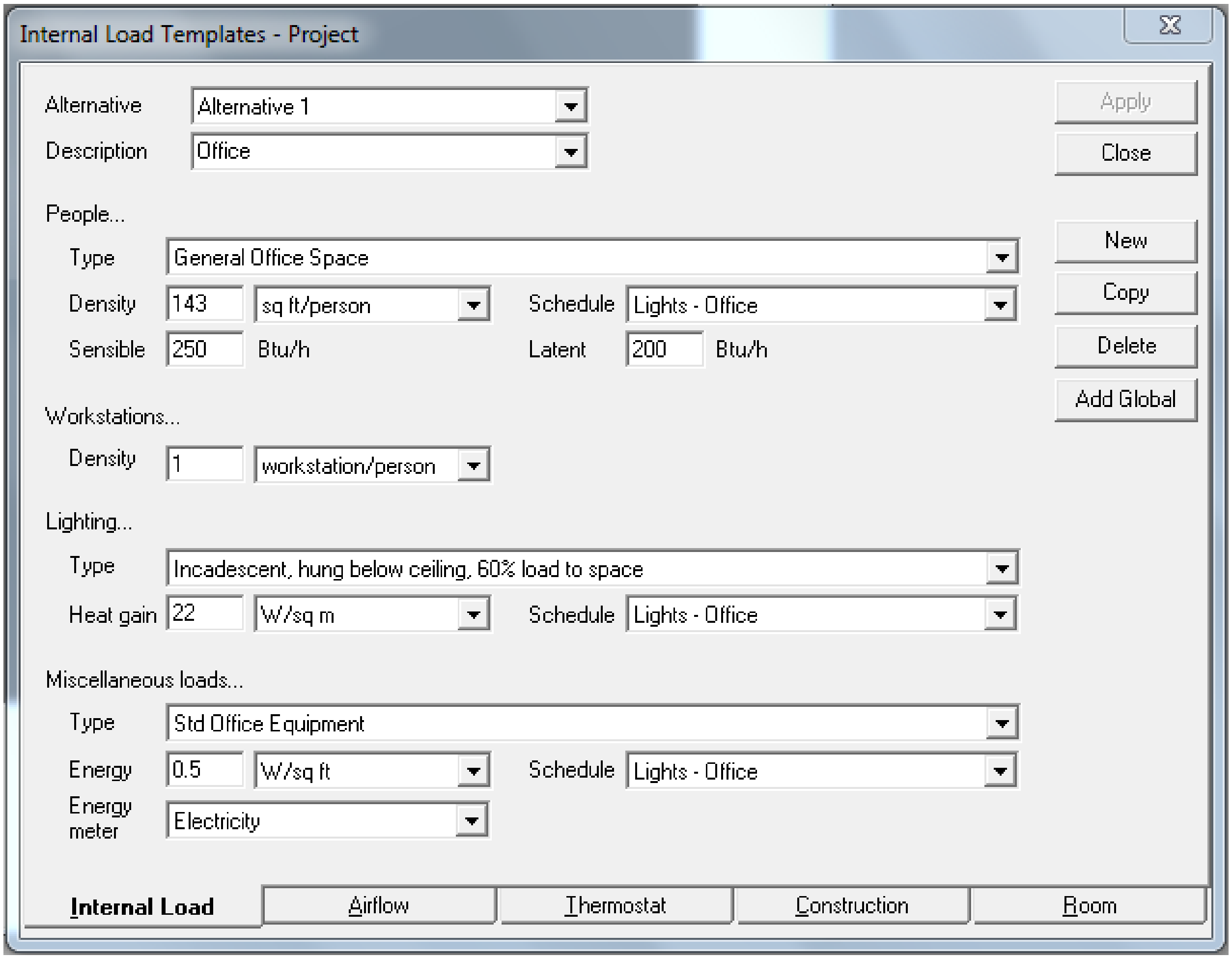


Figure-A1, Example Load Template

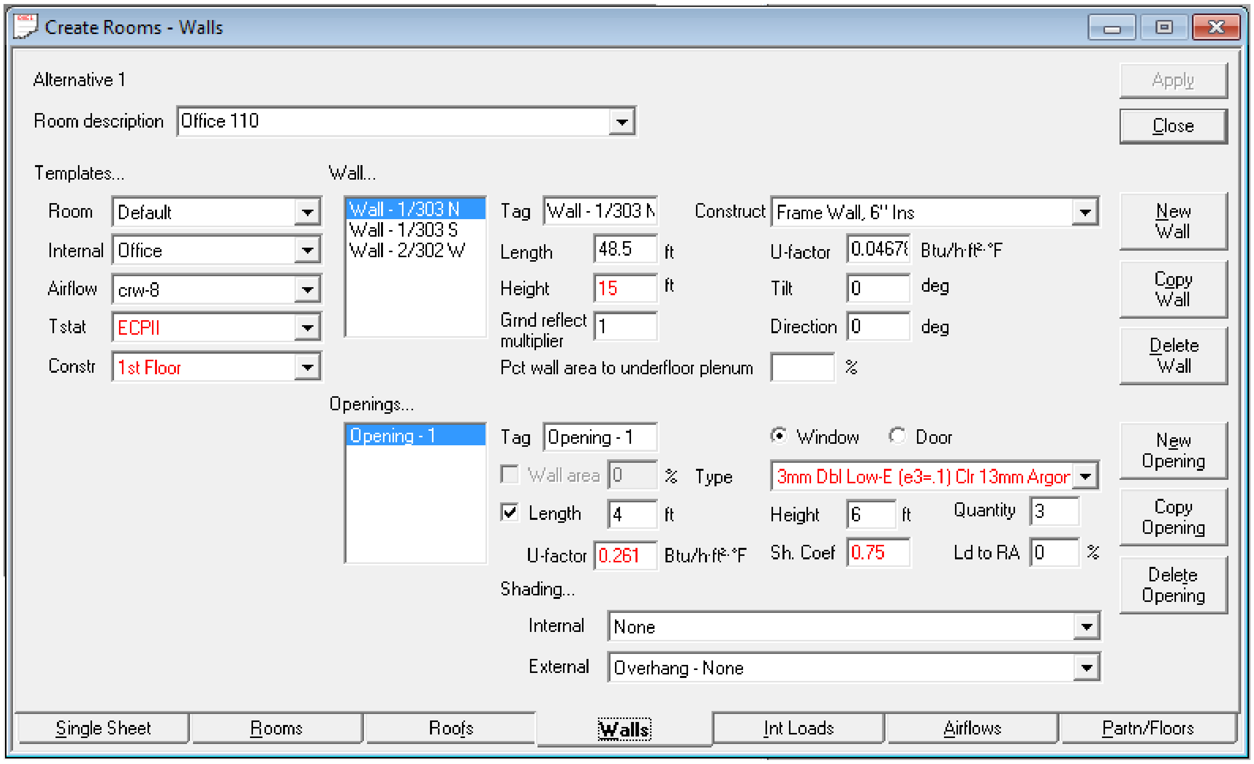


Figure-A2, Example room using multiple wall templates

APPENDIX B

EMISSION FACTORS

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

Table B-1, Total Emission Factors for Delivered Electricity (lb/kWh)

(From *Deru and Torcellini*)