ENVIROCENTER PHASE II

JESSUP, MARYLAND

TECHNICAL REPORT 3

Mechanical System Existing Conditions Evaluation

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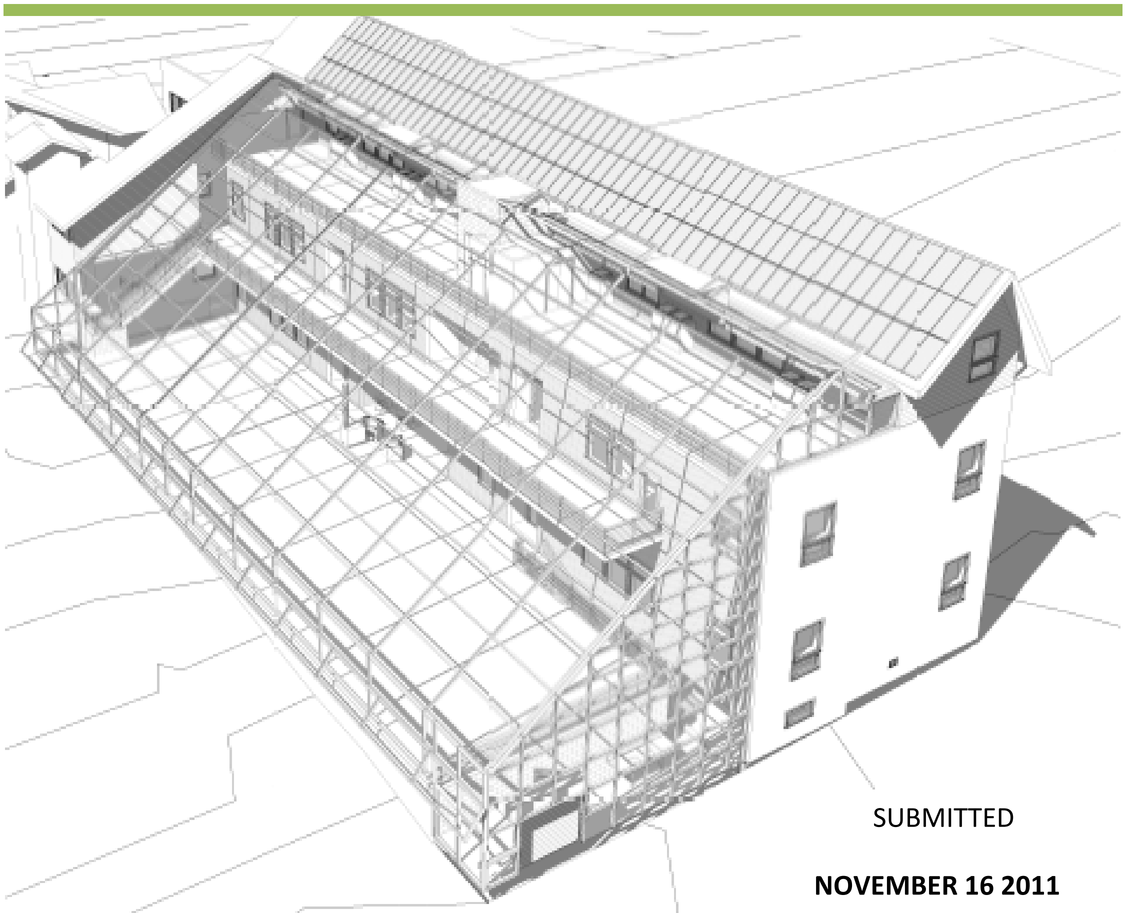

SUBMITTED

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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 an evaluation of the existing conditions related to the ECPII's mechanical system. Items to be discussed include energy consumption, loads and ventilation, as in previous reports, but also sustainability. A LEED point evaluation as well as costs, tax benefits and rebates will also to be discussed.

When looking at the ECPII's mechanical system, there is a lot of space taken up relative to the size of the building. This is largely due to the innovative earth tube pre-treating system being used in the ECPII. It requires that there be two mechanical spaces on either end of the building.

The ECPII is a LEED Platinum building, earning 99 points on the LEED NC 2009 scale. This qualifies it for various rebates and tax breaks granted by local and state authorities. These factors make the high cost of a state-of-the-art building like the ECPII a more viable option.

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EXISTING MECHANICAL SYSTEM DESCRIPTION

LOST SPACE

The sad truth about mechanical systems is that they occupy space that could otherwise be used towards other productive ends. Relative to the size of the ECPII, its mechanical system takes up a great deal of space, especially when plumbing and electrical spaces are taken into account.

LOST SPACE	
Floor Area, SF	Shaft Area, SF
961	0
250	12
0	12
0	12
TOTAL:	1247

Table-1 Lost Usable Space

1247 SF is a lot of area to be occupied by a mechanical system for a building this size. The size of the basement mechanical room is larger than truth however, as it also contains large urine composters that are part of the sanitary plumbing system. However, extra space is taken up due to the earth tubes that run along the building underground. These cause there to be two mechanical rooms: The air handler on one end of the building, and the cooling coil on the other. Space occupied by underground earth tubes and heat pump wells were not counted as that space is not, strictly speaking, a "usable" part of the building.

DESIGN OBJECTIVES

As with the design of any mechanical systems for any office building, the primary objective of the EPCII's mechanical systems are to provide a comfortable atmosphere so that anyone working there can perform to his/her maximum level of output.

Of course there are a number of secondary objectives that the ECPII's systems intend to meet. One of the design goals of this project is LEED Platinum certification – a lofty goal to say the least. Additionally, the ECPII strives to be as energy efficient as possible, running its systems as close to full load as often as is viable. This will stretch the capacity of the system and will require the cooperation of the tenants. It is assumed however, that the tenants of the ECPII are companies who wish to minimize their environmental footprints and as such are likely to go along with such measures.

On a related note, the design conditions are as follows. Note that the design set points are less conservative than typical in an effort to lessen the system size.

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

Table-2 ASHRAE Weather Data

DESIGN SET POINTS		
SEASON	DESIGN DB	DESIGN RH
HEATING	68	-
COOLING	78	60%

Table-3 Design set points

Part of the challenge that these systems must face is the unique architectural features that this building possesses. A large glass atrium containing a green house will be the source of a great deal of solar heat gain in the summer season.

ENERGY SOURCES

Other than solar energy, which is free and used both for heating, and to power a photovoltaic array, the only energy purchased by ECPII is electricity. Both heated and chilled water are provided by electrically powered heat pumps. As such there is no gas or fuel oil to be purchased for powering boilers or absorption chillers, etc.

While a great deal of electricity is to be produced by the PV array on the roof, some electricity will need to be purchased from the grid at times. This purchased electricity comes from Baltimore Gas and Electric. Rates are as follows. These are the same rates used in the Trace energy model constructed for the previous report.

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

Table-4 Electricity costs

COSTS

The ECPII has significant costs associated with it. In spite of being a small system, the designers have gone to great lengths to use the most energy efficient systems possible. These tend to have significant initial costs, and lengthy payback periods – the bane of a typical building owner. The ECPII's owner's goal was to develop an advanced, highly sustainable building and recognized that such things do not come cheaply. Obviously cost was minimized as much as possible but within the constraints of the goals that the ECPII attempt to achieve.

In addition to equipment costs, installation costs can also be quite expensive. The well field for the ground source heat pumps but especially the underground tubing for the earth tubes add construction costs which are atypical in most mechanical applications.

Fortunately, there are numerous tax credits and rebates available to the owner as a result of the various sustainable technologies utilized in the building. Table-x below details a few of the incentives available to the ECPII.

REBATES AND INCENTIVES		
INCENTIVE	MAXIMUM INCENTIVE	REQUIREMENTS
CLEAN ENERGY GRANT	$500/TON UP TO $7,000	GEOTHERMAL HEAT PUMPS
BG & E COMMERCIAL ENERGY EFFICIENCY PROGRAM	UP TO $1M/TAX ID/YR. COMMERCIAL REBATES: 50%	VARIOUS ENERGY SAVING TECH (LED LIGHTING, PROGRAMMABLE THERMOSTATS, VFDS ETC.)
HOWARD COUNTY PROPERTY TAX CREDIT	75% CREDIT FOR A 5 YEAR TERM	LEED PLATINUM CERTIFICATION

Table-5 Tax Incentives, Rebates and Grants

Actual mechanical system cost data was not available at the time of this report.

EQUIPMENT

The ECPII contains two reversible heat pumps which provide the hot and chilled water for the entire mechanical system. This system involves a variety of equipment, the major players of which are listed briefly in the tables below:

GROUND SOURCE HEAT PUMPS						
SYMBOL	COOLING			HEATING		
	MBH	KW	EER	MBH	KW	COP
HP-1	119.5	8.8	13.6	121.1	9.6	3.7
HP-2	119.5	8.8	13.6	121.1	9.6	3.7

Table-6 Heat Pumps

PLATE AND FRAME HEAT EXCHANGER				
	EWT	LWT	GPM	WPD
Hot Side	99.7	90	60	1.2
Cold Side	90	98	46	0.9

Table-7 Heat Exchangers

PUMPS					
SYMBOL	GPM	HEAD	IMPELLER SIZE	HP	RPM
P-1	23	30	5 1/2	3/4	1750
P-2	23	30	5 1/2	3/4	1750
P-3	30	30	5 1/2	3/4	1750
P-4	30	30	5 1/2	3/4	1750
P-5	60	30	5 3/4	1 1/2	1750
P-6	46	35	6 1/4	1	1750
P-7	46	35	6 1/4	1	1750

Table-8 Pumps

FINNED TUBE RADIATORS			
SYMBOL	LENGTH	MBH	GPM
FTR-1	5'	9.3	12
FTR-2	15'	27.1	12
FTR-3	15'	24.5	12
FTR-4	10'	14.8	12
FTR-5	15'	20.8	12
FTR-6	15'	18.8	12
FTR-7	8'	9.1	12
FTR-8	15'	17.1	12
FTR-9	10'	19.1	12
FTR-10	15'	28.7	12

Table-9 Finned Tube Radiators

AHU			
CFM	OA		POWER
	MIN	MAX	
13500	3100	13500	208/3

Table-10 Air Handling Unit. Note that the main Cooling coil is not contained within the AHU

MECHANICAL SYSTEM OPERATION

AIRSIDE

The 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 next to the parking lot and is then naturally pretreated as it flows through a series of earth tubes before mixing with return air and finally reaching the air handler. When in peak cooling mode, the mixed air then travels back through another bank of earth tubes where it can be even more pretreated. It then comes up on the other side of the building where it hits the cooling coil. Finally, the cooled air continues on toward the terminal units. Cool air enters the space, then returns to mix with new outside air. This process can be seen in the figure below:

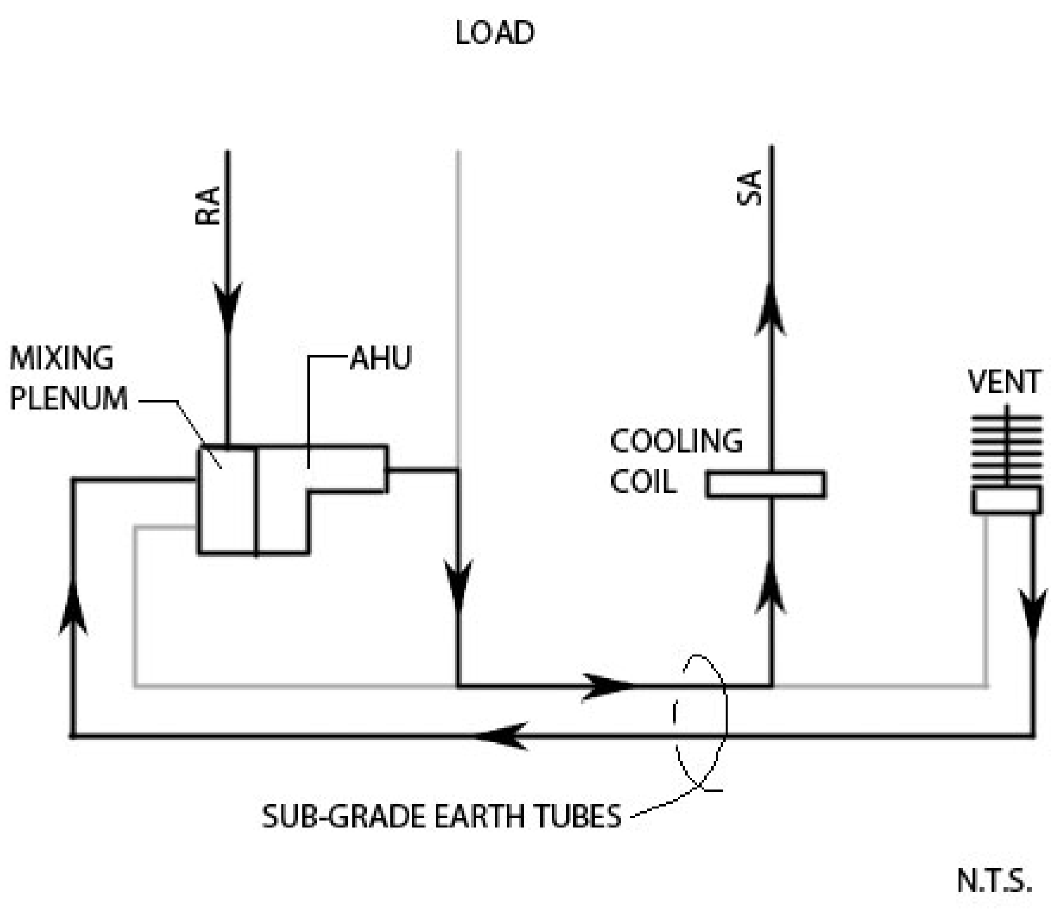

Figure-1 Peak Cooling Airflow Diagram

During winter heating months, the air flows as in the peak cooling case, allowing only the minimum required ventilation air into the vent, and with no temperature drop across the cooling coil. Instead, the pretreated air is heated by the reheat coils in the VAV boxes in each zone.

When sensible outdoor air temperature and total enthalpy are appropriate, an economizer cycle kicks in. In economizer mode, outside air enters both banks of earth tubes from the vent outside. It then travels through the tubes and up into the mixing plenum where it meets the return air, if any. This mixed air is then blown from the AHU to the terminal units without traveling through the earth tubes as had been done in the peak cooling scenario. This process can be seen in the figure below.

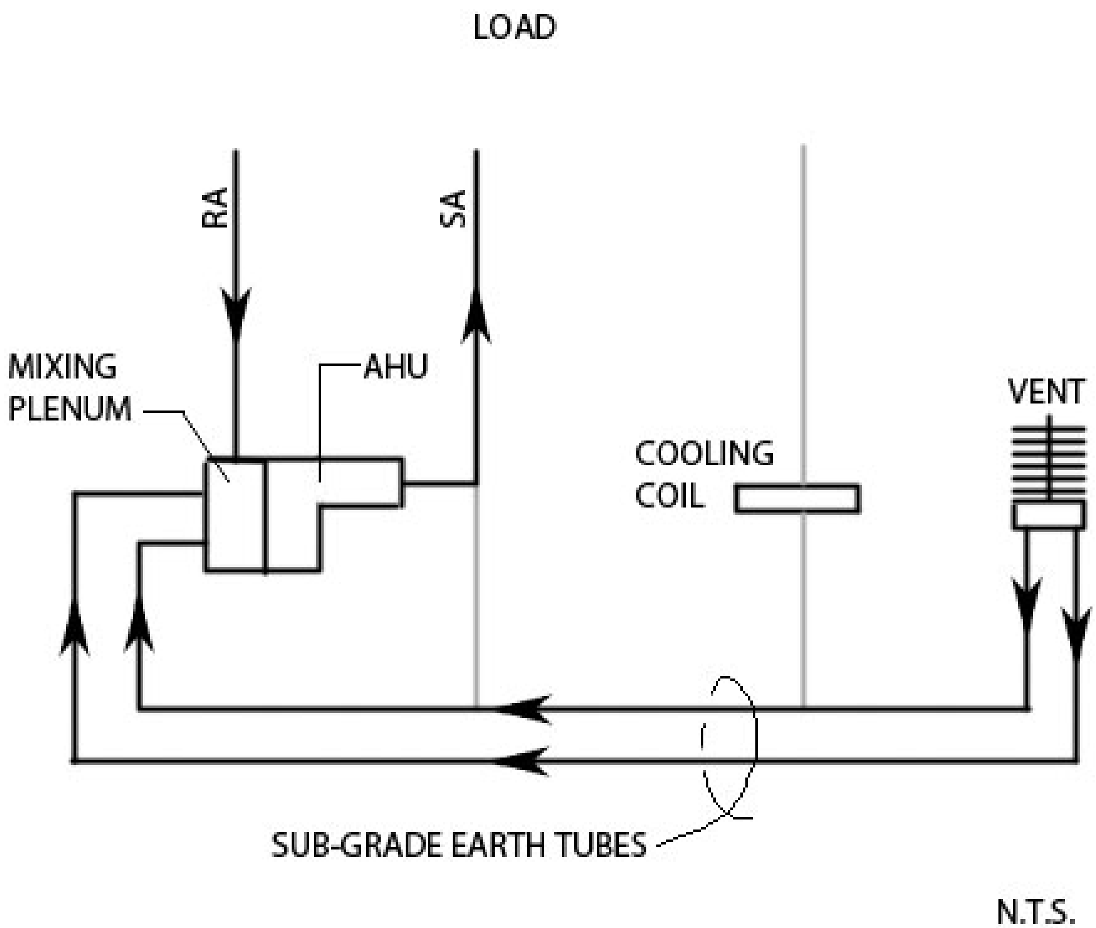

Figure-2 Economizer Airflow Diagram

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.

A well field located under the parking lot for the ECPII will be where the ground source heat pumps reject their heat when cooling water, and absorb heat when heating the water. The heat pumps will have an anti-freeze solution flowing through them, which will transfer heat with the heating and cooling water via a plate and frame heat exchanger. The relationships between these various elements can be seen in the figure below.

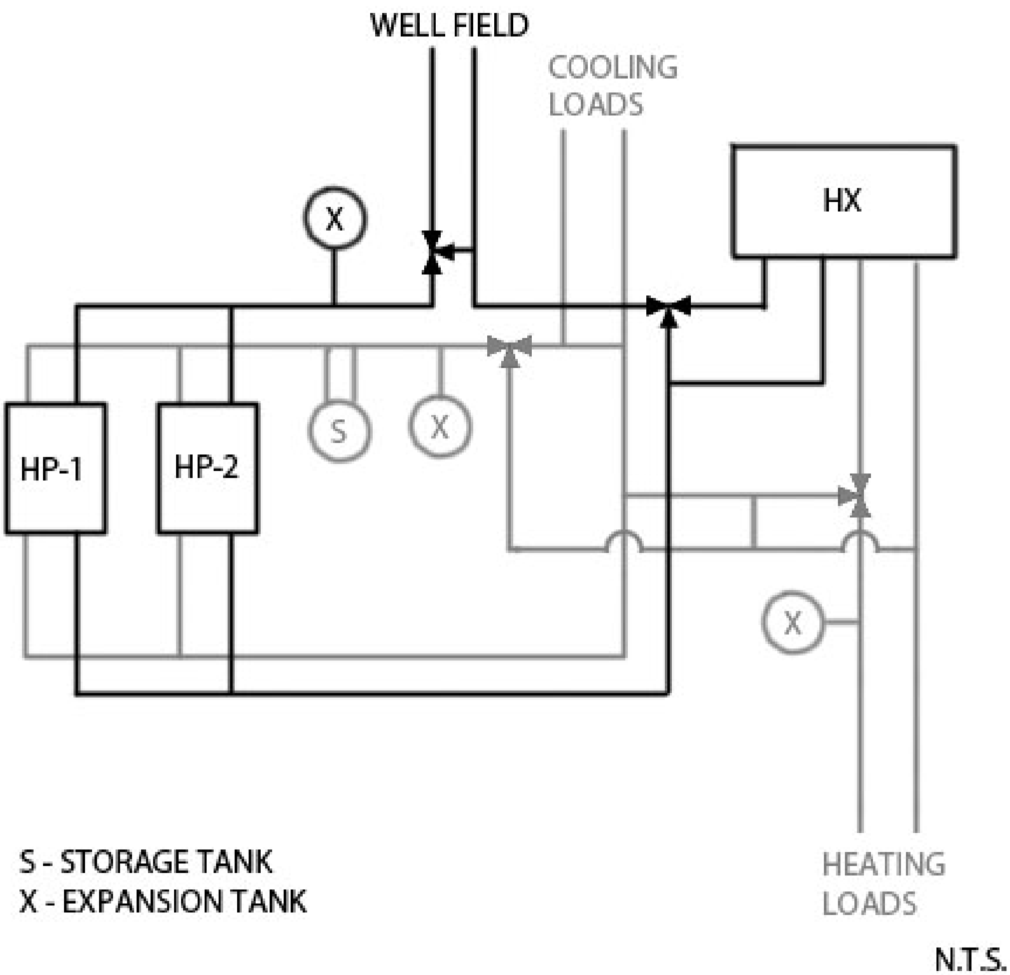

Figure-3 Piping Diagram

The ECPII uses a hydronic radiant heating system to heat its spaces. This is achieved by radiant piping in concrete slabs, as well as a mass wall separating the tenant spaces from the atrium. The mass wall will absorb solar energy and slowly radiate it, and the heat from the hot water piping into the space. The solar heat gain of the mass wall is meant to help lessen the load of the heating system.

VENTILATION

The ECPII has unique ventilation requirements. The large atrium / green house requires a great deal of ventilation in addition to the ASHRAE 62.1 ventilation requirements of the office spaces contained in the building. However, since the AHU system is only responsible for ventilating, the office spaces – the atrium is ventilated naturally via stack effect, and mechanically by a group of fans at the top of it – that is the ventilation that will be discussed in this report. The ventilation requirements I calculated based on ASHRAE standard 62.1 are found in the table below.

ASHRAE 62.1 VENTILATION RATES										
ROOM #	ROOM NAME	Room Data					Vbz = Voz CFM	TOTAL SUPPLY	O.A. SUPPLY	OUTDOOR AIR FRACTION (Zp)
		Az	Pz	Rp	Ra			CFM	CFM	
110	Office	934	5	5	0.3		306	1000	230	0.23
120	Office	755	4	5	0.3		247	1000	230	0.23
121	Office	647	4	5	0.3		215	800	184	0.23
130	Office	1730	9	5	0.3		564	2000	459	0.23
210	Office	1093	6	5	0.3		358	1200	276	0.23
220	Office	1256	7	5	0.3		412	1200	276	0.23
221	Office	1173	6	5	0.3		382	1400	322	0.23
230	Office	729	4	5	0.3		239	1000	184	0.18
231	Office	850	5	5	0.3		280	800	230	0.29
310	Office	1084	6	5	0.3		356	1800	413	0.23
320	Office	658	4	5	0.3		218	1300	299	0.23
						TOTALS:	3577	13500	3103	0.23
						Max Zp:				0.29

Table-11 Calculated Ventilation Requirements.

The designer's ventilation requirements, for comparison, added up to a total Voz of 2379 CFM, which was increased by 30% to 3100 CFM for increased indoor air quality. This discrepancy is largely due to the designers use of a lower value for Ra than I did.

LOADS

The loads I calculated for EPCII are based on a model I constructed in Trane's Trace 700 modeling software. Unfortunately, this software is not perfect, and the lack of ability to accurately model the earth tubes resulted in a skewed set of loads. Regrettably, the designer's loads are not available to be compared with. The best available reference is merely comparing to the size of the equipment. This assumes that said equipment was appropriately sized by the designer. In any event, the results of my model can be found below:

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-12 Trace Load calculations.

ENERGY CONSUMPTION

More data that were obtained from the Trace model of the ECPII, were predicted energy consumption rates. These were even divided by end use, for a more detailed look at the way the building performs. Unfortunately, at the time of this writing, the ECPII has not been opened yet, and historical energy bills are not available for comparison. My results can be seen in the table below.

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

Table-13 Modeled Electrical Consumption

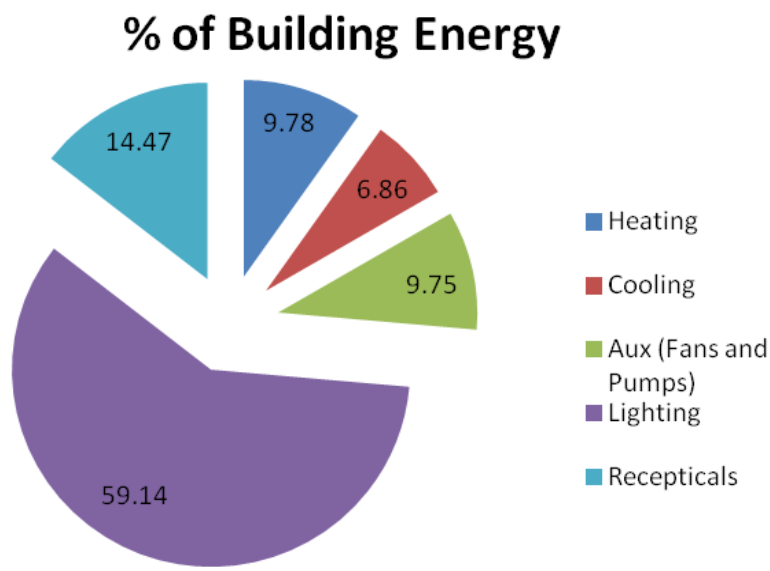

Figure-4 Energy Consumed by End USe

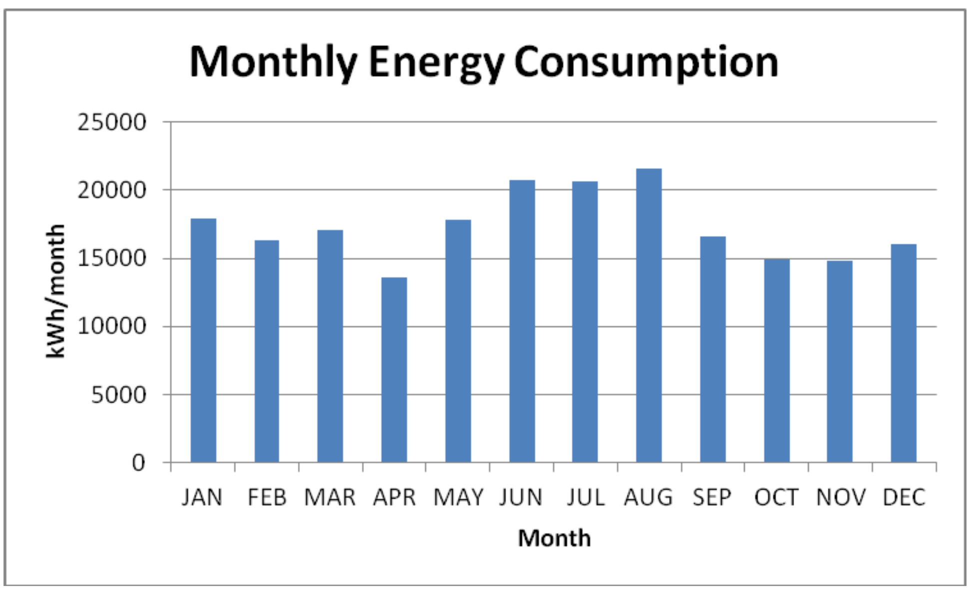

Figure-5 Energy Use by Month

Recall that the only purchased energy by the ECPII is electricity, as it runs on 2 reversible ground source heat pumps. Obviously, things like lighting and receptical loads are going to consume electricity, but in this case, heating and cooling also use that up. Note in Figure-5 that the electricity consumption is relatively constant throughout the year, dipping in transition seasons when the economizer is most likely to be used.

LEED ANALYSIS

The Leadership in Energy and Environmental Design (LEED) system, has been developed by the United States Green Building Council (USGBC) as a way of evaluating the sustainability of buildings that are being constructed and renovated. This project is striving for LEED Platinum certification, and is counting on that for rebates and tax benefits. As such it is appropriate that a LEED evaluation be done on the ECPII.

SUSTAINABLE SITES -19 POINTS

1 – (Credit 1) Site selection

12 – (Credits 4.1 – 4.4) Alternative transportation: Public transit access, bicycle storage, Low-E vehicles, parking capacity

1 – (Credit 5.2) Maximize open space on site

2 – (Credits 6.1, 6.2) Storm water quantity and quality control

2 – (Credits 7.1, 7.2) Heat Island effect, Non-roof and roof

1 – (Credit 8) Light Pollution reduction.

WATER EFFICIENCY -10 POINTS

4 – (Credit 1) Water Efficient Landscaping. No potable water use or irrigation.

2 – (Credit 2) Innovative wastewater Technologies

4 –(Credit 3) Water use reduction. Reduce by 40%

ENERGY AND ATMOSPHERE – 35 POINTS

19 – (Credit 1) Optimize Energy Performance. Improve by 48% for new buildings.

7 – (Credit 2) On Site renewable energy. 13% renewable energy.

2 –(Credit 3) Enhanced commissioning.

2 – (Credit 4) Enhanced Refrigerant Management

3 – (Credit 5) Measurement and Verification

2 – (Credit 6) Green Power

MATERIALS AND RESOURCES – 10 POINTS

2 – (Credit 2) Construction waste management. 75% recycled or salvaged.
2 – (Credit 3) Materials Reuse. Reuse 10%
2 – (Credit 4) Recycled Content. 20% of content
2 – (Credit 5) Regional Materials. 20% of materials
1 – (Credit 6) Rapidly Renewable Materials
1 – (Credit 7) Certified Wood

INDOOR ENVIRONMENTAL QUALITY – 15 POINTS

1 – (Credit 1) Outdoor Air Delivery Monitoring.
1 – (Credit 2) Increased Ventilation (Based on designer's calculations)
2 –(Credits 3.1, 3.2) Construction IAQ Management plan. During Construction and Before Occupancy
4 – (Credits 4.1 – 4.4) Low-E Materials
1 – (Credit 5) Indoor Chemical and Pollutant Source Control
2 – (Credits 6.1, 6.2) Controllability of Systems. Lighting and Thermal comfort
2 – (Credits 7.1, 7.2) Thermal Comfort. Design and verification
2 – (Credits 8.1, 8.2) Daylight and Views.

INNOVATION IN DESIGN – 6 POINTS

5 – (Credit 1) Innovation or Exemplary Performance.
1 – (Credit 2) LEED Accredited Professional

REGIONAL PRIORITY – 4 POINTS

4 – (Credit 1) Regionally Defined Credit Achieved

TOTAL – 99 POINTS. LEED PLATINUM

Totaling 99 LEED points, the ECPII is on track to achieve its Platinum certification. As the LEED system becomes more and more ubiquitous in the building industry, it is important that the way LEED credits are assigned to be a part of a designer's vocabulary. Even if not striving for LEED certification, they are good guidelines for the design of a sustainable building.

OVERALL

As a whole, the Envirocenter Phase II is a solid, well designed building. It was has a state-of-the-art mechanical system which has been designed to operate as energy efficiently as possible. This is fantastic from a sustainability standpoint; however it does have a few downfalls. Cost is a large factor in a building such as this. There is not getting around the fact that these high efficiency technologies are expensive, and have long payback periods. Tax breaks and rebates help, but it takes a very special kind of owner to want to buy a building like this one. It seems costly to have both a radiant heating and forced air cooling system. It seems as though costs could be saved with radiant cooling as well. While often frowned upon, radiant cooling is a viable option. A more robust dehumidification method would have to be implemented to prevent condensation from forming.

Another issue may lie in the tenants. It has been shown that the mechanical systems for this building will be stretched to their limit at all times. That is the best way to operate efficiently. However, it places a great deal of trust in the tenant. It is assumed that the sorts of tenants who will be occupying the ECPII are of the environmentally conscious ilk, but you never know what sort of person could lease office space. Similarly, advanced systems like these need to be controlled. Even owners with the best of intentions can operate a building at low performance as a result of occasional carelessness. It would be imperative that The ECPII be well maintained such that that doesn't happen – another expense. These issues, while a result of the design, are more aptly described as potential issues with the owner/operator. If the owner is up to the task, then the Envirocenter could perform admirably.