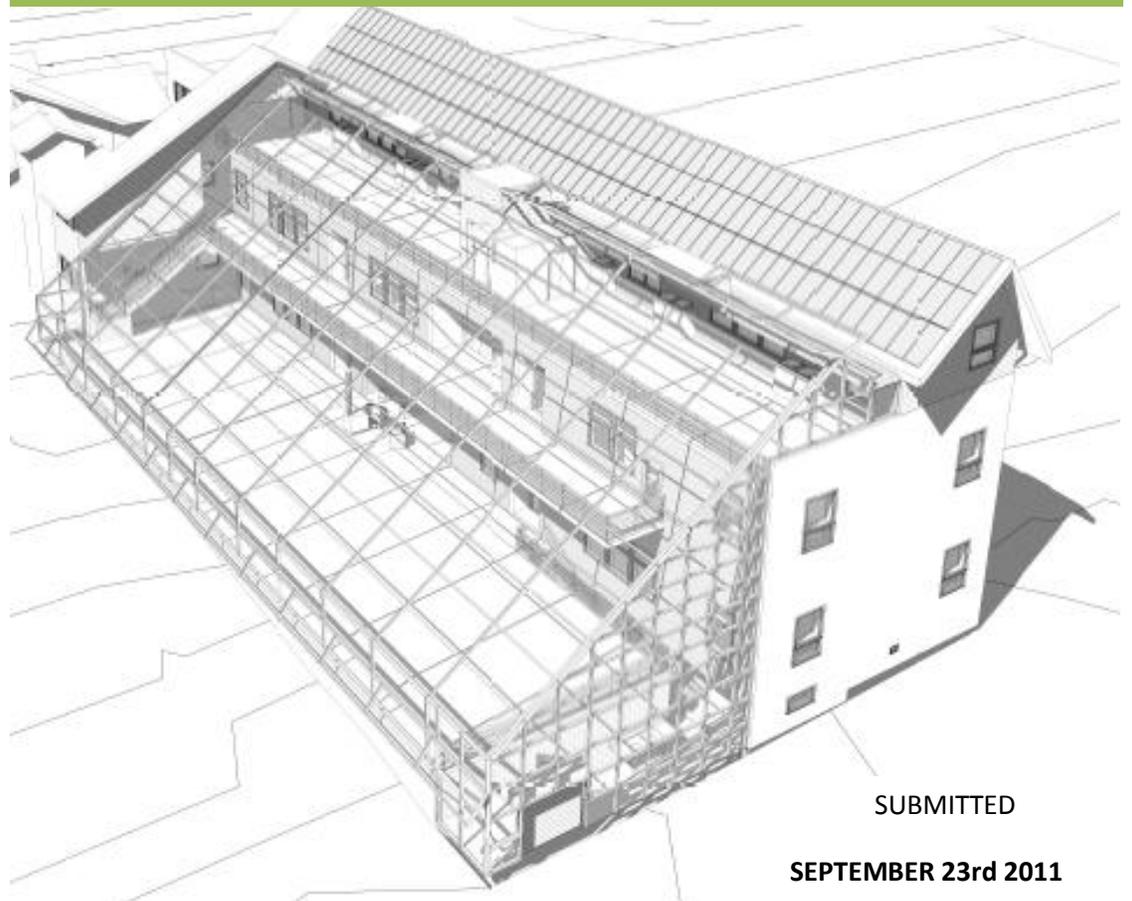

ENVIROCENTER PHASE II

JESSUP, MARYLAND

TECHNICAL REPORT 1

ASHRAE STANDARDS 62.1 and 90.1 ANALYSIS

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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 a collection of research, data and analysis about the Envirocenter Phase II specifically with the intent of benchmarking it against ASHRAE standards 62.1 and 90.1. ASHRAE standard 62.1 deals specifically with the amount and quality of the ventilation air provided to the used space in a building. Standard 90.1 has to do with the amount of energy consumed by the building's various systems like HVAC and lighting. This buildings mechanical system is a multizone VAV system with radiant slab heating.

In regard to ASHRAE 62.1, the Envirocenter meets the standard in every way with regard to lay, construction and installation. As for the actual ventilation rates, they don't appear to meet ASHRAE 62.1's standards. The outdoor air provided by the mechanical system is provided with a fraction of 0.23 – only 3100 CFM of outside air compared to the approximately 3500 CFM expected by this standard. This appears to be insufficient, but the mechanically supplied ventilation is merely a supplement to the natural ventilation which when put together will easily cover space ventilation requirements.

ASHRAE standard 90.1 focuses on the energy consumed by buildings, which the Envirocenter Phase II performed quite well in. As an aspiring LEED certified building, it has many energy saving features, the least of which being well insulated walls, high efficiency mechanical equipment and more. One area where the Envirocenter Phase II did underperform was in the lighting section. It exceeded ASHRAE's maximum lighting power density of 1.0 Watts per square foot by 0.07 Watts per square foot. This is probably because of the lights shining from the upper floors out into the atrium where there is no floor area to be lit.

In general, the Envirocenter Phase II meets these two ASHRAE standards 62.1 and 90.1 except for a couple things. A further discussion on the mechanical system will follow this summary to further elaborate on the details of the Envirocenter Phase II's system.

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.

ASHRAE 62.1 ANALYSIS

ASHRAE Standard 62.1 is primarily focused on the ventilation of the building concerning itself with topics including but not limited to, ventilation distribution, particle contaminants, ventilation air quality and the amount of ventilation required in a space.

SECTION 5 – SYSTEMS AND EQUIPMENT

5.1 NATURAL VENTILLATION

The atrium is ventilated naturally and is in compliance with section 5.1. It has operable windows at the base and at top where air can naturally flow through pulling air up and out. This simultaneously will pull air through operable windows in the office spaces, naturally ventilating them as well. This natural ventilation is also supplemented by a mechanical ventilation system.

5.2 VENTILATION AIR DISTRUBUTION

The Envirocenter meets and sometimes exceeds all the minimum ventilation requirements under any load condition. All VAV boxes have minimum flows to at least meet outdoor air ventilation requirements as specified by section 6.

5.3 EXHAUST DUCT LOCATION

No exhaust ducts in the Envirocenter are carrying especially harmful contaminants. As a spec office building, there are no unusual chemicals being used in any of the spaces.

5.4 VENTILATION SYSTEM CONTROLS

Minimum amounts of ventilation are met and exceeded by the VAV boxes serving each zone. They have the option of being modulated down to the very minimum ASHRAE ventilation rate. Also, natural ventilation may be achieved at the discretion of the tenants by opening the operable windows in the exterior walls and the wall adjacent to the atrium.

5.5 AIRSTREAM SURFACES

All airstream surfaces and duct liners are specified to meet ASTM C 1071 and UL 181. ASTM C 1071 accounts for ASTM C 1338 making the Envirocenter compliant with this section.

5.6 OUTDOOR AIR INTAKES

The primary air intake is a gravity vent located approximately 35 feet away from the building, placing it well clear of potential contaminants. It is located near a parking lot, but is more than the required five feet away. It is waterproof and has half inch bird screen so as to maintain compliance with this section.

5.7 LOCAL CAPTURE OF CONTAMINANTS

A pellet stove used for heat in the atrium is exhausted straight up through the roof, complying with this section.

5.8 COMBUSTION AIR

The pellet stove is owner supplied and is to sit out in the atrium, allowing sufficient air for combustion to take place inside of it.

5.9 PARTICULATE MATTER REMOVAL

Filters in the Fan Coil and Air handling units are specified to comply with ASHRAE 52.2 and have MERV 7, 8, and 13 filters.

5.10 DEHUMIDIFICATION SYSTEMS

The set point relative humidity in the Envirocenter is 60%. Also, the amount of supply air is greater than the amount of exhaust air, ensuring a positive building pressure and compliance with this section.

5.11 DRAIN PANS

Drain pans are specified to be constructed of either plastic or galvanized stainless steel. Their slopes, sizes and outlets are specified to meet ASHRAE 62's standard.

5.12 FINNED-TUBE COILS AND HEAT EXCHANGERS

Drain pans are provided as required by section 5.11. No specification is made with regard to being 18 inches apart as mentioned in this section.

5.13 HUMIDIFIERS AND WATER-SPRAY SYSTEMS

The Envirocenter does not have humidifiers or water spray systems.

5.14 ACCESS FOR INSPECTION, CLEANING, AND MAINTENANCE

Sufficient room is provided around the air handling unit to allow access and maintenance. The access door is 18 by 72 inches. Access doors are also provided with sufficient working space around VAV boxes and heat pumps.

5.15 BUILDING ENVELOPE AND INTERIOR SURFACES

Weatherproofing material and moisture barriers are located behind exterior wall panels and on roof top surfaces. The glazing on the atrium is caulked to seal, with the operable windows having gaskets to prevent leaks. Chilled water piping and other surfaces with the potential to collect water will be insulated.

5.16 BUILDINGS WITH ATTACHED PARKING GARAGES

There are no parking garages attached to the Envirocenter.

5.17 AIR CLASSIFICATION AND RECIRCULATION

The Envirocenter has Class 1 air with a ducted return from the tenant office spaces back to the Air handler for recirculation. The Class 1 atrium air is ventilated out through the roof of the building either naturally or using rooftop fans. Air in the bathrooms is Class 2 and will be ducted away as exhaust

5.18 REQ.'S FOR BUILDINGS CONTAINING ETS AREAS AND ETS-FREE AREAS

The Envirocenter has no ETS areas.

SECTION 6 – PROCEDURES

For the purposes of this analysis, the only air handler (AHU-1) was chosen. It supplies all office spaces in the Envirocenter and will give a complete look at the ventilation required in those spaces. The principle equation that will be employed in the analysis of ASHRAE 62 section 6 is as follows:

Ventilation rate procedure as prescribed by ASHRAE 62.1 Section 6:

Breathing zone outdoor airflow (V_{bz}):

$$V_{bz} = R_p * P_z + R_a * A_z \quad (\text{Eq. 6-1})$$

Where,

A_z = Zone Floor Area: The net occupiable floor area of the zone [ft^2]

P_z = Zone Population: The largest number of people expected to occupy the zone during typical usage. (Estimated values found in table 6-1)

R_p = Outdoor airflow rate per person [CFM/Person] (values from Table 6-1)

R_a = Outdoor airflow rate per area [CFM/ ft^2] (Values from Table 6-1)

Zone Air Distribution Effectiveness (E_z):

$$E_z = 1 \quad (\text{From ASHRAE Table 6-2})$$

Zone Outdoor Airflow (V_{oz}):

$$V_{oz} = V_{bz} / E_z \quad (\text{Eq. 6-2})$$

Primary Outdoor Air Fraction (Z_p):

$$Z_p = V_{oz} / V_{pz} \quad (\text{Eq. 6-5})$$

System Ventilation Efficiency (E_v):

$$E_v = f(\max Z_p) \quad (\text{From ASHRAE Table. 6-3})$$

Uncorrected Outdoor Air Intake (V_{ou}):

$$V_{ou} = D * \sum_{\text{all zones}} (R_p * P_z) + \sum_{\text{all zones}} (R_a * A_z) \quad (\text{Eq. 6-6})$$

Occupant diversity (D):

$$D = P_s / \sum_{\text{all zones}} P_z \quad (\text{Eq. 6-7})$$

Where,

P_s = System population: the total population in the area served by the system.

Outdoor Air Intake (V_{ot})

$$V_{ot} = V_{ou} / E_v \quad (\text{Eq. 6-8})$$

ASSUMPTIONS

I assumed that conference rooms could be treated as office space, requiring 5 CFM per person and 0.3 CFM per square foot.

ASHRAE 62.1 SUMMARY

The Envirocenter's mechanical ventilation rate is slightly below what is prescribed in ASHRAE 62.1. See Appendix A for a table showing the numbers involved in this analysis. ASHRAE 62.1 calls for 3577 CFM of outside air, but the mechanical system only provides 3100 CFM. This is because the primary means of ventilation for the Envirocenter is natural ventilation. The atrium on the south side of the building will create a natural convection current, taking air up and out of vents on the roof, drawing air from the office spaces, and similarly drawing fresh air into them. This will make up for the 500 CFM of ventilation that is not met by the mechanical system. Of the 13,500 CFM supplied by the air handler, 3100 CFM are outside air, creating a fraction of 23% with which to supplement the natural ventilation that will be occurring. In an effort to reduce energy consumption, the mechanical ventilation was kept to a minimum, relying more heavily on natural ventilation in the building.

The airflow rate of 13,500 matches the capacity of the air handler exactly. This is done as a means of operating as efficiently – as close to full load – as possible. This building is designed to achieve a LEED Platinum rating, and as such has many features which save as much energy as possible. The maximum Z_p is in an office space, which seems more incidental than some deliberate move on the part of the engineers. These are all tenant occupied office spaces and there aren't any special occupancy types in this area.

ASHRAE 90.1 ANALYSIS

ASHRAE standard 90.1 is principally focused on matters of energy use by a building. It looks at various systems, including but not limited to the building envelope, HVAC, lighting and electrical systems.

SECTION 5 - BUILDING ENVELOPE

SECTION 5.1.4 CLIMATE:

The Envirocenter is located in Jessup, Maryland which falls into climate zone 4A, as shown by the red arrow in Figure 2 below.

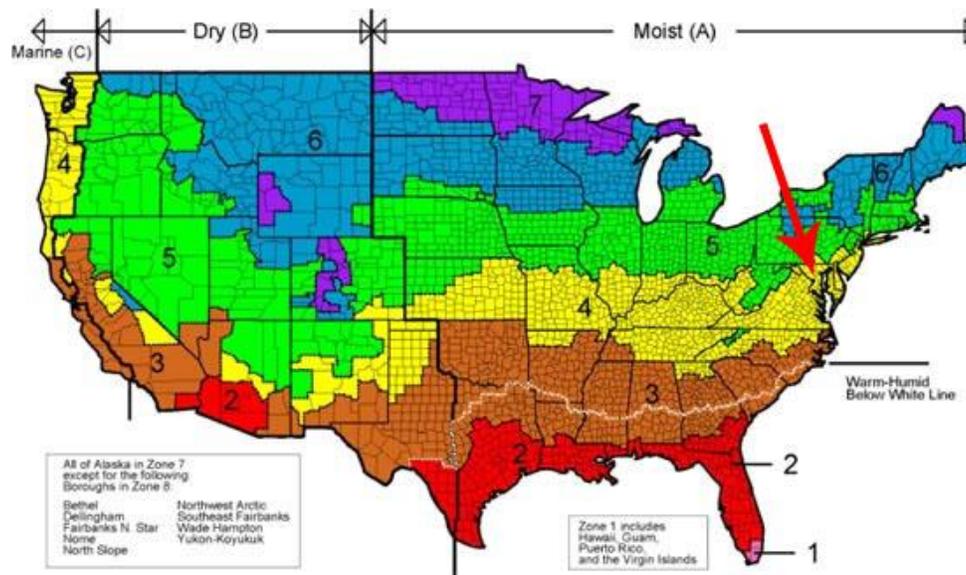


Figure 2 United States climate zones

SECTION 5.4 MANDATORY PROVISIONS

The exterior of the Envirocenter is to be sealed around all fenestration and door openings and at all joints to prevent unwanted air leaking. The two main ways to enter and exit the Envirocenter are either from the connection to the existing Envirocenter Phase I, and the front door from the lot. The latter of these is equipped with a vestibule to minimize the mixing of conditioned and unconditioned air.

SECTION 6 - HVAC

SECTION 6.2 COMPLIANCE PATH

The two paths for determining the compliancy of a building's HVAC system are the simplified method and the mandatory provisions method. The mandatory provisions method will be used for this analysis.

SECTION 6.4 MANDATORY PROVISIONS

The temperature controls for individual zones coincide with tenant office spaces, such that the tenants can adjust their spaces individually. The spaces are conditioned with constant temperature, variable air volume boxes, with dampers that open or close according to the space load. They close to a minimum ventilation mode at which point the only air flowing is ventilation air. This functionality is also tied into the operable windows, such that if they are open, the dampers close to prevent mechanical heating or cooling with the windows open. The ductwork is exposed, double wall spiral ductwork, with a perforated metal lining for acoustical attenuation.

Space heating is provided via radiant heat. A network of tubes will be placed in the concrete floor and mass wall separating the offices and the atrium. Hot water will be supplied to these tubes through a variable-flow pump such that the heating load can be met for various load conditions. Each zone will be individually controllable by the occupants.

SECTION 6.5 PRESCRIPTIVE PATH

The air handler is capable of running in an economizer mode, supplying 100% outside air all pre-treated through the earth tubes. Because this is a VAV system, the following equation from ASHRAE 90.1 Table 6.5.3.1.1A may be used:

$$HP \leq CFM * 0.0015 \quad (\text{Table 6.5.3.1.1A})$$

According to that equation, the following table was produced, showing how the Envirocenter Phase II complies with this standard.

FAN COMPLIANCE				
UNIT	HP	CFM	CFM * 0.0015	90.1 COMPLIANCE
AHU-1 SUPPLY	20	13500	20.25	YES
AHU-1 RETURN	20	13500	20.25	YES
F-1	0.4	400	0.6	YES
F-2	0.4	750	1.125	YES
F-3	0.1	150	0.225	YES
F-4	3	22500	33.75	YES
F-5	3	22500	33.75	YES
F-6	3	22500	33.75	YES
F-7	3	22500	33.75	YES
F-8	0.1	250	0.375	YES
F-9	0.1	50	0.075	YES
F-10	0.1	50	0.075	YES

The Envirocenter Phase II complies quite well with this standard. The closest it comes to non-compliance is in the air handler itself where there is only a difference of 0.25. This is most likely because of the pressure drop associated with the MERV 8 and 13 filters found in the air handler.

No energy recovery system is necessary because the minimum outdoor air supply is less than 70% of the design supply air.

SECTION 6.7 SUBMITTALS

All systems are specified to be tested upon installation to ensure that everything performs as it is designed. This building is intended to achieve LEED certification, and will be commissioned at the end of construction.

SECTION 6.8 MINIMUM EQUIPMENT EFFICIENCY TABLES

The Envirocenter Phase II gets its hot and chilled water from two reversible ground source heat pumps. Compliance efficiency values in the table below come from ASHRAE 90.1 Table 6.8.1B

EQUIPMENT COMPLIANCE			
UNIT	EER	90.1 STANDARD	COMPLIANCE
HP-1 COOLING	13.6	13.4	YES
HP-2 COOLING	13.6	13.4	YES
UNIT	COP	90.1 STANDARD	COMPLIANCE
HP-1 HEATING	3.7	3.6	YES
HP-2 HEATING	3.7	3.6	YES

Both heat pumps perform at a level of efficiency that is in compliance with this standard.

SECTION 7 - SERVICE WATER HEATING

Domestic hot water is provided by a connection to an existing water heater in Envirocenter Phase I. No information was provided about this water heater.

SECTION 8 - POWER

The power system in the Envirocenter Phase II has been designed according to the National Electrical Code (NEC) which requires feeder conductors to not have a voltage drop greater than 2% and branch conductors to not have a voltage drop greater than 3% at the design load. The Envirocenter Phase II complies with this standard.

SECTION 9 - LIGHTING

SECTION 9.2 COMPLIANCE PATHS

The two paths for analyzing the lighting power density are the building area method and the space by space method. The building area method will be used for this analysis.

The table below outlines the lighting fixtures and associated wattages used in the Envirocenter Phase II:

LIGHTING COMPLIANCE						
FIXTURE	BASEMENT	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR	WATTS / FIXTURE	TOTAL WATTS
DPE/42	-	24	37	12	250	18250
DFL/26	-	-	4	2	26	156
RI/24	4	6	11	8	24	696
RI/12	4	4	2	4	12	168
SC/30	-	4	4	2	50	500
WDI/80	-	1	-	6	70	490
I/80	24	4	-	1	70	2030
DPE/40	-	3	-	-	234	702
DP/40	-	2	-	-	234	468
DP/20	-	5	-	-	35	175
CFVT/42	2	-	-	-	52	104
DP/42	-	9	-	-	250	2250

TOTAL:	25989
S.F.	24219
LPD	1.073083

The Envirocenter Phase II does go over the allowable lighting power density by 0.07 watts per square foot. This is likely because of all the atrium lighting on upper levels, shining where there isn't a floor. So the Envirocenter Phase II just barely falls short of this standard.

ASHRAE 90.1 SUMMARY

Upon analysis of several of the Envirocenter Phase II's systems, like building enclosure, HVAC domestic hot water, power and lighting, this building on the whole performs quite well. One area where it does fall short is in the lighting.

The 1.07 W/ft² LPD is just over the 1.0 W/ft² guideline prescribed by ASHRAE 90.1. This is likely due to the extra lighting provided to the glass enclosure and empty spaces of the atrium, which isn't used on a task surface like most of the other lighting in the building.

The electrical power and HVAC systems on the other hand, do meet the standards set forth by ASHRAE 90.1 Fan power efficiencies surpass the standard, though the fans in the air handler just barely so. This is likely due to the fact that it has to force the air through two MERV filters – a MERV 7 and a MERV 13.

APPENDIX A

VENTILATION RATES FOR AHU-1

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