CareFirst Cumberland

Cumberland, MD

Technical Report III

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Mechanical Option

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Table of Contents

Executive Summary 3
Project Background 4
Mechanical Summary 4
Design requirement 6
    Design Conditions 6
    Ventilation Conditions 7
    Designed Loads 8
Energy Source and Rates 10
    Annual Energy Usage 10
    Design Influences 12
Existing Mechanical System 13
    Mechanical System Cost 14
    System Operation 15
    Operating History of System 16
LEED Analysis 17
    Energy and Atmosphere 18
    Indoor Environmental Quality 21
Overall Evaluation of system 25
References 26
    Project Team 26
  APPENDIX A 27
  APPENDIX B 28
  APPENDIX C 30
  APPENDIX D 31
  APPENDIX D 31

Executive Summary

Technical report 3 is evaluation of existing mechanical system condition for the CareFirst Cumberland, MD. Breakdown of lost usable space by the mechanical equipment listed and table of major mechanical equipment also listed and summarized with their capacity and services. To explain the controls and mechanical system operation, schematic drawing with flow diagram of water and air has been simplified. For the design requirement, ASHRAE Standard 62.2 analysis in technical report 1 mentioned. Minimum ventilation or outdoor air intake is core design requirement of the mechanical system. Outdoor weather data of Cumberland, MD is not available, therefore, Baltimore, MD weather data obtained from 2009 ASHARE Handbook for outdoor design conditions. Indoor design condition was determined by Vendeweil Engineer, LLC to maintain comfort thermal zone for the occupants in the building. Its design heating and cooling load are based on outdoor design and indoor design condition, and further in this report, design load and calculated load by TRACE 700 compared. Main energy sources of the building are electricity and natural gas, however, natural gas is disconnected by owner since the usage is fairly low even in winter. Annual energy usage compared with calculated energy usage value again in this technical report, and discusses about the influences of the existing mechanical design. For future redesign mechanical system, LEED rating system for new construction/major renovation from the U.S. Green Building Council discussed in this report. At the end of report, overall evaluation of the existing mechanical system about the project construction cost, operating cost, space requirement, maintainability, environmental control and indoor air quality issue discussed.

Project Background

CareFirst Cumberland relocated in new building for expansion due to lack of office spaces. VOA Architect and Venderweil, LLC., worked with sustainable energy solution of geothermal water system into the CareFirst Cumberland. With façade of clay brick wall with a strip of stone in a center, the CareFirst Cumberland has simple form of rectangular; each exterior façade faced 4 different directions. Most of the space in the CareFirst Cumberland served as office usage. For second floor of the building, open offices are provided perimeter and core zone. For the employee in CareFirst, exercise rooms and cafeteria is provided in first floor. In center of the building space, lobby and break room areas are used for social events. The north side of 1st building is designed for future use.

Mechanical Summary

The CareFirst Cumberland has geothermal water source system with Dedicated Outdoor Air system (DOAS) primarily support the ventilation of the building. On the building site, 50 geothermal wells connect into the building mechanical system for the heat rejection and heat recovery. Ten of geothermal connect as one branch loop. Three geothermal water loops use for existing building design, and rest of two branches are for future expansion. With rooftop unit, the outdoor air intake provided 9000 CFM into the building, then it will be serve into second floor, and branch ductworks connected into first floor. The duck works arranged in core of the building to have branch duck work with the geothermal heat pump unit in each designed thermal zone. To condition air in the CareFirst Cumberland, 45 geothermal heat pumps those connected into roof top unit duct distribution and geothermal water loop, can recover up to 140, 000 Btu/hr. Geothermal water loop can possibly operate to maintain desired geothermal supply set point temperature of 55F, however, in extreme climate changes, the cooling tower and boiler connected into system for just in case of the geothermal heat reject and recovery are not satisfied. If the geothermal water return temperature within a set point temperature of 3F, return does not necessary circulate all of way back to geothermal well, the heat recovery unit can handle. All of control process operates in energy efficiency with direct digital control of building automatic system. IT Computer laboratory, elevator machine room, few of mechanical and electrical spaces condition with separated air-conditioned unit, because Seven of the electrical heaters used in the tenant expansion space to not to affect interior spaces that are right next to the future space.

Design requirement

All building with occupants must comply with ASHRAE Standard 62.1 to provide minimum outdoor intake to supply oxygen and exhaust contaminant air particle, such as carbon dioxide. To supply fresh air possible, local capture of contaminants from the building equipment and outdoor air intake minim separation distance requirements are carefully designed. Not only ventilation rate, the comfort zone for the occupants is core of mechanical design requirement.

Design Conditions

The CareFirst Cumberland is classified as nonresidential conditioned space located in Cumberland, MD, corresponding to the cold-humid 4a climate zone determined by Figure 1/Table B-1 located in ASHRAE 90.1.2007. Since there is no airport weather station in Cumberland, MD, the city of Baltimore, MD weather data used. According to 2009 Fundamentals ASHRAE Handbook, Baltimore located 39.17 N latitude and 76.68W longitude, which is similar to Cumberland, MD, which is 39.65N latitude and 78.76W longitude. The hottest month, which is in July, cooling and dehumidification design condition for critical weather condition of 0.4%, outdoor weather condition is provide in Table-1. The indoor design condition is specified by Venderweil Engineer, LLC; data provided in Table-2.

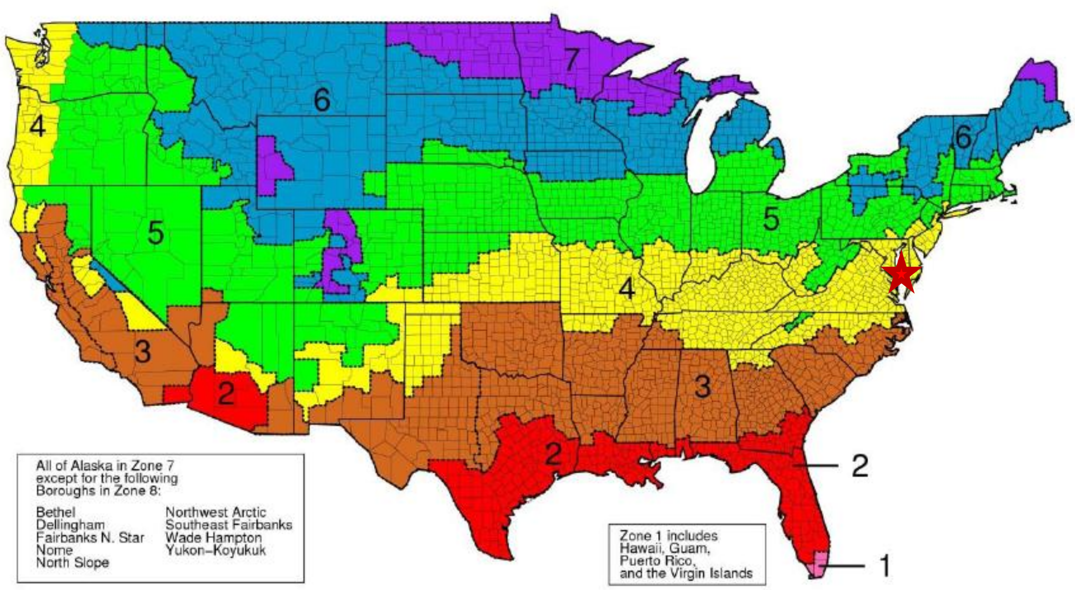

Figure 1 Climate Zone

	Summer		Winter	
	DB (^{0}F)	RH	DB (^{0}F)	RH
Outdoor Condition	93.9	43	12.9	-
Indoor Desing Condition	75	55	70	50

Table 1 Outdoor Condition

Typical Thermostat Parameter	
Cooling Dry Bulb (^{0}F)	75
Heating Dry Bulb (^{0}F)	70
Relative Humidity %	50
Cooling Drift Point (^{0}F)	80$\pm$3
Heating Drift Point (^{0}F)	60$\pm$3

Table 2 Designed Indoor Condition

Ventilation Conditions

The Venderweil Engineer, LLC designed to have a minimum ventilation rate of the common spaces for the CareFirst Cumberland. According to ASHRAE 62.1.2007 Table 6-1, the designed ventilation rate, in unit of cubic feet per minute per person, the designed value is higher than the standard. Therefore, the CareFirst Cumberland provides more air than ASHRAE standard, which means complied. The ventilation is 100% outside air intake delivered from the rooftop dedicated outdoor air system (DOAS) unit to each zone. The outside air intake is ducted into the heat pumps for each zone, and the return into plenum above ceiling. With outside supply air and returned air mixed together to energy recovery, therefore geothermal heat pump is ducted into outside air intake, but it is not always will provide 100% outside air supply. The exfiltration through building façade is about 0.03 CFM/SF.

Modeled Ventilation Rate		
	cfm/person	
Space	Designed	ASHRAE
Lobby	15	11
Office Spaces	20	17
Conference Rooms	20	6
Corridor	0	0

Table 3 Ventilation Rate Comparison

Designed Loads

The Vandeweil Engineer LLC provided load calculation on each geothermal heat pump unit that serving each zone. The list of the designed thermal zones and designed load of envelope and internal is provided in Appendix A. All the comparison for load assumption was mention previously and the comparison of designed and ASHRAE Standard block loads. With 12 zone separation those listed in Table 4, input data of area of space, perimeter of exterior wall, height, building material type, internal load, and units were used in Trace 700 to calculate. At the end of the calculation, the actual calculated load in each zone provided.

Calculated Cooling Load (Btu/hr)		
Zone	Envelope	Internal
Conference_1st	22996	22271
Corridor_1st	8708	9215
IT Comm Room	0	1317
Lobby_1st	30746	33140
Lobby_2nd	22131	13500
Office_1st	165607	103316
Office_2nd	351006	207404
Rm 186 Telcom Demarc	0	306
Rm 195 Eelev Mach Room	62	275
Rm 296	0	360
Rm 201	42026	10149
Rm 219	0	4793
	643282	406046
Total Btu/hr		1049328
Total tons		87.444

Table 4 List of Thermal Zones and its Calculated Load

The comparison of designed and calculated load is provided on Table 5 below.

	Designed	Calculated
Cooling Load (tons)	120	101
Heating Load (btu/hr)	1,324,986	1,672,589

Table 5 Designed and Calculated Load Comparison

Calculated cooling load is underestimated than the actual designed load, because the calculation was made to use only one type of wall type, and it did not have exact same material of the CareFirst Cumberland has. Also, some of the spaces were not included in the calculation process, which were mechanical room, electrical room, and other machinery spaces. Even though calculated load is little off for the designed load, in selection of the equipment, units are selected oversized. Unlike calculated cooling load, calculated heating load is overestimated than the designed heating load. The accuracy of calculation is off with same reason with calculated cooling load.

Energy Source and Rates

The primary energy source of the CareFirst Cumberland is electricity from the Allegheny Power Distribution Company. Fossil fuel of natural gas used for the boiler for the back-up heat recovery for the system, however, since the usage of the boiler determined to be less than $100 utility rate for a month in winter. Therefore, the own decided to disconnect the gas line into the building to cut extra cost of minimum rate. Actual annual utility bills and rates were not available from the Venderweil Engineer, LLC, therefore, average electricity rate in Washington and Baltimore area data founded in U.S. Bureau of Labor Statistics, Table 6 is shown below.

2011 Average Prices of Electricity in Washington & Baltimore Area						
Electricity per kWh Bill ($)	January	February	March	April	May	June
	0.127	0.128	0.128	0.13	0.13	0.133
	July	August	September	October	November	December
	0.135	0.133	0.133	0.126	0.122	0.123

Table 6 Designed and Calculated Load Comparison

Annual Energy Usage

Calculated Trace 700 Report of energy consumption for the each month attached in below Table 7. The CareFirst is primarily used electrical energy in the building. The building energy uses in primary heating and cooling, auxiliary, and lighting. The boiler used natural gas, however, it consumption is fair low to ignore, because the geothermal source system can handle heat rejection and heat recovery. The secondary heat rejection, cooling tower is used, and for the heat recovery, the boiler in mechanical room was used, but as mentioned, the boiler rarely used in the building. For the electrical consumption, in month of July has peak consumption compared to other months.

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**Technical Report 2**												
Electric													
On-Pk Cons. (kWh)	34,356	31,132	37,634	32,737	36,045	36,203	32,932	37,850	32,905	36,041	34,363	32,720	414,917
Off-Pk Cons. (kWh)	68,109	61,641	61,663	63,062	64,397	61,404	68,474	63,008	64,515	62,987	61,061	67,810	768,131
On-Pk Demand (kW)	140	140	140	140	140	140	140	140	140	140	140	140	140
Off-Pk Demand (kW)	148	147	140	140	140	140	140	140	140	140	140	141	148
Water													
Cons. (1000gal)	9	8	11	13	20	21	24	22	20	13	11	9	181

Energy Consumption		
Building	118,076	Btu/(ft2-year)
Source	354,264	Btu/(ft2-year)
Floor Area	34,196	ft2

Environmental Impact Analysis	
CO_2	15,855,690 lbm/year
SO_2	142,781 gm/year
NOX	27,323 gm/year

Table 7 Energy Consumption Monthly

For the design annul energy consumption rate is not available, therefore, with provided the electrical documentation for the building, the overall full demand load used to calculated the annual energy consumption. With total 225.77 kVA of load and assumption of power factor of 0.8, demand load of the building is 180 kW. The main switchboard and list of connected load table is shown below Table 8.

MAIN SWITCHBOARD - MSB

277/480 Volt, 3 Phase, 4 Wire + Ground | Main Bus Amps: 1600 | 42K AIC

CIRCUIT NUMBER	LOAD DESCRIPTION	KVA LOAD CONNECTED	OVERCURRENT DEVICE			REMARKS
			FRAME	TRIP	POLE	
	MAIN BREAKER		1600	1600	3	WITH GFP
1	PANEL M4N1	87.29	225	225	3	
2	PANEL L4N1	17.91	400	400	3	
3	PANEL L4N2	15.54	400	400	3	
4	PANEL L4SL	24.50	100	100	3	
5	ROOF TOP UNIT	133.90	200	200	3	
6	PANEL L4LS VIA ATS-1	13.16	100	90	3	
7	ELEVATOR (40 HP)	44.06	125	125	3	
8	SPACE	--	100	--	3	
9	SPACE	--	225	--	3	
10	SPACE	--	225	--	3	
11	FIRE PUMP	17.40	--	--	--	TAP SECTION

353.75 kVA CONNECTED LOAD
225.77 kVA OVERALL DEMAND LOAD

PROVIDE INTEGRAL TVSS

Table 8 Main Switchboard

Using average rates of electricity in Washington & Baltimore are in table 6, the monthly utility rate of the CareFirst Cumberland can be calculated. Assumed that operation of the mechanical and power system are scheduled for 8 hours of a day, and then monthly utility rate of the building is shown below Table 9. Total annual energy consumption is $ 66908.16.

Monthly Utility Rate of the CareFirst Cumberland						
Electricity per kWh Bill ($)	January	February	March	April	May	June
	5486.4	5529.6	5529.6	5616	5616	5780.16
	July	August	September	October	November	December
	5832	5745.6	5745.6	5443.2	5270.4	5313.6

Table 9 Monthly Utility Rate of the Care First Cumberland

Design Influences

The geothermal water system is recommended by the own, however, specific design influences were not provided to the engineer. However, there are state rebate program and tax cut for the geothermal heat pump system in Maryland. According to the Database of State incentives for Renewable & Efficiency in U.S., the Geothermal Heat Pump Grant Program is the one of the rebate program for the geothermal energy use building. This program apply to the commercial, industrial, residential, nonprofit, schools, local government, and institutional. For the non-residential, amount of rebate is $ 90- $180 per ton, which is varies by system size. Designed individual unit heaters calculated to be 120 tons total, however, the maximum incentive for non-residential is $4,500. Equipment requirement must meet the safety and performance standard of minimum energy efficiency ratio (EER) of 14.0 and minimum coefficient of performance (COP) of 3.0. This incentive funded by Strategic Energy Investment Fund since 2007.

Existing Mechanical System

The CareFirst Cumberland has geothermal water source system with Dedicated Outdoor Air (DOA) system primarily support the ventilation of the building. With rooftop unit, the outdoor air intake provided 9000 CFM into the building, then it will be serve into second floor, and branch ductworks connected into first floor. All of air distribution system place on ceiling, therefore, it does not affect one total gross area, but it does on height of the building. The main mechanical system located in first floor mechanical room and roof for roof top unit. However, roof is not design for usable space, so it is excluded from total net gross area. Additional mechanical room, electrical room, and elevator shaft consider as unusable space. The list of the unusable space is on Table 10 below with its area. Unusable space is about 3% of total area of building.

Room#	Name	Area
185	Mech Room	400
183	Fire Control Room	110
184	Water/sprinkler Room	120
187	Main Electrical Room	110
188	Emergency Electrical Room	50
186	Telecom Demarc	50
195	Electrical Room	65
196	Elev Mach Room	45
1st floor	Elevator shaft	110
295	Electrical Room	80
296	Tele	60
2nd floor	Elevator shaft	110
	Total	1310

Table 10 Breakdown of the lost usable space

Mechanical System Cost

In geothermal well field, circulated water loop is cooled and heated with natural ground source energy. Even though first cost of the geothermal ground source system is more expensive than other mechanical system, but the operation cost is not much as others, because it uses natural heat transfer from ground. Bidding documentation for the first cost for the mechanical system was not available from the Venderweil Engineer, LLC, however, the engineer informed about the geothermal well. Each geothermal well cost is $7000-10,000, therefore with 50 of geothermal wells in the site, total cost of the geothermal wells is $ 350,000 -$500,000. With 45,000 SF of gross area of the building, the cost per square footage is $11.11. The first construction cost of all other mechanical system was not available. The summarization of the major mechanical equipment provides below Table 11.

Major Mechanical Equipements						
Tag	Equipment	Location	GPM			
AS-1	Air Seperator	Mech. Room	230			
			Tank Pressure Rating (PSI)	Tank Acceptance Volume (GAL)		
ET-1	Expansion Tank	Mech. Room	125	39		
			Input/Output (MBH)	Efficiency	Max. GPM	
B-1	Boiler	Mech. Room	1,500/1,300	86%	130	
			Type	Capacity MBH		
HX-1	Heat Exchanger	Mech. Room	Plate & Frame	895		
			Type	Capacity Ton/GPM	VFD	HP
CT-1	Cooling Tower	On Grade	Induced	60/180	Yes	5
			Flow (GPM)	RPM	VFD	HP
GXP-1	Geothermal Water Pump	Mech. Room	230	1800	Yes	15
GXP-2	Geothermal Water Pump	Mech. Room	230	1800	Yes	15
CWP-1	Conderser Water Pump	Mech. Room	180	1800	Yes	5
CWP-2	Conderser Water Pump	Mech. Room	180	1800	Yes	5
			Airflow (CFM)	VFD	HP	
SP-1	Supply Fan	RTU	9000	Yes	15	
EF-2	Exhaust Fan	RTU	5500	Yes	5	

Table 11 Summary of Major Mechanical Equipment

System Operation

The CareFirst Cumberland mechanical system operates with geothermal water source and Dedicated Outdoor Air System. There are three main parts of mechanical system for the building; Geothermal well field, mechanical room in the building, and variable volume rooftop water source heat pump with energy recovery on top of roof. Three loops of ten geothermal wells circulated by geothermal pump, this water loop give up the heat to ground in summer, and pick up the heat to ground in winter.

Water loop passes to the air separator, expansion tank for excess water pressure reason, then boiler if temperature is not satisfied to heat exchanger in winter. Automatic control valve with modulating actuator modulates closed to maximum flow to heat exchanger until geothermal water temperature of 65F. Also, the butterfly valves for in and out to the boiler shut down when the water loop has satisfied temperature so that the boiler does even have to be used. Two of geothermal pumps connect to the water loop, but the GXP-2 is not usually operating, it is standby pump when GXP-1 does not operate with some reason. Both of them conned to the variable frequency drive to modulate to satisfy require pressure set point for water pumping efficiency. The heat exchanger 3-way automatic control valve modulates to the heat exchanger to exchange heat with the cooling tower control loop to maintain the geothermal water supply temperature set point.

Cooling tower loop circulates by condenser water pump, like geothermal water pump, one is standby pump, and two parallel condenser water pumps connect to the variable frequency drive to modulate the pump speed. Cooling tower is located outside of building on grade. It is operates when geothermal supply temperature continuously rise for 15 minutes while the boiler closed, and cooling tower fan is connected to the variable frequency drive to maintain geothermal set point. If the cooling tower water loop below 55F, the cooling tower fan stops and the cooling tower bypass valve control loop is enable. At the temperature 60F, the tower fan works again and bypass valve is unable.

Conditioned geothermal water loop supplies to the heat pump compressor, and then serves to heating or cooling coil. Outdoor air intake is driven by supply fan that connect to the variable frequency drive to modulate minimum to maximum CFM setting. A measure of filter efficiency rating of 8 filters the outdoor air. The outdoor air intake and exhaust air exchanges the heat inside of energy recovery wheel. Mixed air temperature sensor modulates electric preheating, heating and cooling coil, and hot-gas reheat coil to maintain the discharge set point temperature. Then, discharged air temperature sensor modulate outside air damper, exhaust air damper, and return air damper to maintain desired discharged temperature set point. The discharged air temperature can be reset by building automatic system. Bypass damper between supply and return air modulates open to lower static pressure. Return air is filter before entering energy recovery wheel, then it reliefs to the outside. To maintain positive pressure in the building, a constant differential of 1000 CFM for building pressurization should be maintain.

Mode of occupied and unoccupied can be selected my automatically or manually by direct digital control based on time schedule. In occupied mode, all the system runs continuously as described, but in unoccupied mode, the operation of system shuts down. Schematic drawing provides in Appendix E.

Operating History of System

The information of operating history of system is not available from the engineer. Only information obtained is that the own decided to the shut off the gas to the back-up boiler serving the geothermal system, because the geothermal system can handle all the heat recovery desired. For the CareFirst Cumberland, the $29.94 is the minimum bill for the cost to read the meter each month for entire 45,000 SF. In the coldest month, the building used less than $100 of gas of the winter, the owner decided to disconnect the gas entirely. The gas bill for the entire year provide below Table 12

Gas Bill ($)	January	February	March	April	May	June
	86.8	36.35	29.94	29.94	29.94	29.94
	July	August	September	October	November	December
	29.94	29.94	29.94	29.94	29.94	29.94

Table 12 Summary of Major Mechanical Equipment

LEED Analysis

The U.S. Green Building Council, known as USGBC, developed LEED, or Leadership in Energy and Environmental Design, which rating system that provides let owner, architect, and engineer to aware and implement the sustainable practice on building construction. Not only considering impact on surrounding impact, this rating system will directly lead to the building's performance and provide healthy indoor spaces for a building's occupants. To be LEED certified, the building must earn qualified LEED points from LEED rating system for specified by building usage. The rating scale range is total 180 points with named with LEED certified, Silver, Gold, and Platinum. LEED program values at 7 topics to promote healthful, durable, affordable, and environmentally sound practices in building design and construction. The 7 topics are sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design, and regional priority. For the mechanical system renovation, AE students assigned to analysis the LEED to renovate more efficiency mechanical system design. Only 2 of 7 topics were taken into improving mechanical system, which are energy and atmosphere, and indoor environmental quality. LEED rating chart sheet provided in Appendix C for reference.

Energy and Atmosphere

Fundamental Commissioning of Building Energy System

Before start rating, the project must be verified whether energy-related systems are installed, calibrated to perform according to the owner's project requirement. Commissioning is for reduced energy use, lower operating costs, fewer contractor callbacks, better building documentation, improved occupant productivity and verification. For projects smaller than 50,000 gross square feet, which is comply with the CareFirst Cumberland, the commissioning authority can be experienced and qualified on design or construction team. The commissioning process activities are HVAC system and associated controls, lighting controls, domestic hot water system, renewable energy system.

Minimum Energy Performance

Proposed building and system required to have minimum level of energy efficiency to reduce environmental and economic impact associated with excessive energy use. To comply with this prerequisite, either the building performance calculates by whole building energy simulation, or follows the ASHRAE advanced energy design guide.

Fundamental Refrigerant Management

To reduce stratospheric ozone depletion, the use of chlorofluorocarbon must avoid using as refrigerant in HVAC refrigeration system. For the major renovation, for existing small HVAC units must not exceed the 0.5 pounds of refrigerant. For the CareFirst Cumberland, the refrigerant type called R-410A contained in the geothermal heat pump unit. This chemical mixture only contains fluorine that does not contribute to ozone depletion like CFC refrigerant. However, R-410A has high global warming potential that is 1725 times the effect of CO_2.

Optimize Energy Performance

With the compliance of minimum energy performance, increasing levels of energy performance measured to be shown as the minimum energy cost saving percentage. Project can use 1 of 3 options to comply with, but the whole building energy simulation is the option that can get most points in range of 1-19. Calculation based on Appendix G of ASHRAE Standard 90.1-2007 using a computer simulation model for the whole building project. For the CareFirst

Cumberland, the energy and economic analysis computer software, TRACE 700 was used for the calculation. Point rating charts is provided below, Table 13.

New Buildings	Existing Building Renovations	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

Table 13 Minimum energy cost saving percentage and rating points

On-Site Renewable Energy

To increasing levels of on-site renewable energy, environmental and economic impacts those associated with fossil fuel energy use are reduced. The building performance calculates by expressing the energy produced by the renewable system as a percentage of the building's annual energy cost and use the Table below. The CareFirst is supply power with electricity, but the geothermal heat used for the heat recovery, so the project is used some of renewable energy.

Percentage Renewable Energy	Points
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

Table 14 Minimum renewable energy percentage and rating points

Enhanced Commissioning

Commissioning authority review and oversees the owner's project requirements basis of design, architect or engineer of record and submittals, future operation, verified the training for operation, and operation and maintenance staffs.

Enhanced Refrigerant Management

To reduce ozone depletion and consider global warming, the refrigerant management restricts for its usage, whether not use refrigerants at all or select specific types of refrigerants that minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change. The project HVAC&R system must comply with the following formula, Table 15 to set a maximum threshold for the combined contributions to ozone depletion and global warming potential.

Imperial units

$$LCGWP + LCODP \times 10^5 \leq 100$$

Metric units

$$LCGWP + LCODP \times 10^5 \leq 13$$

Calculation definitions for LCGWP + LCODP x $10^5 \leq 100$ (Imperial units)	Calculation definitions for LCGWP + LCODP x $10^5 \leq 13$ (Metric units)
LCODP = [ODPr x (Lr x Life +Mr) x Rc]/Life	LCODP = [ODPr x (Lr x Life +Mr) x Rc]/Life
LCGWP = [GWPr x (Lr x Life +Mr) x Rc]/Life	LCGWP = [GWPr x (Lr x Life +Mr) x Rc]/Life
LCODP: Lifecycle Ozone Depletion Potential (lb CFC 11/Ton-Year)	LCODP: Lifecycle Ozone Depletion Potential (kg CFC 11/(kW/year))
LCGWP: Lifecycle Direct Global Warming Potential (lb CO_2/Ton-Year)	LCGWP: Lifecycle Direct Global Warming Potential (kg CO_2/(kW/year))
GWPr: Global Warming Potential of Refrigerant (0 to 12,000 lb CO_2/lbr)	ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 kg CFC 11/kg r)
ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lb CFC 11/lbr)	GWPr: Global Warming Potential of Refrigerant (0 to 12,000 kg CO_2/kg r)
Lr: Refrigerant Leakage Rate (0.5% to 2.0%; default of 2% unless otherwise demonstrated)	Lr: Refrigerant Leakage Rate (0.5% to 2.0%; default of 2% unless otherwise demonstrated)
Mr: End-of-life Refrigerant Loss (2% to 10%; default of 10% unless otherwise demonstrated)	Mr: End-of-life Refrigerant Loss (2% to 10%; default of 10% unless otherwise demonstrated)
Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of gross ARI rated cooling capacity)	Rc: Refrigerant Charge (0.065 to 0.65 kg of refrigerant per kW of ARI rated or Eurovent Certified cooling capacity)
Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)	Life: Equipment Life (default based on equipment type, unless otherwise demonstrated)

Table 15 Maximum threshold Formula

Measurement and Verification

To provide building energy consumption over time, develop a measurement and verification plan with calibrated Simulation, Energy Conservation Measure Isolation, or meet compliance with Energy and Water Data Release Form. The corrective action process consider installing diagnostics within the control system to alert the staff when the equipment is not working properly.

Green Power

LEED recommends using the Green Power, known as renewable energy for zero pollution on environment. At least 35% of the building's electricity from renewable source required to gain LEED points. All green power must certify with Green-eEnergy or independent verification from the green power supplier. Baseline electricity consumption can be found in the annual electricity consumption or in the U.S. Department of Energy's Commercial Building Energy Consumption Survey database.

Indoor Environmental Quality

Minimum Indoor Air Quality Performance

By ASHRAE 62.1-2007, the project mechanical ventilation system must comply with ventilation rate procedure to provide minimum indoor air for the comfort and health of the occupants. The ventilation rate relates ton impact on building energy usage, therefore balancing energy efficiency and occupant comfort must be considered.

Environmental Tobacco Smoke Control

To avoid exposure of environmental tobacco smoke, smoking must prohibited inside of the building, and within 25' of entries, and provide the building designated area for smoking. Through the outdoor air intake, operable window, and uncontrolled pathway, tobacco smoke can enter the building.

Outdoor Air Delivery Monitoring

In order to supply fresh air for the occupants, the ventilation system monitoring must be provided. The monitoring system ensures minimum ventilation requirements, but the carbon dioxide level vary by 10% or more from the design value, either a building automation system alarm or a visual/audible alert need to be installed. For the mechanically ventilated space, CO_2 monitor can be installed with a design occupant density of 25 people or more per 1,000 square feet. This device will measure minimum outdoor air intake flow with plus or minus 15% of the design minimum outdoor air rate.

Increased Ventilation

ASHARE Standard 62.1-2007 provided minimum outdoor air rate, but all occupied spaces are recommended to design at least 30% above the minimum rates required. This will provide the occupant comfort zone to maximize their workability.

Construction Indoor Air Quality Management Plan-During Construction

During the project construction, indoor air quality management plan should comply, because stored on-site and installed absorptive material can absorb the chemical compound from the building material, such as paint, concrete, and etc. Therefore permanently installed air handler used for the filtration the construction site. According to ASHRAE Standard 52.2-1999, filtration media should be at least minimum efficiency reporting value (MERV) of 8 in order to filter with a minimum dust spot efficiency of 30% of higher and particle size of 3-10 μg.

Construction Indoor Air Quality Management Plan-Before Occupancy

After the construction, before occupants enter, all interior finishes installed and new filtration media installed. To flush-out dust and particles in the air, supply 14,000 cubic feet of outdoor air per square foot of floor area with at least 60F and relative humidity no higher than 60%. Another method is air testing to determinate of air pollutants in indoor air or the ISO method listed below, Table 16.

Contaminant	Maximum Concentration	EPA Compendium method	ISO method
Formaldehyde	27 parts per billion	IP-6	ISO 16000-3
Particulates (PM10)	50 micrograms per cubic meter	IP-10	ISO 7708
Total volatile organic compounds (TVOCs)	500 micrograms per cubic meter	IP-1	ISO 16000-6
4-Phenylcyclohexene (4-PCH)*	6.5 micrograms per cubic meter	IP-1	ISO 16000-6
Carbon monoxide (CO)	9 part per million and no greater than 2 parts per million above outdoor levels	IP-3	ISO 4224

* This test is only required if carpets and fabrics with styrene butadiene rubber (SBR) latex backing are installed as part of the base building systems.

Table 16 Maximum Concentration Levels

Low-Emitting Materials

To reduce odorous, irritating and harmful indoor air contaminant, all adhesives and sealants used on the interior of the building must comply with South Coast Air Quality Management District Rule #1168. Interior finish such as paints and coating must not exceed the volatile organic compound (VOC) content limits. Flooring system, composite wood and agrifiber products are also carefully selected by Architect or Engineer with limit of VOC content and urea-formaldehyde resins.

Indoor chemical and Pollutant Source control

In case of dirt and particulates entering the building at exterior entrance, entryway system must include permanently installed grills or slotted system for cleaning underneath. The exhaust rate must be at least 0.5 CFM per square foot with no air recirculation. The difference in pressure must be at least 5 Pascal (Pa) with the filtration media that rated MERV-13 or higher in accordance with ASHRAE Standard 52.2.

Controllability of Systems-Thermal Comfort

Thermal comfort varies by individual. For the groups in multi-occupants space, mechanically system control provides individual comfort control for 50% of the building occupants for their productivity, comfort and well-being. This control system involves with individual thermostat controls, local diffusers at individual office. Operable window and its area must meet the requirements of ASHRAE Standard 62.1-2007 for natural ventilation.

Thermal Comfort-Design

To provide a comfortable thermal environment for occupant productivity and well-being, designed HVAC system required for the project. Based on ASHRAE Standard 55-2004, designed HVAC system must comply with the Thermal Environmental Conditions for Human Occupancy. Designed HVAC system considers air temperature, radiant temperature, air speed and relative humidity.

Thermal Comfort-Verification

To ensure the building performance, a permanent monitoring system must be provided to conduct a thermal comfort survey of building occupants within 6 to 18 months after occupancy.

The survey should collect by anonymous occupants about thermal comfort in the building. If overall satisfaction with thermal performance indicates more than 20% of occupants are dissatisfied with thermal comfort in the building, it is complied.

Overall Evaluation of system

Overall existing mechanical system of the CareFirst Cumberland is expensive first construction cost and less cost of operation cost since the geothermal water system can have energy for free. Even though the construction cost of the ground source system is expensive and high maintainability, the system is likely used if the operation cost can payback the first cost. The geothermal water system can handle all loads in the building without using boiler; therefore, the system is generally overdesigned. Geothermal wells for future uses still connect into system, so overdesigned mechanical system will operate with full load capacity. To deliver the desired air temperature and quality, the 45 of heat pump units serve in each thermal zone. However, its refrigerant R-410A has highly potential effect on global warming potential, therefore, the maintainability for leakage of the refrigerant needs to be carefully treated. Indoor air quality issue manages with the filter of MERV-8 on both side of outdoor intake and relief air. However, this rating is minimum rate for the office space can filter only up to mold spore, hair spray, fabric protector, and cement dust. That means humidifier dust, lead dust, auto emissions, milled flour, bacteria, tobacco, and smoke cannot be filtered. For the desire air quality of the space, the filtrations of the mechanical needs to be adjust. The table of MERV filtration system provided in Appendix D. Overall mechanical system of the CareFirst Cumberland is fairly effective mechanical system.

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Project Team

- Owner: CFBC Properties, LLC.
- General Contractor: Carl Belt, Inc., http://www.thebeltgroup.com/
- Architects: VOA Associates, Inc.,http://www.voa.com/
- Civil Engineer: SPECS, Consulting Engineers & Surveyors, http://www.specllc.com/
- MEP Engineer: R.G. Vanderweil Engineers, LLP,http://www.vanderweil.com/
- Structural Engineer: Tadjer Coher Edelson Associates, Inc.,http://www.tadjerco.com/

APPENDIX A

2009 ASHRAE Handbook - Fundamentals (IP)

BALTIMORE BLT-WASHNGTN INT'L, MD, USA WMO#: 724060

Lat: 39.17N Long: 76.68W Elev: 154 StdP: 14.61 Time Zone: -5.00 (NAE) Period: 82-06 WBAN: 93721

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	12.9	17.3	-3.3	4.6	17.8	1.3	5.9	22.1	26.2	31.6	24.2	32.1	8.7	290

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	18.7	93.9	74.9	91.2	74.2	88.5	73.1	78.1	88.6	76.8	86.5	75.6	84.3	10.2	280

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	
75.3	133.3	82.1	74.1	127.9	80.8	73.0	123.1	79.8	41.5	89.1	40.2	86.5	39.1	84.5	723

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
22.4	19.2	17.3	84.6	5.1	98.0	6.3	3.3	0.6	100.3	-3.1	102.2	-6.7	104.0	-11.3	106.4

Monthly Climatic Design Conditions

			Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperatures, Degree-Days and Degree-Hours		Tavg	55.9	33.9	36.9	44.2	54.2	63.6	72.7	77.6	75.7	68.3	56.8	47.3	37.8
		Sd		10.07	8.67	9.29	8.30	7.49	6.31	5.08	5.20	6.95	7.72	8.51	9.29
		HDD50	1726	507	376	231	45	1	0	0	0	0	22	152	392
		HDD65	4567	964	787	649	339	119	12	0	2	45	275	532	843
		CDD50	3861	8	9	50	171	424	680	855	796	550	232	71	15
		CDD65	1228	0	0	4	15	77	242	390	333	145	21	1	0
		CDH74	11317	0	1	42	195	792	2240	3853	2963	1071	148	11	1
		CDH80	4315	0	0	8	57	267	849	1669	1125	317	23	0	0
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB		65.2	69.3	80.0	86.9	90.9	94.6	98.0	96.9	92.6	83.2	75.3	68.5
		MCWB		57.7	56.2	62.2	66.7	71.5	74.5	76.5	75.9	72.8	68.9	63.6	60.2
	2%	DB		59.5	61.4	71.1	79.6	86.8	91.3	94.7	92.6	87.1	78.1	69.8	62.1
		MCWB		54.5	53.5	58.1	63.2	69.3	73.9	75.7	75.0	71.7	66.9	60.2	55.3
	5%	DB		53.0	55.5	64.7	74.1	82.6	88.2	91.8	89.2	83.4	74.0	65.3	56.4
		MCWB		46.8	47.5	54.1	60.3	67.9	73.0	74.9	73.8	70.1	64.3	58.7	51.0
	10%	DB		47.6	50.4	59.4	69.3	78.1	85.1	88.7	86.1	80.2	70.2	61.4	51.6
		MCWB		42.7	44.3	50.1	57.3	65.5	71.8	74.0	72.5	69.0	62.5	55.6	46.1
Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures	0.4%	WB		60.1	60.1	64.6	68.9	74.8	78.8	80.2	79.4	77.0	72.2	66.5	62.1
		MCDB		63.2	66.0	76.5	80.5	86.0	88.3	91.3	90.0	85.0	77.8	70.8	67.1
	2%	WB		55.0	53.7	60.2	65.7	72.1	76.5	78.4	77.5	75.0	69.8	63.5	57.2
		MCDB		58.6	58.7	68.8	75.7	82.8	85.9	89.4	88.0	82.1	75.5	67.9	61.0
	5%	WB		47.9	49.1	55.7	62.4	69.7	75.2	77.2	76.2	73.3	66.6	60.1	52.1
		MCDB		50.9	54.0	62.1	71.4	79.4	84.2	87.6	85.0	79.2	71.9	64.1	55.5
	10%	WB		43.3	45.1	51.5	59.3	67.4	73.7	76.0	74.9	71.7	63.8	56.7	47.0
		MCDB		47.2	50.2	58.5	67.2	75.4	81.7	85.2	82.5	77.2	68.8	60.6	50.6
Mean Daily Temperature Range		MDBR		15.5	16.7	18.4	20.3	20.2	19.6	18.7	18.3	18.6	19.8	18.6	16.0
	5% DB	MCDBR		22.7	24.8	26.8	27.7	26.2	23.2	22.4	21.7	22.1	23.8	23.5	22.7
		MCWBR		17.1	17.3	16.6	14.6	12.2	9.6	8.1	8.3	9.7	13.7	16.1	17.5
	5% WB	MCDBR		20.1	21.3	23.7	24.0	22.7	19.6	19.1	18.6	17.7	19.3	19.6	19.8
		MCWBR		17.2	17.0	16.5	14.0	11.7	9.2	8.2	8.2	9.1	12.5	16.2	17.4
Clear Sky Solar Irradiance		taub		0.319	0.353	0.411	0.417	0.474	0.546	0.552	0.580	0.421	0.370	0.342	0.317
		taud		2.373	2.188	1.997	2.036	1.892	1.746	1.769	1.681	2.164	2.286	2.350	2.446
		Ebn,noon		269	272	266	273	258	239	237	225	261	264	258	262
		Edh,noon		30	40	52	53	62	72	69	74	44	36	31	27

CDDn Cooling degree-days base n°F, °F-day
CDHn Cooling degree-hours base n°F, °F-hour
DB Dry bulb temperature, °F
DP Dew point temperature, °F
Ebn,noon } Clear sky beam normal and diffuse hori-
Edh,noon } zontal irradiances at solar noon, Btu/h/ft2
Elev Elevation, ft
Enth Enthalpy, Btu/lb
HDDn Heating degree-days base n°F, °F-day
Hours 8/4 & 55/69 Number of hours between 8 a.m. and 4 p.m with DB between 55 and 69 °F
HR Humidity ratio, grains of moisture per lb of dry air

Lat Latitude, °
Long Longitude, °
MCDB Mean coincident dry bulb temperature, °F
MCDBR Mean coincident dry bulb temp. range, °F
MCDP Mean coincident dew point temperature, °F
MCWB Mean coincident wet bulb temperature, °F
MCWBR Mean coincident wet bulb temp. range, °F
MCWS Mean coincident wind speed, mph
MDBR Mean dry bulb temp. range, °F
PCWD Prevailing coincident wind direction, °, 0 = North, 90 = East

Period Years used to calculate the design conditions
Sd Standard deviation of daily average temperature, °F
StdP Standard pressure at station elevation, psi
taub Clear sky optical depth for beam irradiance
taud Clear sky optical depth for diffuse irradiance
Tavg Average temperature, °F
Time Zone Hours ahead or behind UTC, and time zone code
WB Wet bulb temperature, °F
WBAN Weather Bureau Army Navy number
WMO# World Meteorological Organization number
WS Wind speed, mph

APPENDIX B

Designed Load (Btu/hr)			
	Cooling		Heating
1st Floor	Envelope	Internal	Total
GXHP-101	7301	15644	659005
GXHP-102	12150	21676	15803
GXHP-103	16097	25264	20986
GXHP-104		38062	17509
GXHP-105	17618	17689	19130
GXHP-106	1459	17553	9724
GXHP-107	19525	16851	16534
GXHP-108	18374	23375	18085
GXHP-109	0	29986	10274
GXHP-110	10871	35991	21770
GXHP-111	15840	42794	27488
GXHP-112	9210	34674	20302
GXHP-113	14477	35391	19326
GXHP-114	991	9471	6234
2nd Floor			
GXHP-201	10023	15801	12458
GXHP-202	1884	41861	20251
GXHP-203	28723	42013	35638
GXHP-204	17168	22248	19805
GXHP-205	1884	41861	20251
GXHP-206	5535	30504	17191
GXHP-207	11673	17621	14678
GXHP-208	0	10699	4756
GXHP-209	0	8515	3748
GXHP-210	1390	31324	15075
GXHP-211	33348	42013	38259
GXHP-212	1390	31324	15075
GXHP-213	2997	6963	5598
GXHP-214	18814	25863	22137
GXHP-215	1428	32006	15436
GXHP-216	332	2201	1169
GXHP-217	0	5350	2378
GXHP-218	0	5350	2378
GXHP-219	641	2747	1431
GXHP-220	18814	27213	22550

GXHP-221	1428	33350	15849
GXHP-222	0	2675	1189
GXHP-223	0	6145	2705
GXHP-224	0	7461	3284
GXHP-225	0	3364	1438
GXHP-226	24024	23178	24746
GXHP-227	25149	22222	24844
GXHP-228	14295	23122	18855
GXHP-229	2084	45860	22268
GXHP-230	1899	42134	20396
GXHP-231	12902	21292	16980
	381738	1038701	1324986
Total Btu/hr		1420439	1324986
Total tons		118.3699167	

APPENDIX C

LEED 2009 for New Construction and Major Renovations

Project Checklist

Project Name

Date

Sustainable Sites — Possible Points: 26

Y	?	N			
Y			Prereq 1	Construction Activity Pollution Prevention	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	5
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Roon	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Ve	3
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1

Water Efficiency — Possible Points: 10

Y	?	N			
Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4

Energy and Atmosphere — Possible Points: 35

Y	?	N			
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
	-		Credit 1	Optimize Energy Performance	1 to 19
	-		Credit 2	On-Site Renewable Energy	1 to 7
	-		Credit 3	Enhanced Commissioning	2
	-		Credit 4	Enhanced Refrigerant Management	2
	-		Credit 5	Measurement and Verification	3
	-		Credit 6	Green Power	2

Materials and Resources — Possible Points: 14

Y	?	N			
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Element	1
			Credit 2	Construction Waste Management	1 to 2
			Credit 3	Materials Reuse	1 to 2

Materials and Resources, Continued

Y	?	N			
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

Indoor Environmental Quality — Possible Points: 15

Y	?	N			
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
	-		Credit 1	Outdoor Air Delivery Monitoring	1
	-		Credit 2	Increased Ventilation	1
	-		Credit 3.1	Construction IAQ Management Plan—During Construction	1
	-		Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
	-		Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
	-		Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
	-		Credit 4.3	Low-Emitting Materials—Flooring Systems	1
	-		Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Product	1
	-		Credit 5	Indoor Chemical and Pollutant Source Control	1
	-		Credit 6.1	Controllability of Systems—Lighting	1
	-		Credit 6.2	Controllability of Systems—Thermal Comfort	1
	-		Credit 7.1	Thermal Comfort—Design	1
	-		Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1

Innovation and Design Process — Possible Points: 6

Y	?	N			
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1

Regional Priority Credits — Possible Points: 4

Y	?	N			
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

APPENDIX D

Minimum Efficiency Reporting Values - MERV ratings				
MERV Value	The filter will trap Average Particle Size Effiency 0.3 - 1.0 Microns	The filter will trap Average Particle Size Effiency 1.0 - 3.0 Microns	The filter will trap Average Particle Size Effiency 3 - 10 Microns	Types of things these filters will trap
MERV 1	-	-	Less than 20%	Pollen, Dust mites, Standing Dust, Spray Paint Dust, Carpet Fibers
MERV 2	-	-	Less than 20%	
MERV 3	-	-	Less than 20%	
MERV 4	-	-	Less than 20%	
MERV 5	-	-	20% - 34%	Mold Spores, Hair Spray, Fabric Protector, Cement dust
MERV 6	-	-	35% - 49%	
MERV 7	-	-	50% - 69%	
MERV 8	-	-	70% - 85%	
MERV 9	-	Less than 50%	85% or better	Humidifier Dust, Lead Dust, Auto Emissions, Milled Flour
MERV 10	-	50% - 64%	85% or better	
MERV 11	-	65% - 79%	85% or better	
MERV 12	-	80% - 89%	90% or better	
MERV 13	Less than 75%	90% or better	90% or better	Bacteria, Most Tobacco, Smoke, Proplet Nuceli (sneeze)
MERV 14	75% - 84%	90% or better	90% or better	
MERV 15	85% - 94%	90% or better	90% or better	
MERV 16	95% or better	90% or better	90% or better	

APPENDIX E

Schematic drawing is attached in last page.