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INTRODUCTION:

The following study will compare the current design for St. Francis Friary with a new design that results in reduced energy consumption and consequently reduced green house gas emissions. Stewardship is a fundamental principal of the client and thus reviewing this option provides an opportunity to build more of their principles into the design of the building. The location of St. Francis Friary is Hanceville, Alabama. Due to the location and climate, the cooling system was identified as being the most significant piece of mechanical equipment that contributes to the overall energy use. The proposed system design which maximizes the use of geothermal heat will be reviewed for comparison against the current central chilled and hot water design. Geothermal heat pumps use the constant temperature of the earth to minimize the energy needed for heat transfer. A redesign that incorporates the use of geothermal heat pumps would benefit the environment by lowering the energy consumption and emissions associated with the heating and cooling system of St. Francis Friary.

CURRENT SYSTEM:

The current mechanical system design is a constant volume four pipe system using a combination of fan coil units and air handling units for zone control. Each temperature control zone has multiple similar use spaces served by a single thermostat. The air systems were very successfully designed to not disrupt the open architecture in some of the more ornate spaces. In the chapel and refectory, the ductwork is installed in the crawl space and floor diffusers are used to eliminate the need for mechanical ductwork within the open ceiling space. The chilled water system consists of a central 125KW air cooled chiller which generates chilled water that is in turn distributed via chilled water pumps throughout the building to each of the fan coils and air handlers. The heating hot water system consists of a central 1,500 mbh gas fired boiler which generates hot water that is distributed via hot water pumps throughout the building to each of the fan coils and air handlers.

RESEARCH ON GEOTHERMAL HEAT PUMPS:

Geothermal heat pumps or geo exchange systems utilize the earth’s ability to maintain a constant temperature throughout all the seasons. In contrast to systems that rely on outdoor air which has a variable temperature, by using heat from the ground in the winter and rejecting heat to the ground in the summer, the temperature difference required to meet the design conditions is lessened. Thus, the mechanical equipment will need to do less work to bring the refrigerant to the proper temperature to heat or cool the air. This allows geothermal heat pumps to provide more comfortable and energy efficient heating and cooling year round.

MODIFIED SYSTEM:

The modified system will consist of geothermal heat pump system with high density polyethylene vertical piping and a Puron refrigerant. The piping will be spaced 10 feet apart and will be fed in and out of wells that go 250 ft below the earth’s surface. The “loop field”, as shown in the construction management report will be located in the southeast quadrant of the site where it will have the least interference with site

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landscaping. As well, should maintenance be required, the southeast corner is out of range of the main views from the site. The new system will require 1(8)ton, (7)5 ton, (1)4 ton,(5)3 ton, (8)2 ton, (7)1 ton heat pumps. This will need to be accounted for when determining the electric savings.

SYSTEM MODELING:

The Trace computer program was used to analyze the current system verses the modified system. The output of the program determines the size of the heat pumps as well as the potential savings in energy consumption when using the heat pump system. From the data received, the energy savings and lowered emissions were calculated.

ASSUMPTIONS:

Weather Data: based on Birmingham, Alabama.

Lighting Load: Incandescent, Hung Below Ceiling, 60% Load to Space

OCCUPANCY (NEC 2005 TABLE 220.12)	
CHURCH	3 VA/ft
DWELLING UNIT	1VA/ft

Activities:

ACTIVITY	
GENERAL OFFICE	143 ft^2/person
LIBRARY	50 ft^2/person

Ventilation:

APPLICATION (TABLE 4-2 OUTDOOR AIR REQUIREMENTS FOR VENTILATION)	
BEDROOM	30 cfm/room
LOBBY	15 cfm/room
OFFICE	20 cfm/room
AUDITORIUM	15 cfm/room

Design Conditions:

COOLING (T_{db})	78 ^{O}F
HEATING (T_{db})	65^{O}F
HUMIDITY RATIO	50%

TRACE OUTPUT

	COOLING	HEATING	AUXILIARY	TOTAL
ORIGINAL	247252.2 KWH/YR	3880 KWH/YR	39208.3 KWH/YR	290340.5 KWH/YR
REDESIGN	164843.7 KWH/YR	9605.7 KWH/YR	0 KWH/YR	174449.4 KWH/YR
			ENERGY SAVINGS	40 PERCENT

Based upon the output from the program, the energy consumption of the system is decreased by 40 percent each year.

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EMISSIONS:

The emissions of the original design and the redesign were calculated using the National Renewable Energy Laboratory, Source Energy and Emission Factor for Buildings. Calculations are based on a yearly output.

Table 3 Total Emission Factors for Delivered Electricity
(lb of pollutant per kWh of electricity)

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

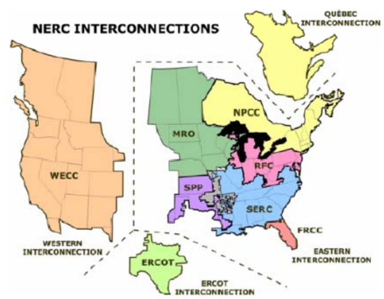

Table 8 Emission Factors for On-Site Combustion in a Commercial Boiler
(lb of pollutant per unit of fuel)

Pollutant (lb)	Commercial Boiler					
	Bituminous Coal *	Lignite Coal **	Natural Gas	Residual Fuel Oil	Distillate Fuel Oil	LPG
	1000 lb	1000 lb	1000 ft^3 ***	1000 gal	1000 gal	1000 gal
CO_{2e}	2.74E+03	2.30E+03	1.23E+02	2.56E+04	2.28E+04	1.35E+04
CO_2	2.63E+03	2.30E+03	1.22E+02	2.55E+04	2.28E+04	1.32E+04
CH_4	1.15E-01	2.00E-02	2.50E-03	2.31E-01	2.32E-01	2.17E-01
N_2O	3.68E-01	ND †	2.50E-03	1.18E-01	1.19E-01	9.77E-01
NO_X	5.75E+00	5.97E+00	1.11E-01	6.41E+00	2.15E+01	1.57E+01
SO_X	1.66E+00	1.29E+01	6.32E-04	4.00E+01	3.41E+01	0.00E+00
CO	2.89E+00	4.05E-03	9.33E-02	5.34E+00	5.41E+00	2.17E+00
VOC	ND †	ND †	6.13E-03	3.63E-01	2.17E-01	3.80E-01
Lead	1.79E-03	6.86E-02	5.00E-07	1.51E-06	ND †	ND †
Mercury	6.54E-04	6.54E-04	2.60E-07	1.13E-07	ND †	ND †
PM10	2.00E+00	ND †	8.40E-03	4.64E+00	1.88E+00	4.89E-01

* from the U.S. LCI data module: Bituminous Coal Combustion in an Industrial Boiler (NREL 2005)
** from the U.S. LCI data module: Lignite Coal Combustion in an Industrial Boiler (NREL 2005)
*** Gas volume at 60°F and 14.70 psia.
† no data available

EMISSIONS COMPARISON FOR MECHANICAL SYSTEM CURRENT AND REDESIGN

ORIGINAL	290340.5	kWh
REDESIGN	174449.4	kWh

ORIGINAL	1413	ft^3
REDESIGN	0	ft^3

	ELECTRICTICY DELIVERED		FUEL COMBUSTION		TOTAL		CHANGE
POLLUTANT(LB)	ORIGINAL	REDESIGN	ORIGINAL	REDESIGN	ORIGINAL	REDESIGN	%
CO_{2e}	505192.47	303541.956	17.3799	0	505209.8499	303541.956	-60.082351
CO_2	476158.42	286097.016	3.2499	0	476161.6699	286097.016	-60.084008
CH_4	1042.322395	626.273346	3.5325	0	1045.854895	626.273346	-59.881476
N_2O	11.23617735	6.75119178	3.5325	0	14.76867735	6.75119178	-45.712907
N_{ox}	871.0215	523.3482	156.843	0	1027.8645	523.3482	-50.916069
S_{ox}	2488.218085	1495.031358	0.893016	0	2489.111101	1495.031358	-60.062862
CO	245.3377225	147.409743	0	0	245.3377225	147.409743	-60.084418
VOC	0	0	131.8329	0	131.8329	0	0
TNMOC	18.72696225	11.2519863	0	0	18.72696225	11.2519863	-60.084418
Lead	0.009813509	0.00589639	0.0007065	0	0.010520009	0.00589639	-56.049285
Mercury	0.008855385	0.005320707	0.00036738	0	0.009222765	0.005320707	-57.691013
PM10	26.9435984	16.18890432	11.8692	0	38.8127984	16.18890432	-41.710222
Solid Waste	59519.8025	35762.127	0	0	59519.8025	35762.127	-60.084418

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COST SAVINGS

	ENERGY CONSUMPTION	UTILITY RATE	TOTAL COST/YR
Current System	290340.5 KWh/yr	$0.08921/KWh	$25,901.27
Redesign	174449.4KWh/yr	$0.08921/KWh	$15,562.63
		SAVINGS	$10,338.64

CONCLUSION:

The current system designed for the St. Francis Friary is a good design. It serves different zones and because it is a four pipe system, it allows for variable heating and cooling control throughout the building. The proposed system, as shown above may have some advantages above the designed system. Geothermal systems utilize the earth's pure resources in order to serve the building with its heating and cooling needs. Because of the use of the natural steady temperature below the earth's surface, mechanical equipment can be downsized and some pieces taken out completely. This allows for a more energy efficient design and as a result savings on energy bills. The most important impact of the new design, however, is the minimization of the impact on the environment. Because the energy use is being reduced, the emissions from the power plant are lower. As well, this can be seen locally because of the elimination of the gas fired boiler from the project scope, reducing the emissions from equipment on the site itself.