HVAC System

Background:

In the United States, buildings consume about 40% of our primary energy. While lighting and electricity usage are a part of this energy use, a sizable portion is dedicated to heating, ventilation, and air conditioning systems. Compounding the dilemma is the fact that most HVAC systems use fossil fuel energy, which is non-renewable and expected to reach a roll-over point this century. Ideally, buildings should strive to use only as much or less energy as they are able to produce. This "energy neutrality" involves a systems approach that also considers passive design techniques, solar design, and improved building envelope design. However, HVAC systems remain a requirement and must be engineered to maximize efficiency. The goals of a well-design HVAC system are:

1. Maintain thermal comfort
2. Provide ventilation
3. Minimize energy use

Thermal comfort entails not just temperature but also humidity. Too dry an environment can cause respiratory complications and dry skin, as well as cause shrinkage and cracking in the building materials. Too wet an environment leads to the growth of mold and bacteria, excessive condensation, and can provide a breeding ground for insects and pests. A range of 30% – 50% is acceptable, with about 45% being ideal. Temperatures which are too high, combined with lack of ventilation, have been shown to raise the incident of illnesses over 70%. A temperature of 68 degrees is believed to be the ideal for comfort and minimizing the spread of disease.

Proper ventilation is required to maintain a high level of indoor environmental air quality. The replacement of stale, conditioned air with fresh outside air can reduce diseases and contaminants and control odor. Ventilation requirements are defined for buildings in the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) standard 62.1. LEED points require ventilation rates 30% higher than ASHRAE standards.

Finally, any HVAC system must accomplish its goal with the minimum energy use possible. As was mentioned, HVAC systems use large quantities of energy which are currently supplied by fossil fuels. This practice also causes large carbon dioxide emissions and furthers our reliance on non-renewable, non-local energy resources.

There are numerous methods to aid in a sustainable energy design for buildings. For new construction, a building energy simulation can be conducted using software available from the US Department of Energy. The most popular and easy to use programs, EnergyPlus 3.1 and eQUEST, are available on the internet and provide designers with advanced tools to model building energy use. Crucial to HVAC design is the performance of the thermal envelope of the building. This aspect will be discussed in another area of this report. It is also important to understand and minimize internal loads on the HVAC system. In a cooling environment, these can include anything which brings excessive heat into the building, such as electronic equipment, cooking facilities, or the occupants themselves. An HVAC system which integrates the use on on-site renewable energy is also a big step towards sustainability. Finally, building owners must understand life-cycle costing. While highly efficient HVAC systems can be a larger up-front cost, their energy savings over the life of the building can easily result in net-present value savings.

HVAC Considerations for the Chapel:

The Chapel at Summit and 16th was designed in 1954. As this is an older, existing structure, we must work within the bounds of the current location and envelope design. Strategies for renovating the building envelope will be discussed in a separate section.

It has been noted by current occupants that in the past, this chapel provided poor thermal comfort. It was excessively hot in the summer, and cold in the winter. It will now be occupied as a community computer laboratory, with approximately two dozen computer stations. As such, there will be large thermal loads from the occupants and computers. Also important to note is the necessity for high indoor environmental quality, with numerous members of the community circulating through the room.

Ventilation strategies can be active or passive. In an active strategy, the HVAC components themselves will be designed to allow the appropriate circulation of fresh air through the space. This will be required in the winter when it is unfeasible to keep doors and windows open. It is also advisable to install a CO_2 sensor in the room to ensure that the ventilation system is working properly. In a passive ventilation strategy, adequate openings should be available to naturally circulate fresh air through the room. ASHRAE 62.1 states that openings should compose 4% of the total occupiable area. In this case, with a room of 1000 square feet, we should ensure at least 40 square feet of openings are available. With two doors at opposite ends of the chapel, and 4 windows along the east wall, passive ventilation can easily be achieved when the outside temperature is appropriate.

There is currently no renewable energy available on the site, but there is great potential for the installation of solar panels.

An energy efficient HVAC system should harvest waste energy through an energy recovery ventilator which transfers heat energy and humidity from exhaust to fresh air. Another HVAC strategy to achieve energy efficiency is an economizer, which uses outdoor air for mechanical ventilation to replace conditioned air when ambient temperatures are within a comfortable range.

Existing HVAC Elements:

The chapel currently uses radiant base-board heating, and is supplemented by a roof-mounted HVAC unit on the northern wall. This baseboard heating relies on the building's central heating system, but is inefficient because heat will have a tendency to rise along the walls and gather at the vaulted ceiling rather than provide the occupants comfort. It also has no provisions to control ventilation or humidity levels. The roof mounted HVAC unit seems to be a patch on an inadequate system, and most likely operates at very low efficiency. It is unknown whether this unit is able to address ventilation or humidity concerns. The unit also lacks duct work to adequately circulate the air through the room. The supply vent is located near ceiling level, and the return vent is located adjacent to the supply vent.

It is important to note that the room has ceiling fans, and to ensure that these are being operated appropriately. According to a website source: "In a room with a 16' cathedral ceiling and the thermostat set at 68 degrees F, the uppermost 3 feet can be 90 degrees or higher before the heater shuts off." Ceiling fans can be used to counteract this effect by setting them in reverse and operating them continuously at low speed. This will cause a mild circulation of the air down to floor level, where it will rise again. The low speed is recommended to avoid drafts. During summer months, ceiling fans can be used in their normal downward setting to give occupants a chilling effect from the draft and resulting sweat evaporation on the skin. It should be noted though that the fans will serve no purpose in cooling the room, and should be shut off when the room is not occupied. Depending on the HVAC design, it may actually be best not to run fans in the summer if a higher ceiling provides an insulating layer between the cool lower air and a hot roof.

HVAC Recommendations:

Budget HVAC Renovation: Utilize natural ventilation whenever outside temperature is appropriate. Operate ceiling fans according to above guidelines, in conjunction with baseboard heaters to provide winter heat. Roof-mounted HVAC unit should have duct-work installed to disperse air evenly through the room. The easiest method would be to install hanging ductwork down the length of the chapel ceiling. However, this may be unsightly. A more complex ductwork installation could route the ductwork down from the HVAC supply vent and through the floor to the crawl space, where it can be routed back up from multiple registers. Care should be taken to minimize restriction of airflow through the ductwork to ensure fan efficiency. Estimated cost: $0-$5000. Quote for ductwork can be obtained through Mike Hassan of Speer Mechanical, (o) 614-261-6331, (c) 614-402-8104, http://www.speermechanical.com/

Recommended HVAC Renovation: Remove baseboard heaters and replace with an in-floor radiant heating system. In-floor radiant heating will greatly improve energy efficiency as well as occupant comfort. ASHRAE led studies have concluded that radiant heating can provide comfort at temperatures 6-8 degrees lower than convective (forced air) heat. With a 65 degree daytime temperature and 59 degree nighttime setback, heat load can be reduced by 25% to 35%. For added environmental benefits, the radiant heating system can be coupled with a roof-mounted solar hot-water heater, resulting in a truly green heating system. More information is available at: http://www.radiantsolar.com/index.php, http://www.radiantec.com/. Estimated cost: $5,000-10,000.

Wish-List Green Renovation: Replace all existing HVAC systems with a geothermal vertical well system. This approach, utilized in the LEED certified 4H building on Ohio State's campus, circulates water deep within the earth and returns it at a constant 55-60 degrees. Minimal additional energy is required to supplement this source to reach comfortable temperatures year round. For added environmental benefit, install roof-mounted photovoltaic panels to supplement the system. Estimated cost: $20,000-40,000.

Low Cost/ Low Energy Pumping systems: Low cost/Low energy pumping systems are more efficient designs to pump water through air handlers. Most traditional systems use three way valves which results in full water flow at all times, regardless of how much heat or cooling is needed. Instead, using a two way valve together with a primary only pumping system with variable flow through the boilers and/or chillers allows much energy to be saved because it only uses what is needed by demand. This design will also eliminate the use of all secondary pumping as well as cut down the amount of pumps that are needed.

Price: $2,000 - $4,000

Radiant Heating and Cooling: Radiant Heating and Cooling involves supplying heat or cooling to a space directly through the floors, walls or ceilings. One of the main advantages is that there is almost no energy lost because the heat travels directly to the people and objects in the building rather than through ductwork and air. This can also be an advantage to people who have allergies because there is less air moving around the space and therefore less that the air could carry to cause you to have a reaction. This may be installed directly into a slab on grade, or in a slab that is directly on a wood flooring sub-base. This is eco friendly because the heat gets transferred directly to the person in the room instead of the whole area, therefore not wasting energy on room that is not occupied. However this method does rely hard on convection to move the heat around the whole room.

Price: $2-$6 per square foot

Lighting

In the church in which we are conducting the energy audit, improvements to the lighting system have already been made as part of the electrical upgrades to the room. This included removal of the outdated lighting system, and installation of a new, more energy efficient fluorescent lights. However, in addition to the upgrades that are currently installed, there are also more ways to improve the energy efficiency of the room.

Starting with the existing fluorescent lights, there are options to reduce operating costs by limiting how long the lamps are on, as well as how bright they are. Sunlight sensors can be installed which are able to dim the lights or shut them off if there is enough natural light entering the room. This helps to reduce energy costs even if the lights have to be on because they are not on all the way. Another option for reducing energy costs in this manner is to install occupancy sensors that detect if there is anyone using the room. There is the possibility that someone may leave the room and forget to turn out the lights, and these sensors would help to reduce energy costs in that situation. These sensors can be manually overridden if necessary. The installation costs for occupancy sensors range from $20 to $80, depending upon the type of sensor and its features. Installation can be done by the church maintenance or by a licensed electrician for approximately $25 per sensor.

Although at this time it may not be an option, skylights could be considered to help cut down on lighting costs. These can work in conjunction with the sunlight sensors, and would help to keep artificial light levels very low. The skylights help to let in up to 30 percent more light than vertical windows, and would greatly increase the amount of light in the chapel considering the small area of existing windows. Skylights that have built-in blinds should be considered for this application because they have the ability to regulate that amount of light that enters into the room, and they would help to prevent glare in the room and on the computer screens by re-directing the light. The orientation of the chapel roof is ideal for using skylights since the sloped sides of the roof face to the east and the west, which would allow the skylights to let in the morning sun as well as the evening sun. Professional installation for one skylight is estimated to be $600, and in order to optimize efficiency, at least 4 sky lights should be considered.

As advances in lighting technology are made, more options will become available to make the room more energy efficient when the lights must be on. LED lighting fixtures are beginning to become more popular as advances in super bright LEDs are made, and the costs of bulbs are slowly decreasing. LED bulbs have many advantages to both incandescent and fluorescent bulbs, with cost and light output currently being the limiting factors. LED bulbs last up to 30 times longer than comparable incandescent bulbs, and they last up to 6 times longer than compact fluorescent bulbs. They can stand on-off cycles much better than fluorescents, which would be an advantage in an environment in which lights were controlled by sensors and subject to frequent cycles. Also, unlike fluorescents, LEDs do not contain any hazardous chemicals such as mercury. Currently, an LED bulb retails for $10 to $40 depending upon light output. There are no options for replacements for the large area fluorescent bulbs yet, but the options will surely become available in the coming years.

As this is a non-profit organization, it is important that funding be secured for improvements though incentives and grants. An option in Ohio for non-profits, as well as other sectors such as Commercial, Industrial, Government, and Institutions is the AEP-Ohio Utility Rebate Program. This program provides funding for new lighting systems, as well as controls and sensors. Rebates are provided based upon number of efficient fixtures, as well as the amount of kilowatts conserved. The amount of the rebate ranges from $1 to $60 for fixtures and from $90 to $400 per kilowatt conserved. The funding can cover as much as 50 percent of the total lighting upgrade costs. The requirements for this rebate is that the eligible lamps and ballasts are listed on the Consortium for Energy Efficiency (CEE) website, and that AEP has the right to inspect the project to insure it meets their standards. Their office is located right here in Columbus, OH which would make contact for securing the rebate quick and easy.

<u>**Building Envelope**</u>

Windows:

Bob Briggeman from the Home Improvement division of Rosati windows came to the church to investigate all the windows of the chapel area. He concluded:

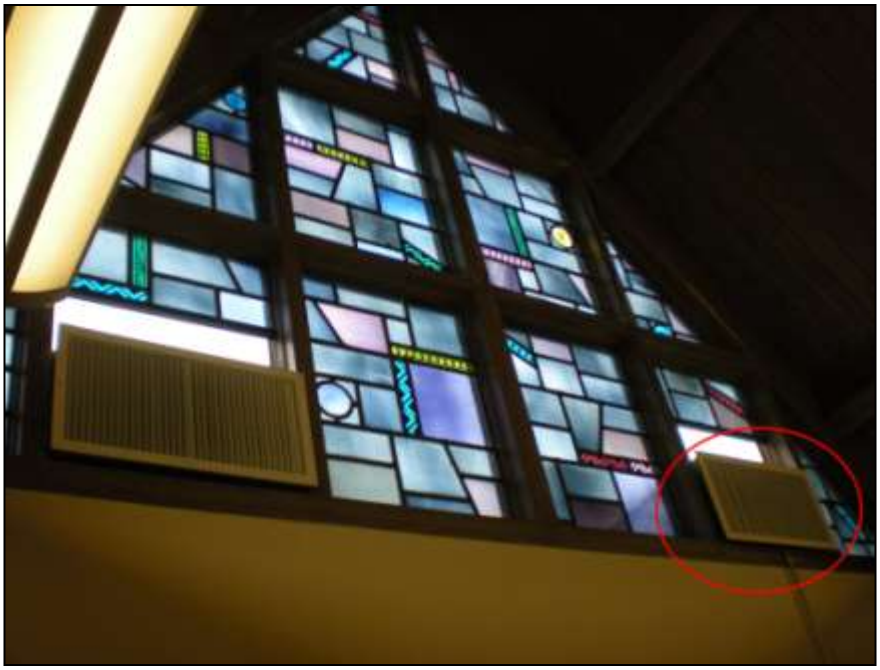
"After inspection of the windows on the east side of the "sanctuary" and the north side of the "sanctuary" I did not see any reason to replace the existing storm windows. In my opinion, the only solution to increase their efficiency would be to completely replace the window with an insulated window. If I can do anything else for you please do not hesitate to reach me."

He recommended if the church wanted to replace the windows, another professional from Rosati could give a free consultation to the church. This consultation could show how much energy could be saved each month if the church replaced the windows.

The concrete framing around the windows could use caulking (concrete framing is shown in the picture below). There is air leaking between the concrete frame and the wall. The energy auditor, Ember Bosart, recommended using Poly Seam Seal Adhesive Caulking which adheres to concrete and has good reviews online. This can be found at Lowes.

Concrete Frame around three windows.

A form of a Polyfoam should be used around the air exhaust vent/unit and the window on the north face of the church (see the picture below). There was a large air leak around the air exhaust vent during the blower test the Energy Auditor performed. Lowes recommended taking a picture of the area and they would provide a more accurate recommendation. Aerosol Foam could be used, but it is difficult to control.



Air Exhaust Vent on North face of church.

Options and Cost:

1.) Not replace the windows, because they are in great condition.

2.) Caulking around the concrete window frame and Air Exhaust Unit. The Poly Seam Seal Adhesive Caulking covers approximately 40'-45' and cost about $5 a tube. I estimate that two tubes would be needed for the concrete window frame. The Polyfoam is slightly more expensive, but it is recommended to take photos into Lowes to get assistance for the optimum insulation.
The caulking project will cost under $15 and provide more insulation for the chapel. The foam insulation around the air exhaust unit will not cost more than $20.

3.) Install new, 85% sun penetration (low-e), double pane, insulted argon gas between panes (6x more dense than air, better insulator and reduces noise), and highly energy efficient windows. Bob gave an estimate that each window would cost $560 each to replace. He stressed a free consultation with an expert to give a more accurate cost
A rough estimate for upgrading the church chapel with new windows (excluding the windows on the north face) would cost $5100.

The Roof:

Photovoltaic Solar Panels were considered for the church's roof. Photovoltaic panels use the sun's light and converts it into electricity. This electricity is free energy supplied to the church to use and reduce their electric bill each month. If too much electricity is generated, it can possibly be sold back to the power company.

After investigating various Photovoltaic manufactures and distributors, the National Photovoltaic Construction Partnership (NPCP) in junction with SHARP as the manufacture was the most helpful. They provided amazing help for determining what would fit for the church. Using Google Earth, they created a rough idea of how much roof area the church (not just the chapel) had available. NPCP accounted for shading and other obstacles on the roof. They provided three thorough photovoltaic approaches to reduce the monthly electricity bill by 17%, 50%, and near 100%. Chris Knight at NPCP said:

"How much will electricity be in 10 years? It's a scary thought, but in our experience Utility costs increase roughly 5% per year. This means that your solar system actually becomes more economically efficient year after year. Considering the modules have a warrantee for 25 years - solar becomes very attractive because not only does it have its environmental benefits, but it is a hedge against future electrical increases".

The NPCP also will walk the church through government rebates and tax credits. Rees at NPCP made it clear that these tax rebates are not around forever, and he said California's rebates for solar just expired. If done correctly, the church could get close to 50% reduced from the total bill for Photovoltaic Panels (that includes installation). NPCP will do this for the church and find an IBEW (International Brotherhood of Electrical Workers) certified contractor to install and maintain the panels.

Benefits for using Photovoltaic Panels:

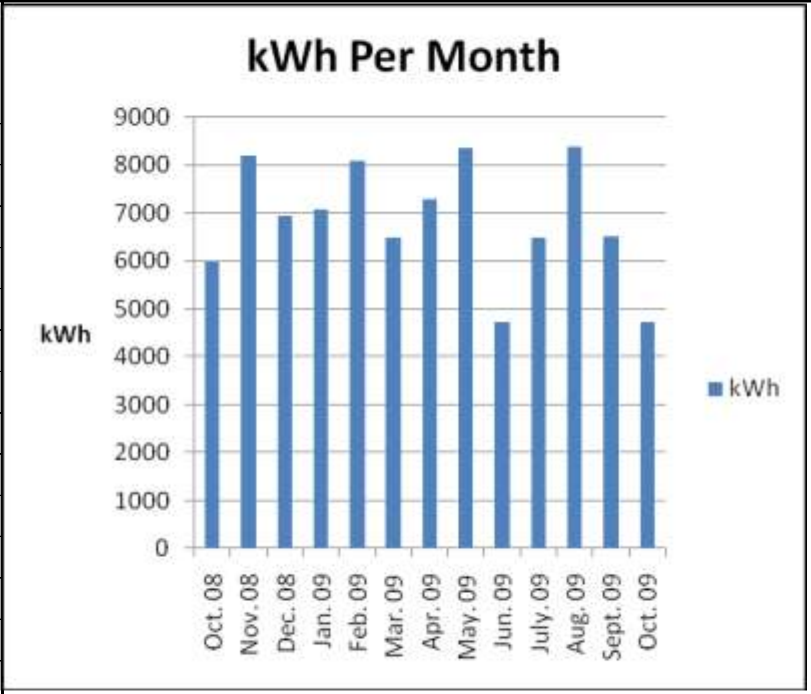
1.) Generates free, renewable energy
2.) Can use the panels as a teaching tool for the community
3.) As the price of energy increases, the Photovoltaic panels will increase in value
4.) Adding Photovoltaic panels instantly increases the value of the church
5.) There is potential to actually sell electricity back to the power company
6.) Currently the solar benefits offered by the government in Ohio cover close to 50% of the total cost
7.) They have a 25 year life warrantee with minimum maintenance
8.) Generally pays for itself in under 11 years.

Options and Cost:

Please contact Kevin Giriunas at giriunas.1@osu.edu for a detailed description for options and costs.

Summit United Methodist Church

Months	kWh	Monthly Cost (dollars)
Oct. 08	5980	693.68
Nov. 08	8200	951.20
Dec. 08	6940	805.04
Jan. 09	7080	821.28
Feb. 09	8080	937.28
Mar. 09	6480	751.68
Apr. 09	7280	844.48
May. 09	8360	969.76
Jun. 09	4720	547.52
July. 09	6480	751.68
Aug. 09	8380	972.08
Sept. 09	6500	754.00
Oct. 09	4720	547.52
Average	6861.54	804.46
Lowest	4720	547.52
Highest	8380	972.08
Total Average per year	82338.46	9653.52
Actual Total per year	89200	9653.52



Assumptions

1.) 11.6 cents per kWh

2.)Electricity increases by 4% in cost each year

3.) There is a 80% efficiency between converting DC (solar) to AC (church electricity)

4.) Assume panels see a yearly average of 4.6 hours of sun a day for Ohio

Option 1

~ 17% Reduction in Monthly Electric Bill with 4% increase per year

Dollar System Cost (after benefits)	21622										Begin Profit	
Year	1	2	3	4	5	6	7	8	9	10	11	12
Elect. Cost (cents/kWh)	11.60	12.06	12.55	13.05	13.57	14.11	14.68	15.26	15.88	16.51	17.17	17.86
kWh generated from Solar Panels per year	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59
Dollar Amount Saved per year from Panels	1604.23	1668.40	1735.14	1804.54	1876.72	1951.79	2029.87	2111.06	2195.50	2283.32	2374.66	2469.64
Dollar Sum of Savings	1604.23	3272.63	5007.77	6812.31	8689.04	10640.83	12670.70	14781.76	16977.26	19260.58	21635.24	24104.88
Dollar Profit	-20017.77	-18349.37	-16614.23	-14809.69	-12932.96	-10981.17	-8951.30	-6840.24	-4644.74	-2361.42	13.24	2482.88

Year	13	14	15	16	17	18	19	20	21	22	23	24	25
Cost (cents/kWh)	18.57	19.31	20.09	20.89	21.73	22.60	23.50	24.44	25.42	26.43	27.49	28.59	29.73
kWh generated from Panels per year	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59
Dollar Amount Saved per year	2568.43	2671.16	2778.01	2889.13	3004.70	3124.88	3249.88	3379.88	3515.07	3655.67	3801.90	3953.98	4112.13
Dollar Sum of Savings	26673.31	29344.47	32122.48	35011.61	38016.31	41141.19	44391.07	47770.95	51286.02	54941.69	58743.59	62697.57	66809.70
Dollar Profit	5051.31	7722.47	10500.48	13389.61	16394.31	19519.19	22769.07	26148.95	29664.02	33319.69	37121.59	41075.57	45187.70

Option 1	**~ 17% Reduction in Monthly Electric Bill with electricity bill staying at 11.6 cents/kWh**												
Year	1	2	3	4	5	6	7	8	9	10	11	12	
Elect. Cost (cents/kWh)	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	
kWh generated from Solar Panels per year	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	
Dollar Amount Saved per year from Panels	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	
Dollar Sum of Savings	1604.23	3208.46	4812.70	6416.93	8021.16	9625.39	11229.62	12833.86	14438.09	16042.32	17646.55	19250.79	
Dollar Profit	-20017.77	-18413.54	-16809.30	-15205.07	-13600.84	-11996.61	-10392.38	-8788.14	-7183.91	-5579.68	-3975.45	-2371.21	
		Begin Profit											
Year	13	14	15	16	17	18	19	20	21	22	23	24	25
Cost (cents/kWh)	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60
kWh generated from Panels per year	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59	13829.59
Dollar Amount Saved per year	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23	1604.23
Dollar Sum of Savings	20855.02	22459.25	24063.48	25667.71	27271.95	28876.18	30480.41	32084.64	33688.87	35293.11	36897.34	38501.57	40105.80
Dollar Profit	-766.98	837.25	2441.48	4045.71	5649.95	7254.18	8858.41	10462.64	12066.87	13671.11	15275.34	16879.57	18483.80

Option 2	**~ 50% Reduction in Monthly Electric Bill with a 4% increase per year**											
Dollar System Cost (after benefits)	64864.8									Begin Profit		
Year	1	2	3	4	5	6	7	8	9	10	11	12
Elect. Cost (cents/kWh)	11.60	12.06	12.55	13.05	13.57	14.11	14.68	15.26	15.88	16.51	17.17	17.86
kWh generated from Solar Panels per year	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76
Dollar Amount Saved per year from Panels	4812.70	5005.20	5205.41	5413.63	5630.17	5855.38	6089.60	6333.18	6586.51	6849.97	7123.97	7408.92
Dollar Sum of Savings	4812.70	9817.90	15023.31	20436.94	26067.12	31922.50	38012.09	44345.27	50931.78	57781.75	64905.71	72314.64
Dollar Profit	-60052.10	-55046.90	-49841.49	-44427.86	-38797.68	-32942.30	-26852.71	-20519.53	-13933.02	-7083.05	40.91	7449.84

Year	13	14	15	16	17	18	19	20	21	22	23	24	25
Cost (cents/kWh)	18.57	19.31	20.09	20.89	21.73	22.60	23.50	24.44	25.42	26.43	27.49	28.59	29.73
kWh generated from Panels per year	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76
Dollar Amount Saved per year	7705.28	8013.49	8334.03	8667.39	9014.09	9374.65	9749.64	10139.63	10545.21	10967.02	11405.70	11861.93	12336.40
Dollar Sum of Savings	80019.92	88033.41	96367.45	105034.84	114048.93	123423.58	133173.22	143312.85	153858.06	164825.08	176230.78	188092.71	200429.11
Dollar Profit	15155.12	23168.61	31502.65	40170.04	49184.13	58558.78	68308.42	78448.05	88993.26	99960.28	111365.98	123227.91	135564.31

Option 2	**~ 50% Reduction in Monthly Electric Bill with electricity bill staying at 11.6 cents/kWh**												
Dollar System Cost (after benefits)	64864.8												
Year	1	2	3	4	5	6	7	8	9	10	11	12	
Elect. Cost (cents/kWh)	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	
kWh generated from Solar Panels per year	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	
Dollar Amount Saved per year from Panels	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	
Dollar Sum of Savings	4812.70	9625.39	14438.09	19250.79	24063.48	28876.18	33688.87	38501.57	43314.27	48126.96	52939.66	57752.36	
Dollar Profit	-60052.10	-55239.41	-50426.71	-45614.01	-40801.32	-35988.62	-31175.93	-26363.23	-21550.53	-16737.84	-11925.14	-7112.44	
		Begin Profit											
Year	13	14	15	16	17	18	19	20	21	22	23	24	25
Cost (cents/kWh)	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60
kWh generated from Panels per year	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76	41488.76
Dollar Amount Saved per year	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70	4812.70
Dollar Sum of Savings	62565.05	67377.75	72190.45	77003.14	81815.84	86628.53	91441.23	96253.93	101066.62	105879.32	110692.02	115504.71	120317.41
Dollar Profit	-2299.75	2512.95	7325.65	12138.34	16951.04	21763.73	26576.43	31389.13	36201.82	41014.52	45827.22	50639.91	55452.61

Option 3	**~ 100% Reduction in Monthly Electric Bill with a 4% increase per year**												
Dollar System Cost (after benefits)	129730										Begin Profit		
Year	1	2	3	4	5	6	7	8	9	10	11	12	
Elect. Cost (cents/kWh)	11.60	12.06	12.55	13.05	13.57	14.11	14.68	15.26	15.88	16.51	17.17	17.86	
kWh generated from Solar Panels per year	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	
Dollar Amount Saved per year from Panels	9625.39	10010.41	10410.82	10827.26	11260.35	11710.76	12179.19	12666.36	13173.01	13699.94	14247.93	14817.85	
Dollar Sum of Savings	9625.39	19635.80	30046.63	40873.88	52134.23	63844.99	76024.19	88690.55	101863.56	115563.50	129811.43	144629.28	
Dollar Profit	-120104.61	-110094.20	-99683.37	-88856.12	-77595.77	-65885.01	-53705.81	-41039.45	-27866.44	-14166.50	81.43	14899.28	
Year	13	14	15	16	17	18	19	20	21	22	23	24	25
Cost (cents/kWh)	18.57	19.31	20.09	20.89	21.73	22.60	23.50	24.44	25.42	26.43	27.49	28.59	29.73
kWh generated from Panels per year	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52
Dollar Amount Saved per year	15410.56	16026.99	16668.07	17334.79	18028.18	18749.31	19499.28	20279.25	21090.42	21934.04	22811.40	23723.85	24672.81
Dollar Sum of Savings	160039.84	176066.83	192734.89	210069.68	228097.86	246847.17	266346.45	286625.70	307716.12	329650.16	352461.56	376185.41	400858.22
Dollar Profit	30309.84	46336.83	63004.89	80339.68	98367.86	117117.17	136616.45	156895.70	177986.12	199920.16	222731.56	246455.41	271128.22

Option 3	~ 100% Reduction in Monthly Electric Bill with electricity bill staying at 11.6 cents/kWh												
Dollar System Cost (after benefits)	129730												
Year	1	2	3	4	5	6	7	8	9	10	11	12	
Elect. Cost (cents/kWh)	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	
kWh generated from Solar Panels per year	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	
Dollar Amount Saved per year from Panels	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	
Dollar Sum of Savings	9625.39	19250.79	28876.18	38501.57	48126.96	57752.36	67377.75	77003.14	86628.53	96253.93	105879.32	115504.71	
Dollar Profit	-120104.61	-110479.21	-100853.82	-91228.43	-81603.04	-71977.64	-62352.25	-52726.86	-43101.47	-33476.07	-23850.68	-14225.29	
		Begin Profit											
Year	13	14	15	16	17	18	19	20	21	22	23	24	25
Cost (cents/kWh)	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60	11.60
kWh generated from Panels per year	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52	82977.52
Dollar Amount Saved per year	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39	9625.39
Dollar Sum of Savings	125130.10	134755.50	144380.89	154006.28	163631.68	173257.07	182882.46	192507.85	202133.25	211758.64	221384.03	231009.42	240634.82
Dollar Profit	-4599.90	5025.50	14650.89	24276.28	33901.68	43527.07	53152.46	62777.85	72403.25	82028.64	91654.03	101279.42	110904.82

Interior

The main focuses when coming up with ideas to upgrade the interior of the chapel were indoor air quality and reducing, reusing and recycling energy and materials. Currently, the chapel has several computers with CRT (Cathode Ray Tube) monitors, which use more energy than newer LCD monitors. There is also a vinyl floor and the walls are painted white. Three small ceiling fans hang along the room and most of the furniture and carpet is reused. The following proposal for this interior space will present both low cost and high cost alternatives for the improvement of indoor air quality and the reduction of energy and materials that are consumed during the use of the chapel.

A high budget improvement that would reduce the amount of energy used and save money over time is the replacement of all of the CRT computer monitors with new LCD monitors. A 17" LCD monitor only uses 35 watts of energy compared to 80 watts used by a 17" CRT monitor. Assuming energy costs 11 cents per kilowatt-hour and that the computers run 12 hours per day and 6 days per week, the LCD monitors will save approximately $20 per computer every year. New LCD monitors can be found at Best Buy for $119.99 per monitor. In order to reduce the waste associated with replacing old monitors, the CRT monitors can be donated to Free Geek. Free Geek will find new owners for working monitors and recycle non-working monitors.

Another way to reduce energy cost is to replace the three existing smaller fans with new 60 inch diameter fans. According to the Energy Star website, a good way to estimate the size and amount of fans needed is to divide the area of the room by 4. Using this method, it can be determined that a room the size of the chapel (1000 square feet) would need four-62.5 inch diameter fans. Since manufacturers do not often make fans with a 62.5 inch diameter, the needed diameter can be rounded down to 60 inches. Farrey's has a collection of fans called the "Heat Fan 60 inch Collection" that have been specially designed for large, tall areas similar to the chapel and for both cooling and warming rooms. These fans cost about $178, which adds up to $712 for four fans. These fans will help pull warm air down from the tall ceiling in the chapel in the winter and cool the area in the summer, reducing the energy costs associated with the heating and cooling system.

Another high budget improvement that would benefit those using the chapel in both aesthetic ways and through indoor air quality improvement is the replacement of the flooring. The current vinyl flooring system was produced using vinyl chloride, a known carcinogen. This material off gases chloride fumes which are then inhaled by the users of the chapel and can cause respiratory issues, vision and hearing issues, and can even cause cancer. A more environmentally friendly flooring material available is bamboo. Bamboo is a resource that is quickly and easily renewed while having a similar appearance to wood flooring. Bamboo flooring can be found at www.123bamboo.com for $1.80/sf - $2.50/sf depending on color and type of installation. One of the options offered is "Quick Click" flooring that can be self installed without the use of glue. This type of installation would be very beneficial to the indoor air quality of the chapel since there will be no toxins or VOCs released from the glue. If it is decided that the chapel should have new floors, there are very few recycling programs for vinyl in the United States. However, if the flooring is taken out in large pieces without damage, it could be donated to a reuse center such as the Salvation Army or to one of Habitat for Humanity's Restore stores.

A cheaper alternative to flooring improvement is to purchase area rugs made from natural fibers and renewable materials. Naturalarearugs.com offers a variety of area rugs made from materials such as bamboo, different types of grasses, Sisal Plant, and wool. Prices range from

$29.00 - $999.00 depending on size and material selection. There is an existing area rug in the chapel that can be reused within the chapel among the new area rugs or taken to a Carpet America Recovery Effort (CARE) drop off location. The contact for CARE in the Columbus, Ohio area is Bruce Moore of Reclamation LTD at (614) 279-2515.

The toxins and VOCs that were mentioned above in flooring materials can also be found in the materials used to manufacture furniture. The main pieces of furniture in the chapel include computer desks and chairs. One company that produces sustainable furniture is Cardboard Design. This company makes furniture and other home accessories from recycled cardboard using a double or triple fluting technique that makes the furniture strong. The desks made by Cardboard Design cost around $300 and chairs cost $58. No chemicals or glues are used in the products and they can be recycled at the end of their lifecycle. Other companies that produce sustainable furniture can be found using the Sustainable Furnishings Council's website.

The remaining suggestions for the interior of the chapel are low budget, but can have a significant effect on indoor air quality and on the environment as a whole. The first, and possibly most important, suggestion is to get the community that will be using the chapel involved in the sustainability movement. This can be achieved by posting signs throughout the chapel explaining and drawing attention to the different sustainable features that the chapel has in place. Facts about energy consumption before and after improvements have been made to the chapel can also be posted. The community can also get involved in saving energy by turning off computers when they are no longer being used. It is also important to set up a recycling program in the chapel. This program can be for members of the community to use while they are in the chapel and also for members to bring in recyclable containers and paper that they may not be able to recycle at home. The items recycled can then be put out for curb-side pick up by Rumpke or taken to the nearest dumpster location. The closest dumpster to the chapel is at 165 E. 15th Avenue on campus.

Another lower budget improvement is the use of environmentally friendly cleaning products. These products are non-toxic, biodegradable, hypoallergenic and do not create harsh fumes. Seventh Generation is a company that sells these types of products which can be purchased online at seventhgeneration.com or at any Walgreens, Target, Kroger, or Giant Eagle in the area. Seventh Generation's household cleaners, such as glass cleaner and all-purpose cleaner, cost around $5 per bottle and a roll of recycled paper towel costs $2.29. This lower cost suggestion will improve indoor air quality including reducing dust, if used regularly.

The last suggestion to provide a more sustainable environment for those who use the chapel is to repaint the walls. Painting the walls using a low VOC paint will improve the quality of the air in the chapel. Also, if a brighter color is used, new paint could also make the rooms seem brighter, reducing the need for lighting. Incorporating some or all of these improvements into the renovation of the chapel will benefit those using it through the improvement of indoor air quality and the reduction of energy costs. Awareness about environmental issues and ways to correct these issues through renovation and construction will also help educate and improve the sustainability of the entire community.

Landscaping

Problem:
The church chapel on 82 East 16th Ave, Columbus, Ohio faces severe heat in summer and chilling cold in winter. Intense heat in summer and chill in winter give a rise to the energy costs. This made the Church representatives to look for ways to conserve energy in the Church Chapel.
Solution:
A large amount of money is spent each year in designing, implementing, and maintaining urban landscapes. Unfortunately, long-term problems are still there when these processes are not carried out properly. Many of these problems can be avoided or curbed by utilizing sustainable landscape practices. A landscape developed with sustainable practices will not only improve the environment by conserving resources, but also create the outdoor spaces environmentally sound, cost effective and aesthetically pleasing.
Proper landscaping can make a significant difference in the amount of energy required to maintain a comfortable zone in the chapel. Proper use of trees, shrubs, vines and man-made structures can modify the climate around the chapel, and will thus reduce the heat gain in summer and heat loss in winter. Plants can protect the chapel from winter winds and shade it from summer sun.
Heat exchange in a chapel might occur through three major processes through windows:

- Air infiltration: Properly placed plants can reduce air infiltration by reducing the wind velocity near the chapel.
- Heat conduction: Landscaping can help control the temperature difference between the inner and outer surfaces of walls and ceilings, and thus reduce heat conduction.
- Transmission of radiant energy: In summer, trees and shrubs can reduce the amount of solar radiation reaching the outside surfaces of the chapel, and thus reduce heat conduction into the chapel. In the winter, solar heating can reduce the rate of heat loss by raising the outside temperature of walls. Blocking cold winter winds also reduces conductive heat loss.

The fact is large expanses of east or west-facing glass admits undesirable solar radiation in the summer. However, large expanses of south-facing glass can help heat the house in winter. Thus, plantation of appropriate vegetation around a home can regulate solar radiation during different seasons of the year.

Design Recommendation:
As we can see from the sketch of the chapel (Figure 1) that windows are on the east side and on the north side of the chapel. Therefore, the recommended way to provide shade to the chapel is to plant deciduous trees on the east, southeast, south, southwest and west sides of the chapel. Tree arrangements that provide shade in summer will shed their leaves and will not block solar heating in the winter. Still the leafless deciduous trees may reduce the amount of sunlight reaching the chapel by more than one-third. To increase the incoming sunlight, one may prune the branches to allow maximum solar heating in winter.
Now, the problem is that the space available to plant the trees is just 1 – 1.5 feet which is not sufficient for trees to be vegetated there. The trees' roots may damage the foundation of the chapel. Therefore, one should not go for trees but shrubs. Again, the windows heights are around 6 ft. Therefore, shrubs of height 6-10 ft will do well.

The window on the north side is at a height of 15 ft. approx., facing the roof of another room. As in summer, the intense sunlight comes from the north side, ignoring this window will not be a right choice. One may plant some vines or climbers (in pots) to shade this window. To let climbers reach the window height, one can use arbors or trellis.

Arbors: For $10-$200 (even more)

Trellis (Figure 2): Expandable Bamboo Trellis for $ 20

Faux bamboo poles for $ 22

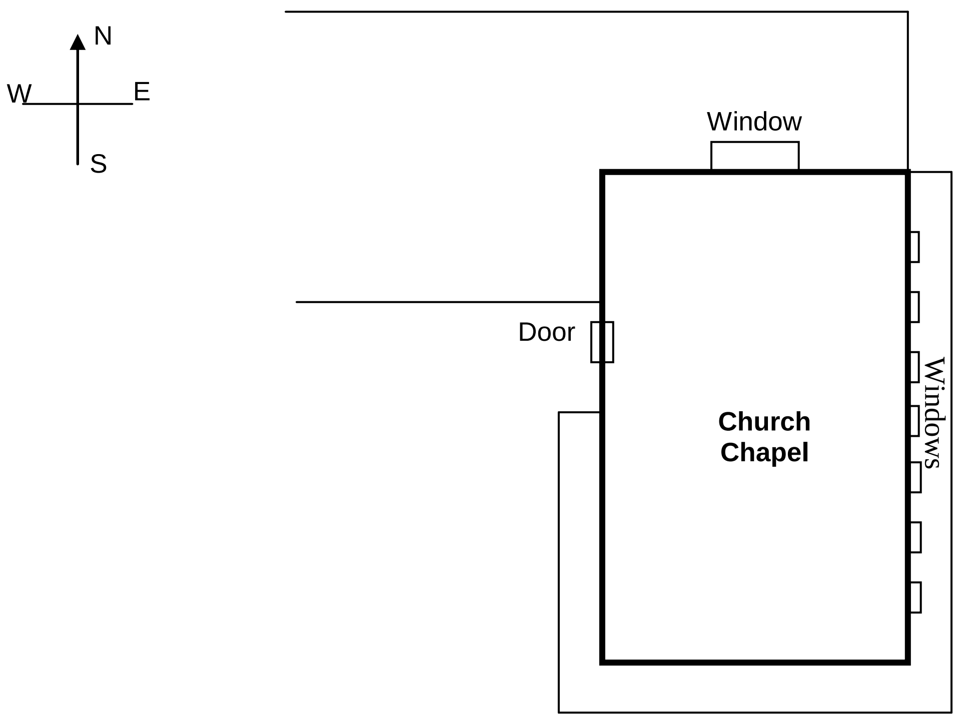


Figure 1: Sketch of the Church Chapel

(a) (b)

Figure 2: (a) Expandable Bamboo Trellis
(b) Faux bamboo poles

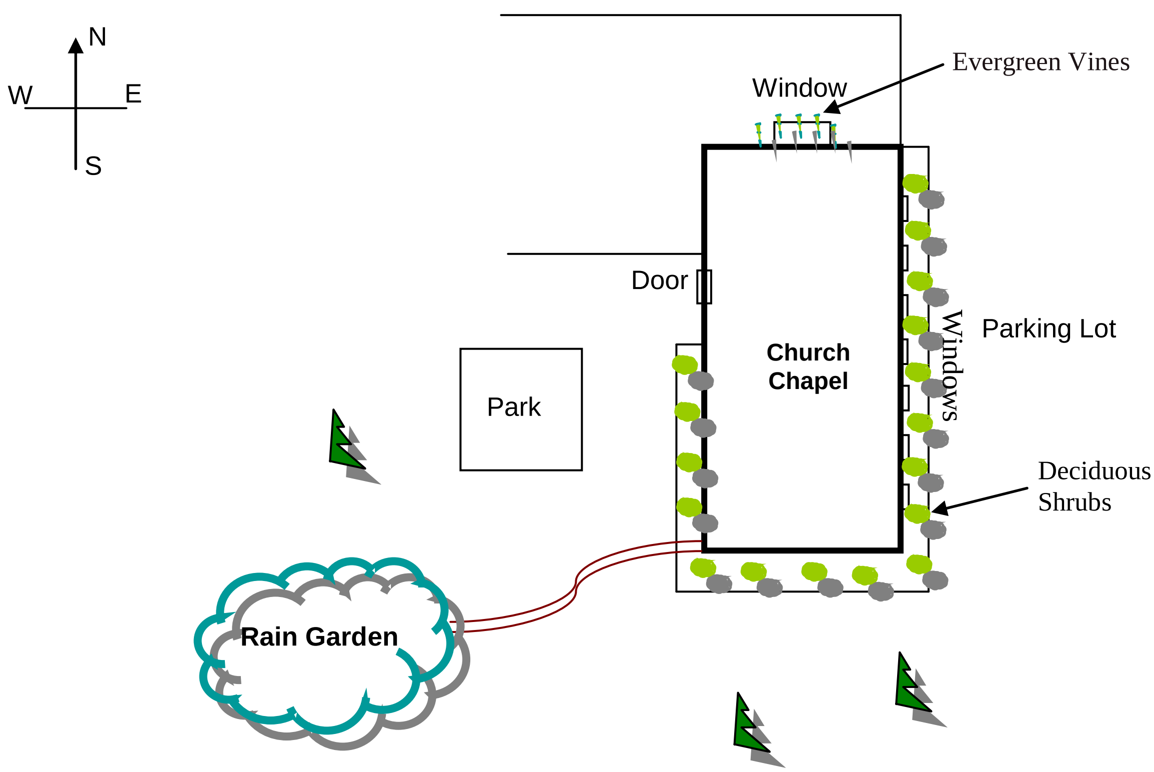


Figure 3: Sketch of the Church Chapel after sustainable landscape changes

Deciduous Shrubs to be planted on East, South and West side of the Chapel (Figure 3):

- Rosa setigera Michx. climbing rose, ROSE2
- Hibiscus syriacus, Shrub Althea; Rose of Sharon == 8'-12' (Cost: $ 10)
- Hamamelis spp., Witchhazel, Native—H. virginiana == 6'-10' (in Spring)
- Clethra alnifolia, Summersweet Clethra, Native == 8' (Cost: $10-15)
- Buddleia davidii, Butterfly-bush == 5'-10' (10-15)
- Myrica pensylvanica, Northern Bayberry, Native ('Myda' is a female, and 'Myriman' the male for pollination.) == 9' (in Spring)

Evergreen Vines and Creepers to be planted on North (Figure 3):

- Waldensteinia fragarioides
- Mitchella repens
- Potentilla simplex
- Phlox subulata
- Climbing hydraza

In order to support these vines, fence, arbors or trellises would be required.

Rain Garden

Additionally, the church representatives may like to have an economical and friendly landscape by incorporating a rain garden. Rain garden is an easy sustainable landscape promoting and preserving the health of nature. The main objective of rain gardens is to filter rainwater, which lands on a hard surface (e.g. roofs, paved areas, driveways and paths). Rainwater is channeled through pipes into the garden, where pollutants are extracted from the water via natural means and filtered water can then be returned safely to the environment.

Rain garden not only improves our quality of life, but also reduces the amount of pollution reaching creeks and streams by up to 30%. There are some other benefits which may motivate the church representatives to go for it. Some of the benefits of rain garden are:

- Filter runoff pollution
- Reduce garden maintenance
- Enhance sidewalk appeal
- Increase garden enjoyment
- Recharge local groundwater
- Conserve water
- Improve water quality
- Protect rivers and streams
- Remove standing water in your yard
- Reduce mosquito breeding
- Slow down the storm water runoff thus reduce potential of flooding
- Create habitat for birds & butterflies

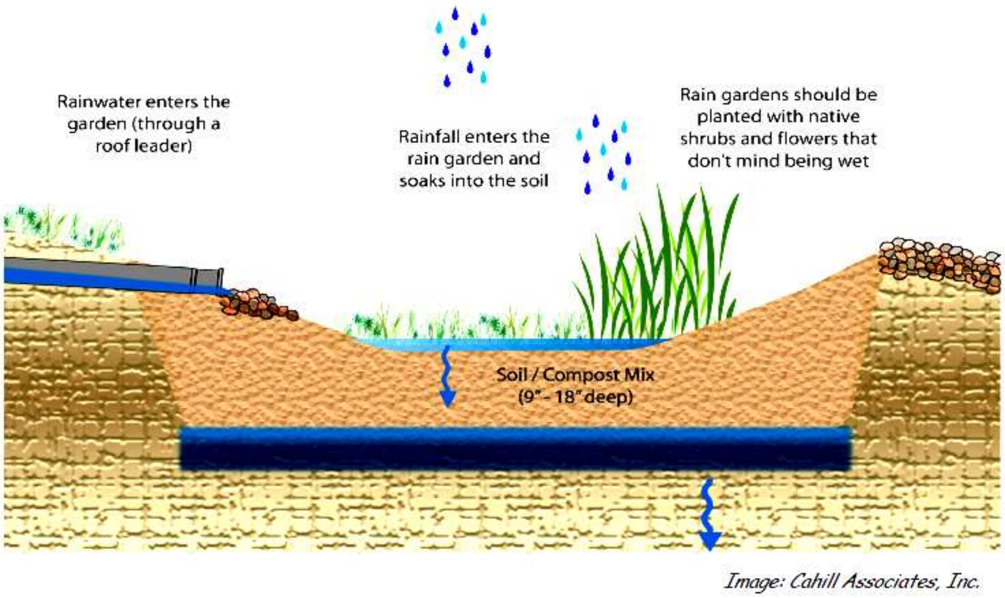


Figure 3: Rain Garden

Construction of Rain Garden

Know the soils: Dig an 8 inches deep test hole, and fill the hole with water. After 24 hours, measure how far down the water has drained.

Size of the Garden

- The depth that the test hole has drained will be the depth of the rain garden (Let it be 4 ft.).
- Calculate how much drainage area will be directed into the garden (e.g. if only chapel rooftop is accounted for draining into the downspout, area = 3000 ft^2).
- Divide the drainage area by the depth of the rain garden calculated in step 1 (i.e. Drainage area = 3000/4 = 750 ft^2).

Digging and Grading

- Before start digging, outline the shape of the rain garden with marking spray, flags, or a garden hose.
- Remove the existing top layer of sod, and dig down to the depth of the rain garden calculated above in "size of the Garden, bullet 1". (i.e. 4 ft)
- Till up the top couple inches of soil.
- Add 2 to 3 inches compost or other organic material and mix into the existing soil.
- Gently slope the sides of the garden.
- Grade the bottom of the garden evenly.

Plants for Rain Garden

- Choose both tolerant of flooding and tolerant of drought types of plants. Consider color, bloom time, and height of the plants. A wide variety of colors and bloom time are available. Also consider using native plants, as they are better suited to the soils, climate, and pollinators. (See list of the native plants in Table 1).
- Locate the plants in the garden according to their tolerance of water – the most water tolerant plants should be placed closest to where the water will enter the rain garden.
- After planting, add a 2 to 3 inches layer of double shredded hardwood mulch or leaf compost to keep in moisture and keep out weeds.

NOTE: Shredded mulch or leaf compost helps to prevent erosion, enhance metal removals, and simulate leaf litter in a natural forest system. One should avoid the use of wood chips as they tend to float during inundation periods.

For Mulch: http://www.kurtz-bros.com/, http://www.mrmulch.com/ (Provides calculator)
Double processed hardwood mulch: $29.99 per cubic yard

Maintenance

- Rain garden will need to be watered throughout the first growing season. If only native plants have been planted then they should take off and do well on their own after their first year.
- The plants will fill in as the years go by, but applying mulch year after year is a good idea. Over time, less mulch will be required.
- Watch for gullies and erosion – a quick fix to an unanticipated path of water entering the garden is to place several cobble stones at that entry point to slow and spread the water.
- In the fall and spring, be sure to clear out any leaves that may have collected at the water entry point to the garden to be sure the flow of water is not restricted.
- Labeling plants is a good idea to distinguish the plants planted to the weeds.

Table 1: List of the native plants for Rain Garden

Blue flag iris (Iris virginica)		**Butterfly weed (Asclepias tuberose)**	
	**Moisture:** Wet **Sun/Shade:** Shade **Height:** 12″-42″ **Flower Color:** Purple-blue **Bloom Time:** May – July In spring		Moisture: **Dry** Sun/Shade: **Part Sun** Height: **1-3′** Flower Color: **Orange** Bloom Time: **June – Sept.** In spring.
Cardinal flower (Lobelia cardinalis)		**Culver's root (Veronicastrum virginicum)**	

	Moisture: **Wet** Sun/Shade: **Shade** Height: **2-5′** Flower Color: **Red** Bloom Time: **July – Oct.**		Moisture: **Med.** Sun/Shade: **Part Sun** Height: **3-6′** Flower Color: **White** Bloom Time: **June – Aug.**
Fox Sedge (Carex vulpinoidea)		**Great blue lobelia (Lobelia siphilitica)**	
	Moisture: **Wet** Sun/Shade: **Part Sun** Height: **2-3′** Flower Color: **Green** Bloom Time: **May – June**		Moisture: **Med.- Wet** Sun/Shade: **Part Sun** Height: **1-4′** Flower Color: **Blue** Bloom Time: **July – Oct.**
Joe-pye weed (Eupatorium maculatem)		**Ohio spiderwort (Tradescantia ohiensis)**	
	Moisture: **Wet** Sun/Shade: **Part Sun** Height: **3-6′** Flower Color: **Pink** Bloom Time: **June – Oct.**		Moisture: **Med.** Sun/Shade: **Part Sun** Height: **2-4′** Flower Color: **Blue** Bloom Time: **May – Oct.**
Dense blazingstar (Liatris spicata)		**Red osier dogwood (Cornus sericea)**	
	Moisture: **Med.** Sun/Shade: **Full Sun** Height: **2-4′** Flower Color: **Purple** Bloom Time: **July – Aug.**		Moisture: **Dry-Wet** Sun/Shade: **Part Sun** Height: **up to 10′** Flower Color: **White** Bloom Time: **May – Sept.** Mid summer/ spring
Royal catchfly (Silene regia)		**Tussock sedge (Carex stricta)**	

	**Moisture:** Dry – Med. **Sun/Shade:** Full Sun **Height:** 2-4′ **Flower Color:** Red **Bloom Time:** July – Aug.		Moisture: **Wet** Sun/Shade: **Part Sun** Height: **2-3′** Flower Color: **Green** Bloom Time: **Apr. – June**
White turtlehead (Chelone glabra)			
	Moisture: **Wet** Sun/Shade: **Shade** Height: **2-4′** Flower Color: **Cream** Bloom Time: **Aug. – Sept.**		

Points to be noted while constructing a Rain Garden

- Rain garden should be at least 10 feet from the home/property (Chapel here)
- Should be located in a low spot and not near tree
- The typical depth of a rain garden is 4 to 8 inches deep
- A rain garden is shaped like a saucer with a flat bottom typically 4 to 6 inches deep and berms along the sides. If the soil contains a lot of clay, dig another 2 inches deep and make the garden longer because clay prevents the water from soaking in as quickly. One can also improve the quality of the soil before putting in the garden. A good soil mix for rain gardens is 50 to 60 percent sand, 20 to 30 percent topsoil and 20 to 30 percent compost, according to the Web site, www.raingardens.org.
- The typical size of a rain garden is a third the size of the surface where the water is being diverted from.
- Extend the downspout across the property or create a rock-lined channel. One can also run PVC pipe underground to the garden.
- Some recommended native plants for Ohio are cardinal flower, great blue lobelia, butterfly milkweed, Ohio spiderwort, purple coneflower and white turtlehead,

About Expenses:

- \$3 to \$5 per ft^2: Purchase plants, and do the work yourself (approx. \$ 2250 - \$ 3750*).
- \$10 to \$15 per ft^2: Hire a landscape consultant to design, construct, select plants, and install plants (approx. \$ 7500 - \$ 11250*).

*Assuming the area of the drainage area = 3000 ft^2 and area of rain garden = 750 ft^2

Some more plants for Rain Garden

Columbine, Swamp Milkweed, Smooth Aster, New England Aster, Blue False Indigo, Marsh Marigold, White Turtlehead, Purple Coneflower, Joe-Pye Weed, Blue Flag Iris, Blazing Star, Cardinal Flower, Great Blue Lobelia, Cut-leaved Water Horehound, Bee Balm, Wild Bergamot, Sensitive Fern, Cinnamon Fern, Royal Fern Shade, Smooth Penstemon, Spreading Jacob’s Ladder, Rough Cinquefoil, Green-headed Coneflower, Branching Coneflower, Arrowhead, Cup Plant, Prairie Dock, Ohio Goldenrod, Celandine Poppy, Ironweed, Culver’s Root, Big Bluestem, Palm Sedge, Fox Sedge, Switch Grass, Prairie Cord Grass.

Benefits

There are a number of viable funding and not-for-profit grant options the Summit on 16th Church should consider applying for. AEP Ohio offers commercial customers incentives to upgrade lighting in their facilities to more energy efficient lighting. This is a utility rebate program that is open to all non-residential customers of AEP Ohio including not-for-profit organizations. However, you must apply for pre-approval before purchasing any equipment or carrying out the project to become eligible for this grant and the window for applications closes December 31st, 2009. Eligible projects include screw-in compact fluorescents, hardwired compact fluorescents, conversion of T12 to T8 lamps, LED Exit Sign retrofits, and lighting occupancy sensors. The program requires that the lamps and ballasts other than compact fluorescents be listed on the Consortium for Energy Efficiency to be eligible. This grant is worth up to 50% of the total project cost and the incentive amount is one to sixty dollars per unit.

In addition to the previous rebate program AEP Ohio also offers commercial customers incentives to upgrade inefficient equipment in their facilities. The program is open to all non-residential customers of AEP Ohio. Pre-approval is required before purchasing any equipment or carrying out the project to reserve funds. Types of high efficiency equipment eligible under this program include industrial process improvements, refrigeration, controls, non-standard lighting (those that do not qualify under the Commercial Lighting Program), HVAC system replacements, and other technologies that reduce energy consumption and peak demand. The incentive payment is capped at 50% of the total project cost in addition to 0.08/kWh for one year energy savings plus $100/kW demand reduction during summer peak hours.

AEP Ohio also offers incentives for commercial customers including not-for-profit organizations who have implemented energy efficiency upgrades on their own. The program is open non-residential customers of AEP Ohio that use more than 700,000 kWh per year. Energy efficiency upgrades implemented since January 1, 2006 are eligible. Customers must apply first to AEP Ohio, who will review the application and make any suggested modifications. Then the application will be submitted to the Public Utilities Commission of Ohio (PUCO) for review and final determination. If the incentive is awarded, the customer may choose to receive a rebate limited to 75% of the incentive as calculated under the regular custom or lighting programs, or an exemption from the energy efficiency program (for a period of time equivalent to the rebate value). Visit the program website for additional qualifications and application information.

The Ohio Advanced Energy Fund is another source of potential project funding. The fund collected fifteen million annually from 2001-2005 and will continue to collect five million annually until January 1, 2011. This fund collects federal grant money and awards it to approved residential, commercial, and not-for-profit energy efficiency projects. Funds may be used to improve the energy efficiency of a structure and may also be used for energy efficiency evaluations. Applications are available through the State of Ohio's website at www.ohio.gov.

References

HVAC

- (http://www.radiantec.com/why/technical-explanation.php)
- (http://www.dansfancity.com/techhelp/wntrsmmr.htm)
- (http://wiki.answers.com)
- Kibert, Charles J. “Sustainable Construction: Green Building Design and Delivery.” 2008. John Wiley & Sons, Inc. Hoboken, NJ.
- (http://www.edcmag.com/CDA/Archives/10f85b6279697010VgnVCM100000f932a8c0)
- (http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12590)
- (http://www.google.com/search?sourceid=navclient&ie=UTF-8&rlz=1T4ADFA_enUS340US350&q=radient+heat+prices)

Lighting

- (http://www.besthomeledlighting.com/)
- (http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH38F&re=1&ee=1)
- (http://www.costhelper.com/cost/home-garden/skylight.html)
- (http://www.superbrightleds.com/cgi-bin/store/index.cgi?action=DispPage&Page2Disp=%2Fedison_globe.html)

Interior

- (http://www.bestbuy.com)
- (http://www.farreys.com)
- (http://www.rumpke.com)
- (http://www.michaelbluejay.com/electronics)
- (http://www.energystar.gov/ia/products/heat_cool/ceiling_fans/H142PA.pdf)
- (http://www.123bamboo.com)
- (http://www.servicemagic.com/article.show.Choosing-Green-Vinyl-or-Linoleum-Sheet-Flooring.16429.html)
- (http://www.naturalarearugs.com)
- (http://www.seventhgeneration.com)
- (http://www.sustainablefurnishings.org)
- (http://www.cardboardesign.com)
- (http://www.carpetrecovery.org/waste.php)

Building Envelope

Contacts:

Windows:
Rosati Windows
614-777-4806

Bob Briggeman
Estimator/Sales Consultant
Home Improvement from Rosati
614-885-2500 phone
614-777-1105 fax
Part of the Rosati Windows family of companies

The Roof:
Rees Haynes
Renewable Energy Solution Strategist

N.P.C.P.LLC
198 Pemberton Ave.
N. Vancouver, BC V7P 2R5
Phone: 1.866.983.2819
Cell: 604.831.6251
Fax: 604.983.2869
Email: rees@unitedpowerltd.com

Chris Knight
Market Development Specialist

NPCP LLC
198 Pemberton Ave.
N. Vancouver, BC V7P 2R5
Phone: 1.866.983.2819
Cell: 604.551.4625
Fax: 604.983.2869
Email: Chris@npcpunited.com

Landscape

- (http://plants.usda.gov/java/charProfile?symbol=ROSE2)
- (http://ohioline.osu.edu/hyg-fact/1000/1085.pdf)
- (http://ohioline.osu.edu/b865/b865_10.html)
- (http://ourohio.org/magazine/2007-2/june-july-august-2007/drain-your-rain/)
- (http://www.ohioprairienursery.com/documents/neo_raingarden_manual1.pdf)
- (http://www.tredyffrin.org/pdf/publicworks/CH2%20-%20BMP1%20RainGarden.pdf)
- (http://www.centralohioraingardens.org/?page_id=130)
- (http://www.tredyffrin.org/pdf/publicworks/CH2%20-%20BMP1%20RainGarden.pdf)

For trellis and Arbors

- (http://www.amazon.com/dp/B001FA6EWC/ref=asc_df_B001FA6EWC968219?smid=A143QXMCJ5WMVJ&tag=nextag-kitchen-mp01-delta-20&linkCode=asn&creative=380341&creativeASIN=B001FA6EWC)
- (http://www.gardeners.com/Faux-Bamboo/35-638,default,pd.html?SC=XNET8035)
- (http://www.amazon.com/s/ref=nb_ss_3_4?url=search-alias%3Dgarden&field-keywords=arbors+and+trellises&x=0&y=0&sprefix=arbo)

Some nurseries in Columbus Ohio

- Oakland Nursery Columbus, www.oaklandnursery.com, 614-268-9466
- Strader's Garden Centers, www.straders.net, 614-(486-2626)/ (889-1314)
- www.growingsolutionsgardencenter.com 614-276-7511
- Fisher's Greenhouse, jonfishergreenhouse.com 614-492-1413

For Mulch

- (http://www.kurtz-bros.com/)
- (http://www.mrmulch.com/)

Benefits

- "DSIRE: DSIRE Home." *DSIRE: DSIRE Home*. N.p., n.d. Web. 30 Nov. 2009. <http://www.dsireusa.org/>.
- "Welcome to Ohio.gov." *Welcome to Ohio.gov*. N.p., n.d. Web. 30 Nov. 2009. <http://ohio.gov/>.
- "Welcome to the Ohio Department of Development." *Welcome to the Ohio Department of Development*. N.p., n.d. Web. 30 Nov. 2009. <http://www.odod.state.oh.us/>.