IS "SUSTAINABLE DEVELOPEMENT" IN CONSTRUCTION ACTUALLY SUSTAINABLE?

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In the construction industry, the trend of "Sustainable Development" has gained tremendous momentum over a short period of time. The United Nations in its 1987 Brundtland Report defines, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The idea of sustainable development has been further broken down into three parts: environmental sustainability, economic sustainability and sociopolitical sustainability. The driving force behind sustainability has been derived from the perception of effects on the environment, most notably, global warming. However, events of recent years have put into question the absolute certainty of global warming. If the environmental aspect is indeed not necessary, can the concept of sustainable development be justified based solely upon economic and sociopolitical factors?

Given the current state of the economy in the United States, as well as the rest of the world, this paper will look on the economic factor of sustainability in construction. While there are many areas in construction that can be investigated, this paper will focus on Residential Building Construction. It is the initial opinion of the author that creative thinking and a great deal of further development is needed to bring sustainable development to a point where it is a viable form of construction (from the economic sense) and be able to stand on its own based upon function and cost effectiveness without the need for justification by other means.

Introduction

This paper is not about whether global warming is occurring or not. The author, who is a skeptic, simply believes that the data and the models used to reach the conclusion is flawed. This paper is to determine is a specific area of "green" construction is economically feasible in comparison to conventional methods in the residential area. This paper will look at the question, "

Are Geothermal Energy and Wind Turbines a cost effective alternative to conventional Electricity and HVAC?" It will also give some history of the systems discussed and how they both have their advantages and disadvantages. It will describe how both systems work and how both have their efficiencies. Other points this paper will raise what kind of locations are best suited for the renewable resource of wind and geothermal means of energy and the comparison of labor installation of each system.

Geothermal Energy (Heat Pump)

Geothermal Energy is widely spreading as being a viable alternative in the residential industry as a means to heat and cool homes with the use of heat pumps. Geo meaning (earth) and therm (heat), when put together creates Earth's heat also known as geothermal energy. Earth's crust is 5-50 kilometers deep and for every mile that is gone deeper the temperature rises anywhere from 50 to 87 degrees Fahrenheit. This heat is caused by the forming of dust and gasses over four billion years ago and since elements in rocks continuously radioactively decompose this is a great renewable heat source for a geothermal energy system. Geothermal energy has a huge potential because of its sheer quantity which has a volume estimated to be 50,000 time that of oil or coal.

Geothermal energy can be traced back to the ancient Romans as they used it to heat their baths and for medical purposes through the use of hot springs. The first known use of geothermal energy in the U.S. was back in 1830 in Hot Springs, Arkansas[1]. The first production of residential heat pumps were seen in the 1950's as a means to heat and cool homes. In the 1980's (GHP) style pumps that are used today evolved from the water source heat pump industry. Geothermal heat pumps are rapidly growing in the housing market as an alternative to the conventional way of heating and cooling homes, and this continues to evolve.

Around the United States there are 69 geothermal power facilities at 18 different sites. (Geothermal power is also being generated in 20 different countries around the world and only supplies less than one percent of the world's energy, but by 2050 the future of geothermal is estimated to grow to meeting 10-20% of the world's power[1].

Wind Turbine Power

Early wind power was utilized to automate the tasks of grain-grinding and water pumping, with the earliest known system being used around 500-900 A.D. in Persia. The first design was of a vertical windmill made of bundles of wood or reeds. One of the best known applications of wind power being used was on the island of Crete. Here, there were literally hundreds of windmills being used to pump water to crops.

The small windmills seen today were perfected in the United States during the 19th century to mainly pump water. These systems started in 1854 with the Halladay windmill design that had relatively rotor diameters of one to two meters in diameter. After the Halladay design they evolved to the Aermoter design as well as the Dempster design which are still in use today. Most early style windmills used wooden blades and graduated to steel blades (introduced in 1870) that were more easily made and had better durability. Between 1850 and 1970 there were over six million small windmills in the United States alone and they were used to primarily pump water to livestock and farm use as well as for the railroad to pump water for steam. The 19th century saw the first known use of wind power in the United States to generate electricity. In 1920 the

first wind powered generator was created in Minneapolis to charge batteries and provide electricity.
Wind turbines work by the blades, most often a three blade design for a residential design. While the wind turns the blades the energy is transferred through a high speed shaft which has a magnetic rotor on it. As the shaft spins the generator works much like an alternator on a car does, spinning in loops of copper that is inside an iron core and this creates electromagnetic induction. The energy created is either stored or fed into a grid. There are a couple of different wind turbine designs, the standard three blade horizontal axis design, but there is also a vertical axis design that is less harmful to birds.

Conventional Forced Air (HVAC)

Dave Lennox was the first to create the first style of the furnace using coal as the fuel supply back in 1885. But with no electricity he used convection of the hot air rising as the means of transporting the warm air though out the home. This was the primary means heating a house until the first forced air furnace using coal was created in 1935 using electricity and a fan to move the air and heat the rooms. Shortly thereafter the use of gas as a fuel to heat the air eliminated the need to stoke the coal fire and this is more efficient. Today about 60% of all the homes in the U.S. use the forced air furnace as a cheaper way of heating a home.

The way a forced air furnace works is by using a cool air return register to pull cool air from the home into the furnace. Once the air enters the furnace, the air is then heated by a set of coils in the furnace and uses a blower fan to force the air across the coils or heat exchangers and heats the air up. The air then travels through the duct work usually under the floors and returns to the rooms through registers usually on the floor.

Standard Electricity

Electricity has always been around on the planet. It was not invented, just discovered. Benjamin Franklin helped understand that electricity and lightning were the same, but he did not discover electricity. In 1882 Thomas Edison, the creator of the light bulb, opened the first power plant in New York that could power 5,000 lights. By the 1920’s only 10% of the homes had electricity, and by 1935 the first forced air furnace was created for a home[2]. Today on average the average household that is 2500 square feet uses anywhere from 18,000 to 20,000 kilowatts of power a year.

Electricity is created a multiple of ways. The most common way is using fossil fuels such as coal, crude oil, or natural gas which accounts for a large percentage of CO_2 emissions produced in the world. The heat created during the burning of these fuels heat massive amounts of water which creates steam and turns steam turbines that are connected to a generator by a shaft efficiently generating electricity. An alternate methods of creating electricity is through nuclear fission which uses a nuclear reaction to generate heat and create steam, and once turned to steam uses the same process to generate electricity.

Why Wind Power and Geothermal Energy Have Their Advantages

Both wind power and geothermal energy alternatives have their advantages over conventional energy production methods. First, they use energy sources which are available at no cost, delivery to the facility is free (for wind power), and the source of their power is virtually limitless. There are also economic reasons for considering these power sources. Large scale energy production receives government subsidies, which facilitate construction, and utilities are required to purchase the energy produced at a premium price. Residential uses of these alternative sources qualify for a tax rebate. With both geothermal and wind being a renewable resource, they qualify for federal tax rebates. Wind turbines that produce 100 kilowatts or less was installed between January 1, 2008 and December 16, 2016, they are eligible for the federal personal tax credit, which is 30% of the total cost of both the wind turbine and the geothermal system. Both systems must meet the entire energy star program requirements that go in effect when each system is purchased. Installation on a residential premise must use the IRS Residential Energy Efficient Property Form 5695 filled out separately for each system to qualify.[3] Also to qualify each system must show the cost of the system, when it was placed in service, and whether or not the system meets all of the qualifying criteria.

Conventional electricity is not a renewable resource. Most often it requires the use of fossil fuels or nuclear power to generate electricity. These methods do have the drawback of either releasing gases into the air or produce nuclear waste. However, efficiency of the methods runs near 85% while wind is roughly 50% and solar around 35%. Because of this, there has yet to be a single conventional power plant completely shut down and replaced by a renewable power plant.

Most residential wind turbine systems are an on grid system which allows homeowners to use the conventional electric company if not enough energy has been produced due to the lack of wind. With being tied into a grid, the electric company can monitor how much electric is being produced and if customers produced more than enough energy in some states the power company will pay owners for the unused amount of energy (referred to as net metering). With net metering (depending on the state), the utilities buy-back the power at an agreed upon price, or buy back the electricity at the average retail rate. However, buying a bigger system then what is needed to have the power company pay the excess back will not offset the initial cost of the stem to the life span of the turbine.

If the consumer decides to go off-grid with their alternative power, owners cannot get paid for their excess power from net metering. A deep cycle battery or batteries will have to be bought to store the excess power for when there is not a sufficient amount of wind power to operate the electrical needs as needed along with the geothermal system that heats and cools the entire house. Deciding on the size of battery bank their system customers will need is determined by the chart below. This deep cycle have a life span of 4-8 years depending on the quality of the battery that is purchased. Also there is a three stage charge to these batteries, a bulk charge where it will accept 80-90% of the safest charge. The second stage is the absorption charge where the voltage is constant but the current decreases. At this stage the maximum amount of volts is charged. The last charge is the float or trickle charge, where it maintains a 12 volt on the battery, thus prolonging the batteries lifespan.

The Location and Size of Each System

The size and location of these systems will be vital as they will be used to power and operate the entire house. The location will be based in Northern Indiana using a footprint of a 2,000 square foot (ft^2) home. The footprint of the wind turbine and field needed would be a 20' x 20' square for a single 5-10 kW turbine.

It is crucial to find the best location possible to capture the most wind as possible. To do that, attention to wind speeds and obstructions is necessary. Take the sites average wind speed with a minimum wind speed of 11 to 13 mph. It should be noted that even small differences in wind speed can have a profound effect on power generation.
Small wind turbines should be installed on sufficient large lots, with as few obstructions as possible. The highest point is often the best place that produces the wind. Trees or obstructions can have a big impact on the speed and direction of the speed. The turbine should be as far away from buildings and treetops as possible. The height of the tower should put the bottom of the blade approximately 30 feet above the top of any obstruction within 300 feet of the tower.

There are also environmental issues that have to also be checked with the local requirements of the area. This includes the impact on wildlife and local air traffic. Wind turbines can produce some noise that could impact the wildlife in the area. The aesthetics of a wind turbine can have an impact on if owners can have one installed in their neighborhood, since they have to be located on the high points it makes them very visible (think Teddy Kennedy).

For a conventional HVAC system there really are not any problems with installation as long as there is an electric hook-up and a fuel source (natural gas, electricity, propane, etc.). The installation can be made in any house. Installation is substantially cheaper and easier when compared to a geothermal and a wind turbine system. The only space that is needed for a furnace is an area big enough for the furnace and the duct work, which is substantially smaller than that of the geothermal and wind turbine system.

The geothermal system is sized in tons, and for the size of the system needed for the size house used for analysis in this paper is a 3 ton system. A system that is undersized will actually cost more in electricity due to the strain put on the system to keep up with the demand needed in the house, preventing any beneficial side to come from the system.

An oversized system is also not a wise choice due to the expected efficiency of the geothermal system. Oversized system causes too much airflow those results in extremely short cycle times, which runs the pump more often (start and stop) using more electricity. Also, in summer months, because of the short run times it will cool the home but will not able to remove the humidity in the home in the summer time resulting in occupants not being satisfied.

It should be noted that quite often a small furnace is needed to supplement the geothermal system for heating. While it can typically bring the home to 68˚F, many homeowners like their homes a little warmer, so a supplemental heat source is often utilized.

In analyzing the two systems, a look at energy usage and U values (The U value measures energy transmission through materials, such as walls (comprised of the exterior cover, insulation, and interior drywall), roofs (comprised of shingles, plywood, and insulation) and other building systems), were calculated based on a modern 2000 ft^2 home in the upper Midwest of the United States. Also, it is important to note that the calculations the follow are for very favorable conditions for the wind power. It was assumed that the energy needed would be completely supplied by the windmill (usage from the grid was offset by the excess power sold back to the utility). There was no battery back-up system included in the cost of the windmill.

U Values								
		Walls	**Ceiling**	**Floor**	**Windows**	**BTU/Hour Total**	**BTU Usage/Month**	**Therms Usage/Month**
		U = 1/R-19 =	U = 1/R-38 =	U = 1/R-5	U = .3			
		0.053	0.026	0.200	0.300			
MONTH	**Average Temperature NW Indiana**	**BTU/Hour**						
January	23˚F	2438.00	1196.00	9200.00	13800.00	26634.00	19815696	198.16
February	27˚F	2862.00	1404.00	10800.00	16200.00	31266.00	21761136	217.61
March	38˚F	4028.00	1976.00	15200.00	22800.00	44004.00	32738976	327.39
April	49˚F	5194.00	2548.00	19600.00	29400.00	56742.00	40854240	408.54
May	60˚F	6360.00	3120.00	24000.00	36000.00	69480.00	51693120	516.93
June	69˚F	7314.00	3588.00	27600.00	41400.00	79902.00	57529440	575.29
July	74˚F	7844.00	3848.00	29600.00	44400.00	85692.00	63754848	637.55
August	72˚F	7632.00	3744.00	28800.00	43200.00	83376.00	62031744	620.32
September	64˚F	6784.00	3328.00	25600.00	38400.00	74112.00	53360640	533.61
October	53˚F	5618.00	2756.00	21200.00	31800.00	61374.00	45662256	456.62
November	40˚F	4240.00	2080.00	16000.00	24000.00	46320.00	33350400	333.50
December	28˚F	2968.00	1456.00	11200.00	16800.00	32424.00	24123456	241.23

Now that the requirements have been set, the size of the units needed can be determined as well as their installation and operating costs, based upon 2012 costs:

90% Efficient Forced Air Gas Furnace with a 500 Watt Fan								
Month	KWH	Therms	Cost For Therms	Cost For KWH	Total Monthly Cost	Cost W/ Duct	AC Unit	Total Cost
January	$0.03	$0.58	$114.77	$4.60	$119.37	$10,250	$4,000	$14,250
February	$0.03	$0.61	$132.50	$4.60	$137.10			
March	$0.03	$0.61	$199.77	$4.60	$204.37			
April	$0.03	$0.61	$251.13	$4.60	$255.73			
May	$0.03	$0.61	$316.05	$4.54	$320.59			
June	$0.03	$0.56	$322.39	$4.54	$326.94			
July	$0.03	$0.57	$365.25	$4.54	$369.79			
August	$0.03	$0.57	$352.28	$4.54	$356.82			
September	$0.03	$0.50	$266.54	$4.54	$271.08			
October	$0.03	$0.49	$222.28	$4.60	$226.88			
November	$0.03	$0.51	$170.39	$4.60	$174.99			
December	$0.03	$0.59	$143.17	$4.60	$147.77			
		Total Yearly Operating Cost			$2,911.44			

Now an analysis of the installation and operating costs of the geothermal heating/cooling unit and the wind turbine:

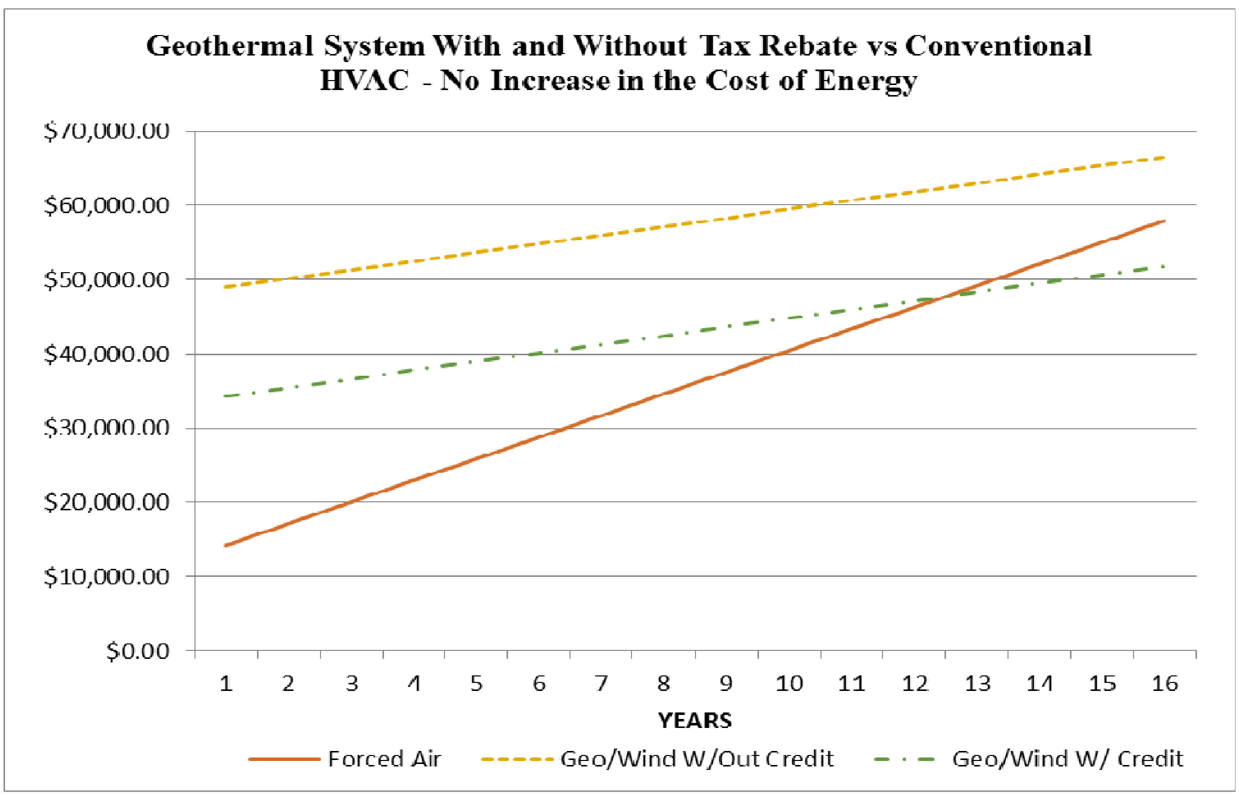
Geothermal Unit with Wind Turbine									
	3% of Installed Cost*	3% Of Installed Cost*							
Month	Average Maintenance Cost (Turbine)	Average Maintenance Cost (Geothermal)	Total Monthly Cost**	Cost with Duct	Ground Loop	Wind Turbine Installed	Total without Credit	With 30% Tax Credit
January	$75.00	$22.50	$97.50	$11,000	$8,000	$30,000	$49,000	$34,000
February	$75.00	$22.50	$97.50					
March	$75.00	$22.50	$97.50					
April	$75.00	$22.50	$97.50					
May	$75.00	$22.50	$97.50					
June	$75.00	$22.50	$97.50					
July	$75.00	$22.50	$97.50					
August	$75.00	$22.50	$97.50					
September	$75.00	$22.50	$97.50					
October	$75.00	$22.50	$97.50					
November	$75.00	$22.50	$97.50					
Total Yearly Operating Cost			$1,170.00					

* The maintenance of the systems is based upon an average of 3% of the initial installation cost.
** The monthly cost is based upon the wind turbine providing all the power needed for the house.

Now an analysis of the two systems can be made. First, the assumption that all costs were paid up front (no financing) with a flat cost of electricity

Average Yearly Cost with No Increase in Energy Costs							
	Year	Forced Air	Geothermal and Wind without Credit	Geothermal and Wind with Credit	Forced Air		Geothermal/Wind Turbine
Initial Cost	0	$14,250.00	$49,000	$34,300	Therms	KWH	N/A
Accumulated Cost (AC)	1	$17,161.44	$50,170	$35,470	$2,856.54	54.9072	$1170.00
AC	2	$20,072.88	$51,340	$36,640	$2,856.54	54.9072	$1170.00
AC	3	$22,984.32	$52,510	$37,810	$2,856.54	54.9072	$1170.00
AC	4	$25,895.76	$53,680	$38,980	$2,856.54	54.9072	$1170.00
AC	5	$28,807.20	$54,850	$40,150	$2,856.54	54.9072	$1170.00
AC	6	$31,718.64	$56,020	$41,320	$2,856.54	54.9072	$1170.00
AC	7	$34,630.08	$57,190	$42,490	$2,856.54	54.9072	$1170.00
AC	8	$37,541.52	$58,360	$43,660	$2,856.54	54.9072	$1170.00
AC	9	$40,452.96	$59,530	$44,830	$2,856.54	54.9072	$1170.00
AC	10	$43,364.40	$60,700	$46,000	$2,856.54	54.9072	$1170.00
AC	11	$46,275.84	$61,870	$47,170	$2,856.54	54.9072	$1170.00
AC	12	$49,187.28	$63,040	$48,340	$2,856.54	54.9072	$1170.00
AC	13	$52,098.72	$64,210	$49,510	$2,856.54	54.9072	$1170.00
AC	14	$55,010.16	$65,380	$50,680	$2,856.54	54.9072	$1170.00
AC	15	$57,921.60	$66,550	$51,850	$2,856.54	54.9072	$1170.00

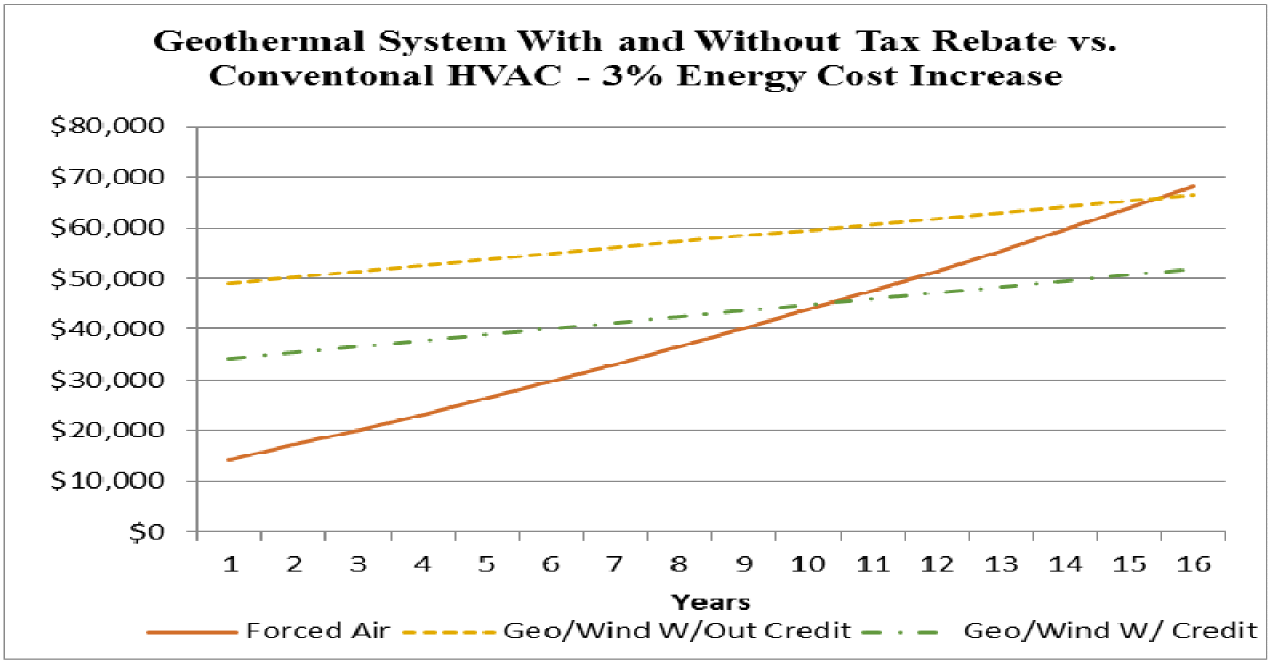
From this, a graph can be generated to graphically display the data:



Is it likely that energy costs will be flat over the next 15 years? Probably not, but with the influx of cheap natural gas from the fracking process, and the additions of the shale oil from the Dakota's and Canada, energy costs from fossil fuels should be relatively cheap for the foreseeable future. Now for arguments sake, the assumption that energy costs will rise moderately (three percent annually) over the same time period.

Average Yearly Cost with Three Percent Annual Increase in Energy Costs							
	Year	Forced Air	Geothermal and Wind without Credit	Geothermal and Wind with Credit	Forced Air		Geothermal/Wind Turbine
Initial Cost	0	$14,250.00	$49,000.00	$34,300.00	Therms	KWH	N/A
Accumulated Cost (AC)	1	$17,161.44	$50,170.00	$35,470.00	$2,856.54	54.9072	$1170.00
AC	2	$20,158.58	$51,340.00	$36,640.00	$2,942.23	54.9072	$1170.00
AC	3	$23,243.99	$52,510.00	$37,810.00	$3,030.50	54.9072	$1170.00
AC	4	$26,420.31	$53,680.00	$38,980.00	$3,121.42	54.9072	$1170.00
AC	5	$29,690.28	$54,850.00	$40,150.00	$3,215.06	54.9072	$1170.00
AC	6	$33,056.70	$56,020.00	$41,320.00	$3,311.51	54.9072	$1170.00
AC	7	$36,522.46	$57,190.00	$42,490.00	$3,410.85	54.9072	$1170.00
AC	8	$40,090.54	$58,360.00	$43,660.00	$3,513.18	54.9072	$1170.00
AC	9	$43,764.03	$59,530.00	$44,830.00	$3,618.58	54.9072	$1170.00
AC	10	$47,546.07	$60,700.00	$46,000.00	$3,727.13	54.9072	$1170.00
AC	11	$51,439.92	$61,870.00	$47,170.00	$3,838.95	54.9072	$1170.00
AC	12	$55,448.94	$63,040.00	$48,340.00	$3,954.12	54.9072	$1170.00
AC	13	$64,210.00	$64,210.00	$49,510.00	$4,072.74	54.9072	$1170.00
AC	14	$65,380.00	$65,380.00	$50,680.00	$4,194.92	54.9072	$1170.00
AC	15	$66,550.00	$66,550.00	$51,850.00	$4,320.77	54.9072	$1170.00

And the accompanying chart:

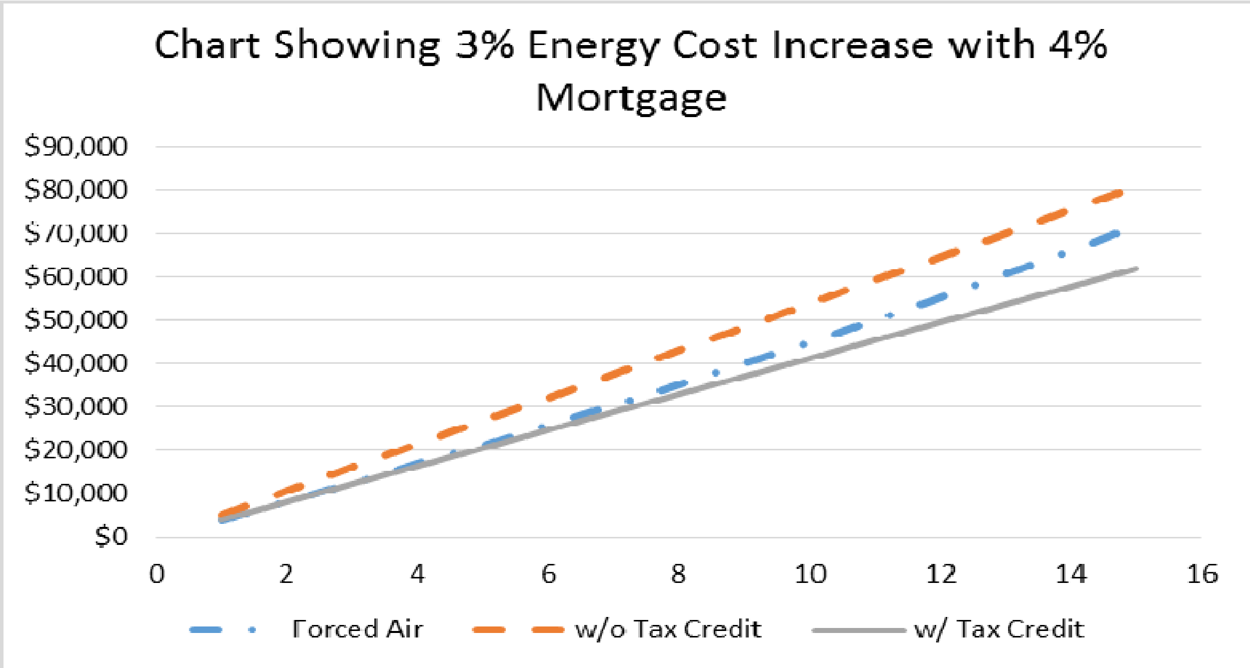


The above figures are based upon up-front costs paid upon installation. A more likely scenario is that the cost of the systems will be part of a homeowner's mortgage. The following assumes that these systems were included in the mortgage (at an interest rate of four percent) and a three percent increase in the cost of energy.

Average Yearly Cost With 3% Annual Increase in Therms and 4% Interest						
	Year	Forced Air				
Initial Cost	0	$14,250.00	Therms	Principal and Interest	Yearly Cost	Total
Accumulated Cost (AC)	1		$2,856.54	$1,222.00	$4,078.54	$4,078.54
AC	2		$2,942.23	$1,222.00	$4,164.23	$8,242.77
AC	3		$3,030.50	$1,222.00	$4,252.50	$12,495.27
AC	4		$3,121.42	$1,222.00	$4,343.42	$16,838.69
AC	5		$3,215.06	$1,222.00	$4,437.06	$21,275.74
AC	6		$3,311.51	$1,222.00	$4,533.51	$25,809.25
AC	7		$3,410.85	$1,222.00	$4,632.85	$30,442.11
AC	8		$3,513.18	$1,222.00	$4,735.18	$35,177.29
AC	9		$3,618.58	$1,222.00	$4,840.58	$40,017.86
AC	10		$3,727.13	$1,222.00	$4,949.13	$44,967.00
AC	11		$3,838.95	$1,222.00	$5,060.95	$50,027.94
AC	12		$3,954.12	$1,222.00	$5,176.12	$55,204.06
AC	13		$4,072.74	$1,222.00	$5,294.74	$60,498.80
AC	14		$4,194.92	$1,222.00	$5,416.92	$65,915.72
AC	15		$4,320.77	$1,222.00	$5,542.77	$71,458.49

Average Yearly Cost and 4% Interest – No Tax Rebate						
	Year	Geothermal and Wind Turbine				
Initial Cost	0	$49,000.00	Maintenance	Principal and Interest	Yearly Cost	Total
Accumulated Cost (AC)	1		$1,170.00	$4,205.00	$5,375.00	$5,375.00
AC	2		$1,170.00	$4,205.00	$5,375.00	$10,750.00
AC	3		$1,170.00	$4,205.00	$5,375.00	$16,125.00
AC	4		$1,170.00	$4,205.00	$5,375.00	$21,500.00
AC	5		$1,170.00	$4,205.00	$5,375.00	$26,875.00
AC	6		$1,170.00	$4,205.00	$5,375.00	$32,250.00
AC	7		$1,170.00	$4,205.00	$5,375.00	$37,625.00
AC	8		$1,170.00	$4,205.00	$5,375.00	$43,000.00
AC	9		$1,170.00	$4,205.00	$5,375.00	$48,375.00
AC	10		$1,170.00	$4,205.00	$5,375.00	$53,750.00
AC	11		$1,170.00	$4,205.00	$5,375.00	$59,125.00
AC	12		$1,170.00	$4,205.00	$5,375.00	$64,500.00
AC	13		$1,170.00	$4,205.00	$5,375.00	$69,875.00
AC	14		$1,170.00	$4,205.00	$5,375.00	$75,250.00
AC	15		$1,170.00	$4,205.00	$5,375.00	$80,625.00

Average Yearly Cost and 4% Interest – With Tax Rebate						
	Year	Forced Air				
Initial Cost	0	$34,300.00	Maintenance	Principal and Interest		Total
Accumulated Cost (AC)	1		$2,944.00	$1,170.00	$4,114.00	$4,114.00
AC	2		$2,944.00	$1,170.00	$4,114.00	$8,228.00
AC	3		$2,944.00	$1,170.00	$4,114.00	$12,342.00
AC	4		$2,944.00	$1,170.00	$4,114.00	$16,456.00
AC	5		$2,944.00	$1,170.00	$4,114.00	$20,570.00
AC	6		$2,944.00	$1,170.00	$4,114.00	$24,684.00
AC	7		$2,944.00	$1,170.00	$4,114.00	$28,798.00
AC	8		$2,944.00	$1,170.00	$4,114.00	$32,912.00
AC	9		$2,944.00	$1,170.00	$4,114.00	$37,026.00
AC	10		$2,944.00	$1,170.00	$4,114.00	$41,140.00
AC	11		$2,944.00	$1,170.00	$4,114.00	$45,254.00
AC	12		$2,944.00	$1,170.00	$4,114.00	$49,368.00
AC	13		$2,944.00	$1,170.00	$4,114.00	$53,482.00
AC	14		$2,944.00	$1,170.00	$4,114.00	$57,596.00
AC	15		$2,944.00	$1,170.00	$4,114.00	$61,710.00



Conclusion

As can be seen, when the green systems are used applying the tax credit, they have a favorable result compared to the conventional methods. However, when the tax credit is removed, the results do not favor the green systems (except when there is no financing and an increase in energy costs, then the results are within 2.5% for conventional versus green without a tax credit). The tax credit is currently due to expire December 16, 2016 and once this happens it will no longer be economically feasible to install this type of system in comparison to conventional methods. There were also three other factors that provided very favorable conditions for the green option:

1. The area analyzed in northwest Indiana was a favorable area with open areas and a good supply wind. For this to occur, ample clear land is needed for a good flow of wind to power the turbine. Heavy urban area with limited amounts of land, or rural areas with trees providing obstructions can severely limit air flow.
2. It assumed that the wind turbine would supply all the power needed for the residence. This is a reach as that with wind turbines, their efficiency is still around 50%. There was no battery backup calculated into the costs and no assumption as to how much power would be needed from the grid.
3. It was also assumed that the homeowners opted not to install an auxiliary furnace to supplement the geothermal system.

It should be pointed out that over the past decade, the cost to install such systems have dropped dramatically (roughly 50%). Also, efficiency of these systems has also increased. However, it is the conclusion that based upon these systems as they currently exist, that the green systems are not as economical as conventional systems. While great strides have been made over the years and efficiencies have greatly improved, it appears to be up to the engineers to continue to improve these systems to make them more economically feasible. If this trend it to continue, it is imperative that young engineers become more familiar with these systems so that continued improvement can be made in the efficiency, design, and construction. Engineering and Engineering Technology programs must include such emerging technologies in classrooms in order to maintain high levels of research and development (a local electrician's union is currently erecting their own windmill for training purposes). With worldwide economies strained, the viability of emerging systems is highly dependent upon innovation in order to make them economically feasible.

[1] http://www1.eere.energy.gov/geothermal/history.html
[2] http://alternativeenergy.procon.org/view.resource.php?resourceID=002475
[3] http://energytaxincentives.org/business/renewables.php