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National Energy Policy

Alternative and Renewable Energy

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Abstract

This Energy Policy is a panoptic view of the current state of electrical energy in the Unites States of America. It contains modeling and research on all major sources of energy, recommendations on how each can change to improve our nation in terms of more available and cheaper energy, and less adverse effects on both the natural environment and daily life. Included in the policy is a notional view of two possible futures: one with plentiful energy and another without.

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Executive Summary

The National Energy policy designed in this project provides a brief overview of the multiple sources of energy available in the United States. The policy highlights the various impacts to the general public, and the impact on the nation based on the type of energy source we choose to use primarily. Current energy consumption and projected energy consumption is compared, and various solutions are suggested in order to mitigate the impact of high fuel demands in the future. The National Energy policy designed in this project analyzes the current energy situation and provides several long term solutions to the energy crisis.

In order to provide a reasonable solution to the energy crisis the current available sources of energy had to be reviewed, therefore a detailed overview of the current sustainability, impact, efficiency, and costs of current energy sources such as Coal, Petroleum, Natural Gas, Solar Power, Wind Power, Hydropower and Nuclear power. The daily life impact highlights the end costs to the consumer from the power company, and the effect on the American Households and their spending based on the amount of money they are spending on fuel costs. Sustainability determines the longevity of the fuel source, and its effect on the country in the long term. Future technologies are suggested which can improve the efficiency of the fuel source and reduce costs of power generation. Costs such as environmental and economic costs to develop the technologies and make them viable fuel sources are highlighted for their respective fuel sources.

To verify that the proposed recommendations and solutions were feasible calculations were attempted to verify the reasoning. A mathematical model which minimizes costs and maximizes sustainability based on different criteria that are provided. Costs, Sustainability, and availability are judged based on a scale and then used in the equation to generate a linear model to find the optimal energy solution.

Resolving the energy crisis is crucial to assuring a strong future for America, but in the event goals are not met the consequences of failure and the changes that will occur in society are predicted. Changes such as communal living, small communication and travel ranges. Spending in general will decrease and people will migrate to prosperous areas in order to maintain their lifestyles. Fuel will become a luxury and only the rich will be able to afford it. On the other hand, if the fuel crisis is resolved there will be prosperity in the world.

If there is an infinite source of fuel, the country will prosper and make large strides in technology, and have an improved economy. Technology will focus more on solutions rather than on conserving power. Once there are no limits on technological progress there will be a boom in the technological market. With the current technological capabilities in the United States technology, it may become the major export in the country.

The solutions suggested must be made in order to resolve the current energy crisis and bring forth a prosperous America. It highlights the steps to take in order to reduce dependency on foreign fuels as well as reduce environment degrading emissions. The National Energy Policy is necessary to improve the lives of the American Public.

Energy Challenges Facing the United States

I. Current Energy Reserves

The United States is currently heavily dependent on non-renewable sources of energy. These sources of energy are consumed by everything people do; driving engines, heating homes, and powering everything electronic used on a daily basis. The problem with the nation's energy dependency is that it relies on resources with a finite quantity. The United State's consumption of oil has climbed every year from 1982 to 2005, but it has decreased slightly in the past four years [1]. Alternative plans need to be made for the future energy consumption of the United States because the current proven reserves of fossil fuels will not last forever.

The primary fossil fuels that the United States is dependent on are oil, natural gas, and coal. The Energy Information Administration (EIA) carefully tracks worldwide proven reserves of fossil fuels and they produce reports regularly with this information. The most recent EIA estimates of the proven reserves conclude that the world has 1.342.207 billion barrels of extractable oil. The average world consumption of oil is 85.46 million barrels (.08546 billion barrels) of oil per day. The leader in oil consumption is the United States with 19.5 million barrels consumed per day (2008). The reserve estimates for oil are the most dramatic out of all of the fossil fuels because the proven reserves are so small compared to our consumption. At the current rate of consumption we would only have enough oil for slightly over 43 years assuming that we were able to extract every last drop of oil and no new oil fields were discovered. If nothing is done to find a better way to detect oil reservoirs or a much more efficient way to economically extract oil, the price of oil will increase beyond the market will pay for it well before the last drop would be extracted 43 years from now. The United States also has a very large dependency on coal [1].

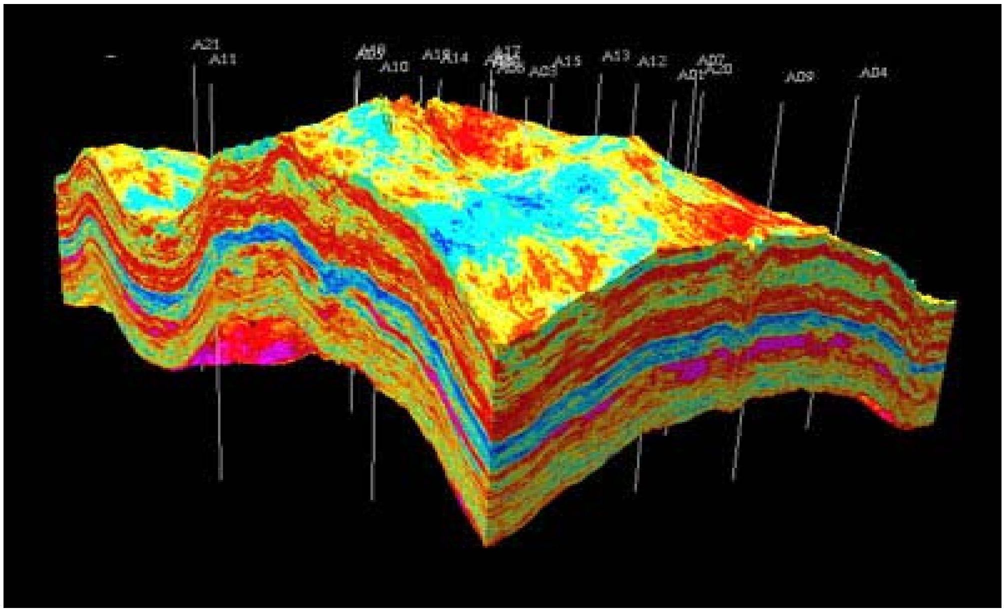
The primary way the United States generates electricity is with coal, a much more abundant fossil fuel. Coal does have more uses than just to boil steam that spins turbines. It is also used in a variety of manufacturing processes. The Energy Information Administration estimates that the worldwide proven reserves of coal total to 1,000,912 million short tons of coal. The world consumes 19.71 million short tons of coal daily mainly for generation of electricity. The world leader in daily coal consumption is China at 7.92 million short tons per day, and the United States is the second largest consumer at 3.09 million short tons per day. Assuming that the current consumption rate stays constant and that every short ton of coal can be extracted, the world would have enough coal to last for the next 139 years. The United States generates 91.11% of electricity with non-renewable resources, and 48% out of that 91.11% is generated by coal. The nation's dependency on coal for electricity generation can be greatly reduced by the improvement of current renewable energy technologies. The world also depends on natural gas, another fossil fuel [1][4][7].

Natural gas has many residential, commercial, and industrial uses as well as being a main source of electricity generation. The main residential and commercial use of natural gas is for space heating, but it is also used for lighting and water heating. The Energy Information Administration estimates that the worldwide proven reserves of natural gas total 6,342.411 trillion cubic feet of natural gas. The world consumes 300 billion cubic feet of natural gas daily, mainly for home heating. The world leader in daily natural gas consumption is the United States at 63.5 billion cubic feet of natural gas consumed daily[1]. Although the nation's supply of natural gas is limited, advancements in shale gas are going to dramatically change the natural gas dynamic in the upcoming years. Concentrated solar power is also a good supplement to natural gas and can be used for heating and power generation. Fossil fuels are not the only non-renewable resource that the United States is dependent on, nuclear power is a main part of our electricity infrastructure. The ability to generate nuclear power depends on our supply of uranium.

Nuclear power is the cheapest way the United States can produce electricity, and remains a great source of power generation. The United States generates 806,424 GWhs of electricity just from nuclear power at a cost of 3.01 cents per kilowatt hour [10]. The production cost of nuclear power is the second lowest next to coal at 2.71 cents per kilowatt hour [1]. The United States is the greatest producer of nuclear power 806,242 GWh, and the world total is 2,594.53 GWh of electricity. The proven world reserves of uranium are 4.4 million tones, and the world consumption of uranium is 183.436 tones per day. Assuming that the world consumes uranium at the current rate and that we do not find any more uranium, the world would be able to produce nuclear electricity for another 65 years. The rates of consumption of resources and the supply of resources change constantly based on our technological advancements [10].

The most frequently used method of approximation for oil reservoirs today is seismic inversion. Seismic inversion is a way of creating a 2D or 3D model of subterranean features such as the one in Image 1.1. Seismic inversion uses a source to generate an S-wave and a P-wave and then the results are recorded and analyzed. The sources used to generate the waves depend on how deep the surveyor wants to capture. The sources vary from a steel plate pounded with a sledgehammer to vibrator trucks or explosive charges. A geophone then used to record the seismic activity. P-waves (primary waves) travel through the any material and travel at different speeds depending on what type of material they are traveling through. The analysis of the speed of the P-waves show what materials they passed through. The S-waves are 60% slower than P-waves and can only travel through solids. The comparison between what P-waves passed through and what S-waves passed through can revile what type of material is underground [5].

Another option that is currently being researched is the use of nano-reporters to discover exactly what is in the oil reservoir. Rice university claims is currently creating 100-300nm hydrophilic carbon clusters, nano-reporters, that will be able to detect what types of materials they came in contact with (water, oil, other chemicals), and by changing their structure periodically the observer will be able to tell when the nano-reporters came into contact with different chemicals. By continually pumping these nano-reporters into the reservoir, changes can be monitored continuously [6].



Seismic inversion 3D map [http://www.kh-oil.at/img/abrak/seismic.jpg]

II. Consumption and Production Rates

America's energy concerns begin with the discussion of American disposition towards energy and the manner in which they utilize it. People in general want to create an ideal system where, the source of the energy is environmentally friendly, relatively inexpensive and the person can utilize as much energy as they see fit. The issue with this mentality is that it is wasteful, and given that humanity has a finite amount of resources to convert into useable energy. A recent gallop poll shows that American's would like to promote alternative energies as well as traditional energy sources [1]. This though process will hinder the progress in the development of new cheaper and cleaner energy. If the U.S continues with this mentality the cost of traditional energy will drastically ascend and there a lack of other viable energy sources for humanity to use.

1. Residential Consumption

If you examine the cost of energy over time (Figure 1.1) and compare the relationship it holds the consumption rates (Figure 1.2) we can come to a conclusion that technological advancements and will reduce the cost of any resource to its physical limits. Even with these fluctuations in cost the ultimate trend is an increase in consumption equates to an increase in cost. Given the particular example of number of T. V's in an average of house hold in the in 1980 and comparing this value with the current average we see an increase of 2 T.V.s [2]. The TV analogy is meant visualize that progression also decreases the cost of “electronic products” and these items will increase the overall consumption of the average residential consumer. In 2008 consumers utilized .09 Quadrillion Btu more compared with the amount of energy produced in 2007(table1). This increasing trend is a major concern and if this trend is not kept in check then humanity will reach a critical energy drought [3].

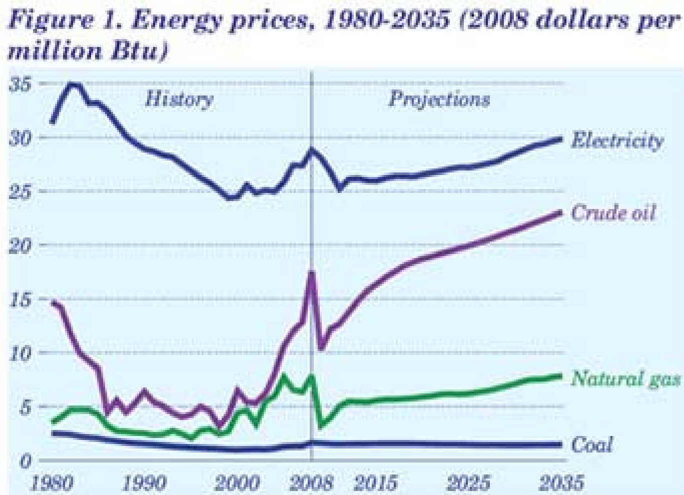


Figure 1.1

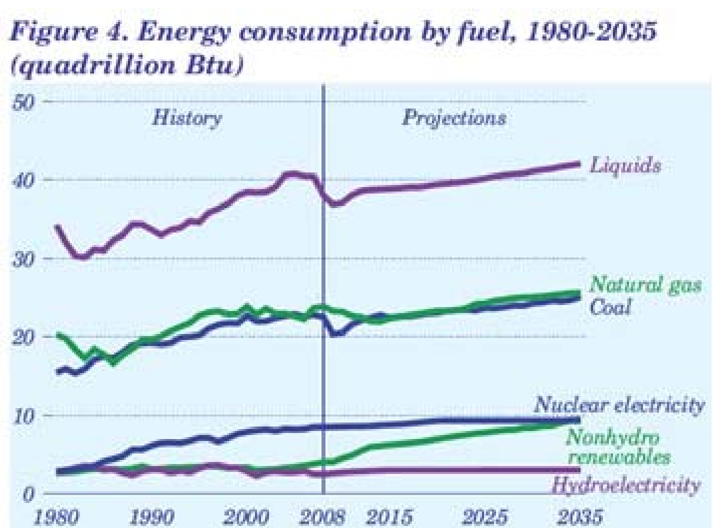


Figure 1.2

2. Commercial and Industrial Consumption

From a commercial and industrial standpoint, advancements in technology affect energy consumption proportional to residential consumption. As technology advances so does the manufacturing process, which in turn reduces the manufactured price and the selling price. This reduction allows consumers to buy larger quantities of the product, which in turn increases residential, but reduces commercial and industrial consumption. In 2008 the commercial sector utilized .14 Quadrillion Btu more compared with the amount of energy produced in 2007 and the Industrial sector utilized .38 Quadrillion Btu less compared with the amount of energy produced in 2007(table1). Since the industrial sector historically increases its energy consumption the difference between 2008 and 2007 must be an anomaly. Even though the manufacturing process improvements have reduced the manufacturing price, the increase in production explains why industry's consumption also increases.

3. Current Energy Production

Production is needed to keep up with consumption rates, but given the vast amounts of production needed, we need different areas to get the maximum production. Areas that use fossil fuels are close to their limits and other areas like wind have almost reached their maximum efficiency. But then you have more breakthrough technologies like new solar cells and nuclear fusion both of which seem promising. The combination of all these resources will allow the use to become self sufficient in there consumption needs.

Fossil Fuels

Oil, coal and natural gas are non-renewable sources of energy which are formed from decayed remains of plants and animals. The fuels are burned to release the chemical energy that is stored within this resource. When talking about oil it is generally common to quantify the energy output of oil in terms per barrel, that is 1 barrel of crude oil is equal to 5.6 MBtu [4].

As we can see from Figure 3 that we currently have to import a substantial quantity of oil from other countries because our domestic production does not meet the domestic consumption. When referring to cheapest form of fossil fuel, coal, we can infer that the average production of coal per year is around 7 billion short tons or 133 quadrillion Btu even though coal is the cheapest directly there are a multitude of other factors such as environmental issues that create an added cost. This “hidden” cost will be discusses later. The last form of fossil fuel mention is natural gas, which include methane and its derivatives like propane and butane. We can see from Figure 4 that we currently do not enough production to meet the demands of domestic consumption.

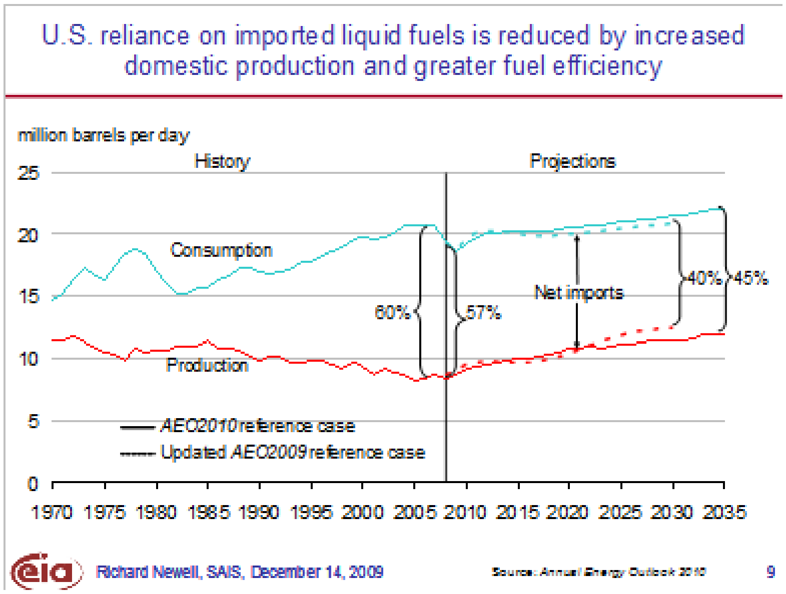


Figure 1.3

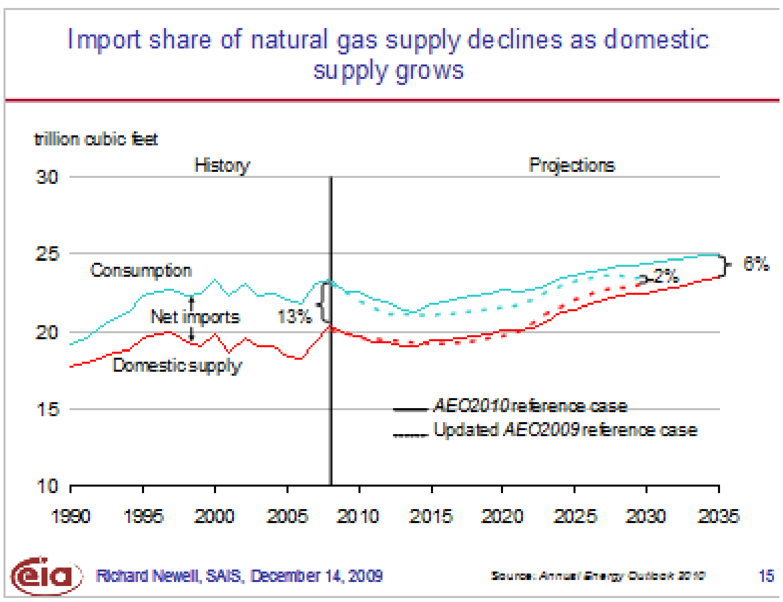


Figure 1.4

Nuclear Power

The USA has 104 nuclear power reactors in 31 states, operated by 30 different power companies. In 2008, the country generated 4,119 billion kWh of electricity, 49% of it from coal-fired plant, 22% from gas and 6% from hydro. Nuclear achieved a capacity factor of 91.1%, generating 805 billion kWh and accounting for almost 20% of total electricity generated in 2008. Total capacity is 1,088 GWh, less than one tenth of which is nuclear. Annual electricity demand is projected to increase to 5,000 billion kWh in 2030. Annual per capita electricity consumption is currently around 12,400 kWh.

Another type of nuclear power is called fusion, it is the power generated by nuclear fusion reactions. In this kind of reaction, two light atomic nuclei fuse together to form a heavier nucleus and in doing so, release a large amount of energy. Some nuclear power reactors are designed to produce approximately 500 MW of fusion power sustained for up to 1,000 seconds. While that might not seem like a substantial about of time, consistently it could make any other energy source obsolete.

Solar Power

The solar power plants are designed to provide electrical power on the same scale as plants that rely on nuclear powers. Solar power plants use sun-tracking mirrors to concentrate sunlight at the top of a tower. The solar power plant built in the Mojave Desert uses 1900 mirrors to reflect sunlight onto a 300 foot tall tower. The power plant was built in the 1980s and generates 10 megawatts. A simple use for passive solar energy is direct solar heating and cooling in buildings. Another form of production would be to use simple method such as an overhang on buildings can passively cool and heat homes during the summer and winter seasons. Due to the positioning of the earth the angle of the sun to the surface of the earth based on the season and time of the year.

Wind Energy

Wind energy as defined by the U.S. Department of Energy (DOE) is the “process by which the wind is used to generate mechanical power or electricity.” Wind's energy is most commonly captured using turbine generators with some type of blades attached. Utility scale turbines built today fall generally in the 700kW to 2.5MW range although continuous output is very dependent on wind speed. Wind has great potential for high production because theoretically you would only need 16% of the US to be covered in wind farms to produce energy for the entire world assuming 8 billion people or less were living on earth and each person needed 200,000 MJ per year.

4. Issues between Production and Consumption

As explained above the consumption rates are too large for the U.S. to be self sufficient forcing dependency on other countries. If more money isn't invested in technologies like fusion or solar cells there will be massive inflation in the future and eventually there will not be any more production for the consumption. Supply and demand dependencies weaken our economy and ultimately create an imbalance in the world because if the consumption keeps rising and the production plateau, prices will inflate rampantly.

III. Projected Energy Rates in the United States

Energy drives our economy, transportation, and is responsible for the livelihood of the American population. The current population, economy and transportation sectors are growing and this growth is not expected to stop. Energy production must also grow at a similar rate. The United States Census Bureau calculates that there are 308,658, 331 people in the United States as of February 10, 2009 4:45 PM. The population however will not remain constant because the Census Bureau expects a birth every 7 seconds, a death every 11 seconds, and an immigrant into the country every 34 seconds. The National Census of 2000 recorded 281, 421, 906 people in the country, and we have crossed another decade and another Census is taking place. Over the past ten years the country has seen a growth rate of 9.67 percent. The country is growing, and the energy sector must grow at a rate sufficient enough to meet the demands of the ever increasing population [2].

Energy is necessary for the transportation of people, goods, and services. It is necessary for the American people to have sufficient energy to commute to work and other places as necessary to sustain their livelihoods. Over the past several decades the number of cars, trucks and other modes of transportation have increased substantially, causing the increase in energy consumption and raised demand for fuels. Between 1960 and 2007 there has been 179,971,282 registered vehicles put on the road, which is a growth rate of 70% over 47 years. If the growth rate is sustained through the tough economic conditions if the current growth rate remains constant it can be expected that 434,374,364 registered vehicles will be put on the road in another 47 years. Energy production must be increased in order to meet the ever growing demands of the transportation sector [3].

As of 2008 the U.S Petroleum consumption rate is 19.50 Million barrels per day, of which 13.70 million barrels are consumed by the transportation sector. The domestic production of petroleum is 6.73 million barrels per day and 12.92 million barrels are imported per day to complete make up the discrepancy in consumption. According to the U.S Energy information Administration the total number of barrels consumed by the transportation department in the year 2008 was 5000 million barrels, and in their annual energy outlook it is predicted that there will be a 0.6% annual growth in consumption between 2008 and 2035. By 2015 it is expected that the transportation department will consume 5012 million barrels per year, with the majority of the fuel source being in motor gasoline.

As the population increases so will the number of homes in the country, therefore increasing the consumption rate of energy in the residential sector. During the 2000 Census it was counted that there are 69,865,957 single family homes, and 6,447, 453 single family attached homes, and 30,549,390 apartment buildings, and 8,779,228 mobile homes in the United States. As of 2008 the Residential sector has used 21.54 quadrillion BTUs per year, and it is projected by 2035 there will be an annual growth of 0.4%. In the year 2015 it is projected that the residential sector will use 21.31 quadrillion BTUs, which is a decrease over a 17 year period, but will once again increase back to 23.92 quadrillion BTUs by 2035.

The United States is a highly industrialized country and the energy necessary to sustain the industrial sector is ever increasing. In 2008 a total of 32.07 quadrillion BTUs was used by the industrial sector, and it is expected that the demand will increase to 32.90 quadrillion BTUs by 2020. The industrial sector currently uses multiple sources of energy with 28% of the energy used being natural gas, and electricity at 14%. Secondary sources of energy are used to produce heat, power, and electricity which include steam, wood, and agricultural wastes.

Current United States production rates are not high enough to meet the energy demands and a large portion of fuel must be imported in order to meet the national energy demand. As of 2008 a total of 74.23 quadrillion BTUs of energy was produced domestically and 32.79 quadrillion BTUs were imported to meet the 100.09 quadrillion BTU consumption. It is projected that by 2035 there will be a 0.8% annual growth in production, but a 0.5% annual growth in total consumption. It is predicted that 9.41 quadrillion BTUs of the 90.83 quadrillion BTUs of energy produced by 2035 will be from nuclear energy sources and 15.62 of the 90.83 BTUs is expected to be produced by renewable sources and biomass. However, production of crude oils, Natural Gas, and Coal will continue to increase annually by a total of 1.6%, with crude oil production increasing at the highest annual rate of 0.9%. It is also projected that imports of crude oil will decrease by 0.4% annually by 2035.

Importing energy will cause increases in prices to the end users. It is expected that the price of Petroleum will increase from 99.57 dollars to 133.22 dollars by 2035 at an annual increase of price of 1.1%. Natural Gas prices are expected to fluctuate over the next 35 years showing no overall increase in price. Coal is expected to decrease in price.

If the population increases and the various sectors grow at their projected rates as well as projected rates of energy consumption, the United States must significantly increase energy production. In order to increase production, new sources of energy, crude oils, and renewable energy must be found. Renewable energies and their sustainability must be a primary focus. Reductions in energy imports must be made in order to reduce energy costs as well as maintain an upper hand in the global economy, and reduce the dependency on foreign sources.

Table A2. Energy Consumption by Sector and Source
(Quadrillion Btu per Year, Unless Otherwise Noted)

Sector and Source	Reference Case							Annual Growth 2008-2035 (percent)
	2007	2008	2015	2020	2025	2030	2035	
Energy Consumption								
Residential								
Liquefied Petroleum Gases	0.48	0.45	0.41	0.40	0.40	0.40	0.40	-0.4%
Kerosene	0.04	0.04	0.04	0.04	0.03	0.03	0.03	-1.0%
Distillate Fuel Oil	0.73	0.68	0.59	0.53	0.49	0.45	0.41	-1.9%
Liquid Fuels and Other Petroleum Subtotal	1.25	1.18	1.04	0.97	0.92	0.88	0.85	-1.2%
Natural Gas	4.84	5.01	4.85	4.97	5.04	5.03	5.01	0.0%
Coal	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-1.3%
Renewable Energy[1]	0.41	0.45	0.40	0.42	0.42	0.42	0.43	-0.1%
Electricity	4.75	4.71	4.78	5.02	5.30	5.58	5.83	0.8%
Delivered Energy	**11.25**	**11.34**	**11.07**	**11.38**	**11.69**	**11.93**	**12.12**	**0.2%**
Electricity Related Losses	10.29	10.20	10.24	10.65	11.08	11.45	11.79	0.5%
Total	**21.54**	**21.54**	**21.31**	**22.03**	**22.76**	**23.38**	**23.92**	**0.4%**
Commercial								
Liquefied Petroleum Gases	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.5%
Motor Gasoline[2]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.2%
Kerosene	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.7%
Distillate Fuel Oil	0.38	0.36	0.31	0.29	0.28	0.27	0.26	-1.2%
Residual Fuel Oil	0.08	0.07	0.09	0.09	0.09	0.09	0.09	0.7%
Liquid Fuels and Other Petroleum Subtotal	0.62	0.58	0.55	0.53	0.53	0.52	0.52	-0.4%
Natural Gas	3.10	3.21	3.32	3.43	3.55	3.66	3.79	0.6%
Coal	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.0%
Renewable Energy[3]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.0%
Electricity	4.56	4.61	5.00	5.37	5.76	6.16	6.55	1.3%
Delivered Energy	**8.44**	**8.58**	**9.04**	**9.50**	**10.00**	**10.51**	**11.04**	**0.9%**
Electricity Related Losses	9.88	10.00	10.72	11.39	12.03	12.63	13.27	1.1%
Total	**18.32**	**18.58**	**19.77**	**20.89**	**22.03**	**23.14**	**24.30**	**1.0%**
Industrial[4]								
Liquefied Petroleum Gases	2.28	2.14	2.31	2.61	2.55	2.46	2.35	0.3%
Motor Gasoline[2]	0.31	0.30	0.30	0.30	0.30	0.30	0.30	0.1%
Distillate Fuel Oil	1.26	1.19	1.19	1.19	1.17	1.17	1.17	-0.1%
Residual Fuel Oil	0.19	0.18	0.14	0.14	0.14	0.14	0.13	-1.1%
Petrochemical Feedstocks	1.31	1.12	1.09	0.81	0.82	0.82	0.81	-1.2%
Other Petroleum[5]	4.45	4.05	4.01	3.95	3.89	3.94	3.92	-0.1%
Liquid Fuels and Other Petroleum Subtotal	9.80	8.99	9.04	9.01	8.87	8.82	8.70	-0.1%
Natural Gas	6.81	6.84	7.08	7.23	7.14	6.94	6.91	0.0%
Natural-Gas-to-Liquids Heat and Power	0.00	0.00	0.00	0.00	0.00	0.00	0.00	- -
Lease and Plant Fuel[6]	1.22	1.32	1.11	1.12	1.23	1.26	1.29	-0.1%
Natural Gas Subtotal	8.03	8.16	8.19	8.35	8.37	8.20	8.20	0.0%
Metallurgical Coal	0.60	0.58	0.52	0.54	0.50	0.44	0.36	-1.7%
Other Industrial Coal	1.21	1.17	1.07	1.08	1.07	1.06	1.04	-0.4%
Coal-to-Liquids Heat and Power	0.00	0.00	0.16	0.24	0.34	0.45	0.55	27.6%
Net Coal Coke Imports	0.03	0.04	0.01	0.01	0.01	0.01	-0.00	- -
Coal Subtotal	1.83	1.79	1.76	1.88	1.92	1.96	1.95	0.3%
Biofuels Heat and Coproducts	0.40	1.03	0.77	1.02	1.49	1.90	2.56	3.4%
Renewable Energy[7]	1.62	1.50	1.59	1.69	1.74	1.79	1.83	0.7%
Electricity	3.51	3.35	3.40	3.51	3.49	3.47	3.47	0.1%
Delivered Energy	**25.19**	**24.81**	**24.76**	**25.45**	**25.88**	**26.14**	**26.70**	**0.3%**
Electricity Related Losses	7.60	7.26	7.29	7.45	7.29	7.12	7.01	-0.1%
Total	**32.79**	**32.07**	**32.05**	**32.90**	**33.18**	**33.26**	**33.72**	**0.2%**

Table 1.1 – Energy Consumption [1]

IV. The Various Energy Sources

This chapter of the Energy Policy aims to introduce all energy sources discussed throughout the document, presenting information about why each was selected, how viable and sustainable each is, and how each might impact our future. The sources covered are coal, natural gas, crude oil, nuclear power, hydropower, solar, wind, and most methods of extracting usable energy from each. Furthermore, all of the above sources also have a dedicated chapter that discusses impact on daily life, raw availability, monetary and environmental costs, available infrastructure, comparisons between sources, and plans for energy collection and distribution nationwide, now and in the future.

1. Coal

Coal has been used as a fuel by humanity for over 1800 years and, over the decades, has grown into the single largest source for generating electricity worldwide. However, coal has also rightly earned a reputation as a polluting fuel, producing more carbon dioxide than any of the other fossil fuels as well as various other pollutants. Because of the above facts, any energy plan must deal with coal and its advantages and drawbacks.

The most recent estimate of coal availability in the Unites States comes from the U.S. Energy Information Administration report released in 3 February, 2009. It claims a total of 489 billion short tons of the various types of usable coal (anthracite, bituminous, sub bituminous, lignite) exist in the U.S. Alone, 262 billion of which would be available for extraction. This large reserve drives coal to be both cheap as an energy source and available for many decades to come.

Coal's polluting properties have also driven technological research towards cleaner use dubbed "clean coal technologies", which are usually focused on reducing CO_2 emissions and capturing sulfur. The first plant to use one of these technologies is a power plant in Spremberg, Germany. It uses a type of Carbon Capture and Storage (CSS) technique with hopes to store the captured CO_2 and store it in various geological formations, reducing emissions 80-90%.

2. Natural Gas

Originally a byproduct associated with other fossil fuels, natural gas has since become a major source of electrical generation. The main gas used for this purpose is methane, which is separated from other gasses found in the same locations. Much like coal, it is a greenhouse gas producing source although in much smaller quantities.

The main reason natural gas must be considered in energy planning are the new reserves continuously being discovered. The re-evaluation of previously deemed unusable reserves such as shale-gas plays due to new technological advances such as modern hydraulic fracturing techniques have led to the Potential Gas Committee to report an increase to 2074 trillion cubic feet (Tcf) of future supply in the U.S. - an almost 25% increased from previous reports. This new availability has turned natural gas into a much longer lasting resource than the previous estimates of 6 decades deemed possible.

3. Petroleum

Since 1950, petroleum or crude oil has become the world's most important energy resource. Factors such as ease of transport, widespread availability, and high energy density have turned oil into the main transportation fuel worldwide. Its composition has also led it to be used in many modern day products such as various pharmaceuticals, solvents, pesticides, and plastics. These two facts make oil indispensable.

Reserves of oil are constantly dwindling at alarming rates, leading some to believe the world faces an energy crisis. However, new reserves and the re-evaluation of unconventional oil reserves such as heavy oil and oil shale have been driving production rates and considered reserves up to keep up with demand.

In the U.S. there are only reserves of around 19 billion barrels of oil (less than 1.5% of world reserves) while the U.S. Remains the world's largest consumer. This leads to a need to evaluate what kind of place crude oil has in the United State's future.

4. Nuclear Power

The term nuclear power can refer to any non-explosive nuclear reaction outputting some useful energy but it most commonly refers to a nuclear fission reaction used to indirectly generate electricity. Nuclear power is fairly widespread in the world, providing around 15% of total electrical generation, and 19% in the U.S.

The fuel used to generate electricity in nuclear power plants are isotopes of with large fissile atomic nuclei such as uranium-235. However, this isotope occurs in nature at concentrations of only about .7% in uranium deposits, and therefore mines uranium must be enriched. Relatively large deposits of uranium yield small amounts of reactor usable isotopes. Despite this, there are enough uranium deposits worldwide to last hundreds of years at current rates of consumption, with the U.S. alone having reserves of 498 million tons of ore.

Challenges that threaten the future of nuclear power include two main categories: the public adversity to nuclear power plants in their area, and the disposal of spent fuel. Due to accidents such as the partial meltdown of a Three Mile Island reactor core and the Chernobyl disaster have rightly driven public opinion against nuclear reactors. Coupled with the hardships of disposing or reusing spent fuel rods, careful consideration must be given to nuclear power's future as a U.S. Energy supplier.

5. Hydro-electric

Hydro-electric generation uses the flow of water to drive an electrical generator and is currently the most widespread and successful renewable energy source in the world. Despite this, hydroelectricity has major drawbacks here in the U.S.

Only 5.74% of all electricity generated in the States is hydro-powered, and for good reason. The total capacity of the U.S. to generate electricity from river dams has almost been reached. In order for hydro-power to be a future competitor to other sources as energy demand increases, the potential of new technologies must be evaluated.

6. Solar Power

Solar power is a term that refers to the generation of electricity from sunlight either by photovoltaic means or by concentrated solar power. Solar power has the potential to supply most if not all of the world's electrical energy needs. This potential is not being met, with only .02% of world electrical supply coming from solar power. The reasons for this are mostly economical.

The cost per kWh of solar is between 2 and 5 times greater than today's average 3-6 cents per kWh, with most of this cost being highly expensive initial components and installation. Solar is also at a disadvantage since it cannot continuously produce power on larger scales. Another factor driving solar down is the inefficiency of photovoltaic panels and the loss of power in the concentrated solar heat to electrical conversion. Even with these many drawbacks, solar power should be included in long term energy planning due to its enormous potential and expectations of improved technology.

7. Wind Power

Generating useful power from wind is one of the oldest forms of extracting energy from nature known to man. Today's focus is using wind to drive electricity generating turbines to help alleviate the pressures of continuously increasing demand.

Wind suffers from similar drawbacks as solar power but also shares the same potential. Wind could theoretically supply all of the world's power using similarly sized areas, but it cannot supply this continuously due to variation in wind speeds. It also suffers from high initial cost and a somewhat high cost of maintenance but both are much lower than all other renewable sources other than hydro power due to larger investments of both time and money, at present and in the past, into developing better, cheaper, and more efficient turbines.

Together with solar power, wind could become a large part of the solution to today's energy problems.

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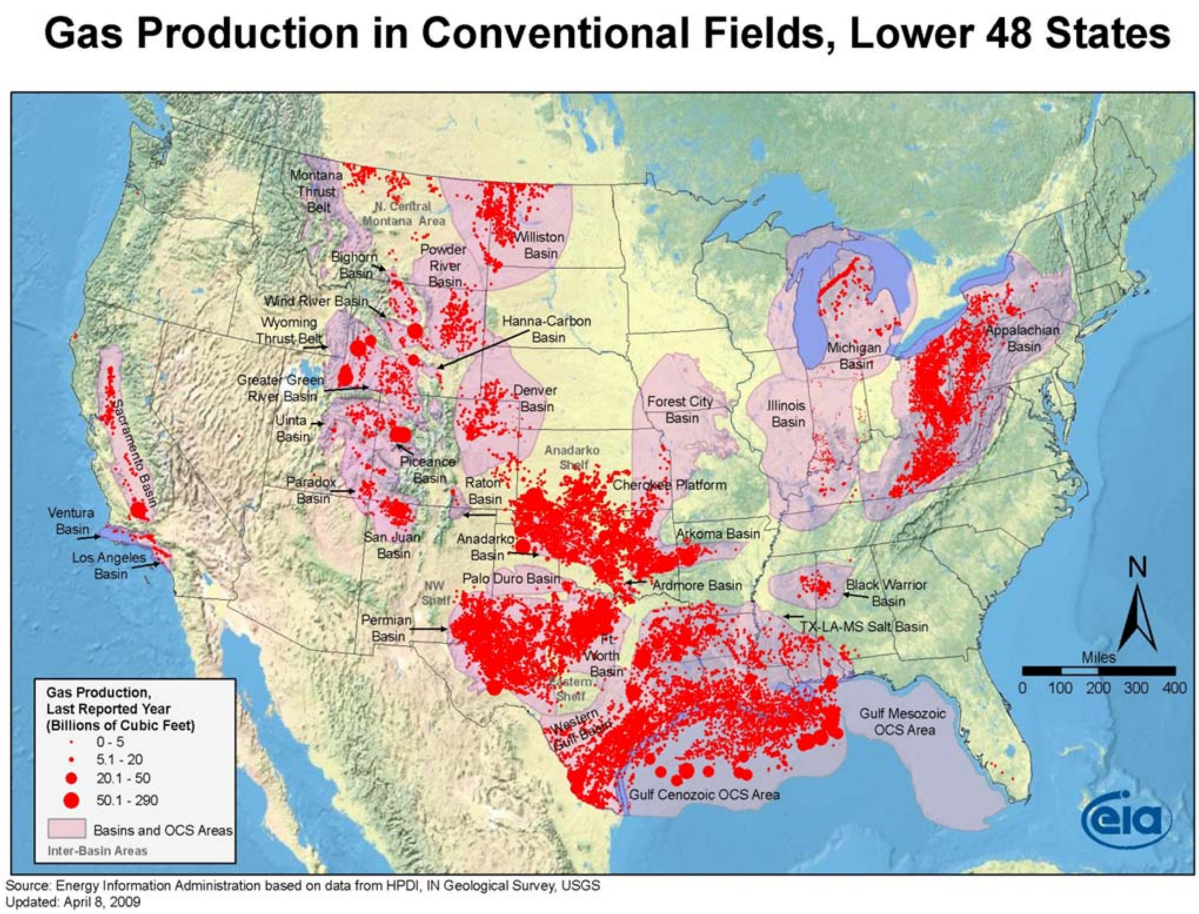
Natural Gas

I. Availability

The availability of natural gas is vital to the United States. Americans primarily use for electricity generation, but natural gas is also used for home heating and transportation. The United States generated 920,378 thousand megawatt hours of electricity from burning natural gas in 2009. Natural gas supplied the United States with 23.3 percent of its net electricity generation in 2009 [1].Natural gas is being consumed at in increasing rate each year worldwide. The total natural gas consumption in worldwide in 1980 was 52,890 billion cubic feet, and in 2006 the world consumed 104,425 billion cubic feet of natural gas. The United States currently consumes the most natural gas out of any country, 21,653 billion cubic feet in 2006. The second largest consumer of natural gas is Russia at 16,598 billion cubic feet. Natural gas is necessary for America's power needs [2].



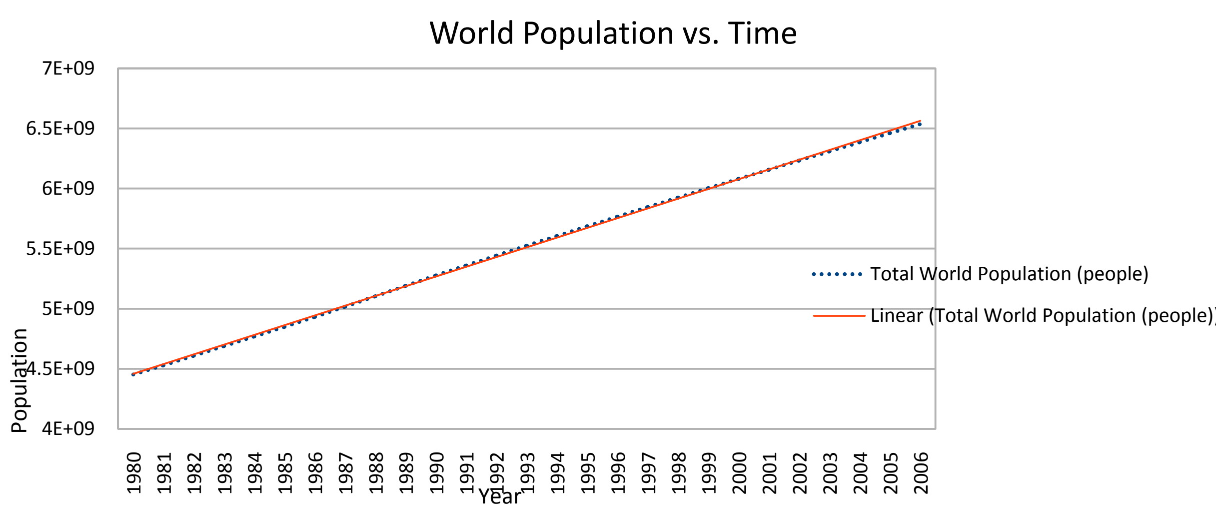
http://www.eia.doe.gov/oil_gas/rpd/conventional_gas.jpg

Most of the world's proven reserves of natural gas lie in Russia. Russia has an estimated 1,654 trillion cubic feet of natural gas that can be extracted. The world only has an estimated 6,436 trillion cubic feet of natural gas. Russia owns a little more than a quarter of the entire world's natural gas reserves. The United States has an estimated 238 trillion cubic feet of natural gas (3.7% of the world's total reserves). However, shale gas will change these numbers in the near future though because surveying and extraction of shale gas has just begun.

Harvesting natural gas from shale has just begun and it looks very promising for the future of world's natural gas reserves. The Marcellus shale (basin of the Appalachian Mountains) has been estimated to have over 494 trillion cubic feet of natural gas that can be extracted, which would more than triple the United States proven reserves of natural gas. The total increase in world reserves by harvesting shale gas is still unknown, but there is a good possibility that natural gas will be one of the last remaining non-renewable sources of energy.

A good approximation of the time the world will run out of natural gas can be made using data of the population growth, and the past consumption statistics. Figure 2.1 is a graph that shows the population of the world, as estimated by NPG, as a function of time. Figure 1 shows that from 1980 to 2006, the population has increased almost linearly at a rate of 81 million people per year. The total natural gas consumption has also increased from 1980 to 2006, but not at a linearly. The total world natural gas consumption can be seen in Figure 2.2. An average number of cubic feet of natural gas consumed per person per year and can be calculated using figure 1 and figure 2. The graph of the average number of cubic feet of natural gas consumed per person per year from 1980 to 2006 can be seen in Figure 2.3.

Figure 2.1



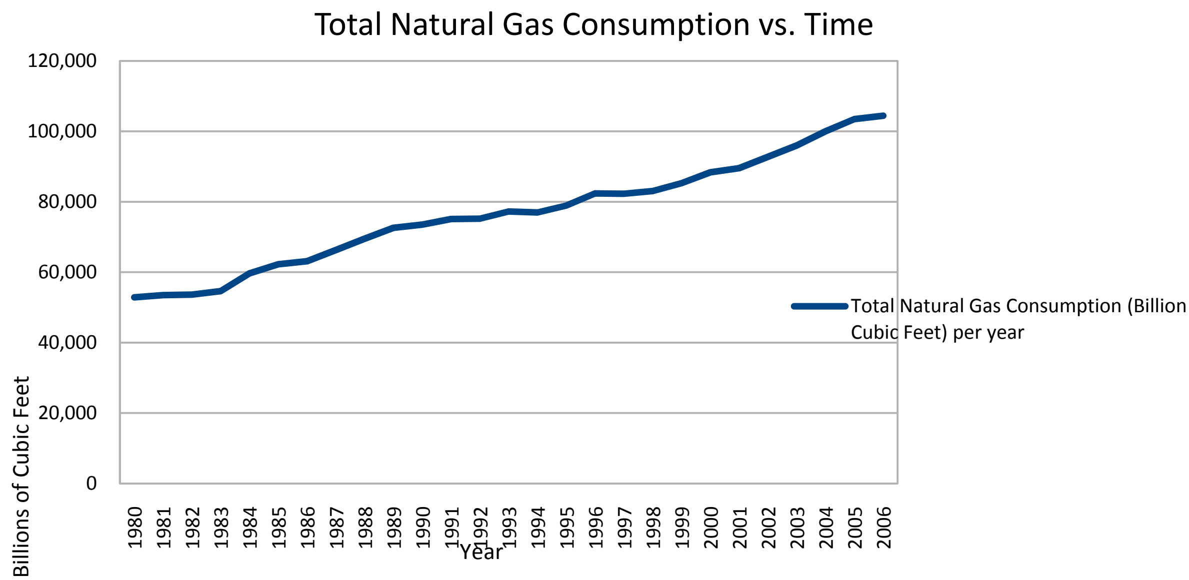


Figure 2.2

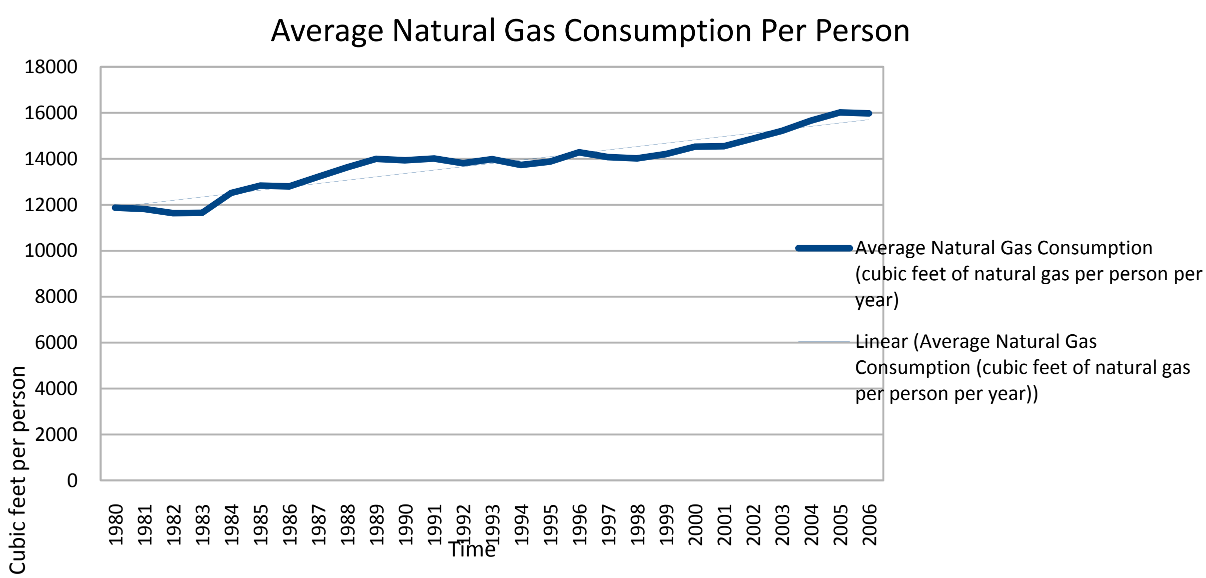


Figure 2.3

The average natural gas consumption per person has increased from 1996 to 2006. Using a least squares regression line, assuming that the average natural gas consumption per person has increased fairly linearly and will continue to increase linearly, the rate of natural gas consumption can be approximated as a quadratic function. An increase of 81 million people per year corresponds to an increase of (1293.73 + 11.85x) billion cubic feet of natural gas. An increase of (1293.73 + 11.85x) billion cubic feet of natural gas per year means that (1293.73x + 11.85x^2) extra billion cubic feet will have to be consumed each year. To find out how long the current reserves of natural gas will last, equation 1 must be used.

$$\int_0^y (11.85\mathrm{x}^2 + 1293.73\mathrm{x} + 104425)\, dx = 6436000$$

eq. 1

Applying the fundamental theorem of calculus yields a simple polynomial seen in equation 2.

$$3.95\mathrm{y}^3 + 646.865\mathrm{y}^2 + 104425\mathrm{y} = 6436000$$

eq. 2

Then the polynomial can be graphed and an intersection between the polynomial and 6436000 can be found.

$$y = 45.36$$

Assuming that the population continues to increase linearly and the total world's natural gas consumption per person grows linearly for the next 46 years, then the last of the proven reserves of natural gas will be depleted in 45.36 years. This figure is much different than the figure if we assumed that population growth and average energy consumption per person remained constant. If the system remained constant, then we would run out of natural gas in less than 62 years. If there are not more explorations into extracting shale gas and improving the efficiencies of current power generation and transmission, then natural gas will only be around for the next half a century.

Natural gas is a much less available than coal so its use for electricity generation should be reduced. The federal government should give large incentives to companies that are currently exploring shale gas to increase our natural gas reserves greatly.

II. Economic Cost

The costs for producing electricity from burning natural gas in the United States are competitive with coal which is why shale gas needs to be exploited. The cost per thousand cubic feet of natural gas at wellhead price has fluctuated wildly in the past decade. The average annual cost of natural gas has ranged from $1.55 per thousand cubic feet in 1995 to $7.96 per thousand cubic feet in 2008. The wellhead price is also reflected in what residential customers pay. The price per thousand cubic feet of natural gas has ranged from $5.80 in 1990 to $13.89 in 2008. The price paid by power plants is also related to the wellhead price, but it is slightly less than the price to residential customers. The price for natural gas for electricity generation has ranged from $2.40 per thousand cubic feet in 1998 to $9.26 per thousand cubic feet in 2008. The costs associated with generating electricity from natural gas are similar to coal or any other fossil fuel based power plant [4].

The large fluctuation in prices of natural gas can be alleviated with the discovery of much more domestic shale gas. The federal government should heavily invest into exploring shale gas.

III. Environmental Effects

The main environmental concern when discussing natural gas and its derivative would be its effect on the climate. Natural gas effects the climate because of it chemical composition. Natural gas is composed approximately of 80% Methane, 10% Ethan, Propane, Butane, 4% CO_2 and trace amounts of Oxygen, Nitrogen and other rare gasses. The top three gasses of natural gas are an issue because they contain three or more atoms; this property renders the spinning molecules incapable of keeping the center of charge stationary. This physical property causes the particular molecule to absorb infrared radiation more efficiently.

This conservation of infrared radiation causes the entire "green house" effect to drastically change the Earth's entire ecosystem. There are many assumptions taken into consideration when idealizing the greenhouse effect. Both the temperature of the surface and the atmosphere of the planet are assumed to be constant. The albedo is the amount of infrared radiation that is reflected back into space, the quantity of the albedo is dependent on the particular material (I.E. the ocean land masses … among other reflective material each of which has its own level of albedo). As Methane, Ethan, Propane, and Butane contain three or more atoms in their respective molecules they reduce the albedo because they absorb the outgoing infrared radiation and reflect the radiation back to the surface of the earth. This increase in the efficiency of the "green house" effect is called global warming and has environmental concerns such as increased surface temperature, rising sea levels, stronger hurricanes, extinctions of entire species, and the decreases of the oxygen concentration of in the oceans.

Due to Methane having more atoms than Co_2 it is a greater contributor to the green house effect, but methane is used as an energy source and the byproducts created when you burn methane and other natural gasses the byproduct are typically Co, Co_2, and water. The consumption of natural gas is not a major contributor of global warming as methane reaches the atmosphere when it leaks in the production and consumption process.

If we compare the Co_2 emissions of other fossil fuels, we find that, in 2006, Natural gas only produced 5,911.83 million metric tons of Co_2 compared with 11,218.94 million metric tons of Co_2 produced from the consumption of petroleum and 12,064.64 million metric tons of Co_2 the consumption of coal.

As explained the major component of natural gas has a larger effect on the environment when compared with Co_2. What allows natural gas to be considered the most environmental friendly of all the fossil fuel is the ratio of greenhouse gasses emitted from the production and consumption of consumable forms of natural gas. We can calculate the ratio of Co_2 over methane and we observe that it produces 6 million metric tons of methane for every 6000 million metric tons of Co_2. Given that Co_2 is 20 times less potent than methane we can say that natural gas actual produces a value of approximately a value of 6250 million metric tons of Co_2 which is still lower than other fossil fuels. We can also compare the efficiencies of the each fossil fuel and their emissions. From the table shown below we can state that the most environmental friendly fuel source is last when you compare the coal petroleum and natural gas. This is not beneficial to the environment as it would require you to produce more emissions to achieve the same energy output of other fuel sources.

In order to reduce the effects natural gas has on the environment, incentives for developing technologies that reduce natural gas based energy production's adverse effects should be considered.

CO_2 Emission Factors by Fuel Type per Unit Volume, Mass, and Energy

Fossil Fuel	*Emission Factor*	*Emission Factor*	*Carbon Factor*	*Heat Content (HHV)*	*Carbon Content Coefficient*
Coal	(lb CO_2/ short ton)	(lb CO_2/ MMBtu)	(kg C/ short ton)	(MMBtu/ short ton)	(kg C/ MMBtu)
Anthracite Coal	5,675.29	226.16	709.04	25.09	28.26
Bituminous Coal	5,086.36	203.99	635.47	24.93	25.49
Sub-bituminous Coal	3,656.14	211.91	456.78	17.25	26.48
Lignite	2,991.33	210.47	373.72	14.21	26.30
Unspecified (industrial coking)	5,444.58	205.11	680.22	26.54	25.63
Unspecified (industrial other)	4,744.80	205.99	592.79	23.03	25.74
Unspecified (electric utility)	4,289.96	207.91	535.97	20.63	25.98
Unspecified (residential/commercial)	4,779.26	208.39	597.10	22.93	26.04
Natural Gas	(lb CO_2/ft^3)		(kg C/ft^3)	(Btu/ft^3)	
Natural Gas	0.120	116.39	0.0149	1,027	14.47
Petroleum	(lb CO_2/bbl)		(kg C/bbl)	(MMBtu/bbl)	
Distillate Fuel Oil (#1, 2, & 4)	930.15	159.66	116.21	5.825	19.95
Residual Fuel Oil (#5 & 6)	1,081.42	171.98	135.11	6.287	21.49
Petroleum Coke	1,342.84	222.88	167.77	6.024	27.85
LPG (average for fuel use)	535.79	138.75	66.60	3.861	17.25
Petroleum (Mobile Fuels)	(lb CO_2/gal)		(kg C/gal)	(MMBtu/gal)	
Motor Gasoline	19.37	154.91	2.42	0.125	19.36
Diesel Fuel	22.23	160.30	2.78	0.139	20.03
Avation Gasoline	18.15	151.01	2.27	0.120	18.87
Jet Fuel	20.89	154.69	2.61	0.135	19.33
LPG (HD-5)	12.70	138.58	1.58	0.092	17.23

Source: See end of document for table sources.

IV. Areas of Impact

As the electricity produced from natural gas ties directly into the localized power grid, the difference in usage by the residential, commercial and industrial sector is greatly reduced. While it would be obvious that the industrial and commercial sector would require more energy than the residential sector, but all three sectors are subjected to the pollution of the air. Another advantage to this energy source would be its capability of allowing people to use it in a variety of manners. Natural gas is capable of being used for transportation, cooking, and electricity.

Due to different motor vehicles laws between countries, other countries might suffer from the scarcity of natural gas more than others. Countries like Australia, Croatia, Hong Kong, India, Philippines, Republic of Macedonia, South Korea, Serbia, Turkey, and the countries in the European Union all enjoy the use of natural gas as the fuel source for their motorized vehicles. The dependency of natural gas for the use in automobiles in some countries reaches 20 to 30 percent of all registered vehicles run on natural gas.

As most fossil fuels have finite reserves, the reduction of any forms of industrial and commercial use of fossil fuels is essential to improve the quality of life for the future.

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Coal

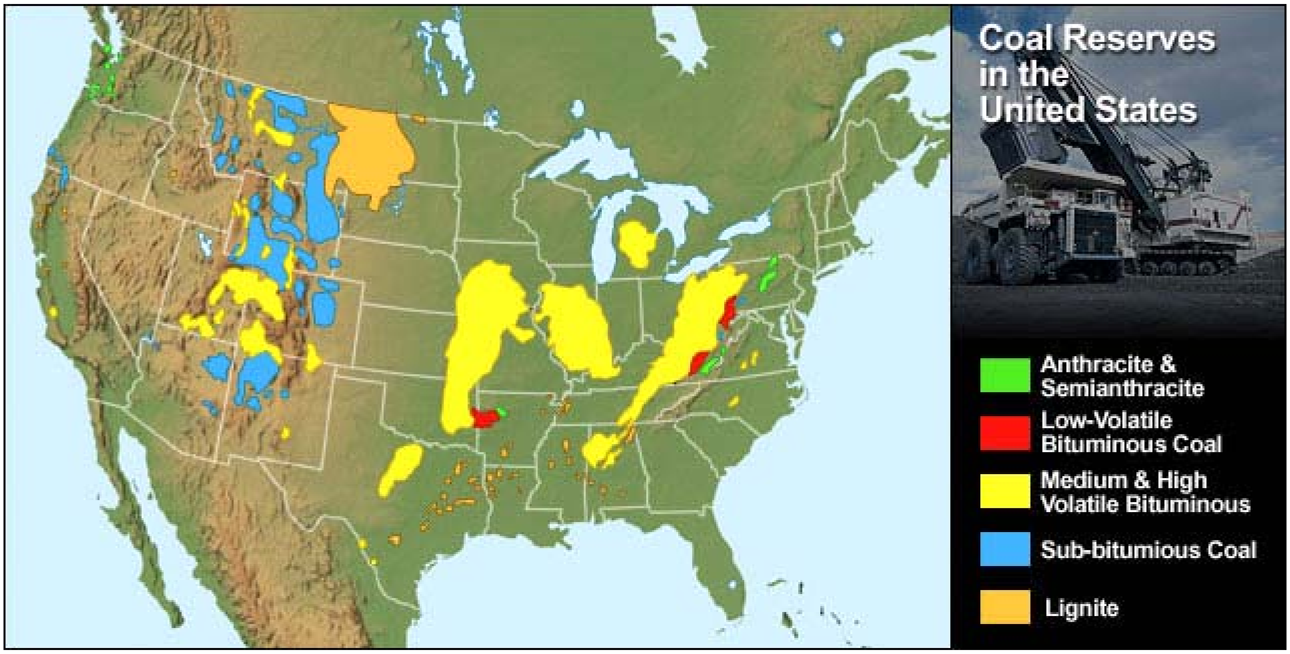
I. Daily Life Impact

America is the second largest consumer of coal in the world, and it remains as the primary source of fuel for American power plants. 48.2 percent of America's electricity is generated through combustion of coal, which is more than twice as much as our second most used fuel natural gas [7]. Without coal we would no be able to produce enough electricity for the demand of the American people and the price of electricity would climb radically. Coal mining directly impacts many American's lives by displacing wildlife, changing the land where the coal is being extracted; mine drainage can also get into the groundwater and endanger drinking water, and lowering the air quality around the mind. Burning the coal in coal-fired power plants also has a negative impact on the American life. The chemical reaction of combustion of coal also releases a lot of carbon dioxide into the air, which some believe to be the cause of global climate change but this is referenced later in this document. Coal may be an even more important asset in the near future when oil reserves start to run low, because the process of coal liquefaction can supply America with another liquid fuel as a substitute for gasoline and diesel. Coal liquefaction may play a much larger role in the future of America because of its vast coal reserves. Coal is one of the most vital fossil fuels that America has and it impacts every American on a daily basis.

II. Current Availability

The current availability of coal is important because it partially determines our foreign dependence of natural resources, it greatly affects the price of electricity, and it allows a buffer for the United States to transfer electricity production to a more permanent solution. The United States has the highest proven amount of coal in the world at 270,718 million short tons of coal [8]. The United States owns more than a quarter of the proven world reserves of coal. There are 1,000,912 million short tons of coal from proven reserves around the world, and with 270,718 million short tons America has almost 100,000 million more short tons of coal than Russia. Russia is the country with the second most abundant amount of coal. The EIA estimates Russia to have 173,704 million short tons of coal [8]. Almost 40 percent of the coal produced by America comes from Wyoming, and most of the coal from Wyoming comes from the Powder River Basin [9]. The United States consumes 3.09 million short tons of coal per day which is 15.7% of what the entire world consumes. Assuming the rate of coal consumption remains constant we will have coal for another 139 years, which makes it our most abundant fossil fuel. The current availability of coal is very important because we use coal primarily for electricity generation, and the availability of coal greatly affects the price consumers pay for electricity. The availability of coal also suggests how much needs to be invested in newer technologies that improve coal-fired power plant efficiencies and better coal extraction tools and techniques.

Coal is our most abundant and stable fossil fuel so our mining and consumption rates should increase to lower our dependency on less available fossil fuels. The federal government should give more incentives to coal mining companies to increase coal mining rates. The federal government should also financially assist in the production of new coal-fired power plants



http://www.teachcoal.org/images/aboutcoal/reserves.jpg

III. Economic Costs

There are many economic costs associated with coal, the biggest being in the sale of electricity. In 2009, the average retail price for residential electricity in the United States was 11.68 cents per KWh. The average retail price for commercial electricity was 10.31 cents per KWh, and the average retail price for Industrial electricity was 6.95 cents per kilowatt hour. The sale of electricity is the end product of most of the coal mined in the United States, but there are other economic figures that need to be observed.

The sale of coal from mines to manufacturers and power plants is the primary sale of coal. In 2007 the average cost of a short ton of coal was $25.82. The price of a short ton of coal increased in 2008 by 21% and ended up at $31.26. We can calculate the average cost of electricity generation by use of coal by finding the average energy efficiency of coal-fired power plants, the energy density of coal, and the price of coal. The energy density of coal is 24MJ/kg [10] which can be converted into 6051kWh/ton. The average efficiency of coal-fired power plants is 31% so the producers of the electricity can expect that the coal will yield 1875.81kWh/ton. The electricity produced by a single short ton of coal will sell to residential consumers at a price of $219.09, $193.40 to commercial customers, and $130.37 to manufacturing customers. The conversion of coal into electricity leaves the power plant with at least 99 dollars per short ton to pay for employees, permits, property, and maintenance.

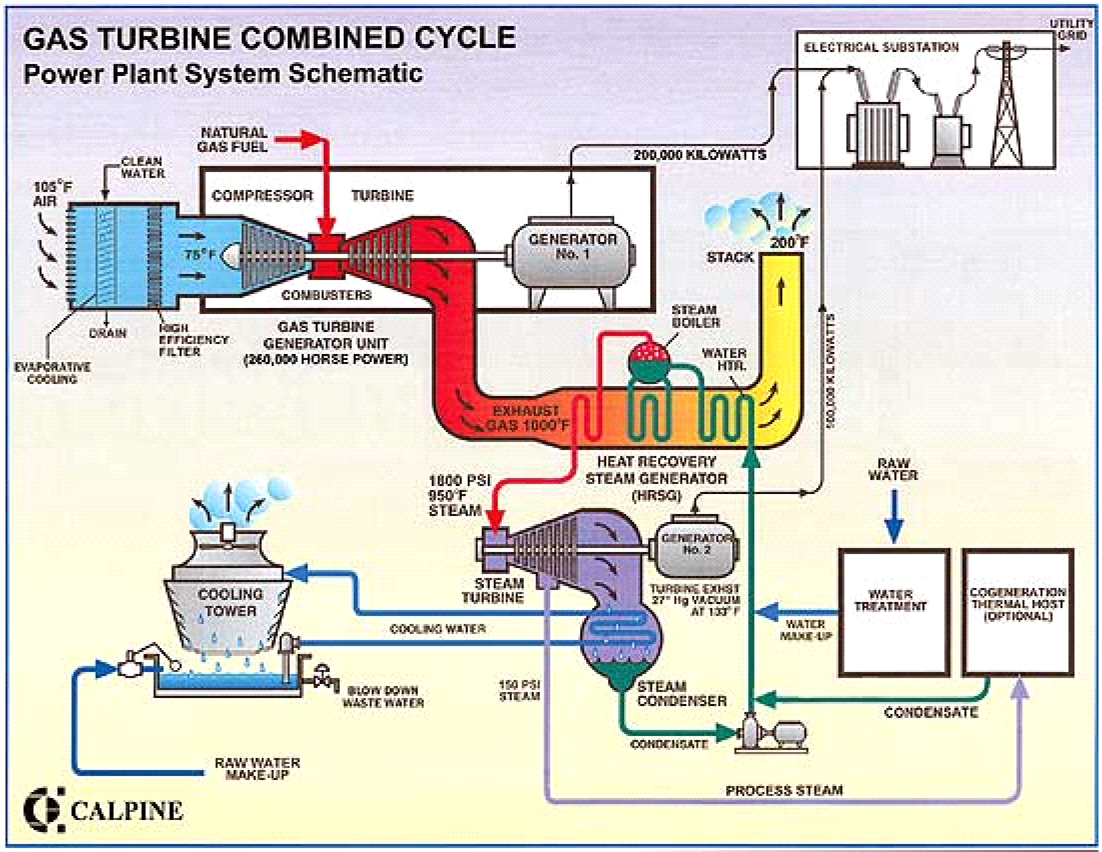
Coal is our cheapest energy source, and we need to continue to use it as our primary electricity generation source. The federal government should plan to increase the amount of electricity generated by coal to keep the cost of electricity to the consumer at a minimum.

IV. Technological Advances

There have been many technological advancements in all aspects on using coal. Some of the most important technological advancements have been made to increase the efficiency of coal-fired power plants. The technological advancements in power generation will allow America to produce enough electricity for the demand of the people, and still use less coal. Upgrades to coal-fired power plants will also help drive down the cost of electricity.

The efficiencies of the mechanisms that utilize the combustion of coal for energy production are currently fairly low. Efficiency in these mechanisms is very important because of our diminishing fossil fuel reserves, and our growing carbon dioxide buildup issue. The average efficiency for coal power plants worldwide in 2004 was 31%, the rest of the energy produced from the combustion of the coal went to waste in the cooling towers and smoke stacks. Although a 31% efficiency is much more than the 1% efficiency coal power plants had at the end of the 19^{th} century [11], it is not even close to the efficiency limit of coal-fired power plants. The efficiency coal-fired power plants can be increased in several different stages of energy production. Efficiency can be increasing the heat and pressure of the steam, improving the turbine design, and using more robust materials to transport the steam. Currently the most efficient types of power plants are combined cycle power plants (CCPP). “Combined cycle type which consists of a gas turbine and a steam turbine that uses high-temperature steam obtained through heat recovery from the gas turbine exhaust gas.” The efficiency of CCPP increases with an increase in the turbine inlet temperature, so the higher temperature the greater the efficiency. With a 1500°C turbine inlet temperature, the efficiency in CCPP has increased to 62%-65%. Mitsubishi Heavy Industries is working on a design that uses a 1700°C turbine inlet temperature that promises even greater efficiency [12].

Technological advancements in coal mining and technological advancements in coal-fired power plants are extremely important. To keep the impact to the environment at a minimum, and to reduce the final price of electricity to the consumer the government should increase grants for research in coal mining technology and more efficient power plant designs.



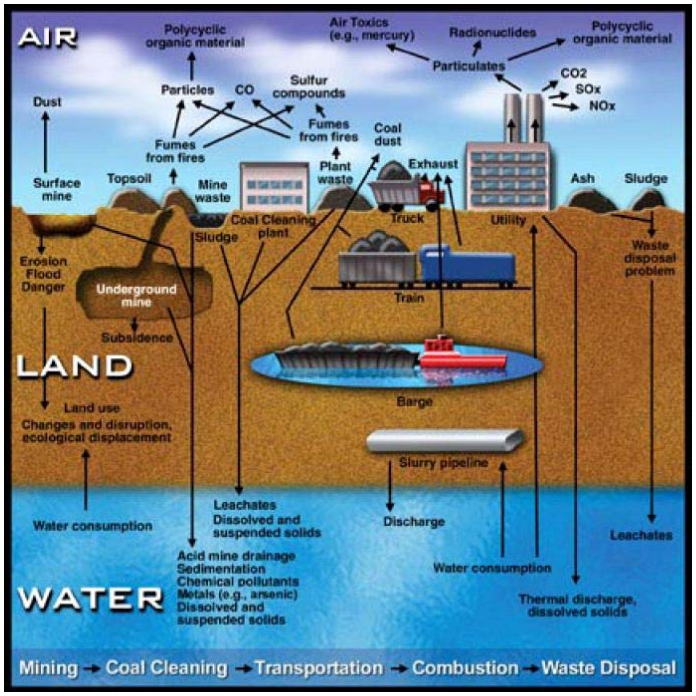
http://www.power-technology.com/projects/san_joaquin/images/Combined3.jpg

V. Environmental Impact

There are many environmental costs associated with mining coal. Surface mining alone causes several environmental problems including "soil erosion, dust, noise and water pollution, and impacts on local biodiversity [13]." Underground coal mining may lead to subsidence, which is when the ground level lowers because of all of the coal that has been mined out. Surface and underground mining have the chance to pollute the nearby groundwater. Methane is also released from the coal during the extraction process which is wasted and accumulates in the atmosphere. Other environmental costs from mining are dust and noise pollution, and acid mine drainage. Mining coal can be harmful to the environment but burning coal is also harmful to the environment.

There are several environmental costs associated with burning coal. Burning coal releases carbon dioxide, sulfur dioxide, nitrogen oxide, sulfur nitrate, and hydrogen dioxide. Coal-fired power plants also have mercury emissions that can be toxic to people who eat animals that eat food that is contaminated with mercury. Burning coal also leads to the accumulation of fly ash sludge. Fly ash is made up of silicon dioxide and calcium oxide, and it is debated whether fly ash is toxic or poisonous. The picture below depicts the extent of the environmental cost of coal usage.

Since coal is our primary source for generating electricity, its environmental impact needs to be taken into consideration when increasing production rates. Stricter environmental policies on coal-fired power plants need to be enforced to ensure that carbon dioxide emissions are minimized as well as reducing other toxic pollutants produced by coal-fired power plants.



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Solar Power

Solar energy has become an ever popular form of energy that has already been applied to multiple commercial uses. The source of solar energy is free, and naturally occurring. It is considered to be a renewable source because the rate at which solar energy is consumed is far smaller than the rate at which it is being generated. The end of the solar cycle is not predicted for many lifetimes. In order create the most efficient form of solar energy conversion however; the source must be further studied.

Solar energy is emitted by a star within our galaxy, the sun as we know it. The energy emitted by a star is generated by nuclear fusion which occurs in the core of the star. The energy is then transferred between atoms until it reaches the surface of the star, the photosphere. The photosphere emits the energy in the form of visible light in the electromagnetic spectrum. Energy is also released from the star in the form of thermal energy from the chromospheres. [1]

The energy which is released by the star reaches earth, and the amount is dependent on the motion of the earth around the sun. The earth has an elliptical orbit around the sun and orbits on the ecliptic plane. Therefore, the distance between two points between the earth and the sun is never constant. The earth is also tilted on its axis which also plays a major role in causing this variation. This can pose a problem when creating any method to harvest the free energy, that is, if no position on the earth attains the same amount of energy over a constant period of time, the method must be able to efficiently generate an amount of energy throughout the year with minimum variation. Solar energy does not necessarily always reach the earth's surface. The light reflected back from the surface (albedo) is approximately thirty five percent. Of the thirty-five percent, clouds reflect twenty-percent, atmospheric particles reflect ten-percent, and the earth's surface reflects five percent [1]. It is possible to capture light in outer space and transfer it back to Earth utilizing microwaves, although the idea may seem farfetched, there are companies tackling a solution to capturing light in outer space.

I. Daily Life Impact

Utilizing solar energy is expected to have an immense impact on the lives of the American people. Utilizing solar energy can mean self reliance on providing energy. There will be energy available for people even out in the remote areas of the country. Anywhere which the sun reaches there can be a solar energy system put in place. Solar energy can be put to use without the need for a system of solar panels. Passive solar energy can be used without the need to convert energy which prevents energy loss during the conversion process.

A simple use for passive solar energy is direct solar heating and cooling in buildings. Using a simple method such as an overhang on buildings can passively cool and heat homes during the summer and winter seasons. Due to the positioning of the earth the angle of the sun to the surface of the earth based on the season and time of the year. During the winter the sun is at a smaller angle to the surface of the earth, it is "lower" in the sky, and therefore the overhang will not cause a shade on the windows of the building allowing all of the solar energy to pass in. In the summer, the sun is at a higher angle to the surface of the earth causing the overhang to absorb most of the light allowing the building to remain cooler during the summer. The passive solar heating method requires the home to be properly insulated as to not let the hot air to be cooled, or the cold air to be heated during the respected seasons. Passive solar energy does not fully eliminate the necessity for fossil-fuel powered forms of heating because during snow and rain days, the sun is not necessarily available. [1]

The Federal Government could provide tax-deductions for homes with passive solar heating capabilities to encourage people to implement passive cooling and heating

Utilizing passive solar techniques can save the American public hundreds of dollars in energy costs allowing them to have more money for food and leisure. Saving the American household money means having more money being filtered through consumer markets which in turn will stimulate the economy. Having a strong economy will create more jobs, and increase the household income even more and cause a strong flow of money into the economy. Although passive solar energy does not eliminate the need for oil or gas powered heating system, it provides enough of an energy buffer. The energy not being used to fuel homes for heating may be redistributed to places where the Sun is not solely enough to heat the home.

If a household desires to become completely self reliant with their energy sources, Electric solar energy may be the appropriate choice. Electric solar energy involves utilizing large solar panels consisting of multiple photovoltaic cells which convert solar energy directly into usable electrical energy. Solar panels are now commonly available in the consumer market, and consumers can choose to purchase and utilize many of the government grants available. It is recommended that government funding be increased in order to cover at the least fifty percent of the costs in order to promote the purchase of household solar panel systems.

Solar energy can also be used commercially; this will be beneficial for households which cannot purchase private solar power systems. Active solar energy can collect convert energy into other forms of energy such as electrical energy with the aid of other mechanical systems. One example of active solar energy use is the Solar Heat Collector. The device allows sunlight to enter through a glass or plastic window causing the solar energy to be trapped inside. The trapped solar energy is used to heat an absorption plate which emits infrared radiation from being heated. The device operates on the same principle as a green house. The infrared is used to heat transfer fluids which is used for some form of heating in another mechanical system. [1]

There are however several efficiency issues which come across with the Solar Heat Collector method. The efficiency of the solar heat collector is defined by the energy input to output ratio. Real world applications are never ideal, and cause energy to escape from the device through convection and radiation. The collector will emit thermal radiation when its temperature is greater than the ambient temperature; this is just a physical principle that exists in the universe which cannot necessarily be countered simply. Energy loss and output must be calculated together to determine the efficiency of the device. Therefore the overall energy conversion efficiency depends on the increase temperature relative to the ambient temperature and the intensity of solar radiation as well as the quality of thermal insulation. However, when used in a larger scale concept, the heat collector method can be used to generate large amounts of energy. [1]

The three forms of solar energy can have a positive impact on American lives; by utilizing passive solar energy households can reduce energy costs significantly making money available for other uses. Using electric solar energy households can become completely self reliant with their energy needs. Electric solar energy will allow people to attain electrical power in remote areas where it is not necessarily simple to provide power and there by also increasing useable land area which was previously limited because of conditions necessary to distribute power. Utilizing active solar energy can supplement power needs in our ever demanding energy grid and prevent rolling black outs across the nation.

The Federal Government could increase tax deduction and create assistance programs for homeowners who are looking to power their homes through solar energy to encourage its use.

II. Current and Pending Solar Power Plants

Solar technology is ever growing; Solar One which operated in California from 1982 to 1986 generated 10 megawatts. In 2008, new plans had been signed to begin work on solar plants in California, and Nevada. Solel, a Israel based company has signed a 3 billion dollar deal along with Pacific Gas and Electric and BrightSource energy to produce the new solar thermal electric plant. PG&E is taking this initiative because of laws in place by the California state government which requires them to generate twenty percent of their energy through green means. The solar power plant is expected to be up and running by 2011. The power plant will use Brightsource's Heliostat technology to drive the collection of solar energy in the tower [3].

The BrightSource LTP 550 heliostats are made up of two flat-glass mirrors, a support structure, and a tracking system which is capable of tracking the sun in two directions. The heliostats are claimed to be more efficient and has a lower installation cost than the parabolic troughs used in the Nevada solar plant. They have an expected life time of 35 years with zero maintenance, but cleaning is required. The software used to drive the heliostat directional systems is individually optimized per heliostat to maximize solar energy collection by the receiver. The software also tracks solar radiation, wind, and air pressure to achieve the optimal beam to the receiver. The receiver is a high efficiency boiler positioned at the top of a tower which converts concentrated energy into superheated steam. The boiler has tubes coated with a material that maximizes energy absorbance, and is designed to generate superheated steam of 550*C and 160 bars of pressure [4].

The SolarOne Power plant which is to be built in Nevada follows the same trend as the power plant being built in the Mojave Desert. The power plant is being built by a company called Solargenix which will utilize the PTR 70 solar receivers. The PTR 70 solar receivers are parabolic mirrors capable of heating the thermo-oil heat transfer fluid to a temperature of over 750*F. They plan to use 19,300 of the PTR 70 receivers to power the Nevada Solar One power plant [5].

There are small businesses that focus primarily on evaluating the needs of a home's solar power and provide estimates to homeowners helping them purchase the solar power system which is right for their home. These companies will not only provide estimates to homeowners but they will also install and make sure the solar power system is fully operational and meeting the need power consumption needs of hoe homeowner. Solar power purchasing services are making it easier for homeowners to make the switch. However cost remains a key factor in limiting the popularity of household solar power systems.

Provide tax incentives could be provided to companies to return their profits into the company in order to increase growth and productivity. Provide tax incentives to companies who may subcontract with the larger companies in order to build Solar Power Plants and Solar Farms. Streamline the process of issuing building permits to companies interested in building solar power plants in order to increase the rate at which plants are built

III. Advances in Solar Power Technologies

All solar power plants use the basic "Concentrating Solar Power (CSP)" technology to power a turbine to generate electricity. The basic principles of CSP involve using mirrors to reflect and concentrate sunlight onto receivers to collect energy to heat water to superheated steam. The department of energy's goal is to increase use of CSP technology in the United States. To achieve the goal they plan on creating cost shared contracts with industry advanced research its national laboratories. CSP has several subsystems as follows: Linear concentration systems, Dish Engine systems, Thermal Storage [6].

Funding could be approved for the Department of Energy to create cost shared contracts to increase use of CSP Technology in the United States

Linear concentration focuses solar energy with large mirrors that reflect the sunlight onto a linear receiver tube. The mirrors heat a receiver fluid which is used to transfer heat to a heat exchanger that creates superheated steam to turn a turbine. A linear concentrating collector field typically consists of a large number of collectors in parallel rows that are typically aligned to a north south orientation, and can turn as needed. Based on the same concept as the linear system, the parabolic trough system is a predominant CSP system currently in use. The receiver tube is positioned along the focal line of each of the parabola shaped reflector. The thermal fluid is then heated and passed to a heat exchanger to generate superheated steam to power a turbine.

Another version of the CSP system is the Linear Freshnel Reflector System. Flat or slightly curved mirrors are mounted on trackers on the ground to reflect sunlight onto a receiver tube fixed in a space above these mirrors. Mirrors can also be fixed above the receiver to further focus the sunlight [7].

The advantage of using a CSP is that all of the energy that is generated during peak sunlight hours can be stored in thermal storage systems. There are several types of systems, two tank direct storage, two tank indirect storage, and single tank solutions. In a two tank direct system one tank contains all of the low temperature transfer fluid, which is then passed through the solar array, and finally passed into the high temperature tank. Fluid from the high temperature tank is then passed through a heat exchanger and back into the low temperature tank to repeat the cycle. The two tank indirect system uses two types of heat transfer fluid. One is the storage fluid and the other is the fluid which is passed through the solar array. The fluid from the solar array heats the fluid in the low temperature tank and passes it to the high temperature tank. The problem with indirect system is that it is not cost effective and it adds an extra heat transfer phase. The device is proposed for use in the USA. The single tank solution is the most cost effective, and it stores thermal energy in a solid medium such as silica sand. The top portion of the tank is high temperature and the bottom portion is at low temperature generating a thermo cline. High temp heat transfer fluid flows in moving the thermo cline and adding energy for storage [8].

All of this technology is driven by the heat transfer fluid and thermal concepts. The goal is to increase efficiency and reduce costs for thermal energy storage. Water is currently capable of storing 334MJ per one cubic meter. In most CSP applications molten salt is used which is made from 60 percent sodium nitrate and 40 percent potassium nitrate. The material is non flammable and non-toxic and is capable of storing energy for long periods of time. The molten salt melts at 221*C and is liquid at 228*C. The focused sun heats the material to 566*C. An 80 foot diameter tank that is 30 feet tall is capable of driving a 100 megawatt turbine for four hours [9].

Solar concentrated power will become a predominant source of renewable energy because it can be easily integrated into the current energy grid. Improving technologies which make solar power plants more efficient should be a primary focus. Providing government funding to companies such as PG&E and Brightsource to produce far more efficient Heliostats and build larger plants which provide greater power output into the grid.

Incentives could be created for leading solar power companies to increase efficiency in solar technologies.

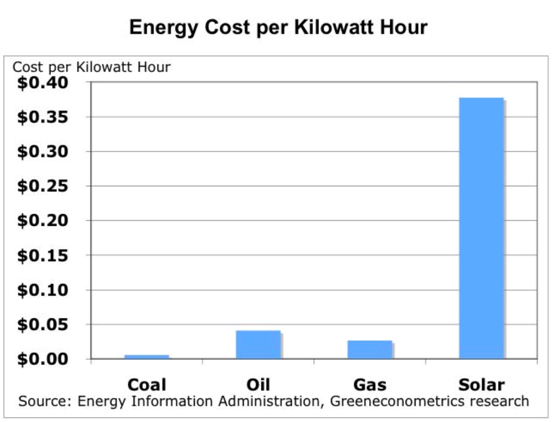
IV. Economic Costs

The current cost of power to the end user averages to $0.1688 per KwH in New England for the month of August 2009. This is a desirable cost to the end user, and in order to take over the current energy market, the end user would have to be offered a price which is at either an equivalent or lower cost. Solar power does not necessarily offer such a solution because of the technology available and their efficiency.

Photovoltaic energy is the most expensive with much of the costs being up front costs. For example, three hours of sunlight on 1 square meters with a conversion rate of about 20% or less is worth less than $0.06 in equivalent electricity costs. For a typical northeastern home which uses about 15,000 kWh of energy a year, a 10 kWh system must be put in place assuming that the home uses 40 kWh per day and there are 4 hours worth of direct sunlight available. The average cost of a solar power system is $95.00 per square foot, and for the 10 kWh system 600 square feet of panels must be installed bringing the cost to $57,000 for just the panels, plus other system costs easily bringing the cost up to $100,000. A system like this brings the cost of electricity to $6.00 per kWh, and even with tax incentives, the cost may be significantly reduced, but reach no where near the $0.1688 per kWh mark [20].

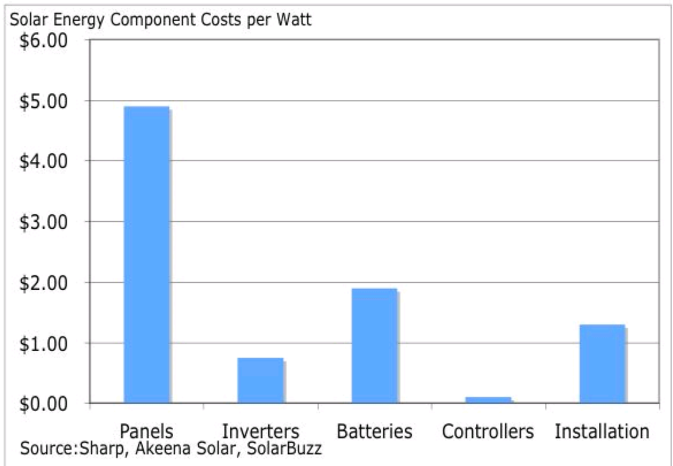
Type	Energy (kWH)	Cost (2009)	Cost per kWH
1 Ton Coal	6,182	$52.30	$0.0008
1 Barrell Oil	1, 699	$79.88	$0.04
1 Cubit foot of Gas	0.3	$0.008	$0.029
5 kW Solar System	4.5	$45,000	$0.38

Table Created with information found at Green Econometrics by Chris Pearson



Note that the 5kW solar system only generates 4.5kWH of energy due to the 10% loss in energy from DC to AC conversion. A typical solar system has an expected life expectancy of 20 years, and the cost per kWh is determined by dividing the energy generated over a period of 20 years divided by the cost of the system. Solar energy however has no direct fuel costs; the up front costs are what determine the price over the 20 year lifespan. The values also assumed that the solar panel would be receiving four hours of direct sunlight every day. If solar systems had a longer lifespan, or lower system costs they would be an ideal source of renewable energy. The greatest cost of a solar system is in the panels, and by reducing costs of the panels solar systems can become significantly cheaper [20].

Solar Energy Component Costs



The above mentioned costs are for solar systems installed in the home, but the cost of CSP (Concentrated Solar Power) is more likely to be amiable by consumers. The chart below shows the expected cost per kWh of energy. The currently in commission Nevada SolarOne facility is generating power at a cost of $0.178 per kWH which is till not lower than the current price for electricity, but $0.01 per kWH may be a small price to pay to progress towards ending coal / oil use. The solar power plant to be commissioned in California by BrightSource energy may be the best example of an idealized solar power plant because of its reduced power costs and high power generation. Solar power plants may clearly be the better source of solar energy than using PV Panels. If we can however reduce the cost of PV to less than $0.10 per kWh we may see every roof decorated with PV Panels. Thermal storage technology will play a major role in these rates because they will determine how much energy is available when energy is not produced [20].

It is recommended to encourage states to reduce sales taxes on parts and materials to build solar panels and solar power systems. It is also recommended that tariffs be reduced on imported parts used for building solar cells and plants.

Table 3. Selected projects and operating parameters

	US			
	Nevada Solar One	**Carrizo**	**Ivanpah**	**Solana**
Status	Commissioned	Announced	Announced	Announced
Owner	Acciona	Ausra	BrightSource Energy	Abengoa
Technology	Parabolic trough	Compact Linear Fresnel	Tower and heliostat	Parabolic trough
Capacity	64MW	177MW	400MW	280MW
Load factor	26%	25%	28%	40% (est)
Power price /kWh*	$0.178	$0.12 (est)	$0.11 (est)	$0.14 (est)
Cost/MW build	$4.15m	$3.1m	$3.3m	$3.6m
Hectare/MW	2.52	1.46	3.44	2.7
Water use (litres) /MW/ day	ND	475	313	ND
O&M notes	Approx. 20% of kWh electricity cost	75 staff, annual payroll $4-4.5m -$0.01/kWh	0.5% of solar components replaced each year. Up to 90 full-time employees.	Approx. 20% of kWh electricity cost
Operating Temp	370°C	285°C	650°C	390°C
Thermal storage	Steam - 30 min	No	No	Molten Salt - 6 hours
Gas backup?	2% or less	No	No	No

Note: *Power price to be received by the operator under current agreements (in Spanish the feed-in-tariff for STEG)

(Table Provided by Claverton energy Research Group)

	Mojave Desert Solar Power Plant	SolarOne Power Plant	Electric power plant (Fossil Fuels)
Cost	2 to 3 billion dollars	268 Million Dollars	1.1 to 1.3 Billion Dollars
Power	553 MWatts	64 MWatts	300 MWatts
Homes Power	375,000	14,000	190,000
Area	6,000 Acres	400 Acres	Up to 1000 Acres
Fuel Cost	-	-	44.07 dollars per Ton (2009)

Compiled from various sources and DoE facts and figures

The above table shows the overall costs of producing and operating a solar power plant and the over all costs of an electric power plant using fossil Fuels to generate energy. The typical cost of a electric power plan costs 1.3 Billion dollars and powers around 190,000 homes per billion dollars plus the cost of fuel, and labor necessary to run the plant. A solar power plant costs upwards of 3 billion and powers about 187,000 homes per billion dollars spent. The building costs of the two plants are similar, but the electric power plant must continuously incur fuel costs where as once the solar power plants are built there is no fuel cost because it uses the ultimate free source of fuel.

V. Environmental and Health Impact of Using Solar Energy

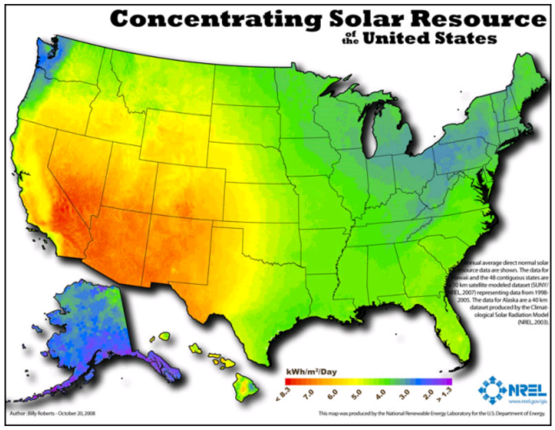
Solar power systems do not generate any emissions or any form of pollution during operation. The largest impact a solar power system can make is during its production where fossil fuels are used to process materials necessary to build the system. Solar power systems are made from one of the most abundant materials on earth, Silicon. Silicon is not a precious material and it is not necessary to dig or mine for it. Some solar cells also use Cadmium to convert solar energy to electrical energy, and cadmium can be a toxic element when found in large concentrations. Manufacturers of Cadmium based Solar Power systems strongly advocate recycling of the systems instead of disposal. Silicon can be dangerous to workers when inhaled in dust form during production or installation of solar panels. The risk is however minimal if proper safety precautions are taken.

Space has become a large concern when it comes to the use of solar power plants and solar panels. Solar power plants occupy large amounts of space to generate power comparable to a less space hungry Coal fired plant. However, the locations of the power plants are in the deserted areas where there is little environmental impact due to occupation. However, as solar power plants begin to expand and become dispersed throughout the nation strict regulations must be put in place in order to limit environmental impact. Solar panels are a good way to minimize the impact on environmental space. Solar panels can be placed on roof tops and do not need to occupy any additional space.

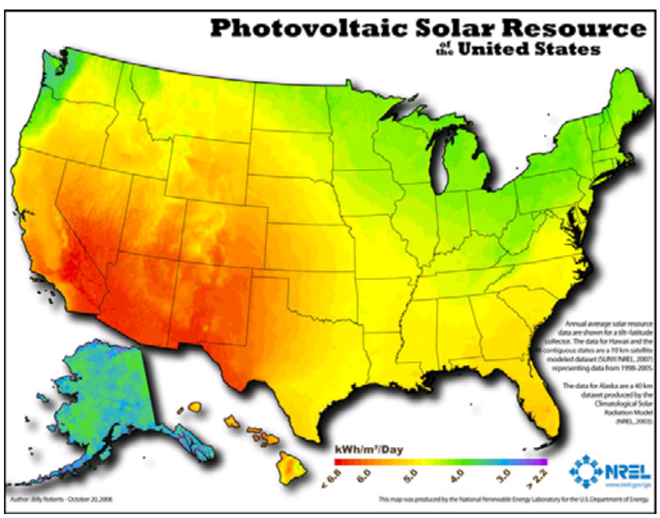
The Federal Government should create strict regulations for disposal of Cadmium based Solar panels and impose regulations on building locations for solar power plants.

VI. Optimal Areas for Solar Farms

Solar energy concentrations are distributed throughout the United States with much of the strongest areas of solar concentration lying in the south west. States such as Arizona, Nevada, Wyoming, Utah, New Mexico, and Southern California would generate the most power per day. It is expected that these states would generate greater than seven kWh/m^2 /Day. The East coast is a poor location for Concentrated Solar power because the region is only exposed to a maximum of four kWh/m^2 /Day, and a minimum of two kWh/m^2 /Day in areas of New York State, Pennsylvania, and West Virginia. The optimal solution in this case is funding Concentrated Solar Power Plant projects in the South West along with building new infrastructure for distributing the power generated in the Southwest to the remainder of the country. However, a short term goal may be to reduce the number of Coal powered plants and increase the number of Solar Power plants and distribute the power to the local region.



Photovoltaic solar panels may be the better approach through out the rest of the country. The difference in energy generated between the highest intensity area and the average intensity area is roughly two kWh/m^2/Day. If photovoltaic solar panels are used in the New England area they will be able to generate at least four kWh/m^2/Day of energy, which is enough to provide enough power to run the critical items in a standard home. This energy can be complemented using the current infrastructure of coal power plants which will be utilizing significantly less coal because the majority of the power will be provided by solar power. Creating large solar panel farms seems viable throughout the country seems viable because of the evenly distributed capabilities of power generation throughout the remainder of the country. However, all areas will need to be complemented with coal power plants.



As it can be seen through the maps presented above, solar energy is viable throughout the country. It can be utilized everywhere. Certain regions may need other energy sources to complement the solar energy, but solar energy can be used to reduce the impact on the Coal Supplies. Solar panel farms and solar plants will need to be distributed through out the country, and in order to reduce the loss in energy from transmission. If programs are put in place to assure that there is a solar power system in every home energy lost to transmission can be nullified because homes will become self sufficient and will need very little energy from the power grid.

Legislation which requires high solar intensity states to generate 30 percent of their energy from solar power by the end of the decade could be implemented.

VII. Space Solar Power

Since the 1970s oil embargo NASA has done extensive research in space based solar power. The concept is fairly simple, and utilized the same principles of ground based solar power. Space Solar power involves launching Solar Power Satellites (SPS) into geocentric orbit, about 22,000 miles and collecting solar energy. Launching an SPS would enable eight times the collection of solar energy than here on earth. The SPS is not limited to conditions such as weather, cloud cover, dust, or Albedo. NASA is also considering using mirrors to concentrate the solar power to the SPS in order to reduce costs of launching Photovoltaic cells into space. The mirrors would also allow them to have greater control of what passes into the SPS, and would eliminate the risk of having high amounts of heat cause damage to the solar cells. The mirrors would also limit which frequency bands in the spectrum can pass through to the cells. They are also looking to retrieve any excess heat that is lost and utilize it for thermal voltaic heat generation [17].

In current practice however, the use of space solar power will not prompt a reduction in energy costs. The initial costs are expected to be about 60 to 80 cents per kWh and slowly being deduced to 7 to 10 cents per kWh over 15 to 25 years. Those prices may compete well with today's market prices of 12 to 15 cents per kWh. However, the prices of coal and fuel are expected to increase as demand increases and supplies diminish. The initial costs will be high because of the high cost of manufacturing photovoltaic cells and launching them into space. Robots are expected to assemble the cells and perform full maintenance with minor human intervention other than supervision [17].

In 2009, Space Energy Inc. was established to build a base structure to take a step into the process of utilizing space solar power. They are a privately owned company aiming to retail energy to governments, and private companies. Their biggest selling point involves being able to distribute power to any location without the need for a form of advanced terrestrial infrastructure. Their solar power satellites are expected to remain in sunlight for 24 hours a day [18].

Using SBSP/SSP (Space based Solar Power/Space Solar Power) Space Energy Inc. expects to bring power to many rural areas providing advantages such as giving them running water, power for hospitals and schools, and an over all increase in the standard of living. They can accomplish this because there is no need for a complex land based infrastructure, and the reception antennas can be built anywhere because the risk which is imposed by the microwaves is no more harmful than cell phone transmissions, microwave ovens, or cordless phones. These antennas are also environmentally friendly because they will allow the light to pass, which in turn will allow the ground beneath them to be used for solar crops, biofuels, etc. Each satellite is expected to generate power equivalent to that of a nuclear power plant, or a coal-fired power plant [18].

Currently the Space Energy Inc is encountering multiple technical challenges which range from needing improved launch capabilities, to managing solar debris and wind. Their commercial challenges include building attaining permits and approvals and risk of a failing market, which is encountered by many companies. They do however, expect to be able to compete with the coal market, but do not have any intention of direct competition [18].

NASA could participate and provide funding and resources to companies trying to harvest energy in space.

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Wind Energy

While being the most successful and the most competitive non-hydroelectric source of renewable power, wind is not the ultimate quick-fix to all our future energy needs, coming with its own set of challenges and drawbacks that must be considered. This chapter of the Policy aims to do just that. Presented below are all the aspects of wind-based power generation that are relevant to its place in the future of energy in the United States including its availability and costs, and daily life or economic impacts, starting with a short overview introducing the basics of wind power. Throughout the chapter are also recommendations on what can be done at a national level in order to resolve or help alleviate issues brought up.

I. What Is Wind Power?

Wind energy as defined by the U.S. Department of Energy (DOE) is the "process by which the wind is used to generate mechanical power or electricity," and is ultimately related to power generated directly through sunlight. The sun heats the surface of the earth unevenly causing differing densities and pressures in the atmosphere [2]. This effect, along with the irregular surfaces of our planet and its rotation, produces the flow of air we know as wind. Therefore, wind power fits the definition of renewable resources – it is a resource that is replaced by natural processes at a rate faster than it is consumed by humans [1].

Wind's energy is most commonly captured using turbine generators. A turbine is a shaft with some type of blades attached. The blades are acted upon by a fluid which causes the shaft to spin generating mechanical motion. An electric generator uses electromagnetic principles to convert mechanical motion into electrical energy. In the case of a wind turbine, the fluid that flows through the turbine's blades is air, and the turbine's motion gets converted into current flow by the generator [3].

II. Availability of Wind Power

There are several ways to analyze how available a resource is, with the simplest being how easy it is to get and make use of by individual citizens. In this respect, wind power is readily available, albeit somewhat expensive (more on wind power costs in section 3. Economic Cost of Wind Power). Smaller sized wind turbines designed for private home use up to small business use are available for sale starting at as little as $467 for 400Watt personal turbines to almost $75000 small business use or homeowner use turbines [4]. Although these prices might seem steep, one has to keep in mind that unlike fossil fuel based generators, these turbines have no fuel cost and will therefore eventually cover their initial price. Some manufacturers even claim the possibility of completely covering monthly electrical costs if certain conditions are met at the device's location further speeding up the recovery of initial investment.

More economic incentives at the federal level similar to incentives and grants the state of Ohio offers its residents would help more homeowners install expensive wind turbine units. Ohio state incentives cover $8500 to $10000 of the cost of homeowner turbines, leading to more people covering their own electrical needs and even helping supply others by selling power back to electric companies.

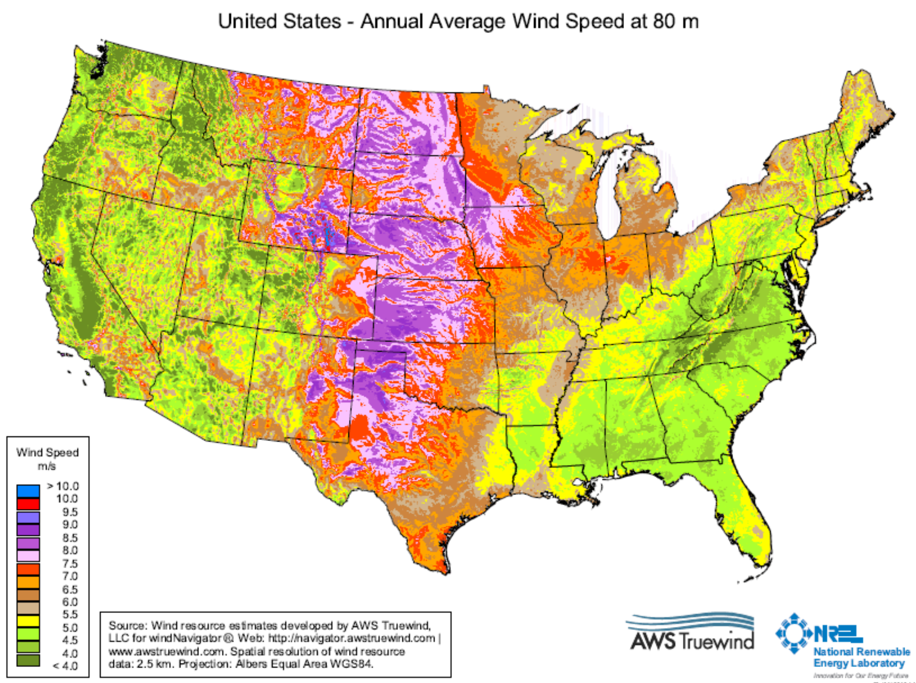
Another way to look at availability is the ease of access regional electrical suppliers have wind turbine technology. Much like in the personal or small business sector, wind turbines are readily available to large electrical supply companies from various manufacturers such as U.S. based General Electric, Canada based AAER Systems, or Denmark based Vestas [5][6][7]. With roughly a dozen such manufacturers in existence today, there is the potential to build tens of thousands of large, industrial scale wind turbines per year. Despite this, the current demand is not being met, driving prices up. This is hardly a surprise however, since the current growth of U.S. wind energy is 50% per year. Thus the most debilitating factor in wind turbine availability is cost, with prices as high as $2.2 million per MW, although policy can help mitigate this cost for the buyer and manufacturers will probably react to this increasing demand with an increase in supply, eventually stabilizing prices.

Wind turbine manufacturers already indirectly benefit from the renewable energy tax credit since it helps increase demand for their products, but in order to more quickly bring prices of turbines down a more direct federal intervention might be necessary such as providing manufacturers with a credit for each unit sold which in turn helps manufacturers expand their production.

Finally, to fully analyze wind power's availability, the availability of its raw resource must be looked into. With most utility scale turbines resting on pillars of height between 65m to 80m, wind speeds at this height would give the most information about an area's suitability for a wind farm. The wind resource map depicted in Image V-I below demonstrates average wind speed at 80m above ground on a national scale. Speeds of 6.5m/s and above are considered suitable for wind development, and with most of the American Midwest having average speeds of 8m/s or above, the available land area for wind expansion cannot be denied. There is also room for wind power growth offshore as well. Less than 60 miles out from most of the U.S. Eastern Coast, average wind speeds range from 7.5m/s to 8.8m/s year-round [9][11].

Using the updated information of the new wind speed map, the renewable energy tax credit could be changed specifically with respect to wind power in order to encourage development in high wind speed areas such as the Midwest plains and coastal areas, ultimately letting the nation get the most out of wind power and driving prices of electricity down.

Image V-I – Wind Resource Map [10]



III. Economic Costs of Wind Power

Wind power is quite expensive, partly due to an increase in demand that is not quite being met as of yet. This expectedly leads to increasing initial costs of turbines. In 2008, for example, the price of offshore based turbines increased 48% to $3.45 million per MW and the price of land based turbines rose a staggering 74% to $2.14 million per MW. Despite this high initial cost and even taking into account capacity factors as low as 23%, the cost per kWh of electricity generated by land based wind turbines is estimated at about 5.5 cents to 9 cents (a capacity factor or coefficient is the ratio between actual output and maximum possible output) [12].

There are also cases when this raw cost in much lower. An American Wind Energy Association (AWEA) article presents some data on how higher wind speeds on location affect this raw cost. Table V-I, based on a 1997 51MW wind farm, shows raw cost at three different wind speeds:

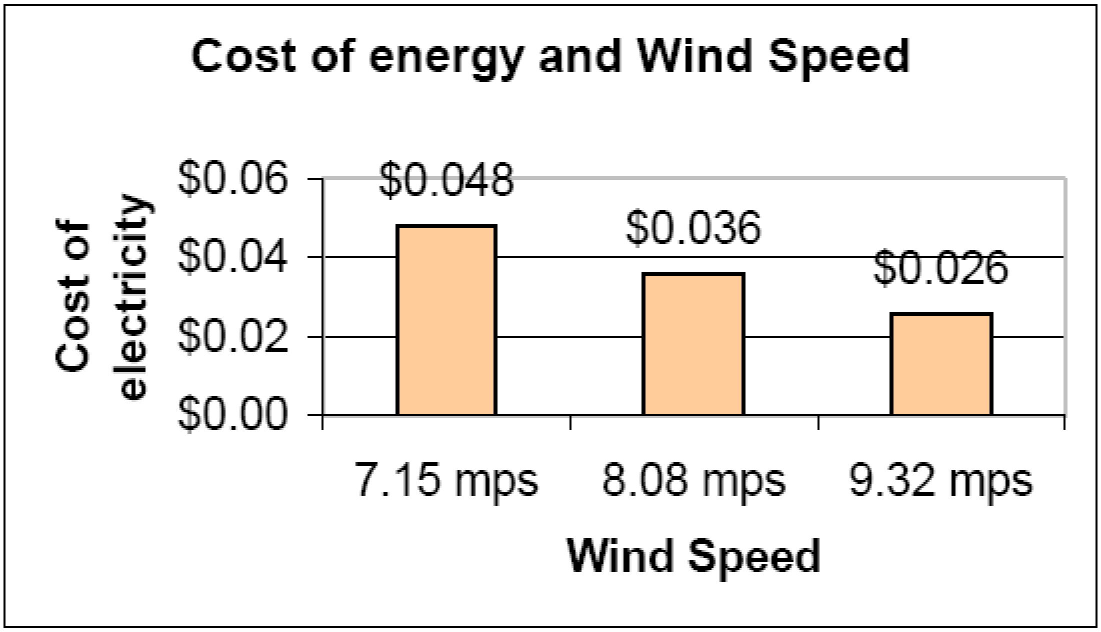


Table V-I – Cost vs. Speed Example [14]

Costs have changed since 1997, but the data reinforces the point that average speed greatly affects cost, and consequently that expanding wind energy production in high wind speed areas is the best way to make wind generation competitive to over resources. Also to note is an average wind speed of 8m/s (a significant portion of the Midwest on the resource map of Section 2) is equivalent to about 18mph, much higher than the 2.6cent speed of 9.32mph of the AWEA chart.

The data on how drastically wind speed affects the final price of electricity from wind farms coupled with the wind map information of Section 2 further reinforces the point that the renewable energy tax credit policy can benefit the industry better if it encourages development in specific areas.

The AWEA article also claims another way to drastically reduce costs. Using data from the same 51MW farm and another project rated at 3MW, the article claims a cost reduction of nearly 40% in favor of the larger wind farm, supporting a strong argument for larger projects. The data is shown in Table V-II:

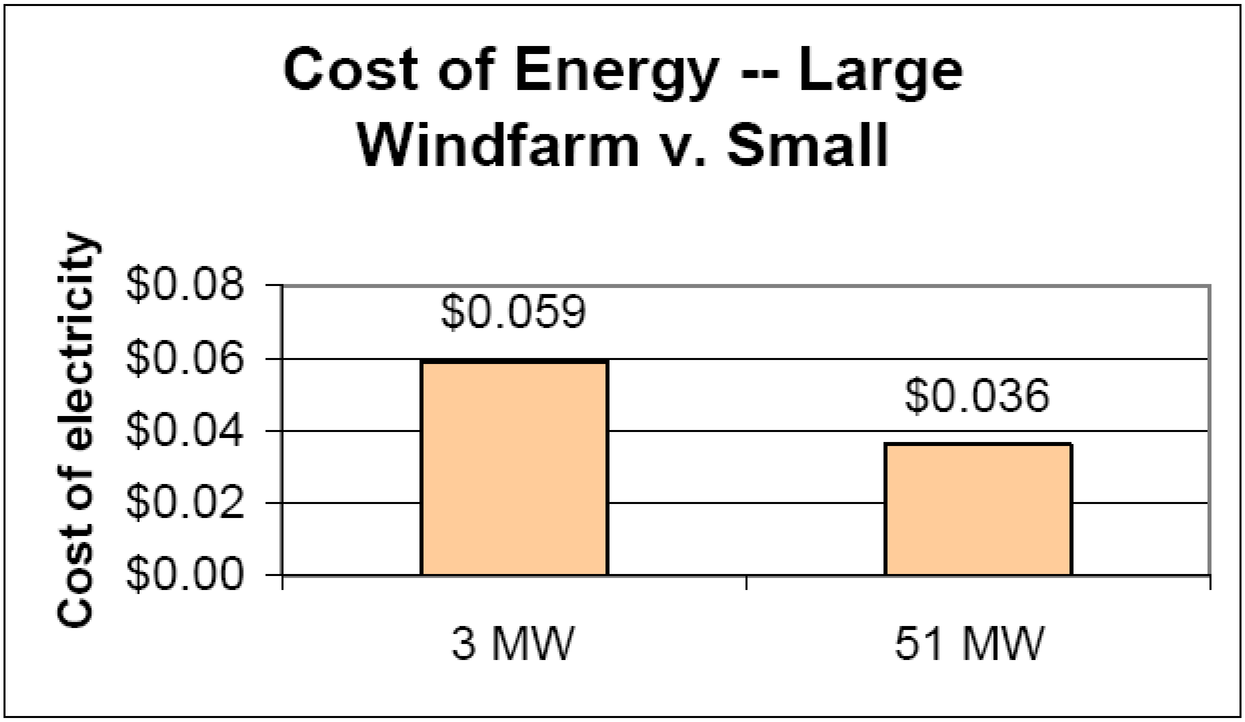


Table V-II – Cost vs. Size Example [14]

The reason cited for why this might be true is lower operating and maintenance costs for larger, more efficient farms. The claim is also supported by today's trend toward larger scale projects such as the $1.4 billion General Electric and Caithless Energy Shepherds Flat Project in Oregon.

Since larger wind farms have proven to be more efficient and less costly when it comes to dollars per MWh, specific incentives toward larger projects would also ultimately help the nation get cheaper sustainable energy from wind.

IV. Environmental Impact of Wind Energy

Unlike fossil fuel sources such as natural gas and coal, wind power does not have a comparable impact on the environment. Wind does not expel carbon dioxide, methane, water vapor or any other greenhouse gas, and it does not produce sulfur dioxide or any other polluting particulates. Since it does not require a fuel to run, there is no secondary effect on the environment such as mining and extracting resources from underground pockets. Therefore, all of wind power's impact occurs only at the site of the particular turbine or farm. The most commonly cited impact of turbines is their effect on birds. Older wind turbine designs included smaller rotors that had to spin much faster to achieve useful generation properties and these fast spinning blades could not be seen by passing birds. The other major concern is about the large areas of land required by wind farms.

Modern industrial sized turbines have much slower moving blades than in the past. This helps reduce bird fatalities since the birds can more easily avoid collisions with the slower blades, but the problem is not completely reduced. The U.S. Fish and Wildlife Service has standing voluntary guidelines for new wind farm developments. Even so, bird death related to wind turbines have been found to be much lower than those related to fossil fuel sources and lower still than from other human-related sources such as automobile traffic, hunting, high-rise buildings, and even the transmission of the power. The other major concern is alleviated by the fact that wind farms can share the large area with other human activities that would have been present regardless. For example, farms can share space with land reserved for grazing livestock and farmers can grow crops right up to the foot of the towers holding the generators and rotors [15].

Congress could have the major or most important guidelines of the Fish and Wildlife serve incorporated into law to minimize impact and reconcile wind development with environmental support groups.

V. Daily Life Impact

As for the impact of wind power development on the day to day life of an average citizen, the reactions are mixed and revolve around two aspects of wind farms: their aesthetics impact and their noise generation.

Historically, wind turbine farms have always had opposition from some residents of the area they occupy, with complaints about them being quite varied. The most commonly heard about complaint is the turbines' change of the landscape they reside on, an issue that has even led to the delay of some projects for substantial periods of time. Other issues include the mandatory warning lights on any tall structure, or the “shadow flicker” caused by the rotating blades intermittently interrupting sunlight [17]. Not all people agree that wind farms are a sore sight, though and there are some past examples of wind not only being accepted but embraced. A 12 turbine farms overlooking Ardrossan, Scotland is one of them. A year after the initial concern when the project was first proposed, one of the town's councilors wrote the following:

"The Ardrossan wind farm has been overwhelmingly accepted by local people - instead of spoiling the landscape, we believe it has been enhanced. The turbines are impressive looking, bring a calming effect to the town and, contrary to the belief that they would be noisy, we have found them to be silent workhorses. [18]"

Unlike the aesthetic concerns, the effects of wind turbine noise have been reported to go beyond annoyances or popular opposition - residents near large wind farms have reported serious health concerns. Some medical professionals have come to call these adverse health effects “Wind Turbine Syndrome” and have identified the following effects in patients: sleep problems caused by the frequent feeling of pulsation or pressure changes, headaches, dizziness, nausea, and tinnitus or ringing in the ears, all of which lead to exhaustion, mood changes or irritability, and a decrease in concentration and learning capacity. Not all residents near farms report any of these issues but that does not eliminate the link between such symptoms and wind farms but merely show that people are affected differently. These symptoms mostly draw from the low frequency sounds produced by turbines that are not necessarily heard but frequently felt. However, this type of noise pollution has a straightforward solution. Increasing distance from farms to urban or residential areas decreases their adverse effects on people [19].

While the use of wind power is a potential boon to the nation, the safety and well-being of citizens should not be a price of its development. The Federal government should take steps to prevent wind farms from disrupting people's daily lives and health by further investigating health concerns relating to turbines and, if necessary, pass laws that would prevent their effects.

It is ultimately the right of area residents to decide whether or not to have wind development where they live, but some proponents of wind development argue that this opposition is misguided. The arguments for this case include the fact that most people do not have to directly face the price being paid for their constant supply of electricity. For example, traditional electrical supply usually came from coal power plants that were not in sight of the people they supplied and therefore people did not see or have to deal with the effects of mining the raw materials, transporting them, and combusting them. Wind power does not enjoy the privilege of being out of sight, out of mind. Some of the highest average wind speed areas are located near or at least within sight of where people live or commute somewhat forcing people to deal with their source of electrical power. The proponents argue that if wind turbines could be "hidden away" much like coal plants, they would not have such strong opposition or actually have much less due to their environmentally friendly aspects of not producing greenhouse gasses or pollutants [16].

VI. Residential, Industrial, and Commercial Impacts

Besides affecting the day to day life of people, wind power also has some economical impact on residential, industrial, and commercial sectors stemming from various sources such as changes of property values and changes in the cost of electricity. The depreciation of homeowner property values due to nearby wind turbine development has been a long time concern with various studies such as the Beacon Hill Institute 2003 Massachusetts study concluding a 4% loss of value for Cape Cod shoreline properties due to the proposed Cape Wind offshore project. Newer studies, however, point to the possibility that such thinking may be a misconception [22]. A 2009 U.S. Department of Energy's Lawrence Berkeley National Laboratory three-year study concludes that:

"..neither the view of wind energy facilities nor the distance of the home to those facilities was found to have any consistent, measurable, and significant effect on the selling prices of nearby

homes. No matter how we looked at the data, the same result kept coming back - no evidence of widespread impacts. [20]"

Other studies such as a 2006 Bard College study and a 2003 Renewable Energy Policy Project conclude similar results. Looking deeper into reports like the Beacon Hill Institute studies reveal some inconsistency between the conclusions of lower values and the results of the study. The groups chosen for sampling in the Beacon Hill study, for example, were homeowners that were long time residents of the area and exposed to anti-wind development arguments for the past couple of years. Despite this, 79% of those interviewed answered that they did not expect a loss of home value, leading to questions as to how the Institute concluded a $1.35 billion loss in property values [21].

Another major impact wind power can have on all three sectors in the reduction in electricity prices. With price per kWh from wind sources as low as 5.5 to 9 cents, and continuing reduction in prices from more efficient wind turbines with higher capacity factors, wind power is well on its way to being more competitive with traditional energy sources. The question that remains to be answered is just how much of our energy needs can wind supply. In his 2005 book, "Energy in the 21st Century," author John R. Franchi argues that the theoretical potential of wind is mind-blowing. Assuming a world population of 8 billion people each of which requires 200000 mega joules or about 56MWh of energy per year, he calculates we would need 12.7 million 4MW turbines to supply all of our energy needs. While this number might seem much too large, Franchi also calculates that the area required is about 465,000 square miles. This translates to about 16% of the continental U.S. or only about 0.81% of the world's total land area [23].

The problem then arising from wind supplying most or all of our energy is not the fact that it cannot produce the sheer amount required but rather with the way in which it produces it. The modern electric grid relies on the supply of energy constantly being produced to match the load demanded and is essentially split into two parts. The base load is somewhat constant and is provided by large coal or nuclear power plants that take long periods of time to fire up and reach their stable output, therefore being unable to be quickly regulated for a desired output. The peak load is the fluctuation from the base load and is provided by more responsive plants that can quickly match the required demand. Since wind farm output varies dependent completely on wind it cannot directly supply either of the above. Instead the reactors changing output to meet peak load can ramp down production when output from wind farms is high and vice versa. This leads to a fundamental discrepancy between what wind can supply and what we need and therefore limits wind to a supplemental, albeit substantial and important, role in our overall energy picture. Despite this, the Department of Energy's goal of "20% Wind by 2030" is still an attainable goal as long as other sources are considered in order to supply what wind cannot [24][25].

VII. The Future of Wind

Section 6 described the reasons why wind power will never be able to be our major source of electrical energy, but it also mentioned the DOE's 20% Wind plan which is the nation's best recourse when it comes to integrating wind in our national energy supply. As the name suggests, it is a plan to have at least 20% of the nation's grid supply come from wind power and it is discussed in depth by the DOE's May 2008 publication on the subject.

The 20% Wind plan has many diverse positive impacts in areas environmental, conservational, and economic such as:

- Reduction of mercury, CO_2, heavy metal and other environmentally impacting emissions.
- Reduces reliance on foreign fuel sources, stabilizing and even reducing prices.
- Benefits for rural land owners and new tax income for wind development communities.
- Generates jobs in sectors developing wind power such as manufacturing, engineering, construction, transportation, and financial services.

Conserves water by reducing electric sector water use by up to 8%

No benefits come without a price to pay, however, but wind development's price is not as steep as might be expected. The DOE predicts that the cost of 20% Wind by 2030 is only 2% higher than if the nation continued developing energy supply without it when considering that much of wind's new cost would be offset by the drastic reduction in fuel consumption [26].

The Federal government should continue to support and do whatever is necessary in the future to ensure that the DOE 20% Wind by 2030 plan comes to fruition.

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Nuclear Power

I. Daily Life Impact

Nuclear Power is the generation of electricity predominantly produced from harnessing the energy released from atomic fission reactions. Fission is an exothermic reaction caused by splitting the atomic nuclei of an isotope of uranium. The exothermic reaction is used to convert water into steam and thus convert the steam into electricity. This source of energy is the most viable source of energy due to its relative compactness in size. There are two types of methods for producing nuclear energy, the mentioned nuclear fission and the fusion reaction. Nuclear power has varying affects on different sectors of the population.

Due to the reliability of nuclear power, the consumers who use its electricity generated from the nuclear reactors do not have to suffer from the issues of power outages as other alternate sources do. In 2005 it was reported that reactors had an approximate 1.6% unexpected loss which equates to an approximate 4,200 Hr of maximum energy production. While these losses do not cause a blackout they do limit maximum output of the power plant [1]. The output of the power plants also reduces production during the summer months for safety reasons as the fundamental methodology of nuclear power is to create heat and harness that energy.

Low level nuclear waste may be something that consumers may come in direct contact as recycled goods. According to the US Nuclear Regulatory Commission Low-level nuclear waste items such as clothing, tools and spare parts that have come into contact with the nuclear reactor should be treated as regular waste and should be recycled into consumer items as the materials are only considered nuclear waste due to its history [2].

Due to the inevitable objects that come into contact with various part of the nuclear reactor we recommend that all low level waste be treated as any other waste but housed for shorter periods of time. This decreases consumer worry and increases consumer approval.

II. Areas of Impact

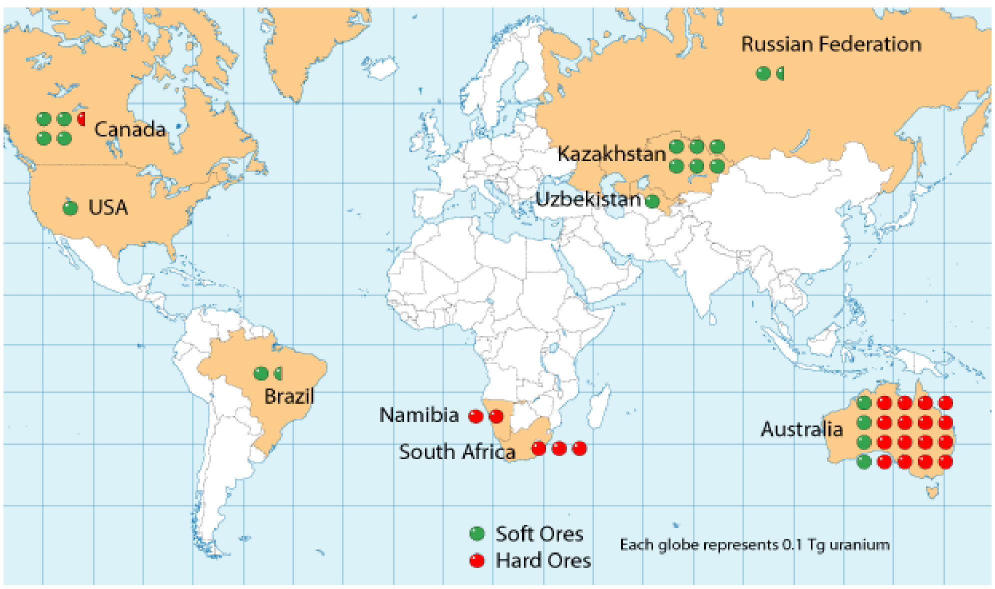
As the electricity produced from nuclear reactors ties directly into the localized power grid, the difference in usage by the residential, commercial and Industrial sector is greatly reduced. While it would be obvious that the industrial and commercial sector would require more energy than the residential sector, they especially benefit by taking advantage of the stability in nuclear reactors. Nuclear energy provides a relative low cost because nuclear reactors are small enough to fit in a relatively small area. By increasing the number of reactors in a certain area it reduces the distance power has to travel and as a byproduct reduces the cost of power.

Due to nuclear power capabilities in creating power plants in relatively small areas, more power plants should be constructed underground in urban areas of high need. This would eliminate blackouts in these areas and provide low cost power to the users.

III. Availability

The availability of uranium is extremely important for the United States primarily for electricity generation. The United States generated 19.4 percent of its electricity in 2006 through nuclear fission therefore making uranium essential to supplying the electricity demand of Americans [12]. The use of nuclear fission has increased over 400 percent worldwide from 1980 to 2006, and it will continue to increase until it is no longer economically profitable to mine uranium. The United States is currently the largest producer of electricity though nuclear fission at 787.22 billion kilowatthours of electricity generated in 2006. The second largest producer of electricity by nuclear fission is France at 427.8 billion kilowatthours of electricity generated in 2006 [13].

In order to compete with other countries leading in the production of nuclear energy. The Unite States should create tax incentives for the creations of new, clean and safe forms of nuclear energy production.



[http://watd.wuthering-heights.co.uk/nuclear/images/uranium-map.gif]

Most of the proven reserves of uranium in the world are in Australia. Australia has 1,243,000 tones of proven uranium as of 2007. Most of the uranium in Australia is located in the Olympic Dam, and almost all of the uranium that is produced here gets exported. Although Australia has the largest uranium deposit in the world, Canada has the highest-grade uranium ore at 200,000 parts per million of Uranium (or 20%). The countries that have the most uranium are: Australia, Kazakhstan, Russia, South Africa, Canada, and the United States. The most recent estimates total the current extractable reserves at 5.5 million tones of uranium. The current usage of uranium is about 65,000 tones per year, and at the current consumption rate, the world would completely run out of uranium in 84.62 years. The uranium consumption will not stay the same, but estimations can be made to get a reasonable length of time when the world will run out of uranium.

Data collected by the Energy Information Administration and NPG are needed to make a good approximation of the time the world will run out of uranium. Figure 1 is a graph that shows the population of the world, as estimated by NPG, as a function of time. Figure 1 shows that from 1980 to 2006, the population has increased almost linearly at a rate of 81 million people per year. The total electricity consumed by nuclear fission has also increased from 1980 to 2006, but not at a linear rate. The total energy produced by nuclear fission can be seen in figure 2. The last piece of information needed to find out how long the world will be able to maintain electricity generation by nuclear fission is the average nuclear energy consumed by a single person. If an average number of kilowatt-hours per person is known, then we can use the assumption that the world population is growing linearly to find out how much extra uranium will be needed each year to supply the demand of electricity. The graph of the average number of kilowatt-hours per person from 1980 to 2006 can be seen in figure 3.

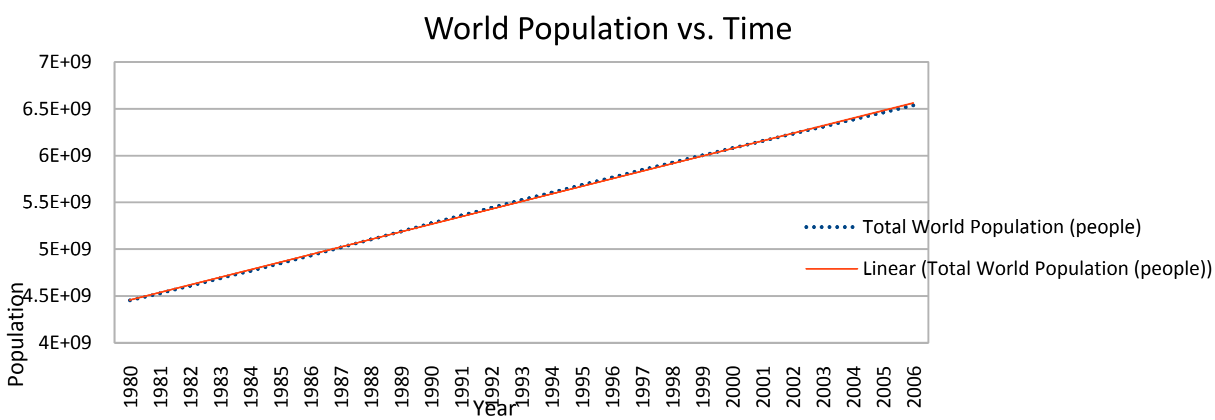


Figure 1

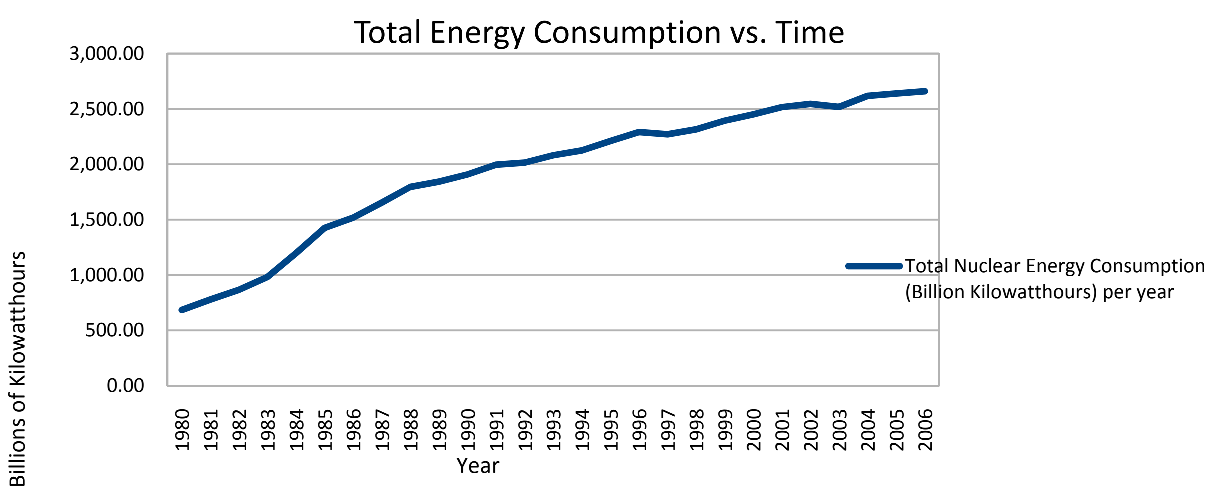


Figure 2

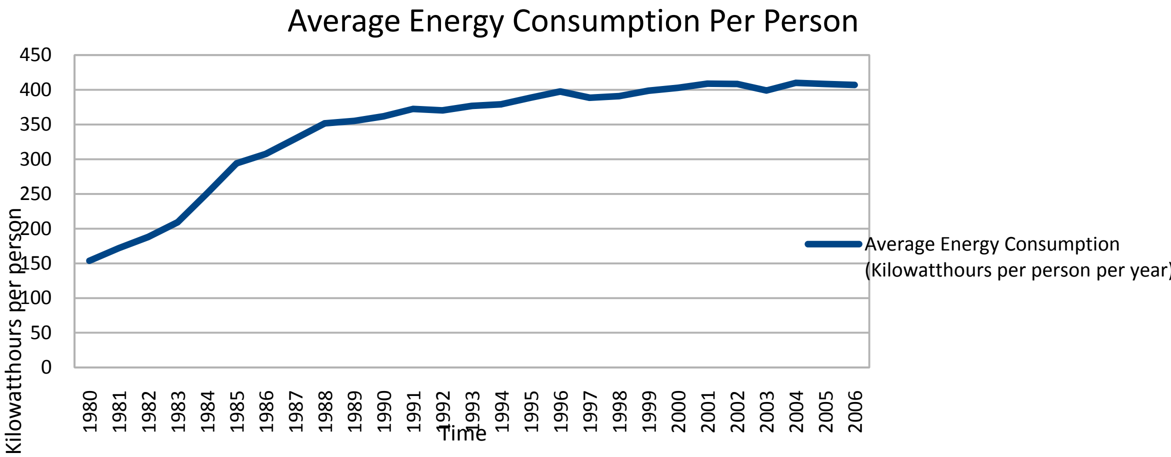


Figure 3

The average number of kWh produced from uranium to meet the electricity demand per person has remained relatively constant from 1996 to 2006. This is important because we can assume that if the population grows linearly and the average electricity consumed per person remains constant, the rate of uranium consumption can be approximated as a linear function. The total world's electricity nuclear power output per person has not fluctuated much from 1996 to 2006 and remains around 400 kWh per person per year. An increase of 81 million people per year corresponds to an increase of 32.4 billion kilowatt-hours of electricity produced by nuclear fission per year. An increase of 32.4 billion kilowatt-hours per year means that 781.87 extra tones of uranium will have to be used each year. To find out how long the current reserves of uranium will last, this equation 1 must be used.

$$\int_0^y (781.87\mathrm{x} + 65000)\,dx = 5500000$$

eq. 1

Applying the fundamental theorem of calculus yields a simple quadratic equation seen in equation 2.

$$390.94\mathrm{y}^2 + 65000\mathrm{y} - 5500000 = 0$$

eq. 2

The quadratic formula can then be applied.

$$y = 61.71$$

Assuming that the population continues to increase linearly and the total world's nuclear electricity power output per person remains constant for the next 62 years, then the last of the proven reserves of uranium will be depleted in 61.71 years. Uranium mining will stop before 61 years though because it will no longer be profitable to extract far before 61 years from now if no other technological breakthroughs or large deposits of uranium are found.

In order to sustain nuclear fission for longer 60 years the US should invest in other forms of viable renewable sources of energy such as wind, solar, hydro, and nuclear fusion.

IV. Economic Cost

The costs involved in producing electricity in the United States through nuclear fission are higher than coal, but still remain competitive. The cost per kilogram of uranium fuel for power plants is very high, unlike coal, because I needs o be converted, enriched, and then fabricated. The cost per kilogram of processed uranium is $2555. In addition to the costs for processing the uranium to be used, nuclear power plants also have costs for spent fuel and plant decommissioning. In 2008 the Energy Utility Cost Group estimated the production cost of electricity by nuclear fission to be 2.866 cents per kilowatt-hour. The Energy Utility Cost Group estimated that 1.832 cents per kilowatt-hour was the cost of maintaining the plant, .449 cents per kilowatt-hour was spent of fuel, and .585 cents per kilowatt-hour was spent on capital expenditure. In 2005, an OECD study found that the cost of generating nuclear power in the United States was 3.01 cents per kilowatt hour, and the cost of coal was 2.71 cents per kilowatt-hour [14].

Data

Year	Total World Population (people)	Total Nuclear Energy Consumption (Billion Kilowatthours) per year	Average Energy Consumption (Kilowatthours per person per year)	% change in population	% change in Average Energy Consumption per person
1980	4453863820	**684.38**	153.66	0	0
1981	4529899224	**778.64**	171.89	1.71	11.86
1982	4610062597	**866.42**	187.94	1.77	9.34
1983	4690307356	**981.72**	209.31	1.74	11.37
1984	4769630537	**1,196.85**	250.93	1.69	19.89
1985	4850224998	**1,425.54**	293.91	1.69	17.13
1986	4932580072	**1,517.66**	307.68	1.7	4.69
1987	5018293296	**1,653.98**	329.59	1.74	7.12
1988	5104636805	**1,794.85**	351.61	1.72	6.68
1989	5190697978	**1,843.39**	355.13	1.69	1
1990	5277725410	**1,908.81**	361.67	1.68	1.84
1991	5360628665	**1,996.14**	372.37	1.57	2.96
1992	5443740826	**2,015.60**	370.26	1.55	-0.57
1993	5525753998	**2,081.63**	376.71	1.51	1.74
1994	5606338688	**2,125.16**	379.06	1.46	0.62
1995	5687011326	**2,210.04**	388.61	1.44	2.52
1996	5766435620	**2,291.53**	397.39	1.4	2.26
1997	5846871429	**2,271.31**	388.47	1.39	-2.25
1998	5925770871	**2,316.01**	390.84	1.35	0.61
1999	6003771994	**2,393.13**	398.6	1.32	1.99
2000	6081002937	**2,449.89**	402.88	1.29	1.07
2001	6157756751	**2,516.67**	408.7	1.26	1.45
2002	6234277496	**2,545.30**	408.28	1.24	-0.1
2003	6310549064	**2,517.76**	398.98	1.22	-2.28
2004	6386542886	**2,617.32**	409.82	1.2	2.72
2005	6462181426	**2,639.25**	408.41	1.18	-0.34
2006	6537660423	**2,660.26**	406.91	1.17	-0.37

http://www.npg.org/facts/world_pop_year.htm
http://www.eia.doe.gov/pub/international/iealf/table27.xls

V. Environmental Effects and Cost

Due to the inevitable consequences in the production of nuclear energy, the radioactive by product has the ability to cause harm to the ecosystem. In order to reduce the impact of nuclear waste on the environment the nuclear industry has build safety measures and created protocols to ensure the safety of any ecosystem. Below are typical issues that companies take into consideration when implementing safety measures. It is important to discuss the issues and the measures themselves because the price to undergo these safety measures is "built in" the overall cost related back to the consumer.

1. Radioactive waste

An average nuclear power plant produces approximately 30 tons of high-level waste on a monthly basis. Due to the composition of nuclear reactor waste, some of the material is useful in creating even more fuel, but as a byproduct produces weapons grade plutonium. This method already reduces the quantity on high level radiation which in turn reduces the environmental effect. In the Unites States, reprocessing of radioactive waste is prohibited by the federal government due to its capabilities in creating plutonium. The current method of dealing with the waste is storing it until the radiation of the material sinks to acceptable levels. Nobel laurite in physics Hannes Alfven described the two main prerequisites of a successful geological disposal to be, a stable geological formations, and (2) stable human institutions over hundreds of thousands of years. The cost of monitoring, maintaining and of a geological disposal facility cost an approximate 5.79 billion dollars for storage to 2025 years. The creation of the facility large enough to store large quantities of radioactive materials cost an approximate 38.3 billion dollars [10].

With an overall cost of 44.09 billion dollars for the span of 2025 years would equate to 21.77 million dollars a year just from storage, which also means a 2 cent increase per MWH. There are several alternatives for dealing with the long half-life of nuclear waste, and the storage of this waste such as above ground dry casks, removal to space and nuclear transmutation which is the conversion of one chemical element into another less harmful element or isotope. The monitoring and storage of radioactive waste is important due its effect on living things. Radiation poisoning is a form of damage to organ tissue caused by excessive exposure to the ionizing radiation that is emitted from nuclear reactor wastes products. The term Radiation poisoning is generally used to refer to acute problems caused by a large dosage of radiation in a short period, though this also has occurred with long term exposure [3, 4, 5].

In order to reduce the possibility of nuclear waste leaking into the ecosystem we recommend that all nuclear waste should be packaged and shipped into an autonomist waste storage facility located on the moon.

2. Waste heat

A normal issue with nuclear reactors is there issue with the amount of thermal energy produced and how to cool these for mentioned reactors. The conventional method of cooling the reactor would be to use natural sources of water such as river, and lakes or the usage of cooling towers, but there are new technologies that are straying from the convention. Many plants have been creating artificial lakes like the Shearon Harris Nuclear Power Plant to compensate for the heat. The environmental effects that are caused by the creation of artificial lakes and the increase of water vapor due to the cooling the nuclear reactors increases the efficiency of the green house effect as it increases the albedo of the planet. These are often weighted in arguments against construction of new plants. [6]

3. **Radioactive emissions**

Nuclear power plants release gaseous and liquid radiological byproducts into the environment as a byproduct of the Chemical Volume Control System. Humans living within 50 miles of a nuclear power plant the person will approximately receive 0.01 milli-rem per year, in comparison the average roentgen per year of coal-fired power plants is approximately 0.03 milli-rem. The total amount of radioactivity released through this method depends on the power plant, the regulatory requirements, and the plant's performance [7]. The Nuclear power plants also have to dispose "low level" in a different manner than regular radioactive waste, because it is more in effective to dispose of materials with less than 5 years of half-life. According to the Barnwell Facility in South Carolina, the competing price of low level storage in 1993 was an approximate 220 dollars per cubic foot [11].

In order to possibly reduce radioactive emissions, the confinement of the reactor core is a necessity and the construction of underground nuclear facilities will be able to reduce the emissions on residential areas.

4. Environmental effects of accidents

In September 1990 fallout levels within the 10 km zone around the Chernobyl Nuclear Power Plant were as high as 5.6 Rontgen per second. The site of the Red Forest which was directly behind the reactor plant remains one of the most contaminated areas in the world. "The explosion at the power station and subsequent fires inside the remains of the reactor provoked a radioactive cloud which drifted not only over Russia, Belarus and Ukraine, but also over the European part of Turkey, Greece, Moldova, Romania, Bulgaria, Lithuania, Finland, Denmark, Norway, Sweden, Austria, Hungary, the Czech Republic and the Slovak Republic, Slovenia, Croatia, Poland, Estonia, Switzerland, Germany, Italy, Ireland, France (including Corsica), Canada and the United Kingdom (UK)".[8] When accident occur in nuclear power plants the consumer pays the ultimate cost, in multiple forms of deadly cancers, poverty due to the relocation of the population and business, and the destruction of nature itself.

Due to its overall the overall cost in environmental protection, the ban on reprocessing nuclear waste in the US should be redacted in order to lower cost. With the new profit, greater research can be done in transmutations and other forms of waste distribution ,leading to future reduction in nuclear energy

VI. Current Technological Advances

1. Pressurized Water Reactors

These reactors use a pressure container to control the super heated water. The hot radioactive water that leaves the pressure and uses convection to heat a secondary (non-radioactive) loop of water to steam that can run turbines. The main issue with this method is the high loss of efficiency and thus energy due to the convection process.

2. Boiling Water Reactors

A BWR is like a PWR without the steam generator. The difference between BWR and PWR is that BWR works at a lower pressure. This allows the water to boil which produces steam that runs the turbines. Unlike a PWR, there is there is no loss due to the convection process.

3. Gas Cooled Reactor

These are generally graphite moderated and CO_2 cooled. They can have a high thermal efficiency compared with PWRs due to higher operating temperatures.

4. Liquid Metal Fast Breeder Reactor

This is a reactor design that is cooled by liquid metal and produces more fissile materials than it consumes. They are called "breeder reactors" because they produce fissionable fuel during operation because of neutron capture. These reactors come in two types and share similar efficiencies to PWR:

Lead cooled:

Using lead as the liquid metal provides excellent radiation shielding, and allows for operation at very high temperatures. Also, lead is primarily transparent to neutrons, so fewer neutrons are lost in the non radioactive coolant. Lead is mostly inert, so there is less risk of explosion or accident, but such large quantities of lead may be problematic from toxicology and disposal points of view.

Sodium cooled:

Most LMFBRs are of this type. The sodium is relatively easy to obtain and work with, and it also manages to actually prevent corrosion on the various reactor parts immersed in it. However, sodium explodes violently when exposed to water.

5. Nuclear Fusion

Nuclear fusion is the process of multiple atomic nuclei joining together to create a unified nucleus. Fusion power is generated by the energy released by each individual nuclei fusing together. Fusion reactions generally release large amounts of infrared radiation, which is then used to operate a steam turbine in a similar manner to electricity generated from steam power. Scientists have been able to successfully create fusion reactions by decreasing the distance between nuclei so that the residual strong force in the nuclei will "fuse" the nuclei together. This is accomplished by increasing the speed in nuclei vibrations.

When you compare the environmental effects of conventional fission reactions to fusion reactions we can observe one significant difference. The half lives of the radioactive isotopes produced by a fusion reaction are considerably less than the fission radioactive isotopes. Fission reactors generally create waste that can have a half life that can last 1000 years compared to fusion's half-life which can last 50 years. It is important to note that during the short 50 year half-life of the fusion waste, it is considered substantially more radio active than fission nuclear waste.

The research of fusion reactors is important because it could revolutionize the methods of producing energy and possibly alter societies view on energy. Nuclear fusion is currently is not a viable source of energy because it currently requires more energy to create the fusion reactions than the energy the reaction themselves produce. In order to break though this technological barriers research must be done in different areas of nuclear fusion. There are three current viable methods of creating fusion reactors the use of Magnetic confinement fusion, Laser inertial devices, and Pinch devices.

Magnetic confinement fusion is a method of generating nuclear fusion via increasing the temperature in the electromagnetically suspended fusion materials. This method is one of two major branches of fusion energy research. In order for the nuclear reactions to form the nuclei must be under a temperature of several tens of millions of degrees, under these conditions they exist in form of plasma. There are several facilities that use this technique and are capable of producing some of the more promising results such as the Joint European Torus (JET) facilities in the UK capable of producing 16 megawatts of fusion power.

Inertial confinement fusion (ICF) is a method of generating nuclear fusion via heating and compressing fuel pellets composed of deuterium and tritium. ICF is the other major branch of fusion energy research. In order to compress and heat the pellet energy is transferred to the surface of the pellet by laser light, electrons or ions. When the surface of the pellet has increased to a high enough temperature the surface explodes. The explosion causes the internal fuel to compress even further. The energy released by these reactions will then heat the surrounding fuel, which may also begin to undergo fusion. This action reaction cycle between temperature and compression is what causes the fusion reactions.

The zeta pinch is a new method of generating nuclear fusion via heating and compressing and electromagnetic containment. This is done by electric currents creating magnetic fields to contain the fusion material in plasma form and compressing it with the same magnetic field. This type of fusion method utilizes principles based of Lorenzo force. An example of Lorenzo's for would be “if two parallel wires are carrying current in the same direction, the wires will be pulled toward each other."

For the continuation of nuclear technologies, the reduction in research of conventional forms of fission reactions and reactors is essential for the resurgence of fusion reaction research. This focus on fusion will lead the world into a prosperous future.

VII. Regional Resource Allocation

Given the consumption chart of conventional Nuclear energy sources we can determine that the areas that have the most energy production are the South and Mid Atlantic regions. These areas are more equipped to handle any style of nuclear power due to the mild weather. However there are areas that could improve in their production by incorporating new reactors into the state. Mountain and Pacific noncontiguous regions should be able to sustain a viable and reliable income of energy because with a colder temperature the reactor can run at higher rates and produce a larger quantity of energy than other power plants. The universality in size of these power plant means that they can be put anywhere including in urban areas. The most optimistic part of this source is that you can incorporate a reactor in a small area and create as many any needed for the population. [9]

Census Division and State	Total (All Sectors)			Electric Power Sector				Commercial Sector		Industrial Sector	
				Electric Utilities		Independent Power Producers					
	Nov-09	Nov-08	Percent Change	Nov-09	Nov-08	Nov-09	Nov-08	Nov-09	Nov-08	Nov-09	Nov-08
New England	**2,397**	**2,455**	**-2.4**	**--**	**--**	**2,397**	**2,455**	**--**	**--**	**--**	**--**
Connecticut	1,131	771	46.6	--	--	1,131	771	--	--	--	--
Maine	--	--	--	--	--	--	--	--	--	--	--
Massachusetts	492	492	-0.1	--	--	492	492	--	--	--	--
New Hampshire	340	895	-62	--	--	340	895	--	--	--	--
Rhode Island	--	--	--	--	--	--	--	--	--	--	--
Vermont	434	297	46.1	--	--	434	297	--	--	--	--
Middle Atlantic	**12,153**	**12,883**	**-5.7**	**--**	**--**	**12,153**	**12,883**	**--**	**--**	**--**	**--**
New Jersey	2,711	2,264	19.7	--	--	2,711	2,264	--	--	--	--
New York	3,696	3,683	0.4	--	--	3,696	3,683	--	--	--	--
Pennsylvania	5,746	6,936	-17.2	--	--	5,746	6,936	--	--	--	--
East North Central	**11,741**	**12,629**	**-7**	**1,282**	**1,601**	**10,459**	**11,028**	**--**	**--**	**--**	**--**
Illinois	7,666	7,891	-2.8	--	--	7,666	7,891	--	--	--	--
Indiana	--	--	--	--	--	--	--	--	--	--	--
Michigan	1,863	2,183	-14.7	1,282	1,601	581	582	--	--	--	--
Ohio	1,472	1,577	-6.6	--	--	1,472	1,577	--	--	--	--
Wisconsin	739	979	-24.5	--	--	739	979	--	--	--	--
West North Central	**2,741**	**3,963**	**-30.8**	**2,297**	**3,524**	**444**	**439**	**--**	**--**	**--**	**--**
Iowa	444	439	1.3	--	--	444	439	--	--	--	--
Kansas	213	858	-75.1	213	858	--	--	--	--	--	--
Minnesota	876	1,152	-24	876	1,152	--	--	--	--	--	--
Missouri	891	579	53.9	891	579	--	--	--	--	--	--
Nebraska	316	934	-66.2	316	934	--	--	--	--	--	--
North Dakota	--	--	--	--	--	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--	--	--	--	--	--
South Atlantic	**14,104**	**15,238**	**-7.4**	**12,844**	**13,976**	**1,259**	**1,261**	**--**	**--**	**--**	**--**
Delaware	--	--	--	--	--	--	--	--	--	--	--
District of Columbia	--	--	--	--	--	--	--	--	--	--	--
Florida	1,739	2,480	-29.9	1,739	2,480	--	--	--	--	--	--
Georgia	2,893	2,704	7	2,893	2,704	--	--	--	--	--	--
Maryland	1,259	1,261	-0.1	--	--	1,259	1,261	--	--	--	--
North Carolina	3,577	2,895	23.5	3,577	2,895	--	--	--	--	--	--
South Carolina	2,733	3,713	-26.4	2,733	3,713	--	--	--	--	--	--
Virginia	1,903	2,184	-12.9	1,903	2,184	--	--	--	--	--	--
West Virginia	--	--	--	--	--	--	--	--	--	--	--
East South Central	**6,238**	**5,417**	**15.1**	**6,238**	**5,417**	**--**	**--**	**--**	**--**	**--**	**--**
Alabama	3,582	2,321	54.3	3,582	2,321	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	--	--	--	--	--
Mississippi	912	880	3.6	912	880	--	--	--	--	--	--
Tennessee	1,743	2,215	-21.3	1,743	2,215	--	--	--	--	--	--
West South Central	**5,058**	**5,829**	**-13.2**	**2,044**	**2,299**	**3,014**	**3,531**	**--**	**--**	**--**	**--**
Arkansas	1,348	726	85.7	1,348	726	--	--	--	--	--	--
Louisiana	696	1,573	-55.7	696	1,573	--	--	--	--	--	--
Oklahoma	--	--	--	--	--	--	--	--	--	--	--
Texas	3,014	3,531	-14.6	--	--	3,014	3,531	--	--	--	--
Mountain	**1,909**	**1,945**	**-1.9**	**1,909**	**1,945**	**--**	**--**	**--**	**--**	**--**	**--**
Arizona	1,909	1,945	-1.9	1,909	1,945	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	--	--	--	--	--	--	--	--	--
Montana	--	--	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	--	--	--	--	--
Utah	--	--	--	--	--	--	--	--	--	--	--
Wyoming	--	--	--	--	--	--	--	--	--	--	--
Pacific Contiguous	**2,731**	**3,049**	**-10.4**	**2,731**	**3,049**	**--**	**--**	**--**	**--**	**--**	**--**
California	2,118	2,416	-12.4	2,118	2,416	--	--	--	--	--	--
Oregon	--	--	--	--	--	--	--	--	--	--	--
Washington	613	633	-3.1	613	633	--	--	--	--	--	--
Pacific Noncontiguous	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Alaska	--	--	--	--	--	--	--	--	--	--	--
Hawaii	--	--	--	--	--	--	--	--	--	--	--
U.S. Total	**59,069**	**63,408**	**-6.8**	**29,344**	**31,811**	**29,725**	**31,597**	**--**	**--**	**--**	**--**

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Hydro-Electric Power

Hydro-Electric power is generated from the manipulation of water and utilizing it to cause a mechanical motion, which produces electrical energy via the magnetic induction of an electric generator. This kinetic energy of water is amplified by either current flown of the water and the effect gravity has upon the stream. Because this source requires vast amount of water, to obtain a viable production rate this method of energy production cannot be utilized in most places. This type of renewable energy produces approximately 7% in the US and 20% of the world's electric energy consumption [1, 2].

I. Daily Life Impact

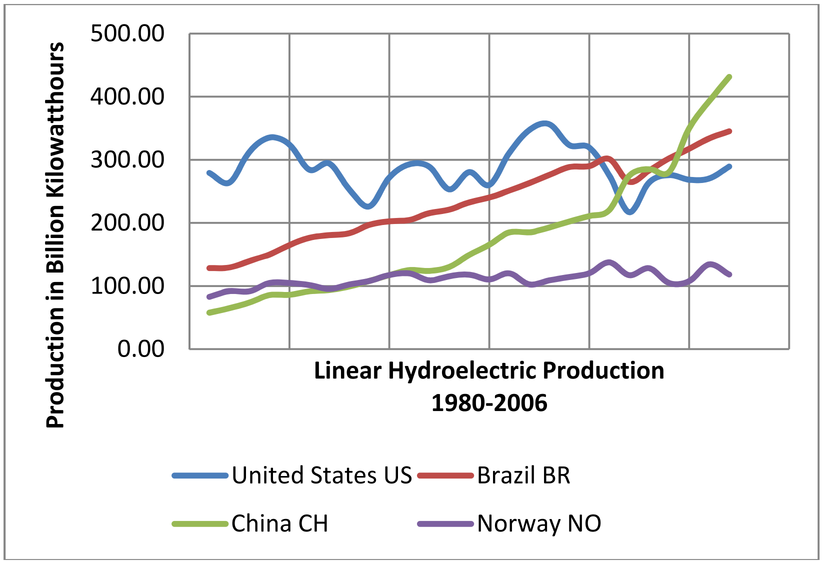
There are various types of Hydro-Electric generation, the most common form are the Hydro-Electric power stations. This station's produce large amounts of power and require large bodies of water. Other forms of production are called small, micro, and Pico hydro; all of which require smaller bodies of water and are more suited for residential use. The major drawback of hydro electric power is time, and its high initial investment, this investment is high not only because of the physical construction of a dam, but of the relocation of the nearby population. [2]

Living near a hydroelectric power plant has many benefits for the consumers, none of which is more important than stability in cost per watt. This stability is the byproduct of a constant and renewable resource of any body of water. There is also a reduced cost of energy when comparing it to other conventional sources, because there is no need transport raw materials. Some hydroelectric power plants are subject to some inconsistency due to weather changes and inconsistencies in the hydrological cycle. These inconsistencies cause power outages and mass blackout for the nearby population.

In 2009 Brazil experienced a massive blackout that affected 60 million people and encompassed 70% of all of Brazil. This blackout was caused by an increase in the expected quantity of rain and causing high voltage transformers to fail due to exceeding the electrical specifications of the particular transformer. However these environmental changes are rare and preventable given a thorough hydrological study of any area of interest. [3, 4].

The minor inconsistencies of hydroelectric power do not seem to be a deterrent to the world's pursuit in utilizing this method of electric production. Projections of electricity production from hydroelectric plants show a linear positive slope [5].

In order to prevent events similar to what the people in brazil expirienced, the government should create incentives for all hydroelectric dams to implement safety measures.



II. Technological Advances

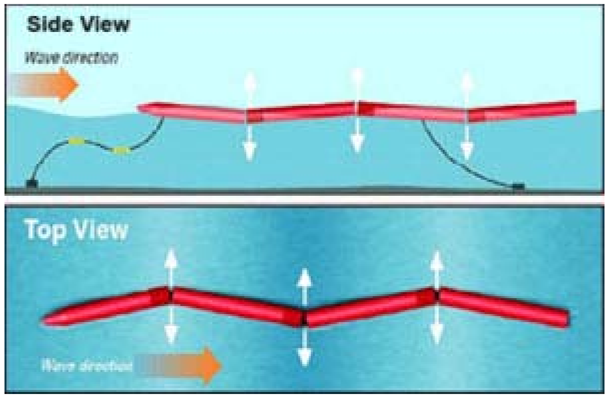
There are many different forms of generating hydro electrical energy and different methods to improve the efficiency, and environmental effects on the system. There are also new breakthrough methods that allow for the expansion of hydro electrical energy into locations that would not support it before. One of the benefits of hydro-electric power is that the technology used can be specialized by location and its hydrological properties. In order to increase the quantity of energy produced we need to utilize these technologies which will improve its efficiency and reduce its effect on river flow, and fauna.

Hydroelectric Water Turbine

The predominant new concept for water turbines for large power plants is the Pelton wheel; these wheels are designed to maximize the efficiency of the turbine. The Pelton wheel maximizes efficiency by increasing the rotational velocity and torque. The blade configuration and materials minimize non idealities and allows the maximum amount of energy to be transferred to the electric generator. This breakthrough turbine is capable of achieving 92% efficiency of the maximum efficiency of turbines. [6]

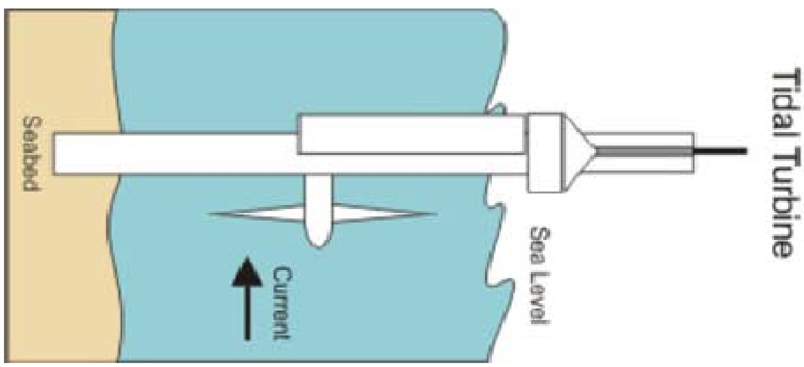
Wave Energy

This method utilizes the power of ocean waves to generate electricity, instead of utilizing a turbine wave energy uses the asymmetrical motion of the ocean to convert mechanical motion to electric energy. There are various devices for wave energy which include: *Oscillating Water Colum, Point Absorber, Attenuator, and Overtopping Device.* The most recent investment in wave energy is an attenuator wave farm that has ten 200 ton buoys and can produce enough energy to power 400 homes. [7]



Tidal Turbine

Tidal turbines are similar to regular turbines but are powered by the oceans underwater current flow. This method seems to be the future of hydroelectric energy as it is more predictable and more consistent than wind and solar power. The world first tidal power station located in France has 24 tidal turbines and is capable of producing 800GWh. [8]



The future of hydroelectric power is bright; the major issue with these new technologies is the effect they have on the environment. If the reduction of the environmental effects is maximized by new improvements then they can be used commercially available like hydroelectric dams are today.

The government should fund research into the development of autonomous hydroelectrical ocean farms which take advantage of new hydro technologies like tidal turbines.

III. Environmental Effects

One of the major advantages for increasing the quantity of hydroelectric production would be the reduction of greenhouse gases that would be produced from using conventional fossils fuels, but for some methods this may not be true. The majority of hydroelectric energy the world produces is generated from hydroelectric dams and these dams have been known to produce equivalent methods of "greenhouse gasses". While the dams don't produce greenhouse gasses directly the procedure in which electricity is generated does. When the reservoir is initially flooded, the decomposed peat and biomass releases both methane and CO_2 over time. Due to the instability of water levels and water currents there is always some form of biomass that is releasing fossils fuels. [9]

There are also more direct Environmental damages caused by hydroelectric dams, such as the failure of dams themselves. One of the basic principles of dams is to retain and restrict the flow of water. If the dam experiences brittle fracture by exceeding the yield strength of dam walls then all of the constrained water will cause flooding and the destruction of anything within the vicinity of the failed dam. This type of failure could occur when there is heavy rain and the water pressure exceeds its intended pressure. This type of scenario seems similar to the incident with Brazil's power plant, and we can imply that the issue of overflow is not a rare occurrence.

The problem of keeping the area's ecosystem intact and unchanged seems to be a common theme among all hydroelectric technologies. The prevention of fish, in particular salmon, to spawn upstream has significantly reduced the salmon population as well as the fish that are engulfed into the turbines. Some of the issues however do not apply to Wave energy and Tidal turbines. Wave energy is the most environmentally friendly of all of the Hydroelectric technologies, known to only produce noise pollution. However for tidal turbines there is little research on how this method will affect the ecosystem. The Rance River tidal power plant reports that sand-eels and plaice have disappeared from the area but sea bass and cuttlefish have returned to the river.

We need to take into consideration the cost of these environmental effects and keep in mind that the cost to "fix" environmental issues are part of the cost the consumer pays. If the goal is to protect the world ecosystem and reduce the production of fossils fuels we should start to see a trend that strays away from convention hydroelectric production and move to a more beneficial source of hydroelectric power from both the perspective of cost for the consumer and the environment.

IV. Economics of Hydro-Electric Generation

Like other renewable energy sources, hydro-power has a critical advantage over fossil fuel based sources. While water flow can be considered this type of generation's fuel, it is not restricted by a reserve amount and has no fuel cost, making hydro-power immune to fossil fuel price fluctuations. The only limiting factor on the amount of energy hydroelectric power plants can generate is the flow available when taking into account usable locations in nature and environmental concerns. These factors, coupled with the fact that hydroelectricity is the oldest and most established form of renewable power, make this type of generation the cheapest of all in terms of operating costs.

Hydroelectricity also has advantages over other renewable sources. Much like solar and wind power, new hydro development has steep initial costs since new sites must be investigated, licenses must be acquired, and the dam housing the generating units is an expensive project. However, hydroelectrical plants can recover this initial cost the fastest out of all renewable sources. For example, the Three Gorges Damn in China is expected to recover its $22.5B pricetag in only 5 to 8 years by generating 84.7B kWh every year. [11]

V. Regional Resource Allocation

Given the consumption chart of conventional hydrogen energy sources we can determine that the areas that have the most energy production are the pacific contiguous and mountain regions. These areas are more equipped to handle convention style hydro power due to the vast quantities of rivers and glacier waters. However there are areas that could improve in their production of hydroelectric energy by incorporating wave and tidal technologies. Due to the strength of underwater ocean like gulf stream and the north pacific drift areas like the south Atlantic and pacific noncontiguous regions should be able to sustain a viable and reliable income of energy.

The abundance of water and waves on the earth allows wave energy production in the costal areas. Wave energy depends on magnitude and the frequency of waves causing mechanical motion on the device. These prerequisites for wave energy are dependent on wind speed and water depth. In order to maximize these productions there should be off shore wave and tidal farms similar to offshore drilling platforms but should be capable of relocation to an area of greater potential, which would be due to any variations in weather and tidal shifts.

Census Division and State	Total (All Sectors)			Electric Power Sector				Commercial Sector		Industrial Sector	
				Electric Utilities		Independent Power Producers					
	2009	2008	Percent Change	2009	2008	2009	2008	2009	2008	2009	2008
New England	**6,218**	**6,060**	**2.6**	**874**	**817**	**4,711**	**4,632**	**NM**	**NM**	**627**	**607**
Connecticut	340	304	11.9	NM	NM	313	280	–	–	–	–
Maine	3,273	3,205	2.1	–	–	2,680	2,631	–	–	593	574
Massachusetts	786	731	7.6	174	162	595	553	NM	NM	NM	NM
New Hampshire	1,106	1,216	-9.1	302	285	799	927	–	–	NM	NM
Rhode Island	NM	NM	–	–	–	NM	NM	–	–	–	–
Vermont	709	601	18.1	371	345	320	238	–	–	NM	NM
Middle Atlantic	**22,899**	**21,951**	**4.3**	**17,832**	**17,286**	**5,017**	**4,608**	**NM**	**NM**	**47**	**54**
New Jersey	NM	NM	–	–	–	NM	NM	–	–	–	–
New York	20,876	19,958	4.6	16,986	16,312	3,839	3,589	NM	NM	47	54
Pennsylvania	1,999	1,974	1.3	846	974	1,153	1,000	–	–	–	–
East North Central	**3,178**	**3,150**	**0.9**	**2,848**	**2,829**	**170**	**157**	**NM**	**NM**	**159**	**161**
Illinois	137	127	8	59	57	78	70	–	–	–	–
Indiana	395	329	20	395	329	–	–	–	–	–	–
Michigan	999	1,039	-3.8	907	951	73	NM	–	–	NM	NM
Ohio	400	342	17	400	342	–	–	–	–	–	–
Wisconsin	1,246	1,313	-5.1	1,087	1,150	NM	NM	NM	NM	139	141
West North Central	**7,348**	**6,737**	**9.1**	**7,216**	**6,598**	**53**	**NM**	**--**	**--**	**79**	**NM**
Iowa	701	704	-0.4	697	700	NM	NM	–	–	–	–
Kansas	NM	NM	–	–	–	NM	NM	–	–	–	–
Minnesota	518	539	-3.8	401	412	38	NM	–	–	79	NM
Missouri	1,305	1,848	-29.3	1,305	1,848	–	–	–	–	–	–
Nebraska	328	375	-12.7	328	375	–	–	–	–	–	–
North Dakota	1,100	949	15.8	1,100	949	–	–	–	–	–	–
South Dakota	3,385	2,313	46.3	3,385	2,313	–	–	–	–	–	–
South Atlantic	**10,633**	**8,975**	**18.5**	**8,293**	**6,405**	**1,840**	**2,079**	**NM**	**NM**	**488**	**482**
Delaware	–	–	–	–	–	–	–	–	–	–	–
District of Columbia	–	–	–	–	–	–	–	–	–	–	–
Florida	153	135	13	153	135	–	–	–	–	–	–
Georgia	2,060	1,706	20.8	2,036	1,685	NM	NM	–	–	NM	NM
Maryland	1,387	1,573	-11.9	–	–	1,387	1,573	–	–	–	–
North Carolina	3,406	2,573	32.4	3,371	2,336	NM	131	NM	NM	NM	98
South Carolina	1,425	1,062	34.2	1,385	1,032	NM	NM	NM	NM	–	–
Virginia	1,033	912	13.2	969	855	57	51	–	–	NM	NM
West Virginia	1,168	1,012	15.4	379	361	333	292	–	–	457	359
East South Central	**15,869**	**10,313**	**53.9**	**15,866**	**10,175**	**NM**	**NM**	**--**	**--**	**--**	**136**
Alabama	7,119	4,334	64.2	7,119	4,334	–	–	–	–	–	–
Kentucky	2,451	1,578	55.3	2,448	1,576	NM	NM	–	–	–	–
Mississippi	–	–	–	–	–	–	–	–	–	–	–
Tennessee	6,299	4,400	43.1	6,299	4,264	–	–	–	–	–	136
West South Central	**7,878**	**8,871**	**-11.2**	**6,910**	**7,915**	**968**	**956**	**--**	**--**	**--**	**--**
Arkansas	3,055	3,628	-15.8	3,054	3,627	NM	NM	–	–	–	–
Louisiana	923	912	1.2	–	–	923	912	–	–	–	–
Oklahoma	2,476	2,992	-17.2	2,476	2,992	–	–	–	–	–	–
Texas	1,424	1,339	6.4	1,381	1,296	NM	NM	–	–	–	–
Mountain	**24,839**	**25,974**	**-4.4**	**21,536**	**22,690**	**3,304**	**3,284**	**--**	**--**	**--**	**--**
Arizona	5,021	5,804	-13.5	5,021	5,804	–	–	–	–	–	–
Colorado	1,406	1,496	-6	1,313	1,381	93	NM	–	–	–	–
Idaho	8,234	8,018	2.7	7,619	7,394	615	624	–	–	–	–
Montana	7,085	7,751	-8.6	4,494	5,211	2,591	2,540	–	–	–	–
Nevada	1,811	1,462	23.8	1,811	1,462	–	–	–	–	–	–
New Mexico	224	224	0.2	224	224	–	–	–	–	–	–
Utah	430	537	-19.8	426	531	NM	NM	–	–	–	–
Wyoming	628	682	-7.9	628	682	–	–	–	–	–	–
Pacific Contiguous	**106,258**	**103,923**	**2.2**	**104,594**	**102,605**	**1,619**	**1,274**	**44**	**42**	**NM**	**NM**
California	23,014	16,524	39.3	21,694	15,553	1,314	965	NM	NM	–	–
Oregon	25,375	25,920	-2.1	25,207	25,751	168	169	–	–	–	–
Washington	57,869	61,479	-5.9	57,693	61,301	137	141	37	36	NM	NM
Pacific Noncontiguous	**1,028**	**964**	**6.7**	**963**	**910**	**33**	**NM**	**--**	**--**	**NM**	**NM**
Alaska	950	897	5.9	950	897	–	–	–	–	–	–
Hawaii	78	NM	–	NM	NM	33	NM	–	–	NM	NM
U.S. Total	**206,148**	**196,919**	**4.7**	**186,930**	**178,230**	**17,717**	**17,078**	**67**	**61**	**1,434**	**1,550**

NM = Not meaningful due to large relative standard error or excessive percentage change.

Notes: See Glossary for definitions. Values for 2007 are final. Values for and 2008 and 2009 are preliminary. - See Technical Notes for a discussion of the sample design for the Form EIA-923, Form EIA-906 and Form EIA-920. Negative generation denotes that electric power consumed for plant use exceeds gross generation. Totals may not equal sum of components because of independent rounding. Percent difference is calculated before rounding.

Source: Energy Information Administration, Form EIA-923, "Power Plant Operations Report."

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Finding the Best Use of Our Fossil Fuels

Electrical power in the United States comes from several sources, both fossil fuel based and renewable. Currently, over half of the electricity in the U.S. comes from coal, about a fifth each from nuclear power and natural gas, and the rest from oil or renewable sources such as hydro, solar, and wind. The exact distribution of fossil fuel use for electricity in 2008 was 51% of electricity supplied from coal, 21% from nuclear power, 17% from natural gas, and 1% from petroleum, totaling to about 90% of electrical power coming from fossil fuels or other fuels that have a limited supply lifetime such as uranium for nuclear power [1]. Since this isn't necessarily the ideal distribution of sources with respect to lowest consumer prices, lowest environmental impact, and sustainability, this chapter aims to find a better split of all fossil fuel or limited supply of fuel electrical sources that supply the electrical needs of the U.S. using the above conditions. Renewable resources are not included in this model since they are ideally infinitely sustainable and would therefore have disproportionate shares due to the sustainability part of the linear programming model.

I. Setting up the Model

To find an ideal or close to ideal distribution, linear programming can be used. Linear programming is a mathematical method for achieving the best outcome in a model given a list of requirements and requires a function to either maximize or minimize and constraints on said function. Thus, all of the energy sources to be analyzed need to be defined as variables in terms of the energy per year they provide:

AmtC = the amount of energy coal will supply towards electricity generation in kWh/year

AmtO = the amount of energy oil will supply towards electricity generation in kWh/year

AmtG = the amount of energy natural gas will supply towards electricity generation in kWh/year

AmtN = the amount of energy nuclear power will supply towards electricity generation in kWh/year

The major constraint on the amount of energy from all sources is that they must supply the total energy required in the U.S. This constraint can be put into an equation as follows:

$$\text{TotalAmt} = \text{AmtC} + \text{AmtO} + \text{AmtG} + \text{AmtN}$$

Next, the equations to be maximized or minimized are needed. Two equations must be minimized, the production cost of electricity from each source, ProdCost, and the environmental impact of each source, EnvImp, since a low cost of electricity and low environmentally detrimental effects are desirable. The sustainability of each resource equation, SusRes, needs to be maximized, since a longer period of usability for all resources is desirable.

ProdCost = CostC*AmtC + CostO*AmtO + CostG*AmtG + CostN*AmtN

EnvImp = WeightC*AmtC + WeightO*AmtO + WeightG*AmtG + WeightN*AmtN

SusRes = ReserveC/AmtC + ReserveO/AmtO + ReserveG/AmtG + ReserveN/AmtN

II. Production Cost Minimization

The production cost was chosen to be minimized instead of the final cost to the consumer mainly because of available statistics. The cost to the consumer varies wildly depending on the region it is sampled from and has record gaps in some periods for differing regions. At the same time, the production cost statistics are freely available from the U.S. Energy Information Administration branch of the Department of Energy for every year since 1995 [2].

The variables to be determined are in units of kWh/year but the desired output of the cost expression is in cents or dollars per year. Therefore, all of the variable coefficients CostC, CostO, etc. need to be in units of cents or dollars per kWh. This is actually convenient for a production cost calculation since most posted statistics for various years are in these units.

The most relevant statistics found are those for predicted prices for the years following 2010 from the International Energy Administration. The IEA's predicted data comes from a study performed on coal fired, gas fired, and nuclear power already in existence of the same type or using the same technologies as that of plants that are planned or under construction and to be commissioned from 2010 to 2015. The IEA gives their predicted results in a range such as 2.5 cents/kWh to 5 cents/kWh for coal, and provides statistics at both 5% and 10% discount rates. For consistency, the range of prices was averaged for each type of plant and the 5% discount rate was used throughout. This can cause some error in the results, but the actual value of prices is not paramount for this model, just the ratios of the prices' values with respect to each other [3]. Using this data, ProdCost becomes:

ProdCost = 3.75*AmtC + CostO*AmtO + 4.6*AmtG + 2.6*AmtN

The IEA's data does not include petroleum power plants due to their limited use affecting broad price predictions such as the more common power plants above. For example, since petroleum power plants are mainly used in the state of Hawaii in the U.S., predicted prices would only be relevant for conditions only present in that area. For the model to work, however, some derived price of oil is needed. To fill this need, an estimated cost of petroleum based electricity was computed using the cost and energy content of a barrel of oil and the average efficiency of oil based power plants. The result is a very rough estimate, but its high value agrees with the comparatively very high electricity costs in Hawaii:

ProdCost = 3.75*AmtC + 12.9*AmtO + 4.6*AmtG + 2.6*AmtN

From the price weights above, the ProdCost function would be expected to drive the model variable assignments towards most of U.S. electrical energy being produced by nuclear and coal power plants with gas power plants still have a significant share, while oil would only be used for electric power in a very limited fashion. This prediction does not quite fit the proportions being used presently since nuclear power only accounts for 21% of U.S. generation, but this can be explained by public resistance to the expansion of nuclear power after incidents such as Three Mile Island and Chernobyl. Also, this prediction does not take into consideration the other two functions to be minimized or maximized.

III. Environmental Impact Minimization

Unlike the production cost and sustainability functions, the environmental impact function has no practical way to work with units since environmental impact is a very broad term that can cover greenhouse gas emissions, the release of polluting or poisonous substances, the damaging or the area around the power plants or where raw materials are extracted, and effects of malfunctions of the power plants. Therefore, the coefficients of the variables are going to be kept in opposite units of the variables themselves that is in years/kWh, in order for the function as a whole to remain unit less.

Also due to the broad scope of this function, the values of the coefficients are not as clear cut as the prices of production costs. For example, the amount of greenhouse gasses released cannot be used because it does not cover the other areas, and a compilation coefficient of all the effects described above cannot be used since some effects simply cannot be measured, but, as mentioned in the production cost section, actual values are not needed. As long the coefficients are proportionate to how much each source effects the environment, the model works the same as if actual values were used.

To start of the assignment of coefficients, coal was given a value of 1 since it is generally considered to have the highest impact due to it being the largest producer of greenhouse gasses and pollutants, and due to the large scale damage mines, especially surface mines, cause. The other two fossil fuel resources are assigned values based on their emissions as a percent of coal's emissions. This isn't an ideal assignment since it does not take into account differences with regards to non-emission impacts of coal, gas, and oil but it is a good estimate for this model [4].

Nuclear, however, is somewhat of a special case. Ideally, nuclear power has very little impact on the environment, with the only concern being the proper disposal of spent fuel rods. This initially swayed the coefficient towards a very low value such as .1 of coal, but nuclear power's potential harmful effects in case of malfunctions need to have a higher weight than those of other plants. Exposed cores can have catastrophic consequences such as those seen in the Chernobyl disaster, and thus push the coefficient value up from .1 of coal. The coefficient should be raised too high, though, since nuclear plants have generally proven reliable and the number of accidents can be drastically reduced or even eliminated in the future using stricter regulation. Taking all of this into consideration, the final weights for EmvTmp are:

EnvImp = 1*AmtC + .79*AmtO + .56*AmtG + .25*AmtN

If one were to take into account only the environmental impact function for the linear programming model, the resource to be used the most is once again nuclear power. The roles of coal and natural gas, however, would be reversed, with gas now taking the majority of the remaining shares after nuclear since it is a much cleaner technology. Oil would see a drastic change in its energy production share since it is also considered cleaner than coal.

IV. Sustainability Maximization

The sustainability function is the only function that in not minimized since it is the only function not dealing with some sort of detrimental effect such as cost or negative impact but rather with the period of time these limited resources are available for use based on remaining reserves. Thus, the equation needs to ultimately result in units of time, with years being the most practical unit due to large reserves.

To achieve this result, the data on the various resources' reserves must be converted into units that would work with the variables' kWh/year units. The simplest method is to have all reserves data in kWh and then divide these coefficients by our variables. The only issue with this method is the fact that data on various national reserves are in units most convenient to use by that particular resource. All reserve data presented below comes from the U.S. Energy Information Administration.

U.S. coal reserves are estimated to be about 263781 millions of tons which can be converted to kWh easily by the conversion factor 6150kWh/ton resulting in 1.62×10^{15} kWh of reserves. Similarly, 22.317 billion barrels of oil can be converted to 3.79×10^{13} kWh of reserves using the conversion factor 1699.4kWh/barrel, 237.726 trillion cubic feet of natural gas can be converter to 7.26×10^{13} kWh using the conversion factor .301kWh/cu.ft., and 1155 million pounds of uranium can be converted to 1.26×10^{15} kWh using the conversion factor 1.09×10^{6} kWh/lb [5]. Using these values in the sustainability equations gives:

$$SusRes = (1.62 \times 10^{15})/AmtC + (3.79 \times 10^{13})/AmtO + (7.26 \times 10^{13})/AmtG + (1.09 \times 10^{15})/AmtN$$

The ideal situation just according to sustainability once again paints a different picture than the actual situation. Nuclear power would be assigned a bigger share of the generation whole since it has about two thirds of the sustainability of coal while oil and natural gas are each two powers of ten below nuclear and coal in terms of reserves meaning they are used disproportionately more.

V. Errors in Results and Conclusions

While the above model is functional, it contains errors in several places due to a variety of reasons. Errors can arise as early as the production cost function from the methods used by the IEA to predict costs but the first guaranteed error comes from the calculation of the price of energy from oil. The calculation used is only based on the energy content of oil and the efficiency of power plants but many other factors such as which petroleum derivate is used by the power plant and differing power plant technologies used in different proportions can each change this number slightly, possible accumulating to a significant error. Also, since all environmental impact coefficients were assigned, not calculated or taken from measured statistics, the entire environmental function can have significant errors. As for sustainability, errors come from two places. The reserve values used above are only reserves on U.S. soil and the sustainability equation has no way to account for these reserves being supplemented by imports. The function also does not take into consideration that not all of the reserves of some resources are used for electrical generation.

Despite these errors and without actually calculating values for the variables, conclusions can still be drawn from this model. In every maximization or minimization function, the model would seem to indicate nuclear power is not currently contributing as much possible towards lowering the prices, lowering the environmental effects, and increasing the sustainability of our total electrical generation. As mentioned in the production cost section, this is mostly due to continued resistance to the expansion of this type of power generation capacity, but the model strongly suggests that its potential is not being met and that steps should be taken to reevaluate its safety issues and see if its low prices and sustainability can be taken advantage of. At the same time, the model suggests that too much natural gas is being used for the purpose of electrical generation since it is the second most expensive source and the source with the least reserves.

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A Glimpse Into Future

Fuel is an everyday necessity to keep our economy and our nation running. It is necessary to ensure that we have enough fuel to keep this nation alive for the long term future. If we fail in this endeavor, the consequences will be dire. The transition will not be an overnight occurrence but it will take place over the next hundred years unless a sustainable source of fuel is found.

There will be many negative effects of a diminishing source of energy on the nation. Overall, we can say that a diminishing energy source will not be the end of the world, but it will affect our productivity, transportation, and government. As oil and other sources of fuel which power the transportation sector begin to diminish there will be a dire impact on our national productivity as a whole. People will not be able to travel to work because of high gas prices. Employees will begin to mass into large scale buildings which act as small towns.

These large buildings will consist of everything from department stores, to full functional companies. These companies will fund the operating costs for these buildings, and the majority of the residents will consist of workers for the company running the building. The company itself will determine how the buildings will be fueled, its own laws, and regulations. There will be little need for government interference or regulations. City skylines will be littered with large self sustaining buildings. These self sustaining buildings will act as small communities where there will be potential to raise crops, and farm animals. They will in turn utilize these animals to feed the population of the building. People will begin to adjust to these life styles, working for a place to live and food to eat, as it was done hundreds of years ago. These companies in turn will be able to exchange their products and services amongst themselves for fuel or necessities to keep their communities running.

The government will begin to play little role in the lives of people because they will be governed by the people who can bring them food, energy and a job which will help them earn it all and maintain their livelihood. People will lose their sense of nationalism and begin to concentrate on their local communities governing themselves or being governed by those securing their livelihoods. As fuel sources completely diminish social structures will begin to collapse. Everyone below the upper class and the extremely wealthy will suffer heavily due to the inability to afford fuel. People will lose faith in the government and attempt to take matters into their own hands out of desperation. There will be mass chaos as the transportation and communication networks disappear. There will be increased amounts of domestic violence as people try to attain the last bits of remaining sources of fuel in order to meet the basic necessities. There will be international wars as countries begin to search out the last remaining wells of fuel. Larger and technologically advanced countries will over power smaller countries and claim the fuel.

These communities will be necessary in order to pool the remaining world resources and efficiently utilizing them. If lifestyles remain the same as fuel begins to diminish there will be multitudes of consequences. There will be fuel shortages in the transportation sector which will prevent people from going to work, and which can be easily remedied by allowing people to telecommute. While, it is a possible resolution to our transportation problems it will severely impact our economy. People will not continue to work at full efficiency from the home because there will be no fear of having to answer to a boss for ignoring work. People will not be able to accept the idea of placing video cameras in the home that a supervisor can continuously monitor in order to assure efficiency. Working from home may be come impossible as fuel continues to diminish because it is necessary to power homes with electricity in order for a person to work. Working from home seems like a logical solution only to certain sectors of business, but there are many other sectors which cannot work from home. For example, the medical industry cannot run a hospital without any doctors being present.

Depending on people there may be a shift in technology usage. Unless a source of renewable energy is found people will begin to revert back to old ways without the need for electricity and oil. Prior to the development of automobiles animals were domesticated in order to move people and goods between two points. However, there is also a good chance that people may in order to avoid reverting to old ways develop automobile technologies which allow for renewable energy to power cars. Manufacturing automobiles which are fueled by sources other than gasoline will not solve any problems but temporarily shift it. Assuming that there is very minimal production of fuel at very high prices the transportation of goods and people will be done primarily by energy efficient trains capable of traveling large distances while utilizing minimal fuel. This will however still become very inconvenient for people will only be able to travel from port to port.

Common luxuries which are taken for granted will begin to disappear. For example refrigeration will no longer be possible because of the large power consumption of refrigerators, so meat storage in the home will no longer be possible for long term. People would have to revert back to old ways of storing meat and other perishables. Active household heating will no longer be possible in the winter and therefore will bring major health risks in the colder states. Some states may also suffer from repopulation or depopulation. The general population may become healthier and possibly show a decline in obesity. There will be a lack of food transportation, and therefore people will once again resume consuming what is grown locally.

As power productions continue to diminish household computing will definitely no longer be in existence and we will most likely see the internet diminish. Without people being able to contribute information or maintain live server technologies the internet will thin out with only select servers remaining up. There will be no longer any home run internet business because the residential sector will no longer be able to maintain any at home manufacturing capabilities Overall the quality of human life and intelligence will slowly diminish because of the inability to use the modern day technologies which everyone has become accustomed to. People will not be able to gain information from the internet because our at home computing capabilities will disappear. Communication capabilities will slowly disappear as well because people will not be able to make phone calls or send emails on the scale that they do now, nor will they be able to travel to interact with others.

Communication is an important key factor which unites multiple countries across the world, which promotes trading. As this communication network slowly deteriorates countries will not know what is happening on the world stage, and it may lead to wars. Trade deficits will form and cause economies to fail. Countries will struggle for resources trying to attain any form of fuel which is available even if it means conquering smaller nations. Conflicts will arise among individuals as they try to attain remaining resources for themselves, and try to attain goods, currency or power by distributing it.

People will find some form of a solution to survive the fuel crisis. The best case scenario would be adapting current technologies to run on low power sources. For example, the best solution would be to design smaller transistors in computers which will use less energy, and create appliances which use very little power. People will begin to transition into utilizing renewable energy sources such as wind, solar, and hydrogen power. People may even begin transitioning to private solar energy consumption in the home by installing solar panels.

The future can take two paths, however, and in the event we do find a source of sustainable renewable energy before our fuel sources diminish we can foresee a flourishing future. Technology will significantly progress if we are not restricted to utilizing small amounts of energy in order to conserve it. There will not only be positive consequences for solving this energy crisis.

Eliminating the energy crisis will open up multitudes of resources which will allow the world to focus on a method for utilizing all of the newly available energy. We would begin to see technology rise in society and improve. Society would focus highly on improving life through technology. We would see more technologies arise which make life simple and stress free. We would see technologies arise which will be able to solve many common disabilities. Increased technology will increase the ability t o extend human life. Life will be on a better level.

Constraints will be lifted on technology; there will be no more need to design power efficient devices. General computing will no longer be restricted by power limitations. Computers will use large amounts of power and increase their computing capabilities and increasing the ability to generate further technologies. Increase computing may also mean increase efficiency in the work place, and technology companies booming, and boosting the overall economy.

Abundant resources will also propel us into space. We will be able to expand and explore other planet once we are able to find a source of energy which will propel spacecrafts to the boundaries of the universe. If energy permits and there is a lack of space on earth for populations to grow, people will begin to colonize space. Self sufficient space colonies will be created which will act as self governed countries. People will see space travel as a common commodity and travel into space to take vacations.

The transportation sector will have the greatest impact; there will be transportation of goods across the country at nominal costs. Companies will be able to move goods across the country faster and more often because there will be negligible costs to ship. Companies will have a greater profit margin which they can reinvest into further research and development causing technological progress. The average gasoline consumer will be able to save thousands of dollars a year in fuel costs. Consumers will tend to leave their homes more often and head to commercial areas to spend money that they would have otherwise spent on fuel. Consumers will spend money which in turn will lead to economic growth and further technological development. It will be a chain effect which will cause non-stop growth economically and technologically.

It will be necessary to create a new highway system because with an abundance of cheap energy people will not feel reluctant about traveling long distances. The roads will become crowded and traffic will be slowed unless larger and wider highways are built. Remote areas of the country will begin to be populated as a new highway infrastructure is built.

The residential sector will also have a major impact. There will be a new industry which is created that specializes in bringing efficient and cheap energy to homes. If solar power becomes the primary source of energy, whether it is Concentrated Solar Power, Solar farms, or Space solar power, it is necessary to develop an infrastructure to utilize this energy. Having cheap power in the home can mean greater savings to the public, and in turn it will allow them to invest more money into other household necessities, or putting money back into the economy.

Having a source of cheap source of renewable energy can mean many things for technological progress. The nation's greatest technological strides were made when we did not have to worry about conserving energy. If we can secure a cheaper source of energy we can build our future technologies around it. Utilizing high efficiency solar panels for example, can be used to power our automobiles, military aircraft, and even power small things such as cell phones and assure that batteries never run out.

Energy hoarding in the world today can prevent progression, and start wars. It is necessary to rely on countries with large fuel sources and have good standing diplomatic relationships. These countries use the diplomatic channels to manipulate countries which are dependent on them. They also can control energy prices easily which impacts the dependent countries significantly. Eliminating the reliance eliminates these diplomatic channels which can be used for manipulation. Countries will become stronger because they will become self reliant.

There are many advantages of finding a cheap source of energy. It will eliminate the reliance on foreign fuels and make us more independent in the world. It would also strongly reduce harmful emissions that are damaging to the planet. Having a cheap source of energy can ensure a bright future for the nation.

Appendix – Collection of Recommendations

Natural Gas:

Natural gas is a much less available than coal so its use for electricity generation should be reduced. The federal government should give large incentives to companies that are currently exploring shale gas to increase our natural gas reserves greatly.

The large fluctuation in prices of natural gas can be alleviated with the discovery of much more domestic shale gas. The federal government should heavily invest into exploring shale gas.

In order to reduce the effects natural gas has on the environment, incentives for developing technologies that reduce natural gas based energy production's adverse effects should be considered.

As most fossil fuels have finite reserves, the reduction of any forms of industrial and commercial use of fossil fuels is essential to improve the quality of life for the future.

Coal:

Coal is our most abundant and stable fossil fuel so our mining and consumption rates should increase to lower our dependency on less available fossil fuels. The federal government should give more incentives to coal mining companies to increase coal mining rates. The federal government should also financially assist in the production of new coal-fired power plants

Coal is our cheapest energy source, and we need to continue to use it as our primary electricity generation source. The federal government should plan to increase the amount of electricity generated by coal to keep the cost of electricity to the consumer at a minimum.

Technological advancements in coal mining and technological advancements in coal-fired power plants are extremely important. To keep the impact to the environment at a minimum, and to reduce the final price of electricity to the consumer the government should increase grants for research in coal mining technology and more efficient power plant designs.

Since coal is our primary source for generating electricity, its environmental impact needs to be taken into consideration when increasing production rates. Stricter environmental policies on coal-fired power plants need to be enforced to ensure that carbon dioxide

emissions are minimized as well as reducing other toxic pollutants produced by coal-fired power plants.

Solar:

The Federal Government could provide tax-deductions for homes with passive solar heating capabilities to encourage people to implement passive cooling and heating.

The Federal Government could increase tax deduction and create assistance programs for homeowners who are looking to power their homes through solar energy to encourage its use.

Provide tax incentives could be provided to companies to return their profits into the company in order to increase growth and productivity. Provide tax incentives to companies who may subcontract with the larger companies in order to build Solar Power Plants and Solar Farms. Streamline the process of issuing building permits to companies interested in building solar power plants in order to increase the rate at which plants are built.

Funding could be approved for the Department of Energy to create cost shared contracts to increase use of CSP Technology in the United States.

Incentives could be created for leading solar power companies to increase efficiency in solar technologies.

It is recommended to encourage states to reduce sales taxes on parts and materials to build solar panels and solar power systems. It is also recommended that tariffs be reduced on imported parts used for building solar cells and plants.

The Federal Government should create strict regulations for disposal of Cadmium based Solar panels and impose regulations on building locations for solar power plants.

Legislation which requires high solar intensity states to generate 30 percent of their energy from solar power by the end of the decade could be implemented.

NASA could participate and provide funding and resources to companies trying to harvest energy in space.

Wind:

More economic incentives at the federal level similar to incentives and grants the state of Ohio offers its residents would help more homeowners install expensive wind turbine units. Ohio state incentives cover $8500 to $10000 of the cost of homeowner turbines, leading to more people covering their own electrical needs and even helping supply others by selling power back to electric companies.

Wind turbine manufacturers already indirectly benefit from the renewable energy tax credit since it helps increase demand for their products, but in order to more quickly bring prices of turbines down a more direct federal intervention might be necessary such as providing manufacturers with a credit for each unit sold which in turn helps manufacturers expand their production.

Using the updated information of the new wind speed map, the renewable energy tax credit could be changed specifically with respect to wind power in order to encourage development in high wind speed areas such as the Midwest plains and coastal areas, ultimately letting the nation get the most out of wind power and driving prices of electricity down.

Since larger wind farms have proven to be more efficient and less costly when it comes to dollars per MWh, specific incentives toward larger projects would also ultimately help the nation get cheaper sustainable energy from wind.

Congress could have the major or most important guidelines of the Fish and Wildlife serve incorporated into law to minimize impact and reconcile wind development with environmental support groups.

While the use of wind power is a potential boon to the nation, the safety and well-being of citizens should not be a price of its development. The Federal government should take steps to prevent wind farms from disrupting people's daily lives and health by further investigating health concerns relating to turbines and, if necessary, pass laws that would prevent their effects.

The Federal government should continue to support and do whatever is necessary in the future to ensure that the DOE 20% Wind by 2030 plan comes to fruition.

Nuclear:

Due to nuclear power capabilities in creating power plants in relatively small areas, more power plants should be constructed underground in urban areas of high need. This would eliminate blackouts in these areas and provide low cost power to the users.

In order to compete with other countries leading in the production of nuclear energy, the Unite States should create tax incentives for the creations of new, clean and safe forms of nuclear energy production.

In order to sustain nuclear fission for longer 60 years the US should invest in other forms of viable renewable sources of energy such as wind, solar, hydro, and nuclear fusion.

In order to reduce the possibility of nuclear waste leaking into the ecosystem we recommend that all nuclear waste should be packaged and shipped into an autonomist waste storage facility located on the moon.

In order to possibly reduce radioactive emissions, the confinement of the reactor core is a necessity and the construction of underground nuclear facilities will be able to reduce the emissions on residential areas.

Due to its overall the overall cost in environmental protection, the ban on reprocessing nuclear waste in the US should be redacted in order to lower cost. With the new profit, greater research can be done in transmutations and other forms of waste distribution, leading to future reduction in nuclear energy.

For the continuation of nuclear technologies, the reduction in research of conventional forms of fission reactions and reactors is essential for the resurgence of fusion reaction research. This focus on fusion will lead the world into a prosperous future.

Hydroelectric:

In order to prevent events similar to what the people in brazil expirienced, the government should create incentives for all hydroelectric dams to implement safety measures.

The government should fund research into the development of autonomous hydroelectrical ocean farms which take advantage of new hydro technologies like tidal turbines.