5-2011

The High Cost of Cheap Coal; Why Can't We Move to Renewable Energy

Cameron Dale Bartlett
Utah State University

THE HIGH COST OF CHEAP COAL; WHY CAN'T WE MOVE TO RENEWABLE ENERGY

by

Cameron Dale Bartlett

Thesis submitted in partial fulfillment
of the requirements for the degree

of

DEPARTMENTAL HONORS

in

Biology
in the Department of Science

Approved:

Thesis/Project Advisor John Flores	**Thesis/Project Advisor** Daniel Holland

Departmental Honors Advisor
Kimberly Sullivan

Director of Honors Program
Christie Fox

UTAH STATE UNIVERSITY
Logan, UT

Spring 2011

Acknowledgments

The author wishes to express his gratitude to his Thesis Advisors, John Flores (Department of Biology, Utah State University) and Daniel Holland (Department of Business, Utah State University) who have been abundantly helpful and offered invaluable assistance, support and guidance in his undergraduate thesis. Deep gratitude is also due to the Biology Departmental Honors Advisor, Kimberly Sullivan, and the Honors Program as a whole at Utah State University.

Table of Contents

Abstract

This article addresses the historic and current use of coal as the main source of electric power throughout the United States. Coal powered power plants remain an important part of the history and industrialization of the United States, even though there are many detrimental health and environmental impacts associated with its use. A slowly growing trend has been emerging with research on and use of renewable energy to replace fossil fuels, such as coal. Greater public awareness and involvement will help drive the slowly emerging use of renewable energy. This article looks at the current barriers that are prohibiting the implementation of renewable energy, and shows that there are technical and non-technical barriers. A public survey demonstrates the understanding, as well as the willingness the public has to move towards renewable energy sources.

Introduction

Background: For hundreds of years the United States has used coal as an energy source to help provide for many basic needs; from heating and cooking, to transportation and production of raw materials. The industrial progress of America was dependent on abundant sources of coal[1].

More than one hundred years ago, Thomas Edison opened the Pearl Street Station on the shores of the lower East River in New York City. This became the first centralized coal-fired power plant in the United States[2]. Since then, this relatively inexpensive source of energy has been able to keep up with the industrialization of the United States, but not without having negative externalities associated with its use. Coal as a source of power has been associated with various health effects such as black lung in the mining industry to acid rain during the generation of electricity to increases of CO2. Today there is growing interest in renewable energy such as wind, sun, water, and geothermal sources as cleaner forms of energy. Renewable energy is energy generated from resources such as wind, rain, sunlight, and geothermal, which are naturally sustainable.

Research Questions: Three questions are addressed in this research: 1) To what extent is the United States dependent on coal as a source for electricity? 2) Does the use of coal power in the United States have negative effects on public health and the environment? 3) What factors are prohibiting us from moving to renewable energy sources?

Survey: A survey of ninety-one Utah State University college students was carried out to better understand public awareness of current energy consumption and trends, and in what way our energy needs should be met in the future.

United States Dependency on Coal Power

Coal has long been known for its potential source of energy, as the earliest reference of using coal as fuel is found writings by the Greek scientiest Theophrastus nearly 300 B.C[3]. But, it wasn't until 13th century when underground mining was developed in England, which lead to it's large scale use starting with the Industrial Revolution.

In the United States, as the population and industrial need for more electricity has increased, there has been a continual growth in the number of coal powered power plants to meet that

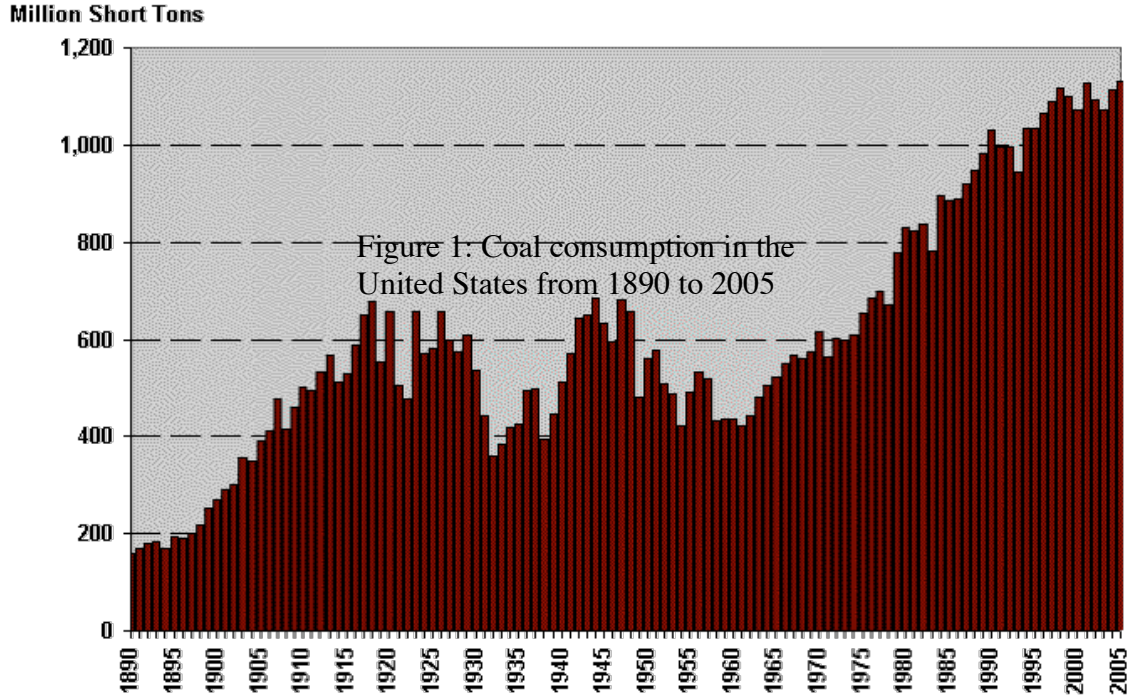
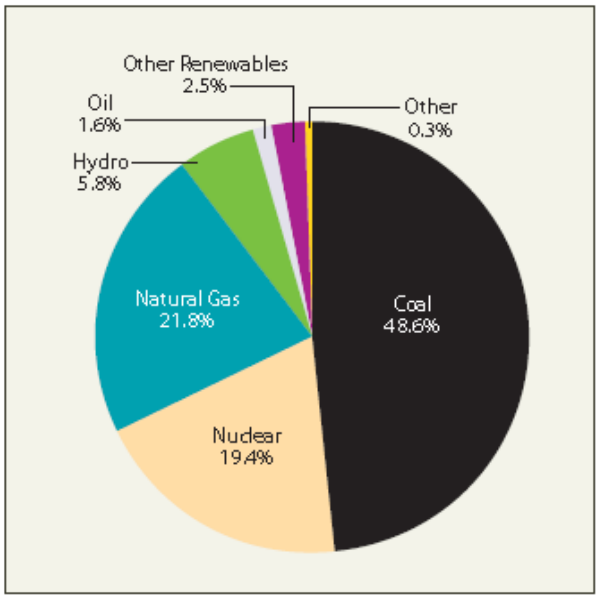


Figure 1: Coal consumption in the United States from 1890 to 2005

demand. By 2006 there were 1,493 coal powered electrical plants (producing 227 GW of

electricity), with over 150 more electrical plants proposed. This level of consumption puts the United States as the largest consumer of coal powered electricity in the world[4].

Figure 2: U.S. Electricity Generated By Energy Source (2007)



Source: *Electric Power Monthly*. Energy Information Administration. June 2008

With the increase in the utilization of electricity, there has been a growing need to produce more coal to meet that demand (see Figure 1), as coal is the number one source of energy for electrical production in the United States. The United States is currently the second largest producer of coal in the world, and produces more than 90% of the coal it consumes each year. A record high was set in 2007 when 1,045.1 million short tons of coal were used to generate electricity[5]. If the United States continues to consume coal at the current rate, it is estimated there are enough known coal reserves to last about 200 years[6].

Source: *Coal Production in the* Information Administration. Oc

Even with the recent but slowly growing trend in the use of renewable sources of energy, coal is the predominate source in supplying energy to generate electricity. In 2007, 93% of total coal consumed was used to generate electricity. Other coal usage in the United States includes smelting for steel and iron manufacturing, as well as coal being used in the process of making

paper, brick, limestone, and cement. In 2007, 48.6% of all electricity generation was fueled by coal (see Figure 2).

Utah is one of the states most dependent on coal power. In 2009, coal provided nearly 85% of Utah's electric power generation, whereas renewable energy amounted to less than 1%[7]. Utah currently has sufficient coal reserves for its consumption needs, and produces more coal then it uses each year.

Detrimental Effects of Coal Power

Due to the General Mining Act of 1872, which was passed to encourage mining on federal lands, mining for minerals and precious metals became a driving factor in the expansion westward throughout the United States. Numerous cities, including Denver and Sacramento originated as mining towns. The increasing demand for coal allowed such mining towns to flourish throughout the twentieth century. Today, the economies of many towns throughout the United States are dependent on current coal mines[8].

Although some communities have received great economic benefit from mining, there are some distinct negative effects that are associated with the use of coal energy. Coal burned in power plants can cause damage to the environment and public health from its mining, production, transportation, and long after it has been burned and used to generate electricity.

Table 1: General effects and facts of coal power plants

260 million	Gallons of water used for coal mining in the U.S. every day
120 million	Tons of solid wastes produced every year by burning coal
90 million	Gallons of waste slurry produced every year while preparing coal to be burned
21 million	People in the U.S. who live within five miles of a coal-fired power plant
12 million	Gallons of water used per hour at an average coal-fired power plant
12,000	Miners who died from black lung disease between 1992 and 2002
1,200+	Miles of streams that have been buried or polluted in Appalachia because of mountaintop removal mining
47	U.S. states and territories with mercury fish consumption advisories for at least some of their waters
150+	New coal-fired power plants proposed for the U.S.
55	Percent decrease in number of coal miners employed from 1985–2000
22	Percent increase in coal mining production from 1985–2005

Source: Alice McKeown. *The Dirty Truth About Coal*. Sierra Club. June 2007.

As the use of coal power has become more prevalent, there has been a large increase in greenhouse gases (such as CO_2) released into the atmosphere. There have been many studies on the long term detrimental effects that additional greenhouse gases has to the environment, and may be the largest reason countries stop using fossil fuels[9]. The issues associated with greenhouse gases will not be discussed in this article, as this article looks at the more immediate and visual impacts coal power plants have on the environment and public health.

The first stage of the coal cycle begins when it is mined from the earth. Coal mining causes irreversible damage to local environments and jeopardizes the health and safety of those undertaking the task. There are two techniques that are used for the production of coal; surface mining and underground mining.

Surface Mining

One of the most ecologically devastating types of surface mining is known as mountaintop removal mining; in which the tops off mountains are removed to reach small seams of coal. In the past, to minimize waste disposal costs, millions of tons of waste were dumped into the valleys and streams below causing permanent damage to the environment. It is estimated that this practice has damaged or destroyed 1,200 miles of streams[10]. This level of waste disposal disrupts drinking water supplies, floods communities, eliminates forests, destroys ecosystems, and disrupts natural wildlife[11]. All of this destruction is done even before the coal is transported to the electrical power plant to be burned.

Underground Mining

As of 2007, about two thirds of coal in the United States comes from surface mining, whereas one third is from underground mining[12]. To access coal which is buried deep in the earth, underground mining is used, and usually involves a system of tunnels and large underground spaces to access the coal reserves. Underground mining has many underlying health issues, and potential safety concerns associated with its use.

For example, in northwestern Emery County, Utah, the Crandall Canyon Coal Mine (formerly the Genwal Mine) collapsed on August 6, 2007. Seismic waves which were caused by the collapse resulted in an earthquake, and six workers became trapped in the mine. Ten days later during rescue attempts the mine collapsed again as one of the walls in the tunnel exploded outwards, injuring six rescue workers and killing three others. Later that month, the six miners were declared dead and their bodies were never recovered[13].

Some environmental impacts from mining involve the practice of "longwall" mining. In this process, about two hundred yard swaths of coal are continuously removed in one pass. As the coal is removed the roof is allowed to collapse behind the mining equipment. This process of mining leaves behind large empty underground spaces, which has the potential to collapse and cause sink holes in the ground above. Both mountaintop removal and long wall mining are being used more commonly because of the low costs to high yields, despite the irreversible damage. Some of the other damage associated with longwall mining includes lowering the water table and changing the flow of underground water and streams[14].

In 1992 there were 75,466 employees working at coal mines throughout the United States[15]. Between 1992 and 2002, the Centers for Disease Control (CDC) estimated that about 12,000 miners died from black lung in the United States alone. Black lung, also known as coal worker's pneumoconiosis, is a respiratory disease in coal miners that is caused by prolonged exposure to coal dust and other particles during coal mining. Symptoms include coughing, spitting up black material, shortness of breath, and eventual hardening and scarring of the lungs[16].

Figure 3: On Site Mining Occupational Fatalities and Injuries, 2007

Commodity and Type of Employer	Occupational Fatalities						Nonfatal Lost-time Injuries					
	Underground		Surface		Total		Underground		Surface		Total	
	No.	Rate*	No.	Rate*	No.	Rate*	No.	Rate**	No.	Rate**	No.	Rate**
Coal Operator	18	42.6	10	21.1	28	31.2	2,120	5.0	822	1.7	2,942	3.3
Metal Operator	3	55.2	4	14.4	7	21.1	178	3.3	620	2.2	798	2.4
Nonmetal Operator	1	40.4	0	0.0	1	5.0	91	3.7	417	2.4	508	2.5
Stone Operator	0	0.0	8	11.4	8	11.1	36	1.7	1,844	2.6	1,880	2.6
Sand and Gravel Operator	NA	NA	5	15.0	5	15.0	NA	NA	657	2.0	657	2.0
Operator Total	**22**	**42.1**	**27**	**13.8**	**49**	**19.7**	**2,425**	**4.6**	**4,360**	**2.2**	**6,785**	**2.7**
Coal Contractor	3	97.7	3	16.3	6	28.0	177	5.8	283	1.5	460	2.1
Noncoal Contractor	2	103.4	10	29.3	12	33.3	43	2.2	454	1.3	497	1.4
Contractor Total	**5**	**99.9**	**13**	**24.8**	**18**	**31.3**	**220**	**4.4**	**737**	**1.4**	**957**	**1.7**
TOTAL	**27**	**47.2**	**40**	**16.1**	**67**	**21.9**	**2,645**	**4.6**	**5,097**	**2.0**	**7,742**	**2.5**

NOTES: Excludes office employees. Table may not sum to totals due to independent rounding.
NA Not applicable.
FTE Full-time equivalent employees computed using reported hours worked (2,000 hours = 1 FTE).
* Fatality rates were computed per 100,000 FTE employees.
** Nonfatal lost-time injury rates were computed per 100 FTE employees.

Source: Center for Disease Control. *NIOSH Mining Safety and Health Research*. Nov 2009

In addition to black lung related deaths, there continue to be on site related fatalities. Though the overall number of fatalities has been decreasing in the last twenty years, there are still many accidents that result in loss of life or time away from job. In 2007, there were 67 reported fatalities and 7,742 nonfatal accidents that were classified as lost-time injuries (see figure 3).

Negative Externalities

Air pollution incidents have provided vivid evidence of the potential health consequences, especially for the elderly and children. December 1952 was a landmark event in recognizing the detrimental effects of air pollution. From December 1 to 5, coal smoke accumulated in the Thames valley (just outside of London) due to a stationary high-pressure area and wind speeds near zero. Due to the pollution build up, it was estimated that there were nearly 4,000 excess deaths, defined as additional deaths above the normal rate, which occurred in London during that week[17].

In the process of both surface and underground mining, huge amounts of water are discharged and eventually ends up back in the environmental water system. The water which is discharged often contains inorganic salts, small particles of solid materials, oils, grease, and heavy metals which contaminate surface and ground water. A common source of contaminated water is found when abandoned mines fill up with water and become acidic as it mixes with heavy metals and minerals that are left[18].

In addition, the air pollution that is emitted from coal power plants usually end up in our water system. As a pollutant, such as mercury or lead, is released from exhaust, it enters the air and eventually rains down into streams, lakes, and other water. Coal power plants are one of the largest sources of manmade mercury pollution in the United States[19]. Mercury enters our water systems where it bioaccumulates in fish and seafood which eventually end up in our food market. The U.S. EPA stated in 2004, that forty-seven states had mercury fish consumption advisories for at least some of their water systems[20].

Even though the coal power plants in Utah are generally distant from major cities, a recent study commissioned under the Huntsman administration reveals bleak impacts associated with its use. The study was undertaken by Synapse Energy Economic Inc. in association with researchers from the Harvard School of Public Health and Tufts University. Although pollution from coal power plants in Utah contribute to a fraction of our total air pollution burden, the study found that there are large public health issues and economic liability. In short, Utah's dependence on coal leads to 175 asthma-related emergency room visits per year, 154 hospitalizations for respiratory illnesses per year, and 202 premature deaths per year, regionally[21].

The findings of this report concur with the 2010 study by the Clean Air Task Force, which estimated that 13,000 premature deaths per year are caused by coal power plants in the United States. The estimated value of heath and water cost of Utah's power plant pollution is between $1.7 and $2 billion per year; this figure exceeds the direct cost of generating electricity[22].

Obstacles to Moving to Renewable Energy

The commercialization of renewable energy involves years of deployment of renewable energy technologies. There are three major 'generations' of renewable energy. The first-generation of technologies have been around for decades and are already well developed and economically competitive, they include hydroelectricity and geothermal power. Second-generation technologies are available in the market today but may not be the most economical source of energy; they include solar heating, photovoltaic, wind power, modern forms of bioenergy, and solar thermal power stations. Third generation technologies still require more research and development to make large scale contributions to our energy consumptions, which include gasification, bio-refinery technologies, hot-dry-rock geothermal power, and ocean power.[23].

Hydropower, such as watermills, has been used since ancient times to grind flour, cut timber, and perform other basic tasks. The use of moving water to generate power has been used for thousands of years. But, it wasn't until nearly 1900 that an electrical generator was developed that could be used with hydropower. In 1881 in the United States, the Schoelkopf Power Station near Niagara Falls began to produce electricity[24]. Since that time, hydroelectric power has become an efficient and economic source of energy.

By 2000, there were 2,000 hydroelectric power plants in the United States[25]. Yet as of 2007, hydroelectricity only accounted for 5.8% of the United States electric consumption, although it accounted for nearly 50% of all renewable energy used. Though there are certain environmental issues such as disturbances to river and stream ecology and fish migration with the use of hydroelectricity, it is a viable option to decrease the United States dependency on fossil fuels.

It is also important to note that there are other negative impacts associated with the manufacture and deployment of most renewable energy; though these issues will not be addressed in this article. Such as solar panel companies using the hazardous chemical cadmium as a key component in their manufacturing, or using fossil fuels to manufacture and transport wind turbines. One major advantage to using renewable energy is lack of additional pollution after their deployment.

As with almost any change in society, there is hesitance to change what may work or seem to be working at that time. In Nicholas Stern's book, 'The Economics of Climate Change: The Stern Review,' he said; "National grids are usually tailored towards the operation of centralized power plants and thus favor their performance. Technologies that do not easily fit into these networks may struggle to enter the market, even if the technology itself is commercially viable. This applies to distributed generation as most grids are not suited to receive electricity from many small sources. Large-scale renewable energy sources may also encounter problems if they are sited in areas far from existing grids (page 403)."

As mentioned before, the use of coal has been a major factor in the modernization and industrialization of the United States. Because of the integrated use in society, current energy markets, institutes, and policies have been developed to support the production and use of coal, from the railway on which they are transported on to tax subsidies for power plants using coal[26]. There has been a lack of government policy support, which includes the lack of policies and regulations supporting deployment of renewable energy technologies and the presence of policies and regulations hindering renewable energy development and supporting conventional energy development. Only within the last five to ten years have major changes started to happen within the government to support renewable energy sources[27].

Another important barrier that is important to discuss briefly is the technical barrier. As technology continues to improve, the cost of renewable energy will continue to decrease. Current prices for coal generated electricity are about 4.8-5.5 cents per kilowatt hour. When California first started using wind power in the early 1980's the cost was 38 cents per kilowatt hour. Since that time, the price has dropped to 4 cents or below at the best wind sites and some long-term supply contracts have been signed for 3 cents per kilowatt hour[28]. This provides great evidence as technology continues to improve, the cost of many renewable energy sources will continue to decrease.

Currently the average price of many renewable energy sources is higher than conventional energy sources, with the exception of hydro power. When compared with the average cost of coal, the current cost of hydro power is about 10% lower than coal throughout the United States, but new sites are limited by suitable geographic locations. The current average cost of wind power is approximately 40% higher than coal. The current average cost of solar power is approximately 440% higher than coal[29].

Public Survey

Almost everything today is run by the power of electricity; from our computers, home lights, microwaves, watches, cell phones, to the batteries in our cars. Supply and demand of electricity has never been as integrated into society as it is today. The use of electricity, and the decision of what power source used to generate it, affects the public every day. Available fuel sources affect the price of our monthly electric bills. The sources of electricity generated (i.e. from coal to hydropower) affect the quality of air pollution, public health, and environmental disturbance.

A survey was conducted to better understand public awareness of current energy consumption and trends, and in what way our energy needs should be met in the future. Ninety-one college students, majoring in one of the eight colleges (agriculture, arts, business, education, engineering, humanities and social services, natural resources, and sciences) as well as undeclared students were surveyed and their responses were recorded.

A random sampling of undergraduate college students was conducted at the Taggart Student Center, at Utah State University. The survey took place over a three day period, with a collection time of approximately two hours each day. The survey was passed out to as many students were willing to participate, and collected several minutes later. The data was then entered into a excel spreadsheet to be analyzed.

The survey was conducted under the approval of Utah State University's Institutional Review Board (IRB). It was approved on December 6, 2010; under 'USU Assurance: FWA#00003308.' It was broken up into two sections; first of which has to do with facts about fossil fuels and coal

powered power plants, and the second section asked questions regarding their opinion on fossil fuels and renewable energy.

For the first section, the correct answers are underlined; whereas with all the questions the percentage of each question chosen by the public is found in the brackets on the right.

Part 1: Facts about Electrical Energy

1. How much of Utah's electrical power is generated by coal?

   10-30% [13.2%]
   31-50% [30.8%]
   51-70% **[42.9%]**
   <u>71-90%</u> [13.2%]

2. How many coal power plants (that can supply over 240,000 homes) do we have in Utah?
   1-2 [16.5%]
   3-4 [35.2%]
   <u>5-6</u> **[42.9%]**
   7-8 [5.5%]

3. As of 2006, how much of electric power was generated in the United States using fossil fuels (such as natural gas, coal, and oil)?
   25% [5.5%]
   45% [14.3%]
   <u>65%</u> [31.9%]
   85% **[48.4%]**

4. The U.S. currently has enough coal reserves to last us how many years?
   100-150 years [38.5%]
   <u>151-200 years</u> **[41.8%]**
   201-250 years [11.0%]
   251-300 years [8.8%]

5. A typical 500 megawatt coal power plant (enough energy to supply approximately 300,000 homes) produces how many tons of sludge each year?
   100-1,000 tons [7.7%]
   10,000-50,000 tons [38.5%]
   <u>150,000-200,000 tons</u> **[39.6%]**
   More than 300,000 tons [14.3%]

In three of the five above questions the most commonly chosen response was the correct answer. Whereas, the most commonly chosen response underestimated the level of coal usage in Utah, and overestimated the United States dependency on fossil fuels.

Part 2: Personal Opinion about Renewable Energy

6. Fossil fuels have a significant negative impact on public health.

Strongly Agree	[14.3%]
Agree	**[41.8%]**
Neutral	[28.6%]
Disagree	[14.3%]
Strongly Disagree	[1.1%]

7. The U.S. is too dependent on fossil fuels (such as coal, oil, and natural gas).

Strongly Agree	[28.6%]
Agree	**[50.5%]**
Neutral	[13.2%]
Disagree	[7.7%]
Strongly Disagree	[0.0%]

8. The public should be more proactive in encouraging the U.S. to move to renewable energy.

Strongly Agree	[30.8%]
Agree	**[46.2%]**
Neutral	[17.6%]
Disagree	[3.3%]
Strongly Disagree	[2.2%]

9. What is the maximum you would be willing to pay per month to have all of your electricity generated by renewable energies (wind, solar, and hydro)?

$0.00	[6.6%]
$1.50	[13.2%]
$10.00	**[34.1%]**
$20.00	[28.6%]
Over $20.00	[17.6%]

10. Who do you believe is primarily responsible to move the United States to cleaner energy?

Public	**[51.6%]**
Government	[23.1%]
Energy Companies	[14.3%]
Other	[11.0%]

56.1% said that they either agree or strongly agree that fossil fuels do have a negative impact on the health of the public, while 79.1% of responders said that they agree or strongly agree that the United States is too dependent on fossil fuels. An interesting finding was that 80.3% of those surveyed said that they would pay an additional ten dollars or more each month to have all of their power generated by renewable energy sources; as well as 46.2% said they would pay twenty dollars per month. This was an intriguing observation, because of the already tight budget most college student have.

51.6% of those that responded believe that it is primarily the public's responsibility to move towards renewable energy sources, while 77% agreed or strongly agreed that the public should be more proactive in encouraging the United States to move to renewable energy sources. The results demonstrated that those surveyed, in general, are aware and to some extent educated about the negative issues that current fossil fuels have for the environment and public health. The next step comes in understanding what barriers are prohibiting the public from more actively promoting renewable energy. Possible barriers may include; time constraints (which may include work or personal commitments), lack of understanding of current energy markets throughout the United States, and not knowing how to turn their knowledge into action that can change society (such as new legislation).

These findings were fairly consistent throughout each of the respective colleges. The challenge comes in understanding what barriers face the public in promoting renewable energy, and how the public can be more proactive in implementing renewable energy sources. Further research may be needed to see in what ways the public can become more involved in promoting and implementing renewable energy sources.

Conclusion

Coal has been a cheap and easily accessible source of energy, and as such has been a driving factor of the industrialization of the United States. It has allowed the United States to maintain the ever increasing demand of electricity, supplied thousands of jobs, and help boost the economy of many local communities.

Yet, the prevalent and widespread use of this 'cheap' energy source is bundled with detrimental effects to public health and to the environment. Steps have been taken in the last 20 years to reduce our dependence on coal and other fossil fuels, and there are projects that will continue to increase renewable energy production in the years to come.

With the progress of renewable energy technology and the integration of renewable energy, many of the current financial and social barriers will be overcome. There will continue to be research and technological innovations that will allow us to generate cleaner and more dependable energy that is not currently available today. As this innovation continues, society needs to be willing to adapt and continue to implement these technologies. Further research is recommended to better understand in what specific ways the public can become more involved in this process.

References

[1] *Coal Production in the United States*. Energy Information Administration. October 2006.

[2] Alice McKeown et al. *The Dirty Truth About Coal*. Sierra Club. June 2007; pp. 3-4

[3] Carol Mattusch. *Metalworking and Tools*. The Oxford Handbook of Engineering and Technology in the Classical World. Oxford University Press, pp. 418. 2008.

[4] *Existing Electric Generating Units in the United States*. Energy Information Administration. 2007.

[5] Fred Freme. *U.S. Coal Supply and Demand: 2009 Review*. Energy Information Administration. 2009.

[6] The National Mining Association. *U.S. Coal Reserves by State and Type – 2009*. October 2010

[7] The National Mining Association. *America's Power: Coal in Utah*. 2009

[8] Carl J. Mayer. *The 1872 Mining Law: Historical Origins of the Discovery Rule*. The University of Chicago Law Review; Vol. 53, No. 2. Spring 1986.

[9] Susan Solomon et al. *Irreversible Climate Change Due to Carbon Dioxide Emissions*. The National Academy of Sciences of the USA. December 2008.

[10] U.S. Environmental Protection Agency, *Draft Programmatic Environmental Impact Statement*, 2003 and *Final Programmatic Environmental Impact Statement*, October 2005.

[11] U.S. Environmental Protection Agency, *Final Programmatic Environmental Impact Statement*, October 2005.

[12] Energy Information Administration. *Coal: A FossilFuel*. February 2007.

[13] Foy, Paul. *3 Rescue Workers Killed at Utah Mine*. Associated Press. August 17, 2007, and CNN. *Search Ends for Buried Utah Miners*. September 1, 2007.

[14] Don Hopey. *How Longwall Mining Works*. Pittsburgh Post-Gazette, November 23, 2003.

[15] National Mining Association. *Trends in U.S. Coal Mining 1923-2009*. October 2010

[16] Alice McKeown et al. *The Dirty Truth About Coal*. Sierra Club. June 2007; pp. 6

[17] London (UK): Her Majesty's Public Health Service. *Mortality and morbidity during the London fog of December 1952*. 1954.6.3

[18] U.S. EPA. *Mid-Atlantic Integrated Assessment: Acid Mine Drainage*. March 3, 2006.

[19] U.S. Environmental Protection Agency. *EPA to Regulate Mercury and Other Air Toxics Emissions from Coal- and Oil-Fired Power Plants*. December14, 2000.

[20] U.S. Environmental Protection Agency, Office of Water. *2004 National Listing of Fish Advisories*. September 2005.

[21] Synapse Energy Economic Inc. *The Co-Benefits of Renewable Energy and Energy Efficiency in Utah*. January 2010.

[22] Clean Air Task Force. *The Toll From Coal*. September 9, 2010.

[23] International Energy Agency. *Renewable in Global Energy Supply*. January 2007.

[24] Power Engineering Society. *History - 25-Hz At Niagara Falls - End of an era on the Niagara Frontier, Part I*. 2007.

[25] U.S. Department of Energy. *History of Hydropower*. 2008.

[26] Delucchi, M.A. and Jacobson. M. Z. *Providing all Global Energy with Wind, Water, and Solar Power, Part II: Reliability, System and Transmission Costs, and Policies*. Energy Policy 2010.

[27] Delucchi, M. and Jacobson, M. *Providing all Global Energy with Wind, Water, and Solar Power, Part II: Reliability, System and Transmission Costs, and Policies*. Energy Policy. 2010

[28] Lester R. Brown. *Plan B 2.0 Rescuing a Planet Under Stress and Civilization in Trouble*. NY, W.W. Norton & Co., 2006.

[29] Renewable Energy Policy Network for the 21st Century. *Renewables 2010 Global Report*. 2010

Author's Biography

Cameron Dale Bartlett, raised in Hyrum, was born in Salt Lake City, Utah. As a highly self-motivated individual, he achieved much of his early schooling through a home-schooling program. He took several classes at Mountain Crest High School during a two year period, before applying to Utah State University. Before starting at college, he volunteered and held positions such as the Mayor of the Hyrum City Youth Council, President of Stand for Decency, and was nominated for Who's Who Among High School Students.

Accepted at the age of 15, he entered Utah State University shortly after his 16th birthday as a Biology major and Chemistry minor, with a pre-dental emphasis. During his sophomore and junior year, Cameron worked as an Honors Undergraduate Teaching Fellow as well as an Honors Ambassador.

Before his senior year, he took two years off of school to serve a volunteer religious service mission in India. It was during this time that his life vision started expanding and he began looking for ways to make a larger impact on society. He decided to switch his emphasis from pre-dental, and bring his science background into the business world. After he graduates in May 2011, Cameron will continue his education that fall by returning to Utah State University to work on a Master's in Business Administration.