The Effects of Global Warming and Possible Engineering Solutions Involving Renewable Energy

Ms. Elizabeth Anne Valdes, University of Florida

Elizabeth Valdes is a freshman at the University of Florida. This summer she was in the Summer Engineering Freshman Transition Program at UF where she gained experience in working with Solidworks and Autocad. She intends on becoming a Mechanical Engineer and working in the field of renewable energy. Elizabeth is involved with FGLSAMP, the Society of Hispanic Professional Engineers, and she is apart of the Emerging Scholars Program. She is the recipient of the Broward County Salute to Education Scholarship and the Davie-Cooper City Chamber of Commerce Scholarship. Currently she is doing research in the causes and effects of global warming with Professor Dr. Najafi and coauthor Carlene Cuadra.

Ms. Carlene Elizabeth Cuadra, University of Florida

Carlene Cuadra is a student at the University of Florida with a current GPA of 3.8. During the summer of 2016 she participated in the EFTP Plus Summer Bridge Program where she was introduced to several types of engineering majors and many professors and students. In this program she developed experience using Autocad and Solidworks. She is a member of the Socieity of Women Engineers and the Society of Hispanic Professional Engineers. Carlene is currently doing research with Dr. Fazil Najafi and Elizabeth Valdes on renewable energy and global warming. Carlene aspires to get her degree in computer engineering in the year 2020.

Dr. Fazil T. Najafi, University of Florida

Dr. Fazil T. Najafi

For more than forty years, Dr. Fazil T. Najafi has worked in government, industry and education. He earned a BSCE in 1963 from the American College of Engineering, in his place of birth, Kabul, Afghanistan, and since then came to the United States with a Fulbright scholarship earning his MS in civil engineering in 1972 and a Ph.D. degree in transportation in 1977. His experience in industry includes work as a highway, structural, mechanical, and consultant engineer and construction manager for government groups and private companies. Najafi went on to teaching, first becoming an assistant professor at Villanova University, Pennsylvania in 1977, a visiting professor at George Mason University, and then to the University of Florida, Department of Civil Engineering, where he advanced to associate professor in 1991 and then full professor in 2000 in the Department of Civil and Coastal Engineering. He has received numerous awards including a scholarship award (Fulbright), teaching awards, best paper awards, community service awards, and admission as an Eminent Engineer into Tau Beta Pi. His research on passive radon-resistant new residential building construction was adapted in HB1647 building code of Florida Legislature. Najafi is a member of numerous professional societies and has served on many committees and programs, and continuously attends and presents refereed papers at international, national, and local professional meetings and conferences. Lastly, Najafi attends courses, seminars and workshops, and has developed courses, videos and software packages during his career. His areas of specialization include transportation planning and management, legal aspects, construction contract administration, and public works.

Dr. Nick M. Safai, Salt Lake Community College

Dr. Nick M. Safai has been an ASEE officer and has served in multiple divisions since 1997 and a member (since 1991) for the past 26 years. He is currently the president of the International Division, and also the Program Chair for the Graduate Studies Division. He also has served as the tresurere and annual program chair previously. He has been the six-time elected as the Program Chair of the ASEE International Division for approximately 15 years. Nick has had a major role in development and expansion of the division. Under his term as the International Division Program Chair the international division expanded, broadened in topics, and the number of sessions increased from a few technical sessions to over eighteen sessions in the recent years. The ASEE International Division by votes, has recognized Nick's years of

service through several awards over the past years. Nick has been the recipient of multiple Service awards (examples: 2010, 2006, 2004, 1996), Global Engineering Educators award (example: 2007, 2005), Best Paper award (examples: 2010, 2005, 2004, 1995) and other awards from the International Division for exceptional contribution to the international division of the American Society for Engineering Education. Examples of some Awards from other Professional Organizations: • American Society of Civil Engineers (ASCE): Engineering Educator of the Year Award 2004. • Utah Engineers Council, UEC: Engineering Educator of the Year 2005 award, in recognition of outstanding achievements in the field of engineering and for service to society. • SLC Foundation; Salt lake City, Utah: Teaching Excellence Award 2004. • American Society of Civil Engineers (ASCE): Chapter faculty Advisor recognition award 2002. • Computational Sciences and Education; recognition for outstanding contributions and for exemplary work in helping the division achieve its goals1998. • Engineering Division; recognition for outstanding contributions and for exemplary work in helping the division achieves its goals 1995. • Science and Humanities; recognition for outstanding contributions and for exemplary work in helping the fields achieve its May 1994. • Math & Physical Sciences; appreciation for academic expertise February 1994.

Academics: Nick Safai received his PhD degree in engineering from the Princeton University, Princeton, New Jersey in 1979. He also did a one year post-doctoral at Princeton University after receiving his degrees from Princeton University. His areas of interest, research topics, and some of the research studies have been; • Multi-Phase Flow through Porous Media • Wave propagation in Filamentary Composite Materials • Vertical and Horizontal Land Deformation in a De-saturating Porous Medium • Stress Concentration in Filamentary Composites with Broken Fibers • Aviation; Developments of New Crashworthiness Evaluation Strategy for Advanced General Aviation • Pattern Recognition of Biological Photomicrographs Using Coherent Optical Techniques Nick also received his four masters; in Aerospace Engineering, Civil Engineering, Operation Research, and Mechanical Engineering all from Princeton University during the years from 1973 through 1976. He received his bachelor's degree in Mechanical engineering, with minor in Mathematics from Michigan State. Nick has served and held positions in Administration (Civil, Chemical, Computer Engineering, Electrical, Environmental, Mechanical, Manufacturing, Bioengineering, Material Science), and as Faculty in the engineering department for the past twenty seven years.

Industry experience: Consulting; since 1987; Had major or partial role in: I) performing research for industry, DOE and NSF, and II) in several oil industry or government (DOE, DOD, and NSF) proposals. Performed various consulting tasks from USA for several oil companies (Jawaby Oil Service Co., WAHA Oil and Oasis Co., London, England). The responsibilities included production planning, forecasting and reservoir maintenance. This production planning and forecasting consisted of history matching and prediction based on selected drilling. The reservoir maintenance included: water/gas injection and gas lift for selected wells to optimize reservoir production plateau and prolonging well's economic life.

Terra Tek, Inc., Salt Lake City, UT, 1985-1987; Director of Reservoir Engineering; Responsible of conducting research for reservoir engineering projects, multiphase flow, well testing, in situ stress measurements, SCA, hydraulic fracturing and other assigned research programs. In addition, as a group director have been responsible for all management and administrative duties, budgeting, and marketing of the services, codes and products.

Standard oil Co. (Sohio Petroleum Company), San Francisco, California, 1983-85; Senior Reservoir Engineer; Performed various tasks related to Lisburne reservoir project; reservoir simulation (3 phase flow), budgeting, proposal review and recommendation, fund authorizations (AFE) and supporting documents, computer usage forecasting, equipment purchase/lease justification (PC, IBM-XT, Printer, etc.), selection/justification and award of contract to service companies, lease evaluation, economics, reservoir description and modeling, lift curves, pressure maintenance (gas injection analysis, micellar-flooding, and water-flooding), Special Core Analysis (SCA), PVT correlations, petrophysics and water saturation mapping.

Performed reservoir description and modeling, material balance analysis. Recovery factors for the reservoir. Administrative; coordination and organization of 2 and 6 week workplans, 1982 and 1983 annual specific objectives, monthly reports, recommendation of courses and training program for the group.

Chevron Oil Company, 1979- 1983; Chevron Overseas Petroleum Inc. (COPI), San Francisco, California 1981-1983. Project Leader/Reservoir Engineer, Conducted reservoir and some production engineering work using the in-house multiphase model/simulators. Evaluation/development, budgeting and planning for international fields; Rio Zulia field – Columbia, Pennington Field – Offshore Nigeria, Valenginan, Grauliegend and Rothliegend Reservoir – Netherlands. Also represented COPI as appropriate when necessary.

Chevron Geo-Sciences Company, Houston, TX, 1979-1980 Reservoir Engineer Applications, Performed reservoir simulation studies, history matching and performance forecasting, water-flooding for additional recovery (Rangeley Field – Colorado, Windalia Field – Australia), steam-flooding performances (Kern River, Bakersfield, California), gas blowdown and injection (Eugene Island Offshore Louisiana) on domestic and foreign fields where Chevron had an interest, using Chevron's CRS3D, SIS and Steam Tube simulator programs.

Chevron Oil Field Research Co. (COFRC), La Habra 1978-1979, California. Research Engineer, Worked with Three-Phase, Three-Dimensional Black Oil Reservoir Simulator, Steam Injection Simulator, Pipeflow #2. Also performed history matching and 20-year production forecast including gas lift and desalination plants for Hanifa Reservoir, Abu Hadriya Field (ARAMCO).

The Effects of Global Warming and Possible Engineering Solutions Involving Renewable Energy

Elizabeth Valdes, Carlene Cuadra, Fazil Najafi, and Nick Safai

Abstract

Global warming is the most important present day environmental issue. It is more than the gradual increase of average temperatures. Global warming is the direct result of human progression and its consequences, such as the rise in sea levels and the loss of biodiversity, are becoming prevalent. The primary objective of this research paper is to analyze the causes and effects that global warming has on the environment resulting from the release of excess amounts of greenhouse gases as well as to compare and contrast many aspects of renewable energy solutions.

The greenhouse gases of carbon dioxide, water vapor, methane, ozone, and nitrous oxide trap some of the solar radiation entering Earth's atmosphere. Though necessary for life, the presence of greenhouse gasses have resulted in an increase of global temperatures. The International Energy Agency has projected this increase to be as great as 6 degrees Celsius resulting in an intensification of desertification and a loss of biodiversity.

Since the start of the Industrial Revolution in the 18^{th} century, about 600 thousand million tons of carbon dioxide have been released into the atmosphere due to the burning of fossil fuels for electricity and transportation, leading to a 30% increase in the concentration of carbon dioxide in the atmosphere, where it can reside for up to 50 years. At the start of the Industrial Revolution, humans were not aware of the damages they were doing to the environment.

The need for advances in clean, renewable energy is a necessity as the effects of global warming become permanent. At the rate of current fossil fuel usage, such energy sources will be depleted within the next century due to their short lifespan. Renewable energies, in the form of solar, biomass, wind, hydropower, and geothermal energy, are paving the way to a more sustainable lifestyle. Breakthroughs in these fields will contribute to the lessening of the negative impacts of global warming.

The study of the effects of global warming and possible engineering solutions involving renewable energy would fit the call in the graduate division and it is consistent with the division objectives. Consistent with the objective above, the subject matter of global warming is multidisciplinary and directly related to engineering education. Engineering educators and engineering students must be aware of the impacts of global warming and the causes such as transportation, electricity generation, industrial waste, nuclear waste, and many other relevant existing technologies that contribute to global warming. It is essential for future generations to be educated in this field. Awareness that our research paper related to the mentioned topic will definitely direct it towards this aim. Specifically, creating a carbon free environment that is sustainable and cost effective should reduce global warming.

Causes of Global Warming

Climate change is the direct result of human progression. Population increase has led to the need for more materials, mass production, and more food in order to sustain the growing number of people present. To fully understand what is happening to Earth, it is necessary to look back at the source of the problem.

Since the start of the 20th century, human population has skyrocketed. The world population growth rate for around 800 years prior to this time was rather stagnant, averaging only about 0.1% growth a year.[18] In the 20th century alone, the human population roughly quadrupled.[3] At the start of the 19th century, human population exceeded 1 billion for the first time in history.[3] It took only 120 years after this for the global population to hit 2 billion in 1920.[3] In 1960, population hit 3 billion; 4 billion by 1974; 5 billion by 1987; 6 billion by 1999; and 7 billion by 2011.[3] In fact, the world population is expected to surpass 9 billion by 2045.[3]

Prior to the Industrial Revolution, human birth and death rates were both high resulting in a low population increase. This changed when death rates began to drop as birth rates rose.[3] For starters, with the Industrial Revolution came much agricultural advancement. More food was being produced due to new methods of farming including crop rotation and better technology some of which improved irrigation. Selective breeding made the average size of each farm animal increase, making meat plentiful and easily accessible. This increased crop and meat yield led to a decrease in famines and an all-around healthier diet for people, thus increasing life expectancy. Medical care, as well as sanitation, improved, thereby greatly decreasing the number of deaths associated with disease and illness[22] and the use of vaccinations greatly decreased infant mortality.[3] The greater crop yield lessened the need for farmers and the industrial revolution opened many jobs in factories resulting in urbanization. Many young people attracted by the higher wages and the jobs available in factories migrated to big cities. This concentration of young adults made it a lot easier to find a partner and start a family.[22] The increase of people getting married and having large families along with an increase in life expectancy and decrease in death rates, led to the population boom witnessed in the 20th century. As the human population grew, so did the demand for fuel, food, and space, in turn, leaving a strain on the environment.[7]

The demand for fuel during the Industrial Revolution led to the use of fossil fuels. Fossil fuels are the heated and pressurized remains of deceased plants and animals that have been buried under Earth's surface for millions of years. Since these remains are organic matter, carbon makes up most of their mass. Thus, when fossil fuels combust in the presence of oxygen from the atmosphere, the reaction yields carbon dioxide (CO2) as one of its products, which is a leading greenhouse gas.

The greenhouse effect is the driving force behind life on Earth. The greenhouse gases of carbon dioxide, water vapor, methane, ozone, and nitrous oxide trap some of the solar radiation entering Earth's atmosphere. Without the presence of these gases, Earth's average surface temperature would be about -6 degrees Celsius which is not suitable for most life on Earth. Though necessary for life as we know it, the greenhouse effect has recently been doing too well of a job in trapping heat. Since the start of the industrial revolution in the 18th century, about 600 thousand million tons of carbon dioxide have been released into the atmosphere due to the burning of fossil fuels for electricity and transportation leading to a 30% increase in the concentration of carbon dioxide in the atmosphere. The danger behind this gas's large emission numbers is that it stays in the atmosphere for at least 50 years.[12] These greenhouse gases accumulate in the atmosphere at a rate much faster than Earth's natural processes can remove them, resulting in global warming.

About 80% of all primary energy used in the world is derived from fossil fuels. The most commonly used forms of fossil fuels are oil, coal, and natural gas. This energy is used for everything from heating to transportation to electricity. In 2010, an average of about 85 million barrels of oil were used per day. The need for fossil fuels is increasing rapidly and is projected to be around 300 million barrels of oil used per day by 2100.[11] Not only does this form of energy increase the rate at which global warming is happening, but it is also available in a finite amount; therefore, as our dependence on fossil fuels increases, the fossil fuels available deplete. Since fossil fuels are such a large part of our economy and standard of living, it is clear to see why greenhouse gas emissions have increased since the start of the Industrial Revolution.

The growing need for more food and space that is associated with the world's growing population can be portrayed through the deforestation of Earth's tropical rain forests. Reasons for deforestation include accommodations for increased urban sprawl, logging, highways, money, and agriculture. Most of the land cleared goes to agriculture. Slash and burn techniques for clearing forests are common for plantations.[11] This technique, however, is very unsustainable being that it releases large amounts of carbon dioxide and aerosols into the atmosphere. Tropical deforestation accounts for 25% of the carbon released into the atmosphere. This release of carbon dioxide comes from the burning of the above ground biomass and by the release of carbon from the soil. During the cultivation phase, soil organic carbon levels can decline by up to 30% in the top meter of soil.[21] Through deforestation, the possible carbon storage in trees is eliminated and evapotranspiration is decreased. In fact, the complete deforestation of the tropics would result in a heating that is equivalent to that caused by the burning of fossil fuels since the year 1850. Not only would temperatures increase, but the rainfall in the US Midwest, Northwest, and South would also decrease during the agricultural seasons, thus negatively impacting crop yield.[16]

Aside from the release of carbon dioxide, another way that deforestation drives climate change is by increasing the amount of water vapor in the atmosphere. The soil found in tropical rain forests is naturally very moist. When forests are cleared, the large tree canopies are no longer present to block the soil from the harsh sun. This results in the evaporation of the soil water which adds water vapor to the atmosphere, in turn, speeding up the process of global warming. Even if this wasn't the case, terrestrial plants absorb 2.3 gigatons of carbon from the atmosphere per year;[12] therefore, the less trees present, the less of the carbon dioxide that is able to be filter out of the atmosphere, also leaving negative effects on the atmosphere. With these numbers, it is worrisome to imagine that land the size of 48 football fields is being cleared from tropical rain forest every minute.[16]

The agriculture made from deforestation is even more detrimental to the environment. Agriculture alone accounts for one fifth of the annual increase in anthropogenic greenhouse gas emissions which include carbon dioxide, methane, and nitrous oxide. Carbon is released when dead organic matter and plants are removed from the soil and when crop wasted is burned. Nitrous Oxide from agriculture mainly enters the atmosphere through heavily used nitrogen fertilizers.[10] Used to increased crop growth, some of the nitrogen in these fertilizers are taken up by the crops. The rest leaches into the surrounding surface, gets denitrified, and then is diffused back into the atmosphere, thus contributing to global warming. The amount of nitrogen absorbed by the crops varies by plant type; however, wet rice plantations absorbs only about one third of the nitrogen in the fertilizers. Lastly, methane is produce by the livestock that graze on these pastures. The second largest contributor to global warming after carbon dioxide is methane. Methane does not get the same publicity that carbon dioxide gets because it is not as plentiful; however, what is not taken into consideration is the absorption power of methane. Methane absorbs ten times the infrared energy and heat that carbon dioxide does making it a much more potent gas.[15] Livestock like cattle and sheep are a part of the class of mammals called ruminants. Ruminants have a four-chambered stomach that involve a long process of regurgitating their food repeatedly in order to digest it through the different stomach chambers. This process releases methane. The methane is detrimental to our atmosphere given that there are about 1.4 billion cows in the world and each of those cows produce 70 to 120kg of methane per year.[20]

Effects of Global Warming

One of the main effects of global warming is the rise in sea levels. Over the last twenty years, the ocean has risen at a rate of about .13 of an inch a year which is nearly double what the natural increase was in the eighty years prior. This increase in the rate that the sea levels are rising validates the claim that more greenhouse gases are entering the atmosphere than can be removed. The ocean is responsible for absorbing 80 percent of the excess heat entering the atmosphere, leading to the three main reasons why the ocean is growing. For starters, when water is heated, its molecules move farther away from each other, causing it to expand. Regardless of the water being added to the ocean, the heat itself is causing the same amount of water to take up a lot more space. Another reason for the rise in sea levels is the melting of the polar ice caps and glaciers. The increase of the global temperature is responsible for more ice melting in the summer than usual and less snow falling in the winter. The surface of artic ice from the North Pole has decreased by 10% in the last decade and the thickness of ice above water has decreased by 40%. Lastly, the major ice sheets in Antarctica and Greenland are facing problems similar to the polar ice caps. The heat melts these ice sheets at a rapid pace and this resulting meltwater acts as a lubricate, causing the ice sheets to move more quickly to the ocean where the warm water further destroys them. The ocean level has increased in the last decades by 15 cm and it is expected to rise a meter by 2100.[12]

The consequences of the rise in sea levels is heavily seen from coastal regions and include the contamination of aquifers, erosion, loss of habitat for many animals and plants, and, lastly, flooding. Coastal cities like Miami, Florida are already seeing reoccurring cases of severe flooding. In fact, large pumps have been installed in Miami to take out water from the streets during high tides. Alas, there is only so much water these pumps can take out of the cities, especially when the warming is expected to accelerate. In fact, at a rising of 30 cm, the saline waters of the ocean are projected to penetrate the interior of continents by 5-15 km in upside rivers, infecting estuaries and ruining our drinking water.[12]

The loss of biodiversity is also attributed to global warming. Many species cannot keep up with the rate at which their environments are changing, resulting in the current extinction rate of 100 species extinctions per million species each year. This rate is around 100 to 1000 times higher than the backgrounded extinction rate. Biodiversity is necessary in forming complex ecosystems that provide provisioning services like the production of renewable resources and regulating services like the lessening of environmental change. Ecological processes in ecosystems that control the fluxes of energy, nutrients, and organic matter through an environment are made possible by the presence of biodiversity.[4] Scientists, doctors, and researchers also look to plants and animals when trying to come up with a cure for diseases and sicknesses; therefore, the decrease of biodiversity directly affects human medical research.

An example of the detrimental effects of a decrease in biodiversity can be witnesses through coral reefs. Coral reefs are home to over a million different species and provide ecosystem services for over 500 million people. Though home for such a large variety of animals, coral reefs are very fragile, being affected by the difference of even 1 to 2 degrees' Celsius change. When temperatures rise, the coral goes into a state of shock and begins to bleach. It expels the chemical responsible for its pigments and turns completely white. If not stopped in time, the corals die from bleaching which can in turn cause a cascade of extinctions.[6] Cases of coral reef bleaching are becoming increasingly frequent and are expected to increase in relation to the ocean temperature. The loss of coral reefs will not only leave millions of animals without homes, but it will also negatively affect the people that rely on this ecosystem for its services.

Ocean acidification is yet another threat to marine life and biodiversity. The ocean absorbs one third of the carbon dioxide released into the atmosphere acting like a "sink". Over the past 250 years, the atmospheric carbon dioxide levels have increased by over 40% from preindustrial levels. This carbon dioxide is causing the ocean's pH level to decrease, becoming more acidic. Acidification alters the chemical speciation and biogeochemical cycles of many elements and compounds. The acidic water is not suitable for many animals but especially shell forming organisms like oysters, lobsters, and even many planktonic organisms. This is because ocean acidification lowers the calcium carbonate saturation states of the water which reduces calcification and growth rates of shell forming marine organisms.[8] Since these organisms are the basis for many marine food chains, ocean acidification has the potential of affecting all animals in the ocean.

Though it is normal for Earth to receive some form of fluctuations, what is not normal is the rate at which these changes are occurring and the linkage it holds to people.[4] Over the past million years as Earth has moved out of ice ages, the global temperature only rose four to seven degrees Celsius over the course of 5,000 years. Over the past 100 years, the temperature has increased about 0.7 degrees Celsius which is ten times faster than the average rate of ice age recovery warming. This rate is expected to increase. Predictions estimate that Earth will warm between two and six degrees Celsius in the next century which is twenty times faster than average.[22]

These are real, present day, human induced problems. Global warming is much deeper than the simple rise in temperature. At the start of the industrial revolution, humans were not aware of the damages they were doing to the environment. Now that this information is exposed, it is time for people to begin to take action. Habitat conservation, protection of the endangered species list, and advances in clean, renewable energy are more necessary now than ever before.

Solar Power Systems (PV)

Over many centuries, there has been a great increase in the demand for electricity generated specifically from the solar rays produced by the sun. Countries throughout the world such as Germany, China, and Japan have researched and generated solar power produced from photovoltaic solar cells. The generation of electricity using these cells greatly reduces the cost of the production of electricity. Although this method manages to save money, it relies heavily on the weather conditions and its efficiency may be hindered during specific times, seasons, and locations. In order to improve on this, many solar panels contain photovoltaic collectors to increase production during times of naturally low productivity. "Waldau (2006) examined the European photovoltaic market and observed a growth rate of 40% increase during a five year period, making photovoltaic production one of the fastest growing industries" (Abolhosseini, Heshmati, & Altmann, 2014). After extensive research on the use of stand alone solar photovoltaic systems in developing countries by Kolhe, the infrastructure that contained these systems functioned at a cost of 15 kWh of energy under unfavorable conditions but would increase to68 kWh/ day in more advantageous conditions. Kolhe then compared the cost of the production of energy and the amount of energy produced by photovoltaic systems in India with the cost and amount produced using diesel fuel and found that in order for the break even point to increase, the cost of the diesel fuel must increase and the cost of the PV's must decrease. [1] Figure 1 illustrates the solar power U.S. consumption. (Source: EIA, MER, March 2016).

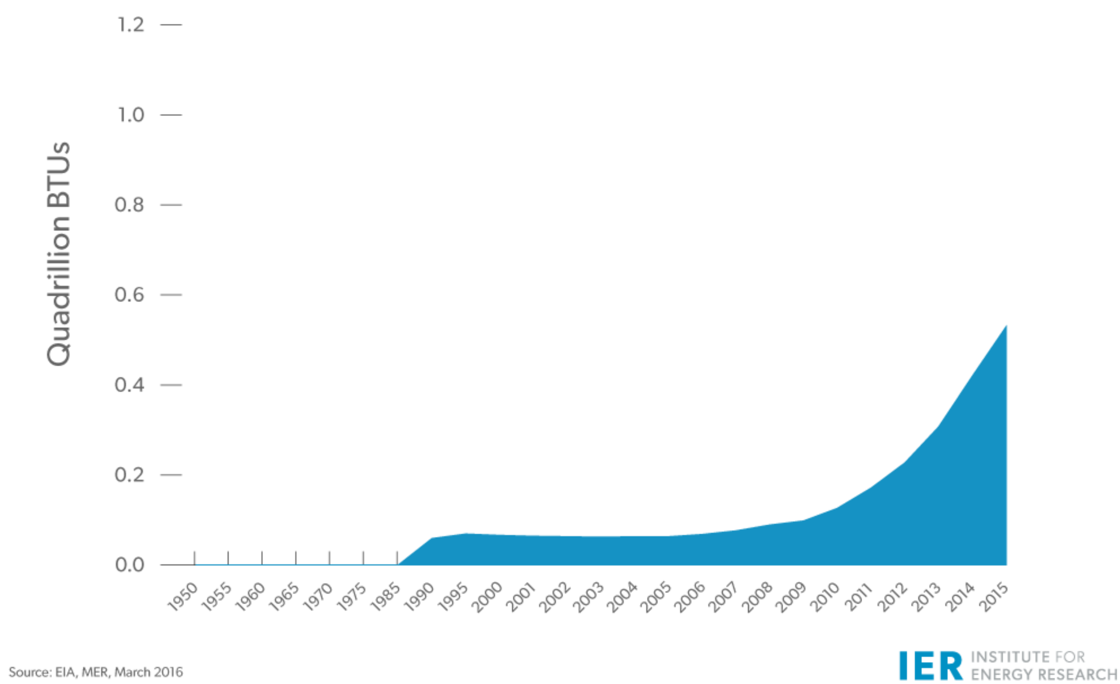

Figure 1: Solar U.S. Consumption

An analysis done by Gordon (1987) compared the efficiency involving cost, CO_2 yield, and energy production between photovoltaic systems integrated into building versus a photovoltaic system plant. With a CO_2 yield of 2.6 for photovoltaic power plants and a yield of 5.4 for integrated PV systems, it was found that the overall effects of integrated PV systems were favorable in terms of CO_2 yield and energy production.

Wind Power Systems

The use of wind to generate electricity using wind turbine has rapidly increased over the past decades and now proves to be a promising source of electricity. Wind turbines were first used in the Great Planes to power small farms and later expanded to the rest of the world. As of now, Denmark and Germany are the leading wind turbine manufacturers providing more than 20% of their country's electricity using the power generated from wind turbines. The main factor that determines the amount of energy produced from the wind turbines is wind speed, causing energy to increase or decrease substantially. It is proven that while wind speed increases by a factor of two, the energy produced will increase by a factor of eight leaving wind speed to be the sole determinant of energy production. Air temperature and density also play a role in determining the amount of energy produced by the wind turbines. [5] Figure 2 displays the amount of installed wind capacity annually. [2]

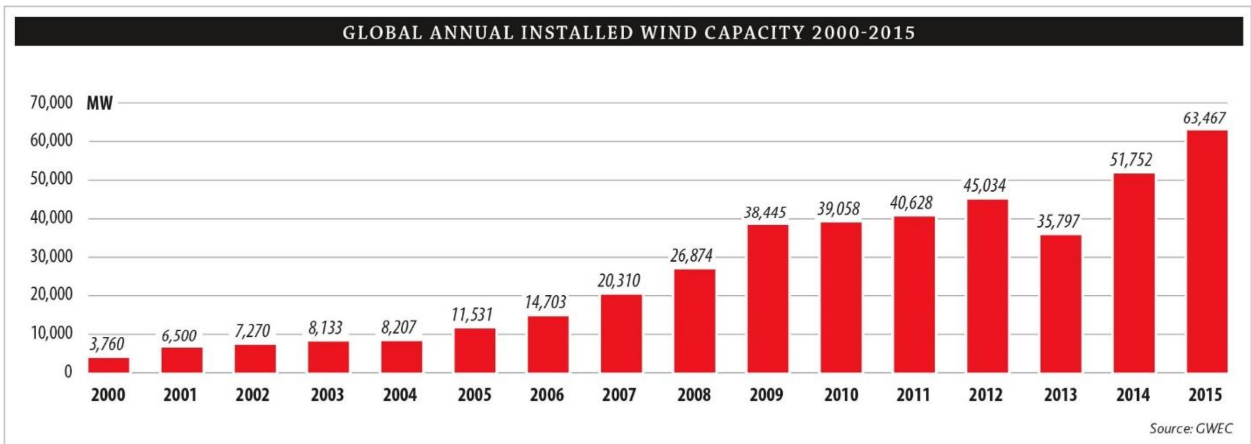

Figure 2: Global Annual Installed Wind Capacity 2000-2015

Recent research done by Ngô and Natowitz (2009) exemplified the drawbacks of wind generated electricity and its productions. Wind comes and goes at spontaneous strengths leading the energy production to vary throughput the year. Many wind turbines are located in low populated areas where the wind is stronger forcing the cost of transportation to increase as the electricity must be transferred to residential.[1] Figure 3 displays the total installed wind capacity in the United States through the end of 2015 (State Blue Map 2015) .

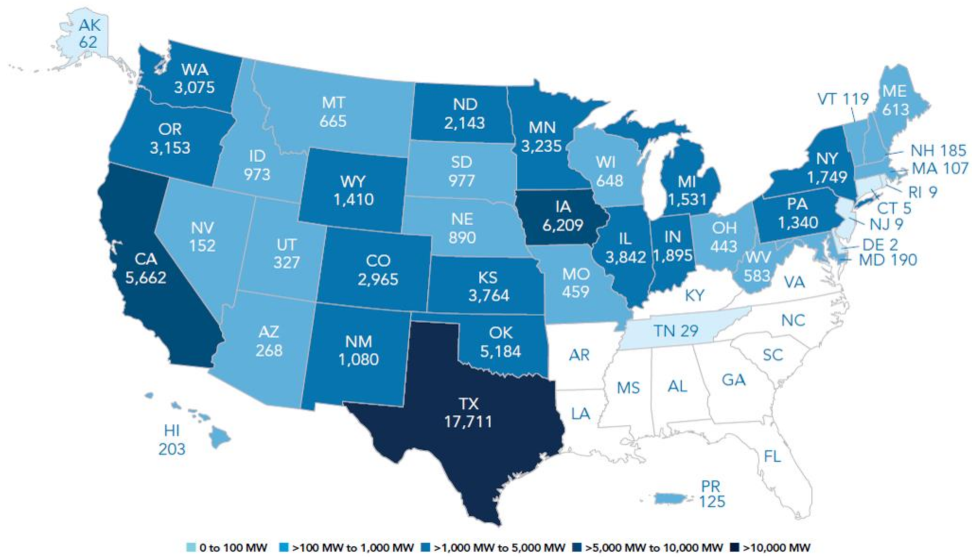

Figure 3: Total U.S. Installed Wind Capacity, Through End of 2015

To compare the use of fossil fuel systems to generate electricity, a 1,500 kW wind turbine's ratios for delivering electricity were analyzed by Devine (1977) finding that the wind turbine system was able to displace a portion of the fossil fuel equivalent (.) While Devine studied the efficiency of a wind turbine compared to the energy produced from a fossil fuel system, Haack (1981) compared the net energy of a small wind conversion system in the United States to systems that implement fossil fuel generation. He produced a model that assessed wind speeds and 890-70-9099 electricity demands in rural areas to prove that the net energy produced from the wind turbine was greater than that produced by other systems.[1] Unlike photovoltaic systems, the cost of the wind turbine varies by size, increasing as the turbine gets larger. This may lead a consumer to utilize the PV system fro small loads and implement the wind turbine system for more demanding loads.[5]

Geothermal Energy

Geothermal energy is a type of thermal energy that originates from radioactive decay within the earth in temperatures around 4000 degrees Celsius. It has been used throughout generations to cook, warm waters, and in heating buildings. Availability of geothermal energy depends highly om location and the geothermal gradient, which indicates whether a location is a promising area for the production of geothermal energy. This geothermal gradient measures the rate at which the temperature increases as the depth of the earth increases.[1] Geothermal energy availability also depends on the permeability of rocks, allowing the researcher to analyze the amount of heat that is able to flow to the surface of the earth. Unlike wind and solar energy, geothermal energy is available at any time during the day and year. In research done by Lund et al. (2005) they analyzed geothermal energy data from 72 countries and came to the conclusion that using 273,372 terajoule per year of geothermal energy would save 128.9 million barrels of oil given the assumption that there are 6.06×10^9 joules of energy in a barrel of oil. [1] Figure 4 shows how geothermal energy was used in Iceland in 2013. [9]

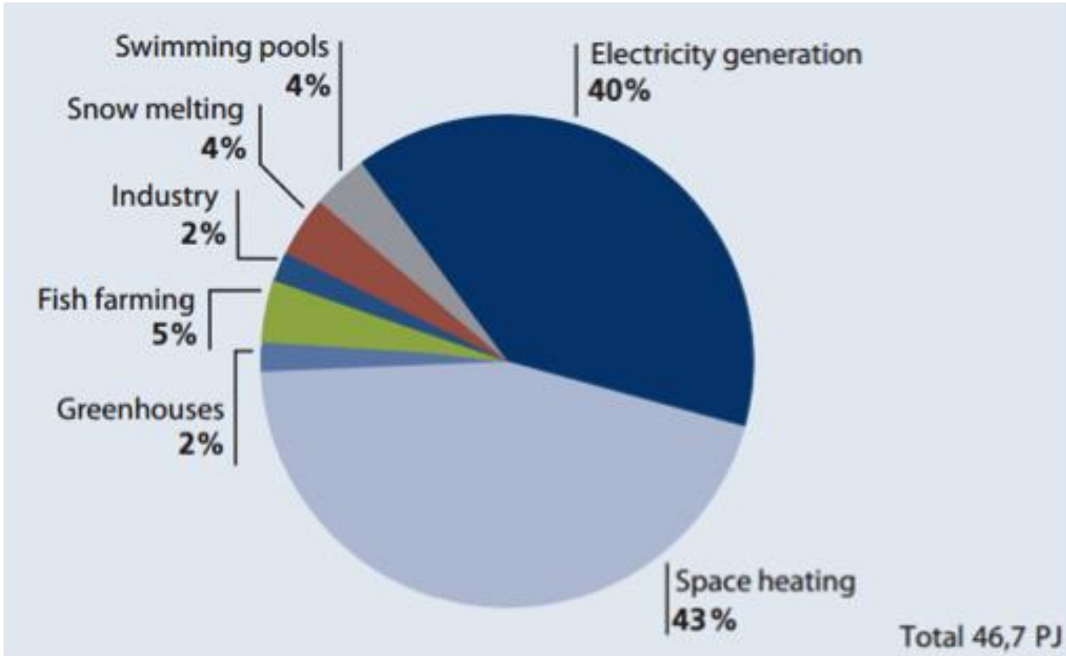

Figure 4: Geothermal Energy Utilization in Iceland 2013

Geothermal energy allows for the increase of the emission of greenhouse gases into the atmosphere due to the fact that there are greenhouse gases below the earth that seep to the surface. Areas where geothermal power plants exist tend to have higher emission rates leading to an increase in greenhouse gases, such as sulfur dioxide and silica, in the atmosphere. The construction of these geothermal power plants also takes a toll on the environment as it can affect the stability of the land surrounding a power plant. This instability may lead to the triggering of an Earthquake such as the one that took place in January 1997 with a magnitude of 3.4 in Switzerland. The earthquakes are caused by the hydraulic fracturing process which is essential to the development of a geothermal power plant. The cost to developing these power plants tend to be high as the drilling of new reservoirs cost around 2 to 7 million dollars fro a geothermal plant with a capacity of 1 megawatt. [17]

Biomass Energy

Biomass is the oldest source of energy as it originates from animal waste and plant material. Biomass energy is easily replaced because it has the ability to regrow in a short period of time as opposed to the regeneration of fossil fuels which takes millions of years. Plants are able to convert the sun's energy from carbon dioxide into carbohydrates which burn to release the energy that was taken up from the sun. it is evident in several studies that the potential for biomass energy will not increase much in the future due to the high cost of production compared to other forms of renewable energy.

There are many disadvantages to implementing biomass energy such as the release of toxic air pollution, a damage to ecosystems due to overharvesting, and the over consumption of water. With the development of new technologies that control the pollution emitted by biomass in industrial facilities, the release of CO_2 in the environment is substantially lesser than the emission of fossil fuel by power plants. The amount of carbon dioxide is also lessened by the intake of CO_2 through photosynthesis by future biomass crops.

In 2011, it was discovered that bioenergy was used as an energy source more than oil in Sweden. The Swedish Energy Agency found that 31.7% of the energy used was generated from biomass while 30.8% of the energy originated from oil. One of the principal reasons for this increase in bioenergy is the fact that biomass is the primary energy source in the district heating sector, a sector that demands more than half of the overall heat demand in residential areas. [7] Figure 5 shows the different sources of energy in Sweden in 2011 (Sweden Energy Use 2010, May 10).

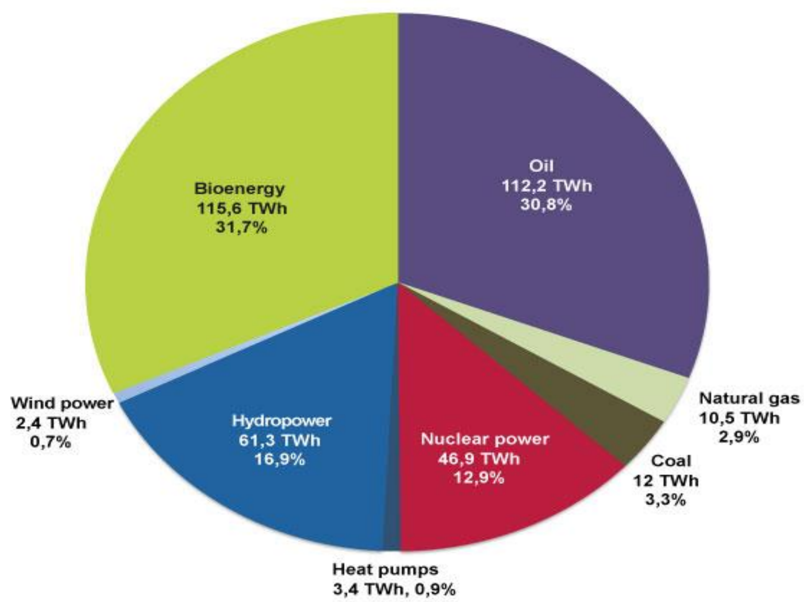

Figure 5: Source of Energy in Sweden 2011

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