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Environmental Science

The Future of Nuclear Generated Electricity

Electricity is everywhere in our modern world. Electricity is the engine that drives everyday operations as well as technological advances. It is a form of energy, the transfer of particles between two mediums; electricity is the transfer of electrons through conductive material. Our society is growing at an exponential rate, and so is our energy demand. In 2006, the United States used 3 terawatts (TW) of energy, compared to 13 TW of energy used worldwide (Lewis, 2005). Forty percent of the energy is in the form of electricity in the United States (DOE, 2008). As our society moves on into the future, we are projected to use 28 TW/year worldwide of energy. (Lewis, 2005) In addition, the current generation methods used for energy produces a substantial amount of carbon dioxide emissions into the atmosphere. A feasible method of generating enough electricity to meet future demands is to deploy more nuclear reactors globally, as they are clean-air, they provide for a substantial amount of energy, and they utilize a closed fuel cycle enabling for a more efficient use of supplies. However, there are many concerns to address before large-scale deployment including safety reputation, the operational cost, and waste mitigation.

Nuclear power has had a negative image after the two largest nuclear accidents in history, the Chernobyl and Three Mile Island incidents. During the Chernobyl accident of 1986, one of the reactors malfunctioned, dissipating the largest recorded amount of radioactive material throughout all of the Northern Hemisphere over the course of nine days. While the plant was located in Russia, radiation affected many European countries, including Finland, Sweden, and Scandinavia and even the United States (The Global Impact of the Chernobyl Reactor Accident). Because of this, there is vast opposition to nuclear power generation by the public, as they believe that nuclear power is susceptible to the radiation issues that doomed Chernobyl. In comparison, the Three Mile Island incident, although it leaked less radiation, is the worst nuclear power plant incident to date, and consisted of a partial core meltdown due to human error coupled with mechanical failure. While nuclear radiation is indeed a concern, the lessons learned in the wake of Chernobyl and Three Mile Island helped pave the way for a safer future with nuclear energy, including stricter regulation of plants as well as streamlined mandated training for all employees operating reactors.

Despite the negative image that nuclear energy has, it can play a gigantic role in tomorrow's electricity generation because nuclear energy is clean air emitting no carbon dioxide into the atmosphere. In 2001, the majority of the members of the Intergovernmental Panel on Climate Change (IPCC) came to an agreement that global warming is real and that human activity contributes to speeding up the process (Climate Change 2001). A clean air solution is needed to mitigate the movement of carbon through electricity generation, as the current methods of generating electricity, such as burning fossil fuels, produce a significant amount of emissions. With a higher energy demands, the amount of emissions will inevitably rise unless a clean air solution is deployed.

Nuclear fission produces a substantial amount of energy. San Onofre Nuclear Generating Station (SONGS) in San Diego County, California is a "two reactor station that produces 2,254 MW of power, the equivalent of the energy needs of 2.75 million households" (Southern California Edison). This is the equivalent of approximately 17,000 GW/Hours of power a year. In comparison, the San Gorgonio Windfarm off Interstate 10 in Riverside County, California produces only 615 MW of power. The wind farm spans 5,487 acres, while SONGS is located on only 84 acres. This equates to only .11 MW of power per acre at the wind farm, and 26.8 MW of power at SONGS. This efficiency per square mile that nuclear energy provides is unmatched by any other energy generating source. According to Southern California Edison, the company that runs SONGS, "one low-cost pellet of uranium 235 – weighing a few ounces – produces the same amount of energy as 140 gallons of oil, 150 gallons of gasoline, 2,000 pounds of coal, or 17,000 feet of natural gas."

At this time, there are four main costs that need to be taken into account when considering nuclear power: "the construction cost of building the plant, the operating cost of running the plant, the cost of waste disposal, and the cost of decommissioning the plant" (University of Melbourne Nuclear Power). The highest cost in the nuclear industry is the construction of the plant, not surprising, as with any venture there is substantial capital required in order to start making progress forward to profitability. A new Westinghouse reactor, the AP1000, has an estimated construction cost of about $1,000/KW for three years. This is not cheap, for a plant with the same specifications as SONGS to be built today, the cost would be estimated at $2.2 million dollars. Currently, the US Department of Energy provides a "subsidy of 1.8 cents per KW-Hour for the first 3 years of operation. This subsidy is equivalent to what is paid to Wind Power companies and is designed to encourage nuclear reactor construction in the USA" (University of Melbourne Nuclear Power). Given our current economic forecast at this time, it would be beneficial for governments to subsidize more in order to help offset the cost of construction of nuclear power plants and have the energy corporations pay back the government after three to five years, essentially a no interest loan. This will allow for more nuclear plants to start up as they will not need a lot of capital.

While construction costs for nuclear plants are high, the operating costs are trivial. The average operating cost is about 1.68 cents per KW-Hour, including a .2 cent per KW-Hour waste disposal fee and the price of Uranium Ore, only .05 cents per KW-Hour (University of Melbourne Nuclear Power). This shows that once the plant is online and producing energy, it is creating electricity inexpensively. The only cheaper way of producing electricity is coal, which runs for .6 cents per KW-Hour. This is only roughly 3/8 of the cost of nuclear, however coal is being depleted at an enormous rate, and it is not clean air, it contributes to the extraneous carbon dioxide concentration in our atmosphere.

The last two costs of Nuclear take place after the electricity is generated, the waste storage cost and the plant decommissioning cost. The storage of nuclear waste is very complicated, and requires to be executed with extreme precision. Therefore, "operators are charged .1 cents per KW-hour to [ensure that they properly dispose] nuclear waste" (University of Melbourne Nuclear Power). Lastly, a lot of funds go into decommissioning a plant once it is technically inferior and is not cost effective to upgrade it. The average cost for decommissioning a plant in the US is approximately $300 million dollars (University of Melbourne Nuclear Power). This cost can be cut down in the future if plants were retrofitted, instead of decommissioned as the low operating cost favors continuous operation. If all else fails, and decommissioning becomes necessary, the government should provide funding if the company owning the plant plans to rebuild a newer, more modern plant.

As mentioned above, one of the main hurdles to the deployment of many nuclear reactors to meet future electricity needs lies in the storage of nuclear waste. Since it is radioactive, special care must be taken when disposing the Uranium remnants. Up until 2009, one of the proposed sites for nuclear waste disposal was at the Yucca Mountain Repository in Nevada. This idea faced controversy by local residents who wanted nuclear waste to be stored “not in my backyard”. Also, since most nuclear plants are located on the east coast of the US, many argued what would happen if an anomaly happened during transport of the waste to Yucca Mountain. Ultimately, in March of 2010, the Department of Energy shut down plans to use Yucca Mountain and is currently looking into alternatives for waste storage. Research and development steps need to be taken regarding nuclear waste in order to discover safer methods before we can move on to deploying more nuclear reactors.

One of the ways to mitigate nuclear waste is to use a closed fuel cycle, which breeds the used uranium in plutonium through forced decay. “Used fuel is about 95% uranium-238 but it also contains up to 1% uranium-235 that hasn’t been fissioned, and about 1% plutonium” (Encyclopedia of Earth). By reprocessing the waste products of nuclear fission, the amount of fuel bundles being removed and shipped off site is dramatically decreased. This method of fuel recycling is currently in use in the country of France, a country that gets the majority of their electricity from nuclear energy. One of the reasons why they can depend on nuclear energy is because of their nuclear breeding process that uses the nuclear waste to produce more fuel. Because of this, they cut down on the need to dispose large amounts of nuclear waste, one of the biggest hurdles to large scale deployment in America.

In conclusion, while nuclear power is a feasible source of electricity in the future because of the large amount of energy it produces as well as the lack of carbon emissions, it is evident that more research is needed in order to offset the operational cost, improve the image of nuclear power, and deal with the nuclear waste in a safe and cost effective way. We cannot rely solely on nuclear power in the future, as Nate Lewis emphasized in his lecture *Powering the Planet*, “in order to meet the project energy demand in 2050 we would need to build a total of 10,000 1 GW reactors, which is approximately a plant every other day for 50 years.” When compared to renewable energy sources such as solar and wind energy, nuclear provides for a significant amount of energy, with minimal space requirements. Even with innovative advances in the field of energy production projected over the next fifty years, we will probably see more nuclear energy plants being built. Though not the complete answer, nuclear energy is a feasible method of planning for tomorrow’s energy requirements.

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