AP Capstone Seminar

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The Nuclear Alternative

Introduction

The end of nearly every modern commodity the developed world has come to take for granted is rapidly approaching. Electricity, the driving force behind these commodities, is currently produced primarily by fossil fuels, which most sources agree will be depleted within this century. Even if a surplus existed however, fossil fuels have been ravaging ecosystems for over a century. By destroying the ozone layer, the greenhouse gases produced by oil, gas, and coal are wreaking havoc on the world's ecology. Their continued use could lead to irreversible changes. Additionally, the major global holders of these resources, especially oil, are able to disproportionately sway world politics and, in turn, dominate the world economy. Clearly, a solution is desperately needed, and nuclear power has the potential to be that solution. The question is, "to what extent could the utilization of nuclear power feasibly replace the American reliance on fossil fuels?"

A conversion to nuclear power will radically alter the face of energy production by improving its sustainability and, contrary to prior belief, its safety (Hansen and Kharecha). Nuclear power has the potential to protect the environment through its low ecological impact and is considerably more efficient than other sources of "green" energy. Shifting towards nuclear power would allow America to stop relying on foreign countries for its energy needs. This would drastically alter its political standing in Middle Eastern nations and ultimately save the

government an immense amount of money. In addition, nuclear power has a lower price and higher stability than the vast majority of alternate energy sources (Landau). To fully assess the situation and make an educated decision on this issue, it is important to understand the history and process of harnessing nuclear energy, the environmental effects of the technology, its political repercussions, and its economic implications.

Scientific Background

One of the strongest arguments against the nuclear alternative stems from its history. As thoroughly explained by Greenpeace, a strongly anti-nuclear environmentalist organization, the Soviet reactor in Chernobyl, Ukraine exploded in a massive power surge in 1986 ("Nuclear Accidents"). It released more radiation than the atomic bombs dropped on Japan and a total of 30 people died within a few weeks of the accident as a direct result of the fires and released radiation. Thousands more died in the ensuing years from lower doses of radiation poisoning, which caused cancer rates in the area to spike dramatically. The surrounding land was rendered virtually uninhabitable and billions were spent to contain the disaster. Several of these accidents have occurred around the world, though none so grievous as Chernobyl, which was so devastating because of the unusual and ill-advised design of the plant and the lack of concern for safety in the Soviet Union. The most recent one, in Fukushima, Japan, renewed opposition to nuclear power by groups like Greenpeace because of its severity. It released dangerous levels of radioactivity, which are expected to raise cancer rates, and was labeled the worst accident since Chernobyl.

However, as asserted by the World Nuclear Association, the international organization promoting nuclear power, the accident at Fukushima did not directly result in any fatalities ("Fukushima Accident"). The only accident to directly result in fatalities was Chernobyl.

Furthermore, according to a study performed by NASA's Goddard Institute for Space Studies, nuclear power has the potential to save over a million lives lost to fossil fuels, even with the increased cancer rates caused by meltdowns (Hansen and Kharecha). This is in strong contrast to popular belief, which holds that nuclear energy is much more dangerous than fossil fuels. In addition, every nuclear accident to have occurred has been completely preventable with proper adherence to regulation ("Fukushima Accident"). Understanding the true safety of nuclear power necessitates a brief overview of the science and mechanics that produce it.

Nick Touran, a reactor physicist who created a nonprofit website for the purpose of promoting nuclear technology, explains in his articles how nuclear plants generate power, first stating that they harness the energy of a reaction known as fission (Touran). Fission occurs in a reactor vessel, when a single neutron is shot at the nucleus of a heavy atom. The neutron splits this atom into two smaller ones, in the process releasing huge amounts of energy, some of it in the form of heat. Coolant, usually water, is pumped from a condenser unit into the reactor vessel, where it is then converted into a gas by the heat of the reaction. The gaseous coolant travels through a steel pipe, to a turbine, which powers a generator. This also cools the fuel and prevents meltdown, by transferring heat away from the reaction. The entire system is housed within a containment structure, which isolates it from the outside environment. Several other types of plants have been created, but they all simply expand upon this general design. One encouraging new type is known as a breeder, or fast, reactor. It has found a way to solve both the sustainability and radioactivity problems by recycling its own waste. Most conventional reactors utilize a rare isotope of uranium, known as U-235, which composes approximately .72% of natural uranium. To be used in a conventional reactor, it must be artificially enriched to 3.5% - 4% U-235. When the U-235 is depleted, the rest, mostly the isotope U-238, is considered waste.

Breeders can use a large portion of this "waste," because of the special nature of U-238. When hit with a neutron, instead of fissioning like U-235, it absorbs the neutron. It then goes through a series of reactions until becoming a fissionable isotope of Plutonium. Running nuclear reactors on the newly-made plutonium greatly increases the fuel supply. In addition, the remaining waste is greatly reduced, allowing it to decay much faster. Instead of lingering for hundreds of millennia, it lasts a mere 300-500 years. Unfortunately, breeders do create more dangers. They must use reactive coolants like sodium, meaning leaks result in sodium fires, and their neutrons must fly at higher speeds to efficiently recycle waste, meaning any problems that do arise escalate much faster. These dangers necessitate extra precautions, both in construction and operation, but they can be overcome. With the correct safety measures the risks can be reduced and further study will enable the design to be improved.

While fission has the potential to sustain modern power demands for a few hundred years, uranium will eventually be depleted. An even more promising prospect can be found in fusion. Rod Nave, a physics professor at Georgia State University, explains on his website, HyperPhysics, that this is the opposite of fission, in that two very small atoms, usually hydrogen, are shot at each other and combine, or fuse, creating a larger atom, usually helium (Nave). The resultant heat release is stronger than that of fission, both the fuel and byproducts are completely safe, and hydrogen is abundant in nature. Fusion could safely power the world indefinitely. Unfortunately, it requires extreme conditions, normally found only inside the sun. The energy required to create those conditions is more than the energy released by the reaction. Nuclear scientists have come close however, and with increased funding for research and development, it could become a reality.

Every major nuclear accident, from Chernobyl to Fukushima, has been the result of poor planning and human error. With improved education, they can theoretically be avoided. Fast reactors can reduce fears of radioactive waste and fuel depletion and fusion has the potential to eliminate the energy problem entirely. The poison of carbon emissions is a slow, discreet danger, but the research proves that the safer, more efficient and sustainable source of energy for the future comes in the form of nuclear power.

Environmental

Nuclear power is not the only way to avoid carbon emissions. The Physicians for Social Responsibility, a group of prominent environmentalists and philanthropists, claim that wind, solar, and hydroelectric power are all better options than nuclear energy ("Dirty, Dangerous, and Expensive"). They claim, "Nuclear power is neither renewable nor clean and therefore not a wise option. Even if one were to disregard the waste problems, safety risks, and dismal economics, nuclear power is both too slow and too limited a solution to global warming and energy insecurity." However, they neglect to cite any facts about the waste or the safety risks other than the quantity of waste produced, which has reached two thousand metric tons of high level waste. The reality is that nuclear fuel is actually a very valuable resource, and causes considerably fewer deaths than any other source of energy.

There are only two byproducts of nuclear fission: High level waste and low level waste. According to the professor of physics at the University of Pittsburgh, Bernard L. Cohen, low level waste is practically harmless, and it emits almost no radiation at all if properly contained (Cohen). In fact, it is so inert that all of it could be buried 20ft underground, completely uncontained, and still it would not cause any significant increase in cancer cases. Even so, it always is contained and buried far from water sources and populated areas, just to be safe. High

level waste is considerably more dangerous. If released into the environment, it becomes highly carcinogenic. However, waste storage processes are very refined, and it is difficult for an accident to occur. Waste is frequently vitrified, or turned into glass, which makes it impossible to leak or be accidentally released into the environment. Currently, the amount of waste produced by running an average nuclear plant for 50 years causes a mere one death compared to thousands by coal burning energy. The amount of high-level waste produced is actually extremely low, especially when compared to waste products of coal burning energy, so it is not difficult to contain it. The problem with this waste is its lifespan. It has the potential to remain radioactive for hundreds of thousands of years, which concerns many environmentalists. However, waste can actually be a valuable resource. As mentioned earlier, fast reactors are able to efficiently convert old nuclear waste into energy, leaving behind minimal secondary waste. This process, which, according to Colin McInnes, a professor at the University of Glasgow, has already been proven to be economically and energetically efficient, is able to solve every environmental problem associated with nuclear waste (McInnes). This process, when combined with the already low risks of storing and producing nuclear waste, makes many of the environmental concerns about nuclear energy completely invalid. The only environmental reason to avoid the utilization of nuclear energy is the unlikely possibility of a large-scale accident.

Political

Although the majority of nuclear waste is not dangerous, its disposal is still a controversial topic in American politics. As explained by the Nuclear Energy Institute, the negative connotations of nuclear power and its byproducts have resulted in protests against its use and, in turn, its disposal ("Disposal"). Disapproval of the legislation has brought up discussion in the United States' government over what the nuclear waste management policy

should be. Currently, the it is the Yucca Mountain program, located in Nevada. In this program, nuclear waste is stored in safe containers that are placed deep into the ground at Yucca Mountain. While it is a very successful and secure method, the Massachusetts Institute of Technology claims that a change in the current legislation could institute a better policy for nuclear waste management and subsequently increase public support ("Update of the…" 11). The school believes that the government should undertake a research and development plan for long-term management, including the examination of alternative methods. Despite the length of the program, the research would provide many benefits by potentially finding an alternative method of disposal that would raise minimal protests from the public. With a small change in America's energy policy, nuclear power could become a popular leading source of energy.

The increased use of nuclear power will not only affect domestic politics but global affairs as well. The United States is dependent upon fossil fuels and therefore the Middle East. This means that when it comes to foreign policy in the Middle East, the United States has to be more accepting and supportive of their actions and beliefs. According to the International Business Times, the majority of United States foreign aid is given to Middle Eastern countries and is typically used for construction of towns and roads ("US Foreign Aid…"). In contrast, the foreign aid given to the rest of the world is most often used for political and social reform. Reliance on Middle Eastern countries for fossil fuels inhibits the United States from enforcing foreign policy. This stems from fears of offending a Middle Eastern leader, which could result in an oil embargo. A heightened American utilization of nuclear power will enable the government to establish new policies for foreign aid in the Middle East. This will give the United States the opportunity to provide foreign aid to other poverty stricken nations across the world, as well as implement social and political reform programs in places where they are truly needed.

Economic

In addition to aiding the United States' global and domestic affairs, nuclear energy's non-reliance on foreign powers also establishes it as a more economically stable source of energy than most fossil fuels. According to CNN science journalist and media specialist Elizabeth Landau, this stability is vital as it retracts foreign powers' ability to halt the American energy supply in times of conflict or disagreement, a dilemma capable of seriously crippling the nation's economy (Landau). Furthermore, nuclear energy does not rely on weather conditions like wind or sunlight to operate, allowing it to thrive despite legions of calm or cloudy days. J. L. Conca and J. Wright, in their magazine article outlining sustainable energy options for the future, argue that other incentives of nuclear power include cheaper energy production per kilowatt than most other sources, allowing nuclear power to triumph over natural gas, solar power, and coal (Conca and Wright). In fact, they calculate nuclear power to be tied alongside both hydro and wind power as the most cost-effective energy source of the modern era. The industry's low environmental impact grants nuclear the ability to thrive despite the high probability of future government regulations limiting greenhouse gas emissions, according to distinguished world energy consultants Schneider, Hazemann, and Froggatt (Froggatt, Hazemann, and Schneider).

However, while nuclear energy may be cheaper in the long-run than most current energy sources, the large $7 billion price tag of building plants force the industry to be funded dominantly by the government rather than private investors (Conca and Wright). Unfortunately, government funding tends to sway dramatically based on public support, and disasters, such as Fukushima and Chernobyl, have led to high public apprehension regarding nuclear power (Landau). Public reluctance to accept nuclear power as a safe and beneficial form of energy has also led to over-constricting regulations in the industry, including short operational licenses.

Because nuclear plants are expensive to build but run relatively cheaply, a small increase in the lifespan of a nuclear plant can translate to a radical jump in profit. However, this is not possible until public fear, and the shorter operational licenses that accompany it, is diminished.

Some, such as Schneider, Hazemann and Froggatt, claim that because the building costs of nuclear plants run an average of 270% over budget and usually require expensive safety upgrades every few years, taxpayers will never lose their apprehension of nuclear power (Froggatt, Hazemann, and Schneider). On the other hand however, NBC scientific journalist John Schoen points out that simply requiring building plans to be finished before the start of construction, which they often are not, and dismissing cost-plus contracts, which actually pay contractors more for running over budget, could significantly trim building costs for the plants (Schoen). If, as Hazemann, Froggatt, and Schneider argue, the only obstacle to public support for nuclear energy stems from finances, then Schoen's solution could easily allow nuclear energy to win over the public. However, as it stands now, the greatest challenge to increasing nuclear power plants' productivity for cheaper energy costs in America is public apprehension.

Solution

There is no question that nuclear energy is an extremely lucrative and viable option for the transition away from fossil fuels. Although completely replacing them is not a feasible option because of the extent of American reliance, the declining supply of conventional fuels can be supplemented by nuclear alternatives over time. This reduction of fossil fuel usage will not only benefit the environment, but also prepare society for their inevitable depletion. Employing breeder reactors will enable this option to endure for a longer period of time and minimize radioactive waste, effectively solving two of its most controversial problems. By regulating nuclear plants more actively, destructive accidents can be avoided, which will improve public

opinion of the resource. This does not mean however, that regulations need to inhibit productivity. With increased popular support, longer operational licenses would be possible, creating power at cheaper prices per kilowatt than ever before. In addition, a national ad campaign promoted by the United States Department of Energy could work to inform the American populace of the safety, reliability, and low-cost of nuclear energy, facilitating more wide-spread public support. Furthermore, the increase in government funding, possible because of these measures, would permit the creation of new plants throughout the country. Discontinuing the use of cost-plus contracts and requiring building plans to be complete before construction can trim plant building costs, dropping nuclear energy's price tag to unprecedented levels. With the additional profit margins caused by the shift towards fission, funds can be invested in research and development of fusion. Currently, although it has not yet been facilitated productively, fusion appears to be an ideal source of sustainable, clean, safe power.

Conclusion

It is critically important for this generation to find an answer to the energy issue. Without it, society cannot continue on its current path. The first step is to educate the public. Fear of the rare and unlikely dangers of nuclear power is the biggest obstacle to its wide-scale adoption. Humanity fears what it does not understand. By explaining the extensive benefits and safety precautions, nuclear energy will gain the support of the people and with the support of the people, its possibilities are limitless. Nuclear energy can safely and effectively power the future, protect the environment, strengthen the government, and reduce the debt, eliminating every problem posed by the energy dilemma.

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