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# THE IMPACT OF NUCLEAR ENERGY

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*The only clean, safe energy source capable of ensuring the continuation of our industrial civilization while protecting the environment.*

**ABSRTACT**

*Energy is a resource on which civil society is built. It affects every aspect of life and is vital to the survival of the modern world. This paper explores nuclear power and the effects it has on a national and global scale. The research looks at both the positive and negative aspects of nuclear energy, giving weight to both sides of the argument to present a detailed look at this resource. The research is compiled from a wide range of authors from scientists and nuclear experts to reporters and strategic intelligence agents. A proposed technology for the advancement of nuclear energy is also examined to show its benefits and compare it to conventional nuclear energy. This paper will assist any concerned citizen in making an informed decision on the world's most vital resource, energy.*

## I. INTRODUCTION

Oil, coal, solar, wind, or nuclear, energy sources have become a permanent necessity of modern society, and consequently, a hotly debated issue. Since energy holds such a prominent role in the world, it affects political decisions, relationships between countries, the economy, and the environment; it has become the core of most day-to-day activities. Nuclear energy has come to the forefront of these sources because of its relative newness and seemingly limitless supply of energy. Congress debates proposals for funding nuclear energy because many believe that it is the technology for the future with the supply of oil becoming harder to control and solar and wind technologies not being expanded or fully developed. The benefits of nuclear energy are plentiful and valid, and yet, so are the negative arguments against it. It is vitally important to understand some of the history of nuclear power, the implications of decisions made on the advancement of nuclear energy, and the far-reaching effects of the decisions made on such a powerful energy source. With a comprehensive understanding of nuclear energy and the expansion of its technology through products such as SMR's, nuclear energy could be the world's next prominent energy source.

## II. HOW IS NUCLEAR ENERGY PRODUCED?

Nuclear energy is produced when an atom's nucleus is split into smaller nuclei by the process called fission. The fission of large atoms, such as Uranium 235 and Plutonium 239, produces a great deal of energy. In fact, the fission of 1 gram of Uranium 235 produces the same amount of energy as the combustion, or burning, of 3 tons

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of coal (1)! The energy produced by the fission of uranium or plutonium can be harnessed to produce electricity, to propel space craft, and to power weapons like the Atomic Bomb. Unlike a traditional coal-burning power plant, a nuclear power plant uses the energy, or heat, produced by the fission of Uranium, rather than the burning of coal, to heat water into the steam required to turn the turbines that power electric generators. The advantage of using Uranium over coal energy is that, unlike for coal, Uranium fission does not produce soot and potentially harmful gases such as Carbon Dioxide. However, like coal, Uranium is mined and then processed before it can be used as an energy source. Also, like coal, the different mining and processing steps, as well as the actual energy production, produce a great deal of waste. Unlike coal, however, these wastes are radioactive, and thus more difficult to handle.

- **Nuclear BenefitS**
- **Environmental Impact**

Nuclear power yields numerous benefits to the world. One such benefit is that it produces fewer emissions than conventional power sources such as fossil fuels (Loudermilk, 2011). Coal is an example of a fossil fuel that is polluting the environment. According to the Sierra Club (2007) which is America's largest and most influential grassroots environmental organization, coal produces twice as much of the global emissions when compared to regular gasoline. Big Coal and its allies have stated that coal or liquid coal, coal that is converted into liquid fuel, would cure the United States of its energy problem, yet in reality, it has been causing countless problems in the economy and the environment such as an increase in carbon dioxide emissions and a costly conversion process (Sierra Club). It is speculated that clean coal causes double the emissions that regular gas does which means that the pricey process to convert it into liquid coal is all for naught (Sierra Club). Harvard's Center for Health and the Global Environment has produced research that speculates that coal causes eighty percent of the United States' warming emissions. Epstein and his team (2011) discovered that "The contribution of particulates (from coal, diesel, and biomass burning) to climate change has, until recently, been underestimated. Though short-lived, the global warming potential per volume is 500 times that of CO2" (p. 88). In the same way, the relentless search for oil to use as energy hurts the environment. Greenberg (2011), a writer for the National Wildlife Federation, reveals that the oil and gas companies are responsible for destruction to wildlife and natural habits as well as "hundreds of deaths, explosions, fires, seeps, and spills" (para. 5) because of their negligence. This is based on researched conducted by the National Wildlife Federation focusing on oil and gas disasters that occurred between 2000 and 2010 within the United States. The never ending search for energy has had a profound effect on the environment that will affect future generations for years to come. Nuclear power is one solution to the problem of greenhouse gases. Moore (2005), the founder and chief scientist of Green Spirit Strategies, states that "a significant reduction in greenhouse gas emissions (GHG) seems unlikely given our continued heavy reliance on fossil fuels. An investment in nuclear energy would go a long way to reducing this reliance and could actually result in reduced CO2 emissions from power generation" (para. 38). He also speculates that nuclear energy would be a solution to securing the United States' energy and meeting the energy demands of the nation. Nuclear would play a large role in reducing the greenhouse emissions and solve the climate problem in order to assure that there would not be an escalation in global warming (Knapp et al, 2010). Some suggest that renewable energy sources would be able to achieve the same ends as nuclear power in providing a clean energy source to reduce emissions for the environment; however, they would be unable to

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meet the increasing energy demands. Compared with nuclear energy, the renewable sources are unable to replicate the type of power generation that is needed to power the grids making nuclear energy a better choice. Loudermilk (2011), a research associate for the Institute for National Strategic Studies, warns that "On the global level, without nuclear power, carbon dioxide emissions from electricity generation would rise nearly twenty percent" (para. 20) He suggests that it is the only power source that could not only meet the growing demand for a stable supply of energy but also reduce green-house gas emissions.

- **Energy Security**

Another benefit of the use of nuclear energy would be energy security for the United States, which means the promise of sustainable energy for the foreseeable future. U.S. military planners are working to prepare for this future, but estimate that within the next twenty years the world's energy demand will increase by fifty percent over what it is currently (Rowell, 2012). The United States Joint Forces Command warns "a severe energy crunch is inevitable without a massive expansion of production and refining capacity" (Rowell, para. 3). Many ideas about how to solve the problem have been discussed and debated, however nuclear energy seems to be the best possible solution. As previously stated, nuclear energy is able to decrease emissions, but also would be able to meet the energy demands. Many politicians and scientists agree. According to Moore (2005), "Prominent environmental figures….have now all stated their strong support for nuclear energy as a practical means of reducing greenhouse gas emissions while meeting the world's increasing energy demands" (para. 43). Securing energy for the future is vital to the well-being of the United States. Other energy sources such as oil, natural gas, and even coal are finite resources projected to last no more than two hundred years if the world's energy demands are to be met

- **Gold Standard of Safety**

Strengthening the nuclear energy sector for the United States could also help ensure that nuclear energy is used safely throughout the world. The United States needs to have the lead in nuclear technology because of the safety standards for their nuclear equipment. China has been closing in on the United States for many years in relation to nuclear exports, yet safety oversight is the weakest area in their nuclear energy sector (Tu, 2012). A restructuring of China's Ministry of Environmental Protection which is the watchdog for their nuclear industry has been stalled by internal conflicts and the unbalanced hierarchical nature of the government (Tu). An overhaul is necessary to ensure that the nuclear technology that they are exporting from their country is safe. Many countries are looking to China to produce supplies and provide them with knowledge to build nuclear power plants. The United States needs to take control of the situation and be the main exporter for nuclear material since the safety standards that accompany their supplies are better than China's. Taking the lead in nuclear development would inhibit China's influence and lessen the attractiveness of their nuclear contracts. Currently, China has a reputation for giving nuclear material to countries that are ill-equipped to handle it. Without proper training, these countries will be unable to probably use the nuclear technology. This could result in them not meeting their energy needs or a malfunction of the equipment because they do not know how to use the equipment safely. United States leadership in the area of nuclear energy is key because of the higher safety standards that are required for U.S. supplies. China will step up to fill the vacuum that is left. The continued advancement of nuclear technology in America will maintain the United States' international standing on nuclear energy and hegemony globally. It is important that the NRC's gold standard is modeled globally in

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order to ensure the safety of the reactors. The gold standard for safety allows for the exploration of an energy source with strong guidelines and measures in order to keep it as safe as possible. It buffers against security threats and proliferation of nuclear materials. If the safety standards are followed, the ability to proliferate nuclear material will be less than if standards like China's were followed.

- **Public Sentiment**

In the current political environment, nuclear energy is popular among the public. After the Fukushima meltdown, its popularity took a dip shrinking from 57% to 43% as reported by the New York Times (Cooper and Sussman, 2011). This sharp dip and recovery has occurred previously. The slow growth of the industry can be traced back to the Three Mile Island disaster because the public was nervous about expanding it (MIT). A March 2012 Gallup poll, however, said that 57% of Americans support nuclear energy and the bolstering of the nuclear energy sector (Whitman 2012). Another poll taken by the Nuclear Energy Institutes reveals that as of April 2013, 68% of U.S. citizens look favorably on using nuclear energy as a source of electricity. One contributing factor to this increase could be the push to reduce the use of fossil fuels and the growing threat of global warming. This has been a major concern for many years, and the use of nuclear energy would be able to solve the problem because it does not release greenhouse gas emissions. Environmentalists have very strong sway in this area because they are the group that most desperately wants to see a reduction in fossil fuels.

- **Nuclear Energy Negatives**
- **Costs**

As is the case with most things in life, there are two sides to every story. Many problems and concerns accompany nuclear energy. The benefits many times do not outweigh the fears that are commonly associated with such a strong energy source especially after the disaster at the Fukushima power plant. The average American could not explain nuclear energy or how the plants work, yet because of previous disasters, they are weary about what could happen. One of the specific negative aspects of nuclear energy is the exorbitant costs that are associated with building up the industry. The cost of a nuclear facility commonly is comprised of four individual costs: capital or construction costs, back-end costs or the cost of decommissioning an old nuclear plant, fuel costs, and Operations and Maintenance (O&M) costs, which are costs related to the management and upkeep of a nuclear plant (Kessides, 2009). These divisions of cost create multiple avenues for cost over-runs which cause delays, licensing problems, and increased complexity in the management of a plant. This is evident in the average construction time of nuclear plants worldwide. When forty-eight nuclear plants were built between 1965 and 1970, the average construction time worldwide was sixty months; in contrast, between 1995 and 2000, twenty-eight nuclear plants were built with an average construction time of 116 months (Kessides). Nuclear power is notorious for not meeting deadlines and causing cost over-runs (Kessides). Cost over-runs have been estimated around 209%-381% over the estimated cost of construction according to an historical look at the United States' experience with cost construction beginning in 1966 (Kessides). These facts often deter private investors from putting their money into a technology that will not yield quick returns because construction is so costly and timeconsuming (Kessides). The risk that is associated with nuclear power plants does not put much confidence in investors for them to stake their money on the construction of a new plant. Costs to construct a new plant have increased making the construction times longer and exceedingly more expensive. Investors are not excited about this prospect even if federal funds were also given to offset costs

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(Severance, 2009). Their hesitancy is due to their concern that the risks of building a new nuclear facility will cost more than projected and not return their investment. The exorbitantly expensive cost is one of the main issues facing the expansion of nuclear power.

- **Lack of Workforce**
- **Manufacturers.**

A second negative to nuclear power is the lack of workforce to run the facilities andcreate the materials for the construction of a new nuclear plant. First, a shortage of manufacturers able to produce the necessary equipment and supplies for the construction of a nuclear plant is one reason for the delays in the building process. David Schlissel, a senior consultant with Synapse Energy Economics (2009), speculates that there are fewer than eighty suppliers of the nuclear materials compared to the four hundred in business two decades ago. The lack of manufacturers creates bottlenecking of supplies delaying any and all new construction projects for years.

- **Workers.**

The shortage of skilled laborers is another reason for the delay in construction which does not reflect well on the nuclear energy sector. In order the meet the demands that are required to maintain the United States' international standing in the nuclear market, the number of workers needs to be increased. "Strong global demand for skilled construction labor, and the retirement of many experienced worker is also leading to labor shortages… more than 45 percent of the engineering labor pool is eligible to retire in the next five years" (p. 17) warns Schlissel (2009). The pending retirement of these workers is cause for concern because there are no trained workers to fill their positions. Even if these workers were not retiring, the expansion of nuclear energy globally would require more workers than are in the nuclear field now. Much of the labor and manufacturing must be outsourced to other countries which incur more costly delays on the construction of a new power plant. Schlissel suggests that the cost of a new plant could be up to six million dollars more than it previously was. Besides increasing the costs for a new plant, outsourcing would also not ensure the safety standards of the United States. Other countries do not have the same expertise and knowledge of nuclear materials or the construction of supplies to build a new plant meaning that security could be compromised if the work was outsourced. Also, the countries where the work would be sent to would not likely have the experts required for such construction projects. In order to bolster the nuclear energy sector, more experts and engineers need to enter the workforce to fill the jobs that will be opened up or created with the expansion of nuclear energy.

- **Trade-off from Renewable**

Energy If nuclear energy receives more funding and focus, it would take those valuable resources from renewable energy sources which many argue is not a good option. Scarcity of research and development funds and natural resources means that only one type of technology is going to reap the full benefits of the nation's focus. Many argue that renewable energy such as solar or wind would be better than nuclear energy because of fewer risks and the size of the technology. Verbruggen, an Energy and Environmental Economics professor at the University of Antwerp (2008), highlights five reasons that nuclear power and renewables are incompatible. The first is that nuclear "is architect of the business-as-usual that has to be changed urgently and drastically" (p. 4046). This means that nuclear would not allow for a radical shift from fossil fuels which is necessary for the expansion of renewable energy. Verbruggen argues that renewable energy needs an immediate expansion that would be thwarted by nuclear power. Next is that renewables and nuclear yield very different results when they

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are added to fossil-fuelled power plants. To convert a fossil-fuelled plant into one with a different energy source, the nuclear add-on would be bulky and cumbersome while the renewable add-on would be flexible (Verbruggen). The third incompatibility is with the power grids that are connecting millions of power sources. Nuclear would need a new type of grid in order to make its output functional. Fourth, Verbruggen states that the risks for nuclear power make it unsustainable while renewable energy is believed to be safer and have fewer risks associated with implementing it. The final aspect is that nuclear and renewables are not the only ones fighting for funding (Verbruggen). Renewables and nuclear would not be able to co-exist because of the extraordinary amount of money that is involved in funding both of these technologies

- **Small Modular Reactors Benefits**

Much of the public is weary of nuclear energy because of past events though they know very little about how it works or the safety measures that accompany it. A large power plant and the knowledge that one just like it melted down causing mass panic across the globe is enough to put any person on edge. Instead of scrapping the idea of nuclear power all together, researchers have come up with safer and smaller reactors that should be able to calm the public's worries. Nuclear power has too many benefits to give up on the idea fully. Large nuclear plants are where many of the fears about nuclear energy have stemmed; new advancements and technologies, however, have emerged that could quell many of the concerns of the public. Small modular reactors (SMR's) seem to be the perfect solution.

- **Design**

Small modular reactors or SMR's designs are a major asset for this new technology both in terms of safety and cost.

- **Safety.**

The first benefit is that SMR's are inherently safer than large conventional nuclear reactors. Rosner and Goldberg (2011) and their team at the Energy Policy Institute at Chicago identified three major differences between large scale reactors and SMR's that made them safer. Firstly, the designs of the SMR's rely on battery power in order to maintain safety operations; this feature lessens or potentially makes obsolete the need for electrical or back-up generators in case of an emergency. The second safety aspect of SMR's is that they are better able to withstand earthquakes. This is achieved though "containment and reactor vessels in a pool of water underground" (p. 5) explains Rosner and Goldberg. The third safety feature in SMR's that minimizes susceptibility or damage that could occur with nuclear energy is the large underground pool storage for spent fuel. The fact that the pools are stored underground greatly reduces the chances that the spent fuel will be uncovered or dangerously leak (Rosner and Goldberg). The International Trade Administration agrees that the underground facility will help minimize any harmful effects. They confirm that "All U.S. SMRs are designed to be deployed in an underground configuration

- **Cost.**

The cost of any new project is always a factor in considering whether it is a viable option. Any new infrastructure is expensive and will need capital to be invested. Small modular reactors are no exception. They are, however, much cheaper and more economically viable than their competition. First, SMR's are a third cheaper than the large reactors that they would be replacing. They are also able to generate a cash flow more quickly than the large nuclear reactors. After one SMR is online, it will immediately begin to produce energy

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and money which allows manufacturers to funnel more money into the next module. The cheaper cost is due to the simplicity of the design as well as reduced siting and building costs according to Kidd (2011), director of Strategy and Research at the World Nuclear Association. The cost of the SMR's are also offset by the benefits that it yields.

- **Desalination**

A third positive aspect of SMRs is their ability to desalinate water. Even though much of the world is covered in water, scarcity of access to this resource is a major problem that causes conflicts around the world. Countries fight over access to rivers and water ways. An example of such conflicts is the tensions between Ethiopia and Egypt over the Nile (Dinar, 2012). Dinar, an FIU International Relations professor, asserts that "There are no strong treaties governing the use of these water reserves in tense territories. Should conflicts break out, there are no good mechanisms in place for dealing with them" (para. 6). Tensions over water create larger conflicts that will eventually escalate because water is a vital resource to life. With the uneven distribution of water and only .008% of the world's water directly accessible for human use, water poverty and wars fought over water are realistic threats (IAEA, 2007). Desalination is the process of removing salt from water, usually from sea water, so it can be viably used as drinking water or for the irrigation of crops (USGS, 2014). The process allows for more of the world's water to be used for human consumption which could eliminate the threat of resource wars fought over water. The option of using nuclear energy to power desalination plants is the best in order to make enough water to meet the growing demands of the world

- **Decentralization**
- **Grid**.

SMRs are also beneficial in the event of an attack on U.S. soil. Attacks on nations have become more sophisticated in recent years due to the increase in technology. A more viable threat to the United States would not be one from the land or sea, but an attack from cyber space. An attack on the electrical grid of the United States would cripple the country not only militarily but also economically. An attack on the grid has become increasingly more likely. The Annual Threat Assessment of the Intelligence Community for the Senate Armed Services committee in 2009 reported that cyber-attacks have become a serious threat to national security. Both state and non-state actors "are targeting the U.S. critical infrastructure for the purpose of creating chaos that will subsequently produce detrimental effects on citizens, commerce, and government operations" (Robitaille, 2012, p. 5). The interconnectedness of the United States' electrical grid would make any attack on it extremely serious. SMRs allow for the grid to be decentralized which would mean that any attack on it would be localized instead of knocking down the entire grid. Two major advantages can be gained from decentralizing the electrical grid. First, decentralizing the grid greatly benefits the Department of Defense by solving their vulnerabilities of being connected to the civilian grid. A single SMR would be able to power a military base allowing them to have their own energy supply separate from that of civilians. If the grid goes down, military operations would be jeopardized because of intelligence and communication being compromised by a collapse. Renewable energy sources such as wind or solar would not solve the vulnerability of the military as well as SMRs. Currently, ninety-nine percent of the electricity used by the domestic military installations comes from the civilian grid.

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## III. CONCLUSION

After all of the research has been conducted and the data has been examined, the negative aspects of nuclear energy do not outweigh the benefits that it could possibly yield. More research and studies are required to prove the potential benefits of nuclear energy, but there is no question that the world is demanding more energy as it grows and develops. New technology will require more energy, and the current supply will not meet the increasing demand. Other energy sources have been tested and tried. Some, like renewables, are unable to meet the growing demands, while others, such as fossil fuels, make the world a more dangerous place to live in by polluting and contaminating the air and water. An energy source is needed that is sustainable, clean, and able to meet the needs of the world. Nuclear energy is a solution to solve many of the problems nationally and internationally. If the United States were to start the expansion of nuclear technology specifically with SMR's, the political and economic gains would be exponential. Nuclear energy could be the answer that the world has been looking for to move into a new era of prosperity.

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