**The Sword of Damocles - Building Additional Nuclear Power Plants in the United States**

In recent years, the energy crisis has become a more severe problem worldwide since traditional fossil fuels have their inevitable shortages. On the one hand, fossil fuels are non-renewable resources; on the other hand, burning fossil fuels leads to environmental problems such as air pollution and the greenhouse effect. In this situation, people put high expectations on burgeoning nuclear power since nuclear energy has many advantages. First, atomic power plants produce neither greenhouse gases nor toxic gases. Secondly, since people are able to produce the resources that nuclear power plants require in labs, nuclear energy is considered a renewable resource. Third, due to its unique physical properties, nuclear power has high power density, and nuclear power plants have a relatively long lifespan. However, building more nuclear power also faces the challenges of financial concerns from the government and safety concerns from the public. In this paper, I will argue that it is wise for the U.S. government to build more nuclear power plants in the future, but the government should proceed conscientiously.

The energy crisis has become a severe problem worldwide with increasing power demand. According to the annual energy review published by the U.S. Energy Information Administration (EIA) in 2022, the total primary energy production in 2019 was 101.437 quadrillion BTU. This number is much higher than the 81.866 quadrillion BTU in 2013 [1]. The increase in the production of energy indicates that consumption is also ascending. The need for power grew at a steady pace of 1 quadrillion BTU from 2005 to 2019, and there is no sign of it slowing down.

Traditional methods usually generate electricity from fossil fuels such as natural gas, petrol, and coal, which make up an absolute majority of electricity production. In 2021, fossil fuels generated 79% of the energy produced in the United States, including 36% from petroleum, 32% from natural gas, and 11% from coal. However, renewable energy, such as wind and hydroelectricity, only makes up 12% of energy sources [2]. There has been a long history of people utilizing these fossil fuels, but they are running out, so people must find substitute energy sources. According to a paper from N. Abas et al., oil output will peak in 2025 at 120 Mbpd, but by 2115 it will have decreased to 40 Mbpd. [2] Thus, it is urgent to find alternative energy sources to replace these dwindling fossil fuels.

The greenhouse effect is also a significant problem triggered by burning fossil fuels. Since most of the components of fossil fuels contain carbon, the chemical reactions that happen in burning produce carbon dioxide. Carbon dioxide makes up about 0.04% of the atmosphere and is harmless to the human body. Carbon dioxide has a warming effect on the earth, and a moderate greenhouse effect keeps the temperature toasty for human living. However, since the Second Industrial Revolution, power plants have utilized fossil fuels more rapidly to provide enough energy to meet consumer demands. The emission of carbon dioxide increases as the consumption of fossil fuels increases. As a result, the surge in carbon dioxide, which depletes the ozone layer, makes the heat from the sun accumulate and ultimately leads to global warming. Global warming stresses ecosystems through temperature rises, water shortages, increased fire threats, drought, weeds, and pest invasions [3]. These problems have been troubling the U.S. government for a long time, so the government should put carbon dioxide emissions under strict monitoring to resolve the greenhouse effect.

Another problem with the use of fossil fuels that troubles the U.S. government is rising pollution levels. Although utilizing fossil fuels has advantages such as low economic input and minimal technology requirements, conventional power generation methods produce toxic gas and fine particulate matter, which is also called PM2.5. Scientific research has proven that the combustion of fossil fuels contributes to mortality [4] as fine particulate matter harms the human body in the long term. In the United States, air pollution damages the local environment and harms other nearby areas through air movement [4]. More and more countries are starting to realize the importance of this issue and develop policies to take control of and reduce the emission of fine particulate matter. The United States began to resolve these problems early. Dating back to April 9th, 1998, the U.S. government enacted the first guidance, "Guidelines for Granting Exemptions for Daily PM2.5 Monitoring", which standardized the monitoring of PM2.5 [6].

Since traditional fossil fuels have the disadvantages described above, the U.S. government is looking for substitute energy sources. Nuclear power, as one of the options, has many advantages, and some consider nuclear power to be clean energy. Atomic reactions generate energy through fission, which is the process of splitting uranium atoms to produce energy. The splitting of uranium atoms producestremendous heat. Devices utilize the heat from fission to generate steam, which turns turbines to generate power without emitting the carbon dioxide and fine particulate matter that fossil fuels do. The phrase "clean energy" also stands for energy that does not produce toxic gas. Since the process of nuclear power generation only relates to atomic movement, no poisonous gases such as methane or nitrogen oxide are produced. Thus, by constructing additional nuclear power plants, the U.S. government could save some of the massive budget it has spent on dealing with pollution and repairing damaged ecosystems.

Furthermore, nuclear power is known as an energy source with a low carbon footprint, which means the carbon dioxide produced per kilowatt is low compared with traditional fossil fuel energy. A carbon footprint is a system for estimating the total emissions of greenhouse gases in carbon equivalents from a product throughout its life cycle from raw material manufacturing to completed product disposal [7]. Some researchers believe that nuclear power could extensively improve environmental conditions by reducing the carbon footprint [8]. Since there is a low carbon footprint with no carbon dioxide emission, switching to nuclear power instead of traditional fossil fuel energy could help ease the greenhouse effect, which would certainly benefit the United States and the world.

Besides the distinct mechanism of electricity generation, nuclear power has some unique properties. For example, nuclear power plants have a relatively long service term compared with other types of power plants. According to research from J. R. Lamarsh and A. J. Baratta in 2001, the lifespans of nuclear power plants in the United States are around 40 - 60 years [9], and this number is increasing with technological breakthroughs in nuclear energy. However, conventional fire-coal power stations have a global average lifespan of only 46 years, and gas power plants have an average lifespan of 40 years [9][10]. The average lifespan of clean energy power plants is even shorter: for hydroelectric power plants, it is 30 years, and windmills have only a 20 year lifespan on average [11]. It is clear that the idea of building power plants that have short lifespans is not economical.

For the U.S. government, replacing traditional plants with nuclear power plants over the next several years would benefit the environment and the ecosystem in other ways. Demolitionists might not properly dispose of the senescent devices: after repurposing parts that are still functional, they might simply abandon the rest of the defunct machines. Moreover, the pollution produced in the process of removing devices is also a tricky problem. A team in China noticed that heavy metals used in coal-fired power plants pollute the land and harm food crops. According to research from Rui Li et al., 79% of vegetable samples and 67% of grain samples grown from land polluted by mercury damage the human body if consumed [12]. A longer serving lifetime for nuclear power plants requires less demolition, which would waste fewer resources and produce less pollution.

An additional reason that nuclear power is considered promising is that it has strikingly high power efficiency. The final step to storing energy as electricity for all power plants is turning the turbine with moving fluid. Both traditional power plants and nuclear power plants heat water to generate steam, which turns turbines. For traditional power plants, burning fossil fuels heats water to get steam. In nuclear power plants, the heat generated by the fission reaction also heats water, producing steam and turning the turbines. However, reactors must use nuclear fuel rods to control the speed of uranium fission, which produces heat significantly more rapidly than burning fossil fuels. Nuclear reactors in spacecraft take advantage of this property. Brown LC et al. found that combining nuclear energy with fuel cells increases power efficiency greatly and facilitates high efficiency production of energy on a large scale [13].

Another reason scientists have high expectations for nuclear power is that it is a renewable resource. Fossil fuels come from decomposing plants and animals, require hundreds of thousands of years to produce, and are not renewable resources. On the other hand, the resources that nuclear power plants need could be produced artificially. Scientists could develop the necessary uranium and deuteroxide with sophisticated devices in laboratories. Moreover, the United States has an abundant uranium reserve; according to the U.S. Energy Information Administration, the United States held 1,227 million pounds of U3O8 in total in 2008 [14]. Thus, switching from fossil fuels that are non-renewable and inefficient to nuclear power with abundant reserves and high-power density would be wise.

Despite the many advantages described above, the public still holds an unfavorable attitude toward nuclear power plants. The opposition to building more nuclear power plants has been getting stronger in recent years. This is because a nuclear power accident is a horrible disaster for the people and the government, no matter how severe the accident is. For the U.S. government, the Three Mile Island incident was a lesson. In 1979, a large amount of nuclear coolant escaped due to mechanical failures at the Three Mile Island nuclear facility in Pennsylvania. Luckily, since the U.S. government responded quickly to this emergency, the situation was controlled before too much radioactive damage occured. According to a report from the International Atomic Energy Agency (IAEA) in 1979, the maximum total increase in radiation measured at ground level was less than 100 millirem, and the average exposure in the Harrisburg area per person was only 1.7 millirem, which does not cause harm to the human body [15]. This accident is considered the most serious nuclear accident in the United States. After this incident, concerns about nuclear safety emerged among the public and anti-nuclear activists, resulting in new regulations for the nuclear industry. In September 1979, in New York, more than 200,000 people participated in anti-nuclear demonstrations with speeches by activists such as Jane Fonda and Ralph Nader [16].

Contrastingly, as one of the most severe nuclear accidents in history, the Chernobyl disaster damaged the USSR in almost every field: political, economic, and environmental. On April 26th, 1986, the No. 4 reactor in the Chernobyl Nuclear Power Plant experienced a reactor core meltdown and steam explosions. What made the situation worse was that the severe reactor core fire, which lasted for a week, impeded rescue and released airborne radioactive contaminants not only to the USSR but also to the whole of Europe [17]. Though the USSR paid great attention to this crisis and responded amazingly quickly, the result was still catastrophic. However, due to the USSR's concealment of data, it is difficult to trace the exact number of direct deaths from this crisis [18]. According to a report from the World Health Organization (WHO), the estimated total number of deaths directly related to radiation exposure from the Chernobyl nuclear power plant accident is about 4,000 deaths, and the number of people who suffer from radiation-related illnesses is countless [19].

Apart from safety concerns, another shortcoming of nuclear power plants is the high expense of building them in the United States. Replacing fossil fuel power plants with nuclear reactors on a large scale would consume a considerable budget. The construction cost for each kilowatt of capacity in an advanced nuclear reactor is $5,366. However, a new wind farm only costs $1,980 per kilowatt in construction [20], and it is even cheaper to build traditional fossil fuel plants.

Like the sword of Damocles, building more nuclear power plants has both risks and benefits. There is always the possibility of another nuclear accident, and nuclear plants can be costly to build. However, people should not ignore their advantages. Nuclear energy is cleaner energy, which does not contribute to the greenhouse effect, and utilizes renewable resources. Additionally, nuclear plants have longer lifespans than traditional power plants and have high power efficiency. The discussion above shows that it would be wise for the U.S. government to build additional nuclear power plants in the future, but it is vital to consider all of the benefits and consequences in order to make deliberate decisions about which type of plants to build.

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