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Nuclear Energy and Climate Change

Global climate change is one of the most complex and pressing issues we face as a global community, and there are many problems it can cause. However, even though climate change remains a serious issue, it's no longer as controversial as it once was. The majority of scientists agree that climate change is both happening and that it's a manmade phenomenon. The real issue surrounding climate change is the issue of, how do we solve and mitigate it? One solution, that is very controversial, is nuclear energy. Many people believe that nuclear energy can help curb the effects of climate change, but just as many people say that nuclear energy is too volatile and dangerous to be a good solution. The premise of this paper is not to argue for or against nuclear energy, but to look at the pros and cons of nuclear energy and compare them to traditional coal energy and alternative solar energy, after which, the paper will decide whether or not nuclear energy is an admirable idea to combat climate change.

Global climate change describes the changes in the Earth's long-term patterns of temperature, precipitation, and storm frequency and intensity. People often use global warming synonymously in casual conversation, but global warming refers specifically to an increase in Earth's average surface temperature and is only one aspect of global climate change. Our planet's climate has always changed naturally, but the climate change taking place today is unfolding at an exceedingly rapid rate. Moreover, most scientists agree that human activities,

notable fossil fuel combustion, and deforestation, are largely responsible for the current modification of the earth's atmosphere and climate. Climatic changes will likely have adverse consequences for ecosystems and for millions of people. For this reason, most scientists, policy makers, and ordinary citizens are seeking action to minimize and mitigate our impact on the climate system. This is where nuclear energy comes in. By reducing our dependence on coal and natural gas, we can mitigate the effects of global climate change (Withgott and Brennan 288).

The history of nuclear energy is only just over one hundred years old. It all started, in 1895, when a German scientist, by the name of Roentgen was experimenting with cathode rays in a glass table that he had sucked the air out of. Roentgen had left the device covered but noticed that the photographic plates off the to the side were lighting up when the device was energized. Roentgen realized that he was looking at a new ray and called it x-ray (Touran).

A year later in France, another scientist by the name, Becquerel noticed that if he left uranium sitting on photographic plates, they would expose even though no cathode ray tube was energized. Becquerel then deduced that the energy must be coming from inside the uranium itself. Soon after, two other scientists by the name, Marie Curie and her husband Pierre studied the phenomenon and isolated two elements, polonium, and radium. They named this phenomenon radioactivity. The Curie's revolutionary research would lay the groundwork for our understanding of physics and chemistry, blazing trails in oncology, technology, medicine, and nuclear physics (Touran).

In England, 1911, Ernest Rutherford started studying radioactivity and discovered that two types of rays came out that was different from x-rays. Rutherford called them alpha- and beta-radiation. He later discovered that the vast majority of the atom's mass is in their center, and thus he discovered the atomic nucleus. He also discovered gamma radiation. Rutherford research

would lay the groundwork for nuclear chain reactions and their potential to produce energy (Touran).

Then in December 1938, two physicists, Lise Meitner and Otto Frisch made a discovery that would revolutionize nuclear physics, lead to the atomic bomb, and give us nuclear power. That discovery was nuclear fission (Touran). Nuclear fission, also known as splitting the atom, is when a heavy atom, like uranium or plutonium, is bombarded with neutrons and broken down, into smaller ones. Normally neutrons move too quickly to split nuclei when they collide with them, but if neutrons are slowed down, they can break apart nuclei. Each split nucleus emits multiple neutrons, together with substantial heat and radiation. These neutrons can, in turn, bombard other uranium atoms in the vicinity, resulting in a self-sustaining chain reaction. If not controlled, this chain reaction becomes a runaway positive feedback, thus creating a powerful explosive, a nuclear bomb (Withgott and Brennan 319-320).

Nuclear fission is the foundation of how nuclear power plants work. First, fission occurs in the reactor core, where fuel rods are submerged in water. The water slows neutrons to initiate a chain reaction in uranium in the fuel rods, while control rods absorb excess neutrons to regulate the reaction. Second, water heated by fission circulates through the primary loop, which is pressurized to prevent boiling. Third, water heated by fission in the primary loop boils water in the secondary loop, creating steam. Forth, the steam drives the turbines, which generate electricity. Lastly, cold water from the cooling towers then circulates within the cooling loop, condensing steam in the secondary loop to be converted into liquid water, which then returns to be heated pressurized water of the primary loop (Withgott and Brennan 321).

In the 1950s, nuclear power was seen as the solution to the world's energy needs. A little over two pounds of uranium fuel can provide as much energy as over two thousand tons of coal

without producing any carbon dioxide or acid-rain gases (Taylor 349). As of today, about sixteen percent of the world's electricity demand is generated from nuclear energy (Dessler 186).

There are many advantages and disadvantages to converting to nuclear power and using it to combat climate change. This is where the real controversy lies. The first advantage is the low greenhouse gas emissions. Compared to coal and natural gas, nuclear power offers the lowest by far in greenhouse gas release (Co, About Renewable Resources). Carbon dioxide and similar gases have been the issue in the climate change debate. According to the Nuclear Energy Institute, nuclear energy produces more clean-air energy than any other source. It produces sixty-two percent of all emission-free electricity in the United States. In nuclear reactors that utilize lager cooling towers, it is a common misconception that pollution is dumped into the air. The clouds leaving the smokestacks are actually water vapor (Co, About Renewable Resources). However, releasing more water vapor into the atmosphere could cause its own problems. Water vapor is a greenhouse gas and it can do one of two things. Water vapor can either reflect sunlight out, cooling down the Earth, or trap heat in, heating the Earth (Dessler 103-104). Also, if compared to solar energy, which produces little to no emissions, nuclear energy still produces quite a bit of greenhouse gas (GreenMatch.co.uk).

One of the most compelling reasons for converting to nuclear energy is its fuel to power output ratio. Only a small amount of uranium is used to fuel one thousand-megawatt plant, providing enough electricity for about half a million people. (Co, About Renewable Resources) When compared to traditional coal energy which produces 2,460 kWh of energy per ton of coal, nuclear energy is the clear winner. (HowStuffWorks) Even though solar panels can produce a lot of energy, that potential will decrease the further from the equator the panels are. For example, countries like Russia only have the potential to produce at most 2.0 kWh/m2 per day, whereas

counties in South America and Africa can produce over 7.5 kWh/m2 per day. In this, nuclear power wins again because it can produce the same power no matter where it is (NKURIYINGOMA).

Nuclear energy produces very inexpensive electricity once up and running. Electricity generated by nuclear reactors is cheaper than gas, coal, or any other fossil fuel plants. Uranium, the source of nuclear energy, is a fairly cheap fuel source, and you can get massive power for very little. When you combine all that with an average lifecycle of a plant, approximately 40-60 years, the costs continue to decrease (Co, About Renewable Resources). After the initial cost of installation, people using solar energy would see a reduction in their electricity bills. This is because not only would they not be paying for electricity, but they could possibly receive payments for energy surplus that is exported back to the grid as well. Also, solar energy systems don't require much maintenance. They only need to be cleaned a couple of times a year. In finance, solar energy wins because solar reduces energy bills, cheap to produce and has very low maintenance (GreenMatch.co.uk).

Possibly the most important benefit of nuclear energy even more than the cost of producing it, is that nuclear energy does not rely on fossil fuels. This means it's not affected by the unpredictability of oil and gas costs. It also means that we will not be depleting the Earth's supply of resources nearly as quickly. At current rates of production coal will only last another 150 years. Nuclear power requires much less fuel to produce a higher amount of energy. With the current supply of uranium, it is estimated that we have at least another eighty years before supply becomes an issue. Other forms of uranium can be used if needed, extending that timeline even further, by about two hundred years. When compared to solar energy that also doesn't use any fossil fuel, it is a tie between solar and nuclear. (Co, About Renewable Resources)

Nuclear power provides a vast array of benefits to the economy. Local communities are usually pro-nuclear due to the number of jobs and prosperity a new plant brings. The main reason is that each facility generates close to five hundred million dollars annually in sales of goods and services. More workers at plants mean more people with money to spend and a boost to the local economy. According to the Nuclear Energy Institute, one new nuclear plant creates four hundred to seven hundred jobs, along with thousands of other jobs during the plant's construction and most nuclear sites have two plants. At a coal facility, the number of jobs created is only ninety, and at a natural gas plant, it's only fifty (Co, About Renewable Resources). However, solar energy can also help in the creation of jobs. The solar energy industry is a national industry that provides high-quality jobs to the country. As more homes and businesses go solar, job opportunities will continue to grow. Since 2010, nearly reaching 250,000 jobs were created in 2015. The median wage for a solar installer in 2014 was $20 per hour, compared to the $17.09 across the total U.S. workforce. Many solar installers are small, locally owned businesses, and supporting them brings more money into local economies (Aggarwal). In this regard, both nuclear and solar can create high paying jobs and will boost the economy.

The first disadvantage of nuclear power is that it has what's called back-end environmental impact. This essentially means that while nuclear energy does not actively produce waste, it does passively produce waste and is part of the reason why nuclear energy is so controversial. A typical nuclear power plant generates about twenty metric tons of used nuclear fuel per year. The problem is that this spent fuel is highly radioactive and potentially dangerous. Spent nuclear fuel cannot be buried in a landfill and requires careful handling and must be stored, in a specially designed storage space. Which storage costs a substantial amount of money. Compared to both coal and solar energies that don't need to be stored, spent nuclear fuel takes

hundreds of years to decompose before it reaches adequate levels of safety. (Co, About Renewable Resources).

Nuclear energy has both high up-front and end-stage costs. To construct a new nuclear power plant can take anywhere from five to ten years to build and can cost billions of dollars. Also, decommissioning a nuclear power plant can cost as much money and time as well. However, most of that money can be recuperated throughout the lifetime of the plant, compared to a coal plant that could cost just as much to build (Co, About Renewable Resources).

Nuclear power plants can also be targets for terrorism. Most people when they hear the word nuclear, they immediately think of the nuclear bomb and Hiroshima. While nuclear power generation is different from weapons, it can represent a threat to national security if exposed to the wrong people. The reason being is that overthought uranium used to power nuclear plants is different from weapons-grade uranium, weapons-grade uranium can be synthesized from reactor grade uranium. Nuclear technology in the wrong hands represents a problem for most of the world. Even though security is tight and the probability of a theft is low, it's still a compounding factor that people don't have to worry about with other energy sources (Co, About Renewable Resources).

Unlike renewable energy sources such as solar and wind which are in infinite supply, nuclear energy is not a renewable fuel source. Although currently in abundance, uranium will eventually be in limited supply. Uranium has to be mined, synthesized, then activated to produce energy and it's very expensive to go through this process (Co, About Renewable Resources).

Nuclear energy power plants are heavily dependent on water, to both run the turbines and cool the core. A nuclear power plant consumes about four hundred gallons of water per

megawatt-hour. This means that a 1,000-megawatt plant will need about 2,600 tons of water. The use of water in this quantity is a problem because if there is a drought or a heatwave that happens in the area where a power plant is, it could drastically decrease the water supply that is needed to run the plant. Therefore, that power plant will have to reduce power output or shut down completely to avoid a meltdown (Ramanujam). When compared to solar energy systems which are very dependent on sunlight for energy and will unfortunately experience a drop in their efficiency despite being able to collect during cloudy or rainy days (GreenMatch.co.uk).

The biggest disadvantage to nuclear energy is that when there's an accident at a facility it can have far-reaching consequences not only in the present but far into the future. This is where the main controversy lies. In 1986, the worst nuclear accident in history took place at a nuclear power plant in Chernobyl. During a late-night safety test, a combination of critical reactor design flaws and human-error built up to a massive steam explosion in nuclear reactor four of the power plant. Over four hundred times the amount of radiation released by the Hiroshima bomb was unleashed into the atmosphere. A radioactive cloud spread over the entire European continent contaminating places as far away as the United Kingdom. However, the majority of the radiation affected the communities surrounding the plant at Chernobyl. The radiation was so intense that an unprotected worker could receive a fatal dose in less than a minute. Over the coming days and weeks, 134 servicemen who responded to the fire were hospitalized for acute radiation syndrome, of whom 28 firemen and operators died within months. The Soviet army then began establishing the Chernobyl exclusion zone, forbidding any civilians from entering within a 30-kilometer radius around the exposed reactor. Roughly the size of Luxembourg and over 120,000 people were forced to leave their home in Pripyat and Chernobyl, which have remained empty ever since (RealLifeLore).

The Soviet government then issued a call for over 600,000 people to come in and work cleaning up the zone after the disaster. This was possibly the most dangerous place to be in the entire world in 1986. However, this didn't stop the workers from constructing the sarcophagus, a giant concrete and steel tomb. The sarcophagus entombed over two hundred tons of radioactive corium lava, thirty tons of contaminated dust and sixteen tons of exposed uranium and plutonium. However, the sarcophagus wasn't designed to last forever. It was only designed to last for thirty years (until 2016) (RealLifeLore).

This is partially why Chernobyl still poses a massive problem today. Repairing the sarcophagus form the inside is considered to be impossible because the radiation levels inside are estimated to be as high as 10,000 roentgen per hour. That's enough to kill a person if they step inside for just three minutes and enough to fry any robots. The deterioration of the sarcophagus over the years since its construction threatens to release all the poison back into the world. (RealLifeLore)

So, in response work began on a new structure that would cover the entire sarcophagus. The new structure became known as the new safe confinement building. Unlike the sarcophagus, it was designed to entomb everything inside for the next century. It took 1,200 workers seven years and 2.38 billion dollars to finish construction. About 3,000 people are currently working inside and around the building today, as they work to dismantle the unstable sarcophagus and eventually remove the tons of radioactive material inside it for a safe burial somewhere else (RealLifeLore).

The exclusion zone gives off a feeling that the disaster was contained in that area but that's not true. Dangerous levels of radiation were dumped all across Belarus, Ukraine, and parts of Russia, and not everybody died immediately. Many victims came down with cancer later on in

their lives and the UN estimates that at least 4,000 people have died from cancer issues related to the accident. Other studies claim that the number is somewhere closer to 93 thousand cancer-related deaths. Some health officials estimate that over the next 70 years there will be a 28% increase in cancer rates across the heavily exposed areas of Belarus, Ukraine, and Russia. The Ukrainian government is currently paying out survivors benefits to over 35,000 families and the economic impacts in Belarus, where most of the radiation landed has been estimated to be over 301 billion dollars. The total cost of the disaster has been estimated to be at least 355 billion dollars. Chernobyl is still a global problem, and it could take between 20 and several hundred years until the area is completely safe to live around again (RealLifeLore).

The catastrophic disaster at Chernobyl was the worst humankind has had to deal with. It was the result of the inability of scientists and engineers to foresee how seemingly small problems can snowball into disasters of an almost unimaginable scale. With this in mind, what is the likelihood of another Chernobyl in the future? We have that answer thanks to the work of Spencer Wheatley, Didier Sornette and Benjamin Sovacool. These scholars have compiled the most comprehensive list of nuclear accidents ever created and used them to calculate the likelihood of other accidents in the future. What they found was most worrisome. They concluded that there was a 50% chance at a major nuclear disaster will occur before 2050 (arXiv, Emerging Technology from the).

There are many pros and cons associated with nuclear energy. However, the real question is can nuclear energy be used to mitigate and potentially reverse the effects of climate change. The answer is yes. Nuclear power, can produce a huge amount of energy, with little to no carbon emissions. Is nuclear power a good long-term solution to meet our energy needs? The answer is no. Nuclear power which uses uranium to produce energy is not in infinite supply and will

eventually run out. Also, nuclear power produces radioactive waste that has to be stored safely. Many people argue that nuclear energy is too volatile and dangerous to use with disasters like Chernobyl, but with advancements in technology and safety regulation, the chances of a meltdown will be reduced. Numerous individuals state that renewable energy sources, like solar, are clean, safer, can produce a solid amount of energy and therefore is the better option. However, solar power on its own could never meet the energy needs of a developed nation, whereas nuclear power can. When it comes to climate change, we need to take action now. The ultimate solution for mitigating climate change is actually an easy one. It is a combination of both nuclear and solar power to meet energy needs. Nuclear power could supply energy to metropolises like New York and solar power could supply to individual homes in residential areas. This is the best solution to mitigate the effects of climate change.

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