

Reasons for the Declining Role of Nuclear Energy

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Energy is the foundation of human civilizations. As of now, there are three main energy sources: fossil fuels, solar/wind energy, and nuclear energy. While each source has its own benefits and drawbacks, nuclear energy stands out for being carbon-free and highly material-efficient. According to Gilles Georges, a Chief Scientific Officer in the American Chemist Society, 5g of nuclear fuel produces energy equivalent to that of 1 ton of coal. They have zero carbon emissions and operate “at full capacity greater than 90% of the time compared to 50% for coal and 25% for solar plants. (Georges, 2024)”. However, certain inefficiencies in nuclear energy production are making nuclear energy obsolete. The UCS, a non-profit science organization that collaborates with many organizations like MIT, states that “now, 35% of the [US’s] nuclear power plants, … are at a risk of early closure.” (Union of Concerned Sci, 2018)”. The issue must be addressed at a global level as the US, EU, Japan, China, India, Korea, and Russia are involved in this problem as indicated by the International Energy Agency (IEA), a global science-based energy organization (International Energy Agency, 2019). Addressing this in a future lens will provide more clarity on how the current inefficiencies of nuclear energy will affect global nuclear energy systems in the long term which can aid in its future development. Seeing as nuclear energy sources are declining, despite their low carbon emissions and material efficiency, we must address the negative future environmental, social/political, and economic implications of current nuclear energy systems to address the issue. If nuclear energy becomes obsolete, global warming will worsen, energy instabilities will deepen, and electricity costs will skyrocket negatively impacting economies and people worldwide.

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High costs of inefficient nuclear energy make it uncompetitive compared to other energy sources making it obsolete in the future. According to Jacobson, an environmental engineering professor at Stanford University, nuclear energy costs 2.3 to 7.4 times that of renewable energy. “The levelized cost of energy was \$151 per Megawatt/hour (MWh) compared to \$43 for wind and \$41 for solar (Jacobson, 2019)”. The US Government Energy Administration states that on average Americans use 4 billion MWh a year (*Use of Electricity - U.S. Energy Information Administration (EIA), 2024*). This translates to a potential cost difference of \$436 billion every year if nuclear energy was used instead of renewables to reach America’s energy demand. In one decade, the costs would rise to a staggering \$4 trillion. This shows the great expense of using nuclear energy. And this is for renewables, fossil fuels are just as cheap as renewables as well.

While other energy sources are getting cheaper and more efficient, nuclear energy is doing the opposite. According to Statista, a leading statistics platform, with data from US/EU government sources, global nuclear energy production went from a high of 17.4% in 1995 to less than 10% in 2021. (Buchholz, 2022). Moreover, UCS explains that currently over 1/3 of existing nuclear power plants will close due to being unprofitable. On average, it would cost \$814 million to bring unprofitable nuclear power plants to a break-even cost. (Union of Concerned Sci, 2018). This shows the current decline of nuclear energy and is predicted to decline even further unless big changes are made. In contrast, IRENA, an international energy organization representing 179 countries, states that solar and wind energy costs have decreased 90% and 70% respectively and both are continually expanding as energy sources (La Camera, 2023). Similarly, UCS states that fossil fuel costs are decreasing because of more technological innovations (Union of Concerned Sci, 2018). Furthermore, electricity generation from solar (Fernandez, 2024a), wind (Fernandez,

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2024b), and fossil fuel energy (Schwandt, 2024) sources are increasing in electricity generation as of 2024. Other energy sources are more profitable because of their cost reductions which makes them have smaller break-even costs compared to nuclear energy. These smaller costs allow for cheaper and more efficient electricity generation which makes them more sustainable in the future. As a result, they are growing and will continue growing as an energy source in the future. This is not happening with nuclear energy because nuclear energy hasn't been getting much cheaper compared to other energy sources because of their outdated technology (Union of Concerned Sci, 2018). This makes nuclear energy inefficient compared to other sources because people don't want to pay more money for the same amount of electricity generation. If nuclear energy doesn't get more cost-effective, they will be replaced by more cost-effective ones.

Nuclear energy may be expensive, however, according to the IEA, without nuclear energy, it would require \$1.6 trillion to replace nuclear energy production by 2040. (International Energy Agency, 2019). This shows that it's too expensive to replace nuclear energy so we must find a way to make it more cost-effective. Differences in costs for nuclear energy and other energy sources show the inefficiency of nuclear energy as a future energy source.

Inefficient nuclear energy production has negative environmental and social impacts, hindering its role as a future energy source. While nuclear energy generation technically has zero emissions, avoiding about 55 Gigatons of CO₂ over 2 years according to the IEA (International Energy Agency, 2019), several studies show that uranium mining which is essential for nuclear fuel, contributes to global warming because it requires fossil fuels (Jacobson, 2019;

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Schuelke-Leech, 2013; U.S. Energy Information Administration, 2022). According to Leeche, an Ohio State University professor with doctoral research on energy policies, nuclear energy also requires large amounts of water to cool it down which decreases water supply due to evaporation and contributes to global warming (Schuelke-Leech, 2013). This shows how inefficient nuclear energy contributes to air pollution and drains environmental resources. She adds that some nuclear power plants operate on the same land as farms (Schuelke-Leech, 2013). The EIA states that nuclear waste (a by-product of nuclear energy) is very radioactive and dangerous because of its high contamination risks (U.S. Energy Information Administration, 2022). Given this info, Jacobson states that as more nuclear waste accumulates, there is an increased risk of radioactive leaks (Jacobson, 2019). One mistake is all it would take to compromise large food and water systems leaving local communities devastated in the future. Given that most farms export their products to other states and countries, the impact could be even greater. Beyond environmental risks, communities oppose nuclear energy for other reasons. According to Baron & Herzog, Yale political science professors, currently, people fear nuclear energy the most. Many see mushroom clouds and bombs when they hear “nuclear” due to nuclear meltdowns like Chernobyl in the past. Furthermore, even before these disasters, nuclear energy support had already started fading due to other reasons. (Baron & Herzog, 2020). The fear of potential disasters has only deepened the initial public opposition. Moreover, the lack of public representation has contributed to nuclear energy opposition. According to Schuelke-Leech, local communities near nuclear power plants are frustrated by the environmental pollution from uranium mining, but their concerns are ignored by US nuclear energy officials. As a result nuclear power plants are struggling due to lack of community support (Schuelke-Leech, 2013). As community frustration/fear over nuclear energy grows, nuclear energy, which is already declining in support, faces a grim future as there

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is little support for future nuclear initiatives. This suggests that in the future, as public opposition increases, nuclear energy will decline further and become obsolete. Inefficiencies of nuclear energy are environmentally damaging and have created growing public opposition which makes it less likely to be a future energy source.

Despite the benefits of nuclear energy having low carbon emissions and its material efficiency, nuclear energy is declining. To address this decline, we must invest more resources in making nuclear energy cheaper and more efficient, similar to renewable and fossil fuel sources. Furthermore, we must find a way to address the environmental pollution from uranium mining and nuclear waste to garner more future public support for nuclear energy. According to Georges, PUREX is a technological innovation that can recycle spent fuel, reduce radioactive waste, lessen environmental pollution (making the public happy), produce more electricity, and lower the costs of nuclear energy (Georges, 2024). However, radioactive waste is reduced, not eliminated which still poses a problem. Additionally, this solution may not change the public's view of nuclear energy because their views are deeply rooted and not everyone will be satisfied. It's the government that ensures the public's satisfaction.

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