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The Role of Nuclear Power in a Green Future

In 2021 President Biden committed to the most ambitious climate goals our country has ever set. To achieve 65% emission reduction by 2030, and achieve net zero emissions by 2050. While these goals are admirable and necessary, they are going to be incredibly difficult and costly to achieve given our current green energy infrastructure. Solar and Wind power are somewhat unreliable, and therefore require further investment in a storage system, and hydropower from dams is incredibly damaging to ecosystems, to the point where many conservationists advocate for their removal. This leaves another, controversial energy source, nuclear power. Nuclear power is divisive in the United States, and globally. On one hand, it is completely clean from a greenhouse gas perspective, and is one of the most efficient energy sources available today. On the other, it can be expensive to produce and maintain safely, produces dangerous waste that we still don't have a concrete solution for, and evokes fear from the majority of citizens. In this paper I aim to evaluate those costs, both financial and societal. It is true that building and maintaining nuclear power plants is expensive, but any way to reach Biden's goals is going to require a massive investment.

It is also true that there is some risk from nuclear power, however disasters like Chernobyl, Fukushima, and Three Mile Island have exaggerated the dangers of nuclear power in most people's minds, especially considering the death toll from carbon

emissions. There are almost no annual deaths from nuclear power, one every 33 years according to “Our World In Data” and many of the deaths at nuclear power plants come from workplace accidents, not nuclear energy. All this being said, there are clear benefits and risks of a further investment in nuclear power, and what your goals and values are will change how you see those.

The national and global view of nuclear power is complicated. After Fukushima Japan's use of nuclear power understandably dropped, from around 13% of power generated in 2010, to 0% by 2014, to rebounding to around 3% by 2014. This also had global implications, as countries like Germany have committed to ending their use of nuclear power, and their usage has been cut in half since 2010. On the other side of the debate countries like Italy, Russia, and France, the most nuclear dependent country in the world, have continued their reliance, and have criticized Germany’s decision. The United States falls somewhere in the middle. Currently we get about 19% of our power from nuclear plants, a number that has remained mostly stable since the 1980’s. Public opinion however is surprising. According to the Pew Research Center, the majority of Americans (37%) have no strong feelings on the use of nuclear power. However, of those who have an opinion, 35% percent think the government should encourage nuclear production, compared to just 26% who think it should be discouraged. So, with a slim majority of public support, and a clear place in Biden’s commitment, what is standing in the way of nuclear power?

The first obstacle is simple; we currently do not have the necessary nuclear infrastructure to make nuclear power a larger part of our energy portfolio. *Energy Technology Perspectives* released a “blue map” scenario that would cut carbon

emissions in half by 2050, that featured a significant investment in nuclear power, an expansion of over 300% of 2005's levels. The Nuclear Energy Agency notes that "Clearly, these scenarios would require mobilizing much greater industrial, human and financial resources than currently exist within the nuclear and related industries" (*Nuclear Energy and Addressing Climate Change* P.5), and while many Americans are pro nuclear power, many are wary of plants opening near their homes. Not only is opening plants difficult, the fuel of nuclear power, uranium is expensive. According to the World Nuclear Association it cost about $1800 to get 1kg of Uranium for fuel in 2007. While that sounds like, and is, a lot of money it is only about a third of the cost of a coal plant. Along with this, Spain was able to cut the cost of Nuclear Power by 29% from 1995-2001. This begins to illustrate an important idea behind the importance of nuclear power, as technology improves it only gets cheaper, more efficient, and safer.

Scientists at The University of Pennsylvania predict that part of this shift will come from Small Modular Reactors (SMRs). SMRs are a " a less capital-intensive and more flexible means to increase nuclear capacity" *(Nuclear Energy Meets Climate Change* P.5). By shifting towards these smaller types of power plants the issue of high costs of production is lessened. Nuclear production is more efficient than other types of green energy, so using smaller power plants doesn't make as big of a difference in the production of energy. Like with any type of nuclear plant there are safety concerns, "due to their small containment structures, the lack of some active safety features" (*Nuclear Energy Meets Climate Change* P.6) as well the risk of a chain reaction that comes from plants in proximity to one another. However, just by the virtue of these plants being

newer, they are safer. Most new power plants have automated safety systems, taking out the risk of human error causing disaster.

If it is decided that nuclear power is part of our future, investment into new plants like SMRs is likely to supplement the current nuclear infrastructure, rather than replace it. According to Ronald Szilard, the technical director of DOE's Light-Water Reactor Sustainability Program at Idaho National Laboratory "The focus right now is very intense on building new nuclear power plants, because we have come to realization that [reducing] greenhouse gas emissions in the future cannot be achieved without pushing nuclear further, both existing and new plants will have to contribute" (*How Long Can a Nuclear Reactor Last?*). Our current nuclear infrastructure is aging, the average age of a plant is about 40 years, but those plants are unlikely to go away in the coming years. We are nearing the end of the intended operation period aging plants, but the forty year lifespan that was initially put on many plants had less to do with safety concerns, and more to do with the prevailing idea at the time that it would be more efficient and cost effective to simply replace plants after a certain time period. As more research has occurred, and our understanding of nuclear energy has grown, the belief has shifted, and many now are of the opinion that it is more effective to maintain older plants, and replace certain aging parts to ensure safety. About ninety-five percent of America's ninety-two plants have been approved for twenty year extensions that will keep them running into the future. Some are looking beyond that, as about fifteen percent have begun to investigate if they can apply for a second twenty year extension, extending their lifespans to eighty years.

Now, this isn't to say fears over aging nuclear power plants are completely unfounded. Some vital parts of nuclear plants are under extreme pressure, and cannot simply be replaced. Every time the reaction generating power occurs the neutrons released "relentlessly pummel the steel and other metals that enfold the nuclear reactor" (*How Long Can a Nuclear Reactor Last?*). Over long stretches of time this takes its toll on plants, making the affective metals brittle, and more susceptible to cracks. These cracks have the potential to be deadly, so the quest for eighty year nuclear power plants hinges on finding a safe, and effective solution to this issue. The "International Nuclear Risk Assessment Group" has advised against retrofitting older power plants to produce beyond their intended lifespans. They cite a plethora of issues related to this strategy including but not limited to; older plants cannot be retrofitted to modern safety standards, retrofitting plants can create new unforeseen issues, or that new threats have emerged. The debate around retrofitting is complicated, both sides have a point. It is important to again mention that the original forty year lifespan was not based on safety concerns, but also to acknowledge that legitimate concerns exist. However, like was mentioned above, plants are already being extended for decades to come, these older plants are going to have a place in our future energy portfolio. If these plants are phased out now, in twenty, or fourty years that should shift the focus back to construction of new plants, not towards new energy sources. The average age of a nuclear power plant is forty years, but the average age *of retirement* for a coal plant is just forty-six years. For dams the life expectancy is about fifty years, as like nuclear plants aging dams have a much higher risk of deadly failure, but unlike nuclear plants

aging dams become much less efficient at generating power. Concerns over an aging power grid exist in every form of power generation, if the goal is to overhaul that system for the future nuclear power has a clear place in that goal.

Finally this brings us to one of the most prominent and well known issues with nuclear power, what to do with the waste. While I have argued that many concerns over nuclear power are overblown, the issue of what to do with nuclear waste is a very real roadblock. Production of nuclear power produces dangerous waste that will remain dangerous for tens of thousands of years. Currently the United States doesn't have a strong long term solution for its nuclear waste. Plans were made for a permanent, deep storage site near Yucca Mountain, but concerns over safety killed the proposal. Therefore most of our waste is stored on site, in "Dry Casks" or "Wet Pools". While this hasn't posed any major problems yet, it is not a permanent solution, especially if our nuclear portfolio is going to grow any substantial amount. This solution has some benefits and drawbacks. One benefit is that it is relatively stable, and therefore safe, another is that storing waste on site cuts out the need for any kind of transportation, which can be incredibly risky. Finally on site storage reduces the number of places exposed to radioactive material, by combining the entire process. The risks are clear as well however. Storing radioactive waste on site adds more dangerous material to an area that could compound the danger in case of an emergency. Another problem is with "Stranded Sites", sites where the nuclear plant has shut down, but the waste remains. The most pressing issue is also the simplest, space. Dry Casks and Wet Pools take up a significant amount of room, and as more waste is produced it becomes less and less

feasible to keep storing waste on site. The solution to this problem isn't simple, the most likely solution is some type of permanent depository, like the proposal at Yucca Mountain, but setting something like that up will be difficult with public fears, which are founded. Finland is pioneering this strategy with their "Onkalo" (cavity or pit in english). It is a large-scale, deep, permanent nuclear waste storage site, the first in the world. This is incredibly promising for the global nuclear future, but only the first step, due to the fact that Finland only produces a fraction of the United States nuclear waste (2,000 metric tons to 70 annually) *(5 Fast Facts about Spent Nuclear Fuel* and *Nuclear Waste Management in Finland*). Our technology is ever evolving, and the potential benefits of nuclear power are great enough to warrant further research into this problem. Our understanding of Nuclear Power is growing as well, as new, less wasteful methods are developing. The waste issue for nuclear power is a roadblock, one that must be solved, but not a death sentence.

Biden's energy goal is a necessary step in the fight against climate change, but it will be incredibly difficult. No solution is going to be free of drawbacks. The fact that nuclear power is incredibly efficient compared to other sources, and doesn't contribute greenhouse gasses makes it incredibly intriguing on its own. Obviously it has the drawbacks I've mentioned, but safety issues are not nearly as severe as they seem to some, and therefore these drawbacks do not outweigh the benefits. Nuclear technology is advancing faster than any other type of power, making it all the more appealing for the future, as its strengths like efficiency grow stronger, and its weaknesses such as meltdown risks are lessened with SMRs. Our energy portfolio going forward is incredibly

complicated for both America, and the world, as our growing demand for energy clashes with our goals of reducing climate change. No one solution or power source has the ability to be our savior, and overreliance on a single source has its own problems. That being said, the benefits of nuclear power make it one of the most appealing candidates for expansion in a potential green future.

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