Analyzing Nuclear Power and its Present and Future Role as a Low Carbon Emissions Energy Source

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Abstract:

This report takes look at nuclear power and its current use around the world and its potential as a key player in the current global climate crisis. Through the analysis of surveys, articles, and research papers, this essay explores how nuclear power plants compare to other low emission energies and how their use can lead to global reductions in carbon emissions. It examines the pros and cons of nuclear and its ultimate role in helping to reduce global carbon emissions,

Introduction:

The world is currently facing a climate crisis largely due to the excess carbon emissions being released into our atmosphere. A major contributor to these emissions is the use of fossil fuels such as coal, oil, and natural gas as energy sources. As our planet continues to warm due the increased carbon levels in the atmosphere, many countries around the world have agreed to try and reduce their carbon emissions. One significant way scientists suggest these carbon emission reduction goals can be met is through the use of low carbon emission energy sources. These include solar power, hydro power, wind power, and nuclear power. Of the four, this paper will specifically be examining nuclear power and its current and potential role in lowering global carbon emissions. This is due to the fact that well some scientists hypothesize we might be able to reach our emission reduction goals without the help of nuclear power, it would require 30 times more solar and wind than what we already have in use (10). The process of building that many wind and solar plants would be very expensive and would use a large amount of resources, especially land (10). Scientists instead suggest a more diverse approach that utilizes all low emission energy sources, of which nuclear power is a major component (3).

Literature Review:

The framework for this essay is a mix of cost analysis and environmental activism. It's a call to action that we are in the midst of energy crisis and we need to start seriously thinking about low emissions energy and which ones are most practical and efficient at lowering emissions. Jacobson et al. suggest in their study a roadmap that would convert all 50 United states' current all-purpose energy systems to ones powered only by wind, water, and sunlight by 2050 (20). Their plan includes massive increases in offshore wind and onshore wind alone with a huge increase in utility scale PV solar plants (20). On top of that Jacobson et al. claims that if their roadmap is followed it will be a relatively low-cost and economically feasible conversion process (20). However, Clack et al. writes in their paper that Jacobson's et al. roadmap "used invalid modeling tools, contained modeling errors, and made implausible and inadequately supported assumptions" and have concerns about approaching our energy problem with such a narrow portfolio of technologies (3). They suggest instead that we address the energy issue with a broad portfolio of energy technologies including nuclear as a more feasible way of meeting our goals (3). Clack et al. also writes that "policy makers should treat with caution any visions of a rapid, reliable, and low-cost transition to entire energy systems that relies almost exclusively on wind, solar, and hydroelectric power," as they are most likely too good to be true and have some underlying issues (3). These reports might contradict one another, but they do both agree on at least one thing; that it is vital we start switching more of our energy from fossil fuels to low emissions energy. It's the way of the future and a way to try and start slowing down the effects of climate change.

Methods/Background:

Data for this report were collected from a mix of scholarly articles, opinion pieces, scientific papers, and research surveys. These included pieces from people who have direct ties to nuclear, who are openly in opposition to nuclear, and from those who are neutral. All articles, reports, and surveys were read and analyzed carefully to gain an understanding of not only nuclear power, but people's understanding of nuclear power. A basic background of nuclear power, specifically nuclear power in the United States is helpful to understanding this report so, to begin with, nuclear power is the largest low emissions energy in the United States and is responsible for over 20% of the total energy generated in the country. (10,18) There are a total of 60 nuclear plants in America with a combined 98 reactors between them (13). Currently only two new reactors are under construction, each costing billions of dollars and taking years to complete (13). In total since 2013, six nuclear plants have been closed down due to having high operating costs and outdated systems (10). In general, the loss of energy production from these power plants has been replaced with energy produced by natural gas (10). Nuclear power plants, unlike other forms of low-emission energy, have a high capacity factor and generate energy consistently and reliably (10). Though because of their high construction costs, they are not always profitable and rely on subsidies from the government to remain available as a viable energy source (10). In the United States there are a round 100,000 people employed directly by nuclear power plants and over 475,000 people employed in secondary job that are linked to nuclear power (8). On average each plant employs between 400 and 700 workers and building a nuclear plant alone can employ up to 3,500 people (8). People employed by nuclear power tend to have higher salaries than the average local salary and, in a year, a typical nuclear power plant can generate around 40 million dollars in labor income (8). In fact, towns with nuclear plants tend to support nuclear power

plants more than the average people because of the jobs and income flow they generate (10). However, on average nuclear power suffers from pretty poor ratings when compared to other energy sources. This is mostly due to people fearing meltdowns, radiation exposure, and nuclear waste (10). A BBC Global Survey found that around the globe only 22% of people support the expansion of nuclear power. In fact, it is often lumped in with the fossil fuel energies and receives the same low-level ratings as they do, as found in a Pew Research Survey. It seems as if people tend to think of nuclear power as a scary and dirty source of energy and don't realize that it is in fact considered a form of clean energy. This is one of the major issues facing the growth and continued use of nuclear power. Because without public support it is hard to get continued support on developing new reactors that are cheaper to build and safer to operate. Therefore, a major component of the nuclear movement has been education.

Results/Discussion:

Nuclear Today:

Most of the nuclear reactors found today are still the original ones that started operating back in the 1960s (13). In fact, in the United States, before construction started on the two newest nuclear power plants, there had been no new nuclear plants being built for almost three decades (13). Globally we have seen a recent shift away from nuclear, especially after the Fukushima Daiichi nuclear disaster that occurred in Japan back in 2011. This movement away from nuclear power has opened up the opportunity for growth in the renewable energies industry. For instance, Germany, once the home to several nuclear power plants, immediately shut down have their reactors after the Fukushima incident and pledged to shut down the rest by 2022 (16). However, since phasing out nuclear they have tried to implement large scale wind and solar to replace the lost energy generated from nuclear (9). And yet instead of seeing decreases in carbon emissions

as is the hope when using renewable resources, Germany has seen few emission reductions since implementing these large-scale renewable power plants (16). This has to do with the fact that solar and wind don't generate electricity consistently, so when they are not generating power, energy companies have to offset them with other energy sources. In the case of Germany, they have to offset the unreliability of their renewables with natural gas (16). Not only that, but they also now have the second most expensive energy in Europe, partly in part with how expensive it has been for them to implement so much large scale solar (17). The two European countries that actually have some of the lowest carbon emissions per capita out of any developed nations are actually the two, who employ some of the most nuclear power (16). France gets a total of 88% of its electricity from zero carbon emissions with 72% of it coming from nuclear and 10% from hydro power (16). Sweden gets 95% of its electricity from zero carbon sources with 42% from nuclear power and 41% from hydro power (16). These countries are proof that nuclear power is effective at lowering carbon emissions as it has successfully done so in both these cases. On the downside current nuclear plants are still quite expensive to build for how much energy they generate. Some estimate that the current minimum cost per Nuclear MWh including the cost of construction is $112 (20). When compared to Utility-Scale Solar having a minimum cost of $46 per MWh and Wind having a cost of $30 per MWh, Nuclear seems outrageously more expensive (20). There is however, a reason solar and wind have been able to become so cheap. As stated in the Introduction section of this essay, nuclear power does rely on subsidies to remain cost-effective, yet solar and wind are receiving 94 times more in US subsidies than nuclear power per unit of energy generated (16). In fact, the average global investment for solar and wind between 2010 and 2016 was $300 billion per year and public and private actors have invested a combined $2 trillion on solar and wind between 2007-2016 (16). Despite all of these investments and

subsidies trying to make solar and wind cheaper and more efficient sources of energy, in 2016 solar made up only 1.3% of the planet's energy and wind made up only 1.9% (16). On top of that, due to the diluted nature of solar and wind they require more land in order to generate the same amount of energy as a single nuclear reactor; a fact that has put several threatened species at risk (16). Not only that, but solar panels create 200 to 300 times more hazardous waste than nuclear power (4). And unlike nuclear waste disposal, which is severely regulated, the proper disposal for waste produced from solar panels is unregulated in the majority of the world (4). On the downside though, nuclear plants can take decades to completely build and something that solar can build in a year might take 7 years for nuclear to build (6). However, current solar arrays only last around 25-30 years, and their efficiency decreases with age, whereas current nuclear reactors can last anywhere from 40-50 years at the same efficiency (17).

Nuclear Tomorrow:

Nuclear reactors are divided up by generations. Most of the generators still in operation today are second generation reactors and the ones that are currently being built are third generation reactors (1). In comparison to second generation reactors these new III generation reactors are going to have a longer operation life of at least 6o years instead of only 40 (1). III generation reactors also have a much more standardized design in order to reduce the cost and time frame of construction (1). The design for these reactors has also been simplified in order to make them easier to operate and they have a higher burn up which allows them to use fuel more efficiently and generate less waste (1). Fourth generation reactors are currently being developed and are expected to start construction after the start of the 2020s (1). Of the six generation IV designs molten salt reactors have been deemed the safest with the most intrinsic safety features (15). Molten salt reactors are a class of nuclear fission reactors (15). Molten salt reactors are also

considered to be the most sustainable as they use molten salt as a reactor coolant instead of water (15). This also means that they do not operate under high pressure as there is no water to make steam, so the possibility of a steam explosion occurring is null (15). The future of nuclear power is a bright one with great strides being made to make reactors more sustainable, cheaper to build, and safer to operate. It is important that this research continues to be supported in order to continue making advancements.

Conclusion:

We are at a turning point in our climate crisis right now where we have limited time to make Some huge decisions on how we're going to prevent the further warming of our planet. Time is a precious resource right, one that we cannot afford to waste. It does not make logical sense to continue to invest trillions of dollars into wind and solar technology when the outcomes we need just are not there and haven't been for years. We need a reliable form of low emissions energy that has proven itself at lowering carbon emissions and helping countries become carbon neutral. Nuclear power is that energy. The technology is already developed and continues to get safer, cheaper, and more efficient with each generation nuclear reactors. It is reliable and consistent and can compete with natural gas and coal. It is clean and produces limited amounts of waste most of which can continue to be reused to produce more energy. We don't have time to wait for the solar and wind technology to catch up, not when scientists are telling us we only have around twelve years to turn things around before we head down a path of no return. If we want to successfully lower our carbon emissions, we need to keep our nuclear plants running, start building new ones, and continue to invest in the improvement of them.

References:

1.Advanced Nuclear Power Reactors. (2018, October). Retrieved April 16, 2019, from http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/advanced-nuclear-power-reactors.aspx

2.Americans' opinion on renewables and other energy sources. (2019, February 25). Retrieved April 16, 2019, from https://www.pewresearch.org/science/2016/10/04/public-opinion-on-renewables-and-other-energy-sources/

3.Clack, C. T., Qvist, S. A., Apt, J., Bazilian, M., Brandt, A. R., Caldeira, K., . . . Whitacre, J. F. (2017). Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar [Abstract]. Proceedings of the National Academy of Sciences, 114(26), 6722-6727. doi:10.1073/pnas.1610381114

4.Desai, J., & Nelson, M. (2017, June 21). Are we headed for a solar waste crisis? Retrieved April 22, 2019, from http://environmentalprogress.org/big-news/2017/6/21/are-we-headed-for-a-solar-waste-crisis

5.Hausman, S. (2015, November 9). The Future of Nuclear Power in Virginia. Retrieved April 22, 2019, from https://www.wvtf.org/post/future-nuclear-power-virginia#stream/0

6.Jacobs, M. (2017, February 16). Solar vs Nuclear: The Tale of Two Energy Sources. Retrieved April 16, 2019, from https://blog.ucsusa.org/mike-jacobs/solar-vs-nuclear

20.Jacobson, M. Z., Delucchi, M. A., Bazouin, G., Bauer, Z. A., Heavey, C. C., Fisher, E., . . . Yeskoo, T. W. (2015). 100% clean and renewable wind, water, and sunlight (WWS) all-sector energy roadmaps for the 50 United States. Energy & Environmental Science, 8(7), 2093-2117. doi:10.1039/c5ee01283j

7.Jiang, J. (2011, October 28). The Price Of Electricity In Your State. Retrieved April 22, 2019, from https://www.npr.org/sections/money/2011/10/27/141766341/the-price-of-electricity-in-your-state

8.Jobs. (n.d.). Retrieved April 16, 2019, from https://www.nei.org/advantages/jobs

9.Morris, C. (2018, January 11). Germany's energy consumption in 2017. Retrieved April 22, 2019, from https://energytransition.org/2018/01/german-energy-consumption-2017/

10.Nuclear Energy in the U.S.: Expensive Source Competing with Cheap Gas and Renewables. (2019, April 02). Retrieved April 16, 2019, from https://climatenexus.org/climate-news-archive/nuclear-energy-us-expensive-source-competing-cheap-gas-renewables/

11.Nuclear Energy in VA. (n.d.). Retrieved April 22, 2019, from http://virginianuclear.org/nuclear-energy-in-virginia/

12.Nuclear Industry and Electricity in Virginia. (n.d.). Retrieved April 22, 2019, from http://www.virginiaplaces.org/energy/nuclearpower.html

13.Nuclear Power in the USA. (2019, April). Retrieved April 22, 2019, from http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx

14.Nuclear Power Stations. (n.d.). Retrieved April 22, 2019, from https://www.dominionenergy.com/company/making-energy/nuclear

15.Serp, J., Allibert, M., Beneš, O., Delpech, S., Feynberg, O., Ghetta, V., . . . Zhimin, D. (2014). The molten salt reactor (MSR) in generation IV: Overview and perspectives. Progress in Nuclear Energy, 77, 308-319. doi:10.1016/j.pnucene.2014.02.014

16.Shellenberger, M. (2019, March 26). We Don't Need Solar And Wind To Save The Climate -- And It's A Good Thing, Too. Retrieved April 16, 2019, from

https://www.forbes.com/sites/michaelshellenberger/2018/05/08/we-dont-need-solar-and-wind-to-save-the-climate-and-its-a-good-thing-too/#65dab0dde4de

17. Trembath, A., Lovering, J., & Luke, M. (n.d.). The Breakthrough Institute. Retrieved April 16, 2019, from https://thebreakthrough.org/issues/energy/cost-of-german-solar-is-four-times-finnish-nuclear

18. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (2019, March 01). Retrieved April 16, 2019, from https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

19. Waxler, K. (2017, November 2). Levelized Cost of Energy 2017. Retrieved April 22, 2019, from https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

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