Nuclear Expansion: The Debate Surrounding America's Energy Future

A Sociotechnical Research Paper
presented to the faculty of the
School of Engineering and Applied Science
University of Virginia

by

Karl Westendorff

May 8, 2021

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Karl Westendorff

Sociotechnical advisor: Peter Norton, Department of Engineering and Society

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Hydrocarbon fuels such as coal, oil, and natural gas currently provide 62.7% of the electricity generated in the United States, but their consumption has had significant environmental consequences (EIA, n.d.). Carbon dioxide and methane from the combustion of hydrocarbon fuels contribute to climate change, which if unchecked may drive 1 million wildlife species into extinction (IPBES, 2019) and submerge coastal cities such as Miami and Boston under rising seas (Hallegate et al., 2013). To avoid these devastating outcomes, environmentally friendly energy sources must be adopted.

Nuclear power is an attractive option because of its high energy output and nonexistent carbon emissions. The Energy Policy Act of 2005 promoted the expansion of U.S. nuclear power capacity, but by 2011 the expansion had ebbed. In the U.S., 98 nuclear power plants generate 20 percent of total electric power, but this share has declined (WNA, 2020 September). Environmentalists are split on the merits of nuclear power, and this debate will shape America's energy future. It is therefore imperative to understand how these participant groups construct their arguments for and against nuclear power. In the U.S., environmentalist groups promote their agendas by framing nuclear power's effects over different timescales.

Review of Research

Researchers have studied public perceptions of nuclear power and have compared the driving forces for its acceptance and rejection. Previous studies have compared nuclear power reception between different countries, the underlying sources of these receptions, and have contextualized nuclear power's reception in the movement towards green energy sources.

Jasanoff & Kim et al. (2013) compared the attitudes towards nuclear power in the United States and South Korea. They suggested that South Korea's positive response was motivated by the government's emphasis on potential benefits to the country at large which overshadowed individual or small community concerns. This contrasts with the American government response which emphasized the possibility for individual energy company success and mitigated potential failures by distributing consequences among the public. Jasanoff & Kim's work is primarily concerned with the scale of nuclear power's potential consequences, but it does not consider how the timescales of these consequences also shaped the discussion surrounding nuclear power. Furthermore, Jasanoff and Kim's work exclusively considers government ideologies; they do not consider environmentalist perspectives, although consequences of nuclear power often involve the environment.

Taylor (2013) investigated the opposition to nuclear power and categorized this group as either survivalist or political. Survivalist opponents to nuclear power reject it due to their belief that it is a "cataclysmic threat" capable of destroying human and environmental life, whereas political opponents reject nuclear power because it overcentralizes energy production and distribution. While Taylor aptly distinguishes these different sources of opposition, he does not describe the timeframes these oppositions are concerned with.

Goodfellow et al. (2011) assessed how public perception of nuclear power influences its implementation. They concluded that the view of nuclear power's risks dominated its perception; those who support nuclear power minimize these risks, whereas opponents exaggerate them. While Goodfellow mentions the environmental nature of some of these perceived risks, this work does not analyze how environmentalists specifically frame the nature of nuclear power to influence public opinion and policy.

Geels et al. (2017) broadly considered the debates surrounding the movement to low-carbon energy sources. This included a temporal analysis of nuclear power which suggested that recent nuclear disasters caused governments to reject it in the short term, whereas the gradual implementation of nuclear power resulted in its successful adoption. Geels et al. implicitly suggests how the timeframes surrounding nuclear power's potential effects influence the outcome of nuclear power debates but does not highlight how participant groups use these timeframes to push their agendas.

Several other researchers have examined the broader politics of nuclear power's implementation. Balogh (1991) examined the emergence of nuclear power options from 1945 to 1975 and determined that the initial driving forces behind nuclear power's development were from the top down; scientists, industrialists, and politicians pushed for its implementation rather than the public. When the public's near-term safety concerns reached a critical mass in the early 1970's, they overcame the long-term goals of experts in the field and prevented further development of nuclear power. Pralle & Boscarino (2011) analyzed more recent political maneuvers and identified the common use of "trade-off" frames among participant groups. These frames often implicitly or explicitly make use of timescales.

Current literature often considers the benefits and risks of nuclear power themselves as motivation to accept or reject its use, but analyses of how nuclear power is characterized are sparse. This motivates the examination of how nuclear power's characterization influences the dialogue surrounding its adoption, and timescales are a central component of these descriptions.

The Role of Timescale Choice in Nuclear Power's Characterization

Timescales of Nuclear Power's Environmental Impact

Both environmentalists who support and oppose nuclear power's implementation discuss its environmental effects at varying timescales to support their positions. Pro-nuclear groups, such as the American Nuclear Society (ANS), cite how nuclear power is being used in the present to decrease carbon emissions. They state that "Many of the world's largest short-term decarbonization efforts have been accomplished using nuclear energy" (ANS, 2020), suggesting that nuclear power implementation can have an immediate impact on society's greenhouse gas emissions. The Union of Concern Scientists (UCS) also appreciates nuclear power's short-term benefits and states that "there is a high degree of uncertainty about whether we will meet or even get close to the pledge we made as part the Paris Agreement—a 26 to 28 percent reduction from 2005 levels by 2025" and that "These sobering realities dictate that we keep an open mind about all of the tools in the emissions reduction toolbox … And that includes existing nuclear power plants in the United States" (Kimmell, 2019). In contrast, the International Energy Agency (IEA), who the United States is a member of, emphasized the long-term benefits of nuclear power, stating that "Over the past 50 years, the use of nuclear power has reduced CO_2 emissions by over 60 gigatonnes – nearly two years' worth of global energy-related emissions" (IEA, 2019).

Anti-nuclear groups tend to exclusively emphasize potential long-term environmental consequences of nuclear power. Conserve Energy Future (CEF), an environmentalist blog, states that "Nuclear waste can have drastically bad effects on life, causing cancerous growths, for instance, or causing genetic problems for many generations of animal and plants" (Kukreja, 2015) and mentions that these waste products "will continue to be radioactive … for many

thousands of years" (Kukreja, 2015). Such a long-term perspective is common among anti-nuclear groups with environmental concerns. Organizations such as Green America staunchly oppose nuclear power's use in the U.S. because "waste generated by nuclear reactors remains radioactive for tens to hundreds of thousands of years" (Larsen, 2020). This 100,000-year figure is cited by multiple sources, including Greenpeace USA and the Sierra Club (Leonard, 2015; Sierra Club, n.d. a).

Neither individual pro nor anti-nuclear groups comprehensively evaluate nuclear power's environmental effects on different timescales. While the ANS (2020) comments on nuclear power's short-term benefits, there is no comment on the longevity of nuclear waste or other long-term drawbacks. Meanwhile, the IEA (2019) exclusively describes the long-term effects of losing nuclear power sources. Anti-nuclear groups, such as CEF (Kukreja, 2015), Greenpeace (Leonard, 2015), and the Sierra Club (Sierra Club, n.d. a) all ignore the potential near-term environmental benefits of nuclear power. Of the sources considered, the UCS is least biased with regards to environmental timescale because it considers both the necessity of reaching short-term decarbonization goals and potential long-term environmental consequences, but this is the exception (Kimmell, 2019). The consistent lack of thorough timescale analyses suggests there are factors which actively motivate the choice of timescale between sides of the nuclear power debate and within participant groups.

Timescales of Nuclear Power's Safety

Environmentalists for and against nuclear power also emphasize nuclear power's safety concerns across different timescales. Proponents often cite the infrequency of nuclear accidents normalized to the plants' operation times as a measure of long-term safety. The World Nuclear

Association (WNA) states that the Chernobyl and Fukushima Daiichi disasters "are the only major accidents to have occurred in over 18,500 cumulative reactor-years of commercial nuclear power operation in 36 countries," explicitly considering the long usage times in its evaluation (WNA, 2021). Other groups, such as the ANS, state that "No member of the public has ever been injured or killed in the entire 50-year history of commercial nuclear power in the U.S" (ANS, 2020). Short term safety perspectives have also been adopted by pro-nuclear environmentalists. In a TEDx talk in Berlin, the president of Environmental Progress, Michael Shellenberger, discussed how the Chernobyl disaster has only been found to cause 43 deaths from radiation in the past 25 years. Shellenberger leverages this recent timescale to compare nuclear power to traditional sources of energy, such as coal, who cause "seven million premature deaths per year from air pollution" (Shellenberger 2017). By intentionally choosing a timescale that supports their argument, proponents not only minimize perceived drawbacks of nuclear power, but also create more favorable comparisons with other energy options.

Environmentalists against nuclear power almost exclusively emphasize recent nuclear disasters to further their agendas. The UCS released a report directly in response to the Fukushima Daiichi nuclear disaster, using the recent event to highlight safety concerns in U.S. nuclear power plants (Lyman, 2016). Similarly, Greenpeace USA published a report in response to the disaster and stated that "The Fukushima nuclear accident marks the end of the 'nuclear safety' paradigm" and extrapolates from this disaster that "a significant nuclear accident has occurred approximately once every decade," but does not explicitly name these disasters (Morris-Suzuki et al., 2012). In the decade since the Fukushima Daiichi nuclear disaster, numerous environmentalist groups, including Green America, Grist, and the Sierra Club, have used it as evidence for nuclear power's dangers (Larsen, 2020; Johnson, 2018; Sierra Club, n.d.

b). None of these sources, however, use longer timescales to describe nuclear power's safety record, especially relative to other energy options.

Sources biased towards or against nuclear power avoid a complete safety analysis of nuclear power's safety across different timescales. The WNA (2021) and ANS (2020) exclusively reference nuclear power's long-term safety record when endorsing its implementation and either downplay or ignore recent nuclear disasters. Opponents of nuclear power, such as the UCS, Greenpeace USA, Green America, and the Sierra club ignore these safety records and almost always use recent nuclear disasters in their arguments (Morris-Suzuki et al., 2012; Larsen, 2020; Sierra Club, n.d. b). This stark and consistent contrast in timescale choice between proponents and opponents of nuclear power suggests there are other influences driving their timescale choices.

Timescales of Nuclear Power Economics

Both pro and anti-nuclear environmentalists use varying timescales to characterize nuclear power's economic impact and supplement their positions. Nuclear proponents often emphasize its future financial promise. The WNA acknowledges the startup costs associated with nuclear power plants but endorses their long-term financials, saying "Nuclear power plants are expensive to build but relatively cheap to run," and further states that "Once a nuclear plant has been constructed, the production cost of electricity is low and predictably stable" (WNA, 2020 March). The WNA goes on to comment on nuclear power plant longevity, stating that "Plants are now expected to operate for 60 years and even longer in the future," framing these projects as worthwhile long-term investments. The Nuclear Energy Institute (NEI) highlights nuclear power's potential to generate stable jobs. In its 2020 report, NEI states "The nuclear energy

industry is a powerful engine for job creation. The U.S. industry directly employs nearly 100,000 people in high-quality, long-term jobs" (NEI, 2020). The NEI also comments on recent nuclear power plant closings, stating "Allowing these facilities to close will have long-term economic consequences: replacement generating capacity, when needed, will produce more costly electricity, fewer jobs that will pay less and more pollution" citing the long-term consequences of doing so.

Opponents of nuclear power often cite its recent economic failures. Green America cites the recent projected expense of building nuclear power plants as a deterrent for their development, stating that "In the mid-2000s [projected] construction costs were already soaring to $5,500 to $8,500/Kw or $6-$9 billion per unit." (Larsen, 2020). Green America elaborates on the actual cost of nuclear power plants and cites recent nuclear plant projects in South Carolina and Georgia. In South Carolina, Green America states that "investors were defrauded after $9 billion was spent" when the projects were abandoned. With regards to the recent Georgia projects, Green America states that they are "five years behind schedule" and projected to cost twice of their original amount. Other anti-nuclear environmentalist groups, such as Greenpeace, also selectively feature the failures of new nuclear power projects to further their agendas. Greenpeace states that "Every nuclear plant under construction in the United States is well behind schedule and at least $1 billion over budget," targeting emerging nuclear power plants. Greenpeace also uses the recency of Fukushima in its economic analysis, stating that "Cleaning up Fukushima, if ever possible, will cost at least $100 billion" (Greenpeace, n.d.). By exclusively highlighting recent nuclear power plant developments and disasters, groups like Green America and Greenpeace implicitly suggest that these projects are financially untenable in the short-term.

Groups who are more cautious of nuclear power, such as the Yale Environmental Review (YER) have commented on the future costs of nuclear waste treatment. In an article which denounced nuclear power for its expensive waste processing, YER states that "It may be complex to measure the impacts of nuclear power, but we must continue to do so for the sake of future generations," emphasizing the importance of considering long-term consequences of nuclear power waste (Leslie-Bole, 2019).

Pro and anti-nuclear groups generally do not conduct economic analyses on multiple timescales. The WNA and NEI, for example, exclusively discuss nuclear power's potential for future economies, even though these sources present data which could be interpreted to show its short-term drawbacks. Anti-nuclear groups utilize a wider range of timescales, but this diversity in timescale choice is at least partially due to the aspect of nuclear power analyzed. When commenting on the profitability of nuclear power plants themselves, environmentalists use their short-term financial deficiencies to further their agendas. When environmentalists are concerned about the costs of nuclear waste disposal, however, their analyses are long-term. This suggests the timescale choice is not only dependent on which side of the debate the participant group is on, but that it is also aspect-dependent. The correlation between each side of the nuclear power debate, the nuclear power aspect considered, and their economic timescale choice is strong, suggesting there are components driving participant groups' timescale choices.

Sources of Variable Timescales

The choice of timescale in environmentalists' arguments about nuclear power is an implicit choice about what environmentalism is. Is environmentalism a short-term pursuit, only to ensure safety of the next generation? Or is true environmentalism concerned with permanent

sustainability? In the nuclear power debate, this is not well defined. Not only does each side selectively choose which timescale to emphasize based on the debate's aspect, but individual participant groups flip timescales within their arguments.

The inconsistent choice of timescales between sides of the nuclear power debate and within individual participant groups may be intentional and motivated by their identity. Of the sources considered in this work, only the UCS and the YER consider nuclear power to be both be a positive tool to achieve humanity's decarbonization efforts and a negative force for future environmental and financial disasters (Kimmell, 2018; Leslie-Bole, 2019). All other participant groups selectively choose information which exclusively supports their side of the nuclear power debate. This may indicate that the identity of the side – whether for or against nuclear power – and the aspect of the debate are the primary motivators for timescale choice. Such a basis is not concerned with environmentalism's definition and is a departure from a strictly rational debate.

The inconsistent choice of timescales within individual participant groups may arise from a lack of well-defined timescales in their goals. Several participant groups considered in this work have documented "mission" or "value" statements, but many of these sources do not explicitly name what timeframes they are concerned with. The WNA's mission page, for example, is primarily concerned with specific aspects of nuclear power's implementation but does not mention whether its goals are short or long-term (WNA, n.d.). Analogous pages for the ANS, IEA, Greenpeace, and the Sierra Club often mention their concerns are for the "future," but do not mention specific timescales of concern (ANS, n.d.; IEA, n.d.; Greenpeace, n.d. b; Sierra Club, n.d. c). When timeframes are implicitly mentioned by groups such as Green America, who states that "We work for a world … where the abundance of the Earth is preserved for all the generations to come," they are not quantitative (Green America, n.d. c). The scarcity

of well-defined temporal frameworks within participant groups allows their arguments to stray across timeframes and indicates a nebulous definition of environmentalism within the nuclear power debate.

The variable choice of timescales within individual participant groups may also arise because they believe all timescales are relevant in the nuclear power debate. No source in this report considers a single timeframe in its contents, and this may indicate participant groups consider all timeframes to be relevant. While this does not explain participant groups' selective use of timescales, it may contribute to their flexible usage.

Conclusion

The scientific consensus surrounding climate change is well-established and its consequences are inevitable if the U.S. and other world leaders do not act. Nuclear power may be one path towards carbon-free energy, but its potential must be rationally evaluated to ensure that its benefits sufficiently address modern energy needs and that its drawbacks do not create dangerous future obstacles.

This work highlights that environmentalists in the U.S., based on their agenda, often selectively choose which timeframes to use in their assessments of nuclear power's potential. Such a practice makes it difficult to draw clear conclusions on nuclear power's place in America's energy future. While it is unnecessary for all sources to consider the same timeframes in the nuclear power debate, it is necessary for all sources to either acknowledge their limited scope or make some reasonable attempt at considering multiple relevant timeframes. The variable definition of environmentalism's timescale prevents consistent timescale use between and within participant groups, but participant groups' identities and unclear timescale concerns contribute as well.

Whereas many environmentalists' arguments for and against nuclear power currently exclude information, future arguments should include as much information as possible and should argue why some pieces of information are more important than others. This work highlights how timeframes are selectively chosen to advance environmentalists' agendas, but more work is needed to understand if this behavior is present in other aspects of their arguments. Furthermore, more work is needed to understand if the selective use of timeframes is present in other renewable energy areas.

Although it is not necessary for every argument to be exhaustive, ignoring reasonable facets which could better inform the reader is unacceptable. If an argument relies on the exclusion of certain information, it is not an argument – it is propaganda – and America's energy future is far too important to be influenced by such incomplete views.

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