Investigating the Impact of the Nuclear Stigma: Encouraging a More Productive Discourse

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

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Introduction

Global energy demand is projected to increase by nearly 50% by 2050, with fossil fuels still providing most of the energy production (Institute for Energy Research, 2021). This will contribute to rising temperatures and an increasingly inhospitable Earth, necessitating the need for renewable or clean energy sources (NASA, n.d.). Nuclear power is a promising source of power with almost no greenhouse gas emissions and can be used as a replacement for or stopgap until renewable energies become more widespread (Rhodes, 2018).

However, there exists a stigma against nuclear power that pervades the discourse of energy production, often for the worse. The nuclear stigma often subconsciously shapes attitudes and "the [laypeople's] imagination" to be biased against nuclear power, even when it may be a reasonable or even beneficial solution (Horlick-Jones et al., 2010, p. 528). While nuclear power is almost certainly not feasible everywhere, whether due to geographic, political, or economic concerns, it is generally a very safe, efficient, and reliable energy source. Ignoring this issue or letting it fester will result in a good energy source being left unused, potentially contributing to increased costs to operate other energy sources and further elevated global temperatures.

In this paper, I argue that the implicit nuclear stigma must be made explicit to promote a more productive discourse regarding the adoption and use of nuclear power. Using both Kerschner and Ehlers's (2016) framework of attitudes towards technology and Horlick-Jones et al.'s (2010) view of the nuclear stigma, I analyze several case studies to see how the nuclear stigma is reflected in ordinary peoples' perceptions of the technology and behaviors in everyday life.

Problem Definition

The Evolution of Public Perceptions of Nuclear Power

As human energy needs continue to increase and global temperatures rise, there is a need to shift to clean energy technologies. Without a rapid and immediate shift to clean energies, the associated negative consequences of climate change will compound. According to the World Meteorological Organization (2023), there is a "66% likelihood that [average global temperatures] between 2023 and 2027 will be more than 1.5°C above pre-industrial levels for at least one year," with a "98% likelihood" that one of the next five years "will be the warmest on record." These astonishingly high numbers can affect the livelihoods of everyone on earth by increasing the severity of weather patterns, causing droughts or extreme heat, harming agricultural production, rising sea levels, and more (NASA, n.d.). The world has begun shifting to clean energy sources, including renewables (wind, solar, hydro, etc.) and nuclear power to limit carbon emissions, slow global warming, and lessen the impacts of climate change. The cost of implementing these clean energy sources has dropped dramatically in recent years, accelerating their adoption, but much work still needs to be done before fossil fuels can be phased out (Gelles et al., 2023). Unlike nuclear power, renewable energy sources do not generally provide constant, reliable output. Before renewables can fill the void left behind by fossil fuels, another energy source is needed to provide the baseline energy needed to power the world – nuclear is well suited to do this, as it is able to produce constant energy 92.5% of the time, higher than any other source. Renewables may only produce energy less than 40% of the time (Rhodes, 2018). Figure 1 shows the capacity factor (ratio of actual energy output compared to the maximum theoretical output over a given time) of nuclear power compared to other sources.

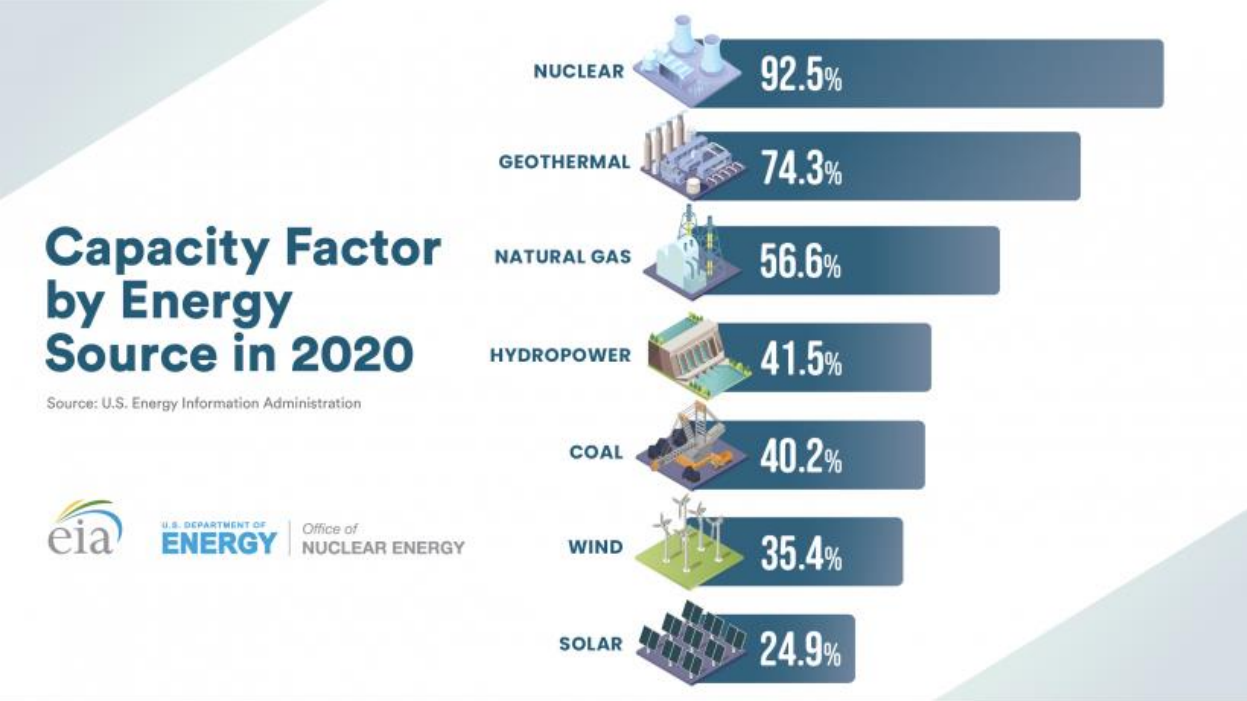

Figure 1. Capacity factor comparison of nuclear power, fossil fuel sources, and renewable energy sources. Nuclear power typically requires less maintenance than fossil fuel sources and renewable energy is often intermittent due to weather conditions. (Office of Nuclear Research, 2021).

In addition, nuclear power releases less radiation than "any other major energy source" such as coal and natural gas (Rhodes, 2018). Waste disposal has been a solved technological problem for some time now and is mainly limited by political or social pushback (Rhodes, 2018). Nuclear power may well be a good solution for the energy transition to cleaner, renewable energy sources, supported by its well-documented history since its inception a century ago.

Nuclear power has ample records ranging from official regulatory documents to popular media describing many aspects of the technology. Soon after its first introduction, nuclear power was generally viewed positively across the American public – even though its use as in weaponry was well known, the public "was not overly concerned about living in a nuclear age" (Palfreman, 2006). Although nuclear reactions were known to be immensely powerful with the capability to

cause enormous destruction, thanks to the use of nuclear bombs in the Second World War, the potential benefits to humanity were emphasized during the 1950s (Palfreman, 2006). The ability to produce energy in vast quantities for years on end was viewed very favorably by many; nuclear power was still developing yet had already proven its usefulness, potentially even being able to "save humanity" (Palfreman, 2006). This excitement and hope for the future even manifested in screenplays like Disney's television show geared towards children, *Disneyland*. One episode, titled "Our Friend, the Atom," extolled the virtues of the atomic nucleus while still providing factual, scientific explanations to a broad audience in schools and across America's television network (Banta & Luske, 1957). It both accurately described the process of nuclear chain reactions and expressed high hopes for what future technology may be able to achieve thanks to nuclear power, resulting in widespread popularization thanks to media outreach (Palfreman, 2006). These sentiments were common in the early days of nuclear, and as they evolved, have been clearly documented over time.

Although nuclear power started off favorably, its large impact on various populations and several incidents have changed its perception for the worse. Power plant failures like those at Chernobyl, Three Mile Island, or Fukushima have certainly caused rippling negative impacts on public attitudes towards nuclear, with much of that due to changing media coverage of nuclear power (Friedman, Gorney, & Egolf, 1992; Orui et al., 2020; Palfreman, 2006). The media's failure to fairly report all relevant facts about the nuclear industry and educate the public about nuclear power likely contributed to these growing negative attitudes (Friedman, Gorney, & Egolf, 1992). Incidents like these, along with concerns about radioactive waste, likely lead to the complete shutdown of all of Germany's nuclear power plants earlier this year. A representative of the World Nuclear Association called this "hugely disappointing, [because nuclear power is a]

secure low carbon 24/7 source of energy… [that] could have continued operation for another 40 years" (Clifford, 2023). In related research, Jarvis, Deschnes, & Jha (2019) found that the German public "cares deeply about climate change yet is distinctly anti-nuclear" due to fears and misconceptions (like those surrounding stigmas) about nuclear accidents. They found that a vast majority of the German public (over 80%) grossly overestimated the likelihood of plant failures and accidents, as well as the subsequent impact to the environment. The complete shutdown of Germany's nuclear power plants would cost an estimated $12 billion per year. Clearly, nuclear power has significant opposition in some parts of the world today due to fears from past incidents.

In addition to historical incidents, several other factors have been shown to significantly influence the public opinion and public perception of nuclear power, regardless of location. Public understanding of nuclear power remains somewhat limited, so many "strongly associate civilian nuclear energy with military nuclear [weaponry,]" causing undue fear regarding its use (Baron & Herzog, 2020, p. 8). The differences in technologies may not be immediately obvious to the general public, causing the association between civilian and military applications of nuclear energy – many would think of mushroom clouds or bombs when a normal nuclear power plant is mentioned (Baron & Herzog, 2020). The complexity of nuclear power and general uncertainties regarding the future, especially about global warming, may intensify these attitudes. The public's apprehension regarding nuclear power exists in tandem with "scientific complexity and expert uncertainty," compounding these issues and potentially contributing to excessively negative opinions of nuclear power (Doble, 1995). Nuclear power may even be associated with other technologies with mixed opinions, like vaccinations, 5G networks, and genetically modified foods (Marques et al., 2021). As Marques et al. (2021) describe it, these technologies

are commonly associated with “conspiracism” and “anti-science” attitudes, potentially causing even more of the public to oppose nuclear power, which can sound nefarious and suspicious. These are just some of the many factors contributing toward negative views of nuclear power, illustrating potential sources of a stigma.

In contrast to populations and countries with negative attitudes towards nuclear, France serves as a prominent example of where support for nuclear power is high. In 2021, France generated 68% of its electricity from nuclear power plants, the highest share in the world (Fasching, 2023). It originally began developing its nuclear power capabilities due to a lack of other readily available natural resources for other large-scale power generation, such as fossil fuels. Its advancements in nuclear power have allowed France to become an electricity exporter, but even here, its nuclear fleet is aging, which may be symptoms of a larger trend (Fasching, 2023). France’s unique geographical situation has encouraged its widespread adoption of nuclear power stations, but its citizenry has approved of its approach. Most French citizens are in support of nuclear power not only because of its technological capabilities, but also because of its ability to “maintain the country’s energy independence” (Messad, 2023). Despite several previous nuclear accidents, French support for nuclear power remains high, showing how public perceptions of nuclear can vary widely and may be limited in scope.

Understanding Attitudes, Perceptions, and Behaviors

In his 2006 article, “A Tale of Two Fears: Exploring Media Depictions of Nuclear Power and Global Warming,” Palfreman discusses how public policy on technologies like nuclear power are closely linked to public attitudes media coverage about it. He noted how risk is a “complicated concept” because of the many factors affecting risk perception. For instance, those

versed in the associated technology (like nuclear engineers) will have very different opinions than a non-expert or general member of the public due to exposure to differing sources of knowledge, media, and other experiences, in addition to a vested interest in the industry to stay employed. He notes how a nuclear engineer might view risk as a "number [or] the probability of a bad event," while social scientists might argue that risk also encompasses how people "know and think about [events]" – risk may be said to be a "product of culture and social experience." He argues that risk perceptions are not just about concrete facts or hard numbers, but a variety of attitudes and uncertainties surrounding the social aspect of technology. These perceptions of risk can affect policy and have real-world consequences, so a way to understand these attitudes is necessary to effectively manage these risks and make progress towards a cleaner, greener future.

One way to understand public attitudes is through a framework created by Kerschner and Ehlers. In their 2016 article, "A Framework of Attitudes Towards Technology in Theory and Practice," Kerschner and Ehlers use four categories to describe the broad spectrum of public opinions of technology: enthusiasm, romanticism, determinism, and skepticism. Each can be divided into several subcategories, such as technocratic enthusiasm, post-normal science in romanticism, automatic technological change in determinism, and entropy pessimism (Malthusianism) as a form of skepticism. Figure 2 summarizes each of the categories and subcategories based on the empirical results obtained by Kerschner and Ehlers.

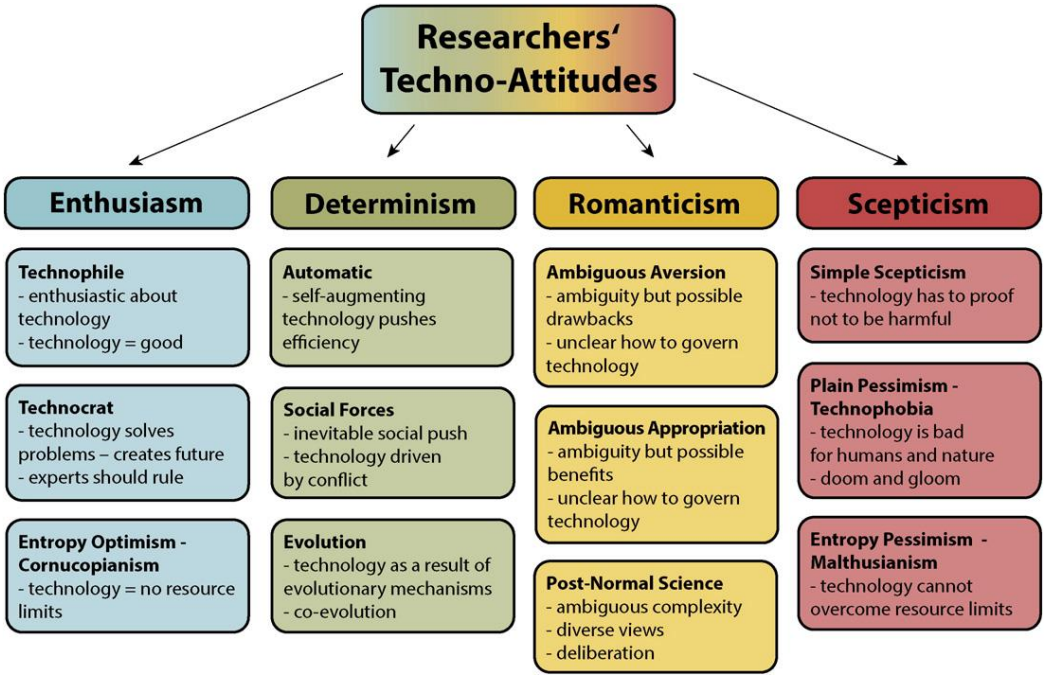

Figure 2. Kerschner and Ehlers's framework of attitudes towards technology. These categories provide an organized system and terminology to characterize perceptions of various technologies (Kerschner & Ehlers, 2016)

These categories can be used to analyze a variety of sources relevant to my research, like public survey data on recent technological changes or even popular cultural artifacts. Kerschner and Ehlers's framework of technological attitudes describes how attitudes can unconsciously influence thinking and is used in this paper to help study several cases.

Understanding and Reframing the Nuclear Stigma

The ever-growing need and demand for clean energy sources necessitates that the "right" technology be used in any given situation. To achieve this, productive discussion and objective analyses must be performed by policymakers, who are beholden to their constituents. Both policymakers and ordinary citizens alike must be made aware of the nuclear stigma to prevent this bias from swaying their judgements against nuclear power. A comprehensive understanding

of the "nuclear stigma" remains unclear – while the origins of the term "nuclear stigma" are not easily attributable to a single source, the term does accurately represent a common attitude towards nuclear power today. According to Merriam-Webster (2023), the term, "stigma," denotes a "set of negative and unfair beliefs" and is often associated with shame. This phenomenon is often associated with any generally negative attitude towards nuclear power even though these attitudes may be caused by a variety of factors, as described previously. Even referring to these collections of attitudes as a "stigma" is detrimental to meaningful, unprejudiced discussion, as the term is inherently biased against nuclear power even before any facts or evidence are provided. It is unclear the degree to which attitudes towards nuclear power can be characterized as part of this stigma or how these attitudes are influenced by it.

The article by Horlick-Jones et al. (2012), "Investigating the degree of "stigma" associated with nuclear energy technologies: A cross-cultural examination of the case of fusion power," further discusses the importance of perception regarding nuclear power by directly examining its association with a stigma. They focused on views towards fusion power, which is closely associated with the much more widely known fission technologies and studied "the extent to which the labelling of fusion as a form of specifically *nuclear* energy source serves to stigmatise the technology." They explicitly focus on the range of negative attitudes towards nuclear power and found that the "[nuclear label] exerts a powerful influence on the lay imagination" and suggest that a "re-framing of the terms under which nuclear power is discussed" has allowed "reluctant acceptance" to be possible. Their study found participants "displayed an *orientation* towards the cultural norm of nuclear stigma," showing how prevalent the concept of a nuclear stigma is and how it subconsciously shapes thoughts and behaviors. This

"nuclear stigma" cannot be said to be an isolated occurrence and is examined explicitly and in greater detail in this paper.

Past research has analyzed public perceptions of nuclear power in relatively limited scopes but has not closely studied these perceptions under the lens of the nuclear stigma. By viewing the nuclear stigma as a distinct social phenomenon and analyzing nuclear power through the lens of this stigma, this research will provide insight into how these attitudes can be changed to be more conducive to productive discussion. Investigating and reframing the nuclear stigma will allow for more sophisticated discourse regarding the usage of nuclear power, which is of ever-increasing importance in the transition away from fossil fuels.

I study several different cases to gain a better understanding of the attitudes different groups have towards nuclear power. These groups are not limited in geographic location to better encompass a variety of attitudes different peoples may have. I view nuclear stigma as a social phenomenon and analyze the nuclear perceptions groups have under the assumption that the stigma is present and influences thoughts and behaviors in society. Using these findings, I analyze how the stigma is reflected in these groups and examine the extent to which their perceptions can be attributed to the stigma. Findings are used to suggest future improvements to the terminology or discourse used regarding nuclear power.

Case Studies: The Effects of the Nuclear Stigma

Here, I examine three case studies focused on the public perception of nuclear power: "Local People's Understanding of Risk from Civil Nuclear Power in the Chinese Context" by Fang (2013), "Living with Nuclear Power in Britain: A Mixed Methods Study" by Pidgeon et al. (2008), and "Public Perception of Geothermal Power Plants in Korea Following the Pohang

Earthquake: A Social Representation Theory Study" by Im et al. (2021). These cases demonstrate how the invisible nuclear stigma affects peoples' thoughts, behaviors, and perceptions in several different contexts. Unlike the outcries and conspicuous reactions to large disasters like Chernobyl or Fukushima, this effect is a subtle one and is often implicitly reflected in many complex behaviors.

Local Insights from a Lack of Stigma

The first case by Fang (2013), "Local People's Understanding of Risk from Civil Nuclear Power in the Chinese Context," focused on rural Chinese citizens' reactions to a prospective nuclear power plant. Fang noted there is a "relative lack of scientific-technological information available to the public in the Chinese context," and that citizens often must depend on institutions for knowledge about nuclear power which results in a "lack of agency" in decision-making. Fang also notes that unlike reporting on Chinese nuclear power, the media is "free to report on accidents and on resistance to nuclear power in foreign countries without any censorship," which is how Chinese people often get information on negative impacts of nuclear power. In the villages Fang focused on, she found people trusted nuclear technology due to several reasons, including trust in government (despite knowledge of nuclear risks) and trust due to the perceived higher social status of scientists and experts. At the same time, villagers were aware of their "lack of agency" and lack of knowledge provided to them. In addition, different villages were logical in analyzing their personal risk-benefit tradeoffs associated with the creation of a nuclear power plant; for example, some may benefit economically from relocating while others may not benefit at all or even lose established village success, land, or heritage if

forced to relocate. While different villages differed in perceived benefits to be gained, they all shared in a common trust in nuclear power.

Unlike the first case study, Fang (2021) focused on a rural area with relatively limited access to information, showing how the nuclear stigma can be characterized and recognized in other scenarios. In other countries, like the United Kingdom (the location of the first case study), nearly all nuclear power plants have historically operated successfully and safely, yet residents have focused on the negative impacts. While not unwarranted, as seen by the true disasters in Chernobyl and Fukushima, Fang's finding that trust in nuclear power is maintained despite knowledge of outside nuclear incidents shows how much local social circumstances affect nuclear perception. The absence of large-scale nuclear disasters in China and these villages' relative isolation from the influences of Western society resulted in underlying fundamental social distrust in nuclear power not forming. The lack of "lay knowledge" of residents of these Chinese villages, and their corresponding attitudes, shows how they lack a societal bias against nuclear power that is so prevalent in other countries. In essence, they simply lack the nuclear stigma much of the world has; being unaffected by these social currents (often seen in Western countries) suggests that these people may have a more open view towards nuclear power. Undoubtedly, they are affected by Chinese social structures, as seen by the perceived elevated status of scientists and powerful government footprint, but these villagers are presented with both positive and negative facts about nuclear power and maintain a distinctly more positive attitude than the British citizens in the first case. This second case demonstrates the impact the nuclear stigma has by emphasizing its absence and how it is associated with this more positive view.

Proximity to Nuclear Power Plants: Effects and Consequences

The second case study by Pidgeon et al. (2008), "Living with Nuclear Power in Britain: A Mixed Methods Study," analyzed British citizens' behaviors, perceptions, and thoughts on living in close proximity to nuclear power plants, revealing how the nuclear stigma has shaped their actions in many aspects. At the time of writing, Pidgeon et al. noted the British government desired to build new nuclear power plants and investigated how proximity to nuclear power plants can affect peoples' risk perception and behaviors. They studied three different locations near current or planned nuclear power plants and surveyed residents using interviews through a narrative approach. A common theme they found was how residents made risk ordinary, such as through "[denying] the uniqueness of living close to [a nuclear power station]" by familiarizing themselves with the station and normalizing the risk. Familiarization involved understanding how the plant worked and knowing the workers there, which served to make the plant seem like just an ordinary part of life. Residents also felt that "living with risk was part of everyday life," much like driving a car or living near other industrial plants. Residents felt that the nuclear power station was a "potential threat" but did not view that this was "limited to areas in close proximity to the power station itself." They drew parallels to Chernobyl and its release clouds of radioactive matter and noted that if a disaster were to occur, proximity (or lack thereof) would not necessarily determine risk or safety. These findings show how while residents may worry and perceive risks to an extent, they adapted their mindsets to still be able to live comfortably.

Another theme noted by Pidgeon et al. (2008) was how residents found risk, threat, and anxiety were a part of everyday life. Despite being able to normalize and live with risk, residents were worried about terrorism, Chernobyl-like events (e.g. explosions), and other health threats, which many learned from mass media or social connections. Pidgeon et al. suggested that

anxiety is “furtive” and “repressed” but always hidden in the discourse, exacerbated by distrust in the government and other institutions. Residents were uncertain about where to gain “impartial information and advice,” contributing to the pervasive atmosphere of anxiety. Pidgeon et al. found that both nuclear and non-nuclear events were factors contributing to the anxiety of residents, illustrating the complexity of residents’ attitudes.

The findings of Pidgeon et al. (2008) show how the nuclear stigma has a direct, negative impact on the mental states and behaviors of those living close to nuclear power plants. The fact that residents have been desensitized to the presence of the nuclear power plants indicates that nuclear power has an underlying negative effect that must be dealt with. Although there are explicit factors like the Chernobyl disaster contributing to the residents’ attitudes, it is the “furtive” and unspoken anxieties and worries that drive these attitudes. Both the implicit familiarization with risk and unspoken anxieties of residents existed simultaneously, which would not have been possible if the driving force was explicit worries and current events. For example, throughout the interviews and data collection by Pidgeon et al., there was an underlying assumption that risk was present with nuclear power plants. This assumption was never investigated further, showing how the nuclear stigma even affected the researchers’ understanding of their subjects. In addition, residents primarily formed their opinions through social connections, media, and reactions to institutional policy and non-nuclear events (like terrorist attacks), all of which contribute to the nuclear stigma. Rather than being a direct consequence to specific events, these factors together influenced the residents’ mental attitudes, supporting the characterization of the nuclear stigma as a social phenomenon. Thus, this first case clearly demonstrates how the nuclear stigma creates an atmosphere of risk normalization and weariness.

Mental Associations with Nuclear Power

The final case by Im et al. (2021), "Public Perception of Geothermal Power Plants in Korea Following the Pohang Earthquake: A Social Representation Theory Study," involves the Korean perception of geothermal power plants after an earthquake. A 2017 earthquake in Pohang was found to have been caused by water injections from the plant, changing its public perception from a "clean/renewable energy source to a potentially devastating threat" (Im et al., 2021, p. 725). Previous research from a 2016 earthquake in Gyeongju, which has several nuclear power plants and is close to Pohang, showed that the public was worried about nuclear accidents due to the earthquake. Im et al. surveyed residents and found a statistical association between nuclear accidents and earthquakes. They also found that the negative transformation in public perception of geothermal power plants was partly due to "connection with the discourse on nuclear power plant risks" (Im et al., 2021, p. 736). These two very different technologies became "either related or classified into one risk category," explaining the residents' extremely negative and fearful reactions to geothermal power (Im et al., 2021, p. 733). Figure 3 shows how geothermal energy's perception was drastically lowered not only because of the actual incident, but also the association with nuclear power.

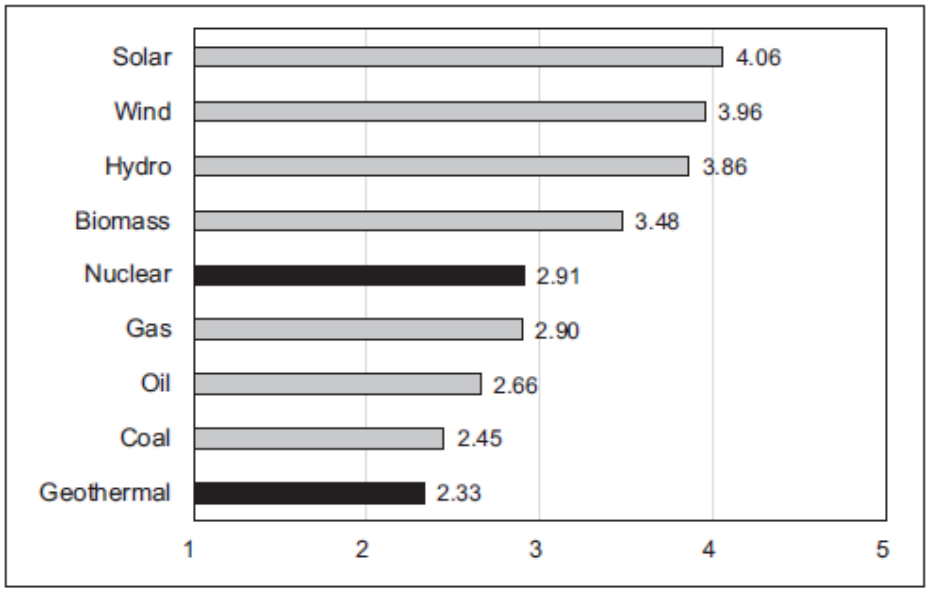

Figure 3. Favorability of energy sources for electricity generation, rated 1-5 from least to most favorable. The public view of geothermal energy was lowered below that of nuclear power due to the multiple associations to disasters (Im et al., 2021).

This "cognitive anchoring" between the "discourse on nuclear power plant risks" and geothermal plants clearly shows the negative consequences of being associated with nuclear power (Im et al., 2021, p. 736).

This case study also implicitly assumes the nuclear stigma to exist but extends its analysis by connecting it to a previously favorably seen technology. Because the negative perception of geothermal power was not solely due to the disaster it caused, but the "cognitive anchoring" to nuclear power, nuclear power is seen to be a catalyst for negative discourse (Im et al., 2021, p. 736). These power generation technologies are very different, with geothermal traditionally being seen as a true clean energy source, so nuclear power's indirect effect on it can be seen to be entirely due to a societal stigma. Thus, this case study demonstrates how the nuclear stigma is a prevalent social phenomenon that affects perceptions and discourse everywhere.

Results: Reframing the Nuclear Stigma

These case studies queried various populations about their perception of nuclear power, and my analysis shows how perceptions, attitudes, and behaviors are affected by the nuclear stigma. The nuclear stigma can both cast a pall over life near a nuclear station or even vastly change the perception of a previously well-liked technology; its absence can improve the outlook of new nuclear power plants. The first case study's participants showed the most unbiased view of nuclear power with regards to the nuclear stigma by placing the most focus on considering direct personal impacts, whether they be social or economic, and relying on local experiences. This is not necessarily a desirable goal, nor is it feasible for Western countries more closely connected with each other, but it does show the importance of being aware of biases present with the nuclear stigma. Together, these case studies help to better characterize the nuclear stigma, showing how efforts are needed to combat this pervasive bias. Eliminating this stigma is almost certainly not possible, but simply being aware that it exists would help to improve the discourse surrounding nuclear power by bringing the voice of reason into the spotlight.

Conclusion

Nuclear power is a controversial technology that has historically provided both enormous yet quiet societal benefits and horrific disasters that draw worldwide attention and gather opposition in many forms. This opposition is not just seen through organizations opposed to the use of nuclear power, but also through the unspoken, implicit emotions and visceral feelings many have, termed the nuclear stigma. Just as it is inappropriate for researchers to be funded by a company interested in one specific outcome, or a judge to rule over a family member's trial, policy on nuclear power must not be influenced by undue bias or emotions. This bias, the nuclear

stigma, is implicit in nature and must be made explicit to promote more productive discourse regarding nuclear power and its practical applications.

Some may claim that combating the stigma is not worth the time, and that effort should be focused on developing renewable energy. While renewables are the "greenest" solution, I have argued that nuclear power is, at the least, a necessary technology during our transition to renewables. This paper has previously described several technological benefits of nuclear power and showed that while it is not always the right choice, it is also not always the wrong one – France is a prominent example of the widespread use of nuclear power. Electricity is needed to power the infrastructure of society and ignoring a promising source due to biases rooted in the past is simply illogical. While everyone must be made aware of the stigma, responsibility also lies with scientists, engineers, and operators of nuclear power plants to improve safety and economic feasibility while ensuring that disasters like Chernobyl never occur again. Such disasters would further contribute to the stigma and erode any recent trust gained, hindering the progress towards a greener future. With modern advances in technology and the most well-educated populace in history, improving the Earth of the future will be possible if everyone, not just policymakers or scientists, put in effort to address this stigma and overcome past biases.

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