The Future of Nuclear Power

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Abstract

The demand for energy is growing exponentially with the U.S. Energy Information Administration projecting a 48% increase in world energy consumption between 2012 and 2040, with 20% of current energy being reliant on nuclear power plants.[1] With such a high percent of energy being generated through nuclear means, it is of economic and cultural importance to support the ever-growing population and economy. However, since the establishment of the first US based nuclear energy plant under Einsenhower's Atoms for Peace program, several challenges have faced the progression and evolution of nuclear energy and continue to do so, specifically in the realms of public opinion, plant logistics, and management of sites.[2] These challenges need to be addressed head-on in the near future or the continuation of nuclear fission as an energy source is at risk. Additionally, these challenges when reinforced with a reformation of how disasters and emergencies are communicated to the public, will support and provide a way to get a handle of the panic that will ensue before it can become deep rooted that could unravel future endeavors of the managerial corrections and improvements of nuclear power.

Objectives

Nuclear Energy holds enormous potential and economic power, but faces an uphill battle to be fully utilize. Public perception of nuclear energy currently is hurting its propagation as a larger source of US energy. This perception has arisen from logistical issue of nuclear waste, security of power plants, and insufficient safety that need to be addressed before the progression and growth of nuclear energy. This proposal aims to address ways to mitigate and tackle these historical and novel problems of nuclear energy, as well as give historical context and examples to explain and support why these methods will be effective.

Introduction and History

In 1934, Enrico Fermi was in search of elements beyond uranium on the periodic table, and after bombarding uranium with neutrons he quickly published a paper indicating his discover of transuranic elements.[3] This publication quickly won him a Nobel Prize in Physics in 1938 for his groundbreaking work of the discovery of new radioactive elements; however, Fermi was too quick to jump to conclusions of new elements and what he actually discovered years before anyone else was nuclear fission.[4]

In 1939, several scientists began publishing contradicting work demonstrating that elements of lighter masses were being produced, even Fermi's top assistant, Emilio Segre published a paper disproving his mentor's previous claim to a Nobel Prize.[5] At the same time the theory for nuclear fission was being laid by Ida Noddack who began to publish about the possibility as early as 1934. Soon after this groundwork, Lise Meitner convinced her husband that Fermi had discovered nuclear fission and convinced him to publish the theory and her calculations. Thus, nuclear fission was born just before the invasion of Poland by Germany, and the beginning of World War II.

This historical chain of events makes it clear that even from its instigation nuclear fission has always presented challenges that must have been overcome to understand, harness, and

control it. These tragic misunderstandings throughout history such as radium being described as "liquid sunshine" throughout the 1910s, the first nuclear bombs dropped on Hiroshima and Nagasaki in 1945, and 3-mile island in 1979 have given nuclear power and radiation an uphill battle with public perception and with governmental policies.[6,7]

Preliminary Results and Previous Studies on Perception

Perception of Nuclear Energy has always been unstable in the public's eye, due in part to the troubled past of nuclear energy programs as stated above. Sadly, nuclear power set an immediate precedent of the potential of uncontrollable power, especially with Little Boy and Fat Man, and devastation which the public grasped and have since associated with nuclear fission.

Due to its explosive beginnings, one of the largest challenges to the future of nuclear energy is the national public opinion of it. Nuclear energy waste and nuclear energy procedure revisions are heavily regulated by the national government which draws upon the opinions of its constituent. Therefore, the less the public trusts and the more they distrust nuclear energy, the harder it is and will be to pass regulations to support the growth of this field.

Take for example the pending nuclear waste site at Yucca Mountains in Nevada. This site was determined to be used as a depository for nuclear waste that has been spent in the generation of nuclear power. This site was determined by the Nuclear Waste Policy Act Amendment in 1987. Over the course of 31 years the site was only licensed for three years from July 2008 to September 2011.[8] One of the main contributing causes of this delay and lack of action is that the public was heavily against it due to their general mistrust of nuclear related concepts.[8]

The public opinion of nuclear energy has been looked at extensively, particularly how the perception changes after a disaster. After Fukushima, a longitudinal study was done in Switzerland with perceptions five months before and one month after Fukushima.[9] The study found that the public's opinion of the perceived benefits from nuclear energy had not changed, but what had was their overall trust in nuclear energy.[9] This suggests that nuclear disasters are not changing the public's risk assessment of nuclear energy but rather their faith that they can be ran carefully and properly. This will present several challenges as any nuclear disaster, no matter the distance, can affect the public's trust as shown in the study, even if the reactors and facilities are running entirely differently.

Efficiency and Economic Impact of Nuclear Energy

Nuclear energy is currently 20% of nationally based energy, with a projected 20% decline by 2050 if no new plants are installed after 2020.[1] With energy being the central power source to other sectors of the economy, it is a fundamental sector that if staggers could have disastrous consequences. Nuclear power is a large enough component of this sector that even a small issue would amplify through the other sectors it influences.

The International Atomic Energy Association reported that 21% of all Northern America Energy was electricity with 19% of the electricity being generated by nuclear energy.[10] Additionally, they project that electricity will grow at a usage of 0.5% per year. Reaching a final energy consumption of about 27% by the mid-century. They also reported nuclear energy projections that suggest the generating capacity will change drastically over the next two decades with 113 GW of nuclear energy being retired by 2030 and only 35 new GW of additionally plant energy.[10] Some power reactors retirements will be delayed but it is clear from the reports that

Nuclear Energy is on the fall. As shown in Figure 1, the worst-case scenario from these projections sees an approximate 67% decrease in nuclear energy. By the projected worse and best-case scenario nuclear energy will make by 4.9% to 14.7% of electricity production.

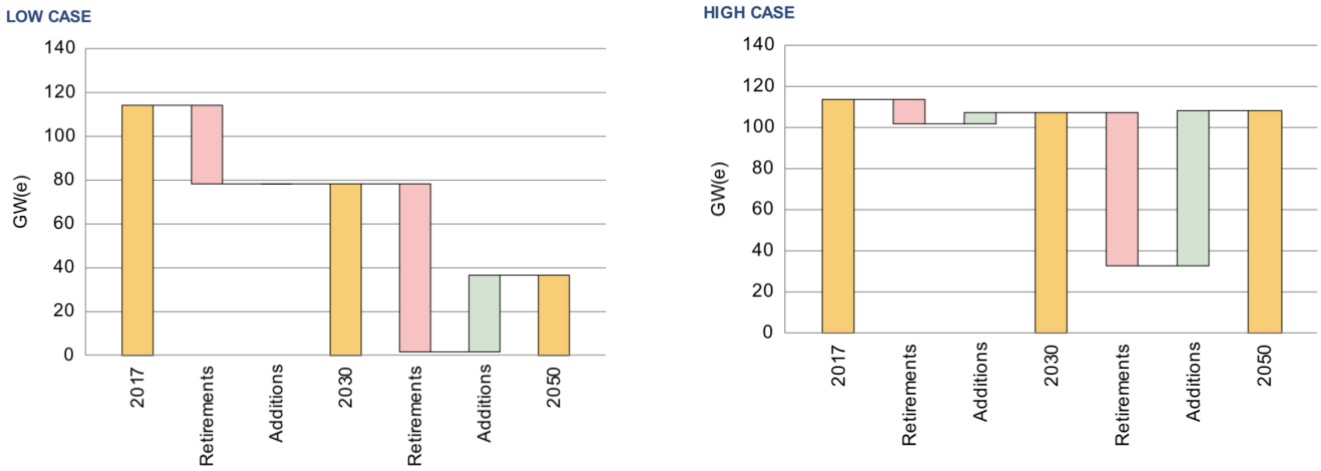

Figure 1: Worst and best case projections (respectively left and right) of the energy produced in Gigawatts by nuclear energy in North America retrieved from the 2018 IAEA report. [10]

These drastic changes indicate that nuclear energy is falling out of favor for other renewable energy sources which respectively require less maintenance and continued investment of capital. So, from these projections there are two courses of actions to address nuclear energy challenges: invest in nuclear energy greatly to see a resurgence of nuclear plants, or allow the phasing out of nuclear plants and reinvest capita in seeing the plants shut down properly and safety including the removal and transportation of nuclear waste.

Current Political, Cultural, Economical, and Logistical Issues of Nuclear Energy

Perhaps one of the most stressing current issue of nuclear energy is the logistics set by national laws. There is not a current standard protocol that allows for the proper storage and disposal of nuclear waste causing it to instead be piled in the nuclear plant. Recently, this piling of spent nuclear waste has been gaining public and media attention.[11] As stated earlier this public attention has generated numerous problems for governmental management and approval of nuclear problems and resolutions.

Perhaps the strongest example of this is the cultural and political impact of nuclear disasters. As shown by the history of nuclear energy, nuclear disasters are not rare occurrences and often linger in the mind of the population as they bring about dire consequences. Studies have shown that the perception of the population is drastically impacted by nuclear disasters, and will likely continue to do so. With the longest time between nuclear being the previous seven years, the public opinion has not been given sufficient time to recourse into a population that values nuclear energy over the dangers of making it.[12]

These stressing political and cultural challenges have already begun putting stress on the economic projections as shown above in Figure 1. The predictive models that project the decline of nuclear power have already begun impacting opinions and decisions of nuclear power as many

organizations and government simply accept the predictions instead of taking actions to change them.

Future Challenges

One of the largest future challenges that will be faced by nuclear energy is waste disposal. Currently, there is no standardized waste disposal practice for spent nuclear energy which is extremely dangerous and biohazardous. The need to protect and properly store nuclear waste is critical in preventing and mitigating future threats and disasters that could result of the current improper jerry-rigged storage in power plants not designed to hold so much nuclear waste for a prolonged period of time.

An additional future challenge is the growing use of nuclear power in acts of terrorism. Terrorism has been on a rise since September 11th, 2002 and the numerous bombings through the early 21st century. Although there has not been much development of nuclear terrorism there have been previous attempts.[13] Nuclear terrorism is commonly represented in popular media as illegal arms sales from nation's old stock, but the far more real threat is improvised nuclear devices (IND).[14] These IND are powered by highly enriched uranium (HEU) which can be extremely dangerous. HEU do not have a global standardize method for storage and safety, which is compounded by the fact that the fall of the Soviet Union released an unknown amount of HEU into the territories it occupied.[14] Current endeavors focus on cataloging and tracking these nuclear materials.

An additionally source of HEU is nuclear waste that is piling up at facilities across the globe as stated earlier. As nuclear waste continues to grow across many facilities the incentives of attacking a power plant in attempt of obtaining some of it for a "dirty bomb" rises. This growing incentive is a challenge that needs to be addressed with extreme urgency because of the falling standards of the protection of nuclear plants which if lapse will ruin nuclear energy's reputation instantaneously.

Another source of nuclear material for "dirty bombs" are industrial and scientific technology and equipment.[15] While the nuclear material in industrial equipment is not as potent as HEUs, it still poses a great threat because there is no tracking method for these lower caliber nuclear materials. Additionally, this type of nuclear material is wider spread as many hospitals have several pieces of equipment that rely on a nuclear energy source. Thus, as nuclear power advances and expands into new fields it becomes increasing available for scientific breakthroughs while at the same time presenting opportunities to be compromised into unintended purposes.

Methods and Strategies to Address Issues and Future Challenges of Nuclear Energy

In order to address the current and future challenges to nuclear energy, a multipronged approach is needed that addresses the many different issues which each occupy their own niche. These niches being composed of public perception, waste disposal, future innovation, and economic necessity and efficiency.

However, an important step needs to be taken before addressing the issues of nuclear energy, and that is to evaluate its usefulness. As demonstrated above by multiple world and national energy organizations, nuclear energy is on track to be slowly partially replaced by other forms of electricity. Nuclear energy is an expensive endeavor and once committed the plant will be around for decades. Thus, a study is needed to determine public and governmental opinion

on nuclear energy, and whether it is worth the risk and the money even though other fields of electricity are becoming more cost effective. After this, a decision needs to be made about whether nuclear power is worth the pursuit or if it too ineffective and too disliked to be transformed again into a growing industry.

As mention above the first step is a study to check the public opinion of nuclear power, however if the study yields unfavorable results there is a counter measure that can be taken to address public opinion before deciding if nuclear power is set to fall into decline. This counter measure entails a public campaign to address the fear of radiation and the fear of any nuclear associated word by emphasizing the misunderstandings of the public and the infinitesimal good nuclear energy has brought over the decades. However, the public fear of nuclear power is deep rooted and will take a relatively long time to change, so again a decision must be made how much to commit to nuclear energy or if it is better to allocate this energy and capital elsewhere.

If nuclear energy is deemed a worthwhile investment after looking at the economic benefits, then the course of the public campaign should be extensively well controlled and designed with intent at every step. The first step would be to develop simplistic media with an example shown below in Figure 2. This media should be able to be understood in under five seconds, should display no jargon and few words, as well as the use of a pastel or other "friendly" color scheme. Several different versions of this type of media should be developed to create a variety and allow for a stronger mass marketing campaign instead of a single image reused for the entire campaign. The next step is to create an online presence through the use of social media and a dedicated website. The website should strictly be for the purpose of the campaign to develop a sense of independence of the campaign. The dedication of the website will strengthen its appearance to the public and give validity to the campaign.

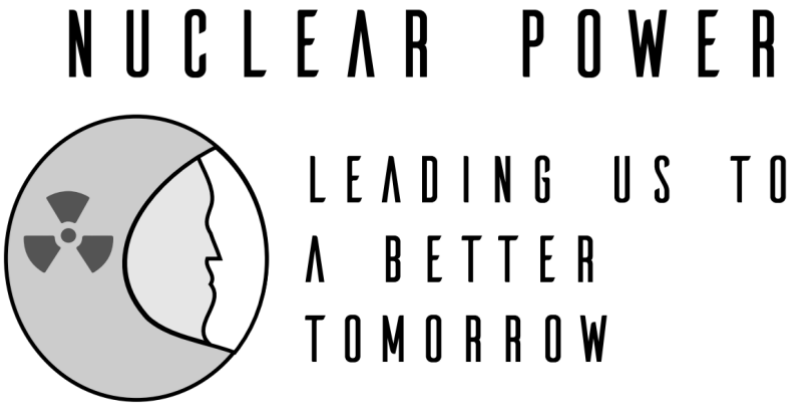

Figure 2 - An example of sample media that could be used to create a campaign to address the public opinion about nuclear power. The futuristic theme helps to reinforce the concepts of advancements in nuclear power will bring about a progressive change.

Additionally, the campaign needs to reach out to politicians and science advocates and work with them to address the public on the matter. With the ultimate goal that politicians take stance pro-nuclear energy and that science advocates can help to address the public's misunderstandings. The public's opinion is vastly controlled by the people who they support and

believe so by getting influential people to take a specific stance can be a strong tactic for changing public opinion.

Once the public opinion has been address, action can finally be taken on nuclear energy. As mentioned above nuclear waste being maintained on site is extremely dangerous as the waste continues to pile up in facilities that were not designed to hold any waste much less a growing stock of it. Therefore, one of the first steps should be advocating for larger governmental funding for nuclear energy, in particular the Yucca mountain waste facilities. Of course the site of Yucca mountain is under constant scrutiny, but the development and investment in the site makes it the best candidate for a site that could be opened in the next decade. Once the funding has gone through for Yucca mountain, a great urgency must be placed on opening the waste facility and designing a system for transporting waste to the site, which can be complicated by traveling across state lines. The best way to tackle the transportation issue is to have a team of engineers designing the transportation in parallel to opening Yucca mountain so that the transportation system is ready when Yucca mountain is open. As soon as the waste facilities has been opened, tested, and approved, the transportation phase of moving nuclear waste across the country should begin.

The transportation phase will likely be heavily debated and a great amount of paper work and "red tape" will need to be dealt with before moving the waste. Thus, this phase will be a long with an important emphasis on address all the details before moving forward. If something should go wrong, nuclear energy will be condemned and the entire campaign will have had little effect. However, if the time is taken to do it right, slowly overtime the public will favor nuclear energy again due to the public campaign addressing the public's fears and governmental action being taken on a matter that has stalled in progress.

Another threat to the future of nuclear energy is the increasing use and accessibility of nuclear power for acts of terrorism. Although nuclear powered terrorism has not been wide spread yet, preventive measures need to be set in place to anticipate the future threats to nuclear energy. The first step that needs to be taken as soon as possible is to increase the security and better standardize while also holding nuclear facilities to this revised security protocol. Throughout nuclear plants' history, several nuclear plants have been found in violation of numerous security protocols, and these lapses are extreme threats.[16,17] To counteract this, grass-root and lobbying efforts should be instituted to bring the methods to a modern standard. Additionally, the consolidation of nuclear waste to a single facility, such as the Yucca mountain facility, would make it significantly easier to better protect the nuclear waste from attack. Thus, the most important step to protect nuclear energy's future once again comes to the consolation and proper storage of nuclear waste.

Potential Problems and their Remedies

The first potential problem of this proposal is operating on the assumption that the media campaign can generate the public to care about nuclear energy. However, due to the mass media favoring nuclear energy as a topic if the campaign can properly address and works with the mass media it can be used to nuclear energy's advantage. Furthermore, it is likely that if there is a new nuclear disaster there will be mass public response and there is a time frame of operation which would be ideal to target political change as the pressure of the public on the government to reform nuclear standards.

Another potential problem is going to be to continue the emphasis on the importance of nuclear facilities security. As over decades, the lack of perceived tangible difference in the security has created misconceived notions of its lack of importance since a terrorist attack has never succeeded. Consistently ensuring the proper funding of nuclear programs is critical to the success of the security of the plants, which can again be reinforced by grassroots efforts and by emphasizing the creation of jobs in the nuclear sector.

Expected Outcomes and Conclusion

After the protocol presented above has been executed, the stress on nuclear energy should be lightened as many of the largest challenges will have been mitigated. Through its use of targeting logistical issues such as Yucca mountain, the stress exerted on the public and government by the flaws of nuclear energy will be lightened allowing for a public campaign to target the public perception of nuclear energy. Additionally, by relieving aspects of public stress governmental actions can be taken to pass proper regulations on nuclear energy as well as working on a global scale to track and contain nuclear sources. All of these factors will ultimately combine to help protect the future of nuclear power which will remain critical in its importance of protecting the planet and our nation for future generations.

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