Journal of the Economic Geographical Society of Korea
Vol.24, No.2, 2021 (163-180)

Beyond Nuclear Power: Risks, Alternatives, and Laypersons' Role

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원자력발전을 넘어: 위험, 대안, 그리고 비전문가 역할

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Abstract: Nuclear power has been an attractive energy efficient and to the pressure with the climate change despite of its risks. There are safety, security, and environmental concerns with the nuclear radiation, but the techno-optimism forms the mainstream by experts and the state to be able to control and manage the risks yet occurred. The disastrous Chernobyl and Fukushima nuclear accidents brought about alternative action and thought including renewable energy expansion, efficient energy delivery and use, and enhancing stewardship to environmental carrying capacity. More significant alternative movement is sought by victims of nuclear radiation, technicians, and the general public who realized the pitfalls of expert and state centered policy formation. These laypersons become counter-expertise competent in recognizing local contamination and considering the risks and emotions seriously affecting peoples' everyday lives. They play important roles in the construction and legitimation of alternative knowledge about nuclear power widely realized across regions.

Key Words: nuclear energy, safety, techno-optimism, alternative energy, stewardship, layperson

요약: 원자력발전은 위험을 안고 있음에도 많은 국가에서 에너지 공급원으로 그리고 지구온난화 대응으로 중요하게 자리잡고 있다. 핵에너지는 방사능 오염의 위험과 핵무기의 위협 그리고 핵폐기물 처리의 문제를 가지고 있으나 효율적인 신기술로 안전 관리가 가능하다는 기술낙관주의가 전문가 그리고 정부 주도로 주류를 이루어 왔다. 그러나 체르노빌 그리고 후쿠시마 원전 사고는 전세계적으로 핵발전의 대안을 모색하는 관심과 노력은 확대되어 대안 모색으로 지속가능한 재생 에너지의 생산을 확대하는 노력, 에너지의 효율적 전달을 위한 스마트그리드와 환경친화적 소비 행태를 통한 에너지 사용 절감, 그리고 핵폐기물의 처리 등을 포함한 환경의 수용능력을 감안한 청지기 정신을 강조한다. 보다 근본적인 대안 운동으로는 대규모 원전 사고를 경험하며 기존 전문가와 정부가 중심이 되어 형성해온 기술주의가 배제했던 지역에서의 피해 사례와 이를 고려하지 못하는 접근에 대한 불만이 보다 광범위하게 피해자, 기술자, 일반인 등이 대안운동을 전개한다. 이들 비전문가들은 지역의 오염을 감지하고 대중의 일상생활에 심각하게 영향을 위험과 감정을 고려하는 능력을 가진 반전문가로 등장한다. 이

This research was supported by the 2020 scientific promotion program funded by Jeju National University.

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https://doi.org/10.23841/egsk.2021.24.2.163

들은 광범위한 지역에서 원자력에 대한 대안적 지식을 구성하고 합법화하는데 중요한 역할을 한다.

주요어: 원자력에너지, 안전, 기술낙관주의, 대안에너지, 청지기정신, 비전문가

1. Introduction

> Future generations will likely tell stories about those who dared question the experts: those who said out loud that the blood of the baby seals still sticks to the fur coats, no matter how well they have been washed; those who understood that nuclear power plants could never be safe and that nuclear waste lasts more than 250,000 years … (Macy and Gahbler, 2010: 9).

Nuclear power plants are one of the most dangerous black boxes in existence. Most of society takes for granted that we receive useful energy from this black box, and the climate change has made the nuclear energy an attractive alternative to decarbonization of energy supply. Considering the need for rapid decarbonisation of the world's energy supply, gaining public support remains an important factor in any political decision about the use of nuclear energy. Opinions vary and are frequently divided over technologies and none more so than with respect to nuclear energy. The hazards of nuclear power are unpredictable, unstoptable and so extensive in terms of time and space.

The operation of nuclear power plants has been the area of professionals and the scientific expert knowledge. The efficient and economic electricity generation have overshadowed the expected danger or harmness of nuclear power plants. The risks of nuclear power cannot be decided and thus in dispute between real and perceptional. Majorities are reluctant to be aware of how this energy is made both in reality and politically. However, the Fukushima nuclear disaster in 2011 became a turnning point to express concerns and anti-nuclear energy production (Hasegawa, 2012; Ahn, 2017; Brown, 2018). The risk perception of the locality and country overall has become the most important criteria to decide the operation and closure of nuclear power plants (Gradiner, 2015; Greco and Yamamoto, 2019).

The Fukushima nuclear disaster opened public concern and participation, and even the government adopts public participatory policy-making in deciding nuclear power plant operation. The previous anti-nuclear movements have been changed to post-nuclear movements to extend the production and use of alternative energies. However, various institutions supporting nuclear power energy are reluctant to move to post-nuclear economy increasing more alternative energy production (Yun, 2015; Min, 2017).

This paper is intended to expose the risks and dangers of the nuclear energy, and to propose the way to strive toward alternative energy solutions. To those ends, the role layperson can play introduced to overcome the technocratic pitfall of nuclear energy. First, this paper focuses on some

of the personal-health, sociopolitical dangers, and environmental problems of nuclear energy. The impact of paradigm named techno-optimism is considered in light of key issues raised by nuclear power. It is at the center of the issues connected to nuclear power which serve to perpetuate the problem. Once the problems are evident, there becomes an unavoidable call for change. Possible alternative energy solutions more beneficial to society should be thought and implementing changes are then proposed including stewardship to environment. These proposed changes encourage laypersons' participation and their role which have the tendency to be more objective in terms of the number and diversity of people involved. They are less likely to have interpretation biases due to the fact that it is less dependent on expertises and state that are complicated by politics. A brief review is presented on the laypersons' role, with particular attention to how they can help gain credibility and build support across broad general public. A conclusion summarizes the materials covered at the end.

2. Safety, Security, and the Environment with Techno-optimism

Among the large majority of environmental scientists around the globe, there is a sizable amount of anxiety for society's general lack of concern for the environment which can be seen in the overconsumption of fossil fuels and in the destruction of rainforests (McElroy, 2010; Robbins *et al.*, 2014). The Intergovernmental Panel on Climate Change (IPCC) claims that the concentration of greenhouse gases has increased exponentially since the beginning of the Industrial age, and that the release of greenhouse gases into the atmosphere has caused the average global temperature to raise one degree in the past 100 years (Cadenas, 2012). The IPCC further projects that if this increase in global temperature continues, we will see devastating effects on the environment in the next century. It is clear that something needs to be done about the increasing amount of greenhouse gas.

This problem is one reason why nuclear power has won the favor of many people with environmental concerns: nuclear power plants produce no carbon dioxide. However, nuclear power is a complicated 'black box' that is networked with science, large corporations, the economy, politics, and the military to name a few, and all of these connections must be understood before one can make a balanced judgment about the risks involved. Concerns of risk mainly fall into three categories: safety, security, and the environment with techno paradigm.

1) Safety Concern

Concerns relating to *nuclear safety* are diverse from individual to overall society. There are concerns for the safety of the workers, the safety of the territories immediately surrounding nuclear power plants, as well as the health of the environment and people living in the environment around (Mori, 2015; Davis and Hayes-Conroy, 2018). Although danger to workers through

exposure to radiation has been nearly eradicated over the years owing to new policies, there are still risks involved when safeguards breakdown, or when a safety system is not robust enough to handle the seemingly infinite amount of possible scenarios that can lead to incidents of failure or even meltdown. Ferguson explains how "comprehensive safeguards system and the companion additional protocol still have shortcomings" (Ferguson, 2012: 123). Let us look at several examples of major incidents to show how "such guidance proved ineffective in preventing the disaster at Fukushima, where worst case scenarios were discounted in the disaster management plans of the site, and as a result, sea defenses were woefully inadequate" (Hester and Harrison eds., 2011: 11).

Fukushima, known as the Black Swan of Nuclear Energy, was hit by the great earthquake of March 11, 2011, and would result in one of the worst disasters of recent times (Brown, 2018; Hasegawa, 2012). At magnitude of 9.0 MW, it was the most powerful known earthquake ever recorded in Japan, and one of the most powerful in recorded history. It released a surface energy on the magnitude of 1017 Joule. For a comparison purpose, it harnessed enough energy to power a city the size of Los Angeles for over a year. The earthquake triggered a powerful tsunami which hit the Pacific coastline of Japan's northern islands, and demolished entire towns with waves reaching almost forty meters in some coastal locations. Ultimately, about 20,000 people lost their lives from the direct impact of the earthquake and following tsunami.

It was the most infamous consequence of the disaster from the nuclear accident since the last twenty-five years. The nuclear power plant in Fukushima demonstrates the unforeseen design weakness of the light water reactor (LWR). LWRs are generally seen as a safe nuclear reactor design because the laws of physics tell us that it is nearly impossible to have a meltdown so long as there is enough coolant to keep the reactors from over-heating. However simple it may sound, the mechanics involved are complex; although physics may never fail, human engineering is known to fail. An LWR needs external power for cooling after a shutdown. The reason for this is that radioactive decay continues after the chain reaction has been stopped.

Although after the earthquake, the emergency generators turned on, the tsunami cut the plant's connection to the grid, rendering even the backup generators to cool the reactor ineffective, which led to the eventual core failure, radioactive explosions, and widespread evacuation of the towns within a twenty-kilometer radius (Cadenas, 2012).

Chernobyl would be another infamous incident.[1] The scary part about this meltdown is that there are still many unanswered questions regarding the exact cause-again because of the complexity of nuclear reactors. However, here are some of the facts that are known. There was an experiment being conducted to test the behavior of an electrical system in the reactor. At 1:23 on the morning of April 26th 1986, the experiment began even though the reactor power output was significantly below that required by the experimental procedure. Additionally, in order to carry out the experiment, several safety systems

had been deliberately disabled, and the number of control rods in the reactor was only half minimum required for its safe operation. Thirty seconds after the experiment began, the reactor power began to increase rapidly, and ten seconds later the operators attempted a full emergency shut down by re-inserting the control rods (Downer, 2015).

The reactor power was now increasing exponentially, leading to a failure in the pressurized cooling water system. Eight seconds later, the reactor exploded, scattering burning core debris over the surrounding area. Over 100 firemen were initially called to the scene. The fire raged for ten days, while emergency crews worked around the clock putting radioactive absorbing materials on the fire. 1,800 helicopter flights were required, and many emergency workers were exposed to doses of radiation far beyond the unhealthy threshold. The explosion and subsequent fires spread volatile radioisotopes over vast areas of the former Soviet Union and parts of Western Europe, contaminating the environment and food supply chains in much of Europe and Asia is.

In addition, because many children did not receive potassium iodide tablets to prevent exposure to radioactive iodine from the contamination, about 1,800 thyroid cancers developed in excess of what would be normally expected in the exposed population. These cancers could have been prevented, but they happened because of the Soviet secrecy in not informing people before it was too late. Experts have disputed whether there were other directly attributable health effects; estimates range from very few additional incidents of cancer to more than 20,000 (Ferguson, 2012). This brings up the question of information validity due to both political cover-ups, and media-propagated political hyperbole.

While we have seen the development of a much stronger safety culture within the industry over the last 20 years, nuclear power plants have the disadvantage of being so complex that almost every reactor has experienced some sort of incident or failure over its history, and even if the risk of a true meltdown is low, the impact of such an accident would be very large (Hester and Harrison eds., 2011). With continuing safety improvements, the industry is trying to avoid any additional major accidents, but nuclear power plants are too complex, and the fact is that imperfect, if well-trained, humans operate them (Ferguson, 2012). One may argue that we simply need to develop a more robust safety system to prevent unforeseen failure, but upon further cost-benefit analysis, is it worth the risk when alternative sources will do the job?

2) Security Concern

The largest immediate impact on society would be related to nuclear security. Since the risk factors are so manifold, let us start off with plausible worst-case scenarios, as is appropriate for risk-assessment. The threat of nuclear weapons is very real.[2] There currently exists about 12,000 nuclear warheads around the world, which is enough to destroy the Earth many times over (Hathaway and Boff, 2006). There exist many people, who with malicious intent would use the

vulnerabilities of the complex network related to nuclear power for vindication or the acquisition of power through intimidation or blackmail (Ferguson, 2012). Nuclear weapons proliferation has been a concern since the birth of nuclear energy, given that the very purpose of the first nuclear reactors was to extract plutonium from the spent fuel for nuclear weapons (Hester and Harrison eds., 2011), and that the proliferation risks have increased.

One avenue toward proliferation is through the nuclear black market. In his Book, *Nuclear Energy: What Everyone Needs to Know,* Charles Ferguson writes, "[t]he greatest proliferation concern presently centers on Iran, which received the beginnings of its enrichment program from a nuclear black market" (Ferguson, 2012: 36), It is far from an irrational fear that the material that can fuel a nuclear bomb can be obtained from these plants, as it has already happened. A.Q. Khan is known as the 'father of the Pakistani bomb,' and he created a vast black market that networked with more than a dozen countries in Africa, Asia, and Europe, which supplied Iran, Libya, and North Korea with both knowledge and equipment (Ferguson, 2012). Further, Ferguson later explains that this black market is becoming more 'proliferation prone' with the development of laser-enrichment, which does not require as large of facilities; these facilities are inconspicuous in an industrial area surrounded by warehouses that are similarly sized (Ferguson, 2012).

Besides individuals or terrorist organizations with ill-intentions, militaries have also used enemies' nuclear power plants as their own weapons. Bennette Rambeg tells us how "governments may be motivated to use their militaries to attack their enemies' reactors in order to damage their electrical power system, destroy a potent status symbol, impede the ability to make fissile material for nuclear weapons, or contaminate their enemies' territories with radioactive material" (Ramberg, 1980: 162). The Middle East has experienced this sort of targeted attack, and there is no indication that this tactic is off limits in any part of the world.

3) Environment with Techno-Optimism

The infamous nuclear power plant disasters have huge impacts on the environment. The nuclear waste question seems the most serious environmental problem. Although nuclear power has the benefit of not producing carbon dioxide, it does have other environmental impacts that are being ignored. The main concern is what to do with nuclear waste. Nuclear power advocates like to quote how burial of nuclear waste need only be a few meters deep (Lovelock, 2006). Although this may be all that is required to prevent exposure to radiation, there are many other issues that arise from superficial burial with regards to environmental contamination.

Currently there exist no permanent nuclear waste dumping ground, because of the expenses involved, with the required deep terrestrial burial in order to have no foreseeable impact on the environment. Hester and Harrison reveal to us a rather disturbing fact, that, in order to avoid the difficulties of proper disposal in the eyes of the public, some countries dumped their nuclear waste into the sea, they reveal that France "from

1967 to 1969 dumped more than 12,000 cubic meters of nuclear waste from the reprocessing plant at Marcoule into the ocean" (Hester and Harrison, 2011: 28).

So far, the US has generated roughly 70,000 metric tons of nuclear waste enough to fill a football field more than 20 feet deep according to the Government Accountability Office (GAO) (Alexander, 2011). The GAO has projected that the number will more than double to 153,000 metric tons by 2055 (Power, 2011). The unanswered questions are: what sort of long-term effects will superficial burial have on the environment? How many billions of dollars will be required to bury the waste at a safe depth? And exactly how deep is a safe depth?

Aside from these unanswered questions, there is a deeper question that ought to be addressed: why is there such a huge demand for energy? It is not until we understand this dynamic of the black box of power systems that we can responsibly ask. What sources of energy are the best investment for now and for the future? There are technical and social tendencies that have led to the high energy-demand, and thus the need for nuclear power. Contemporary society has developed an addiction and a co-dependence on technology (Glendinning, 1995). This can be called *techno-addiction*. The high demand for electricity equates to a high demand for power plants. Currently, the major majority of the world runs on non-sustainable energy sources which create greenhouse gases. Thus, *techno-addiction* has led to societal ignorance, and even apathy of environmental impact. This social paradigm that metaphorically glues people to technology exacerbates this cycle of pollution.

Techno-optimism is a scientific and social paradigm which continues to be conducive to the nuclear option for power. Because of *techno-addiction* there exists a tendency to default to technology for everything. In the same way that an alcoholic can be optimistic that a beer will make things better, a *technoholic* will be optimistic about technology being the solution to everything. Recognizing the huge differences between alcoholism and techno-optimism, there is still a dynamic that is unsettling about the technology-native generations defaulting to technology for everything.

3. Alternative Energy Production and Consumption

There are several approaches to avoiding the risks of nuclear energy, which is intrinsically related to the problem of a high energy-demand. Some, such as abandonment or restricted use of technology, are simply not feasible given human nature, nor are they necessary. However, some of the solutions are quite feasible but would need great collaboration. This collaboration may in fact produce jobs, as well as encourage small science, which has the tendency to be more mobile, flexible, progressive, and adaptive compared to big science (Macy and Gahbler, 2010). These solutions are admittedly techno-optimistic but have eyes open to society and the environment: they seek healthy solutions that are rational and collaborative.

The problem can be looked at in several different ways. The first perspective is that there is not enough power to supply the demands of society. The second perspective is that power transmission is inefficient. And the third way of looking at the problem is that society has too high of a power-demand. All of these three perspectives are valid, and there exists many solutions to each, but for the purposes of this essay, a select few shall be mentioned.

1) Alternative Energy

Alternative energy solutions ought to be sustainable and renewable. The question most critics ask about renewable energy is, "is it possible to provide enough power without going nuclear?" The simple answer is probably "yes." Not only is there a need to pursue alternative energy because of the risks inherent to nuclear power, but also because of its lack of sustainability. Even if someone were a proponent of nuclear power, alternative sustainable and renewable energy is a must:

> … nuclear fission may only be able to play a short-to-medium-term role in meeting these environmental and economic needs, as an enabling technology with a so-called "bridging role." Even then, nuclear energy will face some significant problems…many of which have not yet been adequately addressed (Hester and Harrison eds., 2011: 33).

Hester and Harrison hold that although nuclear energy is a solution for the current power demands of society, it is merely a temporary solution because it is not sustainable.

The most well-known alternatives would renewable energy sources including wind power, solar power, tidal power, and geothermal power. Again, Hester and Harrison report that wind power alone could, if fully harnessed at available locations, meet several times the world's present electricity demands (Ferguson, 2012). Currently solar power, although widely known and used all over the world, merely provides a miniscule fraction of the world's energy needs. The obstacle to wide-spread use of solar power is the fact that it's rendered useless at night due to a lack of sufficient energy storage capabilities. This is where techno-optimism shows its good side: small science may be encouraged to develop innovative energy storage techniques. Currently there is not much resources going into the development of such technologies in comparison with the inconceivable amount of money being pour out into other research that is not sustainable.

Another continual sources of energy, tidal energy does not produce any emissions of greenhouse gases and can offset consumption of an equivalent amount of fossil fuels. The energy source is also more predictable and reliable than wind and solar power (ASME, 2012). Again, the main obstacle here is obtaining the resources for a large enough infrastructure to meet the energy demands of the world. The world theoretical resource from offshore renewable such as wind, wave and tidal is estimated to be between 260,000 and 330,000TWh/year, illustrating the potential significance of the available resource (IEA-RETD, 2012). The fact is, we have the ingenuity to power

the world safely, and nuclear-free, so why is it that we continue to look towards nuclear power as the source and summit of all the world's power needs?

2) Energy Delivery and Consumption Side

Another approach to meeting the power demand of today's society is to consider the pitfalls of power transmission and delivery. There is an estimated eight percent energy loss in the transmission of power between power plants and the consumer. This may seem minimal, but in 2005 alone that translated to 239 million megawatt hours, or $19.5 billion (ABB Inc., 2007). The next factor is congestion, which provides an additional six percent power loss, which also translates to billions of wasted dollars, and a significant impact on the environment. Smart electrical grids enable more effective use of power, and may allow intermittent renewable sources, such as solar power, to provide reliable electricity. Methods to energy delivery systems include underground power-lines, distributed generation micro-grids, smart grids, reducing the number of power-transformers, energy storage devices, higher voltage transmission lines, and voltage optimization through reactive power compensation to name only a few areas for improvement (Ferguson, 2012).

Some of these efficiency-optimizing tactics require much research and development, which is one reason why the world has not addressed these solutions at a large scale. However, many of these solutions simply require making known the anomaly and simple collaboration. Small science may be needed again in this huddle where hybrid solution melding electronics and communication technology is encouraged to develop innovative energy transmission technique working across regions.

The one solution that many are unwilling to look at, but which can produce significant results, is to rely on the consumer. Simply stated, much of the energy delivered to consumers is wasted; first it is wasted due to energy-inefficient devices, second it is wasted due to apathy and ignorance, and third, it is wasted due to what many would consider pointless uses of the energy (Choi, 2013; Lenon *et al.*, 2019; Klein, 2021).

The first category calls for energy-efficient products. This is already being addressed by many electronics makers but can be addressed with greater priority. The second category is due to a lack of awareness, which is what this essay addresses. Many consumers are not aware of the amount of energy they waste. From little things such as leaving a light on, to big things such as using a washing machine to wash one article of clothing, all contribute to widespread energy waste. The third category is a deeper-seated issue which begs the questions of: what is the cause of techno-addiction, and what are some ways that society can become less electricity-dependent?

Technology, with all its mysterious attributes stimulates this delightful experience which can be addicting. These questions are deserving of several books written on the subject, the 'anthropocentrism' would be the beginning deeply embedded in human centered tradition. The idea called dominion thesis is that humans are superior to nature in which nature is only valuable when

useful to humans from the religious background (Robbins *et al.*, 2014). More fundamentally all is too often centered on technology and things. The fact is that there is something addicting about technology, and that we must evaluate our own dependence and determine ways to overcome such addictions, and can have adverse effects on the environment.

3) The Stewardship Alternative

One undeniable fact about earth's environment is that there is no reset button. There is no magical garbage bin to throw away our broken ecosystem. We only have this one, and once it is destroyed, it's destroyed for good. But there is much hope. As pessimistic as some people may think about the irreversibility of the Earth's eco-system, it is far from lost. The Mother Nature has her way of healing its brokenness, so long as it is not continually given more and more wounds. This is a metaphor which James Lovelock took to heart in his book, *GAIA* (Lovelock, 2006).

The idea is that Earth is a living organism with an immune system that can counter-balance regular attacks on its health. However, there are such things as viral infections that could ultimately kill the organism. No matter where one stands as to the reality of this metaphor, it points at the same reality mentioned above: we only have one Earth, and we ought to do what we can to live in harmony with it.

Contrary to the human dominance and indifference to nature, living in harmony with Earth would be begun with stewardship in biblical tradition (Robbins *et al.*, 2014). It is a lifestyle that calls for humanity to take care of creation. There is a strong emphasis on human stewardship of nature, the moral responsibility to care for natural world. As stewards of nature, the mandate is subsumed under an ethic to care and maintain. Such a religious ethic of stewardship can be seen in human activities and movements around the world; witness the Kibbutz movement in Israel, the anti-corporate French peasant farmers' movement, and the recent energetic movement of evangelical churches in the United States to halt global warming (Robbins *et al.*, 2014). In Korea as well, religious organizations including Catholic church and Won-Buddhism have been active in post-nuclear movement with respect to their life movement in Korea (Yun, 2015).

From whichever side, civil and religious organizations, stewardship stands against the Western civilizations, especially those of the modern era in which a human-centered anthropocentric ethic needs to be changed to current post-development era. If one holds that mankind has a responsibility for men and women alike, then they have the responsibility to tend to the needs of the Earth environment which nourishes and sustains life. Likewise, Elizabeth Johnson voices our need to take care of the Earths, but her emphasis is on *kinship* similar to *stewardship* (Elizabeth, 2009). *Kinship*, she argues is closer to reality; it puts human beings and earthlings as companions in the community of earth. In this model, there are no implications of hierarchy. In spite of one's own perspective on where mankind falls in the order of creation, the common ground in both cases motivates one to act in a life-giving and sustainable manor.

The interconnectedness of life is another similar concern expressed in a book, *Active Hope* (Macy and Johnstone, 2012). Its authors emphasize the importance of environmental care by highlighting our dependency on a healthily functioning natural world:

> While Haudenosaunee and other indigenous peoples recognize that our very survival depends on the healthy functioning of the natural world, it is only recently that we have gained scientific understanding of how true that really is...when we carry within us a deep appreciation of how our life is sustained by other living beings, we strengthen our desire to give back (Macy and Gahbler, 2010: 210–211).

It is only recently that there is scientific evidence to prove what ethnoscience has told us about the human body's ability to heal faster in beautiful environments. It is not merely a matter of silly psychological trickery, or a perceived placebo effect that patients in hospitals recover more quickly when they have natural scenery to look out upon instead of the brick walls of a city. We as humans are a forgetful people. It is easy to take life for granted and it iseasy to neglect the amazing complexities which daily sustain our very existence. When we do, however, recognize all that supports our life, we have a natural tendency toward gratitude, which moves us into positive action toward sustaining the environment that sustains us.

4. Laypersons Role

If we have a calling to stewardship or kinship as a human family and move toward sustainability, the next steps must involve scientific and social paradigm shifts; there is an undeniable need for layperson involvement to overcome the pitfalls of techno–optimism and scientific expertism (Yun, 2018; Lennon *et al.*, 2019; Polleri, 2020). One concern that usually surfaces regarding scientific paradigm shifts is that the level of entry into the scientific realm is simply too high in order for layperson to have a significant impact on science.[3] But the Chernobyl and Fukushima accidents have been so disastrous to challenge the technocratic pitfalls and open a debate about nuclear alternatives.

Stereotypical rhetoric has been so long dominant that experts are rational and objective whereas the public are emotional and irrational. As disastrous accidents occurred beyond the controlability and manageability promulgated by the expertise, we now need to take an alternative approach that risks and emotions about nuclear energy should be considered in policy making process involving layperson's on–the–ground knowledge (Topcu, 2008; Roeser, 2011). The risks and emotions associated with new technologies become important forms of knowledge to be taken into consideration if they have direct and/or indirect negative impacts onthe peoples everyday livelihoods.

New forms of knowledge on the risks of radioactivity have to be emerged as Steven Epstein points out from the AIDS experience that

activist movements through amassing different forms of credibility can become in certain circumstances genuine participants in the construction of scientific knowledge (Epstein, 1995: 409). The example of the AIDS movement show how activist movements can have effects on practical changes. The movement highlights the potentiality of layperson to exercise influences on a paradigm shift in the scientific world.

1) Experiences from AIDS Movement

Let us take a brief look at the AIDS movement in order to underscore the dynamics of laypersons' influential role in a scientific paradigm shift, and correlate these roles to the movement beyond nuclear power. AIDS research has diffuse and porous perimeter since actors including immunologists, molecular biologists, epidemiologists, physicians, health authorities and even mass media have all sought to assert claims about the safety and efficacy of particular therapeutic regimens and understandings about which clinical research practices generate useful results (Epstein, 1995). Upon this, AIDS is recognized as a disease of certain already-constituted social groups distinguished by their lifestyle or their social location. Such prejudice and social meaning were fought over by diverse social groups including the infected, gay and lesbian, and other concerned activists.

The AIDS movement made its first significant advancement after the construction of an identity and a cohesive group of individuals, who were seen as having one voice – the voice of those who suffer from AIDS and social prejudice. This permits the perception that certain individuals can speak on behalf of all of the people who suffer. Because AIDS was a nucleus of a certain identity, interests were able to be networked more efficiently.

Additionally, the AIDS movement was built on the foundation of the gay and lesbian movement. This gave strength to the AIDS movement because there already existed a strong network of support. The gay and lesbian identity was seen and recognized throughout all levels of society, which gained much support for the AIDS movement. The gay community held cultural capitol which had a lot of influence in society, and gays in politics and in science and other areas of the network already had social and scientific credibility (Epstein, 1995: 415). This facilitated communication between experts and the public. On evaluating and deciding over socio-technical issues, voices would be authoritative when a diverse but unified argument is more capable over expert scientific voices (Epstein, 1995). would be perceived more credible when connected with organizations having such things as academic degrees and a history of being credible.

One of the first questions the movement of those beyond nuclear power must ask themselves is whether we are seen as one cohesive voice? It seems that the answer to this would be 'no'. There are many voices within those who fit in the category of those who are beyond nuclear power. The questions that this brings up for anti-nuclear activists are then what sort of identity and network community do we have, and what other groups can we collaborate with whom already have such social capitol? And how is it that we can build

greater ties with those who are not necessarily against nuclear power, but are for sustainable alternatives to gain strength while we work toward similar ends?

2) Laypersons Movement

The dangers of nuclear energy are well recognized and we need to lead to viable alternative and sustainable options across place and time. However, still we have the question, now what? It is obvious what required are a large number of people won-over and mass-collaboration across groups. This is not a small task, but it is certainly feasible with strong steps forward. First of all, key players must be identified: those who have the resources and the connection with those with resources to mobilize such a movement. These key players include individuals and organizations not only the localities near the facilities but the whole spectrum comprising the global society.

It is important to make connections rather than re-inventing a new organization; there are many organizations to network with that have already begun work toward a changeover to energy sustainability. Some of such organizations include Greenpeace International, People's Movement Against Nuclear Energy, and Green America to name a few. Additionally, large corporations such as GE and Edison maybe won over with some convincing as to the benefits for their company and for the world. These two companies do have some of their resources invested in alternative energy, but with more societal-wide buy-in, they may see the opportunities of a higher level of investment. Google has recently purchased electricity generated from renewables (Google, 2020). Speculation may lead one to conclude that Google discerned the potential gains of such a strategy. This is a good sign that encourages alternative energy movement world-wide.

To move further ahead, we can use credibility tactics that were implemented in order to effectively bring about change. Particularly relevant for anti-nuclear activists are the tactics which ought to be on the forefront of the minds of those who wish to effectively bring a shift of paradigm to the energy-science realm. The first is to identify those who fall under the identity of nuclear risks at personal and local level (Topcu, 2008; Parkhill *et al.*, 2010), like those who suffer from AIDS to be perceived as representatives, thus being authoritative (Epstein, 1995). Anti-nuclear activists can gain more of a voice if they strengthen their voice by unifying it with other groups who have a similar end-goal of alternative sustainable energy solutions. This leads to the second to learn scientific terminology in order to sound more credible and to engage more fully with the field of scientific research (Epstein, 1995; Eden, 1998).

Anti-nuclear activists to gain support must have a strong enough basis in ecological and social sciences beyond the generic terms and resources of nuclear science. They must base their public statements on credible experience, survey and research in order to gain the credibility needed. They would be to combine hazards, risks, and associated emotions into research-based arguments and knowledge. This created a new form of credibility for activists because they

became the counter or reverse experts in a field that they argue.[4] Simple experience-based research arguments hold a lot of weight, but it may fall short in inspiring a movement of people into action. It would be efficacious for ethical arguments based on risk and emotion to be part of the knowledge toward a paradigm shift toward ethical and sustainable society.

Activists have established credibility as people who might legitimately speak in the language of layperson and scientific realms (Bickerstaff, 2012; Harris *et al.*, 2018). Laypersons are able to educate themselves enough about a topic through real world experiences. To be able to dialogue with those in politics and those in the energy business is a necessary step to gaining credibility in a single voice. There may already be other movements in existence to be tied with against techno-centrism such as vaccination, GMO, carbon capture and storage. This dynamic carries over into the realm of nuclear power. They are able to be networked in a way which will be beneficial for renewable energy production toward sustainable society.

The nuclear power despite of the embedded risks and dangers has been the domain of specialists which led to the expertism, and the energy production has been justified with less CO_2 emission. The increasing demand of electricity has made it difficult to reduce the reliance on the nuclear power even with the disastrous accidents at Chernobyl. But the recent Fukushima nuclear disaster has left huge impact on the way to think about nuclear power along with the raised concern with environment and sustainability after the UN Rio declaration. The coming of post-nuclear, however, still needs a long way to go because various interests depending on nuclear energy system are barriers against the pursuit of energy alternatives (Davis and Hayes-Conroy, 2018).

Laypersons become important player in raising concern and participating in local and global arena. Incorporating diverse persons and groups from local expertise to concerned citizens all over, laypersons could make changes in the legitimation and construction of alternative energy policy (Hillerbrand, 2015). The recent huge negative impacts widens attention not only the sites but the risks not much revealed under technical expertism and state secrecy for a long time. The risks of personal and local level on one hand and the emotions by those who are concerned with the problem at a global level on other hand spurred to mobilize the local and the global simultaneously.

The zones and communities are the place where local expertise are nourished with dangerous and harmful consequences. Broader public reactions intensify not only at a predefined, one-dimensional risk at sites but rather that they are based on a critique of the manner in which official experts are incompetent in the evaluation of radioactive contamination in localized areas and disregard the risks recognized on behalf of the public (Alexis-Martin and Davis, 2017; Pitkanen and Farish, 2018; Yang *et al.*, 2019).[5] It initiated more laypersons participate in the nuclear issue. The real experiences and emotions are shared to form alternative knowledge that influences more people to make bigger concerned communities in global scale.

Korea is not an exception in such reversal even

with a strong efficiency discourse. The Fukushima nuclear power disaster was strong outside impulse to bring changes from the local anti-nuclear or nuclear waste disposal to wider post-nuclear movements as were in other countries. Civil participation was active in regard to nuclear energy related policy making process (Joo, 2018; Kang, 2019). The concerns with alternative energy and participating groups have become widened to layperson turned experts such as medical doctors, professors, law-makers, and religious groups to reducing the energy use and increasing the renewable energy production (Yun, 2015; Kang 2019).

The anti-nuclear and alternative energy movements began initially from the localities nearby the facilities, but now open to general public who are concerned with the nuclear risks and the way to conceive the risks affecting the practical everyday lives. The climate change is universally accepted real problem to be tangible to manage whereas risks tend to be treated asymmetrically to be emotional not empirical to be important in risk assessment. The lay knowledge accumulated from the experienced, the pitfalls divulged from expertism, and the risks and emotions have been significant in the orientation and deliberation of alternative science. Laypersons play important roles in the legitimation of alternative knowledge into practice of nuclear power policy. It tended to be local previously near the physical facilities, but now laypersons are making beyond nuclear landscape across places.

5. Conclusion

Nuclear power has been an attractive energy with its efficiency and with the climate change. However the risks are disastrous and divergent ranging from safety to environment and sustainability. Safety concerns are with system management protocol to design flaws in engineering, and security concerns are of black-market weapons that can lead to nuclear proliferation and confrontation. The history of nuclear power plants also clearly shows the complexity of nuclear power systems and how vulnerable they are to failure and meltdown, as well as the lack of policing and regulations on reactor access.

There have been far too many victims of nuclear power and incalculable environmental impacts. We ought to learn from those mistakes and misconception under the mainstream techno-optimistic thoughts and practices. In order to move beyond nuclear power, there are several approaches against the implausible pathway toward uncompromised safety and environmental problems of nuclear power. The basics are to have sustainable and beneficial options with less environmental impacts and decreasing the demand for electricity by efficient delivery and less usage. The choice is for resources to be invested into renewable alternatives such as wind, solar, tidal, and geothermal energy. Harnessed properly, they can power the world many times over. Taking this route will have exponential benefits for science, for politics, and for the earth. The environmental stewardship is another step to

move over the human centered ethic to companionship with the earth.

The two disastrous nuclear power plant accidents have made laypersons counter-expertise with local knowledge and taking risks into consideration. The dominant paradigm that the public are ill-informed and emotional about new technology and risks has lost its authority, and the conceivable risks and emotions are the basis of unifying diverse individuals and groups into one voice against the techno-bureaucratic decision making about nuclear matters. Laypersons play important roles in making alternative knowledge and ways to reduce the nuclear risks not only in the local but also in numerous places where the efficiency and risks are not evaluated in a balanced way. Laypersons are now able to make a new energy landscape across places beyond nuclear power.

Notes

1) The Chernobyl accident occurred in Ukraine, 1986 is the worst nuclear disaster in history. The second is the Fukushima disaster in Japan, 2011. These are the two rated at the maximum severity level on the international nuclear event. The highest level 7 is named 'major accident' involving major release of radioactive material with widespread health and environmental effects (Downer, 2015).
2) Recent concern with nuclear disaster has been mostly focused on the power plants accident. But the nuclear threat and security from weapons may add certain emotional response to the risks of nuclear technology.
3) The term layperson refers in general to actors outside the spheres of formal science and expertise. It could be called ordinary citizen, but specifically those who are counter-expertise aiming to check, counterbalance, and complement a given formal system of expertise and their knowledge and policy-making (Topcu, 2008; Roeser, 2011).
4) Often when a new technology is introduced, it is typical that experts assure the risks are negligible. But the general public worries about its risky aspects. Society responds to this in two ways: either ignore the emotions of the public or they take them as a reason to prohibit or restrict a technology. This pattern has occurred in controversial technological developments not only in nuclear energy, but others such as cloning, genetic modification, and vaccination (Roeser, 2011; Kim and Jung, 2017). These controversies have their own geographies; for example, GMO food is accepted in the US, but not in the UK (Robbins *et al.*, 2014). It means that there is no definite answer to the benefits and costs of new technology.
5) The Phenol Pollution of Nakdong River in 1991 is regarded as the greatest environmental pollution incident in Korea. It has played a great role to increase the environmental consciousness not because of the damage but because of the distrust governments did on the side of development. It was the turning point in environmental history along with the 1992 Rio declaration (Rho and Park, 2004).

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최초투고일 2021년 06월 01일
수 정 일 2021년 06월 15일
최종접수일 2021년 06월 21일