

Risk considerations and Countermeasures for Nuclear Energy in the ROK: From the perspective of the 4As concept of energy security

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1. Introduction

In 2022, the new government of the Republic of Korea (ROK) announced the abolition of the ‘Nuclear phase-out policy’ and pledged to rebuild the nuclear energy industry. This study intends to examine the risks and countermeasures of the use of nuclear energy from the energy security’s point of view by applying the 4A concepts of Availability, Affordability, Accessibility, and Acceptability.

‘Energy security’ usually means a stable supply of energy (resources). The International Energy Agency defined energy security as ‘the state in which energy sources are available without interruption at an affordable price’ [1]. Yergin defined it as ‘the state in which sufficient energy supplies are available at affordable price’ [2]. Asia Pacific Energy Research Centre proposed to discuss energy security in the categories of 4As [3].

‘Availability’ is demonstrated if a country has energy resources in its own territory or has countries to supply energy resources. Availability risks arise from the local ubiquity of energy resources, which is a geological factor. ‘Affordability’ is determined by economic factors such as production price, transaction price and price stability of energy resources. ‘Accessibility’ depends on geopolitical elements associated with energy resources. Accessibility risks arise when producers and consumers of energy resources do not belong to the same region under local ubiquity of resources (spatial discrepancy). ‘Acceptability’ risks attribute to the social and environmental issues that may arise in the production and use of energy resources [4, 5].

Availability (the supply of uranium) and affordability (the cost of nuclear power) of nuclear energy are identified without much disagreement. On the other hand, the social and environmental issues from the construction of nuclear power plants and spent nuclear fuel repository and the risk of nuclear proliferation face diverse judgements. Hence, this study focuses on accessibility and acceptability risk factors from the use of nuclear energy.

2. Accessibility

2.1 Risk considerations

The local ubiquity of energy resources forms an asymmetric power relationship among countries [6]. Not only market logic but also political interests create accessibility risks. The ambivalence of nuclear energy, which can be weaponized as an energy source, unlike fossil and gas resources, can lead to political and military tensions. The movement of nuclear material is overseen by international norms.

Reprocessing of spent nuclear fuel may pose an accessibility risk due to concerns about ‘nuclear proliferation’. Nuclear power generation can be sustainable by domestic reprocessing of spent nuclear fuel, which cannot happen in the ROK for now. PUREX, a wet processing, enables extracting plutonium from the spent nuclear fuel and thus its application is constrained [7]. Pyroprocessing, a dry processing, does not recollect plutonium and is considered to be free from nuclear proliferation constraint. The 2021 report from Joint Fuel Cycle Studies still cautiously withheld the conclusion about commercialization and proliferation resistance of pyroprocessing [8].

The energy security in the ROK is vulnerable to accessibility risks in the midst of military tensions on the Korean Peninsula. Public opinion for ‘nuclear armament’ is growing stronger in Korean society as North Korea provokes with nuclear tests and missile launches. According to a survey conducted by Gallup (opinion polling company) in 2013, 2016, and 2017, 64%, 58%, and 60%, respectively, were in favor of the ROK’s independent development of nuclear weapons [9]. Since the ROK is a signatory to the Nuclear Non-Proliferation Treaty, the ROK’s nuclear armament is impossible in principle. In addition, the ‘*Agreement for Cooperation Between the government of the USA and the government of the ROK concerning Civil Uses of Atomic Energy (1956)*’ prohibits reprocessing, researching, and building facilities of spent nuclear fuel for military purposes. However, even if it’s not feasible, public opinion of ‘strengthening nuclear capability’ could undermine the ROK’s reputation as a ‘peaceful user of nuclear energy’ and put a brake on its future use of nuclear energy.

A distinction must be made between nuclear energy as a weapon and nuclear energy as an energy source. Since reprocessing is a matter of conflicting identity of nuclear power, a more cautious approach is required.

2.2 Countermeasures

The Korean government must strengthen the trust of international community by continuously expressing its commitment as a 'peaceful user of nuclear energy' to non-proliferation of nuclear weapons. Public opinion such as 'enhancing nuclear capabilities' and 'nuclear sovereignty' should be wary of. The past incidents that made the ROK mistakenly perceived as a nuclear proliferation region should not be repeated. The expanded use of nuclear energy in the ROK should not be recognized by the international community as a sign of nuclear proliferation.

3. Acceptability

3.1 Risk considerations

The necessity of constructing a spent nuclear fuel disposal facility raises social and environmental issues, becoming a major obstacle to the social acceptance of nuclear energy.

3.1.1 Environmental sustainability

'Sustainability' means the use of economic, social and environmental resources to meet the need of the present in a harmonious and balanced manner without wasting or degrading the quality of resources for future generations to use [10]. The production and use of energy inevitably cause unintended environmental damage, such as greenhouse gas emissions and water pollution. Spent nuclear fuel is a risk factor that undermines the environmental sustainability of nuclear power. According to a survey conducted in 2020 by *the Asan Institute for Policy Studies*, 25.3% of the respondents cited 'difficulty in disposing waste' as reason for opposing nuclear power plants. 'Nuclear accident risk' and 'radiation exposure risk' were supported by 38% and 31.5%, respectively [11].

The ROK has not yet decided on a specific plan for reprocessing or disposal of spent nuclear fuel. In *the 2nd High Level Radioactive Waste Management Plan* in 2021, the Korean Ministry of Trade, Industry and Energy predicted that it would take 37 years from site selection to securing permanent disposal facilities. The temporary storage facilities in the power plants are expected to be saturated sequentially, starting with the Hanbit Nuclear Power Plant in 2031.

3.1.2 Social acceptance

Nuclear facilities can cause transnational disasters in the event of an accident, and the risk of harming the health of residents persists over a considerable period of time [12]. Factors influencing the social acceptance of nuclear facilities have been discussed from various perspectives. Previous studies have identified three factors influencing the acceptance of nuclear facilities: (1) perception of risk, (2) economic benefit, and (3) trust in the government and operating institutions [13].

Perception of risk refers to the level of risk subjectively recognized by social members, regardless of objective technical stability [13]. The dictionary definition of 'risk' is 'the possibility of something bad happening at some time in the future' [14]. The risk of nuclear facility can be defined as 'the possibility of undesirable events occurring due to the operation of the nuclear facility' [15]. Nuclear experts and local residents have different perceptions of the possibility of undesirable events. Nuclear experts believe that the facilities are operable if the possibility is very low. However, local residents think that the possibility at any level can be realized and are concerned about the aftermath of the incident. This is the reason why the probabilistic claim that 'the risk of nuclear accident occurs once a million years' is not accepted by local residents.

'Risk acceptance' means 'taking risks with a voluntary attitude under certain conditions rather than being forced by external coercion' [15]. Accepting the risks of nuclear power plants means that local residents are aware of the risks and, at the same time, believe the facility worth taking the risk.

Economic benefits increase the acceptance level [16]. In the region of nuclear power plants (Gori, Wolsong, Yeonggwang, and Uljin), economic benefits affected residents' acceptance [12]. However, despite increasing subsidy since 2007, residents' acceptance has not improved, raising questions about the effectiveness of the current subsidy system. The execution process of the subsidy program is pointed out to reduce the effectiveness of subsidies on the local economy [17, 18]. Most of the subsidy was paid for the construction of public facilities such as roads and buildings. Due to residents' perception of subsidy as compensation for economic damage, money was divided to village units (Eup, Myeon, or Ri) and was used for one-off wasteful projects such as village roads and farm road pavement [19]. Local conflicts over where to spend money always exist.

Finally, trust in the government and operating institutions is a decisive factor in residents' acceptance of nuclear facilities. All information from government and institutions to reduce risk awareness and increase risk acceptance, would be useless if the public does not trust the provider. The project from 1986 to 1998 to construct the disposal facility for low and intermediate level radioactive waste failed due to strong protests from the residents against the government-led unilateral

site selection. Public trust is enhanced as the government and institutions transparently disclose and manage the policy [12]. According to a survey conducted in 2020 by the *Committee on Review of the Spent Nuclear Fuel Management Policy*, the public's confidence in information from the government and nuclear power plant operators on the spent nuclear fuel management policy was only 68% and 48%, respectively [20].

3.2 Countermeasures

So far, only Sweden and Finland have secured public consent for the construction of a spent nuclear fuel depository facility. Table 1 summarizes the current status of nuclear power plants, the calendar of site selecting process, and activities to secure the consent.

Table 1.: Final disposal facilities in Sweden and Finland

	Sweden [21, 22]	Finland [23, 24]
Siting process	- '92 Launch siting process - '09 Select the Forsmark as a site - '22 Granted construction license for final disposal facility	- '83 Launch siting process - '01 Select the Olkiluoto as a site - '15 Granted construction license for final disposal facility
Current status	- Population density: 22.8/ km ² - NPPs: 10	- Population density: 16.5/ km ² - NPPs: 4
Improving risk perception	60 consultation from 2003 to 2009	Newsletters, consultation
Economic benefit [25]	A value-added project worth 50 million £ (Education, Infrastructure, Business)	Assess higher real estate tax (2.85%) on final repository than other facility (0.4~1.0%)
Securing trust	- Based on voluntary responses - Opening of facility and inviting residents	- Based on voluntary responses - The social construction of 'nuclear community'

SKB and POSIVA, Swedish and Finnish waste management companies, respectively, improved residents' understanding of the facilities by providing consultations and sending newsletters. They also provided refined information so that residents perceive

risk from objective points of view. According to SKB and POSIVA, the residents' high level of understanding of the facilities had a positive effect on site selection [21, 24]. Sweden has provided economic benefits by leading regional development through value-added projects. Through more 60 consultations over the eight years, SKB could secure the trust of the residents.

In the ROK, efforts by the government and institutions to form a 'one nuclear community' with local residents are needed. It is important for residents to recognize that the construction of spent nuclear fuel facility is a 'local project', not a 'project of Korea Hydro & Nuclear Power and the government'. Institutional system should be established so that residents can experience that the operation of nuclear facilities is a driving force for regional development. It is worth considering a plan to include a portion of the proceeds or taxes granted to the facility in the city budget and ensure participation of residents in public hearings so that residents' opinions can be expressed in the process of facility operation and policy.

4. Conclusions

Nuclear energy plays a positive role in energy security. *1st and 2nd Energy Master Plans* recognize the contribution of nuclear energy to energy security in the ROK. In order to secure public consent for sustainable nuclear power generation, the risk factors of nuclear power generation should be clearly identified and countermeasures should be suggested.

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