Determinants of Public Acceptance by Spent Nuclear Fuel Management Strategy : Direct Disposal versus Pyroprocessing

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1. Introduction

The management of spent nuclear fuel (SNF) has evolved into one of the most intractable socio-technical challenges for nations integrated into the nuclear energy landscape. As global energy demands and climate imperatives drive a resurgence in nuclear power, the "back-end" of the fuel cycle remains a focal point of intense policy contention. Central to this impasse is the strategic divergence between direct geological disposal—the permanent isolation of untreated waste—and reprocessing/recycling, which leverages advanced technologies to recover fissile materials and reduce radiotoxicity. In the South Korean context, this choice is not merely a technical optimization problem but a profound source of social conflict. While direct disposal offers a linear, theoretically simpler path, reprocessing (specifically through pyroprocessing linked with fast reactors) is often framed as a means to enhance resource sustainability and minimize the physical footprint of high-level waste. However, both trajectories face significant hurdles in public acceptance, as the perceived risks associated with long-term radiological safety and nuclear proliferation intersect with deep-seated public anxieties. In South Korea, significant social conflicts have arisen in the selection and construction of the low- and intermediate-level radioactive waste disposal facility in Gyeongju, and similar public conflicts are anticipated regarding SNF management strategies. Public conflict in Korea is a frequent social phenomenon that emerges during the implementation of national and regional projects, often involving clashes among diverse stakeholders. When such conflicts escalate, they can lead to economic losses, erosion of trust, increased social costs, and ultimately a failure to achieve public acceptance [1].

This study aims to identify the differences between theoretical and actual determinants of public acceptance for two practical technical approaches to spent nuclear fuel management. Moving beyond the traditional theory-driven exploration of public acceptance, the study emphasizes the incorporation of stakeholders' actual opinions to derive factors that can effectively enhance acceptance. The results provide evidence-based insights to inform policy recommendations, highlighting variables that can strengthen public acceptance through transparent engagement and responsive governance in the development of spent nuclear fuel management strategies.

2. Methods

This study employed a three-stage qualitative research design. In the first stage, approximately 50 prior studies on the acceptance of SNF and HLW were systematically reviewed. The analysis primarily focused on empirical and experience-based domestic studies that reflect the perspectives and lived experiences of actual stakeholders. In the second stage, in-depth interviews were conducted with key representatives responsible for communication and decision-making in four NPPs host communities; Uljin, Gijang, Wolseong, and Yeonggwang. A semi-structured questionnaire was developed based on constructs of knowledge, perception, attitude, and behavioral determinants. In each region, participants were purposively selected and divided into pro- and anti-nuclear groups, with two individuals from each group participating in the interviews. In the third stage, to ensure content validity of the findings derived from Stages 1 and 2, expert consultations were conducted with individuals who had participated in nuclear policy-making and public deliberation processes, including committee members and policymakers. Similarly, participants were categorized into pro- and anti-nuclear groups, with two individuals from each group providing in-depth advisory input. Unlike conventional quantitative approaches, this study adopts an integrative qualitative methodology combining literature review, in-depth interviews, and expert consultations, focusing on key stakeholders directly involved in nuclear policy processes. This multi-layered approach enhances the practical validity and contextual relevance of the identified determinants related to SNF management. The findings are expected to provide a robust empirical foundation for future large-scale public surveys and policy development.

3. Results and Conclusions

3-1. Public Conflict Factors and Acceptance of High-Level Radioactive Waste

In South Korea, public conflict frequently arises in national and regional projects, particularly regarding nuclear energy and high-level radioactive waste (HLW)

management. Such conflicts are driven not solely by technical issues, but by social construction, value divergence, and stakeholder interest conflicts. Key determinants include limited transparency in policy-making, information asymmetry, inadequate two-way communication, procedural unfairness, and lack of trust in government and institutions. Empirical studies indicate that conflict types encompass policy, environmental, regional (NIMBY), and socio-cultural conflicts, while causes include unilateral government action, insufficient stakeholder engagement, and absence of conflict mediation mechanisms.

For HLW management, local acceptance is primarily influenced by trust, perceived procedural fairness, and risk perception. NIMBY attitudes are not merely selfish resistance but emerge from complex interactions of distrust in authorities, perceived risks, insufficient information, and lack of participatory processes. Monetary compensation alone is insufficient; participation, transparency, and sustained communication are critical. Governance and policy communication strategies are central to conflict mitigation, emphasizing collaborative approaches, stakeholder engagement, and evidence-based, audience-centered messaging. International comparisons suggest that early information disclosure, institutionalized public deliberation, and inclusive participation enhance acceptance and reduce conflict. In South Korea, however, centralized authority, formalistic participation, limited information disclosure, and incentive-based compensation structures have weakened social trust and acceptance, underscoring the need for participatory governance, legal frameworks, and trust-building measures to achieve sustainable HLW management.

3-2. Perceptions of SNF and Determinants of Acceptance in Nuclear Host Communities

This study synthesizes in-depth consultations with pro- and anti-nuclear local leaders in four nuclear host communities—Wolseong, Gijang, Uljin, and Yeonggwang—to examine local perceptions of SNF and the key determinants shaping acceptance and conflict. Across regions, awareness of SNF as a technical term is generally low, particularly among elderly populations. Residents are more familiar with simplified or emotive terms such as “nuclear waste” or “high-level radioactive waste.” Technical concepts such as pyroprocessing or advanced reactor systems are largely unknown to the general public. Even in communities with long-term exposure to nuclear facilities, knowledge of the actual risk level remains limited, and perceived risk is often shaped by symbolic associations (e.g., nuclear energy = radiation = explosion = danger).

Trust emerges as the most critical determinant of acceptance. Perceived policy inconsistency, past unfulfilled promises, centralized decision-making, and unequal compensation mechanisms significantly undermine institutional credibility. In several regions, residents believe that compensation and development benefits are inequitably distributed, particularly within the 5-km radius of nuclear plants. Procedural fairness—early information disclosure, meaningful participation, and transparent communication—is therefore a stronger predictor of acceptance than monetary compensation alone.

Risk perception varies across regions. In long-standing nuclear communities such as Uljin, experiential familiarity has reduced emotional anxiety, whereas in other regions, political framing, activist mobilization, and media narratives amplify perceived risk. Importantly, opposition is not solely rooted in safety concerns but also in distributive justice, regional equity, and political distrust.

Another significant factor is the politicization of nuclear policy. Local leaders consistently describe SNF management not only as a technical issue but as a political and governance issue influenced by partisan conflict, activist groups, and strategic use of risk narratives to negotiate economic benefits. In some communities, a “compensation-oriented culture” has developed, where heightened expressions of concern are perceived as increasing bargaining power.

Overall, the determinants of SNF acceptance in nuclear host communities can be categorized into five major variables: (1) institutional trust and policy consistency; (2) procedural fairness and participatory governance; (3) perceived risk and symbolic associations; (4) distributive justice and compensation equity; and (5) political framing and social mobilization dynamics. The findings suggest that enhancing acceptance requires long-term trust-building, equitable benefit distribution, context-sensitive communication strategies, and collaborative governance structures rather than one-way promotional [2-4]

3-3. Determinants of Preference for Direct Disposal versus Pyroprocessing of SNF: Insights from Nuclear Policy Leaders

The results of the third stage will be derived from in-depth interviews scheduled to be conducted in March, and the findings will be included in the paper presentation. The discussion will encompass variables influencing the selection of spent nuclear fuel treatment and disposal methods, incorporating human factors, social factors, environmental factors, and physical factors.

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