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RESEARCH ARTICLE

„We have a solution’: Delivering on the promise to take national responsibility for nuclear waste management

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Abstract • We examine the realization of the umbrella promise to assume national responsibility for the final disposal of spent nuclear fuel. Three case studies are used to illustrate how Finland delivers on the promise to take care of its own nuclear waste – a promise that has greatly contributed to the legitimacy of nuclear power in Finland. The article shows how this promise is being challenged by new competitors, business visionaries, and the public. The case studies illustrate the tensions between those who made the promise and the actors who interpret and mobilize the promise for varying purposes and under changing circumstances. We investigate techno-scientific promises by looking at debates about (1) the idea of a national solution, (2) the limitations that the promise of a national solution places on international business opportunities in the waste sector, and (3) the challenges related to credibility and spatial requirements in managing waste from small modular reactors.

„Wir haben eine Lösung’: Einlösung des Versprechens zur nationalen Verantwortung für die Entsorgung nuklearer Abfälle

Zusammenfassung • Wir untersuchen die Umsetzung des Versprechens zur nationalen Verantwortung für die Endlagerung von abgebrannten Kernbrennstoffen. Anhand von drei Fallbeispielen wird gezeigt, wie Finnland das Versprechen umsetzt, sich um seinen eigenen Atommüll zu kümmern – ein Versprechen, das wesentlich zur Legitimität der Kernenergie in Finnland beigetragen hat. Der Artikel zeigt, wie dieses Versprechen durch neue Wettbewerber, unternehmerische Visionäre und die

Öffentlichkeit infrage gestellt wird. Die untersuchten Fälle veranschaulichen die Spannungen zwischen denen, die das Versprechen abgegeben haben, und den Akteuren, die das Versprechen für unterschiedliche Zwecke und unter sich ändernden Umständen interpretieren und mobilisieren. Wir untersuchen technisch-wissenschaftliche Versprechen anhand von Debatten über (1) die Idee einer nationalen Lösung, (2) die Einschränkungen, die das Versprechen einer nationalen Lösung für internationale Geschäftsmöglichkeiten im Abfallbereich mit sich bringt, und (3) die Herausforderungen in Bezug auf Glaubwürdigkeit und räumliche Anforderungen bei der Entsorgung von Abfällen aus kleinen modularen Reaktoren.

Keywords • promises, nuclear waste, repository, Finland, responsibility

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Changing context, changing promises

The promise of national responsibility for the management of spent nuclear fuel (SNF) generated in the country has helped to make Finland a forerunner among the developers of deep geological disposal. Posiva¹, the nuclear waste management (NWM) company has proudly announced: “We have a solution” (Posiva Oy 2022). Other Finnish actors have frequently relayed the message. However, back in the early 1980s, the Finnish SNF management policy relied on the exportation of SNF and thus on international (Soviet and Western) nuclear fuel cycles. The policy

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changed in 1994. The revised Nuclear Energy Act prohibited the export and import of nuclear waste and stipulated that nuclear waste generated in Finland (with the exception of waste from research reactors) must be permanently disposed of in the country itself (Sandberg 1999). Thus, Finland promised to take responsibility for its own nuclear waste. Eurajoki, the proposed repository siting municipality, also adhered to this idea, announcing in 2000 that it would accept only Finnish SNF for disposal on its territory (Kojo 2009, p. 184).

This article examines the ways in which the promise of national responsibility has been gradually transformed, in response to the changing context and as a result of active promise-construction work by the key actors. Three case studies from the post site selection phase in Finland serve as illustration. Document analysis and opinion surveys are used to illustrate the promises and their consequences, including the implications for the credibility of the promise in the eyes of residents.

The government issued a decision in principle (DiP) in 2000 for the final geological disposal of 4000 tU (from the Olkiluoto 1-2 and Loviisa 1-2 nuclear power plant (NPP) units), and confirmed Olkiluoto, in the municipality of Eurajoki as the site for the repository. In 2002, as part of the DiP for the new Olkiluoto 3 unit, the government approved the expansion of capacity by the 2500 tU that the new reactor was expected to produce. The construction permit for the encapsulation plant and the repository with a capacity of 6500 tU was granted in 2015. In 2021, Posiva submitted its application to operate the repository from 2024 until 2070.

The perspective of techno-scientific promises

The ‘success story’ of the Finnish nuclear waste management (Lehtonen 2021) can be described as a process of successfully constructing promises that are collectively experienced as credible and legitimate. Promises and expectations are vital to the development and deployment of techno-scientific innovations. They set things in motion by aligning actors, institutions, and capital; they “guide activities, provide structure and legitimation, attract interest and foster investment” (Borup et al. 2006, pp. 285–286; see also July 2010; van Lente 2012).

In this article, we focus on the continuous need to reshape and even radically transform the promise to ensure its legitimacy and credibility. We use the term techno-scientific promise to encompass 1. the relatively vague visions (‘umbrella promises’), 2. more specific statements about the future of a given technology, and 3. the institutionalization and materialization of promises in policies, laws and regulation, funding decisions, projects, and commercial applications (Parandian et al. 2012). Promises vary in their degree of self-evidence and in their content (e.g., technical, commercial, societal, symbolic, and material aspects). Promises differ from other expectations in that they are, by definition, positive, as well as relational, that is, they en-

tail interaction between ‘promise-makers’ and ‘promise-takers’. The confrontation of promises and counter-narratives in debates between these rival groups can play a constructive role as ‘trials of strength’ that can strengthen the promise and its social robustness (Alvial-Palavicino 2015, pp. 158–159; July 2010).

Van Lente (2012) identified three main positive functions of promises: In particular, broad ‘umbrella promises’ legitimize investment by referring to a promising future; they provide direction by facilitating choice among options; and they help coordinate action by providing insight into the behavior of other actors in the system. When successful, promises create inescapable ‘passage points’, a sense that a particular technology is essential to achieving desired societal goals and visions (July 2010). More generally, promises link past, present, and future by drawing their power from historical precedents, on the one hand, and positive or negative future scenarios, on the other (Chateauraynaud and Debaz 2017).

The construction of umbrella promises of national responsibility

To explain why the promise of national responsibility for SNF management is crucial to the Finnish nuclear industry, we must first examine the origins and institutionalization of this umbrella promise, which can ultimately be traced back to Finland’s accession to the European Union in 1995. The Finnish bedrock was repeatedly portrayed in the public debate as a potential target for imported nuclear waste – the horror picture was a ‘graveyard’ for foreign nuclear waste in Finland.

The emergence of the promise of national responsibility was also fueled by growing criticism of SNF exports from the Loviisa NPP to Russia. As a result, an amendment to the Nuclear Energy Act banned both exports and imports of nuclear waste. This, in turn, prompted IVO and TVO to establish a joint SNF management company, Posiva, in 1995, to help the companies meet their legal disposal obligation (Darst and Dawson 2010, pp. 67–69; Sandberg 1999; Nikula et al. 2012, pp. 37–39, 71).

Without explicitly using the term, the law essentially defines national responsibility by prohibiting the export and import of nuclear waste. The law states that “nuclear waste generated in connection with or as a result of use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland” and that “nuclear waste generated in connection with or as a result of the use of nuclear energy elsewhere than in Finland shall not be handled, stored or permanently disposed of in Finland”².

The promise of national responsibility in Finland was further advanced by a change in policy, namely the abandonment of the reprocessing option. Initially, the policy envisioned reliance on the international nuclear fuel cycle, i.e., shipment of SNF abroad for reprocessing. Responsibility for the practical implementation and funding of NWM rests with licensees. No

2 Nuclear Energy Act 990/1987, 6 a, b.

state nuclear waste agency has ever been established, although this option was included in the Atomic Energy Act in 1978 (Nikula et al. 2012, pp. 58–59, 64).

In 1981–1996, IVO transported SNF from its Soviet Loviisa-type NPP units to the Soviet Union and later to Russia, as agreed by the Finnish and Soviet governments in 1969 (Sandberg 1999, pp. 45–46). TVO also inquired about the availability of reprocessing services in several countries. The situation changed in the mid-1970s when the companies providing reprocessing services changed the terms of the contract and required that waste producers such as TVO commit to taking back and disposing of the remaining high-level waste after reprocessing. TVO also found the contract too expensive (Darst and Dawson 2010, pp. 65–66; Nikula et al. 2012, pp. 58, 79). In 1976, the Ministry of Trade and Industry established a working group to investigate NWM in Finland, and in 1978 and 1983, the government adopted the policy (Suominen 1999, pp. 25–26, 30–31). However, IVO could continue exporting SNF, because the Soviet Union did not require the return of residual waste.

Until the 1994 amendment of the Nuclear Energy Act, reprocessing was the primary objective for licensees, as defined in the 1983 policy decision. In the early 1980s, TVO started planning direct disposal of SNF in Finland, based on the Swedish KBS3 concept (Kojo and Oksa 2014a, pp. 24–25). At that time, the cost of reprocessing was estimated to be twice that of direct geological disposal (Nikula et al. 2012, pp. 77, 88). The import and export ban institutionalized the promise of national responsibility. In the following years, Posiva invoked this promise in its communications by emphasizing that it managed the nuclear waste generated by Finland's NPPs. The company presented itself as guardian of the nation's interests, not just those of its owners (Kojo 2002, p. 41). In addition, the Eurajoki host municipality announced in 2000 that it would only allow SNF from the Finnish NPPs at the Olkiluoto site (Kojo 2009, p. 184).

The case studies

Our first case study examines the transformation work and the dispute over the meaning of the relatively vague and visionary umbrella promise (Parandian et al. 2012). The case shows how this vision of 'our solution' was first challenged by the Finnish energy companies. It illustrates the difficulties faced by a new entrant that wanted to join Posiva's repository project, and how the views of Posiva's owners about a possible expansion of the Olkiluoto repository underpinned the need for a second repository in Finland. To protect their interests, Posiva and its owners had to specify the umbrella promise.

Specifying the umbrella promise: the dispute over the promise of national responsibility

In 2007, the newly established energy company Fennovoima applied for a permit to build a new NPP and therefore needed to demonstrate that it had a reliable NWM solution. The com-

pany announced that it would manage its SNF jointly with Posiva. In doing so, Fennovoima emphasized national responsibility, arguing that Posiva had been established to manage all SNF generated in Finland in a single Finnish repository in Olkiluoto (Fennovoima 2009, p. 11). Posiva, however, developed a counter-narrative by invoking the principle of licensee-specific responsibility – the obligation of each energy company to take care of its own SNF. Posiva also argued that its owners would need the limited space in Olkiluoto for future energy production. It was also unwilling to dig disposal tunnels that would run under the sea or the NPP (Kojo and Oksa 2014b, p. 32.)

The promise of national responsibility has not only underpinned the rejection of reprocessing and long-term interim storage as unacceptable NWM solutions, but also helped to consolidate the position of nuclear power as a cornerstone of Finnish energy and climate policy. In its DiP application, Fennovoima (2009, p. 11) announced that it would develop and implement SNF disposal together with other Finnish utilities bound by the nuclear waste management obligations, to improve operational safety and reduce costs. Fennovoima further noted that the state could require licensees to cooperate if necessary to ensure the general welfare of society, as stipulated in the Nuclear Energy Act.

Parliament ratified the DiP for Olkiluoto 3 in 2002 and for Olkiluoto 4 and Fennovoima's Hanhikivi 1 in 2010. At the same time, the government approved Posiva's application to expand the final disposal capacity to accommodate SNF from Olkiluoto 3 and 4. The government gave Fennovoima six years to either agree on final disposal of SNF with TVO and Fortum or launch an Environmental Impact Assessment (EIA) procedure for its own repository (Finnish Government 2010, p. 16). Fennovoima's EIA program (Fennovoima 2016, pp. 16–17) indicated Eurajoki, albeit excluding the Olkiluoto site, as the first choice for repository, and the municipality of Pyhäjoki – the host of its planned new NPP – as the second option.

The promise of national responsibility failed to coordinate actions when a new player appeared on the scene. Posiva's shareholders, TVO and Fortum, repeatedly indicated that they were not interested in discussing final disposal with Fennovoima. They described Posiva as 'our solution', and the repository as designed to receive waste only from its owners' plants, including the possible new Olkiluoto 3 and 4 units – although the state is the majority owner of Fortum, it did not exercise its steering power on this issue (Kojo and Oksa 2014b, p. 18). Posiva explicitly ruled out nationalization and sought to strengthen its image as a private company accountable solely to its owners.

The ministry struggled to force the companies to cooperate on NWM. Cooperation in the form of know-how and provision of services came about only after the ministry established a joint working group with the companies in 2012 (Kojo and Oksa 2014b, pp. 33–38). Later, in 2016, Posiva's subsidiary Posiva Solutions signed an agreement with Fennovoima on technical expert services related to site selection (Lehtonen et al. 2021, p. 135), but Fennovoima was never allowed to participate in Posiva's SNF repository project.

Stretching the national responsibility to create business opportunities

Our second case study describes another shift in promise, provoked by recent initiatives that propose to turn NWM into a major business opportunity, building on Finland's reputation as a pioneer. For example, the former deputy director general of the International Atomic Energy Agency, Olli Heinonen, proposed building a few additional repositories in Finland for waste from abroad to make the country a model for others and reduce the risks of terrorism and proliferation (Heinonen 2012). To make this promise a reality, economic visionaries sought to extend the scope of the promise from national to international responsibility. This, in turn, would require lifting or softening the ban on waste imports.

For Avalon Energia, a network of repositories would pave the way for further construction of nuclear power. It predicted that “public support for nuclear energy skyrockets if the waste issue is solved” (Nemlander 2019, p. 22). Avalon described Finland as “the best chance for international HLW [high-level waste] repositories due to politics, geology, tech and limited time” (Nemlander 2019, p. 22) but saw permanent geological disposal only as a step towards the ultimate goal of recycling of HLW, once the technology would become available.

Like Avalon Energia, the ESF stressed the importance of waste management in the nuclear technology service packages (ESF 2021 b). The Society's suggestions aligned with calls from Finnish Energy, the Finnish energy-sector advocacy group, for a market-based and technology-neutral approach to NWM from

Nearly half (43 %) opposed final disposal, and 46 % opposed long-term storage in their neighborhoods.

Two recent corporate initiatives illustrate the transformation: One launched by the start-up Avalon Energia established in 2017, and another by the Ecomodernist Society of Finland (ESF), a pro-nuclear NGO founded in 2015. To legitimize the promise, which he described in his LinkedIn-profile as safely disposing of “global high-level nuclear waste in a network of deep geological repositories in the bedrock of Finland”, Robert Nemlander argued this would bring economic benefits to the host municipalities, the company, the government, and society at large, but would also help to create a better world for our children by combating climate change via greater use of nuclear power (Nemlander 2019, pp. 36–37). Importing waste would generate profits of some ten billion euros per year, that is, one trillion euros over the hundred years of the repository operation; enough to allow Finland to introduce universal basic income. If reprocessed, Nemlander argued on LinkedIn, the imported SNF could “power the entire planet with clean energy for over 70 years”. Avalon's action plan highlights gaining public support and identifying repository sites as important steps on the path to Finnish NWM business.

In 2021, the ESF suggested legislation and research and development as tools for advancing Finnish NWM exports. The ESF proposed amending the Nuclear Energy Act to allow trade in SNF, as this would remove barriers to rational climate solutions and vast export opportunities for Finland in technologies such as nuclear-powered district heating. In addition, the amendment would help other countries to clean their energy systems, consolidate Finland's reputation as a low-carbon country, and enable Finland to export service packages for the entire nuclear energy life cycle including the handling of nuclear waste. Given Finland's pioneering role in responsible nuclear waste management, the change would also be ethically justified (ESF 2021 a).

small modular reactors (SMRs) to keep the door open for various disposal options, including reprocessing and SNF export. “The regulation should enable business in new areas of nuclear energy” and “guide solutions only to the extent necessary to ensure safety, security, and non-proliferation” (Finnish Energy 2021, p. 5).

Credibility of the promise: NWM of small modular reactors

A third challenge for the initial promise of national responsibility stems from the planned SMRs, and local residents' views on the options for managing SNF from such reactors. A positive expectation of citizens regarding SMR waste would be an indication that promise-building has succeeded in convincing a stakeholder group that is important for the development of the technology. Crucially, the decentralized nuclear power production model entailed in the SMR vision questions the promise of national responsibility. As nuclear power is increasingly framed as a key contributor to energy security and combat against climate change, SMRs have been suggested as a means of decarbonizing district heating, necessary for the cities in the Helsinki Metropolitan area to reach its CO₂ emission reduction targets. However, little attention has been paid to the management of nuclear waste from SMRs – a potential obstacle to the fulfilment of the SMR promise. Crucially, the option of siting the waste locally challenges the vision of a centralized national solution. Results from a resident survey conducted in the Helsinki metropolitan area in November 2021 reflect the ambiguities, hesitations and contradictions involved. Indeed, citizen's opinions were divided, both on the possible construction of SMRs and on the associated waste management options (Kojo et al. 2022).

Most respondents expressed reluctance to the idea that SNF accruing in SMRs should be handled at the local level. Nearly

half (43 %) opposed final disposal, and 46 % opposed long-term storage in their neighborhoods.

However, in apparent contradiction with this reluctance to accept local solutions, 57 % of the respondents agreed that transporting waste generated by SMRs would be dangerous. The possibility of transnational waste trade faced mixed views: 45 % opposed the idea of disposing of imported nuclear waste at the Eurajoki site, while 48 % held a neutral opinion regarding a possible amendment to the Nuclear Energy Act that would allow SMR waste to be returned to the producer abroad.³ Most respondents (60 %) favored a centralized solution to the final disposal of SMR waste. However, the preferred location of SMR waste management remained unclear, as half of the residents were neither clearly in favor nor against disposing of the waste in Eurajoki, the site of the original 'national solution'.

Conclusions

In the past decades, the promise of national responsibility was a political statement used to allay fears that nuclear waste would be imported to Finland (after the country joined the European Union) and to demonstrate that nuclear waste from new NPP units would be managed responsibly. In the 1990s, the nuclear industry still believed that the construction of multinational repositories would conflict with the national disposal plan (Nikula et al. 2012, p. 92). Since then, the situation has changed. Some actors have suggested legislative changes that would allow imports and exports of nuclear waste, generate business opportunities, and diversify the options for managing waste from possible SMRs.

This article described the gradual transformation, in reaction to changing circumstances, of the umbrella promise that has underpinned the continuity and legitimacy of nuclear power in Finland, namely that the country takes care of its own nuclear waste. Changing policy circumstances and pressure from diverse involved actors have led to further specification and continuous disputes over the very nature of the promise of national responsibility, with attempts to redefine this responsibility in international rather than national terms. This promise-transformation work involved, first, the entry of a new player in the field. The incumbent players were unwilling to accept the new entrant, and prioritized licensee responsibility for SNF management over a national centralized repository solution. Second, the transformation of the business landscape further spurred a move away from the narrative of a centralized national solution, as the energy industry, start-ups, and ecomodernists brought to the table visions in which waste trade and SMRs would open lucrative new business opportunities, in the spirit of national interest. Third, the incipient efforts to bolster the legitimacy and credibility of the

SMR vision in the eyes of the public are reflected in the relatively positive views among local residents concerning possible SMRs. However, the unresolved issue of how to deal with the waste from a possible decentralized SMR fleet divides residents' opinions and forces further changes to the initial version of the national responsibility promise, built on the vision of centralized waste management.

Earlier research on techno-scientific promises have often either stressed the role of hype-disappointment cycles (Parandian et al. 2012) or analyzed the various functions of promises (Van Lente 2012). Our case studies highlight the need to complement such analysis of the performative power of a given promise with more fine-grained studies of the ways in which the initial promise gets transformed through active transformation work undertaken by the involved actors, and how policy, innovation, promises as well as actor behavior and preferences co-evolve. In current Finnish NWM policy, such transformation efforts imply pressures towards more market-oriented policy approaches.

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³ In 2016, almost three out of four of Finns disagreed with the statement "I accept the final disposal of nuclear waste generated abroad in Olkiluoto, if it is found to be safe", Aarnio et al. 2017, p. 19

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