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Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea

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Abstract STS research has devoted relatively little attention to the promotion and reception of science and technology by non-scientific actors and institutions. One consequence is that the relationship of science and technology to political power has tended to remain undertheorized. This article aims to fill that gap by introducing the concept of "sociotechnical imaginaries." Through a comparative examination of the development and regulation of nuclear power in the US and South Korea, the article demonstrates the analytic potential of the imaginaries concept. Although nuclear power and nationhood have long been imagined together in both countries, the nature of those imaginations has remained strikingly different. In the US, the state's central move was to present itself as a responsible regulator of a potentially runaway technology that demands effective "containment." In South Korea, the dominant imaginary was of "atoms for development" which the state not only imported but incorporated into its scientific, technological and political practices. In turn, these disparate imaginaries have underwritten very different responses to a variety of nuclear shocks and challenges, such as Three Mile Island (TMI), Chernobyl, and the spread of the anti-nuclear movement.

Keywords Sociotechnical imaginary · Nuclear power · Science and technology policy · Comparative policy · US · South Korea

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Introduction

Work in science and technology studies (STS) has done much to reveal complex social dynamics in the production of scientific claims (Jasanoff et al. 1995), the design of technological artifacts (Bijker et al. 1987; Winner 1986), the assessment of risks and benefits (Wynne 1987), and the formation of expert knowledges and cultures (Jasanoff 1990). STS scholarship, however, has devoted substantially more attention to the products of scientific disciplines, labs, clinics, and other professionally bounded spaces than to the promotion and reception of science and technology (S&T) by non-scientific actors and institutions. One result is that the relationship of science and technology to political institutions has tended to remain undertheorized. Even in highly political environments, STS research tends to be drawn to scientific and technological innovation as an end in itself, in preference to more complex relationships among knowledge, its applications, and power. For example, STS scholars have illuminated how technical knowledge gets made in regulatory standard-setting, litigation, and expert consensus-building (Jasanoff 1990, 1995; Hilgartner 2000; Edmond and Mercer 2000). Increasingly, as well, attention has turned (or, more accurately, *returned*) to the role of experts in technical decision making (Collins and Evans 2007; Jasanoff 1995; Wynne 1982). Why states support science rarely gets asked.

With few exceptions (Jasanoff 2005; Ezrahi 1990; Mukerji 1989), empirical work in STS has not interrogated the role of the state in defining the purposes of publicly supported science and technology: what constitutes the public good, which publics should be served by investments in S&T, who should participate in steering science and by what means, and how should controversies be resolved about the pace or direction of research and development? A reciprocal question has also gone largely unnoticed: how do national S&T projects encode and reinforce particular conceptions of what a nation stands for? Only by addressing such questions head-on can one begin to understand why S&T policies take the forms they take, why they often diverge radically across nation states, and how S&T policymaking could better serve democratic interests in an era of globalization.

In this paper, we introduce the concept of "sociotechnical imaginaries" to explore the sources of long-lasting cross-national variations in S&T policy. We define national sociotechnical imaginaries as "collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects." Imaginaries, in this sense, at once describe attainable futures and prescribe futures that states believe ought to be attained. In the 2008 US presidential campaign, for example, Barack Obama repeatedly referred to the Apollo mission—shorthand for the claimed US capacity to plan and execute superhuman technological feats—as the inspiration for a massive program to achieve energy self-sufficiency in ten years. Such visions, and the policies built upon them, have the power to influence technological design, channel public expenditures, and justify the inclusion or exclusion of citizens with respect to the benefits of technological progress.

A basic assumption of this article is that sociotechnical imaginaries can be identified, illuminated, and critiqued through cross-national comparison. National

policies for the innovation and regulation of science-based technologies are useful sites for examining imaginaries at work. Such policies balance distinctive national visions of desirable futures driven by science and technology against fears of either not realizing those futures or causing unintended harm in the pursuit of technological advances. S&T policies thus provide unique sites for exploring the role of political culture and practices in stabilizing particular imaginaries, as well as the resources that must be mobilized to represent technological trajectories as being in the "national interest."

To give these observations empirical weight, we offer a two-country comparison of a single policy domain: nuclear power in the US and South Korea over the past half-century. Our aim is not to produce a comprehensive historical account of nuclear energy policies in the two countries; nor is it a conventional exercise in paired comparison that relates policy differences between similar political systems to identifiable causal factors ("independent variables"). Indeed, there was not much in common to start with between the superpower that originally harnessed atomic energy and a small East Asian latecomer in nuclear technology. In the current global market, however, the US is no longer the leader it once was. In a recent interview with us, the noted physicist and science adviser Richard Garwin said that, even if the US were to resume nuclear power plant construction, it would have to "buy plants from foreign manufacturers. We don't have the capacity... We don't have any domestic manufacturers who are experienced in building nuclear plants."[1] By contrast, South Korea now has the sixth largest nuclear power capacity in the world—after the US, France, Japan, Russia, and Germany—and is aggressively pursuing the export of its own reactors, power plant equipment, and engineering services to new markets in China, Southeast Asia, and Eastern Europe (IAEA 2008; KHNP 2009). This remarkable change of position provides a starting point for comparing the imaginaries of nuclear power that drove state policies in such different directions.

Although nuclear power and nationhood have been imagined together in both countries since the beginning of the atomic age, the nature of those imaginations has remained strikingly unlike. In the US, the explicit, central move was to create a newly manageable entity, the "atom for peace," which converts nuclear energy from terrifying to benign form. As custodian of *this* atom, the state represents itself as a responsible regulator of a potentially runaway technology that demands effective *containment*. At the same time, the state has largely delegated the task of development and promotion to the private sector. South Korea, by contrast, retains responsibility not just for regulation but also for the development of nuclear power through a logic of self-reliance. In the national imaginary, the implicit source of nuclear power is the "atom for development," which South Korea has incorporated into its functioning as an effective and credible state. In turn, these disparate logics have underwritten very different responses to a variety of nuclear shocks and challenges, such as Three Mile Island (TMI), Chernobyl, and the spread of the anti-nuclear movement. The technological systems for nuclear power that have evolved

[1] Interview with Richard Garwin, April 16, 2009, Cambridge, MA.

in each country have also diverged, not only in power plant design, but in strategies and techniques of risk assessment and radioactive waste management.

Below, a brief theoretical elaboration of the concept of sociotechnical imaginaries lays the groundwork for the two national case studies, a comparative discussion, and conclusions. Our method is longitudinal and interpretive. The relative stability of sociotechnical imaginaries can only be illustrated through historical analysis, showing how these are invoked and re-performed at key turning points in policy formation. Since language is a crucially important medium for the construction of imaginaries, we identify and compare recurrent discursive elements in each country's official policy narratives for nuclear power.[2] We thereby establish not merely that broad societal imaginations have shaped the life trajectories of nuclear power, but that the processes of formulating and implementing nuclear energy policies have simultaneously reinforced particular imaginations of risk and benefit, public good, and nationhood.

Sociotechnical Imaginaries

The concept of sociotechnical imaginaries builds in part on the growing recognition that the capacity to imagine futures is a crucial constitutive element in social and political life. Imagination is no longer seen as mere fantasy or illusion (Sarewitz 1996), but as an important cultural resource that enables new forms of life by projecting positive goals and seeking to attain them. Nor is imagination understood as simply residing in individual minds in the form of aesthetic considerations. Rather, imagination helps produce systems of meaning that enable collective interpretations of social reality (Castoriadis 1987); it forms the basis for a shared sense of belonging and attachment to a political community (Anderson 1991); it provides the gaze through which "the Other" is constructed and represented (Said 1978); and it guides the simplification and standardization of human subjects so as to govern them more efficiently (Foucault 1979; Bowker and Star 2000; Scott 1998). In short, imagination, viewed as "an organized field of social practices," serves as a key ingredient in making social order (Appadurai 1996; Taylor 2004).

Histories of scientific and technological discovery long maintained that, in these specialized domains, imagination appears primarily in the creative minds of individual scientists and engineers. STS studies have demonstrated, to the contrary, that promises, visions and expectations of future possibilities are embedded in the social organization and practices of science and technology (Fujimura 2003; MacKenzie 1996); so embedded, they inform and shape trajectories of research and innovation (Borup et al. 2006; Hedgecoe and Martin 2003). It should be emphasized, however, that these "technoscientific imaginaries" (Marcus 1995) are not tied to future possibilities solely through scientific or technological practices. They are almost always imbued with implicit understandings of what is good or

[2] Mass media, popular culture, and visual materials also play critically important roles in the articulation of sociotechnical imaginaries. Though worth analyzing in their own right, these materials fall beyond the scope of this article.

desirable in the social world writ large—for instance, how science and technology can meet public needs and who even are the relevant publics (Wynne 2005; Fortun and Fortun 2005). In that sense, technoscientific imaginaries are simultaneously also "social imaginaries," encoding collective visions of the good society.

An analytic concept can be clarified by distinguishing it from other similar notions—in other words, by making explicit not only what it is but also what it is *not*. Imaginaries, in our view, are not the same as policy agendas. They are less explicit, less issue-specific, less goal-directed, less politically accountable, and less instrumental; they reside in the reservoir of norms and discourses, metaphors and cultural meanings out of which actors build their policy preferences. Neither are imaginaries simply master narratives that justify scientific or technological investment, such as the pervasive modern narrative that equates science with progress. Unlike master narratives, which are often extrapolated from past events and serve explanatory or justificatory purposes, imaginaries are instrumental and futuristic: they project visions of what is good, desirable, and worth attaining for a political community; they articulate feasible futures. Conversely, imaginaries also warn against risks or hazards that might accompany innovation if it is pushed too hard or too fast. In activating collective consciousness, imaginaries help create the political will or public resolve to attain them.

It is also important to distinguish imaginaries from discursive frames that guide media representations of science and technology. In an influential article on US media discussions of nuclear power, the sociologists Gamson and Modigliani (1989: 3) referred to such frames as "media packages." These were defined as "interpretive packages that give meaning to an issue." Packages, for these authors, cluster around one or more core ideas and may arise or recede over time, with more than one package fighting for public recognition at any given moment. Gamson and Modigliani showed, for example, how a package around "runaway" accidents in the nuclear field emerged only in the 1970s, and how various news media selectively downplayed negative packages, such as "runaway" or "not cost-effective."

Unlike media packages, whose social reality rests on the repeated use of words and images in public communicative space, sociotechnical imaginaries as we define them are associated with active exercises of state power, such as the selection of development priorities, the allocation of funds, the investment in material infrastructures, and the acceptance or suppression of political dissent. Our inquiry centers on the ways in which the multiplicity of possible discursive framings or narratives circulating in society (sometimes consolidated into "media packages") are filtered and repackaged into dominant targets of public action and associated public reasoning. In short, imaginaries operate for us in the understudied regions between imagination and action, between discourse and decision, and between inchoate public opinion and instrumental state policy.

Sociotechnical imaginaries should not be seen as static or tightly bounded belief systems. It would be naïve, too, to think that there are unique imaginaries guiding the production of knowledge or knowledge-based technologies in the contested spaces of democratic policymaking. Yet, of the multiple contending sociotechnical imaginations at play in any society, some tend to be more durable at the national level because powerful instruments of meaning-making and goal-selecting often lie

within the control of nation states (e.g., political campaigns, state controlled media, official policy narratives and instruments). Further, as previous comparative studies have shown, despite the increasingly global flows of capital, media, knowledge, and skills, the framing and bounding of S&T projects and related policies remain closely intertwined with nation-building (Jasanoff 1995, 2005; Brickman et al. 1985). National imaginations can penetrate the very designs and practices of scientific research and technological development. And the resulting politics of science and technology may shape not only the narrow issues surrounding those specific enterprises but also wider social and political understandings about a nation's past, present and future (Sunder Rajan 2005; El-Haj 2001; Hecht 1998).

The persistence of nation states and their policies as important units of analysis does not, of course, mean that terms such as "nation," "national interest," or "state" should be taken for granted. We consider none of these entities to be black-boxed or immutable. Instead, using the case of nuclear power, we hope to illuminate (consistent with Anderson 1991; also Elam 1997) how these entities are themselves reimagined, or re-performed, in the projection, production, implementation, and uptake of sociotechnical imaginaries: in short, how technoscientific and political orders are co-produced. This requires going beyond the study of single countries or single policy decisions to a more systematic comparative analysis of the ways in which features of national political life—or, more accurately, of national political culture—both embed and are embedded in the development and reception of science and technology. How, we ask, have national political cultures been implicated in forming powerful visions of the "goods" and "bads" of nuclear power? What material, social, and policy promises have these visions sought to fulfill? And how have different ideas of nationhood, democracy, and citizenship figured in the resulting processes of co-production (Jasanoff 2004)? The long histories of the development and regulation of nuclear energy in the US and South Korea offer fertile ground for exploring these questions.

US Case: A History of Containment

The US involvement with nuclear power can be seen as one continuous attempt to put back into the bottle the genie released by the bombings of Hiroshima and Nagasaki in 1945. Those cataclysmic events ended a hot war, but they opened the door to a Cold War arms race that eventually threatened humanity with a nuclear holocaust that could consume all life on the planet.[3] The bombing of Japanese cities, followed by above ground atomic tests, gave the twentieth century one of its indelible images of technology out of control: the mushroom cloud, towering into the skies, and carrying in its very name the meaning of "mushrooming," or unchecked growth.[4] How to stop the proliferation of nuclear weapons occupied

[3] These fears have to some extent been subsumed in a more recent set of concerns about nuclear terrorism. See, for example, Sharp and Poff (2008).

[4] Our use of the "mushroom" metaphor presents an instructive contrast with work on media analysis and public communication such as that of Gamson and Modigliani. Their essay on nuclear power notes that the mushroom cloud was infrequently used in the media during a ten-year period that included the Three

military strategists, foreign policy experts, and arms control advocates from the immediate aftermath of World War II. The atom bomb also fed the public fears that energized anti-nuclear movements throughout the Western world in the 1970s and 1980s.

The term "anti-nuclear" encompasses social movements against weapons as well as power plants. Ironically, US efforts to control proliferation proved more successful in the civilian than the military sector. Weapons stockpiles grew, until the number of warheads peaked in the 1980s at about 70,000, the vast majority held by the US and the Soviet Union; each warhead packed 8–100 times the destructive force of the two bombs dropped on Japan.[5] A well-known anti-nuclear image of the 1980s displayed the world's nuclear arsenal as an eleven by eleven grid, with each box of dots representing some 150 megatons of destructive force. A single dot in the center square represented the entire firepower of World War II, estimated at 3 megatons.[6] The total nuclear firepower represented by the remaining 120 squares was about 18,000 megatons. Antiwar movements targeted this mindless weapons build-up from the late 1950s onward with the formation of groups such as Britain's Campaign for Nuclear Disarmament and America's Committee for a SANE Nuclear Policy. Peace marches occurred in Western capitals with some regularity throughout the following decades. Yet, even with the end of the Cold War, nuclear stockpiles in Russia and the US remained at levels in the tens of thousands. It was the movement against nuclear power—the peaceful application of the atom's deadly force—that scored more decisive victories, bringing US nuclear power plant construction to the standstill described by Garwin.

Part of the reason for this discrepancy, we argue, is that in the case of nuclear power both state and society were engaged in implementing a shared imaginary of containment, although by markedly different means. Accordingly, there was a consensus on the ultimate aims of policy—namely, the prevention of radioactive releases from nuclear power plants and, less directly, the escape of nuclear materials into unsafe, non-peace-loving hands. In the case of nuclear weapons, by contrast, it was primarily citizens who pleaded for weapons control or, still more idealistically, for total disarmament. With the US as role model, the leading nuclear powers favored containment only for other nations, especially those not yet officially in their club. Indeed, Nadel (1995) has argued that the metaphor of containment dominated US cultural life during the Cold War, encompassing both communism abroad and domestic security at home. This asymmetry opened the door to a politics

Footnote 4 continued
Mile Island accident (Gamson and Modigliani 1989: 22). This is a misleading observation in our view. A Google image search today pulls up on the order of 40,800 instances, while the term itself is attested more than a half-million times on the web. It circulates in popular culture through countless media, including even a computer screen saver. As the historian Weart (1988) has suggested, the association between the bomb image and nuclear power does not have to be explicit to be "real." The association can be forged through the subconscious channels of what Weart called "nuclear fear."

[5] These numbers are taken from the website of the Union of Concerned Scientists. http://www.ucsusa.org/global_security/nuclear_weapons/worldwide-nuclear-arsenals.html (visited December 2008).

[6] See http://c-g-i.info/images/nuclear-weapons-chart.jpg (visited December 2008). The original chart can be found in Willens (1984).

of containment that pitted Western states against their own societies: when it came to arms control, states wanted to contain other states, especially their ideological opposites, whereas democratic societies wished to rein in their own nations' as well as their adversaries' nuclear ambitions across the board.

Below, we rehearse the playing out of the imaginary of containment in the case of nuclear power in the US. We stress not only the discourses and material practices of containment (addressed, for example, in Kinsella 2001), but also the mobilization of analytic resources and technical logics, such as risk assessment, to implement the imaginary of the containable atom. We show how the legal process became a primary battle ground for testing the validity of containment, and how the law was mobilized to effectuate closures that could not be accomplished through natural or engineered means.

Containing the (American) Atom

On December 8; 1953, US President Dwight D. Eisenhower gave a speech to the United Nations General Assembly laying out major elements of the American state's imaginary of the postwar atom. Entitled "Atoms for Peace," the speech was designed as much to calm domestic anxiety as to quell international fears. It exemplified the embrace of self-regulation on a national scale for a global audience—a superpower with world-destroying capabilities promised to use that potential exclusively for the good of world society.[7]

Several themes in Eisenhower's epochal address bear teasing apart, since they recur throughout subsequent attempts to make nuclear power more tractable in the US and, to some extent, the world. The first is the self-conscious and explicit distancing of the atom used in power generation from the atom used in war. As the president observed, "The United States would seek more than the mere reduction or elimination of atomic materials for military purposes. It is not enough to take this weapon out of the hands of the soldiers. It must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace." To be sure, the president spoke without a later generation's understanding of the complex and deep-seated ways in which human objectives are built into the very materiality of technological objects. Design, as STS scholars have demonstrated, incorporates ethical and political choices that are not so easily detached from the things themselves. Thus, artifacts have politics (Winner 1986), technologies are as social as human masses (Latour 1992), and even the accuracy of a missile system is "invented" (MacKenzie 1990); technologies, in sum, are at once sites and objects of politics (Jasanoff 2006). For all these reasons, it would prove much less easy than Eisenhower imagined to strip the atom from "its military casing and adapt it to the arts of peace." Nonetheless, his speech represented a good faith effort to reimagine the atom in a self-contained new ontological frame, that of peace rather than war, and of sustaining life rather than destroying it.

[7] See President Eisenhower's (1956) "Atoms for Peace" Speech. Its full text can be found at http://www.atomicarchive.com/Docs/Deterrence/Atomsforpeace.shtml (visited December 2008).

A second, less obvious theme in the speech was that of containing not just atomic weapons but their first developer and only actual user—the US. The "atoms for peace" speech represented as much an attempt to control the image of a runaway superpower as of its runaway weaponry. The text is studded with references that seek to subordinate American power to overarching normative principles and to resituate the nation as standing responsibly within, rather operating irresponsibly outside, the community of nations. The choice of the United Nations as a venue for the speech was itself significant, especially for sharing thoughts that the president said, "I had originally planned to say primarily to the American people." In the same paragraph, he deferred to the "concepts of universal peace and human dignity" enshrined in the UN charter, and he indicated that the age of atomic warfare, with its new language, threats, and hopes, was a global, not a national concern. In a self-abnegating move, this military commander who had led the Allied forces to victory just eight years earlier stated:

> It is with the book of history, and not with isolated pages, that the United States will ever wish to be identified. My country wants to be constructive, not destructive. It wants agreements, not wars, among nations. It wants itself to live in freedom and in the confidence that the peoples of every other nation enjoy equally the right of choosing their own way of life (Eisenhower 1953).

Eisenhower's intent was to downplay the events that led to the "page" written on July 16, 1945, the date of Hiroshima's bombing. The "book of history" was concerned with the pan-human search for peace and well-being, and the US, he suggested, was committed to writing this book together with the rest of humankind. Implicitly, of course, the president's aim was to distance his country from the Soviet Union, whose people notably did not "enjoy equally the right of choosing their own way of life." The speech was the product of a bipolar world order, with the US occupying the pole of freedom, self-determination and life. Containment, in this context, can be seen as a dialectical move: at once cordoning the US off from irresponsible imperial ambitions and enabling it to speak, by example, for an emerging, democratic, global society.

A third theme was the containment of fear. The world, the president noted, should not be doomed to wait and watch, trembling indefinitely as "two atomic colossi" malevolently faced each other with increasing destructive power at their disposal. In a speech that could not have taken much more than twenty minutes to deliver, Eisenhower used the words "fear" or "fearful" sixteen times, and the solutions he proposed to contain the fear were part political and part technical. Looking outward to the General Assembly, he invited support for multilateral supervision of the peaceful uses of fissionable materials, through a new International Atomic Energy Agency (IAEA). Speaking perhaps more to the domestic audience he had originally planned to address, he expressed confidence in the capacity of experts to contain atomic risks, viewed as coming from rogue activities: "The ingenuity of our scientists will provide special safe conditions under which such a bank of fissionable material can be made essentially immune to surprise seizure." But it would take a lot more work to implement the imaginary of containment that Eisenhower's 1953 speech eloquently set forth.

Containing Fear

Even before the birth of the nuclear age at the Trinity test site in New Mexico, the US government was aware that it had embarked on an enterprise of uncommon risk—to property, to human lives and to its own legitimacy. In a series of tersely worded, graduated press announcements, the War Department planned in advance how it would report the results of the big bang that would be heard around the Alamogordo bombing range. The messages played loosely with the facts, referring to the explosion as accidental, as involving mere "high explosives," and as the result of only some weeks of experimentation. They covered scenarios ranging from negligible damage to the deaths of some scientists to the destruction of entire communities. Only the last and most dire version revealed that the material involved was being tested for "improved war weapons against Japan."[8] These embryonic exercises in public reassurance (the taming of fear) continued after the war, as the state attempted to harness, tame, and commercialize the energy of the atomic age.

Despite assurances from presidents and policymakers, the American public remained noticeably skittish about the possibility of containing the atom, even when it was deployed for peaceful purposes. The theme of possible catastrophe was never distant from public debate, and ways had to be found to convince the nascent anti-nuclear movement that someone was minding the store in case of accidents. Several landmark policy actions from the 1950s to the 1980s, including legislation, regulatory risk assessments, and Supreme Court decisions, sought to curb the public anxieties that threatened to derail the government's plan to develop a profitable private nuclear industry.

An early legislative step addressed the issue of responsibility for damages resulting from a severe accident. In 1957, Congress passed the Price-Anderson Nuclear Industries Indemnity Act (Price-Anderson Act for short), which initially provided up to $560 million insurance cover to pay for worst-case accidents; the nuclear industry was responsible for raising $60 million of this amount, while the federal government contracted to provide the balance.[9] The law sought to reassure both the private sector and the American public that, economically at least, the cost of disasters would be completely covered.

In 1978, the Price-Anderson Act withstood a constitutional challenge to its validity. The Supreme Court held in *Duke Power Co. v. Carolina Environmental Study Group*[10] that Congress had rationally set the liability limit at $560 million consistent with its objective of encouraging the private development of nuclear power. The guarantee of recovery, the Court held, was no less just than the uncertainties of the common law liability system that the Act replaced. Moreover, there was no abdication of state responsibility, since the law expressly provided that Congress would "take whatever action is deemed necessary and appropriate to

[8] Documents declassified September 27, 1958. We are indebted to Alex Wellerstein for calling our attention to these documents.

[9] The law has been amended at regular intervals, most recently by the Energy Policy Act of 2005; the self-insurance requirement for each site has also been increased numerous times, to a level of $300 million in the early 2000s.

[10] *Duke Power Co. v. Carolina Environmental Study Group*, 438 U.S. 59 (1978).

protect the public from the consequences of" a nuclear accident.[11] Public anxiety was deemed to be irrational under these circumstances; law joined hands with politics to contain that anxiety within manageable limits.

A similar exercise in containment happened in the wake of Three Mile Island, the worst and most expensive accident in America's involvement with nuclear power. In this case, a local anti-nuclear group, People Against Nuclear Energy, sued to keep the undamaged reactor at TMI from being started up again, on the ground that potential psychological harm to the community had not been considered, as required by the environmental impact assessment provision of the National Environmental Policy Act (NEPA). In *Metropolitan Edison Co. v. People Against Nuclear Energy (PANE)*[12] the Supreme Court again moved to contain fear through law. NEPA, the Court held, did not require the assessment of psychological harm; and, besides, such harm could not easily be assessed anyway since it would be difficult to distinguish mere opposition to the plant from genuine stress occasioned by fear (see, *contra*, Freudenburg and Jones 1991). The state's imaginary of containment here overrode the public's democratic right to imagine worse-case scenarios than were contemplated by the government's experts, or to demand that such fears should be redressed (for a different take, denouncing popular fear itself as a form of unreason, see Sunstein 2005).

Containing Radioactivity

Release of radioactivity is the primal threat associated with nuclear technologies, both civilian and military. To contain that threat effectively, policymakers have attempted to persuade their publics that unmanageable releases will not occur (Kinsella 2001). Once again, in the American case, law and politics have joined hands to shore up the state's containment imaginary.

By the middle of the 1970s, protesters in many Western countries had mobilized against nuclear power despite policymakers' assertions that it was safer than other energy technologies and far safer than mundane activities such as driving a car or riding a bicycle. Legal strategies to contain the atom in the US focused in part on the licensing process by which the federal government sanctioned the construction of new nuclear plants. If sufficient objections were raised against the grant of licenses, activists concluded, they could bring the technology to a halt. In this spirit, the Natural Resources Defense Council (NRDC), a US environmental organization noted for its effective use of litigation, sued the Nuclear Regulatory Commission (NRC) for insufficiently addressing the problem of wastes generated by a plant's operations. NRDC argued that the commission had not sufficiently considered the environmental hazards of waste disposal, thereby condoning a major weakness in the presumption of containment. The liberal Court of Appeals for the D.C. Circuit agreed with the challengers, but in *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*,[13] a unanimous Supreme Court reversed the lower

[11] 438 U.S. 59, at 91.

[12] *Metropolitan Edison Co. v. People Against Nuclear Energy (PANE)*, 460 U.S. 766 (1983).

[13] *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council*, 435 U.S. 519 (1978).

court's decision. The opinion rested entirely on an interpretation of judicial power under American administrative law. Judges may not, so the high court held, require a regulatory agency to adopt procedures beyond those specified by law. In this case, neither the Administrative Procedure Act nor any other specific statute required the NRC to do more than it had by way of public consultation. By sealing off the agency's licensing process from further debate, the Court in effect completed the task of containment by legal means. The back end of the fuel cycle was deemed safe, not because the public was convinced of its safety but because the agency in charge had done all it needed to demonstrate the reasonableness of its actions.

Determined to press the issue of containment, NRDC again challenged the NRC, this time on grounds related to the reliability of its technical analysis. The commission, NRDC argued, had arbitrarily adopted a "zero release" assumption for the environmental impact of long-term storage of high-level nuclear wastes. Once again, the D.C. Circuit proved sympathetic, concluding that the agency's assumption precluded full consideration of the uncertainties of environmental damage, as required by law. Once again, in *Baltimore Gas & Electric Co. v. NRDC*,[14] the Supreme Court unanimously reversed the lower court, citing a broad policy of deference toward the technical judgment of an expert agency (Siegel 1987). The NRC was found to have acted rationally by assuming that the permanent storage of high-level nuclear wastes would have no significant environmental impact. The law thus produced procedural containment where neither technical expertise nor politics had sufficed to cordon off the uncertainties associated with the threat of radioactive release.

For American experts and policymakers, deep geologic burial in salt beds has served for a half-century as the technology of choice for containing the radioactivity from nuclear wastes. Officially floated by the National Academy of Sciences in 1957, the idea of burying wastes in a single national repository took hold by the late 1970s, when the Department of Energy began studying Yucca Mountain in Nevada as the site most likely to contain radioactive wastes safely for up to 10,000 years.[15] That time period itself speaks to a powerful imaginary of containment, assuming (not so long after Adolf Hitler's failed ambition of a thousand-year Reich) that human societies can make reliable predictions ten millennia into the future through existing analytic methods. By 2003 the federal government had spent $7 billion on technical analyses to show that this vision was feasible, attainable, and made good social and political sense. Not surprisingly, this attempt to nationalize nuclear waste disposal, to locate the solution in a single site, and to appropriate time and nature in its defense proved to be hugely contested. During a generation of controversy, both problem and solution were substantially reframed. By the turn of the new century, it was no longer nature but DOE's own engineering expertise that served as the prime guarantor of containment (Macfarlane 2003). Whether or not Yucca Mountain ever comes on line for its envisioned purpose, it will remain a haunting symbol of

[14] *Baltimore Gas & Electric Co. v. NRDC*, 462 U.S. 87 (1983).

[15] To put the Yucca Mountain controversy in perspective, it is worth comparing the cases of civilian and military waste disposal. DOE began planning for the geological disposal of defense-related transuranic radioactive waste without needing to placate civilian populations. In March 1999, DOE commenced disposal operations of the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico (Mora 1999).

America's imaginary of nuclear containment—the mountain, both material and symbolic, needed to put back into the ground the genie of radioactivity set free through humankind's greatest act of hubris in the twentieth century.[16]

The South Korean Case: "Atoms for National Development"

The atomic bombings of Japan in 1945 had no fewer repercussions in Korea than they did in the US. Above all, they liberated Korea from 36 years of harsh colonial rule under Japan, forcefully drawing the attention of Koreans to the power of nuclear energy. Korea was as much a victim as a beneficiary of the atomic bombs. Before the end of World War II, there were over 80,000 Koreans living in Hiroshima and Nagasaki. More than half were estimated to have died instantly or in the months following the dropping of the atomic bombs (Tong 1991). Notwithstanding these consequences, the leaders of the modern Korean nation did not see nuclear energy as a fearful, runaway technology that needed to be contained. Rather, they viewed it as a symbol of the power of science and technology that Korea should actively seek to acquire in order to develop into a strong, modern nation. The mood of the time was nicely captured in an introductory remark to *Donga-ilbo*'s special column series on science and technology published in 1947:

> What did the atomic bomb that defeated Japan in this war teach us? ... [T]he only thing that would make our fatherland wealthy and strong is the power of science. No matter how independent we are politically, without scientific independence, we will be enslaved again. The total mobilization of science and technology [and the] scientification of production ... are the only ways to place our beloved nation on a stable foundation of self-reliance and independence ...[17]

This yearning for a strong and wealthy nation built through science and technology was severely disrupted by the ensuing conflicts in the Korean peninsula. After liberation, Korea was divided into North and South, controlled by the Soviet Union and the US respectively. As the Cold War set in, the two Koreas established separate governments in 1948, eventually leading to a civil war from 1950 to 1953. These Cold War tensions put Korea under the direct threat of nuclear attack. From the early stages of the war, the US contemplated the use of atomic bombs against North Korea. In 1958, US tactical nuclear weapons began to be deployed in the South (Cumings 1998). Yet, nuclear technology continued to be imagined through the lens of national reconstruction, though—echoing the bipolarity of Cold War divisions—it was now reframed by the politics of ethnic nationalism over which side would legitimately represent the Korean nation. The greatest threat, in the view

[16] Even for the already operating and less controversial WIPP disposal site, DOE has to acknowledge that engineered containment remains vulnerable and is at pains to design and construct "permanent markers" to deter "inadvertent human intrusion" (DOE/WIPP 2004).

[17] *Donga-ilbo* had been one of Korea's most influential newspapers since its founding in 1920. The title of the column series was "Scientific Design for Reconstructing the Fatherland." See *Donga-ilbo* (January 1, 1947).

of both Koreas, was that each might remain weak and underdeveloped and fail to secure the future of the Korean nation against aggression from the other side and its patron. The lack of nuclear technological capability was seen as part and parcel of this predicament.

Accordingly, when the Atoms for Peace initiative was introduced to South Korea, it was welcomed, but not necessarily for the reasons that the US intended. As part of the initiative, Seoul and Washington signed a cooperation agreement in 1956 to provide for American nuclear research assistance. The agreement was confined to the purchase and construction of a small nuclear reactor for basic research and the use of radioisotopes in agriculture and medicine. Neither power reactors nor power demonstration reactors were covered, not to mention politically sensitive nuclear fuel cycle technology (Koh 1992; KAERI 1979, 1990). But for South Koreans, the arrival of nuclear science and technology was an important step toward the acquisition of advanced technologies that would help build up the nation, both economically and militarily. The distinction between atoms for peace and atoms for war did not matter in this imaginary of development. While the cooperation agreement with the US generated high hopes among many South Koreans for the prospect of nuclear power generation, others, including South Korea's first president Rhee Syngman, supported the agreement partly because of their interest in atomic bombs.[18]

Nuclear activities in the late 1950s were modest. It was only under the Park Chung Hee military regime (1961–1979) that a serious nuclear program commenced, through which the atom became firmly situated within the state's imagining of national development. In effect, atomic power needed to be incorporated and made Korean—not dissociated and set apart from the vision of nationhood, as in the US case. Below we observe some of the key moments in deploying the South Korean nuclear imaginary. Initially relying on the import of technology from foreign countries—especially the US—South Korea soon aspired to attaining an indigenous nuclear capability. With the onset of democratization, the anti-nuclear movement gradually emerged, challenging the state's nuclear power program. The dominant imaginary of "atoms for development," however, proved remarkably tenacious and resilient.

Constructing the Korean Atom

During the Rhee Syngman regime, protection of the Korean nation against communism was at the core of the state's imaginary of national development. Rhee in his anti-communist rhetoric constantly requested US military and material support to defeat the North and reunify Korea. Techno-economic development, though important, was a subsidiary goal. Hence, whereas nuclear research was keenly supported, its import was construed primarily in the Cold War context. This was well displayed in Rhee's (1956) speech at the Atoms for Peace exhibition, in

[18] Yoon Se-Won, one of the physicists who led South Korea's early nuclear program, later recalled that, during his visit to the presidential office in 1957, Rhee asked him about the technical feasibility of building atomic bombs (Park 1999a: 9). For Rhee's interest in atomic bombs, see also Kim (2005).

which he stated that atomic energy meant "freedom" and "would facilitate reunification (with the North) by helping make (South) Korea a strong and great democratic nation." How nuclear energy would be incorporated into the techno-economic restructuring of South Korea was not addressed. In response to the South Korea–US nuclear cooperation agreement, the government did enact the Atomic Energy Act, creating a government agency, the Office of Atomic Energy, and setting up the Atomic Energy Research Institute (later renamed the Korea Atomic Energy Research Institute, KAERI). As yet, however, no systematic efforts were made to broaden the scope of South Korea's nuclear activities, which were still significantly constrained by the terms of the South Korea–US agreement.

Things started to change when the military junta led by Park Chung Hee seized power in 1961. Like Rhee, Park took a militant anti-communist stance, but he put techno-economic advances at the forefront of his national development strategies. He advocated "national restoration" through state-directed programs to accomplish the "modernization of the fatherland" and a "self-reliant economy." The Korean nation was imagined, first and foremost, as a cohesive community of shared economic interests and developmental goals (Kim 2006). Science and technology were crucial constitutive elements in this developmental nationalist imaginary. They were conceived as "the foundation for increasing productive forces and the source of power for accelerating economic development." It would be imperative for South Korea to develop an indigenous capability to master them. The state was deemed responsible for planning and directing national S&T activities. Scientists and engineers were praised as the "motive power for national development" and the "pride of the nation," and were, in turn, expected to "willingly accept today's sacrifices for tomorrow's scientific Korea." In a similar vein, ordinary Koreans were continuously reminded that, as responsible members of the nation, they have a duty to support and assist the state-led techno-economic development.[19]

Nuclear power was seen as a perfect example of such techno-economic development; it responded to an urgent need to move away from dependence on foreign oil and the energy demands of rapid industrial growth. It would thereby facilitate South Korea's transition from resource-poor, technology-dependent, developing country to sovereign industrial nation.

After lengthy planning and feasibility studies, the construction of the first nuclear power plant, Kori-1, began in 1970. Subsequently, spurred by the 1973 oil crisis, South Korea's nuclear power program expanded rapidly (Ha 1982; KAERI 1979, 1990). The US saw this as opening up a market for its nuclear industries, and willingly amended the South Korea–US cooperation agreement to allow the transfer of power reactors and their fuel. Indeed, because of the shortage of Korean nuclear engineers, the first two nuclear power plants had to be built on a turnkey basis, completely led by US firms. From early on, however, the Park government framed nuclear energy not just as a means for, but as an object of, national development.

[19] See Park (1966, 1967). This sociotechnical imaginary was later incorporated into the South Korean constitution. In 1972, when Park issued the authoritarian *Yusin* (restoration) constitution to extend his tenure, a new article was introduced in the chapter on Economy, stating that "the development of the national economy, and of science and technology for this goal, should be encouraged and promoted."

Already in 1969, the government's long-term nuclear plan set out the attainment of "self-reliance in the development and use of atomic energy" as its basic principle (AEC 1968). Dependence on US nuclear technology and fuel, it was feared, would compromise the nation's economic and energy security (O 1994).

South Korea's efforts to incorporate the atom entered a new dimension in the mid-1970s. Increasingly doubtful of US support, Park and his technocrats accelerated the indigenization of nuclear power while at the same time seeking to develop nuclear weapons capability. KAERI attempted to purchase an NRX research reactor from Canada in 1973—the same type that India later used in its first nuclear test—and a fuel fabrication facility from Belgium in 1975. The government-owned Korea Electric Power Corporation (KEPCO) also finalized a contract with Canada to build a heavy water reactor for the third nuclear power plant, with the hope of using natural uranium as fuel and securing nuclear fuel independence from the US (O 1994). A year later a comprehensive nuclear program was launched, with the establishment of the Korea Nuclear Engineering Services and the Korea Nuclear Fuel Development Institute, in order to indigenize reactor design, power plant equipment, and nuclear fuel technology. From the construction of the fourth nuclear power unit, a non-turnkey approach was adopted to ensure more effective technology transfer. All these moves were multi-purposed, aiming to enhance South Korea's own nuclear capability for both peace and war. After Park's assassination in 1979, the US pressured the new military government, headed by Chun Doo-Hwan, to abandon its nuclear weapons program (Kim 2004). However, the imaginary of atoms for national development, with "technological self-reliance" as its cornerstone, persisted through the 1980s and 1990s.

Contesting Atoms for Development

Despite a marked increase in the construction of nuclear power plants, it was not until the mid- to late-1980s that nuclear safety emerged as an issue of major public concern. This was to a significant degree because the Park and Chun military regimes suppressed dissident voices, but also because they were often quite successful in garnering mass consent for their growth-first policies.[20] A large segment of the South Korean public, and even many opposition politicians and dissident intellectuals, shared the vision of developmental nationalism espoused by the military regimes (Kim 2003, 2006). The failure to escape from underdevelopment and to catch up with advanced industrial nations, economically and militarily, was perceived as one of the most serious risks for the nation. In this atmosphere, nuclear safety was relegated to secondary importance. For example, while the Act on Compensation for Nuclear Damage and the Act on Indemnification Agreements for Nuclear Liability—equivalent to the US Price-Anderson Act—were adopted relatively early, in 1969 and in 1975, liability limits were set very low to avoid

[20] For recent historical studies that highlight the importance of spontaneous consent from below in maintaining the Park Chung Hee military regime, see Hwang (2004); Part III of Kim and Lim (2005) and Jang and Lee (2006).

hindering national efforts to expand nuclear power.[21] There was no independent nuclear regulatory agency. Safety analyses were conducted on a more or less ad hoc basis by the government-funded KAERI, which was not only committed to promoting nuclear energy, but also heavily involved in the actual development and construction of nuclear power plants.

The 1979 TMI accident did attract some media attention, particularly since the news coincided with a temporary shutdown of the Kori-1 plant because of a small leak of radioactively contaminated cooling water.[22] A series of policy responses ensued. Immediately after the TMI accident, the Ministry of Science and Technology formed a special task force to assess the safety of Kori-1. The Nuclear Safety Center (NSC) was set up in 1981 as a regulatory expert organization, albeit within the KAERI (KINS 2000; KAERI 1990). In the following years, the Atomic Energy Act and its enforcement decrees were amended to upgrade the procedures and standards for nuclear regulation. Still, nuclear safety was not at the top of the policy agenda. The government approached it as a subsidiary, strictly technical problem that needed to be fixed in order to successfully implement state-directed national economic development plans, and nothing more.[23] Societal reaction, too, was minimal. The public seemed to acquiesce in the government's framing and handling of nuclear safety. The anti-dictatorship social movements, for their part, were preoccupied with issues of human rights and political democracy, and did not treat nuclear or other environmental hazards as urgent problems (Ku 1996).

Skepticism over South Korea's expansion of nuclear power initially focused on the state's advocacy of national development. Questions arose over whether state-directed capitalist development would actually lead to the prosperity of the national community or would attend only to the private interests of a few. Disappointed by US support for the new military dictatorship even after the Kwangju massacre in 1980, dissident intellectuals and activists also became critical of US involvement in the South Korean political economy (Shin 1995). The military regime's strong push for rapid economic growth, they suspected, would only serve US neo-colonial domination and the ruling elites benefiting from it. Nuclear power was no exception. In 1983, *Multinational Monitor*, a US investigative magazine founded by Ralph Nader, uncovered a World Bank confidential report criticizing South Korea's overcommitment to nuclear energy and its inaction regarding safety and waste (Shorrock 1983). The magazine argued that, in order to expand the potential market overseas for an industry unwelcome at home, the US had irresponsibly exploited

[21] As of 1975, the maximum liability limit was 3 billion South Korean Won, which amounted to U.S. $6.2 million. The South Korean government increased the liability limit to 6 billion Won in 1987 and to 50 billion Won in 2001, but these amounts still fell far short of the corresponding U.S. figures—the total of $10 billion.

[22] While this episode was regarded as a minor mechanical and electrical malfunction rather than a serious accident, national newspapers ran several articles on the safety of South Korea's nuclear power plants. See, for example, *Donga-ilbo* (April 3 and 4, 1979); *Chosun-ilbo* (April 1, 3 and 5, 1979); and *Hankook-ilbo* (April 1 and 3, 1979).

[23] Such a framing of nuclear safety was repeatedly found in various government documents, including *Annual Report of the Korea Atomic Energy Research Institute* and *Science and Technology Annual*.

that risky situation.[24] Reports like this consolidated South Korean activists' suspicion that the government's nuclear energy policy was geared toward an unjust and exploitative, neocolonial capitalist economy, not genuine national development that would bring benefits and justice to the entire nation.

South Korea's first generation of environmental activists shared this view. These groups were deeply concerned about the potential human and environmental consequences of nuclear power, but were less interested in waging the battle on technical fronts. For them, those risks were the product of the military regimes' dependent capitalist development, and scientists and engineers were subordinated to its political-economic logic. Containing the atom was therefore simply not possible without tackling the real source of the problem: an unequal capitalist order under US hegemony. In the next few years, activists attempted to reframe nuclear power, together with US tactical nuclear weapons in South Korea, as threats to the Korean nation imposed by US imperialism and its client dictatorship (KPRI 1987). Their attempts were only partially successful. The Chun government strongly countered that any doubts about nuclear energy, or about the Korea–US relationship, were subversive, making it difficult for citizens to undertake anti-nuclear activities. Besides, even though South Korea still had to rely on US firms for the construction of nuclear power plants, a plan to develop its own standardized reactor and plant design was well under way by the mid- to late-1980s (KOPEC 1984), somewhat weakening the dependency argument. Nevertheless, anti-nuclear sentiments slowly gained ground as the long taken-for-granted tie-in between the atom and South Korea's national development continued to be contested.

Democratizing Atoms for Development

The Chernobyl disaster in 1986 solidified the US moratorium on nuclear power and added visible impetus to South Korea's growing anti-nuclear movement. The accident was extensively reported in the press, conveying a powerful image of catastrophe which anti-nuclear activists would repeatedly mobilize. Its immediate impact, though, was ambiguous. Even after months of news reports about the devastating consequences of Chernobyl, a national poll suggested that only 16% of Korean respondents perceived nuclear power plants as dangerous or unsafe; more than 70% supported the continuation of nuclear power plant construction (Gallup Korea 1986). For the government, the Chernobyl disaster not only demonstrated the superior safety of the US-type reactors that South Korea had adopted, but also provided a unique opportunity to increase the nation's nuclear autonomy. The subsequent shrinking of the global nuclear power market was used to secure more favorable terms of technology transfer from foreign nuclear industries. As a result, beginning with the construction of the eleventh and twelfth nuclear power plants, Yŏnggwang-3 and -4, in 1989, KEPCO and other South Korean firms resumed responsibility as prime contractors (Park 1992). The completion of the Korean Standard Nuclear Power Plant (KSNP) model in the early 1990s, based on a

[24] Shorrock (1982), the editor of *Multinational Monitor*, together with Hayes and Shorrock (1982a, b) of the Nautilus Pacific Action Research Center, had been making this argument for some time.

reduced-sized design of an ABB Combustion Engineering reactor, owed much to these experiences and represented a major step forward in the indigenization of the Korean nuclear industry (KNS 1994; Sung and Hong 1999).

More important to South Korea's anti-nuclear politics was the democratic transition of the late 1980s. Increasing resistance against the repressive Chun regime culminated in nationwide mass demonstrations in June 1987, forcing Chun to concede to demands for political liberalization. With a more open political climate, there was a burst of civic activity. A number of new national and local environmental organizations were formed (Ku 1996). Local disputes also broke out over the disposal of heated waste water from nuclear power plants. Several other episodes followed, casting additional doubts on the safety of nuclear power, including nuclear plant workers giving birth to deformed children (Park 1995). By early 1989, public support for nuclear power seemed to be waning. Exploiting this situation, anti-nuclear activists in coalition with other civic groups waged a national campaign against nuclear power. One of the central issues in the campaign revolved around the construction of Yŏnggwang-3 and -4. As prototypes of the KSNP model, these plants were proudly portrayed as a big step toward South Korea's nuclear self-reliance. Opponents, however, did not trust the safety of these "Korean" nuclear power technologies; they criticized the undemocratic nature of nuclear energy policymaking and demanded complete abandonment of the construction plan.[25]

By the 1990s, South Korea's incorporation of atomic power was increasingly subjected to protests and resistance from local environmental and civic activists. Already in 1989, opposition from residents in the region abruptly halted the government's search for the site of a low- and intermediate-level radioactive waste (LILW) repository in North Kyŏngsang Province. In late 1990, as news of a covert plan to build a LILW facility in Anmyŏn Island was leaked to the press, violent local protests erupted and lasted for several days. The plan had to be cancelled, and the Minister of Science and Technology was dismissed (Park 1995). A similarly fierce controversy arose in 1994–1995 over the proposed siting of a LILW repository in Kurŏp Island, leading to the postponement of the entire nuclear waste disposal plan for an unspecified time (Park 1998). Intense protests by environmental and community groups also delayed the construction of the seventeenth and eighteenth nuclear plants, KSNP-based Yŏnggwang-5 and -6, for more than a year (Park 1999b).

On the surface, these events seem to have forced the government to pay more attention to nuclear safety issues, especially after a civilian president came to power in 1993. Indeed, the Ministry of Science and Technology issued its Nuclear Safety Policy Statement in 1994, adopting the US NRC's five principles of good regulation—independence, openness, clarity, efficiency, and reliability—and held the first "Nuclear Safety Day" in September of the following year. In 1996, the Atomic Energy Act also was amended to set up the Nuclear Safety Commission (NSC), a new high-level agency responsible for nuclear safety regulation (KINS 1998). Yet, beneath these reforms, the basic framing of nuclear energy and safety

[25] This issue became a hot topic during the 1988 National Assembly audit (*Chosun-ilbo*, October 21, 1988; *Hankook-ilbo*, October 21, 1988). In order to allay the public anxiety, the Ministry of Science and Technology invited a group of experts from the IAEA to conduct an independent preliminary safety analysis of Yŏnggwang-3 and -4 (Jo 1989).

remained relatively unchanged, even though there was growing public distrust of the government's intention to enforce strict regulations. The imaginary of empowering the nation through science and technology was still compelling to many South Koreans. This left room for the government to mollify criticism and to retain its policy focus on securing the capability to assess and improve the safety and performance of the KSNP model.

In 1995, the multi-lateral Korean Peninsula Energy Development Organization (KEDO)—established to resolve the first North Korean nuclear crisis—adopted the KSNP as the official reactor model (MOU 1996). This was heralded as evidence of international recognition that South Korea had acquired national nuclear capability. Although anti-nuclear voices were becoming more potent, both locally and nationally, the government thus did not hesitate to press its aggressive nuclear power policy. Nuclear power expansion was deemed not only to enhance South Korea's national competitiveness by meeting domestic energy needs and exporting KSNPs to other developing countries, but also to secure the peace and prosperity of the Korean nation.[26] What was thought to be lacking was public understanding and appreciation of the benefits and safety of nuclear power. The logical follow-up, from the government's perspective, was to launch massive pro-nuclear public relations campaigns through the Korea Nuclear Energy Foundation.[27]

Around that time, reflecting an ideological shift within South Korean social movements, environmental activists gradually moved away from a rigid anti-capitalist stance and increased efforts to challenge the government's policy through legal and technical contestations.[28] Yet, the critique of a runaway developmental state out of democratic control, threatening the nation's well-being, still lay at the base of opposition to nuclear power. At least initially, activists' call for more transparency and participation in nuclear decisionmaking had wide appeal, especially to local communities. In 2004, after a year of bitter disputes over the siting of a LILW repository in Wido Island, residents in the Buan County organized a local referendum and rejected the plan by a landslide vote of 91.8% (Kim and Cho 2004). However, by stressing that the disposal of radioactive waste was urgent and vital to national interests, and by passing a special law providing huge economic incentives to the siting region, the government successfully persuaded citizens in other areas to join together in making South Korea an "advanced nuclear nation."[29] Only a year

[26] The provision of KSNP reactors to North Korea through the KEDO project was expected to ease the tension between North and South, as well as the economic hardships of ordinary North Koreans, and was generally greeted in the South, even by many social movement activists who adopted—or were sympathetic to—an anti-nuclear power stance.

[27] The Korea Nuclear Energy Foundation (formerly the Organization for Korea Atomic Energy Awareness) was established in 1992 by the Ministry of Commerce, Industry and Energy in order to assuage growing concerns about the safety of nuclear facilities after the Anmyŏn Island incident.

[28] The end of the Cold War and the collapse of the Soviet Union—together with the improvement of procedural democracy—had a profound impact on South Korean progressive social movements. For an ideological shift within the environmental movement, see Ku (1996).

[29] The government promised that it would provide the host region with a special state subsidy of U.S. $300 million, in addition to an annual fee of U.S. $8.5 million for storing the waste. The headquarters of the Korea Hydro & Nuclear Power Co. (KEPCO's subsidiary responsible for nuclear power) would also be relocated to the area.

after the Buan referendum, residents in the Kyŏngju city voted by a large majority to host a LILW facility (Yun 2006). Anti-nuclear activists tried hard to portray their resistance as a struggle against the legacy of military-led developmental dictatorship and for the democratic and sustainable future of Korea. But it proved extremely difficult for any political interest group to disrupt the dominant imaginary of atoms for national development.

Comparing Imaginaries

What do the foregoing political and policy histories of nuclear power in the US and South Korea tell us about the role and significance of national sociotechnical imaginaries? Here we wish to argue not only that there are systematic divergences in the ways the two nations have imagined and implemented this particular technological system, but also that the divergences have proved profoundly consequential for each nation's broader political development. Table 1 summarizes and compares the most significant and durable features of the national sociotechnical imaginaries delineated in previous sections. In each nation's engagement with nuclear power, cross-national differences were particularly salient in the following respects: framing the most pressing risks, defining the main policy focus, crystallizing the stakes behind the policies, articulating social and technical controversies, providing avenues and means of closure, and justifying policy through successful appeals to national civic epistemologies.

With regard to risk framing, nuclear power arrived on the US scene with explosive force, in a nation preparing for and carrying out acts of war. There was no need to establish that the power released from the atom was American power. The bomb was unquestionably an American achievement, demonstrating the state's ability to defend its citizens against foreign threats. The question from the start was how the state would govern that unprecedented power for peaceful purposes. We have shown that the American nuclear imaginary was dominated even before the

Table 1 Comparing imaginaries

	United States	South Korea
Framing risks	Runaway accidents	Failure to develop
	Catastrophic damage	Dependence on foreign powers
Policy focus	Containing radiation release	Building domestic capacity
Controversies	Safety of plants and disposal sites (e.g., Yucca mountain siting controversy)	Political inclusion and participation (e.g., Buan siting controversy)
Stakes	Responsible governance of (hazardous) technology	Accountable governance of (democratizing) nation
Closures	Legal decisions	Bureaucratic enforcement
	Nationalization of risk	Appeal to "national interests"
Civic epistemologies	Quantitative risk assessment	Questioning national needs
	Expert-lay conflicts	State-civil society conflicts

Trinity test by notions of containment, encompassing not only the hazards of radiation but also the political hazards of public dissent and rejection (Kinsella 2001).

By contrast, South Korea's involvement with nuclear energy coincided with a project of national self-sufficiency and development that directed the state's official imagination toward incorporating atomic power imported from abroad. For the South Korean establishment, even substantial risks to citizens' lives and safety were tolerable so long as the technological project could ensure national self-reliance and erased any real or felt threat of dependency. Citizens, too, collaborated in that project of nation-building, with the result that the fear of losing national autonomy, competitiveness and developmental steam largely overrode public concerns for physical safety. To be sure, South Korea was not immune to fears of radioactivity, and institutional reforms designed to enhance power plant safety occurred in Korea as well as in the US. Dissent, however, produced few results as dramatic as the derailing of an entire industry that the US anti-nuclear movement accomplished in atomic energy's national birthplace.

Divergent imaginations of state responsibility toward citizens drove sharp wedges between US and Korean nuclear policy and outcomes by the end of the twentieth century. Where the US sought to commercialize and privatize nuclear power, detaching the technology from exclusive association with the state, South Korea remained the technology's official custodian, as owner and operator of the nation's nuclear facilities. Where American activists and courts struggled to master the multiple uncertainties of risk regulation, a democratizing South Korea managed to quell citizens' doubts by displaying increasing domestic ownership of nuclear technology and expertise. Where the US instituted a virtual moratorium on building new power plants from the late 1970s onward, South Korea produced a model plant, trained two generations of nuclear physicists and engineers at home, and shed an early history of dependency in favor of a proactive role as exporter of technology and capacity. Starkly put, the US "contained" its nuclear power know-how to the point of virtual paralysis. If climate worries foster increased acceptance of the nuclear alternative, it is the US that will need to import technology and human resources to build and staff its new power plants. South Korea, by contrast, has so thoroughly incorporated nuclear know-how into its scientific and political practices that it now offers resources for the region, and possibly beyond.

What can we say, though, about the implications of these two imaginaries for the democratic governance of technology in the nuclear case? In brief, the half-century or so of debates about the future of nuclear power in each country not only drew on sociotechnical imaginaries of the public good but also reinforced patterns of public reason, evidence production and knowledge uptake that constitute a nation's political culture, more specifically, its civic epistemology (Jasanoff 2005).

In the US, nuclear debates helped establish the pattern of expert-lay controversies that marked the rise of health, safety and environmental regulation after the Second World War. Quantitative risk assessment, extended in the 1950s to assessing dangers at nuclear power plants, strengthened the US penchant for translating political debates into technical controversies, as well as the growing regulatory reliance on mathematical objectivity as a substitute for experiential judgment. More

subtly, failures of state-sponsored containment, especially with regard to nuclear fears, gave rise to efforts to explain divergences between lay and expert opinion, and so created a new branch of risk perception studies within social psychology (Slovic 2000; Slovic et al. 1982). These developments in turn shored up a powerful, expert-validated, and still persistent construction of publics as technically ignorant and driven by irrational fears of the unknown (Sunstein 2005). In the US state's imaginary of nuclear decisionmaking, therefore, the public figures as needing containment just as much as the potentially runaway physical hazards of atomic energy.

In South Korea, nuclear energy exemplified how the nation should deal with the risks and opportunities of modernization. Nuclear safety was framed as subordinate to national efforts to improve nuclear technological capability, and thereby to convert South Korea into an advanced nation. Official discourse repeatedly invoked the urgency and necessity of "national development," and reminded the public that, as dutiful Korean subjects, they should actively support these efforts. It was no accident that opponents of nuclear power first put their effort into questioning the state's advocacy of national development. Since the democratic transition of the late 1980s, the public has claimed a more active position as citizens. However, democratization did not immediately extend to a critical reflection on the dominant ideas of "nation" and "development" deeply embedded in the nuclear imaginary and its material products. Moreover, while conflicts between state and society called into question the pro-development alliance between the state and expertise, they also increased the felt need for independent expert authority to legitimize policy decisions, paradoxically limiting the policy influence of citizens.

Conclusion

We have argued that, in order to make sense of national policies supporting the development of science and technology, we need to invoke not only the material and organizational resources that states deploy but also the imaginative resources with which they relate such policies to the public good. To this end, we introduced the concept of sociotechnical imaginaries, using it to show how different imaginations of social life and order are co-produced along with the goals, priorities, benefits and risks of science and technology. Through a comparative examination of the development and regulation of nuclear power in the US and South Korea, we have illustrated the analytic potential of this concept in providing more nuanced understandings of national technology policies and their cross-national variations.

The US and South Korea entered the atomic age at different times and by different pathways, and they incorporated the power of the atom into different imagined futures for their respective polities. In both countries, the imaginary of nuclear energy was deeply tied to state-society relations and to evolving understandings of democracy.

As the country that developed and launched the only atomic weapons as yet used in war, the US felt no need to assert ownership over nuclear power. Rather, over decades, American policy was directed toward the problematic goal of peaceful

containment, a goal that proved increasingly frustrating to the state because of the complex tie-ins between the escape of radiation and the escape of dissent from managerial institutions such as expert committees, regulatory agencies, and the courts. By 2009, the experienced physicist and nuclear expert Richard Garwin was prepared to say (in a personal interview) that some aspects of containment had failed and should be abandoned. In particular, he concluded that nation states should no longer be held responsible for disposing of nuclear waste within their own borders; instead, disposal should be opened up to competitive commercial handling, under international standard-setting and regulatory surveillance by the IAEA.

The South Korean imaginary of atoms for national development proved significantly less sensitive to radiation hazards during an early period when the state's prime mission was to develop indigenous nuclear capability. As democratization advanced after the 1990s, new imaginations of nationhood—allowing for greater dissent and local autonomy—emerged, questioning the monolithic figure of "national development" and raising resistance against top-down nuclear development. South Korea's recent move towards more stringent nuclear regulation reflects not only multilateral pressure from the IAEA but also these far-reaching changes in domestic politics. Growing disenchantment with the state's prerogative to define legitimate development goals for the nation has fueled some opposition to nuclear power; but it has not been readily translated into effective challenges to the widely felt imperative to secure the nation's autonomy through domestic ownership of critical technologies.

Looking through the lens of the sociotechnical imaginary, we are forced to render a mixed verdict on the democratization of national science and technology policies in the nuclear age. In the US, what appeared on the surface to be a lively testing of expert judgment led to a moratorium on an uncontainably hazardous technology. The ensuing conflicts between experts and laypeople, however, fostered a perception of the public as emotional, untutored in probabilistic thinking, and incapable of rational intervention in technical debates. Where society remained fixated on the containment of nuclear releases, the state, in an ironic rethinking of democracy itself, developed new concerns about runaway publics, incapable of informed self-governance. We note, too, the bifurcation of the anti-nuclear field into a civilian sector marked by novel forms of participatory engagement and the consolidation of a powerful military-industrial complex that remained essentially impervious to public scrutiny and control.

In South Korea, decades of democratizing efforts and resistance gradually opened up the black box of state-dominated technical decisionmaking. The once unquestioned link between atom and the nation's desirable future came under increasing scrutiny. But expanding democratic action continued to operate within a developmental nationalist imaginary that viewed science and technology primarily as instruments to achieve a strong and wealthy nation. The risks of nuclear power were constantly weighed against the risk of failing to develop, and were tolerated, if not dismissed, often with public consent. Without alternative imaginaries, participatory democratic experiments pushed by anti-nuclear activists and other civic groups thus did not lead to fundamental changes in the existing politics of nuclear power. In fact, this impasse seemed to invite a new form of technocracy,

further undermining South Korean civil society's already precarious attempts to democratize nuclear policy.

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