CHAPTER CONTENTS

9 Communicating Nuclear Power

A Programmatic Review

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Civil and commercial nuclear power production is a material and discursive phenomenon posing theoretical and practical questions warranting further attention by communication scholars. We provide a brief discursive history of nuclear power, followed by a review of scholarship in communication and related disciplines. We then examine five areas for further research: (a) the fragmentation of technocratic and public discourses; (b) regulation and governance; (c) the politics of nuclear waste; (d) critical social movements; and (e) intersections of communication, rhetoric, and nuclear risk. We provide a rationale and foundation for further work in these and other areas related to nuclear power.

The Fukushima Daiichi nuclear disaster, which began in 2011 but continues to unfold, has brought heightened visibility to a topic deserving close attention from communication scholars. Influential theorists and philosophers (e.g., Beck, 1987, 1992; Giddens, 1990; Heidegger, 1977; Luhmann, 1989, 1993) have identified nuclear technologies, both military and non-military, as paradigmatic features of modernity, late modernity, or contemporary "risk society." Some aspects of those technologies receive regular attention in public and scholarly discourses, while others are often regarded as taken-for-granted, common sense features of the present age. For example, Taylor, Kinsella, Depoe, & Metzler (2005, 2007) note that while the scientific and policy dimensions of nuclear weapons are broadly recognized, the ongoing industrial processes of nuclear weapons production are often considered mundane and unremarkable. We argue here that commercial or civilian applications of nuclear energy—designated *nuclear power* in this chapter—also receive comparatively limited attention. Normalized as inevitable products of technological progress, essential for sustaining a growing, energy-intensive society, more than 400 nuclear power plants operate globally. Those plants are

manifestations of a larger system in which material and symbolic power are closely intertwined and in need of closer scrutiny.

"Nuclear power" takes multiple forms; it is simultaneously a material phenomenon, a communicative accomplishment, and a discursive resource (Kinsella, 2004a). Throughout this chapter we use the term to denote a range of activities understood as complex sociotechnical and symbolic systems rather than self-contained technologies. We focus on processes related to commercial/ civilian nuclear electricity production, while recognizing their connections with other commonplace activities such as medical and industrial applications, food irradiation, and smoke detection. Our emphasis is on commercial/civilian rather than military uses, but throughout the chapter we note ways in which that boundary is constructed, permeable, and often problematic.

A body of communication-based scholarship on nuclear power does exist, but necessarily spans a range of focal concerns, methodological approaches, and publication venues. Other relevant scholarship exists outside the field, inviting interdisciplinary engagement. No comprehensive guide to these materials exists; thus, our chapter provides an integrative assessment of such work within and beyond the communication discipline, developing a framework to foster more systematic consideration of this consequential topic. We argue throughout that the institutional, political, and material implications of nuclear power are substantial, as are its implications for communication theory and practice. We incorporate concepts from organizational and institutional communication; environmental communication; science, technology, and risk communication; rhetoric of science and technology; political communication; social movements; communication theory; and related disciplines as appropriate. Our purpose is twofold: to use concepts from those fields to illuminate problems and issues (both theoretical and practical) posed by nuclear power, and conversely, to use the case of nuclear power to inform those fields of study.

Nuclear Power as Theoretical Problematic

Nuclear power presents important theoretical questions regarding relationships among materiality, language, and human agency. Rogers (1998) and Kinsella (2007) have argued that through their strongly recalcitrant materiality, nuclear phenomena challenge core concepts of social, rhetorical, and discursive construction, defying both representational and constitutive models of communication. Nevertheless, nuclear phenomena are in important ways linguistic accomplishments, achieved through processes such as naming, constructing categories, and articulating relationships and boundaries. Much of that discursive work happens in institutional settings including basic science, technology development, policy debate, public discourse, governance, and regulation. Thus relationships among the recalcitrant material world, human institutions, and language, as manifested in nuclear discourses, warrant closer attention by communication scholars and can provide important theoretical insights.

Related to this point are questions of *linguistic representation* involving, for example, technical and technocratic discourses, conceptualizations of nuclear processes, and computer modeling and simulation. These modalities enable and constrain what is said, and what can be said, about nuclear phenomena, with implications for scientific knowledge production as well as for the politics of knowledge (Kinsella, 2005, 2007, 2010, 2012; Kuchinskaya, 2011, 2012). Also related are questions of *political representation*: who gets to speak regarding nuclear topics, in what settings, under what conditions, and with what outcomes (Endres, 2009a, 2009b, 2009c, 2012, 2013). Such questions are often framed in terms of a divide between "expert" and "public" communities (Katz & Miller, 1996; Wynne, 1996) or "technical" and "public" rationalities (Goodnight, 1982), involving fundamental issues of democratic process and social justice.

Latour (2004) argues that although technoscientific discourses seek to establish "objects with clear boundaries," or "matters of fact" to be managed by experts on behalf of society, those objects inevitably entail "risky attachments" among "tangled objects" or "matters of concern" demanding broad democratic engagement (pp. 22–25). More broadly, Beck (1995) theorizes a state of "reflexive modernity" in which society's immersion in self-induced risks demands greater systematic reflection to move beyond current conditions of "organized irresponsibility" (p. 58).[1] Nuclear power exemplifies both of these assessments of prevailing social and political conditions, linking theoretical and practical concerns.

Nuclear Power as Sociopolitical Practice

Before the events at Fukushima, nuclear power was receiving considerable attention in public and policy discourses, viewed as a potential, albeit partial response to problems of climate change and energy security. As early as 1982, commentators and proponents envisioned a "nuclear renaissance" in which issues of safety, regulation, economics, and public support would be resolved and the promises of nuclear energy fulfilled (Hileman, 1982; Weinberg, Spiewak, Phung, & Livingston, 1985). During the 1990s the nuclear industry and its allies began a global promotional effort employing tropes such as "nuclear renaissance," "nuclear renewal," and "nuclear new build." That discourse spread beyond the industry, adopted by politicians and even some environmentalists seeking alternatives to greenhouse gas-emitting energy technologies (Bickerstaff, Lorenzoni, Pidgeon, Poortinga, & Simmons, 2008; Sovacool, 2007). Fukushima has posed new challenges to that narrative, although responses have varied across national contexts and the industry has found ways to discount and deflect nuclear safety concerns. Despite those efforts, longstanding questions remain regarding the economics of nuclear power, the intractable problems posed by long-lived and pernicious nuclear wastes, and links between nuclear power and nuclear weapons proliferation. Climate change has not sealed the case for nuclear power, nor has Fukushima sealed the case against it. The

arguments persist, warranting closer analyses of nuclear power as a communicative phenomenon and a topic for democratic debate.

Discursive Civilian/Military Boundaries

Although this chapter focuses on commercial/civilian applications, our discussion is informed by the substantial literature regarding communication and nuclear weapons. Bryan Taylor (1998) has provided a valuable review of work in that area, including the "nuclear criticism" program that emerged in the 1980s in response to the clear political significance and existential threat posed by nuclear weapons, and has pursued a rich program of original analysis comprising works and topics too numerous to summarize here. Brummett (1989) identified important themes of entelechy and perfection evident in nuclear weapons discourses, while Kauffman (1989) and Schiappa (1989) examined linguistic practices that establish and sustain hegemonic nuclear symbolism. Taylor, Kinsella, Depoe, & Metzler (2005, 2007) expanded the focus of this literature to include the implications of nuclear weapons production in the United States for organizational, environmental, and political communication. These and other studies inform our present project.

As we indicate throughout this chapter, nuclear rhetors actively work to construct boundaries between military and civilian/commercial applications. Nevertheless, those fields overlap and interact in important ways. Nuclear waste issues involve materials generated by both military and civilian activities; research laboratories conduct both civilian and military projects, antinuclear protest groups often address both dimensions, nuclear technology choices are driven by both (and sometimes competing) military and civilian priorities, "dual-use" technologies can support nuclear power production while providing paths to weapons proliferation, and emerging terrorism concerns affect both military and civilian nuclear operations.

Preview of the Chapter

In our chapter, we address certain perceptions regarding nuclear power that may have established some traction in public discourse and within the communication discipline. First, we argue that although its discursive and material context has changed as issues of energy and climate evolve, nuclear power has not lost significance as a matter of concern for society or for communication scholars. Nuclear power posed important questions before Fukushima provided a "focusing event" (Birkland, 1998) stimulating public attention, and will continue to do so even if attention wanes until the next prominent nuclear event. The high consequences of nuclear failures, the complexity of nuclear regulation and governance discourses, and the recalcitrant materiality of nuclear processes call for sustained, rather than intermittent, attention. Second, we call not for a return to a topic that has already been examined adequately, but for more systematic focus on this persistently important topic. As nuclear power's rhetorical and

political-economic situation changes, its internal discourses and institutional strategies evolve; thus, its historical legacies and new discursive innovations both warrant sustained attention. Within the prevailing space constraints we provide a fairly comprehensive inventory of relevant scholarship, mapping its complex terrain and proposing a framework for future research. We write with multiple audiences in mind, including scholars with established interests in the areas examined below and scholars with broader interests (e.g., technology governance more widely; the role of materiality in communication theory). Professionals in the policy community, regulatory institutions, and industry may also find value in our integrative and interdisciplinary assessment.

We begin with a brief history of nuclear power discourses and then synthesize existing scholarship in communication and related fields. We then pursue some material, social, political, environmental, organizational, and policy dimensions of nuclear power, focusing on particular areas of interest viewed as communication processes. Throughout, we argue that "nuclear power" incorporates not only material, organizational, and institutional phenomena related to the production and use of nuclear energy, but also a range of rhetorical and discursive activities that constitute social and political power. Accordingly, we provide programmatic suggestions regarding how communication scholarship can inform nuclear issues, and how studies of nuclear power can inform the communication discipline, suggesting an agenda for continued research guided by our map of the field. Our analysis draws, as well, on the authors' extended engagements with organizations and institutions including nuclear engineering research programs in the United States and Germany, government agencies involved in promoting (U.S. Department of Energy) and regulating (U.S. Nuclear Regulatory Commission) nuclear power, and critical nongovernmental groups. Although we are U.S.-based scholars and most of our work has addressed U.S. settings, we seek to balance U.S. and global perspectives throughout our analysis. While the United States has played a key role in its history, nuclear power has global origins and is best understood as a globalized system. Most recently, the Fukushima disaster has demonstrated the global consequences of particular nuclear events.

Nuclear Power and Nuclear Discourses

All nature, then, as self-sustained, consists
Of twain of things: of bodies and of void
In which they're set, and where they're moved around . . .
Name o'er creation with what names thou wilt,
Thou'lt find but properties of those first twain,
Or see but accidents those twain produce.
                                    Lucretius, *De Rerum Natura*

Arguably, "nuclear" discourses are prefigured in the teachings of the atomist philosophers, whose models of the material world established still-unresolved

questions regarding causality, agency, and relationships between language and reality. Alternatively, the origin of modern nuclear discourse can be located in late 19th and early 20th century physics, with the identification of phenomena such as x-rays and radioactivity and the theoretical explanations that followed, leading to events of profound historical consequence (Kinsella, 2005). Public awareness of nuclear energy's implications expanded dramatically with the Hiroshima and Nagasaki bombings, entangling military and civilian applications in ways that have generated rhetorical boundary work ever since.[2] The physicist Edward Teller, for example, appears to have viewed the "legacy of Hiroshima" primarily as a public relations problem impeding the advancement of nuclear technologies of all kinds (Teller, 1962). Teller's colleague Alvin Weinberg (1985) argued for the "sanctification of Hiroshima," invoking a moral stricture against further violent uses of nuclear energy. As advocates and agents for the promotion of nuclear technologies, both Teller and Weinberg sought to enact a rhetorical boundary between "military" and "peaceful" uses.

The U.S. "Atoms for Peace" program initiated in 1953 (Chernus, 2002; Medhurst, 1987, 1997) pursued three related objectives: (a) to reframe nuclear energy as a beneficial force; (b) to contrast U.S. nuclear undertakings with those of the Soviet Union, thus helping to enroll developing nations into the U.S. camp; and (c) to establish a global market for nuclear technologies. While some nations looked to the United States and the Soviet Union as suppliers of nuclear energy infrastructures, others such as France sought to develop indigenous capacities (Davis, 1987; Hecht, 1998; Zonabend, 1993). Such efforts do not only address energy needs; they also produce symbolic value for nations striving for status as technologically advanced players on the modern world stage (Jasanoff & Kim, 2009). Other nations have deliberately avoided the nuclear power path; as Felt (2013) argues using Austria as an example, this choice can also constitute an explicit national identity.

Nuclear crises[3] including those at the Chalk River research reactor in Canada in 1952 (Mosey, 1990), the Windscale plutonium production reactor in the United Kingdom in 1957 (Wynne, 1982), a commercial reactor at Three Mile Island in the United States in 1979 (Farrell & Goodnight, 1981), and a dual-use reactor at Chernobyl in the Soviet Union in 1986 challenged the program of global nuclear energy development in varied ways across national settings (Balogh, 1991; Flam, 1994; Giugni, 2004; Goldsteen & Schorr, 1991; Joppke, 1993; McCafferty, 1991; Mehta, 2005; Morone & Woodhouse, 1989; Nelkin & Pollak, 1981; Rüdig, 1990; Walker, 2004; Wills, 2006). In Germany, widespread contamination from Chernobyl enhanced the position of the Green Party and contributed to what may be the strongest national-level movement against nuclear power. In the United States, nuclear advocates attributed the events at Chernobyl to a failure-prone Soviet design and to mismanagement by the plant's operators, while a reactor of related design was quietly shut down at the Hanford plutonium production site. While allegations of design flaws and mismanagement at Chernobyl are accurate, they also exemplify a recurrent form of nuclear rhetorical boundary work: the assertion that technical, geographic, institutional, and/or cultural differences preclude disasters in more advanced

or more conscientious nations (Kinsella, 2012, 2013). Controversially, the English-language summary of the Japanese Diet's report on the Fukushima disaster (National Diet of Japan, 2012) sustains such exceptionalist claims, suggesting that the failures there were a product of a distinctively Japanese culture of regulatory deference (Juraku, 2013a).

Safety concerns may provide the most dramatic antinuclear arguments, but in many nations the industry's greatest challenges have been economic ones. Although economic and safety issues are often separated rhetorically and administratively (Kinsella, Kelly, & Kittle Autry, 2013), they are intertwined in practice: enhanced safety measures, regulatory scrutiny, and public opposition following safety failures have contributed to ever-increasing budgets for nuclear operations and construction (Cooper, 2012; Schneider & Froggat, 2013). Nevertheless, even before the events at Three Mile Island, numerous project cancellations in the United States were driven primarily by economic and managerial factors (Birkland, 1998; Pope, 2008; Wellock, 1998). With no new domestic plants licensed from 1978 through 2012, the U.S. industry survived by way of exports, research and development contracts, and corporate investments predicated on the rhetoric of a "second nuclear era" made possible by the development of "inherently safe reactors" (Weinberg & Spiewak, 1984; Weinberg et al., 1985).

According to the International Atomic Energy Agency (IAEA), from 1995 through 2012 the number of power reactors operating globally varied between 430 and 441 without demonstrating a pattern of growth.[4] Schneider and Froggat (2013) report that nuclear power's total electricity production reached its historic peak in 2006, although as a share of total global electricity production the peak occurred in 1993 at 17%, declining steadily through 2010 and then more sharply to reach a 10% share in 2012. These statistics challenge the industry's renaissance narrative, which has nevertheless persisted throughout that same time period and declined little (if at all) since the events at Fukushima. Further challenges to the narrative include a reduced rate of energy demand growth attributable to the 2008 global recession, improved energy conservation and efficiency, new extraction techniques that have lowered the costs of natural gas, and technological advances and policy initiatives that strengthen the competitive position of sustainable energy sources such as wind and solar power.

Accordingly, timely questions for further communication research include how the industry works to sustain a narrative of nuclear power as a "commonsense" response to climate change and energy demand, and how critics contest that narrative (Kinsella, 2015). Other questions follow from the events at Fukushima and their potential to affect nuclear programs and practices in terms of cost, safety, regulation, policies, and public acceptance (Hindmarsh, 2013; Kinsella, 2015a). Additional questions involve the nuclear power discourses of nations such as China (Xu, 2010) and India (Mathai, 2013; Ramana, 2013), where expanding populations, increasing per capita energy consumption, and efforts to reduce dependence on fossil fuels drive ambitious nuclear agendas, and the Republic of Korea, which seeks to become a global nuclear technology provider (Sovacool, 2010).

Research Approaches to Nuclear Power Communication

With this brief and partial discursive history in place, we now identify some approaches that scholars in communication and cognate fields have applied to topics related to nuclear power. Our inventory is selective rather than exhaustive, focusing on examples from within the communication discipline as well as related work of direct significance for the discipline. Our review demonstrates that although there has been communication-focused scholarship on nuclear power, it is broadly distributed and variegated. By identifying and categorizing this work we provide a resource for a more sustained and integrated research program as outlined later in this chapter. Following Latour (2004), we regard the following six areas as comprising a field of tangled objects, risky attachments, and matters of public concern imbricating questions of materiality, discourse, agency, and democratic governance.

Media Representations, Popular Culture, and Public Opinion

Media attention to nuclear power has often been driven by high-profile crises that punctuate its history (Friedman, 1981, 2011; Friedman, Gorney, & Egolf, 1987; Rosa & Dunlap, 1994; Rubin, 1987). Media studies following the Chernobyl disaster highlighted the implications of message content for the safety of local residents (Gale, 1987) and for political debates informed by the event (Young & Launer, 1991). In the U.S. context, Gamson and Modigliani (1989) conducted an influential study of media framings of nuclear power, cited widely by scholars applying framing theory across multiple topical areas. However, Mazur (1990) argued that for both nuclear power and chemical hazards, "intensity and volume of reporting" affect public attitudes more strongly than "what is reported about the topic" (p. 295). Further research can help disentangle the relative effects of quantity and content of reporting, while updating the literature in light of the changing context for nuclear power.

Examining the rhetoric of government and industry proponents, Gwin (1990) argued that systematic understatements of risks and overstatements of the promises of nuclear power fostered a "promotional heritage" that continues to inform public and institutional discourses (cf. Cohn, 1997). Mechling and Mechling (1995) and Nadel (1995) recount how the atom was domesticated and its material and political hazards rhetorically contained through popular culture artifacts such as novels, films, music, and television programs, while Boyer (1985), Henriksen (1997), Lynch (2012), Weart (1988, 2012) and Winkler (1993) highlight the cultural mediation of persistent nuclear anxieties. In the U.K. context, Bickerstaff et al. (2008), Doyle (2011), and Pidgeon, Lorenzoni, and Poortinga (2008) have examined more recent reframings of nuclear power as a response to climate change and their effects on public opinion.

These studies address varied ways in which society makes sense of complex nuclear technologies, while producing the discursive and normative framework for their continued evolution. To extend and contemporize this

scholarship, we offer four areas for further research reflecting the changing context for nuclear power. The discursive links between climate change and nuclear power provide a particularly timely exigence for further communication scholarship, including cross-national comparisons. Another exigence is the opportunity to utilize earlier scholarship as a foundation for further longitudinal studies charting changing trends in media reporting, popular culture representations, and public opinion. A third, related exigence involves the still-evolving effects of the Fukushima disaster, and a fourth is the emergence of online media as pervasive communication venues enabling timely but volatile public discussions (Binder, 2012; Friedman, 2011; Ionescu, 2012; Kittle Autry & Kelly, 2012). Together, these four research trajectories can provide valuable insights regarding the intersections among complex technologies, evolving media systems, and public discourses in contemporary risk society.

Social Movements

Social movements provide a counterpoint to the global promotion of nuclear power, and cross-national comparisons are of particular interest (Flam, 1994; Nelkin & Pollak, 1981; Rüdig, 1990). Germany may provide the strongest case of public protest, wherein the influential Green Party has consistently and strategically incorporated opposition to both military and civilian nuclear technologies into its political identity, gaining strength from that emphasis (Hunold, 2001; Joppke, 1993). German protesters often interrupt nuclear fuel and waste shipments, have aggressively blocked efforts to create a permanent waste repository (Hocke & Renn, 2009), and have clashed violently with police on multiple occasions. U.S. opposition to nuclear power has been less widespread and less dramatic, enacted more by groups with particular concerns (including concerns related to specific facilities) in a climate of ambivalent public opinion and limited attention rather than broad national sentiment. U.S. nuclear opponents have also linked concerns about nuclear weapons with concerns about nuclear power, challenging entrenched rhetorical boundaries, but have generally placed less emphasis on those connections.

Globally, opponents' rhetorical foci include risks of catastrophic plant failures and ongoing low-level emissions (Mehta, 2005, in Canada; Morone & Woodhouse, 1989, in the United States), facility siting (Aldrich, 2008, comparing Japan and the United States), uranium mining (Banjeree, 2000, in India; Falk, Green, & Mudd, 2006, in Australia), nuclear waste disposal (Johnson, 2008, in Canada), environmental justice (Fan, 2006a, 2006b, in Taiwan), regulatory policy and practice (Duffy, 1997, in the United States), nuclear power economics (Cooper, 2012; Pope, 2008, in the United States; Ramana, 2013, in India), and relationships between nuclear power and nuclear weapons proliferation. Focusing events such as those at Three Mile Island, Chernobyl, and Fukushima have highlighted nuclear risks and mobilized opposition (Birkland, 1998; Friedman, 2011; Friedman, Gorney, & Egolf, 1987). Further communication-focused

studies can facilitate more detailed comparisons across national, political, historical, and media contexts.

Nuclear Discourses, Master Themes, and Foundational Premises

A distinctively modern phenomenon, nuclear power articulates discursive themes including material and social progress, technological creativity and entelechy, international development, political power, national identity, technocratic rationality, prosperity, consumerism, and the common good (Cohn, 1997; Felt, 2013, Hecht, 1998; Jasanoff & Kim, 2009; Mathai, 2013; Mechling & Mechling, 1995; Welsh, 2000). Hecht (2003, 2012) uses the term *nuclearity* to map the postcolonial geographic and political hegemony of this discursive constellation, addressing questions of global environmental and social justice. Kinsella (2005, 2007) has examined four "master themes"—mystery, potency, secrecy, and entelechy—linked across the military and nuclear power domains, and the environmental, social, and political consequences of nuclear discourses, while Kinsella et al. (2013) have explored the role of rhetorical boundary work in sustaining the nuclear power enterprise.

A related foundational theme is the material and discursive formation described as *nuclear colonialism* (Endres, 2009a, 2009b; Kuletz, 1998; LaDuke, 1999). This term addresses global patterns of relationship, manifested differently across geographic contexts but similar in their consequences, wherein indigenous peoples suffer disproportionate negative effects from the development of military and civilian nuclear technologies. Endres (2009a) observes that discussions about nuclear power often disregard the "cradle" (uranium mining) and "grave" (waste disposal) of the nuclear fuel cycle, which affect indigenous people in Australia, Canada, India, Taiwan, the United States, and several African nations. Communication scholarship has begun to identify discursive strategies that sustain nuclear colonialism and to reveal linkages between its material and discursive elements. Future research could investigate nuclear colonialism as a broader phenomenon affecting not only indigenous people, but also other marginalized communities including populations living close to nuclear facilities and temporary workers not protected by radiation exposure controls (Caulfield, 1989; Jobin, 2012; Parkhill, Henwood, Pidgeon, & Simmons, 2011; Zonabend, 1993). Further, lessons regarding nuclear colonialism can be brought into conversation with research on other forms of resource colonialism such as mining practices and oil and gas extraction.

Democratic Discourse, Public Participation, and Environmental and Social Justice

Communication scholarship also addresses the implications of nuclear power for democratic institutional practice. One line of research examines public participation in decision-making about nuclear power and nuclear waste (Besley, 2010, 2012; Clarke, 2010; Endres, 2009c; Johnson, 2008; Kinsella, 2016;

Kinsella et al., 2013; Ratliff; 1997). In most national settings, all phases of nuclear power production are regulated by public agencies; thus, proposals for new plants, nuclear waste storage and disposal facilities, and other changes to the status quo often trigger mandated public engagement processes. Following broader environmental communication research that indicts institutionalized processes for their lack of genuine opportunities for public influence (e.g., Depoe, Delicath, & Elsenbeer, 2004), analyses of the process for the proposed U.S. high-level nuclear waste repository at Yucca Mountain have revealed numerous anti-democratic aspects (Endres, 2009b, 2009c, 2012; Ratliff, 1997). Although these studies have primarily examined official processes, less formal modes of public engagement such as social movement activism, public protest, and performative and visual rhetoric also warrant further attention (Nelkin & Pollak, 1981; Peeples, 2011; Taylor, 1997).

Related research highlights the environmental justice implications of nuclear power including questions of argumentative strategies, rhetorical inclusion and exclusion, and institutional transparency. Nuclear facilities are often located in marginalized spaces (Hevly & Findlay, 1998), as in the case of a plant adjacent to the Prairie Island Indian Community in the United States. Juraku (2013b) argues that the "nuclear village" model in Japan, exemplified by the "concentrated siting" of ten reactors at Fukushima Daichi and Daini, encourages communities with limited economic opportunities to accept risks that more affluent communities can avoid. Fan (2006a, 2006b) examines the controversy surrounding a nuclear waste facility in Taiwan, located in the homeland of the aboriginal Yami tribe. Focusing on the dispute over storing high-level nuclear waste on the Skull Valley Goshute Reservation in the United States, Clarke (2010) examines the mutually constitutive relationship between materialities and discourses, while Fried and Eyles (2011) and Peeples, Krannich, and Weiss (2008) demonstrate the complexity of defining what constitutes environmental injustice in cases where marginalized communities actively seek opportunities to store nuclear and other toxic wastes. Questions of environmental justice in nuclear power contexts present a range of discursive/material practices embroiled with larger discourses of energy, environment, community identity, security, sacrifice, and climate change (Banjeree, 2000; Grinde & Johansen, 1995; Hecht, 2003; Hoffman, 2001; Kuletz, 1998; Sze, 2005). Collectively, these studies illuminate multiple forms of democratic engagement in nuclear power contexts. Further research can move beyond individual case studies to develop comparative and integrative findings of value not only in the nuclear power domain, but across a range of risky technology governance settings.

Communication, Risk, and Expert versus Public Knowledge

Beck (1992) argues that society is now characterized by problems of equitable risk distribution, accompanying and often superseding traditional problems of resource distribution, and that the construct of risk provides "a systematic way of dealing with hazards and insecurities induced and introduced by

modernization itself" (p. 21). Nuclear power provides a paradigmatic example: enacted as a solution to problems of energy supply, the technology has generated new risks demanding constant vigilance and democratic decision-making. Nevertheless, democratic discourse is often short-circuited by approaches to defining, assessing, and managing risk that privilege technocratic rationality and disregard broader forms of public engagement.

In the U.S. context, Farrell and Goodnight (1981) examine the role of communication failures at Three Mile Island, identifying implications of technocratic rationality for nuclear safety, crisis management, and public trust, while Goodnight (1982) addresses the fragmentation of "personal, technical, and public" discourse fields and the domination of the technical frame in domains such as nuclear power. Katz and Miller (1996) examine a controversy surrounding a proposed low-level nuclear waste facility, concluding that decision makers maintained a "contemptuous" view of community members' capacities to engage with the issues at stake. Miller (2003) argues that a landmark nuclear safety analysis informing regulatory policy (USNRC, 1975) relied on presumptions of technical authority and tacit professional judgments, emphasizing ethos over logos while purporting to demonstrate the latter.

These rhetorically-grounded critiques resonate with arguments made in the literature on public understanding of science, challenging a "deficit model" of public understanding that presumes "scientific *sufficiency* and public *deficiency*" (Gross, 1994, p. 6; cf. Sturgis & Allum, 2004). In the European context, Renn (1992, 2008) provides a typology of approaches to risk, including but extending beyond technocratic frameworks, and offers a more complex model of risk governance aligned with approaches influential in the European Union. Horlick-Jones (2005) emphasizes the role of "informal logics of risk" and practical modes of reasoning as complements to technical rationality. Across national settings but playing out differently in varied political and cultural contexts, vernacular knowledge provided by non-experts can challenge and recontextualize technocratic reasoning (Endres, 2009c; Kinsella, 2004b, 2012; Kinsella & Mullen, 2007; Kinsella et al., 2013; Kuchinskaya, 2011; Wynne, 1991, 1996). Such studies suggest possibilities for new grammars, vocabularies, and forms of democratic engagement for the governance of risky technologies.

Organizational and Institutional Communication

Nuclear power is a complex sociotechnical activity enacted through nongovernmental and governmental organizations and institutions including electric utility providers; equipment vendors; engineering and construction firms; financial, investment, and insurance organizations; regulatory agencies; academic, commercial, and governmental research and development organizations; and myriad technical, legal, and managerial consulting organizations. The roles and relationships among these entities vary across national settings. For example, German nuclear safety regulation emphasizes a partnership of

federal and state-level authorities with substantial involvement by independent "technical service organizations," while the U.S. system is more centralized and incorporates a greater degree of industry self-regulation (Kinsella, 2011). Frameworks for nuclear power plant financing, ownership, and management vary from fully privatized, to hybrid, to fully state-controlled. International nongovernmental organizations, particularly the International Atomic Energy Agency and various United Nations working groups, coordinate regulatory standards and organizational practices but are constrained by expectations of national sovereignty. Industry-based groups play important roles facilitating autonomous self-regulation (e.g., World Association of Nuclear Operators, and in the United States, Institute for Nuclear Power Operations) and policy advocacy (e.g., World Nuclear Association, and in the United States, Nuclear Energy Institute). These complex inter-organizational relationships involve blurred boundaries between civilian and military applications, exemplified by the IAEA's dual promotional and regulatory missions and the regular flow of U.S. nuclear naval personnel to the civilian nuclear workforce and U.S. Nuclear Regulatory Commission (USNRC).

The challenges of nuclear safety have provoked much theorizing about organizational practices in high-risk contexts. The Three Mile Island failure inspired two influential streams of thought: normal accident theory and high reliability theory (Rijpma, 1997). Normal accident theory, originated by Charles Perrow (1984/1999), argues that nuclear power plant safety cannot be guaranteed by human organizations, which cannot match the systems' complexity and anticipate all possible failures. Tight subsystem coupling, potential failure combinations, and potentially rapid accident progression led Perrow to conceptualize "normal accidents" as inevitable consequences of complex but pervasive technologies such as nuclear power.

In contrast, high-reliability organizations theory (HRO) proposes that certain organizational practices, such as "collective mindfulness," match organizational and technological complexity, helping to prevent failure and enabling recovery from small failures (Bourrier, 2011; Weick & Sutcliff, 2007). HRO research has examined the "negotiated order" of safe and reliable performance at a nuclear power plant (Schulman, 1993) and organizational learning following non-catastrophic failures (Perin, 2006). Organizational communication scholars have studied how teams of nuclear inspectors make sense of ambiguous information (Barbour & Gill, 2013), and have extended HRO theory to other high-risk domains. Normal accident theory and HRO theory are complementary: one emphasizes the unforgiving demands of nuclear technologies, while the other addresses the organizational and individual vigilance necessary to prevent or minimize failures.

The Chernobyl disaster provoked a "safety culture" discourse that circulates within the nuclear industry and regulatory agencies (Myers, 2005; Silbey, 2009). The IAEA defines safety culture by emphasizing organizational factors and individual attitudes that establish safety as an overriding priority (International Nuclear Safety Advisory Group, 1988), devoting considerable efforts to

policies and standards and more recently, questions of "security culture" related to sabotage and terrorism threats. Those efforts inform the regulatory oversight activities of all nations with civilian nuclear power, and have inspired quantitative and qualitative research to assess the safety culture construct at plants in Brazil, Denmark, Finland, Spain, Sweden, and the United States (Branch & Olson, 2011; Carvalho, dos Santos, Gomes, & Borges, 2008; Mariscal, Herrero, & Toca Otero, 2012; Navarro, Garcia Lerín, Tomás, & Pieró Silla, 2013; Reiman, Oedewald, & Rollenhagen, 2005).

Although the organizational communication literature has not focused directly on nuclear power plant safety culture, it offers insights that complicate prevailing practices such as technically-focused safety audits, and challenge approaches to organizational culture that privilege managerial imperatives over other outcomes. This scholarship is especially relevant for the nuclear industry, which perpetually struggles with inherent tensions between profit and safety. For example, a day of lost electricity production can cost a U.S. nuclear utility approximately $1 million; thus, decisions regarding reactor shutdowns in response to ambiguous risk indicators can pit safety culture expectations against production expectations (Hausman, 2013; Perin, 2006). These complex tensions provide rich theoretical terrain for further exploration. Nuclear power poses stark but subtle questions regarding the limits of human agency and control, democratic risk governance, and the co-constitutive relationships among high-risk materialities, political-economic structures, and organizational discourses.

Focal Areas for Further Communication Research

We now revisit some of the topics introduced above and consider additional related topics, identifying areas of particular interest for further communication scholarship. All the areas discussed so far invite further development, and the selections made here partly reflect our own research interests and ongoing projects. These areas, and those outlined above, are best seen as overlapping, mutually constitutive, and particularly suited for interdisciplinary scholarship to which communication and rhetoric can make substantial contributions.

Explicating Material and Discursive Entanglements

Technical and policy discussions regarding nuclear energy often begin with a sketch of the "nuclear fuel cycle," involving uranium mining and milling; chemical conversion; enrichment; another chemical conversion followed by reactor fuel fabrication; irradiation of fuel in reactor cores to produce energy; and removal, cooling, storage, and (ideally) disposal of highly radioactive "used" or "spent" nuclear fuel.[5] Some nations engage in reprocessing, extracting plutonium from used fuel for use in further cycles of energy generation, while others have chosen to avoid reprocessing due to nuclear weapons proliferation risks.

Such discussions may effectively describe the material aspects of nuclear energy production, but they disregard its complex institutional, political, social, and discursive aspects. Although the process is described as a "cycle," suggesting movement through a series of stages and eventual closure, it is actually a set of processes that are rhetorically and institutionally separated but practically intertwined. For example, reactor design decisions affect uranium enrichment requirements and implications for proliferation of weapons-grade materials (plutonium and highly-enriched uranium), choices between permanent disposal and used fuel reprocessing affect reactor design choices and proliferation potentials, and on-site storage of used fuel complicates nuclear plant operations and economics. The social and discursive aspects of nuclear energy production are neither separable nor self-contained; they are complex, interconnected, recursive, and always negotiated. Further, each stage of the fuel cycle involves regular or potential releases of radiological materials into the environment: uranium mill tailings threaten workers and local communities, ongoing reactor operations can involve unintended leaks, reprocessing produces large volumes of high-level liquid nuclear wastes, and catastrophic failures of containment present ongoing risks across the fuel cycle.

We now identify five broad areas in which nuclear power exemplifies those conditions, where approaches grounded in communication, discourse, and rhetoric can contribute to more democratic outcomes by (a) overcoming the fragmentation of technical and public discourses, (b) enhancing the vision of nuclear regulatory institutions, (c) addressing the intractable problems associated with the politics of nuclear waste, (d) illuminating the place of protest and critical social movements in nuclear power debates, and (e) explicating the intersections of rhetoric, communication, and understandings of nuclear risk.

Fragmented Discourses of Nuclear Power

Contrasting with technocratic discourses emphasizing probabilities and cost/benefit calculations, society appears to seek more definitive answers to questions of nuclear risk and safety. The quest for such answers often leads to debates characterized by the rhetorical strategy of extreme case formulation (Pomerantz, 1986), a preference to articulate extreme cases rather than more complex arguments. Such tendencies strip nuclear power issues of the rhetorical richness and technical nuance warranted by such a complex and consequential technology (Weart, 1988). Approaches including issue framing (Lewicki, Gray, & Elliot, 2003), collaborative learning (Daniels & Walker, 2001), and moral conflict (Littlejohn & Cole, 2013; Pearce & Littlejohn, 1997) can help to address the intractability of nuclear debates, reclaiming their potential richness.

Although achieving a richer public debate is challenging, opportunities are seen in the nuanced communication within particular communities concerned with nuclear risks. For example, while promotional industry rhetoric consistently claims that "nuclear power is safe," technical experts can be uncomfortable with such absolute statements. Occupationally obsessed with safety, nuclear

professionals often prefer to speak of it as an ongoing process or to use adverbial forms such as "nuclear power can be managed safely." Meanwhile, local communities living with nuclear risks often use discursive strategies such as humor to save face and avoid dwelling unproductively on potential consequences (Parkhill et al., 2011; Zonabend, 1993). Such subtleties of in-group communication rarely appear in public discourses, one marker of the differentiation of personal, technical, and public argument spheres (Goodnight, 1982). Nevertheless the potential exists for overcoming such barriers, and public dialogue scholarship seeks to design communication strategies that embrace differences and address tensions productively (Barge & Andreas, 2013).

Nuclear Regulation: National and Global Challenges

Nuclear power regulation encompasses and engages with multiple discourses including law, administration, politics, engineering, science, risk, economics and finance, probability, cost/benefit analysis, ecology, and antinuclear critique. These discourses are often fragmented, incommensurable, and separated rhetorically by actors for strategic purposes (Kinsella et al., 2013), often operating in tension with the materialities of nuclear safety. National-level regulatory frameworks are informed by diverse historical, cultural, and political influences (Pool, 1997). The legitimacy of regulatory agencies is affected by public evaluations of independence versus "capture" by the regulated industry (Laffont & Tirole, 1991) or "recreancy," understood as " the failure of institutional actors to carry out their responsibilities with the degree of vigor necessary to merit the societal trust they enjoy" (Freudenburg, 1993, p. 909).

Due to its historical precedence and global influence, the U.S. system is of particular interest. The U.S. Atomic Energy Commission was created in 1946 with an emphasis on weapons technologies, accompanied by a statement that "the development and utilization of atomic energy should be directed toward improving the public welfare" (quoted in Pool, 1997, p. 70). Accordingly, the 1954 Atomic Energy Act expanded the institution's activities to include developing, licensing, and regulating reactors for commercial electricity generation. The conflicting mandate to both promote and regulate nuclear technologies ultimately led to a legitimation crisis, and in 1974 the missions were separated, with the USNRC inheriting the regulatory mission and an agency that would become the U.S. Department of Energy inheriting the promotional mission (Walker, 1984, 1992; Walker & Wellock, 2010). The French system, by comparison, does not emphasize boundaries between promotion and regulation and legitimizes more direct cooperation between private industry and government in the development, operation, and oversight of nuclear power systems (Davis, 1987; Hecht, 1998). Most recently, Japan has moved closer to the U.S. model by separating promotional and regulatory activities in response to the events at Fukushima.

In the U.S. case the federal government granted permission, in principle, for nuclear power generation with little public deliberation, enabling the development of technologies and regulatory structures while limiting democratic dialogue. For example, the USNRC's statutory mandate authorizes nuclear safety regulation without encompassing the fundamental question of whether nuclear facilities should exist; thus, the technical-legal discourse constituting licensing and oversight processes provides no basis for denying licenses in response to general objections to nuclear power raised by communities or nongovernmental groups. Nevertheless, several public controversies influenced the evolving shape of U.S. regulations: concerns about fallout from atmospheric weapons tests, debates regarding the cumulative impacts of low radiation doses, uncertainties about the effectiveness of nuclear power plant safety systems, and concerns about the consequences of severe failures (Walker, 1992, 2000). Failures at facilities, including Three Mile Island, Chernobyl, and Fukushima, have periodically forced U.S. and international regulators to reevaluate their policies and processes.

Across national contexts, questions of legitimacy and voice are crucial to the activities of regulatory rule-making, facility licensing, and ongoing oversight (Barbour & Gill, 2013; Besley, 2010, 2012; Perin, 2006). Further research can more fully illuminate processes that build, maintain, and challenge public trust and the legitimacy of regulatory institutions; relations between those institutions and the nuclear industry; and relations between regulators and nuclear critics.

Nuclear Waste and Public Deliberation

The material and discursive aspects of managing nuclear wastes are consequential and intertwined. In the United States, for example, nuclear wastes are classified using categories including "low-level waste," "high-level waste," "waste incidental to reprocessing," and "uranium mill tailings," confounding radiological criteria (low vs. high radioactivity) with criteria based on origin (mill tailings, reprocessing). Critics often challenge these categories and their implications for the institutional status, regulation, and disposition of particular materials. One such critique asserts that the "incidental to reprocessing" category provides an institutional space for dealing with what is, in effect, high level-waste at lower levels of regulatory scrutiny (Makhijani & Saleska, 1992). As in the case of "spent" or "depleted" reactor fuel, which is in fact more hazardous than unused fuel, official terminology often understates risks posed to nuclear workers and communities.[6] Parallel controversies prevail in other national contexts.

Disputes regarding how, and where, to store or dispose of nuclear waste provide some of the most salient topics for further research (Clarke, 2010; Dawson & Darst, 2006; Endres, 2009a, 2009b, 2009c, 2012, 2013; Fan, 2006a, 2006b; Gerrard, 1996; Gowda & Easterling, 1998; Greenberg, 2013; Hoffmann, 2001; Johnson, 2008; Katz & Miller, 1996; Kinsella, 2016; Lidskog & Sundqvist, 2004; Macfarlane, 2011; Peterson, 2001; Ratliff, 1997). These controversies not only highlight interrelationships between discursive and material aspects of

nuclear power, but also provide valuable case studies of deliberative democracy, public participation in environmental decision-making, "not-in-my-back-yard" reactions, and environmental justice concerns regarding disproportionately affected communities. In the U.S. context, much interdisciplinary scholarship has addressed the social, political and cultural considerations surrounding siting a proposed high-level waste facility (Easterling & Kunreuther, 1995; Jacob, 1990; Macfarlane & Ewing, 2006; Shrader-Frechette, 1993; Vandenbosch & Vandenbosch, 2007; Walker, 2009). Within communication studies, Endres (2009a, 2009b, 2009c, 2012, 2013) highlights the importance of rhetorical strategies in those controversies.

Waste siting challenges remain problematic for every nation engaged in nuclear power production, posing health and safety risks for communities and international weapons proliferation risks related to plutonium contained in used fuel. In addition to their material risks, nuclear wastes present particular symbolic power as mysterious, potent, and enduring threats that still await solutions. Questions of temporality further complicate problems of equity, democratic process, and divergent cultural understandings of these products of reflexive modernity.

Social Movements and Social Meanings

Activist critics of nuclear power demonstrate classic social movement characteristics including shared identification, moral rhetorics, and long-term commitments to opposition. Nevertheless, the interests, positions, and rhetorical strategies of critics vary within and across national settings, warranting further national-level, comparative, and global studies of opposition to nuclear power. One approach views social movements from a discursive perspective, as evolving systems of meaning interacting with larger social contexts (DeLuca, 1999; Kinsella, 2015; McGee, 1980).

Nuclear power issues have informed the environmental movement's organizational tensions and strategic positions about energy sources. In one U.S. case, in the 1960s the California Sierra Club focused on resisting dam construction and preserving the Pismo Sand Dunes, leading the group to support a nuclear power project at Diablo Canyon. The organization's resulting internal conflict shaped early arguments against nuclear power and split the Sierra Club, with the strongest nuclear opponents forming Friends of the Earth (Wellock, 1998; Wills, 2006). This debate is now echoed as claims regarding the value of nuclear power for addressing climate change complicate oppositional discourses, with a small number of environmental organizations, antinuclear organizations, and opinion leaders reconsidering their opposition.

Another feature of the antinuclear movement is its challenge to the patriarchal foundations of the nuclear power enterprise. Petra Kelly (1994), a much-revered founder of the German Green Party, linked feminist and environmentalist themes that continue to inform a particularly strong national-level antinuclear movement. Markovits and Klaver (2012) cite "ecology, feminism

and women, peace and pacifism," and an emphasis on "democracy from below" as the "four pillars defining [German] Green identity" (p. 17). In the United States, the antinuclear organization Mothers for Peace utilized ecofeminist themes to protest the Diablo Canyon reactor project in the late 1960s (Wills, 2006). The group's rhetorical tactics challenged masculinist ideologies characterizing the public hearing practices of the Atomic Energy Commission, and later the USNRC, putting a nurturing face on nuclear power concerns. The influential Australian antinuclear activist Helen Caldicott (2006) has stressed similar themes, articulating them with her professional ethos as a pediatric physician.

Aspects of "public expertise" (Kinsella, 2004b; Kinsella & Mullen, 2007) add another characteristic dimension to antinuclear activism. Groups including Mothers for Peace and Friends of the Earth have developed their own technical and legal proficiencies as needed for engaging with the esoteric details and technocratic policy processes associated with nuclear issues. Nuclear opponents receive further support from organizations that supply both technical capacity and scientific authority, such as the U.S.-based Union of Concerned Scientists and the German-based Öko-Institut. Most recently, new media, open-source, and "do-it-yourself" (DIY) tools have facilitated emerging citizen science initiatives and collaborations linking technical specialists, grassroots activists, and "maker" communities responding to the Fukushima disaster (Kelly & Miller, in press; Kera, Rod, & Peterova, 2013; Morita, Blok, & Kimura, 2013). New media applications constitute an important emerging nexus of democratic engagement, knowledge production, and evolving forms of expertise.

Risk Analysis, Risk Representation, and Risk Communication

Questions of risk circulate prominently both in theories of contemporary society (Beck, 1992, 1995; Luhmann, 1989, 1993) and in public, regulatory, and industry nuclear discourses. In regulatory and industry contexts such questions are largely operationalized through concepts of risk analysis, which simultaneously inform and exist in tension with concepts of risk communication. The practice of risk analysis has ancient roots (Covello & Mumpower, 1985), but has assumed a fundamental role in contemporary technocratic discourses. An approach known as probabilistic risk analysis, widely utilized in nuclear power contexts, seeks to quantify the probability of events such as damage to the core of a distressed reactor, a particularly hazardous scenario for radiological releases. The USNRC's 1975 Reactor Safety Study pioneered this approach, producing the mathematical conclusion that the risk of fatality from a nuclear power plant failure was less than one in a million per reactor per year (USNRC, 1975). The study's controversial executive summary argued that nuclear power plants were safe compared to other risks such as automobile transportation and lightning strikes. Responding to intense objections noting the qualitative differences obscured by such analogies, the USNRC withdrew its support of the executive summary, coincidentally

months before the events at Three Mile Island (Keller & Modarres, 2004). This coincidence publicly highlighted the difficulties of assessing theoretical probabilities in contrast with the realities of an event that actually occurred. The events at Fukushima have again demonstrated the limits of representation associated with efforts to reliably quantify nuclear risks (Kinsella, 2012; Paté-Cornell, 2012).

Probabilistic numbers can play a range of roles in sense-making and decision-making about complex reactor systems and other nuclear hazards. Parties making decisions and judgments about risk often focus on the analytical result, a specific numerical probability, either to support or discredit it. Technical specialists often focus instead on the analytical process and operational insights provided by the models and calculations that produce the final number. For example, the U.S. nuclear industry uses probabilistic risk analysis to understand day-to-day plant operations and diagnose risks that need the most attention, while the USNRC uses "risk-informed regulation" principles to guide its oversight activities (Keller & Modarres, 2004; Siu & Collins, 2008). Public understandings of risk often diverge from such institutional understandings, contributing to mutual incomprehension and undermining legitimacy and trust in regulatory processes (Poortinga & Pidgeon, 2003).

Within this larger problematic, scientific and policy questions regarding the concept of "permissible radiation dose" evoke particular issues of communication and rhetoric (Walker, 2000). Technocratic approaches typically assume that some level of radiation exposure beyond "natural background levels" can be considered acceptable, contrasting with the intuitions and embodied narratives of individuals (Kinsella & Mullen, 2007; Lynch, 2012).[7] One example involves the material/discursive tension that nuclear power plant workers face when participating in radiation protection programs. While institutional discourses assert that risks are managed safely, workers' individual dosimeters and safety badges provide direct material evidence of ever-accumulating exposures. Ambiguous workplace exposure standards such as "as low as reasonably achievable," and implicit incentives to under-report doses to retain risky job assignments at higher pay rates, produce paradoxical conditions for many nuclear workers (Jobin, 2012).[8]

More broadly, technical debates regarding setting radiation standards in the face of scientific uncertainty have fundamental communicative dimensions (Walker, 2000). Social scientific research indicates that positions taken in these debates are often informed more by institutional and political factors than by scientific evidence (Silva, Jenkins-Smith, & Barke, 2007). Such findings can be illuminated further by recognizing the multivocality of scientific rhetoric and the complexity of interdisciplinary communication (Thompson, 2009). Public concerns about radiation exposure are especially potent (Weart, 1988), warranting closer examination of the technical and scientific discourses that legitimate policy decisions and institutional practices regarding radiation standards and exposures.

Conclusion: Communication Scholarship and Nuclear Power

The five areas sketched in the previous section represent topics of particular interest for continuing communication scholarship. The research mapped in this chapter provides a strong theoretical and empirical foundation for further work within and beyond the areas we have identified. We expect that communication scholars across a range of methodological traditions and analytical foci can recognize other topics of interest suggested by the map we have provided.

Although the scope of our review has been fairly broad, it remains partial. One topic we have deferred for later attention is a teleological narrative that has persisted throughout the history of nuclear power, promising that "next generation" technologies will overcome the concerns associated with current technologies (e.g., Weinberg & Spiewak, 1984). Rhetorical visions regarding "small modular reactors," "traveling wave reactors," thorium-fueled reactors, nuclear fusion, and other speculative technologies sustain present versions of that narrative. Another topic we have not addressed in detail is the contested rhetorical separation of commercial and military nuclear applications, especially in relation to issues of technology transfer, used fuel reprocessing, and the ambitions of emerging and prospective nuclear power nations. A third area warranting closer examination is the relationship between nuclear power and other nuclear energy applications in industry and medicine, which are less controversial and help to legitimate the larger nuclear power enterprise, but nevertheless pose their own risks and policy challenges. A fourth area concerns the temporality of nuclear phenomena, simultaneously far faster than timescales for human consciousness and action (as in the case of rapid fault progression in reactor systems), and far slower (as in the multi-millennial lifetimes of hazardous nuclear wastes). The relationships among temporality, human agency, and nuclear materialities pose significant challenges for communication theory.

Nuclear power involves a complex discursive terrain encompassing competing promotional and oppositional narratives; ambiguous relationships to problems of climate change and energy security; varied forms of negotiation and rhetorical boundary work; fragmented and often-incommensurable discourses and forms of knowledge; and organizational, institutional, and political challenges related to managing and governing a high-risk technology. All of these areas provide crucial sites for further communication research. Such scholarship can advance communication theory and practice by interrogating relationships among materialities, discourses, and agency, and at the same time, engage across disciplines to address urgent problems of energy, environment, technology governance, and democratic process.

Notes

1. In an interview with a Japanese newspaper (Ohno, 2011), Beck applied the organized irresponsibility concept directly to the Fukushima disaster. Following the onset of the disaster the German government's Ethics Commission for a Safe

Energy Supply (*Ethik-Kommission Sichere Energieversorgung*), on which Beck served, recommended ending nuclear power production.

2. Regarding sociological and rhetorical boundary work see Gieryn (1983, 1995) and Taylor (1996). For boundary work and "discursive containment" in nuclear contexts, see Kinsella (2001), Kinsella and Mullen (2007), and Kinsella, Kelly, and Kittle Autry (2013).

3. Disagreement exists regarding how to characterize nuclear "crises," "accidents," "incidents," "events," "failures," or "disasters," but recognizing the inherent risks of nuclear technologies we choose to avoid the term "accident." One widely-used criterion for a serious nuclear failure is reactor "core damage," also known as full or partial "meltdown." To date, eleven such instances are generally recognized. Broader lists of nuclear failures (e.g., Rogers, 2011) cite more than thirty significant events and additional "near-misses." The International Atomic Energy Agency's International Nuclear and Radiological Events Scale, widely cited since the Fukushima disaster, includes events beyond core damage but relies heavily on geographic extent and number of people affected as indicators of severity.

4. Statistics from IAEA Power Reactor Information System, www.iaea.org/PRIS/.

5. Critics often challenge the institutional use of the term "spent fuel," arguing that it normalizes and downplays the associated radiological hazards.

6. Further compounding terminological confusions, "depleted" reactor fuel differs from "depleted uranium," a byproduct of uranium enrichment used controversially in ordnance. Nuclear insiders internalize such distinctions and find them unproblematic, but they pose barriers for other stakeholders.

7. The concept of natural background level is itself problematic, as it ambiguously addresses components such as fallout from weapons tests and exposures from medical diagnostic procedures.

8. See www.nrc.gov/reading-rm/basic-ref/glossary/alara.html and http://hps.org/publicinformation/radterms/radfact1.html

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