UNITED NATIONS UNIVERSITY
UNU-IAS

Fukushima Global Communication Programme
Working Paper Series
Number 18 — December 2015

Being "Post-Fukushima": Divergent Understandings of Sociotechnical Risk

William J. Kinsella North Carolina State University

Fukushima Global Communication Programme

This working paper series shares research produced as part of the Fukushima Global Communication (FGC) Programme, a research initiative of the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS). The FGC Programme applies a human security approach to examine impacts of the Great East Japan Earthquake, tsunami and nuclear accident of 11 March, 2011 on people and society, and the challenges of the recovery process in Fukushima. It also focuses on issues of risk and information provision, aiming to improve understanding of how the threat of radiation is perceived, and the specific challenges of risk communication related to nuclear energy.

This working paper is an output of the FGC research workshop "Understanding and Communicating Risks Post Fukushima", held in Tokyo on 12–13 November 2015. The workshop brought together international experts to explore the specific challenges of understanding and discussing risks related to nuclear accidents, and identify appropriate and effective forms of risk communication.

To find out more, please visit **fgc.unu.edu**

ABSTRACT

This working paper examines the failures at the Fukushima nuclear power plant as an "emancipatory catastrophe" in the sense suggested by Ulrich Beck (2015): an event that creates the possibility for new insights regarding sociotechnical risks. Linking Beck's concept with insights from Niklas Luhmann's theory of social systems, the paper identifies key participants in the post-Fukushima conversation and explores the prevailing limits of that conversation. Significant barriers to productive, reflexive consideration of the implications of Fukushima are noted, and corresponding recommendations for policy and practice are offered.

抄録

本ワーキングペーパーは、Ulrich Beck (2015年) が示したように、社会技術に起因したリスクに関する新しい洞察の創出を可能にしたという意味での「解放的な惨事」として、福島原発事故の過失を検証する。本ペーパーは、Beckの考えをNiklas Luhmannの社会システム理論と関連付けながら、ポスト福島の対話の主要な参画者を特定し、広く見受けられる対話の限界を探る。福島の影響を生産的、内省的に考慮することを阻む重要な障害因子を示し、それぞれについて政策、実務に関する提言を行う。

Introduction

Since the introduction of nuclear power as a commercial energy source, a number of high-profile events have captured public attention and prompted broad debates regarding nuclear safety. The best-known events, at Three Mile Island, Chernobyl, and Fukushima, have been variously described as "accidents," "disasters," and "catastrophes." While subject to diverse interpretations, these terms suggest different degrees of perceived severity and consequence, warranting different kinds of responses. Typically, we expect that we can learn from "accidents" and move on, incorporating incremental improvements. "Disasters" pose greater challenges and call for more extended reflection, perhaps leading to more substantial changes in policy and practice.

The term "catastrophe" suggests something more profound. In the English language, and consistent with its original Greek meaning, early uses of the word linked two key ideas: fundamental, irrevocable change; and an inevitable culmination of a process that was implicit from a phenomenon's origin and has unfolded over time. The second of these ideas, related to Aristotle's concept of *entelechy* as fulfillment or fruition of some inherent principle (Burke, 1969; Kinsella, 2005; Lindsay, 1998) has faded over time but may be relevant to the topic of our workshop. Only later did the meaning of catastrophe devolve into something more prosaic, coming to mean any kind of highly unfortunate event.

Our workshop addresses the challenges of "understanding and communicating risks post-Fukushima." Accordingly, this paper is prompted by the question: what does it mean to be "post-Fukushima"? Should we view Fukushima as an "accident," a term often applied to the events at Three Mile Island? Many commentators have chosen the stronger term "disaster," although some suggest that the nuclear component of the 3.11 "triple disaster" was, itself, something less than a disaster (I don't agree with that claim). Or is Fukushima better understood as a catastrophe, and if so, in what sense of the term—a highly unfortunate event, a moment of fundamental and irrevocable change, or an inevitable fulfillment of some essential feature of nuclear power, revealing new insights regarding nuclear technologies and their place in society?

The last and strongest of these interpretations resonates with the well-known concept of "normal accidents" developed by Charles Perrow (1984) in response to the events at Three Mile Island and other failures of industrial safety. In brief, Perrow argued that certain technologies, including nuclear power, are so inherently complex and so prone to rapidly-developing failure modes that they exceed the limits of human control. Failures in such systems can be limited in scale and frequency to some degree, but according to Perrow, can never be fully eliminated (cf. Perrow, 2011).

Multiple schools of thought have responded to Perrow. The "high-reliability organizations" perspective maintains that adequate defenses against systemic failures can be achieved through diligent and mindful practices, while the "safety culture" perspective emphasizes the role of organizational culture (for further discussion see Bourrier, 2011; Kinsella, 2013; Kinsella, Andreas, & Endres, 2015; Silbey, 2009). A third perspective, embraced by many nuclear engineers and nuclear power advocates, suggests that "lessons learned" from failures such as those at Fukushima, together with increasingly sophisticated designs employing principles of "inherent safety," can reduce disastrous failures to acceptable levels (for an early statement of the inherent safety concept, see Weinberg & Spiewak, 1984). The events at Fukushima pose challenges to all of these perspectives, and have been read by some critics of nuclear power as confirming its fundamental vulnerabilities.

A more recent perspective involves the notion of "emancipatory catastrophism" developed by the risk sociologist Ulrich Beck toward the end of his life. Although Beck (2014, 2015) introduced the concept in relation to global climate change, others have suggested that a wider range of catastrophic events might produce "emancipatory" effects by revealing fundamental structural problems and thus prompting societal "metamorphosis" (see Han, 2015). Such

a metamorphosis might be evident in the post-Fukushima turn away from nuclear power adopted by a number of nations, most notably Germany; indeed, Beck served as a member of the German *Ethik-Kommission Sichere Energieversorgung* (Ethics Commission for a Safe Energy Supply) that recommended such a response. Although many current and prospective nuclear power nations have not responded in such a manner, a less drastic version of social metamorphosis might involve an overall reduction in the use of nuclear power and a thorough revision of engineering standards, operational practices, and regulatory systems, without complete disengagement from the technology. Conceivably, such a change might further challenge the economics of an already-fragile industry, eventually leading to a more complete transition away from nuclear power. Whether the events at Fukushima might produce such effects remains to be seen, but one factor affecting that possibility is the degree to which society opens itself to a reflexive re-examination of nuclear power policies and practices. Choosing to regard Fukushima as an emancipatory catastrophe might be a first step toward it actually becoming one.

This paper pursues the question of what it means to be post-Fukushima by examining some of the event's implications, as they have been understood to date, for public perceptions and attitudes, regulatory institutions and activities, the nuclear industry, nongovernmental public interest groups, and nuclear energy policy. A few comments are in order regarding the premises guiding this analysis. First, within any of those domains, the meanings of Fukushima are not viewed the same way by all parties; instead, they are often controversial and contested. Differences between those domains often are even greater than the differences within them, for reasons considered below. Second, my analysis positions processes of communication as fundamental to the questions at hand. How we talk about Fukushima does not simply *describe* the event's objective reality; rather, varied representations of Fukushima combine to *construct* or *constitute* its evolving meanings. Those representations circulate across a wide range of venues including (but not limited to) journalistic reports, technical risk analyses, organizational and institutional discourses, advocacy messages in traditional and new electronic venues, and policy documents and debates. Third, competing understandings of Fukushima and its implications are inherently political: they are consequential in varied ways for different communities, social groups, and sectors, and thus must be the focus of broad democratic engagement. Contestedness, constructedness, and consequentiality are all central to what it means to be "post-Fukushima." Thus, whether we view Fukushima as an accident, a disaster, or a catastrophe is not a question of its ontological status, but is instead, a practical question of how its implications are constructed, and with what consequences.

Discussion

To address that practical question, I begin by identifying some key participants in the post-Fukushima conversation. Who speaks with authority in that conversation is crucial to its outcomes. I then suggest an analytical approach for examining the effectiveness of that conversation, which illuminates some of the challenges involved. I outline some implications of that analysis, and then offer a number of recommendations for policy and practice.

Mapping the nuclear power conversation

The categories identified here illustrate how nuclear power is socially constituted as a network of institutions, organizations, material infrastructures, and practices. These categories are neither comprehensive nor clearly separable; they overlap significantly and their relationships are complex and dynamic. Nevertheless, they correspond to a set of widely recognized, influential social actors, or communities of practice, with relatively coherent institutional and political interests. Adapting a set of categories established in an earlier, primarily U.S.-oriented analysis (Kinsella, 2013), those social actors include:

- *Nuclear producers and promotors*: plant operators, equipment and material suppliers, contractors, trade advocacy groups (e.g., Japan Atomic Industrial Forum, Nuclear Energy Institute, World Nuclear Association); industry safety self-regulation organizations (e.g., Institute of Nuclear Power Operations, Japanese Nuclear Operators, Japan Nuclear Safety Institute, World Association of Nuclear Operators); intergovernmental coordinating organizations (e.g., the Organization for Economic Cooperation and Development's Nuclear Energy Agency)

- *International and national nuclear safety and security regulators* (e.g., International Atomic Energy Agency, Japan Nuclear Regulation Authority, U.S. Nuclear Regulatory Commission)

- *Energy policy makers* in a wide range of international, national, and sub-national contexts

- *Research and development organizations* operating in governmental, nongovernmental, academic, and industry settings

- *Financial institutions and organizations* involved in nuclear plant construction, ownership, insurance, and reinsurance

- *Risk analysts* working in governmental, nongovernmental, academic, industry, financial, and advocacy group settings

- *Risk communicators* working in governmental, nongovernmental, academic, industry, financial, and advocacy group settings (overlapping with, but not identical to, the category of risk analysts)

- *Public communities* at regional, national, and local levels, often distinguishable (but not always analytically distinguished) by categories such as social class, race, ethnicity, age, gender, or affluence, affected directly and indirectly (via health, safety, and/or economic factors) by activities across the nuclear fuel cycle

- *Educational organizations and institutions* across settings ranging from professional nuclear engineering education to public education for general scientific and technical literacy

- *Media and journalism organizations and institutions* operating in traditional and new media contexts

- *Independent commentators and opinion leaders* (a category of growing importance due to the possibilities for provided by new communication media)

A robust vision of democracy would involve a rich conversation among all these parties, but clearly, such an ideal faces many challenges. Those challenges include inherent technical complexity; underlying technocratic premises that further limit topics, venues, and modes of discussion; frequent assumptions of a public deficit of knowledge and competency; conflicting political-economic interests; institutional and organizational power differences; and divergent understandings of fundamental principles such as government regulation, market economics, environmental protection, social and technological progress, equity, justice, and the public interest (Kinsella, 2015; Kinsella, Andreas, & Endres, 2015).

Analytical approach

One way to examine communication among these parties draws upon the work of Niklas Luhmann (1979, 1989, 1990, 1992, 1993), which has been applied in a number of nuclear risk contexts (e.g., Kinsella, 2012, 2016; Kinsella, Kelly, & Kittle Autry, 2013; Moeller, 2006; Ylönen and Litmanen, 2015). Luhmann views society as a composite of multiple social subsystems, specifically identifying economics, education, law, politics, religion, and science as fundamentally differentiated areas of activity. Each of those subsystems operates by way of its own, unique communication code, regarding the others as parts of its environment; this inside/outside distinction is essential as a way of simplifying the activity of each subsystem. Luhmann considers such functional simplification not only as necessary for the effective operations of those social subsystems (and of modern society as a whole), but also as an essential principle of technology (Luhmann, 1993; Valentinov, 2012, 2014).

Communication between subsystems involves varying degrees of "resonance," and both insufficient resonance and excessive resonance can be problematic. For example, in retrospect the events at Fukushima demonstrate that there had been insufficient resonance between the political subsystem's responsibilities for nuclear safety and the scientific subsystem's understandings of seismic hazards. Arguably, at the same time there was excessive resonance between the political subsystem and economic imperatives at the national level (e.g., energy production to support the Japanese economy) and at more local levels (e.g., economic benefits extended to communities accepting the risks of hosting nuclear plants; see Kingston, 2012).

Clearly, Luhmann's subsystems do not correspond uniquely and directly to the communities I have identified as significant parties in the nuclear conversation. Economics, law, politics and science, for example, are relevant to all of those communities, but in different ways. Nevertheless, it may be useful to apply a similar analysis to those communities, viewing each as focused on its own activities, organized through its own discourses (or communication codes, in Luhmann's terms), and strongly oriented to the reduction of complexity. Such complexity reduction is accomplished, in part, by externalizing the focal concerns of the other communities; that is, treating those concerns as part of the organizational or institutional environment (where they may appear as challenges or as resources) rather than as internal areas of responsibility. Luhmann (1989, p. 138) argues that as such tendencies increase, "system rationality increasingly loses its claim to be world rationality." Valentinov (2014) suggests that Luhmann's model implies a form of "governance pessimism": as functional differentiation continues, efforts at regulation, social activism, and social change are increasingly confined to individual subsystems. Meanwhile, the possibilities for coordinating those subsystems become increasingly limited. Valentinov (2014, p.17) observes that although subsystem differentiation "allows a tremendous increase in [total] societal complexity, it makes societal communication erratic, unpredictable and ungovernable."

Implications

In the post-Fukushima nuclear conversation it is possible to identify particular distinctions made by participants, differentiating between "internal" and "external" factors. The boundaries thus created may limit resonance between those parties in unproductive ways, or conversely, may fail to prevent excessive resonance. These boundaries are continuously negotiated by the parties, in efforts to minimize turbulence within their own domains and to promote their own interests as understood internally. However, with reflexive insights provided by the events at Fukushima it may be possible to intervene in that process of boundary

construction, by designing forms of communication that modify the prevailing forms of interaction. I now consider some of the most significant boundaries that currently limit the potential for a productive post-Fukushima dialog.

- An often-implicit but highly consequential participation boundary limits access to conversations about energy policy, nuclear safety regulation, and other matters deemed "technical" or "specialized." This fragmentation of "technical" and "public" discourses has long been well-documented and theorized (e.g., Goodnight, 1982; Wynne, 1991), but calls for further examination in the light of Fukushima.

- Rhetorically-negotiated boundaries separate "internal" and "external" phenomena, affecting how risks are defined and addressed by responsible communities. For example, regulatory debates persist regarding what kinds and levels of hazard should be recognized in the engineering "design basis" for nuclear plants. Hazards such as earthquakes, flooding, and extreme weather events are typically classified as "beyond design basis" when they exceed anticipated levels established through prevailing methods of risk analysis (see Acton & Hibbs, 2012; Alvarenga & Frutuoso e Melo, 2015; Kinsella, 2013). Such decisions do not only affect the robustness of facility designs; more subtly, they provide rationales for reducing regulatory, operational, and planning activities related to these possibilities.

- Discursively-constructed geographic and cultural boundaries affect how risks are understood and evaluated. By asserting that the failures at Fukushima were products of specific geological conditions, or flawed regulatory systems, or cultural biases toward regulatory deference, global nuclear producers and promoters can minimize the need for reconsidering the vulnerabilities of their technology.

- Negotiated boundaries govern the locus of nuclear regulatory responsibility and structure the nuclear regulatory process. The U.S. case provides a useful example. Following the failures at Three Mile Island, the U.S. nuclear industry moved quickly to establish a more robust system of self-regulation, creating the industry-based Institute for Nuclear Power Operations (INPO) in December 1979. INPO has been recognized as a successful mechanism for improving nuclear safety (Rees, 1994), but also provides a warrant for industry efforts to avoid more intrusive, direct scrutiny by the federal Nuclear Regulatory Commission (USNRC). Following the failures at Fukushima, the U.S. nuclear industry moved more quickly than its federal regulator, announcing a plan for "Diverse and Flexible Response" (FLEX) that would mitigate—rather than prevent—future nuclear disasters (NEI, 2011). By enacting this plan before the USNRC completed its analysis of appropriate regulatory responses, the industry gained significant control over those responses (Kinsella, 2013).

- Rhetorical and institutional boundaries artificially separate safety and economic concerns in ways that may inhibit the larger goals of nuclear safety. Often, nuclear safety regulation and cost regulation are assigned to different agencies, and efforts by public interest groups to link these activities are impeded (cf. Kinsella, Kelly, & Kittle Autry, 2013). In fact, if the true costs of adequate post-Fukushima safety enhancements were to be internalized, the economic cases for new nuclear plant construction licenses, license extensions, and consumer rate charges would often be less strong than they otherwise appear (cf. Cooper, 2012).

The recommendations offered at the end of this working paper are intended to help manage boundaries such as these more productively, fostering more effective resonance where needed and reducing the potential for excessive and disruptive resonances.

Conclusion

A number of commentators consider Luhmann's pessimism regarding technological governance not as a form of fatalism, but as a useful diagnostic resource (cf. Moeller, 2006; Valentinov, 2012, 2014; Wan, 2010). Beck's notion of "emancipatory catastrophism" (Beck, 2015) provides an optimistic frame for such diagnosis, suggesting that catastrophic events can make the hazardous aspects of sociotechnical systems more clearly visible. Expanding the nuclear conversation in ways suggested here may help address the hazards made so evident by the events at Fukushima.

Recommendations for Policy and Practice

The first five of the following sets of recommendations are organized to roughly correspond to the five systemic boundaries identified above, although substantial overlap exists. The sixth recommendation addresses education and training programs for nuclear professionals.

1. Expand the nuclear power conversation by cultivating greater participation by non-specialists. Evolving digital media provide one set of tools for expanding inclusion, but are not a complete solution. Other possibilities include experimenting with novel public venues, expanding long-term engagements through advisory bodies, and incorporating affected communities more fully into the design of public consultation (cf. INSAG, 2006). Rather than being directed toward "public acceptance," efforts can be oriented toward inclusive dialog steered equally by all parties. The technocratic barriers to such participation are formi-

dable and well-documented, so this recommendation is intended to provoke further reflection on possible fundamental changes.

2. Recognize more fully that phenomena including seismic and weather events, losses of supporting infrastructures, human errors, management failures, and security breaches are not "external hazards," but are intrinsic to nuclear power as an environmentally embedded, sociotechnical system (cf. Alvarenga & Frutuoso e Melo, 2015; Funabashi & Kitazawa, 2012; Kinsella, 2013; Perrow, 1984, 2007).

3. Incorporate greater attention to geographic and cultural contexts (e.g., seismic characteristics, weather hazards; governmental transparency and public participation) to inform technological choices and regulatory processes. Emerging and aspiring nuclear power nations pose particular challenges for ensuring sufficient and appropriate regulatory capacity. Efforts to "harmonize" regulations across national contexts may sometimes conflict with goals for rigorous and transparent standards.

4. Complement the prevailing emphasis on quantitative safety metrics with broader qualitative appraisals of safety as understood by a broader range of parties (cf. Leveson, Dulac, Marais, & Carroll, 2009; Silbey, 2009; Ylönen & Litmanen, 2015). Reexamine the pros and cons of industry self-regulation (cf. Perin, 2006; Rees, 1994), which has proven effective in many respects but has the potential to become excessively autonomous in ways illuminated by Luhmann's systems theory.

5. Although safety and economic concerns are often separated rhetorically, they are in fact deeply intertwined (cf. Cooper, 2012; Kinsella, Kelly, & Kittle Autry, 2013; Kinsella, 2015; Lewis, 2014). Increasingly prominent discourses of "regulatory efficiency," "customer focus" (where regulatory "customers" are increasingly understood as nuclear plant licensees rather than affected public communities), and "cumulative effects of regulation" have the potential to affect the balance of cost and safety concerns.

6. Nuclear engineering education may benefit from greater inclusion of humanities, social science, and policy science perspectives, to help inform the work of engineers and regulatory staff. Support for sustained, collaborative programs linking these disciplines can play a valuable role. The University of Tokyo's Nuclear Education and Research Initiative (University of Tokyo, 2007), conducted from 2007-2012 and linking participants across multiple disciplines and institutions, provides one example.

William J. Kinsella is a Professor of Communication at North Carolina State University, where he directed the interdisciplinary program in Science, Technology, and Society from 2009-2014. His work addresses the overlapping areas of environmental and energy communication, science and technology communication, risk communication, and organizational communication. He earned a bachelor's degree in physics (Manhattan College), pursued graduate studies in astronomy and physics (New Mexico State University) and worked as a science educator before completing his master's and doctoral degrees in Communication at Rutgers University. During 2010 he was a U.S. Fulbright Scholar at the Institute for Nuclear Energy and Energy Systems, University of Stuttgart, Germany. His work on nuclear energy communication has encompassed the areas of nuclear fusion, environmental cleanup across the US nuclear weapons complex, and commercial nuclear energy in U.S. and global contexts.

Dr. Kinsella's research has appeared in journals including Communication Monographs, Communication Yearbook, Environmental Communication, Management Communication Quarterly, Science as Culture, and Technical Communication Quarterly, and in several academic books. He is a co-editor and contributor to Nuclear Legacies: Communication, Controversy, and the U.S. Nuclear Weapons Complex (Lexington, 2007). His work has received five awards from the U.S. National Communication Association and its Environmental Communication and Organizational Communication divisions, and a Best Research Article Award from the Canadian Association for Studies in Discourse and Writing. He serves on the editorial boards of the Atlantic Journal of Communication, Environmental Communication, the KB Journal (Kenneth Burke Journal), and Science Communication. He co-directed the Seventh Biennial Conference on Communication and the Environment (2003) and the Second Annual Research Symposium on Communication, Rhetoric, and Digital Media (2011), and served as President of the National Communication Association's Environmental Communication Division during 2009-2010. Email: wjkinsel@ncsu.edu

---

References

Acton, J. M., & Hibbs, M. (2012). *Why Fukushima was preventable.* Washington, DC: Carnegie Endowment for International Peace.

Alvarenga, M. A. B., & Frutuoso e Melo, P. F. (2015). Including severe accidents in the design basis of nuclear power plants: An organizational factors perspective after the Fukushima accident. *Annals of Nuclear Energy, 79*, 68-77. DOI: http://dx.doi.org/10.1016/j.anucene.2015.01.016

Beck U (2014) How climate change might save the world. *Development and Society, 43*(2), 169-183.

Beck, U. (2015) Emancipatory catastrophism: What does it mean to climate change and risk society? *Current Sociology, 63*(1), 75-88. DOI: 10.1177/0011392114559951

Bourrier, Mathilde. 2011. *The Legacy of the Theory of High-reliability Organizations: An Ethnographic Endeavor.* Geneva: University of Geneva (Working paper #6/2011).

Burke, K. (1969). *A rhetoric of motives.* Berkeley: University of California Press.

Cooper, M. (2012). *Nuclear safety and nuclear economics.* South Royalton: Vermont Law School.

Funabashi, Y., & Kitazawa, K. (2012). Fukushima in review: A complex disaster, a disastrous response. *Bulletin of the Atomic Scientists, 68*(2), 9-21. DOI: 10.1177/0096340212440359

Goodnight, G. T. (1982). The personal, technical, and public spheres of argument: A speculative inquiry into the art of public deliberation. J*ournal of the American Forensic Association, 18*, 214-227.

Han, Sang-Jin (2015). Emancipatory catastrophism from an East Asian perspective: Feedback from the dialogue organizer. *Current Sociology, 63*(1), 115–120. DOI: 10.1177/0011392114559851

International Nuclear Safety Group (INSAG) (2006). *Stakeholder involvement in nuclear issues: INSAG-20.* Vienna: International Atomic Energy Agency.

Kingston, J. (2012). Japan's nuclear village. *Asia-Pacific Journal, 10*(1), 10 September. Available at: www.japanfocus.org

Kinsella, W. J. (2005). One hundred years of nuclear discourse: Four master themes and their implications for environmental communication. In S. Senecah (Ed.), *Environmental Communication Yearbook, vol. 2* (pp. 49-72). Mahwah, NJ: Erlbaum.

Kinsella, W. J. (2012). Environments, risks, and the limits of representation: Examples from nuclear energy and some implications of Fukushima. *Environmental Communication, 6*(2), 251-259. DOI:10.1080/17524032.2012.672928

Kinsella, W. J. (2013). Negotiating nuclear safety: Responses to the Fukushima disaster by the US nuclear community. STS Forum on the 2011 Fukushima/East Japan Disaster, University of California-Berkeley, 11-14 May. Available at: http://go.ncsu.edu/kinsella-fukushimaforum2013

Kinsella, W. J., Kelly, A. R., & Kittle Autry, M. (2013). Risk, regulation, and rhetorical boundaries: Claims and challenges surrounding a purported nuclear renaissance. *Communication Monographs, 80*(3), 278-301. DOI:10.1080/03637751.2013.788253

Kinsella, W. J. (2015). Rearticulating nuclear power: Energy activism and contested common sense. *Environmental Communication, 9*(3), 346-366. DOI:10.1080/17524032.2014.978348

Kinsella, W. J. (2016). A question of confidence: Nuclear waste and public trust in the United States after Fukushima. In R. Hindmarsh & R. Priestly (Eds.), *The Fukushima effect: A new geopolitical terrain.* London: Routledge.

Kinsella, W. J., Andreas, D., & Endres, D. (2015). Communicating nuclear power: A programmatic review. In E. Cohen (Ed.), *Communication Yearbook 39* (pp. 277-309). London: Routledge.

Leveson, N., Dulac, N., Marais, K., & Carroll, J. (2009). Moving beyond normal accidents and high reliability organizations: A systems approach to safety in complex systems. *Organization Studies, 30*(2-3), 227-249. DOI: 10.1177/0170840608101478

Lewis, E. E. (2014). *How safe is safe enough? Technological risks, real and perceived.* New York: Carrel.

Lindsay, S. (1998). *Implicit rhetoric: Kenneth Burke's extension of Aristotle's concept of entelechy.* Lanham, MD: University Press of America.

Luhmann, N. (1979). *Trust and power: Two works* (Ed. T Burns & G. Poggi; Trans. H. Davis, J. Raffan, & K. Rooney). New York: Wiley.

Luhmann, N. (1989). *Ecological communication* (trans. J. Bednarz). Chicago: University of Chicago Press.

Luhmann, N. (1990). Technology, environment, and social risk: A systems perspective. *Industrial Crisis Quarterly, 4*, 223-231.

Luhmann, N. (1992). What is communication? *Communication Theory, 2*, 251-259.

Luhmann, N. (1993). *Risk: A sociological theory* (trans. R. Barrett). New York: de Gruyter.

Moeller, H.-G. (2006). *Luhmann explained: From souls to systems.* Chicago: Open Court.

Nuclear Energy Institute (2011). FLEX: The industry strategy to enhance safety. Available at: http://safetyfirst.nei.org/industry-actions/flex-the-industry-strategy-to-enhance-safety/

Perin, C. (2006) *Shouldering risks: The culture of control in the nuclear power industry.* Princeton: Princeton University Press.

Perrow, C. (1984). *Normal accidents: Living with high-risk technologies.* New York: Basic Books.

Perrow, C. (2007). *The next catastrophe: Reducing our vulnerabilities to natural, technological, and terrorist disasters.* Princeton, NJ: Princeton University Press.

Perrow, C. (2011). Fukushima and the inevitability of accidents. *Bulletin of the Atomic Scientists, 67*(6), 44-52.

Rees, J. V. (1994). *Hostages of each other: The transformation of nuclear safety since Three Mile Island.* Chicago: University of Chicago Press.

Silbey, S. S. (2009). Taming Prometheus: Talk about safety and culture. *Annual Review of Sociology, 35*, 341- 369. DOI: 10.1146/annurev.soc.34.040507.134707

University of Tokyo (2007). Nuclear education and research initiative. Available at: http://www.n.t.u-tokyo.ac.jp/gcoe/eng/program/index.html

Valentinov, V. (2012). System–environment relations in the theories of open and autopoietic systems: Implications for critical systems thinking. *Systemic Practice and Action Research, 25*, 537–542. DOI: 10.1007/s11213-012-9241-0

Valentinov, V. (2014). The complexity–sustainability trade-off in Niklas Luhmann's social systems theory. *Systems Research and Behavioral Science, 31*(1), 14-22. DOI: 10.1002/sres.2146

Wan, P. Y. (2010). Systems theory: Irredeemably holistic and antithetical to planning? *Critical Sociology, 37*(3), 351 –374. DOI: 10.1177/0896920510380067

Weinberg, A. M., & Spiewak, I. (1984). Inherently safe reactors and a second nuclear era. *Science, 224*(4656), 1398-1402. DOI: 10.1126/science.224.4656.1398

Wynne, B. (1991). Knowledges in context. *Science, Technology, & Human Values, 16*(1), 111-121.

Ylönen, M., & Litmanen, T. (2015). Signaled and silenced aspects of nuclear safety: A critical evaluation of international nuclear safety thinking. *Risk, Hazards & Crisis in Public Policy, 6*(1), 22-23.