Half-Lives/Afterlives:
Labor, Technology, Nature, and the Nuclear Decommissioning Business

(MSCA-IF Project 101025603 NUCLEARDECOM)

Project overview

Introduction.

"After twenty years, we realized that decommissioning nuclear power plants is much more challenging than constructing and operating them," revealed in a recent interview Emanuele Fontani, the newly appointed managing director of SOGIN, the public company in charge of decommissioning nuclear power plants in Italy.[1]

Shutting down a nuclear plant does not end its life, nor does it extinguish its hazardousness. Nuclear decommissioning, the complex and lengthy process of taking a nuclear power plant out of service, consists of various phases: the removal of spent fuel, the conditioning and interim storage of contaminated material, the decontamination and demolition of buildings and other structures, the release of the site to "brownfield" or "greenfield" conditions. As I will show below, decommissioning is not just the removal of a nuclear power plant from a contaminated site but a transformative process itself, because it alters socio-ecological relationships shaped by the presence of nuclear power plants over years and decades of operations. Until the mid 1970s, the problem of how to deal with obsolete nuclear power plants (NPPs) had received marginal attention. Constructors and operators were not even required to submit decommissioning plans to obtain operating licenses. The decommissioning industry has grown considerably after first-generation NPPs reached the end of their operating life.[2] Since the late 1970s the European Commission has been a major promoter of and contributor to decommissioning R&D and sponsoring various programs, including the study and documentation of five pilot decommissioning projects that had the objective of comparing site-specific experiences and approaches.[3] Today, only within the European Union, 80 nuclear power reactors are at different decommissioning stages[4] and the number is destined to grow further in the next two decades also for the effect of the Fukushima accident in Japan.[5] Political decisions to phase-out nuclear energy production—like Italy and Germany did, respectively after Chernobyl (1987) and Fukushima (2011)—have also contributed to the total number of NPPs to be decommissioned. In 2011, the European Council issued a directive (2011/70/Euratom) aiming at harmonizing EU member states' policies concerning nuclear waste management and disposal, but other phases of decommissioning remain very much anchored to site-specific practices and dependent on national interests.[6]

Despite the magnitude of the phenomenon and its impactful socio-ecological implications, the Social Sciences and the Humanities have paid scarce attention to nuclear decommissioning, preferring to focus only on its end-tail problem: nuclear waste disposal. Consequently, decommissioning has remained a problem almost exclusively dealt with by technical experts. NUCLEARDECOM aims to reduce that knowledge gap through a dynamic and comprehensive analysis of expert strategies, workers practices, and local communities' responses to decommissioning projects in Western Europe. To this end, it adopts a comparative, interdisciplinary approach consisting of two main components. First, it documents the history of the nuclear decommissioning industry from its inception to the present. Second, it produces ethnographic

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[1] "Nucleare, ecco il nuovo piano di smantellamento delle centrali al 2035," *La Repubblica*, July 16, 2020.

[2] The first report commissioned by the International Atomic Energy Agency (IAEA) on the subject is G. R. Bainbridge, et Al., "Decommissioning of Nuclear Facilities: A Review of Status," *Atomic Energy Review* 12 (1), 1974, pp. 145-160.

[3] European Commission, *Decommissioning of Nuclear Installations in the European Union: Supporting document for the preparation of an EC communication on the subject of decommissioning nuclear installations in the EU*, EUR 18860, 1999.

[4] In the United States the number of NPPs undergoing decommissioning is 29. Source: International Atomic Energy Agency, *Nuclear Power Reactors in the World*, 2019 edition, Vienna, May 2019. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/RDS-2-39_web.pdf

[5] Noriko Hikosaka Behling, Thomas, G. Behling, Mark C. Williams, Shunsuke Managi, *Japan's Quest for Nuclear Energy and the Price It Has Paid: Accidents, Consequences, and Lessons Learned for the Global Nuclear Industry*, Elsevier, 2019.

[6] Gianluca Ferraro, *The Politics of Radioactive Waste Management: Public Involvement and Policymaking in the European Union*, London: Routledge, 2019.

evidence of how expert knowledge, working practices, ecological conditions, and community involvement shape site-specific decommissioning projects.

State of the art.

Thirty years ago, in a pioneering book addressing the "social links to nuclear decommissioning," cultural geographer Martin Pasqualetti wrote: "Little information on decommissioning exists which may be applied in a social science context. This fact is reflected in the narrowness and inaccessibility of the literature."[7] Pasqualetti revealed a problematic divide between expert knowledge production and social analyses of nuclear decommissioning, which remains unresolved today. A cursory exploration of the technical literature suffices to realize that the decommissioning field has grown considerably since the early 1980s[8], yet social scientists and historians have only sporadically engaged with it. More up-to-date social studies of nuclear decommissioning focus almost exclusively on waste disposal and respository siting—the end-tail of the problem—leaving other crucial aspects of the afterlives of NPPs to the technical experts.[9] This analytical imbalance is due to the fact that nuclear waste management has attracted the attention of many historians of science and technology and diplomatic historians interested in the scientific and public controversies over nuclear atmospheric experiments and waste dumping at sea during the Cold War.[10] In addition to that, since the late 1970s waste disposal has catalyzed political protest both for its immediate public health and environmental implications, and for the difficulty of reckoning with the deep temporal scales of underground repositories' siting projects.[11] Socio-technical controversies around the feasibility and safety of megaprojects like the Yucca Mountain waste repository have understandably become a hot topic for social research.[12] Decommissioning makes the problem even more urgent, as it creates large amounts of highly radioactive wastes that need to be dealt with, and that back in the 1970s could only be grossly estimated.[13]

Evidence from recent case-studies shows that nuclear decommissioning is not just the removal of a nuclear plant from a site (a space), but a transformative process in itself, with deep socio-ecological implications, which so far have remained largely unexplored.[14] How do the different characteristics of reactor's

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[7] Martin J. Pasqualetti (Ed.), *Nuclear Decommissioning and Society: Public Links to a New Technology*, London: Routledge, 1990. Cit. p. 17.

[8] A technically accurate and accessible text written by a former IAEA decommissioning officer is Michele Laraia, *Nuclear Decommissioning: Its History, Development, and Current Status*, Springer, 2018. Another volume from the same author, although more challenging to non-expert readers, is Michele Laraia (Ed.), *Nuclear Decommissioning: Planning, Execution and International Experience*, Woodhead Publishing, 2012.

[9] Andrew Blowers, *The Legacy of Nuclear Power*, London: Routledge / Earthscan, 2017; Achim Brunnengräber at Al. (Eds.), *Challenges of Nuclear Waste Governance: An International Comparison, Vol. 1 and 2*, Springer, 2018; Achim Brunnengräber and Maria Rosaria Di Nucci (Eds.), *Conflicts, Participation, and Acceptability in Nuclear Waste Governance, Vol. 3*, Springer, 2019; Gianluca Ferraro, *The Politics of Radioactive Waste Management: Public Involvement and Policy-Making in the European Union*, London: Routledge, 2019.

[10] Adri de la Bruhèze, "Closing the Ranks: Definition and Stabilization of Radioactive Wastes in the U.S. Atomic Energy Commission, 1945-1960," in Wiebe E. Bijker and John Law (Eds.), *Shaping Technology/Changing Society*, Cambridge, MA: The MIT Press, 1992, pp. 140-174; Jacob D. Hamblin, *Poison in the Well: Radioactive Waste in the Oceans at the Dawn of the Nuclear Age*, New Brunswick, NJ: Rutgers University Press, 2008; Toshihiro Higuchi, *Political Fallout: Nuclear Weapons Testing and the Making of a Global Environmental Crisis*, Stanford, Stanford University Press, 2020; Rachel Rothschild, "Environmental Awareness in the Atomic Age: Radioecologists and Nuclear Technology", *Historical Studies in the Natural Sciences* 43, 2013, pp. 492-530; Ronald Rainger, "A Wonderful Oceanographic Tool: The Atomic Bomb, Radioactivity, and American Oceanography," in Helen Rozwadowski, and David von Keuren (Eds.), *The Machine in Neptune's Garden: Historical Perspectives on Technology and the Marine Environment*, Sagamore Beach, MA, Watson Publishing International, 2004, pp. 93-131.

[11] Vincent Ialenti, *Deep Time Reckoning: Nuclear Waste, Anthropocene Expertise, Far Future Finlands*, Cambridge, MA: The MIT Press, forthcoming; Peter Galison and Robb Moss, *Containment*, 2015, available at: www.containmentmovie.com; Michael Madsen, *Into Eternity*, 2010.

[12] Early works on nuclear waste disposal include Gerald Jacob, *Site Unseen: The Politics of Siting a Nuclear Waste Repository*, Pittsburgh: Pittsburgh University Press, 1990. Frans Berkhout, *Radioactive Waste: Politics and Technology*, London: Routledge, 1991; Riley E. Dunlap, Michael E. Kraft, and Eugene A. Rosa (Eds.), *Public Reactions to Nuclear Waste: Citizens' Views of Repository Siting*, Durham: Duke University Press, 1993. More recent works include Allison MacFarlane and Rodney Ewing (Eds.), *Uncertainty Underground: Yucca Mountain and the Nation's High-Level Nuclear Waste*, Cambridge, MA: The MIT Press, 2006; J. Samuel Walker, *The Road to Yucca Mountain: The Development of Radioactive Waste Policy in the United States*, California University Press, 2009; William M. Alley and Rosemary Allen, *Too Hot to Touch: The Problem of High-Level Nuclear Waste*, Cambridge: Cambridge University Press, 2013;

[13] Frans Berkhout, "The management and regulation of decommissioning wastes," in Martin J. Pasqualetti (Ed.), *Nuclear Decommissioning and Society*, cit., pp. 59-84.

[14] Martin J. Pasqualetti and K. David Pijawka, "*Un*siting Nuclear Power Plants: Decommissioning Risks and their Land Use Context," *Professional Geographer* 48 (1), 1996, pp. 57-69; Angelica Greco and Daisaku Yamamoto, "Geographical political economy and nuclear power plant closures," *Geoforum* 106, Nov. 2019, pp. 234-243; Melissa Haller, Michael Haines, and Daisaku Yamamoto, " The End of the Nuclear Era: Nuclear Decommissioning and Its Economic Impacts on U.S. Counties," *Growth and Change* 48 (4), 2017: 640-660; Andrew Blowers and Pieter Leroy, Power, politics and environmental inequality: A theoretical and empirical analysis of the process of 'peripheralisation'," *Environmental Politics* 3

technologies, ecological conditions, and local communities influence site-specific decommissioning strategies?[15] Experts and regulators have grown aware of the importance of attending to the cultural and organizational aspects of decommissioning projects, but in their assessments they tend to reproduce top-down approaches like the "social acceptability of risk" paradigm and reductionist formulas like "stakeholder interests" and "labor motivational training."[16]

NUCLEARDECOM addresses these critical issues through a novel interdisciplinary approach that attends to the technical, environmental, and social aspects of nuclear decommissioning in tandem. In particular, it explores the following dimensions: 1) Identity, role, and processes of knowledge production of decommissioning experts; 2) Emergence and characteristics of the global decommissioning industry; 3) Interconnections between technological and socio-ecological problems of specific decommissioning projects, including common practices of labor organization and safety.[17]

Specific objectives of the project

NUCLEARDECOM explores and documents the interconnections between the technological, social, and environmental dimensions of nuclear decommissioning projects beyond waste disposal and repository controversies. In particular it focuses on the following *Specific Research Objectives*:

SRO1. Documenting the history of nuclear decommissioning and decommissioning knowledge production.

SRO2. Assessing the characteristics of the global market of nuclear decommissioning services.

SRO3. Developing a novel interdisciplinary comparative approach that analyzes the technical, ecological, and social implications of decommissioning projects in tandem.

The planned work is organized around three *Work Packages* that are directly related to the project objectives and will be described in more detail in the methodological section below:

WP1. History of nuclear decommissioning: Consultation of archival records (mostly available on-line) of expert international agencies and regulators such as the International Atomic Energy Agency (IAEA), EURATOM, and OECD-Nuclear Energy Agency to examine early debates on nuclear decommissioning and to understand their practical implications for decommissioning projects.

WP2. The Emergence and Characteristics of Decommissioning Markets: Close examination of two cases, *Ansaldo Nucleare* and *Studsvik*, who are leading companies in the decommissioning business, involved in current decommissioning projects within and outside the European Union.

WP3. Site-specific Practices of Nuclear Decommissioning: Comparative field study of decommissioning sites in Italy and in Germany to understand how technological, ecological, and social factors interact and contribute to shape site-specific decommissioning projects.

Research Methodology and Approach.

This research adopts an interdisciplinary comparative method rooted in the tradition of Science and Technology Studies (STS). One of the basic assumptions of STS is that technoscience and culture are mutually shaping, thus technology's development is inextricably intertwined with social and cultural

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(2), 1994, pp. 197-228. See also Andrew Blowers, *The Legacy of Nuclear Power*, cit.; Martin J. Pasqualetti, "Introducing the Geosocial Context of Nuclear Decommissioning: Policy Implications in the U.S. and Great Britain," *Geoforum* 20 (4), 1989, pp. 381-396.

[15] Young A Suh, Carol Hornibrook, and Man-Sung Yim, "Decisions on nuclear decommissioning strategies: Historical review," *Progress in Nuclear Energy* 106, 2018, pp. 34-43. Michele Laraia (Ed.), *Advances and Innovations in Nuclear Decommissioning*, cit.

[16] See, for example, Michele Laraia, "The cultural aspects of decommissioning," in Michele Laraia (Ed.), *Advances and Innovations in Nuclear Decommissioning*, London: Woodhead Publishing, 2017, pp. 54-72.

[17] From this point of view this research will complement the existing literature on occupational risk, safety regulations, and subcontracting in the nuclear maintenance sector: Yuki Tanaka, "Nuclear Power Plant Gypsies in High-Tech Society," in Joe Moore (Ed.), *The Other Japan: Conflict, Compromise and Resistance since 1945*, M.E. Sharpe for the *Bulletin of Concerned Asian Scholars*, 1997, pp. 251-271; Constance Perrin, *Shouldering Risk: The Culture of Control in the Nuclear Power* Industry, Princeton: Princeton University Press, 2005; Gabrielle Hecht, "Africa and the Nuclear World: Labor, Occupational Health, and the Transnational Production of Uranium," *Comparative Studies in Society and History*, 51 (4) (October 2009), pp. 896-926; Annie Thébaud-Mony, *Nuclear Servitude: Subcontracting and Health in the French Civil Nuclear Industry*, Baywood Publishing Company, 2011; *Paul Jobin,* "Dying for TEPCO? Fukushima's Nuclear Contract Workers," *The Asia-Pacific Journal 9*, Issue 18 No 3, May 2, 2011; Gabrielle Hecht, "Nuclear Janitors: Contract Workers at the Fukushima Reactors and Beyond," *The Asia-Pacific Journal 11*, Issue 1, No 2, Jan. 7, 2013.

phenomena.[18] This approach, commonly known as Social Construction of Technology (SCOT), conceives of technological systems as *sociotechnical systems* in which technological artifacts, organizations, and communities of experts and users interact to shape technological choices and meanings of technology.[19] One of the main insights provided by STS case studies over the past decades is that the designs of technological artifacts and systems embody and enact specific world views and political goals of the designers. Thus, instead of asking questions about the "social effects" of nuclear technology, this study engages directly with the technical aspects and the mechanisms of expert knowledge production to unravel the cultural values, political intentions, and power relations embedded in the design and the implementation of nuclear decommissioning projects.

The first research objective of NUCLEARDECOM consists in writing a history of nuclear decommissioning from its early stages (in the mid-1970s) to the present. During preliminary interviews I conducted over the past months, decommissioning experts often described their job with the metaphor "decommissioning is not rocket science" to make evident that most of their knowledge comes from lessons-learned and hands-on experience. The systematicity acquired in the nuclear decommissioning industry is the outcome of this empirical approach, retrievable in early decommissioning reports (most of them available on-line) and in the first international debates about those experiences. I will conduct archival research at major international and European agencies like the International Atomic Energy Agency (IAEA), EURATOM, and OECD-Nuclear Energy Agency that since the mid-1970s promoted international studies, pilot projects, and exchanges on the challenging task of NPPs decommissioning. In this context, I will examine expert knowledge management and documentation. As mentioned above, decommissioning projects depend heavily on the assemblage of sociotechnical systems specific for each site. For example, different reactor technologies demand alternative decommissioning strategies, for which available expertise (often provided by retired operators and designers) is site-specific and unique.[20] Maintaining the memory and documentation of operating experiences is crucial. Thus, my study explores a different dimension of experts' role in nuclear decommissioning. Rather than focusing only on formal decision-making processes, I examine how history and memory become crucial components of technical work and intergenerational expert communication that allow for site-specific decommissioning projects to take place. At the same time, I will analyze how site-specific experiences and information become available to the international community of decommissioning experts and practitioners through knowledge exchanges (formal and informal), methods of communication, and documentation.

While decommissioning brings to the fore the entire life cycle of NPPs and reveals the costs of handling their afterlives, it also generates economic opportunities for companies offering decommissioning services. Several companies working in the development of nuclear technology began to include decommissioning in their core business. This transformation coincided with the decline of nuclear optimism at the end of the 1970s and the emergence of decommissioning as an urgent problem in need of solutions. The second objective of this research is to document this transition through archival research and oral interviews with decommissioning professionals of two companies: *Ansaldo Nucleare* (Italy) and *Studsvik* (Sweden). *Ansaldo Nucleare* is involved in all projects directed by SOGIN, the public company in charge of implementing all Italian decommissioning plans, including Eurex in Saluggia and the Latina NPP, two sites in which I will conduct fieldwork research. *Studsvik* is a global actor present in the US, UK, Germany, and China. By documenting the emergence of two leading companies in the decommissioning sector, NUCLEARDECOM endeavors to tackle the ambiguities and paradoxes of nuclear waste characterization: to what extent do recycling technologies allow decommissioning companies to smelt, decontaminate, and sell scrap metal coming from decommissioned plants? How do decommissioning companies generate value

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[18] Langdon Winner, "Do artifacts have Politics?" *Daedalus* 109 (1), 1980, pp. 121-136; Madeleine Akrich, "The Description of Technical Objects," in Wiebe E, Bijker and John Law, *Shaping Technology/Building Society*, Cambridge, MA: The MIT Press, 1992, pp. 205-224.

[19] Thomas P. Hughes, *Networks of Power: Electrification of Western Societies, 1880-1930*, Baltimore, Johns Hopkins University Press, 1983; Wiebe E. Bijker, Thomas P. Hughes, Trevor Pinch (Eds.), *The Social Construction of Technological Systems*, Cambridge, MA: The MIT Press, 1987; Wiebe E. Bijker and John Law (Eds.), *Shaping Technology/Building Society*, cit.

[20] Michele Laraia, *Nuclear Decommissioning: Its History, Development, and Current Status*, cit.; Vincent Ialenti, "Spectres of Seppo: the afterlives of Finland's nuclear waste experts," *Journal of the Royal Anthropological Institute* 26 (2), 2020, pp. 251-268.

out of the most unwanted material in the world?[21] This project will expand and shift the analysis of *nuclearity*, the politics of defining something as nuclear[22], into the general frame of waste theory and theories of value, which promise to offer a pathbreaking intervention into the field of Social and Humanistic Nuclear Studies.

The third objective of NUCLEARDECOM is to examine closely the relationship between technological, social, and environmental features of nuclear sites and decommissioning strategies. I will accomplish this part of the project by conducting fieldwork at different locales during the second part of my fellowship tenure. Fieldwork research will consist of authorized visits to decommissioning sites, interviews with decommissioning workers and engineers in Italy (Saluggia/Trino Vercellese and Latina) and in Germany (Essenbach, Bavaria). In addition, I will conduct archival research and oral interviews to document how the emplacement of NPPs has changed the socio-ecological landscape of local communities and how their displacement through decommissioning projects is affecting their lives now. One of the key components of this research strategy is the comparison of different decommissioning sites to gauge to what extend and how technical and socio-ecological variables influence decommissioning planning and project implementation. The selection of Italian and German cases has the following rationale: Italy and Germany, at different times, decided to phase out nuclear energy production. Despite the apparent similarities, the two cases differ significantly in terms of their political systems and the policy-making processes that led to the same choice. Italy dismantled its nuclear program after a long crisis, culminating in a referendum held in 1987, after the Chernobyl accident. Also, Germany announced its nuclear phase-out strategy after the Fukushima accident but implemented this decision within a broader energy transition plan (*Energiewende*), investing relevant resources in the development and employment of renewables. The selected decommissioning sites also vary in terms of reactor technology. Saluggia hosts a decommissioning reprocessing plant and is close to Trino Vercellese, where one of the first NPPs was built and is undergoing decommissioning. The reactor is a Westinghouse Pressurized Water Reactor, whose characteristics commanded specific decommissioning measures, different from the NPP of Latina. The latter has been the first NPP project launched in Italy. The reactor is a graphite Magnox design of British origin. Latina has obtained the decommissioning license approval from the Italian authorities after 20 years just at the beginning of July 2020. This represents a unique opportunity to monitor a decommissioning project in its initial phase. Finally, the Isar 1 NPP in Essenbach (Bavaria) is a boiling water reactor built in 1977 and shut down in 2011. In 2017 the company in charge of the plant has received a decommissioning license from the German Federal authorities.

[21] See for example, Simone Müller, "Hidden Externalities: The Globalization of Hazardous Waste," *Business History Review* 93 (Spring 2019), pp. 51-74.

[22] Gabrielle Hecht, *Being Nuclear: Africans and the Global Uranium Trade*, Cambridge, MA: The MIT Press, 2012.