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Nuclear denial in Japan: the network power of an energy industrial complex

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Abstract

Given the known hazards of nuclear energy in seismically active Japan after the Fukushima meltdowns as well as the presence of viable conservation and renewable energy options, the question of Japan's stalled energy transition warrants critical interrogation. To better understand why, after Fukushima, Japan's energy policy trajectory maintained the nuclear status quo and an increased reliance on fossil fuels, this article employs network and historical analyses to examine the confluence of post-Fukushima political forces connected to Japan's nuclear energy sector. Our novel network dataset combines with historical analysis to identify a dense network of overlapping executives and officials in Japan that forge long-term ties between the nuclear energy industry, the state, and the leading business federation in Japan. Following the 3.11 disaster and the meltdowns at the Fukushima-Daiichi facility, a long-standing nuclear safety myth and a tightly networked nuclear energy industrial complex provided an ideological and structural context to re-legitimize nuclear energy in spite of widespread public concern. Instead of a bold, ecologically rational policy to quickly phase out nuclear power and phase in renewable energy, well-worn class and state networks aligned to recommit Japan to a nuclear-reliant energy path. These findings support a theoretical synthesis around our concept of an energy industrial complex with applications in environmental and political sociology.

Keywords Network analysis · Energy policy · Environmental sociology · Fukushima Japan · Nuclear disaster · Power elite

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Introduction: the Fukushima crisis

On March 11, 2011, a massive 9.03 (M_w) earthquake occurred 70 km (43mi) off the coast of Tohoku, the largest in Japan's history. The world watched as the subsequent *tsunami* included waves of up to 40.5 m (133ft) in height, devastating homes and displacing communities as it reached up to 10 km (6.2mi) inland. These events culminated in level-7 meltdowns in three nuclear power plants at the Fukushima Daiichi Nuclear Power Plant Complex owned by the Tokyo Electric Power Company (TEPCO), the world's largest private nuclear utility corporation. Over 140,000 residents within a 20 km (12mi) radius were evacuated during the crisis. Amid efforts to contain the meltdown, contamination and clean-up will persist for decades.[1] In the months that followed the disaster, speculation about the future of nuclear power abounded in Japan and around the world. Amid mass protests in Germany, a plan to phase-out nuclear energy was adopted. In Japan, too, renewed challenges to the prevalence of nuclear power were evident in mass protests after Fukushima and a major decline in public support for the use of nuclear energy, even among officials associated with the nuclear industry. As indicated in Fig. 1, support for using nuclear energy in the future plummeted after 3.11.

For the first time, the main liberal-left party (Democratic Party of Japan—DPJ) formed a loose coalition in government[2] in the year prior to the disaster and, in response to 3.11, established plans to phase-out nuclear energy. The plan initiated safety inspections for all nuclear reactors, some of which were nearing the end of their operational life-cycle. In September 2013, Kansai Electric Power Co. confirmed that their last operating reactor (number 4) shut-down – the last of 50 reactors operating after the disaster—leaving Japan temporarily without nuclear-generated electricity, as indicated in Fig. 2. However, the phase-out conversation in government was short-lived. The center left party was swept from power in 2012 as top business lobbyists warned of severe consequences if nuclear energy was phased out, including "pressure from the U.S. government regarding proliferation implications of Japan's large plutonium stockpiles if all reactors are mothballed" (Kingston, 2014: 466). Under the conservative Liberal Democratic Party (LDP) and Prime Minister Shinzo Abe a new energy plan was approved on April 11, 2014, calling for more renewables while also insisting that nuclear power remain Japan's "most important energy source," including the building of new nuclear reactors. The conservative government has been slower to make the kind of investments in renewables that close comparator Germany continues to develop; at the end of 2021 a full 44.9% of their grid was based on wind, water, and solar, while renewables in Japan

[1] For a number of technical reasons, and fortunate timing, the scope of the nuclear material released was a very small fraction of what occurred at the single Chernobyl reactor explosion (Steinhauser et al., 2014).

[2] Although the DPJ's Prime Minister Naoto Kan tried to form a coalition with the LDP and failed, the plans to phase out nuclear energy were nonetheless agreed upon though never adopted as policy.

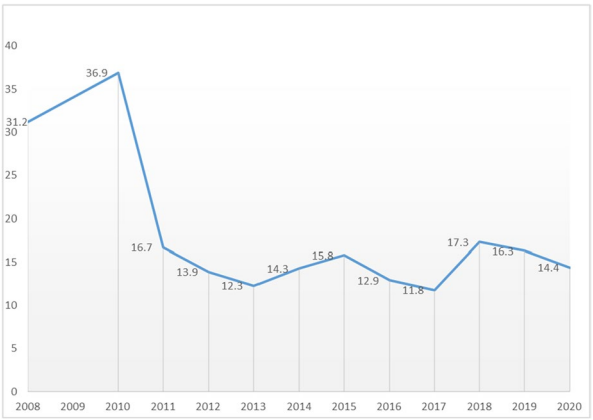

Fig. 1 Percentage of Respondents Who Support Using Nuclear Energy in the Future, 2008–2019. Source: Japan Atomic Energy Relations Organization (2020), Nuclear Opinion Poll. Accessed November 2, 2021, https://www.jaero.or.jp/data/01jigyou/tyousakenkyu2020.html (in Japanese)

constituted 26.2% of their grid supply in the same year.[3] Japan once held the promise as a model for green modernization, in part due to its pre-Fukushima levels of relatively low-carbon nuclear power usage.[4] Instead, Japan now relies even more on imported coal, crude oil, and natural gas, together totaling 86% of their *total primary energy supply* and 69.14% of the grid supply in 2021. By the end of 2021, even as multiple reactors were back online, Japan has not restored nuclear power production to pre-crisis levels when electricity from nuclear power constituted approximately 30% of the electricity-grid's supply (see Fig. 2).

Given the costs and known hazards of nuclear energy and the presence of viable conservation and renewable energy paths, the post-Fukushima case demands further interrogation.[5] Despite mass civil unrest, dramatically declining public support for nuclear energy, changing views among scientific elites, and mounting seismic concerns by geophysicists, what prevented state officials from charting a new energy course for the nation (like Germany or Italy) when faced with the costs, risks, and challenges of nuclear energy? Coupled with some of the largest mass protests in Japan's recent history, conservative party elite and government officials did not change course but instead doubled down on their commitment to nuclear energy and the continued reliance on imported coal, crude oil, and natural gas.

To better understand why Japan's energy policy largely kept this status quo path, this article offers historical and network analyses to examine the confluence of post-Fukushima political forces arising from Japan's nuclear energy sector in alliance with the dominant political party and the wider corporate community. Instead of

[3] About 16.5% of Germany's primary energy is sourced from coal, which continues to decline (See BP Statistical Review of World Energy (2021)). Japan's renewable energy profile has been boosted by steady growth in wind sources (ibid).

[4] The seismically active, and tsunami-prone coastlines of Japan make nuclear energy development riskier, especially absent additional safety measures (see Nöggerath, Geller, and Gusiakov (2011) for a survey of the geophysical risks in Japan).

[5] Doubts about the capacity of renewable energy to supply a modern grid like Japan's continue to hinder the development of renewable energy production. The most comprehensive engineering report on renewable energy explains succinctly and by geography how wind, water, and solar can replace dirty energy sources globally (See Jacobson 2020). Japan is well suited to lead by phasing out nuclear and fossil fuel sources.

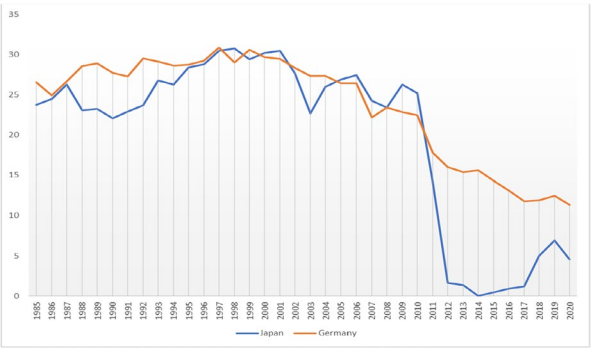

Fig. 2 Percent Share of Electricity from Nuclear, Germany and Japan. Source: BP. 2021. BP Statistical Review of World Energy, 70th Edition. Accessed on January 12, 2022. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

a bold ecologically rational policy to quickly phase out nuclear power and phase in renewable energy, something akin to Germany, Italy, or Switzerland, well-worn class and state networks recommitted Japan to a nuclear-reliant energy path.[6] Ecological reflexivity, though initially promising, failed to move markets or the state. Theoretically, we introduce the concept of an *energy industrial complex* to integrate theoretical work in environmental and political sociology and illuminate the systems of political domination that interfere with ecological rationality and advance nuclear industry interests with the support of a power elite in Japan. Empirically, our novel dataset builds on sociological work in Japan that explains the contradictions by examining the historical embeddedness of the nuclear energy industry in larger corporate and state networks prior to and following the Fukushima meltdown.

Theoretical literature

The denial of environmental hazards

In the fall of 2011, seven months after the devastating triple disaster—earthquake, *tsunami* and nuclear meltdown—*The New Yorker* published an expose on the political "fallout" of the catastrophe. Osnos (2011) provides several examples of how "Japanese nuclear regulators, like their American counterparts, have frequently been criticized for following a revolving door into lucrative jobs in the industries they police, and vice versa" (p.11). One telling case involved a top official from TEPCO, Tokio Kano, who "left the company to run, successfully, for parliament, where he led an effort to prevent the adoption of new textbooks until the Education Ministry removed references to the anti-nuclear movement in Europe" (p.12). Mr. Kano

[6] France is the most prolific nuclear energy producer in the world and the state-owned industry is highly regulated. France also lacks the seismic risks found in Japan. In Germany, where a history of anti-nuclearism, the presence of a strong independent Green Party, and proximity to the world's worst nuclear energy disaster (Chernobyl) have diminished the relative political influence of the nuclear industry there. In a separate project, we also find that the renewable energy industry in Germany has grown and wields considerable political influence.

returned to TEPCO after his stint in parliament. It is well known that critics of nuclear energy in Japan have faced uphill struggles against the entrenched industry and political apparatus. A "nuclear complex" (Funabashi, 2012), alternately referenced as an "atomic circle" (Hasegawa, 2012) or "nuclear village" (Kingston, 2012, 2014), has promoted a high-tech safety myth, *anzen shinwa*, for over a generation, blurring or denying real risks from the industry.[7]

Within Japan, a long tradition of scholarship and activism has raised critiques of nuclear energy and its public health and environmental risks. Yet, until 3.11, Japan was one of the most prolific generators of nuclear energy, which requires a high level of public subsidy in its development, maintenance, and clean-up. Corporate interests in nuclear technology are ubiquitous in Japan. The largest electric utility corporation in the world, TEPCO, operates in Japan, and two other Japanese multinational corporations, Toshiba and Mitsubishi Heavy Industries, are at the forefront of exporting nuclear energy technology. As we elaborate below, collectively, the industry enjoys influential connections at every level of power in the nation. This privilege also "nurtured a collective blindness… [and] the nuclear safety myth left Japan unprepared for responding to nuclear disaster" (Kingston, 2014: 465).

The influence of the nuclear industry to shape energy policy and public opinion was bolstered by efforts to promote nuclear denialism as a means to dull critique and continue industry expansion. As Perrow (2013: 57) describes: "Nuclear denial creates scientific ambiguity that provides cover for governmental and commercial interests and allows nuclear power to continue expanding worldwide." Yet, widespread denialism can also foreclose opportunities to deliberate the risks and engage in risk management strategies that may protect against the worst forms of disaster. The parallels of the nuclear safety myth to climate change myopia and denialism in the U.S. are striking and, as we argue below, are rooted in similar forms of corporate political organization and public relations operations.

A recent and growing body of social science literature employs network methods and power structure approaches to study the capacity of fossil fuel interests to energize a climate change denial campaign (Brulle, 2014, 2018; Carroll, 2017; Carroll et al., 2018; Dunlap & McCright, 2011; Farrell, 2016a, 2016b; Levy & Egan, 2003). Building on the climate denial machine (McCright & Dunlap, 2003), this genre of research details forms of corporate power that capably distort policy and public discourse, overriding ecological reflexivity. Brulle (2014) provides an analysis of the financial and network mobilization of the "climate change counter movement" (CCCM), which was able to "institutionalize delay" by raising obstacles to ecologically rational energy policy through the collective power of key energy corporations, their foundations, sponsored think tanks and politicians. Farrell's (2016a, 2016b) analyses expand on Brulle's and identify "network power" – when organizational influence stems from "entry into a well-connected and powerful core of the network" as opposed to "sheer financial power" – as the driver of influence on

[7] Seismologist Katsuhiko Ishibashi coined the Japanese phrase *genpatsu-shinsai* in 1997, signifying "nuclear power plant earthquake disaster," warning of extreme risk of an earthquake that would disable a major nuclear reactor and release radiation. See Nöggerath et al. (2011) for an account of failed responses by the industry to warnings by geophysicists.

"semantic similarity" between climate contrarian organizations and news media. Carroll et al. (2018) map out the carbon-capital "sector's reach into civil society [to] reveal the architecture of a stage 2 denial regime" (p. 429). Their network mapping project exposes the structural power of carbon capital in advancing and legitimizing fossil fuel extraction in direct contradiction to Canada's pledges to reduce carbon emissions.

Jacques et al. (2008) argue that publicly prominent skeptics of environmental concerns, broadly conceived, "are predominately agents of CTTs [conservative think tanks], and their success in promoting skepticism about environmental problems stems from their affiliation with these politically powerful institutions" (p. 351). The campaign strategy of environmental skeptics reflects a committed, countermovement strategy to thwart the enforcement of environmental regulations, diminish public support for environmental causes and preclude future environmental policies. Bonds (2016) demonstrates further that denial and skepticism are not the only political tool used by conservative think tanks intent on limiting environmentalist agendas. With respect to climate politics, conservative, corporate-funded organizations develop a range of scenarios and contingency plans. That many corporations and industry groups mobilize against renewable energy policy agendas is well established. Further, the success of conservative and corporate interests in promoting the denial of environmental risks and the delay of policy responses is not isolated to the U.S. (Luke, 2000).

Understanding the institutional denial of nuclear hazards and the resumption of nuclear energy in earthquake-prone Japan requires a fusion of thinking from environmental and political sociology. Specifically, we seek to address a conceptual gap in much of the environmental sociological literature on environmental and energy policymaking. In general, we find a lack of analytical precision concerning the mechanisms by which polluting industries exert political power on environmental or energy policy issues. To remedy this gap, we introduce a power structure approach to energy policy, one that helps specify the analytical and empirical relationships between energy corporations, public relations campaigns, larger corporate and industry associations, and agencies within the state. The power structure approach, rooted in the sociology of C. Wright Mills (1956), provides a baseline framework for linking sociological research agendas in environmental and political sociology.

A power structure approach to energy and environmental policy

Part of the sociological dilemma in explaining Japan's commitment to nuclear energy after the Fukushima crisis stems from an assumption in much of the social sciences that state actors exercise a fair amount of autonomy from non-state ones, particularly class actors. Various state-centric institutional, pluralist and modernization theories explain how state actors apprehend and respond to non-state interests or exogenous crises (Block, 1987; Dahl, 1982; Finegold & Skocpol, 1984; Lindblom, 1977; Martin & Swank, 2012; Poulantzas, 1968/1973; Salisbury, 1992). As relatively autonomous state actors, it is presumed that public

policy develops through rational, civil, and technocratic deliberations unhindered by a single monopoly of political power outside of the state. As represented in these theories of state autonomy, corporations, though powerful, are seen as competing – as if in the market – amongst themselves and with other constituencies to advance their specific interests, thus failing to congeal as a class force (Lindblom, 1977; Martin & Swank, 2012). Instances of corporate collective action from these perspectives are conceived as temporary issue-based alliances among otherwise competing economic interests (Salisbury, 1992). Industry-wide associations are reduced to their rent-seeking motives and strategic interests while broader, long-term inter-industry corporate alliances are underspecified (Dreiling & Darves, 2016). Instead, state managers are presumed to internalize and embody state interests as they respond to endogenous pressures as well as those external to the state apparatus (e.g., war, economic crisis, domestic political crisis, etc.) (Finegold & Skocpol, 1984; Skocpol, 1979, 1992).

Within environmental sociology, the assumption of state autonomy undergirds the ecological modernization premise of an autonomous ecological sphere capable of shaping a reflexively modern environmental state (Mol, 2000, 2006).[8] Japan has been grouped along with other advanced industrial democracies as a candidate for the promises of ecological modernization theory (Fisher & Freudenburg, 2001; Mol & Sonnenfeld, 2000). According to this theory, scientific communities provide an essential space for reflexive modernization and the advance of ecologically rational initiatives for environmentally responsive state actors (Mol, 2000; Mol & Spaargaren, 2002). Similarly, social movements in civil society enable state and market institutions to develop sensors to environmental problems and subsequently respond reflexively to those problems with either production changes or policy initiatives (Mol, 2000). These theoretical expectations presume that the political modernization of the state advances its autonomy from class forces and shifts away from centralized regulation and policy authority toward more decentralized, participatory, and reflexive policy making (Jänicke, 1990; Mol & Sonnenfeld, 2000). This theoretical framework is part of an extended debate within environmental sociology, often juxtaposed with political economic critiques of capitalist environmental degradation.

The "treadmill of production" approach offers a political economic understanding of the environmental contradictions of capitalist modernization, specifically explaining how polluting industries capture both labor and corporate political interests to assure continuity in capitalist expansion and prevent regulatory changes to

[8] Ecological reflexivity is associated with critical social ecology and ecological modernization theory. It refers to the capacity to change behavior or institutions in light of reflections on the ecological consequences of past actions. See Pickering 2018 for a discussion. Ecological rationality is a closely related concept. Mol (2006: 33) explains how "the ecological perspective started to challenge the monopoly of economic rationality as the all-determining organizing principle in the sphere of economics. Since most scholars agree that the growing autonomy of an ecological rationality and perspective from its economic counterpart in the domain of production and consumption is crucial to 'the ecological question,' this last step was the decisive one. It meant that economic processes of production and consumption were increasingly designed and organized, analysed and judged, from both an economic and an environmental point of view (even if the two are not given equal weight, even today)."

production and consumption relations (Gould et al., 2008). Subsequent empirical and theoretical work buttressed the claim that modern states maintain parallel interests with capitalist expansion. This structural affinity is amplified as states cede authority to large capitalist enterprises. From the treadmill perspective, the expansion of capitalist accumulation entails routine and sustained cost and technological adjustments to production relations with little reason to internalize ecological or social costs. Politically, capitalist industries forge alliances with the state and labor to prevent ecological rationalization of production. However, a specification of the channels by which corporations obstruct, dilute, or dominate policy making is lacking within the model. Indeed, neither the ecological modernization nor the treadmill perspective offers specific concepts to analyze how powerful polluting interests shape and influence policy and governance.

Building on Downey's (2015) "organizational, institutional and network-based" (OIND) inequality model, and Bonds' (2011) invitation to bring power structure tools into environmental sociological theory, we introduce the concept of a nuclear *energy industrial complex* (EIC) to examine the conditions under which corporate dominance of energy policy making in Japan may occur. Since President Eisenhower's warning of a "military industrial complex'' in his 1961 farewell speech, the concept has found new life in Sudbury's (2005) prison industrial complex and a variety of other industrial complexes (Best et al., 2011). Uses of the concept resonate closely to Mills' representation of the power elite, but the literature generally focuses on a specific industry where profit-seeking business is intertwined with political and social institutions in a way that supports their continued dominance over policy related to that industry (see Best et al., 2011; Sudbury, 2005). We examine the utility of this concept using a novel data set and network methodologies. Incorporating power structure theoretical tenets, we propose that the capacity of a polluting industry to dominate policy making and public opinion is conditioned by the network overlaps of industry executives relative to dominant business class networks among executives from leading firms and inter-industry business associations as well as with prominent offices in the state. These overlapping executive networks have the potential to create inter-organizational ties that connect government office via "golden parachuted" officials, major business associations, think tanks, political parties and policy planning organizations.

Power structure tools direct our attention to the overlapping networks among organizational and institutional actors, forged over time and synchronously by overlapping executives who sit on multiple boards or retire from one office and move to another private sector position. First, the approach does not assume ontologically neat and discrete boundaries between economic and political institutions, but instead empirically considers actual interconnections within and across corporate and state bodies. Rather than assuming modern states are relatively autonomous from non-state actors or completely dominated by class or other socio-political blocs, this approach bypasses the dualistic conceptualizations found in various traditions of state theory. Power structure theory embraces an historically contingent framework on the dynamics of class dominance and state autonomy that oscillate across historical events, conflicts, and processes. State institutions are contested and political control over state institutions is the product of historical relations and contingencies,

like Max Weber's historical dice. The strong assumptions of state autonomy produce a paradox that hermetically seals off the state from the possibilities or actual instances of corporate or class dominance, a priori, preventing researchers from developing theory that explains occurrences, however contingent, of extensive corporate involvement in and dominance of state bodies or policy trajectories (Dreiling & Darves, 2016).

Softer variants of state-centric theories, such as historical institutionalism observe that state actors actively solicit the involvement of corporate actors, seeking to build alliances for political purposes (Martin & Swank, 2012). Critics wonder if these actions by state actors in turn produce consequences that help further unify and empower corporate, class actors who act back on those same state structures with a unique capacity to dominate them. Our historical and network data analysis suggests this happened with major bureaucracies within Japan's post-war state. Dreiling (2000, 2001) and Dreiling and Darves (2016) observed state actors facilitating corporate involvement in U.S. trade policy, drawing from well-networked and high-profile corporate leaders. In this work, state actors in these "facilitative state structures" provide an influential and strategic forum for formulating and advancing institutional change, drawing from both state leaders and well-networked corporate actors. For this reason, it is imperative that we borrow from state theories to weigh preceding actions on the part of state actors in constructing avenues for corporate leaders to unify and act collectively. Once created, these facilitative state structures congeal already-organized corporate leaders, boosting their relative class leadership and authority. As much of the power structure research has shown over decades now, prominent corporate actors find valuable leverage at an interface where influence may be wielded between the state policy apparatus *and* the political organization of the wider business sector via business groups, policy organizations, political parties, and think tanks. These processes approach "negotiated accommodation," a situation referring to the preparations made by state elite and leaders of commerce in the mobilization for war (Tilly, 1985). Perhaps a more appropriate reference to the phenomenon is found in Mills' (1956) discussion of the power elite's overlapping positions at the "command posts" of society.

Domhoff (2022) has argued that Mann's (1986) social theory overcomes the problematic assumption of ontologically distinct spheres separating the state from classes and society. For Mann (1986), the four sources of social power overlap and intersect across spheres. These intersections, of course, occur in historical relations involving organizations and networks. Understanding macro-structural dynamics through this lens we can observe, as Downey (2015) argues, how "elite-controlled organizations, institutions, and networks are the concrete tools that elites use to achieve goals, such as accumulating capital, maintaining capitalist social relations, dominating public policy making, and shaping public opinion" (p. 6). Downey echoes Domhoff's (1990) argument that the power structure approach does not deny the role of state actors, nor imply a monolithic domination by a ruling class; instead the approach merely asserts "that there is likely to be a complex interaction between states and social classes in democratic capitalist societies" (p. 28).

Second, and consistent with the power elite model of Mills (1956), power structure concepts point to the actions that transform organizations and interests into forms of

social power (Mann, 1986). Similar to the "iron triangle" thesis (Adams, 1981) used widely in critical policy studies in Political Science, the power structure approach examines the intersection of key lobbying interests and the state agencies they target. Both bodies of literature also consider the revolving door between those outside industry interests and state agencies. Each also examines the capacity of industry interests to shape electoral politics, especially in the form of campaign financing of candidates and political parties. The power structure approach, however, goes a step further, urging investigation into the historically specific socio-political networks within the larger corporate community that ground corporate politics in wider class segments (Best et al., 2011). This draws into our scope not only the flow of financial resources from "the corporate rich" (Mills, 1956) or specific industries, but also personnel from a range of organizations, including foundations, corporations, think-tanks, policy groups, universities, and state agencies. What Domhoff (1978) coined as the "policy planning process" unfolds across these types of networks. The power structure approach thus provides analytical tools for studying iron triangles, but also larger, longer-term class groupings capable of intersecting with state institutions and dominating policy agendas for decades (see Dreiling & Darves, 2016).

In the power structure approach, the "opinion-shaping process" (Domhoff, 1990, 2022) is not just about public relations campaigns that frame narratives about an industry, but involves accessing and dominating larger societal levers to influence public opinion, from the mass media to the curriculum in schools (Keeney, 2021). Legitimation tools that shape opinion involve long-term investments from elite foundations and public relations investments, pouring large sums of money into think tanks, issue-based astro-turf campaigns, expert public relations contracts that develop and promote events which then circulate ads and experts on mass media, and more.

An operational concept: energy industrial complex

Research on different patterns of industry-state interaction, or institutional capacities as described by Ikenberry (1986), formed the foundation for a generation of comparative energy scholarship and the more recent literature on energy transitions with its attention to technical and geopolitical pressures that influence patterns of energy development among states (Cherp et al., 2017). This research tends to view industry-state relations in terms of interest groups taking action in institutional fields. Our approach seeks to open new vistas on these industry-state interactions with the power structure premises discussed above and operationalized as energy industrial complexes. Conceptually, industrial complexes create and inhabit "strategic action fields" that orbit and structure state political processes in ways partially theorized by Fligstein and McAdam (2011). A power structure lens adds specificity to this conceptual frame by inferring that such a field is propelled along by immense resource commitments deployed by the industry elite—all of which can be observed and traced through networks. Further, the power structure theory anchors our understanding in class inequality, specifying the historically specific conditions under which corporate wealth gets translated into forms of political power (Best

et al., 2011; Domhoff, 1967, 1978, 1990, 2022). Rooted in economic wealth, energy industry actors wield extraordinary forms of influence that are further amplified by strategic alignments with wider corporate-class, civil society, and political networks (Best et al., 2011). Consequently, an EIC is propelled and aligned with larger power structures, working concertedly to reproduce political, economic, and cultural dominance.

Conceptually, a nuclear EIC comprises three distinct power structure relationships. First, the presence of industry elites overlapping in state institutions as state officials, *and* vice versa. This dynamic is often referred to as the "revolving door" in the study of policy iron triangles and power structure literature. In the case of Japan, the concepts of *amakaduri* (to descend from "heaven," i.e., from government to corporate or nonprofit positions) and *watari* (to migrate across positions). These concepts signify the context of personnel flows, which consequently create the kind of inter-organizational networks that power structure and institutional scholarship measures. Not all industries wield sufficient influence to gain stature in top government posts; and conversely, not all industries warrant sufficient interest from the state bureaucracy to enter these networks. Our thesis assumes that relatively marginal industries that are also isolated from larger corporate networks – such as the premiere business associations or membership on the most central corporate boards – will lack dense ties to the state apparatus, whereas centrally networked firms and industries will possess greater network affinity to top state agencies (see Dreiling & Darves, 2011, 2016). Within an EIC, both state and industry actors are involved over time—with varying starting points—in the creation of personnel and organizational networks that facilitate concerted action by government and corporate actors.

A second condition for an EIC is the *coupling* of the energy industry elite to leading, inter-industry business federations and other corporate policy planning networks. These industry elite reach outside of their own industry associations and find connections to the more central, leading corporations and top business federations. Our primary interest is in ties to *Keidanren*, the nation's premiere business association. Decades of scholarship in the U.S. has revealed the central role of the Business Roundtable in corporate networks and its impact on corporate political action (Burris, 1992; Dreiling & Darves, 2011, 2016; Domhoff, 2022; Useem, 1984). We expect a similar correspondence between *Keidanren* membership and prominence in government appointments.

The first and second conditions establish the socio-political context for the exercise of network power by the industry. A well-positioned energy industry within a larger network of *state and corporate* associations will be better able to frame and advance their *industry interests as consonant with wider corporate class and national interests*. Prominently located in relation to leading corporate associations and top-level state agencies, the corporate leadership within that industry acts within a historical network that positions their industry in an interdependent web of policy, financial and historical relations associated with the development of the energy sector, and the large national economy. Economic interdependencies enhance the ability of industry elites to frame their particular sectoral interests as consonant with wider class and national interests.

The third condition of an EIC also draws from power structure theory and specifically Domhoff's concept of the "opinion-shaping process" (1978, 1990). In power structure research, the capacity to wield power is not just structural, i.e., through interpersonal and organizational networks with state institutions and other corporate institutions, but also cultural. The ability to shape public opinion is positively associated with connections to prominent think tanks, public relations firms, extensive advertising expenditures, and astro-turf organizations. Farrell's (2015) research on the capacity of fossil-fuel sponsored climate skeptics to diffuse their strategic doubts through a media echo chamber convincingly establishes this point.

Consequently, an EIC can pursue particular policy pathways and utilize their political capacities to act on the state apparatus *and* public opinion to secure long-term energy development agendas suited to their particular profitability interests. EICs penetrate the executive and administrative agencies associated with energy policy, lobby and campaign in legislatures and parliaments, and mobilize astro-turf and public relations campaigns to shape public opinion and national conversations about energy, jobs, and the environment.

Our central proposition is this: nuclear energy corporations will possess sustained network ties to the state and the central business organizations of Japan and utilize points of class and bureaucratic leverage to dominate policy discussions, guide government commitments to energy development, impair assessments of changing energy needs, and promote denial of environmental problems associated with their industry. In short, the political capacities and structural power of the nuclear utility corporations are enhanced by their position within intercorporate and state networks. Similarly, this structural power entails the exercise of cultural power, exhibited by nuclear industry ties to policy planning groups that implement public relations campaigns, coordinate advertising, and maintain network relationships with the advertising and media sectors, both of which profit from long standing expenditures aimed at the promotion of a nuclear safety myth in Japan.

In our case we see conditions not unlike the powerful fossil fuel interests in the U.S. that funded public relations, lobbying, and think tank initiatives to neutralize critiques of fossil fuels while delaying policy initiatives to curtail greenhouse gas (GHG) emissions (Brulle, 2014; Carroll et al., 2018; Farrell, 2016a, 2016b). In the case of Japan, a power structure approach can explore how the nuclear energy industry is networked with state and non-state institutions to influence national energy policymaking and dominate public discourse about nuclear power.

Data and analyses: historical and network methods

We examine the assumptions of an interconnected, nuclear energy industrial complex with data collected after the March 11, 2011, disaster. The primary data provides an historical snapshot spanning several years prior to and immediately following the Fukushima meltdowns. This study began with the collection of extensive archival data on the membership of major corporate, bank, and business association boards, government ministers, and civil society affiliations (universities, nonprofits, unions, and media organizations). Historical documents (in Japanese) inform

both the membership rosters and the historical narrative that follows. We used this archival data to construct multiple data matrices that mapped the network of organizational affiliations among major government, corporate and civil society bodies. Specific membership data was collected on leading officials from the Ministry of Economy, Trade and Industry (METI), the Ministry of the Environment (MOE), and other agencies concerned with nuclear, environmental, or energy regulation. Lists of officials from these agencies and the boards that they served on were documented and board membership of major business organizations, including *Keidanren,* were obtained for a six-year period (2006–12). Using membership profiles on government officials and the board members of the electric utility corporations, we tracked these individuals' participation on other boards, identifying how government officials served in other organizations, including media corporations, universities, banks, insurance companies, industrial corporations, nonprofits, and local governments. Native Japanese speakers verified names across multiple positions to be sure that we were tracking the same person. Financial contributions by corporate executives to political parties were also collected for 2011–12.

These efforts resulted in data on 202 Keidanren member companies, 34 additional financial institutions (banks and insurance companies), and the 9 private utility corporations. In this data, we also have 51 environmental groups, 18 media company boards, leaders, and scientists from 45 major academic institutions, and the board members for 184 business, think-tanks, policy groups, trade associations, and various independent agencies. Additionally, we coded instances where a board member from a company or association board formerly served in a government ministry or as a government official from one of 22 prefectures. This data was formatted into a two-mode affiliation matrix for subsequent analysis. From this point, the data provide a social biography of the flow of person-organizational ties, allowing us to examine connections that result from overlapping personnel serving concurrently or in separate positions over the study time frame.

The historical narrative focuses on the intersections of state initiatives and the development of an increasingly powerful nuclear energy treadmill of production, which obviates the need for a relational, process-oriented approach to account for the continued prominence of nuclear energy interests in post-Fukushima Japan. We couple this historical narrative to a series of analyses and visualizations of our network data on the industry and its embeddedness in the wider political economy. Of particular interest, per the theoretical propositions above, is the network pattern arising from the ties between the private utility corporations, the METI, and Keidanren. The graph visualization method is used to construct an image of these organizations and their ties in a manner that spatially distributes similar (or "like") pairs of organizations proximate to one another, with more central vertices located more prominently in the graph. We use the Fruchterman-Reingold algorithm, which is part of a class of spring-embedded methods that establishes an attraction and repulsion force among each vertex (or node) in the graph, defined by the relative distance of all possible pairs and an iteratively determined solution to plot each node (Kolaczyk, 2009). Adjustments to the "strength" of repulsion were made and we used 50 iterations (Smith et al., 2010). Minor manual adjustments were made to improve the

visibility of some vertices. This graph representation provides a visual heuristic of the underlying network structure.

Analysis of the network data also reveals a dense inter-institutional structure of affiliations created by overlapping executives and officials in Japan, reinforcing the historical narrative. The network visualizations offer analytically meaningful representations of structural connections (Mayer, 2012; Moody et al., 2005), which in this case are formed through the career paths and joint memberships of high-level government, corporate, media, and various university and nonprofit boards. These elite affiliations link the nuclear energy industry, the leading business groups, state bodies, and various public institutions in ways that promote the continued development of nuclear energy.

Presented alongside an historical account of the development of nuclear energy in Japan, the network visualizations are combined as an historical-network analysis, accentuating and validating aspects of our narrative on Japan's nuclear energy "treadmill of production." In this way, elements of our historical narrative get mapped, empirically, via our network visualizations. Evidenced by network overlaps, the analyses portray a bundle of interests and power structures that scholars name as a "nuclear village," "atomic circle," or, as we term it, an *energy industrial complex* (EIC). The historical literature shows that since 1956 the nuclear utility corporations have worked with the larger corporate community and state leaders to present nuclear energy as a powerful force for national development, and more recently as a mitigating force to reduce greenhouse gas (GHG) emissions. The combined network power of the EIC suggests an apparatus capable of steering policy, even in the wake of the devastating Fukushima disaster.

In the sections that follow, we demonstrate this allegiance to nuclear energy through two pivotal moments in Japan's energy history, namely the Kyoto meetings in 1997 and the Fukushima disaster in 2011. The consolidation of the industry power structure around nuclear power peaked with the national embrace of nuclear energy as a climate-friendly solution to the greenhouse gas problem in Kyoto in the 1990s. This rebranding of nuclear energy reframed how the costs and dangers of nuclear energy were calculated, in light of the much "dirtier" emissions from fossil fuels. After the Fukushima disaster, the costs and risks of nuclear energy were once again publicly reframed not as inherently dangerous, but as technological problems to be solved by greater investment into upgraded nuclear power infrastructure. We illustrate in both moments—the peak moment whereby nuclear energy is defined as climate-friendly (Kyoto) and the low moment whereby nuclear power is vulnerable to disaster and a legitimacy crisis (Fukushima)—the mobilization of a larger power structure to shape public policy and opinion, both of which are predicted by power structure theory. These moments reveal the importance of network ties between the energy sector and central business organizations in the nation as they attempt to generalize their interests with a classwide rationality (Useem, 1984) in a moment of opportunity (Kyoto) and crisis (Fukushima).

A power structure analysis of Japan's nuclear industry

Johnson (1982) argues that state and industry relations in Japan diverge from the liberal assumption of state autonomy found in much of the political science and sociological literature. Yet we also observe a clear case where state actors acted decisively, in concert with strategic industry partners and international actors (the U.S. government alongside major U.S. businesses), to develop nuclear energy within a postwar capitalist democracy. Japan's postwar state elite established domestically what several observers have termed a "ruling triad" linking business, ruling party, and the state (Broadbent, 1998). Yet the state apparatus remained decidedly robust, facing development pressures internally and geopolitical pressures internationally, especially in its new postwar alliance with the U.S. Tracing the configuration of business and state relations in Japan, Johnson centers on the special role of the "elite bureaucracy…" that "makes most major decisions, drafts virtually all legislation, controls the national budget, and is the source of all major policy innovations…" (1982: 20–21). Upon retirement, members of the elite bureaucracy, especially in the Ministry of International Trade and Industry (MITI), later named the Ministry of Economy, Trade and Industry (METI), "move from government to powerful positions in private enterprise…" (ibid). This practice is widely acknowledged in Japan and is referred to as *amakudari*— "the descent from heaven" (Terada, 1998:11). Institutional capture occurs via a process of obligatory appointments of former government officials to corporate and nonprofit boards. Often termed "golden parachutes," these appointments bring perks and constraints to officials and the recipient organizations (Terada, 1998:11; see also Kerbo, 1995). These early retirements "descend" from positions in the bureaucracy into industries they previously regulated or into political leadership where they can impact, via legislation, the same industry or bureaucratic environment they once directed.

Funabashi cites a report to show how *amakudari* works with the electric utility corporations, where "at least 50 high-ranking officials from METI gained prestigious positions after retirement from METI in nine major electric power companies in recent years" (2012: 68, citing *Shukan Daiyamondo*, 21 May 2011: 33). Table 1 presents this data from the METI report. These personnel interchanges form the structural basis for a power structure that scholars alternately refer to as a "nuclear village," an "atomic circle," or a "nuclear complex." Hasegawa (2012: 88), for instance, describes an "atomic circle" in specific terms, inclusive of "people from the nuclear industry, engineers of companies… that manufacture nuclear plants, people of the nuclear power division of the electric power companies, scholars of nuclear engineering, officers of nuclear regulation sections of the government, officers of the Agency for Natural Resources and Energy within the Ministry of Economics, Trade and Industry (METI) and related politicians." Similarly, Funabashi (2012) offers distinct propositions relating to his key concept of a "nuclear complex" (pp. 68–69). Historical and institutional analyses by scholars have shown how the economic and institutional power of the nuclear industry, the electric utility corporations, and METI have longstanding ties that dominate politics and information.

Funabashi (ibid.) argues that the "nuclear complex," structured by a convergence of economic, political and informational power, "had too much confidence in their own judgments and consequently have underestimated the real dangers of earthquakes and tsunami" (p.69).

Political scientist Kingston (2012) refers to these institutional patterns as an historical adhesive that reinforce the three sides of an *iron triangle* that link industry lobbyists, government bureaucrats, and political party elite. Key state powers, in other words, are interconnected with leading industry elites. Kingston (2014: 470) further argues that "Japan is at the center of the global nuclear-industrial complex…" The hub of this energy industrial complex is composed of some of the world's largest corporations, including three Japanese corporations engaged in joint ventures to develop and promote nuclear energy technology: General Electric with Hitachi, Westinghouse with Toshiba, and AREVA (French) with Mitsubishi Heavy Industries (ibid). Each of Japan's regional private utility corporations also develop nuclear energy and are part of the complex. The largest of these utilities, TEPCO, is the biggest nuclear operator in the world. Heavy industries, including cement and steel, enjoy lucrative contracts with the utilities and major financial corporations insure and finance nuclear energy development. In 2011, TEPCO alone had 7% of all corporate debt in Japan (Samuels, 2013). These market and institutional interdependencies assure overlapping interests across market sectors and major corporate players. Ongoing political and economic support for the industry is assured as the specific interests of the nuclear sector overlap with other major economic sectors. Additionally, major universities and many nonprofit organizations contribute to the development, operation and management of nuclear facilities and their waste. Consequently, these interdependent market and political interests forge a complex that transcends the particular interests of the electric utility companies or the nuclear technology manufacturers. We argue below that a wider class segment has developed in concert with the national economic policy guidance of METI and the conservative Liberal Democratic Party (LDP), a "ruling triad" (Broadbent, 1998), establishing an institutional coupling between the energy-industrial sector, a dominant class segment, and the state.

The development of a nuclear energy treadmill

World War II saw the first atomic bombs deployed in war, when in 1945 the United States dropped bombs on Hiroshima (August 6) and Nagasaki (August 9), Japan, killing over 100,000 people instantly and thousands more over the days following as they dealt with injuries and the effects of radiation exposure. For years the Japanese grappled with the aftermath of the atomic bombs and the widespread human tragedies among bomb survivors, or *hibakusha*. Initially, the U.S. and Allied forces suppressed evidence of the human devastation resulting from the bombs, forming the first international instance of decades of denials about nuclear risks. Eight years after the bombing and amid growing concerns about nuclear weapons, the newly formed global community embodied in the United Nations General Assembly (UNGA) sought to broker solutions to avoid future use of atomic bombs in November 1953.

Weeks later, seizing the opportunity to reframe atomic energy as ripe for development, U.S. President Eisenhower called for nuclear research for civilian purposes in a speech to the UNGA. In Japan, this atomic reframe was embraced as a member of parliament and future Prime Minister, Yasuhiro Nakasone, worked with the chair of Japan's business federation *Keidanren*, the influential publisher of the newspaper *Yomiuri Shimbun*, and the electric utilities to begin plans for nuclear energy development (Dusinberre & Aldrich, 2011; Kingston, 2014; Samuels, 2013). It took another five years before the program launched. Serious investments in nuclear energy infrastructure were initiated with the construction of the first commercial reactors in 1960, which began operating in 1965; their numbers expanded rapidly in the 1970s and 1980s. Aside from the supply of electricity, especially for heavy industry, nuclear energy policy was linked to both U.S. military and private sector interests. Steady guidance and increasing investments from the state helped integrate the industry into Japan's national economic development strategy. METI assisted with the further development of the industry by establishing partnerships for Toshiba and Mitsubishi Heavy Industries with two U.S. giants, General Electric and Westinghouse respectively, whose designs and technology were used to build Japan's first reactors (Aldrich, 2008; Dusinberre & Aldrich, 2011; Samuels, 1987).

To facilitate this development, the Japanese government, in cooperation with the industry, created the Japan Atomic Industrial Forum, Inc. (JAIF) to subsidize and legitimize nuclear energy in Japan on March 1, 1956. JAIF is a nonprofit organization incorporated under the auspices of the industry to promote peaceful utilization of nuclear energy, radioisotopes, and radiation in a wide variety of fields. The organization sought to forge consensus, consolidate information and advance policy, all under the auspices of the industry. Throughout its long history, the JAIF consistently serves as a forum for discussing and developing political and policy priorities for the industry.

Table 1 Instance of Senior Ministry Officials' *Amakudari* to Private Electric Utility Corporations

Electric Power Company	Number of Former Executives who were in Senior Ministry Positions
Hokkaido Electric Power Co., Inc. (HEPCO)	5
Tohoku Electric Power Co., Inc. (TOEPCO)	7
Tokyo Electric Power Company, Inc. (TEPCO)	5
Hokuriku Electric Power Company, Inc. (RIKUDEN)	6
Chubu Electric Power Company, Inc. (CEPCO)	5
The Kansai Electric Power Company, Inc. (KEPCO)	8
The Chugoku Electric Power Co., Inc. (ENERGIA)	3
Shikoku Electric Power Company, Inc. (YONDEN)	4
Kyushu Electric Power Company, Inc. (KYUDEN)	7
The Okinawa Electric Power Company, Inc. (OKIDEN)	4
The Japan Atomic Power Company (JAPCO)	8
Electric Power Development Company, Ltd. (J-POWER) *	6

Source: METI 2011b. (in Japanese). * (After privatized in 2003)

It has done that by networking with the major corporations, banks, and foundations. The organization conforms to Domhoff's (1978) concept of a policy planning organization. Founding board members and advisors included executives from five major newspapers, representatives from Keidanren, and METI officials who crafted a narrative of science, technology and advanced manufacturing coming together in nuclear energy to create a domestic power supply that would promote Japanese development.

The industry developed with the support of the national government using various incentives to compel local prefectures to accept sites for the nuclear facilities, mostly in rural, coastal communities. Aldrich explains how the "Tokyo Electric Power Company (TEPCO) and regional power monopolies… [received] logistical and financial support in mapping out potential host communities" (2012: 3). Industry documents from the time revealed that planners explicitly considered rural communities for siting because of their political and organizational vulnerabilities (Aldrich, 2008, 2012). In the immediate postwar era, these communities saw declining populations and recurring local government deficits, which weakened local civil autonomy and resources. Effective resistance to the siting of nuclear facilities was curtailed by these conditions even as local authorities embraced the opportunities for mobility and resources. Murphy sums it up well: "weak horizontal bonds made it difficult for residents to mobilize independently of the state, strong vertical bonds made it easy for pro-nuclear interests to lobby influential men who held leadership roles in overlapping local associations. Once utilities gained the support of local heads of chambers of commerce, fishing and farming cooperatives, and district and neighborhood associations, these opinion leaders were able to induce their rank-in-file to support the new plant" (2014: 21). These same communities would suffer the frequent mishaps and accidents among many of the nuclear facilities (ibid).

As investments in the industry expanded, resistance to nuclear plants occurred primarily at the local level until the 1970s and 1980s, when "several national anti-nuclear organizations sprang up and began to organize protests across the country" (Aldrich, 2012: 3). To appease local elite, subsidies expanded and enriched the local villages where plants were constructed. Local communities benefited from new jobs, civic centers, museums, other infrastructure and the public relations campaigns that propped up the nuclear modernizing projects. Dissuading protest, these incentives from the central state expanded public acceptance and helped establish long-term socio-political dominance of party leaders and, ultimately, a cultural mythology of low-risk energy development (Funabashi, 2012; See also Aldrich, 2012; Murphy, 2014). *A classic treadmill of production was established.*

Even as new industry regulations developed under the METI, academic and civil society critics expressed concern that the Nuclear and Industrial Safety Agency (NISA) and Nuclear Safety Commission would be captured by the nuclear sector. Kingston (2012) and Aldrich (2012) also make this point: the METI developed alongside the nuclear industry. This condition eroded bureaucratic autonomy over energy policy—which it is responsible for developing and regulating—because party officials also received campaign money from the utility corporations and their executives, at least until 1974 (Murphy, 2014).

Ramseyer (2012) recounts that technocrats within METI had close ties with the industry by the 1970s and 1980s. The utilities essentially wrote their own safety guidelines and minimized safety warnings from the NISA. As a result, Japan's safety

standards failed to rise to international standards (Ramseyer, 2012). Table 2 reflects this cozy relationship, demonstrating how top government officials routinely landed top executive and board positions following their employment as the Vice-Ministers of Japan (Nakano, 2009). The Vice-Minister is the top non-elected position in the government.

By 1989 anti-nuclear power voices were growing, accelerated by the Chernobyl nuclear disaster (1986), spurring calls within the nuclear industry for more active campaigns to shape public opinion on the merits of nuclear power. The former president of the *Nikkei Shimbun* (newspaper) made a public statement at the annual meeting of the Japan Atomic Industrial Forum: "It is an extraordinary event that some people are devoting themselves to the grass root movement (against nuclear power) like a fashion. Because their movement is based on emotions which stir the fear of radioactivity, we must fight them bravely without sitting idly" (*Asahi Shimbun*, 2013: 284). The JAIF was well-established as a policy planning organization for the nuclear sector and maintained very close ties to the decision-making and regulatory environments. In other examples of "treadmills of production" we see how the polluting industry leverages vertical (workers and communities) and horizontal networks (allied industries) to sustain political influence in favor of their industry (Gould et al., 2008).

In the 1990s, JAIF became more actively engaged in shaping public opinion with the added role of public relations promotion to its advocacy portfolio. After the Chernobyl crisis, the promotion of Japan's nuclear safety myth, long-established as a meme, was increasingly supplanted by the promise of nuclear energy as green and climate-friendly in response to a persistent environmental and anti-pollution movement. Even as business and state leaders aggressively developed nuclear power plants and nuclear fuel recycling facilities through the 1980s, it became clear to industry elites that a new frame was needed. Growing concerns about climate change at the global level offered an opportunity to rebrand nuclear power as a greener energy solution, simultaneously rationalizing continued investment in nuclear energy and casting Japan as a leader in addressing global warming.

Kyoto: rebranding nuclear power as a solution to climate change

As global warming increasingly became a public concern in the late 1980s, and with the hindsight of the second oil crisis in 1979, the Atomic Energy Commission of Japan (AEC), and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) began to insist early in the 1990s that nuclear power was essential for mitigating climate change (AEC, 1990; MEXT, 1994).[9] By October 1990, the *Action Program to Halt Global Warming* was adopted with the intent of reducing per capita CO_2 (Kondoh, 2009). The leading business organization in Japan, *Keidanren*

[9] As Miyadai concluded, the promotion of nuclear energy as carbon neutral is misleading: "If we look just at the process of generating electricity, it appears that there is no carbon dioxide emission. But seen in light of the entire process – including mining, refinement and enriching of uranium; transportation; building of power plants; decades of cool temperature storage; and more than 10 years of plant closure – such claims turn out to be pure exaggeration" (2012: 99).

Table 2 Re-employment of Vice-Ministers from Ministry of Economy, Trade and Industry

Name & Term as Vice Minister	Places of re- employment from METI
K. Tamaoki: 1952–53	Toshiba (Director, General Manager, President, Chairman) → IHI Corporation (Board Director) → Nippon Atomic Industry Group (President) → New Energy Foundation (Chairman) → Japan Cooperation Center for the Middle East (Chairman)
T. Ishihara: 1955–57	FURUKAWA ELECTRIC (General Manager) → TEPCO (Vice President) → Overseas Petroleum Corporation (Board Director) → TEPCO (Full- time Corporate Auditor•Counselor)
K. Ueno: 1957–60	KEPCO (Counselor•Director) → Maruzen Oil (Senior Board Director) → KEPCO (Managing Director) → Kansai Oil (President) → KEPCO (Vice President•Counselor) → Japan Indonesia LNG (President) → Venture Enterprise Center (Chairman)
H. Tokunaga: 1960–61	Fuji Iron & Steel (Senior Managing Director) → Nippon Steel (Vice President •Full- time Counselor) → Japan National Oil (President•Special Advisor)
K. Matsuo: 1961–63	NKK (JFE) (Executive Director•Senior Managing Director•Vice President•Chairman) → Fuyo Petroleum Development (Chairman) → Overseas Petroleum Corporation (Board Director) → NKK (Director and Senior Advisor)
Z. Imai: 1963–64	Nippon Petrochemicals (Senior Managing Director•President) → Ukishima Petrochemicals (President) → Nihon Plastic and Chemical (Director)
Y. Oojimi: 1969–71	Arabian Oil (Vice President•President•Director and Senior Advisor) → Fuji Oil (Director and Senior Advisor) → Research Institute of Economy, Trade and Industry (Chairman) → Japan Cooperation Center for the Middle East (President) → Center for Information on Security Trade Controls (President) → Japan Energy (Counselor)
Y. Morozumi: 1971–73	Electric Power Development (Governor) → Schlumberger (SKK) (Chairman) → Bank of Japan (Member of the Policy Board)
I. Fujiwara: 1981–82	Electric Power Development (Vice Governor•President) → Electric Power Development (Vice Governor•President)
K. Sugiyama: 1982–83	Industrial Bank Japan (Advisor) → NIPPON STEEL (Advisor•Executive Director•Vice President) → Electric Power Development (President)
H. Sugiyama: 1988–89	Industrial Bank Japan (Advisor) → Sumitomo Metal Industries (Executive Managing Director•Vice President) → Electric Power Development (President)

Source: "Study on Golden Parachutes," Masashi Nakano (published by Akashi Syoten, 2009/9/25. Written in Japanese)

coordinated these goals closely with leaders in the LDP and officials in METI – as well as with industry leaders internationally – promoting nuclear energy as a solution to global warming. Together, state leaders in the LDP aligned a domestic and foreign policy strategy to boost international stature and domestic energy industries.

At the Third Conference of Parties (COP3) to the UN Framework Convention on Climate Change (FCCC) in Kyoto in 1997, nuclear power was at the center of the carbon reduction discussions. Hosting the COP3 meetings reinforced a view among

national officials that global warming is the problem and nuclear energy is a solution. In 1997 *Keidanren* announced that:

> "[W]e should place nuclear energy at the center of key energy choices… It is essential to get understanding from Japanese citizens to proceed with the nuclear policy smoothly" (Japan Business Federation 1997).

The timing of the 1997 COP3 (Kyoto Protocol) meetings created opportunities for both state bureaucrats and prefecture level political leaders to align domestic political agendas with a national project to assert international environmental leadership in the UN climate talks. In accordance with these political circumstances, the Environmental Agency (later the Ministry of the Environment, MOE, in 2001) endorsed nuclear energy as an essential measure to mitigate global warming. In October 1998, they enacted a law, "Promotion of Measures to Cope with Global Warming," that established 55 national centers in each prefecture to oversee a program aimed "to limit greenhouse gas emissions in everyday life" (Hiraoka, 2005: 107), amidst the renewed national embrace of nuclear energy as a greener approach.

This green rebranding supported Japan's continued significant national investment in nuclear energy. The International Atomic Energy Agency (2012) documented that Japan outspent all other countries on nuclear research and development, with approximately 55% of the energy budget devoted to nuclear (France was second at 38%). Oshima (2010) reports that between 1970 and 2007 approximately 10 trillion yen were spent on nuclear energy by the Japanese government, or roughly one-third of all public energy spending, demonstrating overwhelming support for nuclear energy among political elites.

This rebranding also demonstrates how nuclear industrial elites were in alignment with government bureaucracy, enjoying close relationships for generations. These industry-government connections shaped energy policy decisions as well as disciplined the field of political candidates to be favorable to nuclear industry interests. In fact, power-company executives are some of Japan's most generous political donors (Kingston, 2012). Though direct company donations stopped in 1974, the utilities make indirect campaign contributions via personal executives. For example, 400 TEPCO executives contributed about 60 million yen between 1995–2009. In 2009, this amounted to approximately 70% of all individual donations to the conservative LDP in this period (Samuels, 2013: 121).

Following Kyoto, support for nuclear energy among political and industry elite was bolstered by investments in shaping public opinion favorably towards nuclear power. The industry, media, and politicians promoted nuclear energy through public relations campaigns and mass advertising, successfully increasing popular support for nuclear power to its highest levels by 2005 (Aldrich, 2013). These investments and campaigns were even successful in winning the support of moderate environmental organizations who aligned with nuclear power as a greener energy solution post-Kyoto and pre-Fukushima (Dreiling et al., 2017).

As *The New York Times* reported, industry, the mass media and government agencies collaborated in constructing a myth about nuclear power: "Plant operators built lavish, fantasy-filled public relations buildings that became tourist attractions. Bureaucrats spun elaborate advertising campaigns through a multitude of

organizations established solely to advertise the safety of nuclear plants. Politicians pushed through the adoption of government-mandated school textbooks with friendly views of nuclear power" (Onishi, 2011). Advertising is a key opinion shaping tool, and electric utilities are Japan's biggest advertisers, spending ¥88 billion (more than $1 billion) a year, according to the Nikkei Advertising Research Institute. TEPCO's ¥24.4 billion alone is roughly half what a global firm as large as Toyota spends in a year on advertising. Before the Fukushima crisis, TEPCO's advertising largesse may have helped silence even the most liberal of potential critics. According to *Shukan Gendai*, the utility spent roughly $26 million on advertising with the *Asahi Shimbun*, and TEPCO's quarterly magazine, *Sola*, was edited by former Asahi writers (McNeill, 2012). Sustaining the promise of nuclear energy produced both public support for nuclear power and major revenue for mass media, and critics argue that this made it very difficult for the media to oppose or to even express something negative about the industry. Both public support and media compliance would be tested in the days after the Fukushima crisis.

3.11.11: disaster and a legitimacy crisis for the nuclear complex

Following the triple disaster on 11 March 2011, large citizen mobilizations escalated from spring 2011 through late summer 2012. Demonstrations of 20,000–75,000 people were reported several times in Tokyo, with protesters chanting "Sayonara nuclear power" (Associated Press, 2011; Dreiling et al., 2017). Mass protests continued over the course of a year and much of Japanese society grew critical of the risks of the nuclear industry. The critique of nuclear energy and the industry promoting it was imminent. The Japanese and international press scoured the archives and interviewed former officials to learn how the nuclear regulators failed in their charge. The term "nuclear village" was popularized. Even the conservative, nuclear-supportive paper *Yomiuri Shimbun* explained that "destroying the nuclear village will be no easy task" (cited in Samuels, 2013: 119). Once the crisis began, it was weekly Japanese magazines who were most likely to criticize the nuclear EIC and its corporate executives, politicians, academics, corporate lawyers and mainstream media who promoted nuclear energy in Japan. Critiques in weeklies were ubiquitous: one weekly stated that "the government and TEPCO became one and… pushed nuclear power forward" (Samuels, 2013: 119). *Shukan Shincho* dubbed TEPCO's management "war criminals," and *Shukan Gendai* named and shamed the most culpable of Japan's *goyō gakusha*, a non-endearing reference by nuclear critics to pronuclear scientists. Conservative member of the Diet, Representative Taro Kono explained how the massive advertising and public relations budget of TEPCO had been used to make the media ripe for "stories of the nuclear safety myth" (Samuels, 2013: 120).

In the months after 3.11, these criticisms prompted concerns of a legitimacy crisis for industry and political elites, who then sought to control information and manage the public reaction. For example, mainstream journalists were denied access to crucial information about nuclear reactors and radiation, among other issues, as they were briefed directly by TEPCO or through industry press releases. In turn, Norris notes how the reporting generally reflected a blanket support of TEPCO's official

position, with very little critical perspective: "Foreign correspondents and Japanese freelancers regularly ask probing questions while mainstream journalists simply record and report company statements reiterating that the situation is basically under control and there is nothing to worry about" (Norris, 2011). Furthermore, there was a chilling effect on criticism as outspoken journalists were openly silenced, such as Takashi Uesugi, a prominent journalist formerly employed by *The New York Times* and TBS Radio, who was dismissed by the latter after criticizing TEPCO for stifling information flows to the public (Hadfield, 2011). Additionally, TEPCO filtered massive amounts of money into media events designed to sway the favor of the reportage (JPS 2011), and, on some occasions, journalists were denied "access to an official press club building that would allow them to cover anti-nuclear demonstrations" (Reporters Without Borders, 2012).

In this period, we see a dramatic change in public opinion in regard to nuclear energy. By 2005, the EIC had leveraged the Kyoto meetings to amplify the claim that nuclear power is "green energy;" it was done so successfully that public opinion in support for nuclear power reached its height, even among environmental groups. After 3.11, however, public opinion underwent a dramatic swing from favoring more nuclear energy development post-Kyoto to strong sentiments to decrease, phase-out, or abolish nuclear power in the wake of the Fukushima disaster (Aldrich, 2013). By 2014, three years after 3.11, 59% of Japanese opposed the restart of nuclear reactors (*Asahi Shimbun*, 2014).

In the immediate aftermath of the 3.11 triple disaster, mass protests and demands for transparency of the nuclear regulatory system triggered a series of actions which ultimately resulted in leadership of the center-left DPJ coalition to begin a country-wide shutdown of all nuclear reactors. As reactors across the country began to shut down, opportunities expanded to widen the public discourse about nuclear energy. Inspections for earthquake damage and new seismic standards were implemented. During his tenure, Prime Minister Naoto Kan publicly discussed plans to phase-out nuclear energy while expanding support for solar and wind energy – though he faced rejection by officials in METI. As news of the regulatory failures spread, and German Chancellor Angela Merkel responded to pressures to phase-out nuclear energy in Germany, even former Prime Minister Shinzo Abe, running for Prime Minister again, promised to end nuclear energy, something he later renounced.

For a brief period, it seemed that a reflexive ecological rationality would win the day. However, this period of doubt about the future of nuclear power lasted for less than one year before the industry and national political leadership pivoted, facilitating the powerful EIC to ascend again under a public framing of a coming *nuclear renaissance*. This promise of a technological renaissance reactivated Broadbent's (1998) ruling triad of industry actors, political party elites in the LDP, and top-level government bureaucrats whose intra-elite networks justified a continuation and expansion of investments in nuclear energy in Japan post-Fukushima.

Post-Fukushima: the return of the LDP and the nuclear renaissance

Despite the ongoing consequences of 3.11 and the risks of future nuclear hazards from earthquakes, the mainstream media, industry and political elites continued to defend the inevitable reliance on nuclear power for increased electricity needs in the summer and winter seasons, and continued to position Japan as the rhetorical leader in the global struggle to reduce greenhouse emissions. Indeed, the renewed emphasis by the Japanese government that nuclear power is not only safe, but also 100% carbon free, went hand in hand with their insistence that there is "no immediate effect (of radiation) on health" (Hita Regional Councils, 2011).

Amidst the public opinion legitimacy crisis for the industry, key players across the nuclear industry network actively designed and mobilized a public relations campaign to convince the Japanese population that nuclear power remains the most environmentally sound response to the country's energy needs. The belief in the capacity of technological developments to solve every problem Japan might confront, no matter how immediately daunting, was not only propagated by the energy industrial complex, but it also resonated with substantial portions of the population. The campaign to restore legitimacy for the industry began only months after the disaster and it emerged from the center of the policy planning organizations that form the energy industrial complex, particularly the JAIF. Enlisted in these efforts were long-time partners of JAIF—TEPCO and Keidanren—who collectively defended the utility corporations and the larger regulatory apparatus. Collectively, the EIC responded with promises of a technological renaissance as the answer to both the risks of nuclear contamination and as a fix to the nation's energy needs. Business poured money into the conservative LDP, winning a majority in the national Diet on a platform that centered on plans for a nuclear renaissance (Samuels, 2013).

In February 2012, the *Nuclear Power Renaissance Forum* (NPRF) was founded. Former Education Minister Akito Arima (and former President of University of Tokyo) assumed the post of President and chose the former chair of the Japan Atomic Industrial Forum to also chair the NPRF. The NPRF includes as its members presidents of electric power companies such as TEPCO and Kansai Electric Power, the CEOs of the three nuclear technology manufacturers—Toshiba, Hitachi, and Mitsubishi Heavy Industries—and also the presidents of Nippon Steel Corp. and Toyota Motor Corp. The NPRF upheld the promotion of export of nuclear power plants abroad and boasted that: "Securing such orders by the joint effort of the public and private sectors is essential for the future growth strategy of the Japanese economy" (Samuels, 2013: 283). Other members of the Forum included three prominent media executives; Shoichi Oikawa, executive adviser to The Yomiuri Shimbun Holdings; Hisashi Hieda, Chairman of Fuji Television Network; Masayuki Shimada, president of TV Tokyo.

With the election favoring the LDP, candidate-Abe reneged on his campaign pledges to phase-out nuclear energy and recommitted Japan to its continued dependency. Kingston's examination of the electoral strategies of the LDP, which successfully reinstalled Shinzo Abe as Prime Minister, helped set the stage for a "nuclear renaissance" even "after the triple meltdowns, an endless cascade of damning revelations about safety, a bungled clean-up, and overwhelming public support for

phasing out nuclear energy…" (2014: 468). In an appeal to this belief in technology, Prime Minister Abe explained his justification for restarting the nuclear power industry, claiming that "new reactors will be totally different from the ones built 40 years ago – those at the Fukushima Daiichi plant that caused the crisis" (*Taipei* Times, 2013). In this rejection of calculable risks and promotion of faith in the ingenuity of the nuclear industry, Abe reveals the powerful discourse that conceals risks in a way that promotes a particular energy industrial complex: despite Fukushima, nuclear energy will continue as a principal strategy in meeting Japan's energy needs. In an even more direct remark, he admitted that part of the strategy would include efforts at convincing the public that nuclear power is safe, before such safety standards are actually reached. "We will be building them while earning understanding of the public as to how different they are" (Ibid).

Network visualization of the nuclear energy industrial complex

Our data allow us to approach this historical moment with a network approach to detect the presence of a structurally embedded nuclear complex. While the analysis is not aimed at hypothesis testing with tests of statistical significance, the data visualizations can be used to observe the parameters and the contours of our historical argument. The concept of an "energy industrial complex'' is further illuminated using these methods of network visualization. Specifically, the data presented in the following figures reveals dense inter-organizational connections formed by personnel in the nuclear industry, the wider business sector, major financial corporations, policy groups, and of course major ministries in the government. The method complements the historical narrative by grounding empirically a large-N representation of institutions and organizations that connect the nuclear industry, the state, the LDP, and big business more generally. Using these network-historical analytics can help explain the persistence of the nuclear complex in Japan, post-Fukushima.

There were 34 banks or insurance companies in our data. Sixteen of them had executives who were members of one or more of the policy planning groups (such as JAIF or the NPRF) and the METI, between 2006–2012. Over time, many of these banks also shared executives or board members with electric power companies and pro-nuclear foundations but also had worked previously in METI or other government agencies. Banks and insurance companies are not under the jurisdiction of METI but the Ministry of Finance, though they may connect indirectly through former or current officials who have served in multiple government bureaucracies and business associations.

Table 3 presents a list of financial corporations whose executives have held one or more connections to this power structure in the years immediately prior to and following 3.11. These large banks and insurance companies play an important role in financing and insuring investments by the private utility corporations. In Fig. 3, we visually represent these ties to the larger network. At the center of the network is the METI, consistent with expectations from historical and case analyses of state bureaucracies in Japan's postwar capitalism. The postwar state worked with U.S. political and economic elite, as well as extant industrial elite in Japan, to forge a capitalist development path. State

Table 3 Banks and Insurance Companies tied to the EIC

Abbreviation	Financial Company	Count of ties
B_Aozora	Aozora Bank, Ltd	1
B_Boj	Bank of Japan	3
B_Dbj	Development Bank of Japan	2
B_HOKK	Hokkoku Bank, Ltd	3
B_HOBA	Hokuriku Bank	2
B_Jbic	Japan Bank for International Cooperation	13
B_MYLI	Meiji Yasuda Life Insurance Company	2
B_MIUFJ	Mitsubishi UFJ Financial Group, Inc	2
B_Msins	Mitsui Sumitomo Insurance Co	2
B_MICB	Mizuho Corporate Bank	4
B_Nlic	Nippon Life Insurance Company	15
B_ORICO	Orient Corporation	2
B_SMBC	Sumitomo Mitsui Banking Corporation	2
B_Smfg	Sumitomo Mitsui Financial Group, Inc	6
B_Ufj	The Bank of Tokyo-Mitsubishi UFJ, Ltd	3
B_Tbank	Tochigi Bank co	2

actors developed robust facilitative state structures in the complex METI bureaucracy to advance business and financial interests with the Keidanren supporting the ruling party elite. Again, the visualization aligns with Broadbent's (1998) description of the "ruling triad" of state, business, and the ruling party. As with the complete network presented in Fig. 4, METI plays a critical role in linking the corporate and government sector via overlapping personnel. The visualization clearly depicts the long-term field of action that is established through the "golden parachute" dynamics, as explicitly theorized from the power structure model. Further, the executives from these financial firms (in gold) are heavily networked with the nuclear industry (red), other large companies (brown), and the policy planning groups (teal). Even more important, several executives from these banks are also connected to other institutions in the EIC network, including many who previously served in government ministries (black).

In Fig. 4, we again use the Fruchterman-Reingold algorithm in NodeXL to plot the vertices and edges of the full network. This network visualization depicts overlapping institutional fields that result from the continuous flow of organization-personnel ties across the nuclear energy industrial complex. The result is a remarkable dispersion of personnel that connects a wide swath of institutions, ranging from local governments to the country's most influential corporate boards. Per the group-level graph on the right, types of organizations are color-coded. Within this group-aggregated graph, vertex size is scaled by the maximum betweenness centrality score found within each category. The aggregated connections across institution type (right) reveal the critical role that business federations and associations play in bridging personnel flow between corporate and government bodies. Research in corporate policy networks in the United States and European countries reveals an analogous intermediating role of the policy and industry association networks.

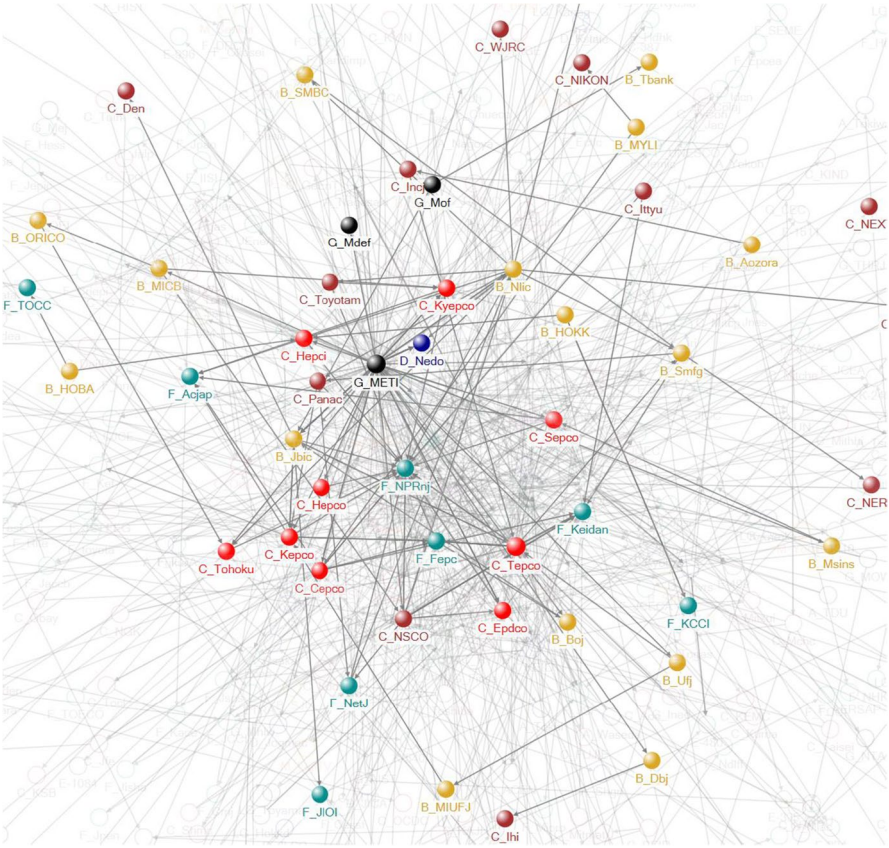

Fig. 3 50 Corporate, Banking, Business Association, and Utility Corporation Ties to METI and the NPRF. B: Bank, Insurance, Leasing; C: Company (red: Electric Power Company); F: Foundation; D: Independent Agency; G: Government; F_NPRnj: Nuclear power renaissance; F_NetJ: Net Journalist Association; F_Acjap: AC Japan; F_Keidan: Keidanren; F_Fepc: The Federation of Electric Power Companies of Japan

Of note, the nine nuclear utility corporations (red), by law, cannot share board members; hence they share zero edges within their group. Within the main panel, there are 619 distinct vertices and 1,283 edges among them. Repeated ties (390) serve as weights and determine the thickness of lines between two entities. All of their vertex sizes are scaled to their betweenness centrality scores.[10] Table 4 presents the 10 most central labeled entities from the figure. These organizational hubs occur because highly connected individuals circulate among their boards or in official positions. Keidanren is second in centrality to METI. Visually, these two form large cores in the network. During this time frame, METI shared 115 personnel with other entities in the network, notably forging ties to eight of the nine nuclear utilities.

[10] Betweenness centrality is a robust indicator of the influence of a vertex in a network. It is equal to the number of shortest paths from all vertices to all others that pass through that vertex.

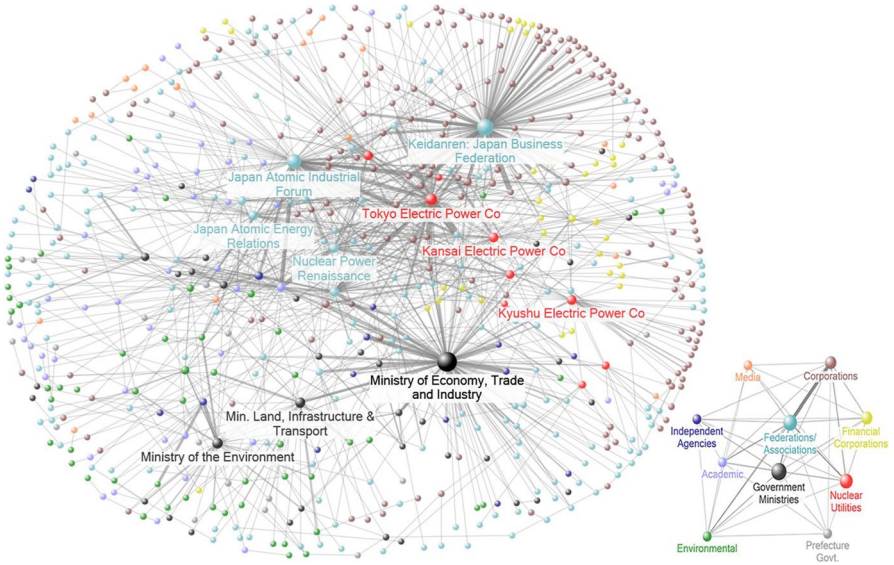

Fig. 4 Main Component of the Nuclear Energy Industrial Complex

To continue examining the proposition that an EIC will possess dense connections to the central business federations of a country, Fig. 4 reveals the ties formed by Keidanren (light blue) and its member companies (brown) with the major policy planning groups (also light blue) and the private utility corporations (red). All the nuclear utilities remain in proximity, forging links to the various nuclear trade associations and policy planning groups, including JAIF. Such hubs draw together diffuse participants from the EIC to achieve strategic economic, political, or cultural objectives. The overlapping personnel facilitate interactions and information flow that sustain awareness of the industry as a whole and its wider class and state connections. TEPCO executives are regularly observed in this role historically, and the network visualization renders visible the *bridging role* that the company plays between Keidanren, the industry policy network, the smaller utility corporations, and the state. For decades, TEPCO executives have served in top leadership roles for Keidanren, including former Presidents, Chairmen, Vice-presidents, and Vice-chairmen of the powerful organization.[11]

Nested between METI and Keidanren are the nuclear industry policy advocacy groups, some of the largest nuclear utilities, and several financial and manufacturing firms.

TEPCO, like Toshiba and Hitachi, bridges both Keidanren and METI, sharing officials from both institutions over many years. Crucially, as the visualization portrays, the

[11] Incidentally, company ties to one another in this network are significantly correlated with their political campaign contributions, evident in the bivariate correlation of .406 between the amount donated to the LDP and the centrality of the company in the network of Keidanren member-corporations. The more connected a company is within this corporate network, the more financially supportive they are of the ruling party in Japan.

Table 4 Ten most central nodes in Fig. 5, Betweenness Centrality

Institution	Betweenness Centrality
Ministry of Economy, Trade and Industry	125,581.1
Keidanren: Japan Business Federation	84,174.13
Japan Atomic Industrial Forum	59,591.17
Tokyo Electric Power Company	34,445.55
Ministry of the Environment	26,785.16
Ministry of Land, Infrastructure and Transport	22,323.53
The Kansai Electric Power Company	21,725.05
Kyushu Electric Power Company	21,328.3
Nuclear Power Renaissance Forum	20,983.97
Japan Atomic Energy Relations Organization	20,953.74

broader partnership between industry and the state is mediated by organizations such as the JAIF, the third most central body in the network, which also maintains expansive ties via personnel exchanges among major universities, media, major corporations, and government officials. JAIF is also a global player in the global nuclear sector, partnering with industry leaders in Canada, U.S., UK, France, South Korea, and China to promote continued development of nuclear power. In the figure, and to the left of JAIF, we see ties to numerous universities, well known for their expertise in nuclear chemistry and engineering, denoted in light purple. At the bottom left, we find a clustering of environmental organizations (green) closely connected to the Ministry of Environment and the Ministry of Land, Infrastructure, and Transport, consistent with accounts that show the state and industry facilitate certain environmental causes (Broadbent, 1998; Dreiling et al., 2017).

The network visualizations demonstrate a robust institutional overlap between the electric utility corporations and the most central ministries of Japan's national government. This observation is consistent with the expectations of power structure theory and our specific criteria for an energy industrial complex. The structure of the network thus reflects the facilitative role of the state and the striking dominance of nuclear interests in shaping energy policy in Japan, a phenomenon sustained since early initiatives to develop nuclear energy in the country.

Resumption of the nuclear treadmill and contradictory energy development

After the first government bailout of TEPCO, which involved an infusion of 1 trillion yen ($12.78 billion) on July 31, 2012 (Samuels, 2013), it was clear that the power structure we have termed a nuclear energy complex, rooted in a treadmill of nuclear production, would continue support for future nuclear projects despite significant public concern. Our historical narrative identifies the relationship between the development of this nuclear energy treadmill and a parallel development of an integrated power structure, an EIC, to advance the interests of the treadmill in the institutions of the state, economy, civil society, and in public opinion. Over decades, the industry formed many political, economic, and institutional interdependencies, some of which are reflected in the inter-organizational networks observed in our network analyses, and the long-term circulation of personnel

and elites in related sectors. These enduring ties empower the nuclear sector with wider class and state leverage, linking the industry in a complex web with state bodies, political party elites, the wider business class network, and an array of nonprofit think tanks, foundations, and experts. For example, in 2013, Keidanren expanded on its 1997 "action plan on the environment" with a promise to take the plan "to the next level… where we contribute through nuclear technology to achieving the goal of halving global greenhouse gas (GHG) emissions by 2050" (Keidanren, 2013). Prime Minister Abe regularly promoted the industry abroad, including newer designs for Small Modular Reactor technology. In November 2020, Keidanren reiterated their view that nuclear power "is an essential technology" and promised to collaborate with Prime Minister Suga to develop "advanced reactors" including small modular reactors and high-temperature gas-cooled reactors, to be carried out as "national projects" (Ohno, 2020). Their November 2020 report also calls for continued safety upgrades to restart existing reactors. The renewed commitment by the nation's most powerful business federation echoed their earlier promises that nuclear energy would mitigate the environmental threat of climate change in the mid-1990s. As in the 1990s, leadership in the LDP, major government ministries, and industry and media boards were once again the top promoters of a nuclear renaissance. This commitment from the national power elite simultaneously narrated the potential of a new and improved nuclear sector while diminishing anti-nuclear activism and ongoing concerns about risks and safety.

Events have exposed the unfortunate negative consequences of choosing to resume nuclear power rather than phase it out and aggressively pursue renewables. When critics of the nuclear village refer to the nuclear safety myth in Japan, they are not suggesting that promoters of the industry lack an understanding of the dangers of nuclear radiation. Instead, they are pointing to a persistent discourse and worldview that denies or minimizes those risks, as Perrow (2007, 2013) explained. Japan's nuclear safety myth is less about antipathy to the science per se, or even the interests of a single industry, but is part of a pattern, like the fossil fuel campaigns in the U.S. (seeBrulle, 2014; Farrell, 2016a, 2016b), where dominant energy interests, including the state, integrate with wider class political networks to aggressively minimize or deny the environmental and human hazards of their industry and protect the vast capital expenditures associated with their use. Whether it is the nuclear or fossil fuel sector, a power structure approach exposes the political and economic interests that override transparent and reflexive policymaking as well as ecological responsibility.

In terms of meeting national energy goals and reducing carbon emissions, this chosen path was also unfortunate. To illuminate this point, a brief comparison with Germany is instructive. After 3.11, many Japanese scholars and activists suggested Japan had the opportunity to embrace renewables in a way that few other countries could do, given the extraordinary capacity of Japan's technological and engineering sectors, and already steady investments in hydropower and solar dating back to the 1970s and 80 s (Cherp et al., 2017). Instead of embracing ecological rationality, and in contrast to Germany, the conservative leadership in Japan maintained a path for nuclear energy development but did so by becoming even more dependent on a global fossil fuel energy industrial complex that was eager to fill the gap resulting from a reduced supply of nuclear sources. Figures 5 and 6 present the share of electricity generated from fossil fuels and renewables,

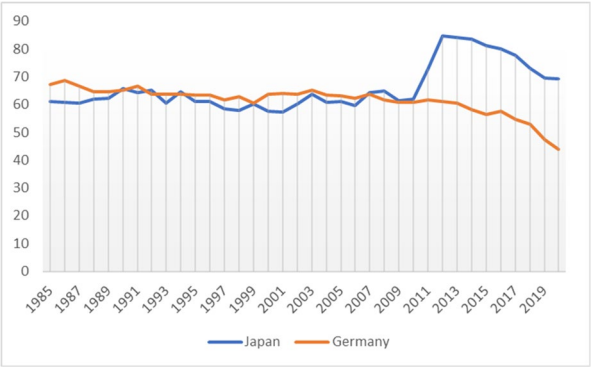

Fig. 5 Share of Electricity from Fossil Fuels—Germany and Japan. Source: BP. 2021. BP Statistical Review of World Energy, 70th Edition. Accessed on January 12, 2022. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

respectively, for Germany and Japan, 1985–2019.[12] Figure 5 reveals a striking increase in fossil fuel use in Japan after 3.11. While both countries experienced a decline in the use of nuclear power, Germany has rapidly accelerated growth in renewables while phasing out nuclear *and* reducing fossil fuels, whereas Japan, with much greater initial assets in hydro and solar power, has not been able to replace the lost energy from nuclear with renewables but instead remains highly dependent on imported fossil fuels from the Middle East.[13] Japan's latest energy strategy aims to supply 22% of grid electricity from nuclear reactors by 2030 (METI, 2021); Germany plans 0%.[14] Like Germany, prior to 3.11, Japan relied heavily on imported crude oil, natural gas, and coal—today, Japan is even more reliant on these imported sources of dirty energy, with as much as 86% of their total primary energy supplied from these sources in recent years.

Perhaps inadvertently, the nuclear energy industrial complex—in its vigorous defense of itself—delayed, and at best slowed Japan's pursuit of a lower-carbon, conservation, and renewable-energy path for national energy development. Worse, significant ecological consequences remain unaddressed from the nuclear meltdowns. Looming on the horizon are several interconnected and unresolved clean-up challenges for the vast radioactive wastes associated with the reactor meltdowns. For example, TEPCO and METI are storing and treating over *1.25 million tons* of cooling water with the expectation of slowly releasing it into the Pacific Ocean over decades. Despite assurances from TEPCO, vast amounts of this water were found to contain dangerous radionuclides, including cancer-causing strontium-90. TEPCO had to apologize in 2018 for insisting previously that the huge pools of radioactive

[12] The point is to reveal how past energy supply choices reduce resilience in the face of a crisis. Japan now has higher ecological costs to support their grid than if they began transitioning to renewables much sooner – especially pertinent given the fact that geophysicists have warned of the seismic risks with nuclear power.

[13] Since Russia's invasion of Ukraine, Germany has delayed phasing out its last two reactors, but has publicly announced that these are temporary extensions. See report from the Federal Ministry for Economic Affairs and Climate Action (2022).

[14] In order for Japan to achieve 22% of its electricity from nuclear power by 2030, additional reactors must be constructed or the nuclear regulatory authority must extend some existing licenses beyond the statutory 40 years; incidentally, the NRA authorized 20 year extensions for three reactors (NRA, 2016).

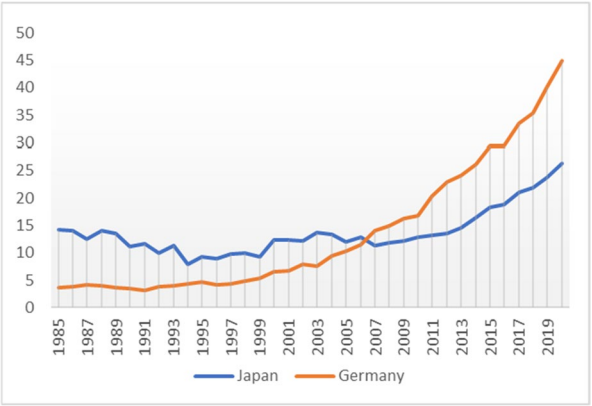

Fig. 6 Share of Electricity from Renewables—Germany and Japan. Source: BP. 2021. BP Statistical Review of World Energy, 70th Edition. Accessed on January 12, 2022. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

cooling water only contained tritium (which, over decades, can safely decay into a helium isotope). It has been widely reported that both the government and TEPCO want to begin releasing this radioactive water by 2025 rather than after it is fully treated. Why? Because they are running out of space to store it (Denyer, 2021). Not surprisingly, environmental groups and nuclear scientists alike have criticized this approach. Even bigger problems remain, however. In one of the many METI plans to clean-up the radioactive wreckage is a pledge to remove the highly toxic corium inside the reactors by the middle of the century. METI (2011a), in partnership with TEPCO, made this and other pledges with the assumption that technology will be developed to remove such waste; but to date there is no viable technology or method for doing so, or for cleaning up the highly contaminated soil in surrounding fields. In March 2021, Greenpeace Japan (2021) reviewed METI's clean-up pledges and their current progress to conclude that the "Fukushima Daiichi decommissioning roadmap is unachievable…" and that a "new plan is inevitable." Given these persistent contradictions, environmental disaster theory must account for the elite power structures in industries that contribute to human and ecological crises. A power structure theoretical perspective offers a clear analytical and empirical framework for understanding the industry's responses to 3.11, as also suggestive in research on the fossil fuel industry's delay and denial campaigns.

Conclusion

Two moments in recent Japanese history demonstrate how nuclear energy was embraced and elevated by networked industry, media, and government actors even as nuclear's centrality in Japan was questioned, first over post-Chernobyl concerns in the 1980s and 1990s and second, by the devastating Fukushima crisis in 2011. After the Chernobyl disaster, concerns about nuclear safety were expressed across much of the world, including in Japan. The industry responded then by promising that nuclear energy could help Japan become a model of green modernization and that Japan's nuclear industry used better technology than what

was used in Chernobyl (Funabashi, 2012). Combined, this narrative was compelling for elites and much of the public. The widely promoted assurances prior to and following the 1997 Kyoto meetings resulted in growing favorability and legitimacy for the industry. This period was accompanied by a dramatic growth in the public relations and advertising spending by the industry (Funabashi, 2012; Samuels, 2013). The industry relied on cultivating a positive sense of nuclear safety and a low-carbon energy future to achieve its peak favorability in the mid-2000s. Confronted with the triple crisis on 3.11, the industry's legitimacy crisis appears to have been resolved for many elites but not the public. Nuclear denial, in this sense, is not an individual's belief or attitude; it is a consequence of strategic action to shape policy and elite opinion about Japan's energy portfolio.

The resumption of nuclear power in Japan was favored by a long-standing energy industrial complex that wielded network power in ways that power structure theory predicts. Actively immersed in the central business networks, the state regulatory bodies, policy planning associations, and various civil society organizations, the nuclear power industry shifted the conversation from the triple meltdowns in Fukushima to a slow but determined nuclear renaissance. Throughout the immediate aftermath of the 3.11 crisis, the industry experienced substantial public outcry and mistrust. Within the EIC, however, the central business federation, the primary government ministries, and a swath of policy planning organizations never severed their ties to the industry that failed to implement basic safeguards in seismically active Japan. Instead, the interorganizational networks that form a resilient power structure for the industry and METI doubled down on their commitments to prop up nuclear power in the wake of the 3.11 earthquake, tsunami, and nuclear meltdowns.

We introduced the concept of an EIC as a synthesis of class-state relations within power structure theory in political sociology and the treadmill of production theory in environmental sociology. Our analyses do not conclude with evidence of monolithic class dominance, or an autonomous state, but rather elucidate the concept of an EIC that conforms to a power structure framework where relations between industry and the state forge a nexus of control, helping to explain the historical development of the nuclear industry with its dense ties to both the state and wider corporate class actors. METI's long-term role in promoting nuclear power also nurtured the capacity of the industry to network with this important state body as well as solidify lasting ties to the larger business class. By the 1990s, class and state actors were able to act concertedly to avance this treadmill and the nuclear safety myth. By historically situating energy industries and state actors in networks, this approach helps explain and more fully understand the capacity of an energy industry to wield network and cultural power. The latter capacities are understood to operate in a wider field of strategic action aimed at opinion- and policy-shaping actions. In our theoretical section, we cite literature that suggests state structures are simultaneously sources of invention and targets for class political action. By facilitating unity among business leaders, often across sectors, state structures like METI's powerful bureaucracy can actually contribute to the network cohesion of the business class, enabling prominent class actors to act in turn back on the state. When considering energy transitions, understanding the energy

sector's ties to larger state and class networks is important. In this case, the triple disaster forced the EIC out of the shadows, long described as a nuclear village by journalists and scholars in Japan, to confront a legitimacy crisis that threatened to phase out nuclear energy. Instead, the EIC responded by promoting a variation of the nuclear safety myth, indeed, a nuclear renaissance, to bolster legitimacy among segments of the public and especially among elites, despite the obvious and intractable environmental risks and ongoing contamination in Fukushima. Eleven years after the disaster, an advisory panel set up by Prime Minister Fumio Kishida – the son of a once powerful METI official—approved plans to extend the lifespans of existing reactors beyond sixty years, fully reversing the policies put in place after 3.11 (Reynolds & Umekawa, 2022).

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Data Availability The data that support the findings of this study are available upon reasonable request from the corresponding author, MD. The data are not publicly available due to their containing information that could compromise the privacy of some study participants.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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