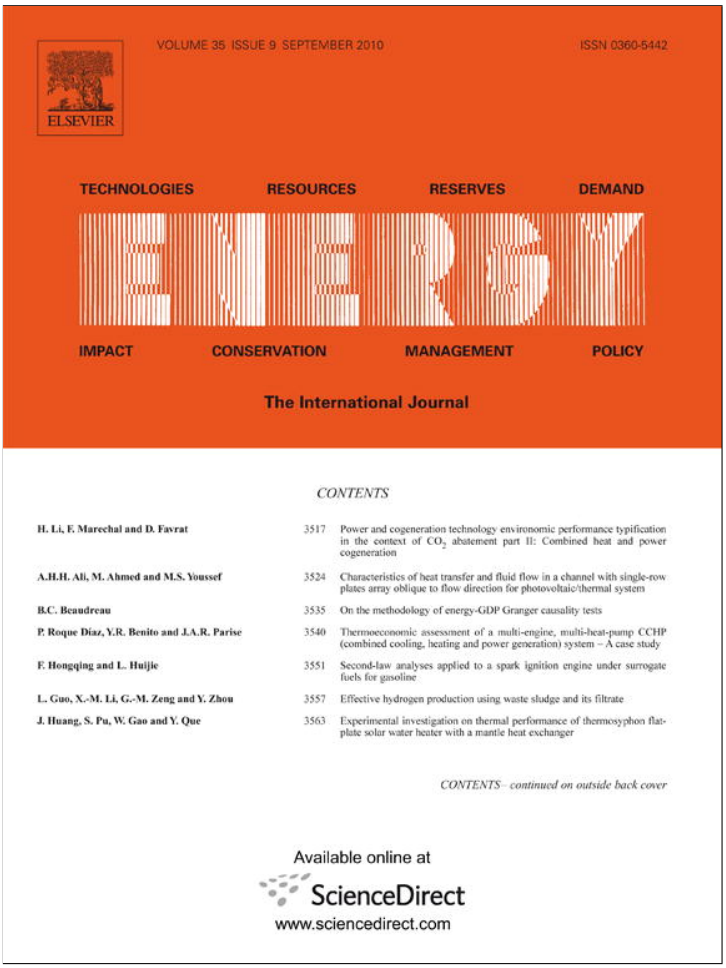

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The socio-political economy of nuclear energy in China and India

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ABSTRACT

This article investigates forms of social, political, and economic organization conducive to nuclear power expansion. We begin by developing a theoretical framework of nuclear socio-political economy based primarily upon the evolution of nuclear energy in France. This framework posits that (1) strong state involvement in guiding economic development, (2) centralization of national energy planning, (3) campaigns to link technological progress to a national revitalization, (4) influence of technocratic ideology on policy decisions, (5) subordination of challenges to political authority, and (6) low levels of civic activism are influential factors in supporting development of nuclear power. Accordingly, we seek to verify the causal properties of these six catalysts for nuclear power expansion in two nations – India and China – that are on the brink of becoming major nuclear powers. We validate our framework by confirming the presence of the six catalysts during the initial nuclear power developmental periods in each country. We also apply our framework as a predictive tool by considering how present conditions in the two nations will impact nuclear power development trends. We conclude by highlighting the emergence of a potential seventh catalyst – the influence of greenhouse gas emission abatement policy on nuclear power development.

1. Introduction

Globally, growth in the nuclear power industry has been lagging for the past two decades. Since the Chernobyl incident in 1987, installed nuclear power capacity has grown annually by a mere 1.3% amidst annual growth in electricity demand of approximately 3%. In the decade 1996–2006, while total global primary energy consumption increased by 26%, the aggregate increase of installed nuclear power was a mere 15%. Concurrently, some renewable energy technologies, notably wind and solar energy, posted annual growth rates above 30% [1]. However, fossil fuel price volatility and international pressures to abate CO_2 emissions have revitalized nuclear power industry prospects. Some indications suggest that this resurgence will be spearheaded by non-traditional players.

Historically, the nuclear power industry has been highly concentrated. Twenty-two countries are home to more than 90% of the world's nuclear power plants. Three countries—the United States, France and Japan—are home to half of the world's 436 nuclear reactors [2]. Until recently, investment in further nuclear power development was waning. In the United States and France, the average age of reactors has risen to 24 years [2]. Globally, nuclear electricity generation decreased 2% from 2007 to 2008, and in the European Union, it dropped 6%, the highest decline since the first reactor was connected to the Soviet grid in 1954 [3]. The unresolved challenge of finding permanent geologic repositories for spent nuclear fuel and the rising cost of decommissioning aged facilities had vitiated the appeal of nuclear power in these countries [4].

However, the decline of nuclear power is suddenly uncertain. In the United States, utilities have announced plans for about 30 new reactors in response to political pressures to bolster nuclear power capacity. In Asia, 18 plants are under construction and an additional 110–319 plants (with a capacity totaling 325,488 MW) are in the short-term planning pipeline [4]. There are also indications that new nations are clamoring to gain membership in the elite club of nuclear power nations. Over 60 countries have conveyed to the International Atomic Energy Agency interest in introducing nuclear power to their energy mix [2]. In addition to high-profile initiatives in Iran, Iraq and North Korea, leaders in nations such as Bangladesh [2], Belarus [2], Indonesia [2], Jordan [5], Myanmar [6], and Zimbabwe [7] have expressed nuclear power aspirations. France has courted Algeria, Morocco, and the United Arab Emirates with promises of nuclear technology [8] and the United States has also been championing the export of reactors to Argentina, Brazil, and South Africa under its "Generation IV International Forum" partnership [4]. The extent to which nuclear power blossoms in these emergent nations will significantly impact the market dynamics of

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the industry and will subsequently alter the global energy mix, influence global concentrations of climate changing emissions, and complicate international security. Given such changing dynamics, predicting the evolution of the nuclear power industry represents a major challenge to energy policymakers.

A complex interplay of social, economic, and political factors makes anticipating the scale and scope of nuclear power expansion difficult for both established and aspiring nuclear nations. In response, this article investigates the forms of social, political, and economic organization conducive to nuclear power expansion. We define "socio-political economy" as the dynamic forces of state and society which influence the nuclear power industry. We begin by developing a theoretical framework of nuclear socio-political economy based primarily upon the evolution of nuclear energy in France (with supplemental insights from the former Soviet Union, United Kingdom, and United States). This emergent framework posits that (1) strong state involvement in guiding economic development, (2) centralization of national energy planning, (3) campaigns to link technological progress to a national revitalization, (4) influence of technocratic ideology on policy decisions, (5) subordination of challenges to political authority, and (6) low levels of civic activism were influential factors in supporting the expansion of nuclear power in France.

These six catalysts create conducive conditions in unique ways. First, a history of strong government intervention in guiding the direction of economic development is a requisite condition seemingly because nuclear power is a "socio-technically inflexible" technology that requires a high degree of supply chain coordination which only the government is capable of unifying [9]. Second, a highly centralized energy sector infuses the requisite control for planning and implementing a sustained expansion of nuclear power in the midst of a politicized environment. Third, the presence of a government strategy that attempts to link technological developments to a national renaissance fosters the formation of a national culture which tolerates risks associated with risk-prone technologies. Fourth, the dominance of a technocratic approach to policymaking appears to provide the necessary ideological support for the development of nuclear power aspirations. Fifth, conditions which minimize political and public debate over proposed government programs seem to enable governments to seamlessly make the jump from agenda item to nuclear power development program implementation in a less contentious manner. Sixth, conditions which keep civic activism to a minimum appear to help government planners avert high levels of public opposition which can threaten to derail nuclear power program development.

We seek to validate the causal properties of these six catalysts for nuclear power expansion by testing for their presence during the main nuclear power developmental periods in India and China, two Asian nations that have significant levels of installed nuclear power capacity and ambitious plans for expansion. If these catalysts are "influential" for fostering the expansion of nuclear power programs, they should be present in the developmental stage of the nuclear programs in each case study country. We then apply our framework as a predictive tool by re-examining the six catalysts as they currently exist in India and China, highlighting significant changes to the elements and offering predictions on nuclear power development trends given these changes.

The analysis presented herein stands out from previous scholarship on nuclear energy and political economy in at least four respects. First, this study presents a current perspective on nuclear power development. Much of the previous work on socio-political dimensions of nuclear energy is dated. A search of some of the leading political journals, such as *Comparative Politics*, *World Politics*, *Journal of Politics,* and *American Political Science Review* failed to uncover articles in the past decade exploring nuclear energy development, its socio-political economy dimensions or otherwise.

Second, to our knowledge, this is the first study to explore the socio-political economy affecting nuclear power development in a predictive manner. Many analysts and studies have investigated electricity demand, climate change, and energy security as drivers of nuclear power expansion, but these aspects do not tell the whole story. Our case studies explore the deeper, socio-political dimensions behind such drivers, and they serve as conduits for achieving two goals. In addition to vetting the applied relevance of the theoretical framework in two other nations, the studies also evaluate changes in these catalytic elements which permits speculation on future nuclear power expansion prospects within each country.

Third, our piece offers a timely cross-national comparison of nuclear power development with a focus on two Asian countries which appear on the brink of ascendency to global nuclear power leadership. Previous studies have predominantly focused only on experiences in European and North American countries [10–12].

Fourth, our study avoids assigning a priori primacy to any one type of factor. Instead, our theory envisions influential social, political, and economic conditions interacting within a mutually constitutive, dynamically evolving environment. In our view, this socio-political economy perspective appropriately sees governance unfolding within a complex, adaptive system [13] that evolves as influential variables within the system evolve. As the case studies will demonstrate, the interactive nature of the socio-political economy explains why nations with a history of nuclear power expansion can suddenly enter a phase of capacity contraction and why nations that previously spurned nuclear power can suddenly embrace nuclear power ambitions.

2. The political economy of nuclear energy in France

Following World War II, much of France's infrastructure lay in ruin and its citizens left demoralized by German occupation. Humiliated and defeated, the French government faced the daunting task of rebuilding an entire nation both physically and psychologically [14]. Ironically, the reconstruction model that the government embraced exhibited marked similarity to the technocratic model which had helped reform Germany into technological global powerhouse following its defeat in World War I. The core elements of France's reconstruction model provided the fodder for cultivating the country's nuclear power program.

2.1. Strong state involvement in guiding economic development

French post-war reconstruction needs were substantial with railways, factories and buildings extensively damaged during the war [15]. The government faced the challenge of facilitating widespread reconstruction amidst financial limitations. The approach it adopted came to be known as "*dirigisme*" which can be loosely described as a strong form of government involvement in targeted economic development. The French government opted for absolute control over the railways and electric utilities. However, in other strategic industries, the government encouraged the development of "national champions" through industry consolidation and subsidized R&D efforts. By publicly earmarking strategic industries for support in reconstruction plans, the government effectively enticed private funding to these industrial sectors, thereby alleviating the necessity for government capital investment.

2.2. Centralization of national energy planning

The French nuclear power program was highly centralized. In 1945, the government formed the CEA (Commissariat à l'Énergie

Atomique) for the purpose of developing a French gas-graphite nuclear reactor. All initial research was conducted within this one agency under a veil of secrecy, creating an insulated policy network wherein nuclear knowledge was monopolized [16]. When the fruits of research produced an operational reactor, commercialization of the technology was transferred to a government monopoly, Framatome. Framatome was charged with the task of exclusively manufacturing nuclear power plants (This consolidation has continued to today, with CEA and Framatome merging together in 2001 to create the Areva group with one of its divisions – EDF (Électricité de France) – still operating all 59 French nuclear reactors. So powerful were these three organizations that they were authorized to build plants in the 1980s and 1990s well in excess of electricity demand and despite two recessions. EDF was privatized in 2006 but the French state still owns the controlling share). Concurrently, the government's utility monopoly, EDF was created in 1946 and assigned responsibility for incorporating nuclear power into the national electricity grid. A great deal of cooperation was required between these three government organizations. The closed nature of this network was such that when disagreements occurred between these three organizations, resolution processes were private and internal [16]. Control over nuclear energy in France remained consolidated among these three organizations from 1946 to 2006, when an independent General Department of Nuclear Safety and Radiological Protection was created.

2.3. Campaigns to link technological progress with national revitalization

Heavy government involvement in guiding economic development can lead a country down varying developmental paths, many of which would not involve nuclear power. In France, a major catalyst supporting development of France's nuclear power program was the strategic decision to focus national reconstruction around high-tech industry. This represented an ideological shift in industrial policy. Prior to WWII, the French economy was largely characterized by a plethora of smaller family-run businesses specializing in the production of low-tech trade goods such as wine, cheese, perfume and leather goods [15]. However, in post-war France, there was adamancy in both government and civic circles that reverting to an economic system that left France defenseless to invasion was undesirable. Consequently, the new government strategy to fashion a renaissance for France based on technological advancement served to both infuse the populace with optimism [17,18] and provide the government with justification for the development of contentious industries such as nuclear power.

2.4. Influence of technocratic ideology on policy decisions

As the technological reconstruction of France progressed, scientists and technological specialists began to exert a stronger influence on public policy. Ultimately, this nation, bent on facilitating a technological renaissance, needed experts to identify what was technologically feasible. Over time, these technological elites and the politicians that supported them gained progressively greater control over the political process. Eventually, those without technological expertise were marginalized due to an inability to effectively challenge the technological rationale of these new power holders [19]. To this day, the French political environment very much remains what one analyst called a "nucleocracy" [20].

2.5. Subordination of challenges to political authority

In effective liberal democratic systems, opposition parties and the media serve vital roles in preventing the ruling party from implementing policies and programs which run contrary to public interest. In theory, political opposition can be attenuated by the existence of political conditions which allow the ruling party to isolate itself from external scrutiny. Media opposition can also in theory be weakened by a number of emergent conditions which include all mechanisms that allow the government to either directly or indirectly induce the media to avoid criticism of government activities [21].

In post-war France, mitigation of challenges to the government nuclear power development policy was not so much a result of tangible government actions as a result of widespread acceptance of the precepts supporting a technological renaissance. The 1950s and 1960s were decades during which nuclear power was touted as an energy source that, once perfected, would produce low-cost energy [22]. The allure of cheap electricity for powering France's technological renaissance convinced the vast majority of French stakeholders that nuclear power was indispensable for the nation's reconstruction success. In particular, political debate among the major political parties was notably absent, with both the Gaullists and the Republicans advocating nuclear power and only differing on minor points. Under the French system of governance, parties that fail to gain 12.5% of the popular vote are structurally marginalized [23], so none of the few anti-nuclear leaders ever had an opportunity to politically challenge France's nuclear power aspirations [24]. To illustrate the degree of political cohesiveness that existed, in later years of program expansion, when Pierre Messmer, the Minister of France under Georges Pompidou, proposed to construct 63 new nuclear power plants from 1974 to 1985, the decision to go forward was not even debated in Parliament [25].

The absence of political opposition was supplemented by a number of government initiatives to insulate the nuclear power development program from public scrutiny to avoid destabilizing public support. The state-owned utility EDF wielded its influence to prevent safety breaches from becoming public knowledge [24]. The centralized licensing process fast-tracked all applications for nuclear power plant construction permits [25]. Even the French courts and the judicial system exhibited antipathy toward legal challenges to nuclear development, viewing such challenges as contrary to the national interest [19,26].

2.6. Low levels of civic activism

Typically, nuclear power programs are opposed by certain civic groups over potential threats posed by radiation leaks and inadequate nuclear waste disposal. In France, civic activism in opposition to nuclear power development was diluted by the prevalent esprit de corps of *volantarisme* which was an emergent penchant on the part of the populace to accept short-term pain for long-term gain. Opposition to national development during this period was widely considered unpatriotic [14]. Moreover, environmental activism in France was subdued due to an underlying belief that economic success could repair any damage done to the environment. France's experience of rebuilding from the catastrophic effects of two world wars demonstrated the power of economic well-being in fostering environmental improvement. Finally, there was also an element of "out of sight, out of mind" that existed in regard to nuclear power development because the general public was seldom privy to permitting and licensing discussions [19].

2.7. A renaissance powered by atomic energy

The confluence of these conditions supported the emergence of a nuclear program that would grow to become the second largest in the world, a program that also intensified after the oil shocks of the 1970s. France was also able to utilize its colonial relationship with

Niger to receive uranium to convert into fuel rods for its domestic nuclear reactors. Some have gone so far as to classify the French nuclear program as having three elements similar to the main groups of actors in Greek mythology: the government which has acted as the "gods" with almost complete power, large industries and utilities closely aligned with the gods that act as "titans," and the general public as mere "mortals" that have little to no control over the country's nuclear future [27,28]. Others have posited that France typifies a country where strong political support for nuclear energy has coalesced with a state-owned electricity monopoly replete with significant engineering and financial resources and a highly concentrated manufacturing industry capable of producing advanced nuclear components and materials [29].

These conceptualizations of the French nuclear power, and our own conceptual framework, however, does not imply that nuclear power development in France has lacked drama. In the late 1960s, French industrial interests publically contested the decision to abandon indigenously designed gas-graphite reactor technology in favor of American light water reactor technology. In the 1970s, the Ministry of Finance and EDF squabbled publically over the rate of nuclear expansion. Moreover, in the 1970s and 1980s, periodic outbursts of public protest, some of them violent, took place. These rough patches, nonetheless, never seriously threatened the nuclear program, and in some ways served to enhance government control over the policy process [24,30]. Gaullist attitudes that favor social isolationism and the notion of an independent French path have sheltered the nuclear industry from criticism, and government planners and experts have been able to bar opponents of nuclear power from the political process [25]. A public willingness to defer to technical and scientific cadres and an entrenched propensity in political circles to embrace centralized, hierarchical and non-participatory forms of social control remain strong even to this day [9].

2.8. Implications of the emergent framework

In considering the applicability of our framework, it is worth noting that the inverse also appears to be true; an absence of the six catalysts stunts nuclear power expansion. Nuclear energy is no longer an expansive industry in societies that prioritize pluralism, competition, and openness. Countries that have comparatively open and decentralized political structures characterized by a multiplicity of views and which embrace broad stakeholder involvement in tend to exhibit stagnant nuclear power development [12,31]. In the US, the nuclear energy program was most successful during the early years when development was closely supervised by the military and conducted in secret [32]. The program stalled once dissenting groups forced open access to the policymaking process through hearings, litigation, lobbying for anti-nuclear legislation, books and articles, demonstrations, and election of anti-nuclear politicians [33]. In the Soviet Union, nuclear technology thrived until Chernobyl obliterated the control that party officials, economic planners, and scientists and engineers were able to exert over the media [34]. The British nuclear power program worked best when tightly controlled, nationalized, and run as a monopoly. When political reforms ushered in an era of participative government, support for nuclear power abated [35].

There is also a degree of symbiosis between a particular form of technocratic ideology, nuclear weapons development, and nuclear power. A nation's commitment to nuclear weapon development bolsters the prospects of nuclear power development from three perspectives. First, the existence of a nuclear weapons program engenders the political will necessary to support nuclear technology for other non-military uses. Second, there is a degree of technological spill over from nuclear weapons research which provides a nation with the requisite expertise in nuclear technology to design and implement nuclear power equipment. Third, a nuclear weapons program is frequently shrouded in a veil of secrecy which affords technocrats the time and the freedom to experiment with diffuse applications of nuclear technology and bar the public from contesting nuclear power research.

Although the strength of these conditions (as well as the lack of them) implies a relationship between socio-political economic factors and nuclear power expansion, we accept that a degree of uncertainty remains over whether these six catalysts are relevant across cultures and political systems. To test the external validity of our six catalysts, we review nuclear power program expansion in India and China. In each case study, we endeavor to confirm whether or not the six catalysts were present during the development of the respective nuclear power programs. We also seek to identify any additional catalysts which appear influential in the development of these nuclear power programs. In seeking out additional conditions, our intent is to try and enhance and update our theoretical framework, if possible. For example, we postulate that aspirations to reduce CO_2 emissions (driven by international pressure, a sense of civic duty, or prioritization of environmental values) may represent an emergent catalyst for supporting nuclear power expansion initiatives. For each case study, we also attempt to evaluate whether or not the six conditions have materially changed since the original nuclear power expansion period and speculate on the influence that any evident changes to these six conditions will have on the pace of nuclear power development.

3. The socio-political economy of nuclear energy in India

The Indian government began investigating nuclear energy in 1945, when they formed the Tata Institute of Fundamental Research and appointed a prominent physicist, Homi Bhabha as its director [36]. In 1948, Jawaharlal Nehru, India's first prime minister, made an impassioned speech to the General Assembly of India advocating nuclear energy and an advisory board (the Atomic Energy Commission) was established later that year under the Indian Ministry of Natural Resources and Scientific Research to further study the issue [37]. These early events precipitated the creation of a DAE (Department of Atomic Energy) with full ministerial powers and duties in 1954, and by August 1956, the first research reactor was operational despite the accidental death of Babha [36]. The first commercial nuclear power plant, the Tarapur Atomic Power Station located 100 km north of Mumbai, was completed in 1969.

Since then, the Nuclear Power Corporation of India Limited has commissioned a total of 18 units at six plants totaling 4120 MW of installed capacity (See Table 1). Indian planners are currently constructing six additional nuclear units totaling 3160 MW of capacity and have announced ambitious plans for another 15 units with 14,000 MW of additional capacity by 2020 [38]. The technical objective is to become completely reliant on thorium-powered nuclear reactors by 2050.

3.1. Strong state involvement in guiding economic development

Indian policymakers embraced strong state planning in the 1950s to maximize economic development efficiency [39]. A social convention that the government is best at making economic policy decisions, and a government perception that they are themselves active harbingers of progressive change, enables them to exert significant influence in the economy directly through government action, and indirectly through state-owned enterprises and by shaping public attitudes [40].

Table 1
Existing Indian nuclear power plants.

Name	Location	Date commenced	Date operational	Units	Capacity (MW)	Type	Supplier	Operator
Kaiga Atomic Power Station	Karnataka	1989	2000	3	660	Pressurized heavy water reactor	Nuclear Power Corporation of India Limited	Nuclear Power Corporation of India Limited
Kakrapar Atomic Power Station	Gujarat	1984	1993, 1995	2	440	Pressurized heavy water reactor	Nuclear Power Corporation of India Limited	Nuclear Power Corporation of India Limited
Madras Atomic Power Station	Kalpakkam	1970	1984, 1986	2	440	Pressurized heavy water reactor	Nuclear Power Corporation of India Limited	Nuclear Power Corporation of India Limited
Narora Atomic Power Station	Uttar Pradesh	1974	1991, 1992	2	440	Pressurized heavy water reactor	Nuclear Power Corporation of India Limited	Nuclear Power Corporation of India Limited
Rajasthan Atomic Power Station	Rawatbhata	1963	1973, 1981, 2000	5	740	Pressurized heavy water reactor	Atomic Energy of Canada Limited (Canada)	Nuclear Power Corporation of India Limited
Tarapur Atomic Power Station	Maharastra	1962	1969, 2005, 2006	4	1400	Boiling water reactor and pressurized heavy water reactors	Bechtel (United States), General Electric (United States)	Nuclear Power Corporation of India Limited

The Indian nuclear program was no different, and it was orchestrated exclusively by the government and displayed a rigid adherence to centralized planning. The strong hand of central government planners was inadvertently fortified due to lack of international support for nuclear program development. The close connection between India's military nuclear weapons program and the commercial atomic energy program made many international partners nervous. Canada, France, Russia, the United Kingdom and United States withdraw all support in 1974 after India's first nuclear weapons test, forcing Indian scientists to go it alone [41]. The Former Secretary of India's Atomic Energy Commission recently stated that this made the Indian experience special, as scientists had to pursue nuclear design options while under embargo and outside of the Nuclear Nonproliferation Treaty [35].

3.2. Centralization of national energy planning

From inception, the Indian nuclear program was highly centralized. The DAE reported directly to the Prime Minister. Unlike similar organizations in the United States and United Kingdom, the DAE was mandated responsibility over managing the entire nuclear fuel cycle, from mining uranium to produce electricity. All research activities were carried out by one government organization, the Bhabha Atomic Research Center, headed by the physicist Homi K. Bhabha [35]. The DAE gave Bhabha complete control in an "exceptional departure from normal practice" and permitted him to establish operations away from Delhi in Mumbai presumably to insulate the program from political interference [42]. Research on nuclear power in India began as a military partnership and reactor work heavily centered on using plutonium to enrich fuel [36]. The DAE delegated responsibility to the Nuclear Power Corporation of India Limited for designing, constructing, and operating Indian nuclear power plants, and tasked the Uranium Corporation of India Limited with mining and milling of domestic uranium [36].

The Atomic Energy Act of 1962 further consolidated control by enabling the Indian government to restrict the distribution of any information relating to the theory, design, construction, and operation of nuclear reactors or other nuclear energy components. Secrecy was justified on the grounds that proprietary knowledge had to be protected from exploitation by industrialized countries and to avoid sensitive nuclear technology from falling into the wrong hands (i.e. Pakistan) [32].

3.3. Campaigns to link technological progress with national revitalization

The fledgling nuclear energy program was seamlessly connected to a vision of a prosperous and technologically advanced Indian society. Upon attaining independence, the Indian economy was dominated by the agrarian sector and the industrial sector was in a primitive state. From the outset, planners conceived of the national nuclear program as key to confirming the country's place in the modern era and intersected with the widely held belief that energy abundance underpinned social progress [43]. Nehru argued in 1948 that India had failed to capitalize on the first Industrial Revolution due to lack of technical skill, and believed that success in the ongoing second Industrial Revolution was predicated on engineering prowess, typified by nuclear power [39]. Later in the 1970s, Prime Minister Indira Gandhi reiterated Nehru's position that nuclear power was as an essential technology for rescuing developing economies such as India's from "poverty and ignorance." She was convinced that a bold display of scientific and technological might could impress the populace enough to win her reelection [39,42].

3.4. Influence of technocratic ideology on policy decisions

Because advanced technology was so closely linked to national progress and central planning, Indian government planners and scientists displayed unwavering faith that research advances will inevitably overcome the possible shortcomings of best-available nuclear technology. Contrary to original programs in Canada, France, the former Soviet Union, and the United States, which all based their initial designs on proven gas-graphite technology or light water reactors, the Indian program embraced research on high-tech fast breeder reactors and thorium reactors. The government pursues a three-stage development strategy that has not changed for the past three decades. The first stage involves the use of uranium fuel in heavy water reactors, followed by reprocessing of spent fuel to extract plutonium. When enough plutonium created, the second stage will begin by using plutonium in heavy water reactors or in fast breeder reactors. The third stage aims to bring thorium reactors online, designed to utilize India's large cache of thorium resources. The government has continued to push such advanced technology research despite the high financial commitment required and the commercial limitations [36]. Roughly one-quarter of all Indian R&D spending was directed toward nuclear research from the 1950s to the 1980s [32].

3.5. Subordination of challenges to political authority

The structure of government in India is such that in times of a governing party majority, the PM and his/her chosen Cabinet have a virtual lock on policymaking authority. Even governing party backbenchers who disagree with Cabinet policy avoid levying public criticism to avoid being politically marginalized by

senior party members. In the pioneering era of the nuclear power program, the dominant political party, Bharatiya Janata Party, strongly advocated both nuclear power and nuclear weapons and managed to quash political opposition due to high levels of public support for the type of progress that the nuclear program epitomized [44]. Furthermore, advocacy for the program exhibited by popular party leaders such as Jawaharlal Nehru, Lal Bahadur Shastri, and Indira Gandhi all but guaranteed a degree of political cohesiveness in supporting nuclear power development [32]. For those in dissent, the veil of secrecy behind which the program was shrouded further served to further subordinate opposition.

The nuclear power program was part of a strategic ethos characterized by secrecy and military control [41]. Linkages between nuclear power research, military weapon development and space program research permitted nuclear power research to be conducted behind closed doors. The nuclear power program was initially coupled with the Indian space and missile program, with the National Committee for Space Research endorsing the idea of using atomic power to propel spacecraft [32]. Senior government officials decided to formalize their support of nuclear power in 1948, when India passed its Atomic Energy Act, modeled after the British Atomic Energy Act of 1946 but conveying far more power to the Indian DAE. The Act legally allowed research to be conducted entirely in secret and granted the government power of control overall material relevant to atomic energy, particularly uranium and thorium [45].

3.6. Low levels of civic activism

During the inception of India's nuclear power program, the existence of more pressing problems, socio-cultural barriers to resistance and a widespread desire to escape from the poverty trap dampened civic activism toward nuclear power development. Infrastructure for providing access to safe drinking water, proper sanitation, proper health care, adequate education and a host of other daily services were lacking and remained at the forefront of political efforts for change. In contrast, public opinion polls conducted throughout the developmental phase demonstrated that nuclear power was not a significant variable in determining elections [32]. Aside from a focus on more pressing matters, there were many socio-cultural reasons for apathy toward nuclear power development including widespread illiteracy, social norms which discourage criticism of those in power (a caste mentality), and a comparatively high level of risk-aversion due to religious tenets such as reincarnation. Overall, nuclear power development implied expanded access to electricity and this was viewed as a desirable outcome that could help liberate impoverished communities. This convinced many Indians that nuclear energy was an acceptable risk for the good of the people [32]. In summation, in the absence of both political and civic opposition, the nuclear power "debate" in India was relegated to technical discussions among scientists at international conferences and symposia [36].

Taken together, all six of the catalysts to nuclear power expansion were evident during the nascent stages of India's nuclear power program. Nuclear power development was driven by a tightly controlled government-led network, incorporating a select number of elite scientists and institutions that were line managed by DAE officials. The major organs of the nuclear program were able to operate in secret amidst limited opposition from political parties and high levels of public apathy. Government technocratic propaganda linking nuclear power to nation-building and poverty alleviation further entrenched support for nuclear power development among Indian decision makers [46].

3.7. Prospects for the future

Looking forward, it appears that nuclear power is likely to retain a preeminent position as a preferential source of electricity supply in India. Although Indian civil society has experienced change since the start of the nuclear program, with new social groups and movements gaining political power and influence, these have been primarily organized around issues relating to human rights, agricultural reform, poverty alleviation, and environmental governance. Nuclear power has largely flown under the political radar. Overall, civic protest has had little influence in deterring the overall trend towards economic industrialization and the marginalization of disenfranchised communities [47]. For example, some members of the communist party in India protested the recent U.S.-India nuclear deal on the grounds that the government was too "obsessed" with nuclear energy and not focused on more important concerns. Hundreds of university students organized a hunger strike to oppose the deal, and rural villagers have protested the siting of new nuclear plants for displacing their homes and farms [48]. However, ultimately most Indians and especially government planners positively viewed the agreement as potentially enabling India to achieve the access to commercial vendors of nuclear technology needed to assure a domestic nuclear renaissance [49]. Civil society and activism in India is active and prominent in many realms, but success in challenging nuclear power has been negligible due to legitimacy afforded to the nuclear industry by the state and ongoing secrecy of the program. So far, the scant number of anti-nuclear activists has been unable to cultivate the kind of technologically-credible opposition that has backed successful movements in Europe and North America.

The nuclear power program continues to be a closed affair, segregated from scrutiny by ordinary citizens, politicians, industry and academics. The DAE remains an impenetrable entity and adverse information on costs, leaks, technical failures and so forth continue to remain highly inaccessible [37]. The passage of the Right to Information Act in 2005 does not apply to the nuclear industry. Environmental activism and civic awareness remain comparatively low in India, and environmental laws remain poorly enforced, ignoring nuclear power issues altogether [50].

Economic development continues to be largely government directed despite the ongoing proliferation of private companies amidst the "deregulation" and "liberalization" of the economy [51]. National energy planning remains the domain of central government ministries and state government electricity boards. The association between nuclear energy and visions of progress and national revitalization persists, supplemented by notions of pride and prestige, "Hindu nationalism" and the connection between nuclear technology and the protection and self-defense of India [52,53]. Moreover, there are indications that the challenge of abating greenhouse gas emissions has emerged as a new catalyst to justify the further development of nuclear power as an important electricity source in a carbon-constrained world. Given the confluence of these factors, it seems likely that India's target of adding 20,000 MW of nuclear power by 2020 will not be derailed.

4. The socio-political economy of China

The prospect of developing nuclear power was broached in the China's first Five-Year Plan in 1953, which emphasized the need for a centralized nuclear development program managed by the government and state enterprises [54]. With aid from the Soviet Union, China constructed research reactors near Beijing and Lanzhou in 1956. It then proceeded with construction of a gaseous diffusion enrichment plant at Lanzhou, erected a uranium mine near Urumchi, and began indigenous research on light water reactors in 1964 [36].

China's commercial nuclear program formally began in 1972, when the central government approved the first nuclear program, known as the "728 project", to develop submarine reactors.

In 1985, the CNNC (China National Nuclear Corporation) began construction of the first Chinese designed nuclear power plant in Qinshan. Power shortages in the south of China near Shenzhen promoted another cooperative project between the Ministry of Nuclear Industry, Guangdong Joint Venture Nuclear Power Company, and Hong Kong's China Power and Light Corporation for a facility at Daya Bay. The first nuclear power plant became operational in 1991; and since then, Chinese planners have completed 11 units in six locations, totaling about 9000 MW installed capacity (See Table 2) [55].

China is now managing four nuclear power construction projects at a time, has committed billions of dollars to future expansion, and has signed contracts with multinational corporations for more than US$50 billion worth of investment in the nuclear power sector [52]. In 2007, the national government released a national nuclear development plan calling for 40,000 MW of nuclear power capacity by 2020 and announced US$66 billion in government subsidies [56]. In March 2008, the NEB (National Energy Bureau) announced a revised 2020 target of 50,000 MW of nuclear power capacity and in June 2008, the target was again revised upward to 60,000 MW [12]. In April 2009, reports emerged that the State Council was once again considering an upward revision of the 2020 target to 70,000 MW to reflect the current pace of development, and 18,000 MW of new nuclear power capacity was reportedly under construction [53,57]. The target announced by the NEB for 2030 is a whopping 160,000 MW, which would easily establish China as the world's largest producer of nuclear power [58].

4.1. Strong state involvement in guiding economic development

The essence of a communist state lies in state management of public assets. In China, the power rests with the State Council which is comprised of the premier, vice-premier, State counselors, ministers, the auditor general and the secretary-general. The premier of the State Council is appointed by China's President while all other members of the State Council are nominated by the Premiere and appointed by the President. The State Council is tasked with the responsibility of supporting the principles and implementing the policies of the Communist Party and has ultimate control over governance related to internal politics, national defense, economic development, education, cultural developments and fiscal management [59].

4.2. Centralization of national energy planning

Overall responsibility for energy planning is split between two agencies. Much of the power rests with the NDRC (National Development and Reform Commission), which is the body within the State Council that guides all national development planning and approves large construction projects across the country including dams, power stations, highways, and airports. The National Energy Administration, as the arm of the NDRC that is responsible for formulating and implementing energy development plans, continues its historical remit of managing energy development in China. It finances and directs R&D projects, plans and implements the construction of new power plants, directs energy conservation programs and controls all investment in energy projects. Of the world's major economies, state involvement in guiding energy development in China has been and still is an exemplar of autocratic control. The second key agency is the CAEA (China Atomic Energy Authority), which is responsible for planning, reviewing, and approving nuclear power plant projects, spent fuel storage, and construction and operating permits. The CAEA receives safety reports, impact assessments, and suggestions from the National Nuclear Safety Administration and the State Environmental Protection Agency and then submits comments and recommendations to the NDRC for final approval [60].

China's nuclear power development strategy in the 1980s sought to harness benefits from both self-reliance and foreign partnership [52]. China's first foray into nuclear power plant development was an indigenous project designed by the Shanghai Nuclear Engineering Research & Design Institute utilizing Generation II technology [54]. This project dubbed "Qinshan 1" began construction in March 1985. When it came time to commission a second nuclear power plant, the NDRC decided to adopt the same strategy it had employed in the auto industry in the 1970s & 1980s and chose to seek out alliances with foreign firms in order to gain experience [52]. China's second nuclear power plant commenced construction in Daya Bay in August 1987 through an alliance with French nuclear power plant developer, Framatome. Since then, imported technology has been extensively used in the construction of reactors although some critics have argued that cobbling together a diversity of imported technologies has impaired technological transfer and adversely influenced domestic production [54]. Regarding management of nuclear facilities, responsibility rests with a state-owned enterprise, the CNNC [52]. However, the NDRC retains ultimate operational control in that the President of CNNC is appointed by the State Council.

Throughout the initial developmental stage, one of the NDRC's key objectives had been to build requisite knowledge and capacity in all stages of the fuel cycle (uranium extraction and refining, fuel processing, plant construction, operation, and decommissioning) so that the Chinese could become self-sufficient by the end of the 1990s. Although foreign inputs have been sought at various stages, the NDRC's predominant role in nurturing such self-sufficiency has been pervasive [52].

Table 2
Existing Chinese nuclear power plants.

Name	Location	Date commenced	Date operational	Units	Capacity (MW)	Type	Supplier	Operator
Daya Bay	Guangdong	1987	1993, 1994	2	1968	Pressurized water reactor	Framatome (France)	China Guangdong Nuclear Power Corporation
Ling'ao	Guangdong	1997	2002	2	1980	Pressurized water reactor	Framatome (France)	China Guangdong Nuclear Power Corporation
Tianwan	Jiangsu	1999	2007	2	2000	Pressurized water reactor	Russia	China National Nuclear Corporation
Qinshan 1	Zhejiang	1985	1991	1	300	Pressurized water reactor	China National Nuclear Corporation	China National Nuclear Corporation
Qinshan 2	Zhejiang	1996	2002, 2004	2	1200	Pressurized water reactor	China National Nuclear Corporation	China National Nuclear Corporation
Qinshan 3	Zhejiang	1998	2003	2	1456	Pressurized heavy water Reactor	CANDU (Canada)	China National Nuclear Corporation

4.3. Campaigns to link technological progress with national revitalization

Throughout the 1970s and 1980s, China experienced average annual electricity supply deficits exceeding 70 billion kWh. The government had to replace more than 100,000 boilers at conventional power plants between 1972 and 1978, and rolling blackouts hit every major province within China at least twice a year for much of the two decades. China also suffered from serious blackouts and shortages of oil, coal, and electricity in 2003, 2004, and 2008, triggering further embracement of nuclear power among many elites. Moreover, Taiwan had embarked on its own nuclear program [61]. Nuclear power was seen as instrumental in overcoming the energy supply deficits, improving Chinese economic competitiveness, and "catching up" with Taiwan and other industrialized countries. Chinese officials initially toyed with the idea of exporting both nuclear technology and electricity to the rest of Asia and even built one facility, the Yibin Fuel Component Factory in Sichuan, to manufacture prefabricated components of nuclear power plants for export. They sold one set of components to Pakistan in 1989 and planned to earn billions of dollars of foreign exchange exporting similar packages to Africa and the rest of the developing world [57].

4.4. Influence of technocratic ideology on policy decisions

The death of Mao Zedong in 1976 marked the end of the Cultural Revolution that had greatly damaged the Chinese economy. Mao's passing also ushered in a change in leadership that was fathered by Deng Xiaoping. Deng's cohort embarked on a program of economic revitalization based on the principles of market liberalization and industrialization. Major initiatives during these early stages included de-collectivization of agriculture, liberalization of private businesses, privatization of state-owned companies, and the creation of special economic zones to attract foreign investment [62]. Although the reform process was as much about structural reform as technological reform, the pragmatic approach that the Deng regime adopted inevitably gave rise to an increasing awareness that technological progress represented the best prospect for revitalizing the Chinese economy. Deng summarized the reform process as akin to "crossing a river by feeling the stones". Over time, the process of "feeling the stones" led Chinese leadership which was dominated by engineering school graduates to foster a high degree of confidence that technological development was the way to move China into the upper echelon of global economies. Jiang Zemin, Hu Jintao, Wen Jiabao and Zhu Rongji were all graduates of engineering schools.

4.5. Subordination of challenges to political authority

Beginning in the 1970s, devolution of power to provincial and local communist party authorities occurred in many areas in response to demands by local politicians and interest groups for more control over economic and environmental governance. However, the nuclear power sector remained centrally insolated. The central government's Eighth "Five-Year Plan" explicitly called for nuclear energy despite opposition from more than 100 Chinese scientists and provincial officials. Government officials displaying an "independent attitude" towards official government policies found themselves quickly demoted or transferred to undesirable posts, creating a strong incentive to tow the party line [63].

4.6. Low levels of civic activism

Although Chinese history is rife with prominent examples of civic activism, opposition groups have been unable to stop nuclear power development. When a small group tried to protest construction of the Daya Bay plant, officials detained and arrested them. When more than one million people in Beijing signed a petition against nuclear power, Chiang Hsin-Hsiung, the Minister of Nuclear Industry, rebuffed the complainants by issuing a statement that the government "the unscientific objections from some people would not halt the Daya Bay project" [57]. When United Kingdom authorities and the Hong Kong Civic Association released a series of reports questioning the safety of Daya Bay, the government responded that "reports compiled by other countries do not constitute legal documents" and thus held no sway over the siting process [57]. With no success to show for their efforts and no nuclear power mishaps around which to rally support, opposition to nuclear power has waned since the late 1980s.

In summary, during the inception of China's nuclear power program, all six of the catalysts identified in the France case study as being conducive to nuclear expansion were in clear evidence.

4.7. Prospects for the future

Many of the historical catalysts supporting Chinese nuclear power expansion seem to have diminished, however. Strong centralized government control which was evident during the inception of China's nuclear energy program has given way to a system of centralized policymaking and decentralized program implementation. Regional government authorities have gained more sway over economic and social development within their municipalities and this has made it easier for civic groups to protest nuclear power plant siting decisions. Traditionally, the strongest support for nuclear power plants came from a small, wealthy minority who did not live close to the power plants; the most vocal opposition came from grassroots organizations [64]. These organizations now have access to regional political power. Although Shanghai Boiler Works became the first manufacturer in China to obtain nuclear accreditation from the American Society of Mechanical Engineers in 2006, it also remains unclear whether the country has the scientific and technological capacity to fuel a domestically driven nuclear resurgence.

Structurally, energy industry reforms over the past decade have shifted power, requisite knowledge and resources away from central government planners to state-owned energy companies [52]. Furthermore, energy market liberalization has complicated government control over the nuclear power industry. The CNNC is no longer the sole government player, and must compete with the newly formed State Nuclear Technology Corporation (charged with helping coordinate investment) [52]. Disagreements have emerged over approaches to nuclear energy promotion and technology development strategies. These disagreements have been accentuated by a proliferation of players participating vociferously in policy discussions including newly corporatized large energy companies, universities, think tanks, and the media. The nuclear power policy network is now said to include over 300 different enterprises [52]. With local governments and foreign investors gaining more control over the Chinese nuclear power program, some investors even see a trend towards a US-style "competitive market model" [54].

Although there is still a technocratic influence on policymaking and technology is still revered for facilitating China's economic resurgence, pragmatic economic concerns are tempering support for nuclear power expansion. China's abundance of cheap coal encourages use of fossil fuels over the more expensive fission to produce electricity. Moreover, political concerns over becoming too dependent on uranium imports are emerging among senior officials [53].

In the civic realm, nuclear power is emerging as an issue of social concern. Sensitivities over nuclear waste management have

Table 3
Historical and current socio-political economic catalysts for nuclear power.

	France	India		China	
	Historically	Historically	Currently	Historically	Currently
Strong state involvement in guiding economic development	Strong	Strong	Strong	Strong	Weaker
Centralization of national energy planning	Strong	Strong	Strong	Strong	Weaker
Campaigns to link technological progress to a national revitalization	Strong	Strong	Slightly weaker	Strong	Strong
Influence of technocratic ideology on policy decisions	Strong	Strong	Strong	Strong	Strong
Subordination of challenges to political authority	Strong	Strong	Slightly weaker	Strong	Slightly weaker
Low levels of civic activism	Strong	Strong	Slightly weaker	Strong	Weaker

prompted some local groups and communities to oppose nuclear projects. A strong NIMBY (not-in-my-back-yard) element has emerged wherein local protest groups and adverse public opinion have challenged the legitimacy of proposed projects, especially in rural areas [60]. Although not directed at nuclear power specifically, the number of officially recorded protests throughout China has risen from 10,000 in 1994 to 74,000 in 2004 and 97,000 in 2005 [65]. Conversely, concerns over the pollution caused by coal-fired power plants and the contribution that fossil fuel combustion makes to global warming have spawned nuclear power advocacy groups. Subsequently, pronounced disagreements often percolate to the surface as pro-nuclear advocates clash with pro-coal advocates [52,53].

The implication is that the fate of the industry remains uncertain, and that if the nuclear power program is to expand as planned, one can expect to see either a reversion to central control and a clamp down on public protest (as was the case during the construction of the Three Gorges Dam) or more strategic citing of new nuclear plants in regions with lower levels of public opposition.

5. Conclusion

The history of nuclear energy in France suggests that countries promoting nuclear energy tend to have closed political systems that minimize opposition, debate, and discussion and foster low transparency and accountability. They have economies with a history of central planning and government intervention. They have a strong social commitment to technological progress and modernization, but a weaker commitment to pluralism, civic policy participation, and environmental protection. In the case studies of India and China, we found evidence that both countries exhibited characteristics attributed to the six catalysts derived from the France study, albeit through socio-political mechanisms that differed in form but not in substance. With this in mind, we advance three preliminary conclusions. First, our theory highlights that the catalysts for nuclear power expansion are simultaneously social, political, and economic. While some catalysts may distinctly *appear* political (such as strong governmental control), social (low level of public activism), and economic (linking technology to an economic renaissance), the catalysts tend to be influenced by all three domains. For example, aspirations to embrace nuclear energy expansion as a way of modernization conflate *political* aspirations such as enhancing domestic energy security while abating greenhouse gas emissions, *economic* aspirations such as the generation of energy from fuels sources that exhibit lower price volatility than fossil fuel, and *social* aspirations such as moving toward a carbon-free economy without sacrificing economic prospects. While we believe all three dimensions (social, political, economic) are important, the political realm commands a certain degree of primacy because once a political regime has ascended to power, it has the capacity to significantly influence the other two dimensions, before suffering repercussions. Thus, the three dimensions can be conceptualized as a sushi roll with the seaweed (nori) as the political dimension holding the roll together, the rice being the social element that binds the contents and the economic dimension being represented by the aquatic delicacy.

Put another way, although the forces within the sushi roll are constantly in flux, some catalysts appear more influential in encouraging nuclear power program expansion. For example, a dictatorship that decides to embrace nuclear power program expansion will likely be able to overpower all other factors that may in other nations constrain nuclear power expansion (i.e. civic concern over the safety of nuclear power). Similarly, India is able to diminish opposition by maintaining central government control by managing its nuclear program in secret and central Chinese authorizes are able to obviate civic opposition through harsh response. This implies that further research is needed in regard to the interplay of the six catalysts in order to understand how the catalysts inter-relate. Another important element of research left unaddressed in this study pertains to the extent to which political authorities can alter the influence of the six catalysts in terms of supporting or discouraging further development of nuclear energy.

Second, although many of the catalysts in the table manifest themselves differently across countries, the substance of the strategies employed is similar. For example, France employed military research to shield program development from public scrutiny while India (which was secretly developing and testing nuclear weapons) shielded their nuclear power program by making it illegal to disclose information to the public about it. Our analysis of past and present conditions demonstrates that the conditions favoring (or constraining) nuclear energy are not static and evolve in terms of influence and importance (See Table 3). This implies that at any given period of time, economic and social dimensions establish boundaries within which political actors can make decisions. Policies which fall outside of these limits face resistance. Conversely, once decisions are made, the impacts of these decisions exert a feedback influence on the evolution of the socio-economic dimensions. In this manner, the three dimensions are mutually constitutive.

Third, although we were able to confirm that the six catalysts identified in the France study as conducive to nuclear power program expansion were present during the inception of the nuclear power programs in India and China, there were indications from our analysis that they may not represent a comprehensive accounting of influential factors. One emergent influence that is increasingly mentioned in studies related to energy policies in India and China relates to the appeal of nuclear power in supporting climate change abatement efforts. Although both India and China have publically announced intentions to place economic growth ahead of CO2 emission abatement efforts [66], official documents from both countries have identified CO2 emission abatement as an important justification for continued nuclear program expansion [67,68]. We opted to exclude this new influence as a seventh catalyst because more research needs to be conducted to confirm its influence at the *inception* of a nuclear power program. We

speculate that further research in countries that are about to adopt nuclear power programs will confirm "linking nuclear power to CO2 emission abatement" as a seventh catalyst.

If one accepts our theory and its conclusions, then the emergence of a global nuclear renaissance is highly dependent on social, political, and economic conditions. Countries that meet many but not all of the conditions may still embrace nuclear energy, and each country will have its own unique context in which our theory manifests itself. The development of nuclear power programs is not merely about transferring technology but sculpting societies that have the requisite norms and values, political systems, and economies to simultaneously favor centralized planning, technocratic development strategies, and subordination of political and social opposition. Building, fuelling, operating, and decommissioning a nuclear reactor is complicated enough. Building societies to meet these conditions in an increasingly well-informed, electronically connected world adds a new dimension of complexity.

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List of acronyms

CAEA	China Atomic Energy Authority (China)
CEA	Commissariat à l'Énergie Atomique (France)
CNNC	China National Nuclear Corporation (China)
DAE	Department of Atomic Energy (India)
EDF	Électricité de France (France)
NDRC	National Development and Reform Commission (China)
NEB	National Energy Bureau (China)

References

[1] U.S. Energy Information Administration. International total primary energy consumption and energy intensity. Washington, DC: U.S. Department of Energy. See also, http://www.eia.doe.gov/emeu/international/contents.html; May, 2009.
[2] World Nuclear Association. World nuclear power reactors 2007–09 and uranium requirements. London, UK: World Nuclear Association. See also, http://www.world-nuclear.org/info/reactors.html; May 1, 2009.
[3] Schneider M. World nuclear industry status report: global nuclear power. Bulletin of Atomic Scientists. September 16, 2008. Available at: http://www.thebulletin.org/web-edition/reports/2008-world-nuclear-industry-status-report/ [accessed on 11.15.2009].
[4] Sovacool BK, Cooper C. Nuclear nonsense: why nuclear power is no answer to climate change and the world's post-Kyoto energy challenges. William & Mary Environmental Law & Policy Review 2008;33(1):1–119. Fall.
[5] The Associated Press. Jordan's King Abdullah II wants his own nuclear program; January 19, 2007. p. 5.
[6] New Scientist. Russia to build nuclear reactor in Myanmar; May 15, 2007.
[7] Meldrum A. Mugabe hails uranium find and vows to pursue nuclear power. The Guardian; 2005 November 21.
[8] Marignac Y, Dessus B, Gassin H, Laponche B. Nuclear power: the great illusion. Paris: Global Chance; October, 2008.
[9] Rochlin GI. Broken plowshare: system failure and the nuclear power industry. In: Summerton J, editor. Changing large technical systems. San Francisco: Westview Press; 1994. p. 231–61.
[10] Hodgson Peter E. Nuclear power, energy, and the environment. London: Imperial College Press; 1999.
[11] Jasper James M. Nuclear politics: energy and the State in the United States, Sweden, and France. Princeton University Press; 1990.
[12] Hevly Bruce William, Findlay John M, editors. The atomic West. University of Washington Press,; 1998.
[13] Beinhocker E. Robust adaptive strategies. Sloan Management Review 1999;4(3):95–106.
[14] Price R. A concise history of France. Cambridge, UK: Cambridge University Press; 2005.
[15] Jones C, Ladurie ELR. The Cambridge illustrated history of France. Cambridge, UK: Cambridge University Press; 1999.
[16] Rudig W. Outcomes of nuclear technology policy: do varying political styles make a difference? Journal of Public Policy 1988;7(4):389–430.
[17] Hecht Gabrielle. The Radiance of France: nuclear power and national identity after world war II. MIT Press; 1998.
[18] Scheinman L. Atomic energy policy in France under the fourth republic. Princeton: Princeton University Press; 1965.
[19] Barkenbus JN. Nuclear power and government structure: the divergent paths of the United States and France. Social Science Quarterly 1984;65:37–47.
[20] Barthe Y. Le pouvoir d'indécision: La mise en politique des déchets nucléaires. Paris: Economica; 2006. pp. 47–48.
[21] Dryzek JS, Honig B, et al., editors. The Oxford handbook of political theory. Oxford, UK: Oxford University Press; 2008.
[22] Kaku M, Trainer J, editors. Nuclear power: both sides. New York, USA: W.W. Norton & Co; 1982.
[23] Carter N. The politics of the environment: Ideas, activism and policy. Cambridge, UK: Cambridge University Press; 2004.
[24] Hadjilambrinos C. Understanding technology choice in electricity industries: a comparative study of France and Denmark. Energy Policy 2000;2000(28):1111–26.
[25] Hatch MT. Nuclear power and post-industrial politics in the west. In: Byrne J, Hoffman SM, editors. Governing the atom: the politics of risk. London, UK: Transaction Publishers; 1996. p. 201–46.
[26] Baumgartner Frank R. Independent and politicized policy communities: education and nuclear energy in France and in the United States. Governance January 1989;2(1).
[27] Grubler Arnulf. An assessment of the costs of the French nuclear PWR program, 1970–2000. Vienna: International Institute for Applied Systems Analysis; October 2009. IR-09-376.
[28] Jasper JM. Gods, titans and mortals: patterns of State involvement in nuclear development. Energy Policy 1992;20(7):653–9.
[29] Finon D, Staropoli C. Institutional and technological co-evolution in the French electronuclear industry. Industry & Innovation 2001;8(2):179–99.
[30] Nelkin D, Pollak M. Political parties and the nuclear energy debate in France and Germany. Comparative Politics 1980;12(2):127–41.
[31] Feldman David Lewis. Public choice theory applied to national energy policy: the case of France. Journal of Public Policy 1986;6(2):137–58.
[32] Jasper JM. Nuclear policy as projection: how policy choices can create their own justification. In: Byrne J, Hoffman SM, editors. Governing the atom: the politics of risk. London, UK: Transaction Publishers; 1996. p. 47–66.
[33] Cook E. The role of history in the acceptance of nuclear power. Social Science Quarterly 1982;63:3–15.
[34] Josephson PR. Projects of the century in Soviet history: large-scale technology from Lenin to Gorbachev. Technology and Culture 1995;36(3):519–59.
[35] Winskel M. Autonomy's end: nuclear power at the privatization of the British electricity supply industry. Social Studies of Science 2002;32(3):439–67.
[36] Hart D. Nuclear power in India: a comparative analysis. London, UK: George Allen & Unwin; 1983.
[37] Mathai MV. Elements of an alternative to nuclear power as a response to the energy-environment crisis in India. Bulletin of Science, Technology, & Society 2009;29(2):139–50.
[38] Rajagopal S. India's nuclear power program: Challenges and opportunities. Paper Presented to the Emerging Challenges to Energy Security in the Asia Pacific International Seminar. Chennai, India: Center for Security Analysis, March 16 and 17; 2009.
[39] Indian State Planning Commission. Tenth plan five year plan 2002–2007. Available from, http://www.tn.gov.in/spc/tenthplan/.
[40] Gadgil A. Development, environment, and energy efficiency. In: Socolow R, Andrews C, Berkhout F, Thomas V, editors. Industrial ecology and global change. Cambridge UK: Cambridge University Press; 1994. p. 461.
[41] Tomar R. The Indian nuclear power program: myths and mirages. Asian Survey 1980;20(5):517–31.
[42] Banerjee B, Sarma N. Nuclear power in India: a critical history. New Delhi, India: Rupa & Company; 2008. p. 4.
[43] Byrne J, Hoffman SM. The ideology of progress and the globalisation of nuclear power. In: Byrne J, Hoffman SM, editors. Governing the atom: the politics of risk. London, UK: Transaction Publishers; 1996. p. 11–46.
[44] Basrur RM. Nuclear weapons and Indian strategic culture. Journal of Peace Research 2001;38(2):181–98.
[45] Rethinaraj TSG. In the comfort of secrecy. Bulletin of Atomic Scientists; 1999 November/December:52–7.
[46] Krishna VV. Dynamics in the sectoral system of innovation: Indian experience in software, biotechnology, and pharmaceuticals. In: Turpin T, Krishna VV, editors. Science, technology policy and the diffusion of knowledge: understanding the dynamics of innovation systems in the Asia Pacific. Cheltenham, UK: Edward Elgar; 2007. p. 193–233.

[47] Williams G, Mawdsley E. Postcolonial environmental justice: government and governance in India. Geoform 2006;37:660–70.
[48] The Hindu Times. India left launch nuclear protest; July 22, 2006.
[49] Rethinaraj TSG. US-India nuclear deal: regional security implications for Asia. Jane's Intelligence Review; 2007 January:58–61.
[50] Guha R. How much should a person consume? Environmentalism in India and the United States. Los Angeles, USA: University of California Press; 2006.
[51] Kohlim A. State, business, and economic growth in India. Studies in Comparative International Development 2007;42:87–114.
[52] Das R. Encountering Hindutva, interrogating religious nationalism and (en) gendering a Hindu patriarchy in India's nuclear policies. International Feminist Journal of Politics 2006;8(3):370–93.
[53] Mawdsey E. Hindu nationalism, neo-traditionalism and environmental discourses in India. Geoform 2006;37:380–90.
[54] Cudahy RD. Asian amperes: chinese electric power. Energy Law Journal 2008;29:33–48.
[55] Xu YC. Nuclear energy in China: contested regimes. Energy 2008;33:1197–205.
[56] Wang Q. China needing a cautious approach to nuclear power strategy. Energy Policy 2009;37:2487–91.
[57] Zhou S, Zhang X. Nuclear energy development in China: a study of opportunities and challenges. Energy 2010. in press: doi:10.1016/j.energy.2009.04.020.
[58] Ma L, Li Z, Fu F, Zhang X, Ni W. Alternative energy development strategies for China towards 2030. Frontiers of Energy and Power Engineering in China 2009;3(1):2–10.
[59] State Council of the Republic of China website, http://english.gov.cn/links/statecouncil.htm [accessed 21.06.09].
[60] International Atomic Energy Agency. People's Republic of China. country profiles. Vienna, Austria: International Atomic Energy Agency; 2002. pp. 214–235.
[61] Gallagher M. Nuclear power and mainland China's energy future. Issues and Studies 1990;26(12):100–20.
[62] Evans R. Deng Xiaoping and the making of modern China. London, UK: Penguin Books; 1995.
[63] Schwartz J. Environmental NGOs in china: roles and limits. Pacific Affairs 2004;77(1):28–49.
[64] Fang X. Risks or Benefits? The social construction of the risks of inland nuclear power stations in China. presentation to the Society for the Social Studies of Science & European Association for the Study of Science and Technology annual conference, Rotterdam, The Netherlands; August 20–23, 2008.
[65] Zackey J. Peasant perspectives on deforestation in Southwest China. Mountain Research and Development 2007;27(2):160.
[66] Institute for Global Environmental Studies. Asian perspectives on climate change regime beyond 2012: concerns, interests and priorities. Tokyo, Japan: Institute for Global Environmental Studies; 2005.
[67] NDRC. China's national climate change programme. People's Republic of China: National Development and Reform Commission; 2007.
[68] India. National action plan on climate change: Prime Minister's council on climate change. Government of India; 2008.