East Asian Science, Technology and Society: An International Journal (2018) 12:277–308
DOI 10.1215/18752160-4386762

The Making of Power Shortage: The Sociotechnical Imaginary of Nationalist High Modernism and Its Pragmatic Rationality in Electricity Planning in Taiwan

Chih-Yuan Yang, Bronislaw Szerszynski, and Brian Wynne

Received: 6 April 2017 / Accepted: 24 November 2017

Abstract High modernism, the dominant sociotechnical imagination in postwar Taiwan, manifested in tacit answers to the questions of what a better society would look like and the most pragmatic and viable approach to make the particular dreamed-of future become reality. This article explores the exclusion of alternative energy futures brought about by a high modernist imaginary. This imaginary underlies a strategy of emphasizing shortage at present and prosperity in the future—as long as the current shortage is solved in a reliable way. Focusing on the contention over energy supply between 2011 and 2015, this article provides an analysis of how power shortages are presented in discursive ambiguity, how the claimed crisis over the electricity shortage moves to the center of public debate via the institutional practices of power rationing, and how its public authority is established through collective witness. Renewable energy is continually represented as an "immature" and "unviable" technology when it comes to satisfying the nation's need, through particular routinized practices in the calculation of "reserve margins" in electricity planning and the collective witnessing of (limited) operating reserves. We argue that both of these come with their own assumptions and political implications and therefore invite scrutiny.

Acknowledgments We are grateful to Gordon Walker and the journal's reviewers and editors for their helpful suggestions in response to earlier drafts. C.-Y. Yang is financially supported by the Government Scholarship to Study Abroad (GSSA) of the Ministry of Education (Taiwan) and the Risk Society and Policy Research Center, National Taiwan University.

C.-Y. Yang
Department of Sociology, Lancaster University, UK
e-mail: c.yang5@lancaster.ac.uk

B. Szerszynski
Department of Sociology, Lancaster University, UK
e-mail: bron@lancaster.ac.uk

B. Wynne
Department of Sociology, Lancaster University, UK
e-mail: b.wynne@lancaster.ac.uk

Keywords sociotechnical imaginaries · technopolitics · power shortage · habituated expertise

Abstract 極度現代主義是戰後臺灣具有主導優勢的社會科技想像,尤其,它透過對「我們該追尋的更好社會為何?而又該由何最務實與可行的途徑來達成它?」一問題,提供默會不宣的答案來獲得彰顯。本文探索,在極度現代的想像下,對於不同能源未來選擇的排除。該合理性經由對當下的短缺與未來的富裕之強調,也就是,透過暗示當下的短缺需由「可靠」方式解決。本文聚焦在介於 2011 年與 2015 年之間,能源供給面上的爭論,由此來分析,「缺電問題」是如何經由論述上的模糊來呈現,所宣稱的「缺電危機」又是如何經由環繞在限電上的制度實做而位移到公眾爭論的核心,且其對於公眾的權威又是如何透過共同的見證而獲確認。當談到滿足國家需求時,再生能源不斷的被描繪成為一種「不成熟」與「不可行」的科技,而這是由電力規劃上,備用容量計算時的特定例行慣常化實做與對於有限備轉容量的集體見證而達成。我們強調,上述兩者皆帶有其自身的假定與政治上的意涵,因此,必定要招致仔細審視。

Keywords 關鍵字: 社會科技想像 · 技術政治 · 缺電 · 慣常化的專業

1 Introduction

The Fukushima nuclear disaster caused by the earthquake in March 2011 triggered an outcry in Taiwan for increasing the use of renewable energy in generation portfolio and the phase-out of existing nuclear power plants. In response, the Nationalist (Kuomintang/KMT) administration initiated the Millions of Rooftop PVs and Thousands of On/Off-Shore Wind Farms programs, both of which commenced in March 2012. However, four and half years later, when there was a change of government, the accumulated installation of photovoltaics and wind power was merely 842 MW and 647 MW, respectively, and renewable energy still only accounted for 2.3 percent of electricity generation in Taiwan. This unsatisfactory state of affairs was the result of a long contention between nuclear power and renewable energy, in which nuclear power was depicted as cheap, reliable, and safe while renewable energy technologies were deemed technologically immature, expensive, and not viable. At the same time, the idea of a perennial power shortage had the effect of instilling a deep fear in the public's mind of the overwhelming consequences that the power shortage can bring to the nation as a whole.

Powering the nation with nuclear energy once was presented in policy discourse as the only reasonable and viable answer to this national predicament. The focus of democratic debates about energy politics moved from the open question of what a desirable common future might be, to a particular narrow framing of the problem. A singular, overwhelmingly supply-side-focused approach, largely based on the imaginary of an unlimited and highly controllable energy source—nuclear energy—was tacitly inserted into the policy agenda and regarded by the government at the time as the only feasible way of solving this imminent power shortage. This difficult situation has to some extent been settled down after a series of actions by the antinuclear movement and the subsequent mothballing of Nuclear Power Plant 4 (NPP4) in 2015. Although the Democratic Progressive Party administration, which came into power in 2016, has

been following a quite different direction in energy policy, nevertheless other aspects of how that energy policy is being done—such as the technically formed agenda of power shortage and the demonstration of public authority through public witness—remain largely unchanged. A puzzle remains: How does the tacitly attempted institutional knowledge-expertise in electricity planning routines retain its normative meaning and political strength?

Drawing on the interpretative approach in science and technology studies (STS), we argue that to answer such questions we must go beyond the web of factuality that constitutes an established order in economic and engineering issues and instead probe the meaning-making dimension of energy-production routines. In this article, we explore the embroiled imaginaries in the contemporary sociotechnical energy system in Taiwan, shedding light on the legacy of postwar nationalist high modernism and the developmental state, which continue to influence today's energy politics. Nationalist high modernism, as one of the prevailing imaginaries in postwar Asia, is shared by elite bureaucrats and administrators in developing countries, where they make authoritative decisions over the ways to reach a particular version of the collectivist public good. This "will to develop" (Chu 2011) keeps coming back in the forms of nationalist-pragmatist storylines and rationalities in the policy-making process and controversy regarding what the energy future ought to be. Furthermore, this inherently autocratic imaginary, which assumes an impoverished state-society relation, does not simply fade away in recent waves of democratization; on the contrary, it is maintained by deeply routinized practices in institutions and reinvigorated in arguments about technical viability and reasonableness. The reasonableness, and even desirability, of a particular energy future is enacted through the modalities of visualization, discursive storylines (Hajer 2006), and argumentative registers of technical necessity, all of which we document and illustrate in the following sections.

We rely on empirical materials that derive from interviews and content analyzes of media reports and policy documents. Extensive documents are used to develop an analysis of the technical terms, frameworks, and concepts used in Taiwanese energy debates between 2011 and 2015; key documents include Taipower's *Long-Term Power Development Plan 2015*, electricity terminology dictionary, and *Measures to Power Rationing during the Period of Power Shortage*; Office of Gas and Electricity Markets (OFGEM)'s *Electricity Capacity Assessment Report 2014*; Royal Academy of Engineering's report on Great Britain's capacity margins; and press releases from the Ministry of Economic Affairs (MOEA). Four interviews were conducted with Taipower workers in the Departments of Power Dispatching, Research Institute, Public Affairs, and Power Development to understand how the actors in the field understand, interpret, and practice these knowledges. Because of length restrictions, only some of the interviews are presented here.

2 Sociotechnical Imaginaries and Science and Technology as Meaning in the Making

When we review the literature on science and technology policies and the postwar history of Taiwan, one common trope emerges: How can we catch up with Western countries? How can we develop further in economy, industry, and society? How should

we be modernized? The desire for development and the adoption of a "latecomer" identity profoundly shape knowledge interests in the Taiwanese humanities, social sciences academia, and, more specifically, technology studies (Chen 2015). Certainly, this phenomenon is not limited to Taiwan; for example, in postcolonial South Korea, science and technology are exclusively associated with their role in rapid industrialization and technological achievement (Kim 2015, 2013). In this context, aspirational imaginaries such as being *developmental*, *modernized*, and *progressive* provide a common language shared by different factions in politics and divergent social groups; it is the indispensable premise for broad social negotiation and collective meaning making in postwar Taiwan.

However, the conventional theory of modernization attributes this great social transformation to the coming of rationality and technicality all around the globe, implying a linear and homogeneous development of society involving the institutionalization of science and technology and rapid industrialization (Smith 1983; Ichijo 2013; Scott 1998; Eisenstadt 2000). Rationalization, especially in its embodiment in science and technology, is seen as the most fundamental driving force behind this global movement of conformity. Even more, science and technology, in this rationalist view, are considered purely instrumental, objective, and politically impartial. However, this oversimplified, misleading, and teleological view of science and technology is problematized if we cast a critical eye on the diverging technological trajectories found around the world and the distinctive criteria of objectivity performed in one regime or another. Studies taking an alternative approach (Wynne 1996a, 2010;Wynne and Dressel 2001; Jasanoff 1996, 2004, 2005, 2015; Hecht 1998; Porter 1995; Winner 1980; Eisenstadt 2000; Ichijo 2013; Scott 1998; Welsh and Wynne 2013) suggest that the role that science and technology plays in modernization and policy making is far from apolitical, disinterested, and purely objective; on the contrary, science and technology are done materially, politically, and culturally and are done differently in different societies, cultures, and polities.

Hermeneutic dimensions of science and technology have been rather downplayed in STS (Jasanoff 2015; Welsh and Wynne 2013), and even anthropological work has tended to emphasize the epistemic dimensions of cultural difference relating to technoscientific initiatives. Therefore, an effort needs to be made to put social imaginaries and their enmeshed meanings, commitments, and beliefs center stage as objects of analysis. Specifically, there is an urgent need to go beyond the surface of the strategy and science and technology policy deployed by actors, and ask how we can reveal the underlying visions of technoscience and social order that shape the actors' very considerations, reasoning, and aspirations (Jasanoff and Kim 2009). It is such reasoning that lies behind our choice of an approach that focuses on social meaning making rather than a more conventional interests-based rationalist interpretation of science and technology.

We take a hermeneutic approach to science and technology, enlisting the concept of "sociotechnical imaginaries" as proposed by Sheila Jasanoff and Sang-Hyun Kim (2009). Jasanoff and Kim use the term *sociotechnical imaginary* to capture a particular gestalt of "less explicit, less issue-specific, less goal-directed, less politically accountable, and less instrumental" but "pervasive meanings" around science and technology (123). Jasanoff goes on to say that these imaginaries are "collectively held and performed visions of desirable futures (or of resistance against the undesirable) . . .

animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (2015: 19). Sociotechnical imaginaries "are collective, durable, and capable of being performed; yet . . . also temporally situated and culturally particular" (2015: 19). They are representations of "factuality"—of what is the case—but also present what are seen as legitimate, moral, and normative ways of ordering lives into forming realities. They are coproduced (Jasanoff 2004), emerging from policy discourses, state administration, and established institutions and are backed up by technical routines and material infrastructures. Sociotechnical imaginaries are continuously and collectively negotiated meanings about what the realities now are and how the realities in the future ought to be (Jasanoff 2015: 4).

Since science and technology are cultural and hermeneutic enterprises, especially as they are used in the process of policy making, we should also notice that institutionalized practices and public reasoning in science and technology may seriously constrain the imagination of new forms of order and new ideas about how their social legitimation may be better founded (Wynne 1996a). The paramount characteristic of scientific knowledge in policy making is its ostensible ability to establish facts and factual descriptions from the chaotic and ambiguous mundanity and its indispensable power to create social-political order in an apparently impartial way. However, the actual criteria of factuality, impartialness, and objectivity and the institutional culture that guarantees and performs them vary between institution and institution and between country and country since the use of scientific knowledge in public reasoning always depends on unspoken commitments, promises, and ambitions (Wynne 2014).

As argued by Yaron Ezrahi (1990), the dichotomy between fact and fiction is a necessary "imagination" in a modern democratic society founded on rational individualism. Science produces the knowledge of facts that informs the rational and voluntary choices made by actors. However, social actors' values and goals are revealed to be often vague, relational, conflicting, unstable, and open to negotiation (Welsh and Wynne 2013). Political performance and discourse, including technical assessment, bureaucratic planning, and scientific experiment, can guide people tacitly in certain ways, influencing what is regarded as reasonable, indispensable, and desirable, or at least tolerable. Scientific knowledge in this sense is not only politically instrumental—irrelevant to meaning making and being impartial—but also generative in conveying normative meanings and creating moral judgments (Wynne 2010, 1996a, 1996b, 2011, 2014); it is a political practice that generates a particular form of understanding of effectiveness, objectivity, and trustworthiness.

In focusing on the unspoken cultural dimension of science and technology in policy making, the aim is therefore to reveal the less obvious, more subtle, and routinized practices, presumptions and commitments that are embedded as constitutive components in institutions and local cultures in the form of taken-for-granted habitual practices, identities, relationships, assumptions, and beliefs (Wynne and Dressel 2001). Following this course, we propose an analytical tool: technopolitics in-the-making. Drawing on both the concepts of "technopolitics" (Hecht 1998) and "in-the-making" (Callon 1987), this concept helps us to understand how the politics of artifacts (Winner 1980) are brought into action through technical choices and habituated expertise by both actors and materials. Technopolitics must be understood as a continuous struggle to define who the actors in play are and how the system should work, both in technical

and social-cultural terms (Hecht 1998). We add the term *in-the-making* to signify that, even in circumstances where contestation is absent, the dominant sociotechnical imaginary and its modes of legitimation have to be continually reproduced through material and discursive practices.[1]

Sociotechnical imaginaries certainly provide a powerful explanatory concept that we can use to critically explore technological development and especially state-implemented scientific projects and policies, but they do not, by themselves, constitute the means through which decisions are shaped from day to day. Therefore we argue that culturally situated, less obvious, more subtle, and routinized practices in institutions play an indispensable role in sustaining the particular relationships, identities, and assumptions that sociotechnical imaginaries live upon. Imaginaries are not purely abstract and ideational or purely material but a combination of the two. In the same way, technologies are not themselves technopolitics; rather, the practice of using technologies in political processes or in the construction of public authority (Jasanoff 2015; Wynne 2008) constitutes technopolitics. Technology cannot be reduced to politics. In short, we need the concept of technopolitics in-the-making to understand the normative-cultural-material admixture of politics and science.

3 Nationalist High Modernism and Depoliticization

Before entering our case of perennial power shortage, the relevant historical context needs to be described. To understand nationalist-pragmatist storylines and their full significance, we need to trace their origins back to the Taiwanese history in the postwar period and introduce the concept of high modernism. The island of Taiwan, or Formosa, was populated with aboriginal peoples until the early seventeenth century, after which it saw centuries of immigration and colonization from the Dutch (1624–62), the Spanish (1626–42), the Cheng family (1662–83), the Qing Empire (1683–1895), the Japanese (1895–1945), and the authoritarian Nationalist regime (1945–88) (Jacobs 2013, 2012). As suggested by Bruce Cumings (1999), East Asian countries such as Taiwan, South Korea, and Japan are seen as successful models of the postwar developmental state and share similar strategies of development. Industrialization is the ultimate goal of the state and the major approach to building a nationalistic economy; more important, this goal was made possible through the creation of a powerful and extensive bureaucracy and a centralized government.

[1] In this anthropological-STS/SSK (sociology of scientific knowledge) approach, we are interested in the practical forms of reasoning (or sense making) among Taipower engineers, which have become an established culture by dint of internal repetition and collective reinforcement, with little or no significant contradiction or challenge. This is a different understanding of *rationality* from a scientific one, where at least in public it is taken that the evidence which leads to that rationality's particular propositional stance can be identified and clearly stated. This more cultural approach which we would take is far more difficult to cleanly document, precisely because of its historical nature, accumulating and gaining "natural" authority and de facto monopoly by repetition and reinforcement. Although the creation (or design) of certain institutional habits, identities, and relations is possible, an imaginary as a form of cultural asset does require a process of slow and often tacit accumulation. Conventions and routines are often performed unconsciously or, at least, inadvertently. Shared values, visions, and aspirations (or fears) can be repeatedly enacted (or coproduced) through protocols, assessment schemes, and technical choices along ingrained storylines.

After the Republic of China was founded in 1911, the Nationalist regime undertook coordinated efforts to institutionalize technoscientific development in China, for example, by sending young students abroad to study *shíxué* 實學 (industrially relevant subjects) such as science, engineering, medicine, and agriculture (Chang 2013) and establishing the Jīngjì wěiyuánhuì 經濟委員會 (National Economic Council, the predecessor of the MOEA) and the Zīyuán wěiyuánhuì 資源委員會 (National Resources Commission; Greene 2008). Many returning graduates later became the elite bureaucrats (as scholar-officials) who led the high modernist statecraft of industrialization of China and Taiwan. *Kējì* 科技 (technoscience), *gōngchéng* 工程 (engineering), and *xiàndàihuà* 現代化 (modernization) were perceived not only as the means but also part of the ends of the historical mission of *jiùguó* 救國 (nation saving) (Chang 2013). During the Second Sino-Japanese War of 1937 to 1945, a pervasive sense of external threat led to a planned economy and a mighty state being seen as the most effective way to acquire rapid industrialization and a strong nation. Industrialization was deemed as a public asset (Chu 2007; Amsden 2001). Wan-Wen Chu (2011) argues in common with Ronald Dore (1990) that this "will to develop and modernize" comes from a strong feeling of backwardness, even humiliation, sensed by the ruling elites and intellectuals concerning the international status of their nation. Not surprisingly, the grand storylines in China today are about how, starting in the mid-nineteenth century, "China had suffered from foreign bullying, resisting foreign powers, and committed to striving for independence and prosperity" (Hsiau 2013: 181). The Bǎinián guóchǐ 百年國恥 (Century of National Humiliation) is not only a recurring theme in both the pre-1949 Republican writings (in China) and the post-1949 nationalist discourse (in Taiwan) but also the official view of modern Chinese history in the People's Republic of China (Hsiau 2013).

In 1949, after being defeated in mainland China by the Chinese Communist Party and fleeing to Taiwan, the Nationalist regime imposed martial law and adopted a bureaucratic authoritarian industrializing regime in Taiwan from the 1950s to the late 1980s, making this the main ruling approach in postwar Taiwan (Cumings 1999). As argued by Chu, the massive industrial estate left by the defeated Japanese colonial regime which was in Taiwan between 1895 and 1945, and the fact that these estates and factories were state owned and operated from a centralized government under the supervision of Japanese Empire, created an easy-to-adopt premise for the Nationalist regime (Chu 2010) and their retreating elite bureaucrats.

In the 1950s, the Korean War erupted. As part of the first island chain fighting against the expansion of the Communist party, the Nationalist regime received a lot of US aid. In the Korean War, Taiwan took the role of a logistical supply base; however, the Nationalist regime did not receive the full trust of the United States. The operation of US aid was deliberately segregated from other institutions in the regime and handed over to a group of engineers (Chang 2013). Engineers (as the majority of elite bureaucrats) became the surrogate of the authoritarian regime in Taiwan during this period (Kirby 1990; Chang 2013).[2] In the Nationalist regime's view, that engineers

[2] The group at least includes Chia-Kan Yen 嚴家淦, Chung-Jung Yin 尹仲容, Chi-Tseng Yang 楊繼增, Kwoh-Ting Li 李國鼎, Kuo-Hwa Yu 俞國華, Hung-Chun Yu 俞鴻鈞, Po-Yuan Hsu 徐伯園, Meng-Lin Jiang 蔣夢麟, Tsung-Han Shen 沈宗翰與, and Yun-Suan Sun 孫運璿 (Chang 2013).

replace military generals as the direct channel to the US government was also seen as benefiting the regime by diminishing the possibility of military mutiny (Chang 2013). Within this historic context, engineers unexpectedly took the crucial but "neutral" role in Taiwanese politics.

Nationalist high modernism is the dominant social and political trend in postwar East Asian countries. In the nationalist modernists' eyes, industrial, scientific, and technological developments would not only rebuild the nation's economy after the destruction brought by wars but also restore the nation's significance on the world stage (Chu 2011). Furthermore, the clear aspiration to use science and technology to forge a new planned social order underlies the foundation of high modernism in many nation states during the twentieth century, such as the Japanese technical consultancy-led "comprehensive development" in Southeast Asia (Moore 2014). As argued by James Scott (1998: 4), high modernism is defined as "a strong, one might even say muscle-bound, version of the self-confidence about scientific and technical progress, the expansion of production, the growing satisfaction of human needs, the mastery of nature (including human nature), and, above all, the rational design of social order commensurate with the scientific understanding of natural laws." Three tropes in high modernism need to be pointed out so as to illustrate the aspirational aspects of this prevailing sociotechnical imaginary in Taiwanese history.

The first is the aspiration to administrate and order nature and society through the statecraft of measuring, standardization, aggregation, and typification; for bureaucrats to comprehend messy reality, complexity must be reduced to schematic categories. That is, uniformity is highly preferred under statecraft. The invention of this statecraft and the deployment of abstraction illustrate an immense leap in state capability (Scott 1998). In Taiwan, the Nationalist regime inherited the rich legacy left by the colonial Japanese regime, including not only tangible assets but also intangible institutions such as the household registration system, land survey, population census, natural history research, and the sophisticated mapping of natural and social terrain. Through fifty years (1895–1945) of governance under colonial Japanese regime, the key elements of high modernism had already been well established. This gave the elite bureaucrats of the Nationalist regime an excellent opportunity to fulfill the master plan of modernization that had been interrupted in mainland China after 1949 (Chu 2007, 2011).

Second, high modernism involves massive programs of social engineering, carried out by the state but encouraged by progressive elites. High modernism, in this sense, is the extensive prescription of a new society in the future which will be brought about by realizing a planned and intended blueprint. The dream of a utopia of egalitarianism and utilitarianism can be perceived clearly in postwar Taiwan. For instance, comparing the case of South Korea with Taiwan, Chu (2011: 256–57) argues that the Nationalist regime in Taiwan achieved comparatively even wealth distribution by the principle of "Yǔlù jūnzhān" 雨露均霑 (roughly translated as "spreading rainfall evenly"), enabling "equal opportunity" for state-owned large enterprises, private large enterprises, and small and medium businesses, while in South Korea the state-privileged *chaebols* (family-run conglomerates) dominated the postwar development of capitalism through the policy of incubating "national champions" (see also Wang and Tsai 2009; Wang 2007; Chu 2010). However, this state-planned economic egalitarianism in Taiwan should be considered as a form of state-monopoly capitalism.

Finally, according to Scott (1998), the third and most troubling feature of high modernism is its affinity with authoritarianism, which derives from its tendency to disallow other competing sources of judgment. Owing to its assumption that a radical break with existing reality and tradition is needed, it insists that traditions ought to be reexamined and redesigned to fit the order informed by scientific and technological knowledge. Echoed by the "savior morality" of nationalist bureaucratic elites, the key feature of high modernism in postwar Taiwan is thus the tendency to devalue wider political participation.

As illustrated above, the predominant phenomenon that emerged from the historical context of the postwar authoritarian Nationalist regime (1945–88) was the rise of engineers as the dominant fraction of elite bureaucrats. They prefer to be called *jìshù guānliáo* 技術官僚 (technocrat), but this does not mean that "technician" is their primary identity; nonetheless, most of them came from an applied science background and received some forms of education from the US (Chang 2013). The prevalence of nationally organized capitalism can be exemplified by the pursuit and study of national economy. National economy is considered as a branch of applied science and is often called *jīngjì jiànshè* 經濟建設 (economic planning and development). Elite bureaucrats are not limited to persons who have applied science training, but their common trait is the experience of undertaking economic policy making (Chang 2013). As expressed by one of the most iconic figures, economist and politician Kwoh-Ting Li 李國鼎: "People say the industrial committee only has engineers and no economists, but this is totally wrong" (Li quoted in Chang 2013: 103). In fact the industrial committee took pride in their expertise in economic planning and development.

Here, planned national economy does not only refer to macroeconomic policies such as monetary policy and financial market regulation but also to more "pragmatic" topics such as the establishment of mining, refinery, steel, electricity, agriculture, and military industries. For nationalist high modernists, these industries form the foundation of the national economy and productivity. Li (1987: iii) once said, "I am from a science background, participating in economic planning, industrial development and financial decision-making." One distinctive example is that some elite bureaucrats have worked as the head of the Arsenal Department or the chief engineer of Taipower before taking office in the Ministry of Economy (Chu 2011; Chang 2013). These are not technicians who just work under political commands from above; their identity was bound up with an ethic of national service rather than a desire for profit. These elite bureaucrats are state engineers (Porter 1995) who share a belief in pragmatic engineering. However, this does not mean that these elite bureaucrats are just a fig leaf on an authoritarian regime. While the commands from high authority are definitely influential, the details in this nation-building project are too trivial to be contemplated directly by the regime leader. Detailed technical strategies and plans are left to the engineers to deal with (Tsai 2006). The integrated circuit development program serves as a good example to illustrate this point: integrated circuit manufacturing was the strategic industry selected by these engineers to achieve national autonomy, despite disapproval from the scientists in the National Science Council (Tsai 2006).

The expert bureaucrat's technical rationality of developmental planning was used to depoliticize their tasks. Depoliticized economic planning is highly compatible with the operation of authoritarian government. The conciliation of authority and technicality is

brought to reality through the efforts of engineers. The sense of depoliticized objectivity (Porter 1995) in the project of industrialization and engineering comes from its technicality and pragmatism. On the one hand, transforming the moral term "national strength" into a technical and pragmatically doable one provides these engineers with some protection against day-to-day court politics in the Nationalist regime (Chang 2013). For instance, Li argued that they are not economists but engineers in action; he said, "Economists may hold different opinions on issues but we, engineers, only try to deal with the real challenges facing us and try to solve them in pragmatic ways" (Li quoted in Chang 2013: 113). Another elite technocrat Chung-Jung Yin 尹仲容 similarly argued, "My basic point of view simply is how to do effective problem-solving in the real situation" (Yin quoted in Chang 2013: 115). On the other hand, national economic growth is depicted as the emblem of a maximized general utility—the pursuit of national productivity and competitiveness within the international market. This constructs an affinity between a clear, mathematical, and economic figure—GDP (gross domestic product)—and a more abstract moral-normative concept: national strength.[3]

Indeed, the idea that solving problems merely with engineers' eyes and hands to restrain invested political interests provides an excellent way to gain great vast public authority without much overt resistance. Depoliticization and the appeal of sacrifice in service of the public-collective good constitute the very core of the nationalist-pragmatist storylines that keep coming back and exerting influence in contemporary energy politics.[4]

4 Perennial Power Shortage and the Obsession with Growth

As discussed previously, the vision of a nationalistic and autonomous economy plays a pivotal role in high modernists' eyes, and the question of how to build a powerhouse that secures technological development and an abundant power supply is at the center of their agenda. Industrial policy, as the bastion of the developmental state and

[3] By naming nationalist high modernism the dominant sociotechnical imaginary in postwar Taiwan, we do not claim that the imaginary in Taiwan was homogeneous or deny that nationalist high modernism was confronted by other challenging imaginaries. However, it is crucial to point out the dominant version of a sociotechnical imaginary can establish the perimeter of acceptable legitimacy. The key features of the high modernist imaginary we are illustrating here includes the fear of lagging behind (latecomer); a mighty state; a belief in the prowess of science and technology; a "pragmatic," depoliticized engineering; engineers with a savior morality; a nationalist expanding economy; and rapid industrialization.

[4] Alongside the nationalist high modernism discussed here, an alternative imaginary can also be observed in the same period. This can basically be conceptualized as a native, land-oriented modernism and as a cultural and political reformism (Hsiau 2013), both of which can be traced back to the civil moments in the Japanese colonial era; this point is advanced further in the concluding section. Additionally, with the ongoing tide of democratization in Taiwan since the late 1980s, the face of high modernism changed while still remaining pervasive as a latent and common cultural and political resource. The impact of democratization on nationalist high modernism can be further analyzed in three dimensions: industrial policy, engineer's identities, and the forms taken by the democratic and civil movement in Taiwan. However, our aim here is not to provide a comprehensive diagnosis or to predict if there will be power shortages in the near future, but to highlight the legacy of high modernism in electricity planning and to provide a cultural explanatory insight to the technical choices made and practices done by the Taipower engineers to reveal their technopolitics.

therefore the manifest practice field for high modernists, is subjected to an intense gaze from the state. It was in this context that the Gōngyè jìshù yán jiù yuàn 工業技術研究院 (Industrial Technology Research Institute, ITRI) was established in 1973 to facilitate a "coordinated and state-led developmental network" (Wang and Tsai 2009: 66–67). According to Chen (2012), "advanced technology" is the key goal of ITRI engineers, even if this means that the products from their projects might lack market attractiveness. When it comes to the electricity sector of Taiwan, the Táidiàn 台電 (Taiwan Power Company, Taipower) is the dominant player. Based on the infrastructures built by the Japanese colonial government, Taipower has been the most powerful actor in the electricity sector since its establishment in 1946. It monopolizes the power sector in its three key domains: generation, transmission, and distribution. The monopolistic influence of Taipower registers not only in physical infrastructures such as transmission lines and transformers but also in institutional knowledge, expertise, and ways of thinking in electricity planning.

The prominent figure among technocrats in the electricity sector is Yun-Suan Sun 孫運璿. He is often hailed as the founding father both of Taipower and ITRI. As a member of the National Resources Commission in the Nationalist regime, he like many other elite engineers was sent to the US Tennessee Valley Authority to gain experience of managing the electricity grid and power stations; when he came back in 1945 after the surrender of Imperial Japan, he took the central role in the takeover of the key public infrastructures left by the Japanese colonial regime in Taiwan, including the repair and further expansion of the Taiwanese electricity system. The repair of the transmission lines, hydropower dams, and coal-fired stations was done not only by the group of mainlander elite engineers but also by engineers of Japanese, Taiwanese, and other nationalities. However, Sun played the crucial role in guiding the transition of the original Japanese technical system to one with a strong American influence (Lin 2013). He was promoted to chief engineer of Taipower in 1950 and laid the foundation of power planning for the company. As a key figure of the elite technocrats, he had an excellent chance to realize the high modernist dream of improving the nation through developmental planning and engineering as later he was inaugurated as the minister of the MOEA, the Energy Committee, the State-Owned Enterprise Commission, and finally the premier of Executive Yuan in 1978. The way that the high modernist imaginary links national strength, productivity, and the ethos of state engineers can be exemplified vividly using his own words:

> The main purpose of accelerating economic modernisation is to strengthen the responding capacity of our economy, and another is to strive for the competitiveness of our agriculture, industry and commerce sectors in the international market. The primary means to achieve these ends is to increase our overall productivity. . . . And the primary responsibility for increasing productivity should be borne by our engineers. (Sun quoted in Chang 2013: 114)

In the following sections we will explore this cultural (meaning-making) dominance in an analysis of discourses, practices of public witnessing, and technical routines and choices. At the end of 2011, in the aftermath of the Fukushima nuclear disaster, the Nationalist party's Ma Ying-jeou administration proposed a "Xīn néngyuán zhèngcè" 新能源政策 (New Energy Deal) in response to the mounting demand

from civil society calling for the termination of nuclear power plants and increased energy saving. At the center of this policy are three promises—no power rationing, a rationalized electricity price, and fulfilling carbon-reduction commitments (MOEA 2012). The promise of *bù xiàn diàn* 不限電 (no power rationing) is clearly prioritized in the policy actions. It was also argued that, to avoid power rationing, nuclear power should be reserved as one of the possible options so that it is available for the next generation to choose.

When we look back to the energy politics between 2011 and 2015 in Taiwan, probably the most recognizable feature is the perennial warnings of power shortage issued by the government. The core storylines of this episode can be briefly summarized in the following paraphrase:

> A higher and higher electricity demand pushed up by hot weather is inevitable. At the same time, renewable energy is still too immature to become a major player in generation. Given this situation, the termination of NPP4 and the scheduled retirement of existing nuclear power plants would reduce the reserve margin to the level where there is a high risk of power rationing. When it is lower than 10 percent the chance is highly likely; when it is lower than 7.4 percent, it is inevitable. The impact that power shortages have on society, industry, and economy is tremendous.

While the assertions rely on questionable assumptions and no case of power rationing has been recorded since 2003,[5] these are the storylines widely shared by governmental actors such as Executive Yuan, the MOEA, the Bureau of Energy (BOE), the State-Owned Enterprise Commission, and the Atomic Energy Council.[6] According to Taipower's *Long-Term Power Development Plan (10302)*, the reserve margins were predicted to drop to 9.8 percent in 2018, under 10 percent, the threshold of high risk for power rationing, and even to −0.3 percent in 2025 (see Fig. 1). This forecasted "national predicament" nonetheless came with an imposed solution, the operation of NPP4. However, in contrast to the carefully displayed unanimity, the BOE's 2014 report (MOEA 2014a), after being officially criticized by the Control Yuan (the governmental watchdog) in 2012, tacitly provided a more optimistic prediction, indicating that the margins will soar up from 4.8 percent in 2019 to 14.2 percent in 2021. In our interviews, we also found that the power dispatching engineers may hold different opinions from their counterparts in the Department of Power Development on the issue of predicted negative reserve margins.

In the following sections we look into the features of this particularly imagined sociotechnical future via the nationalist-pragmatist storylines shared by governmental

[5] The calculation of a reasonable reserve margin is a key part of the nationalist-pragmatist storylines observed in the energy politics during this period of time. The statutory reserve margins decreased from 25 percent in 1983 to 15 percent in 2012. An "emergent power rationing" was recorded as the latest incident in August 2017 due to an operation error attributed to the fuel provider CPC Corporation (Taiwan). Dissidence can also be found within Taipower, as implied by the interviewee D2: forecasting a negative margin is totally unacceptable; this is the power development plan that should be negotiated in the internal coordination meeting.

[6] The BOE is an administrative body under the MOEA. Both of them are under the command of the Executive Yuan.

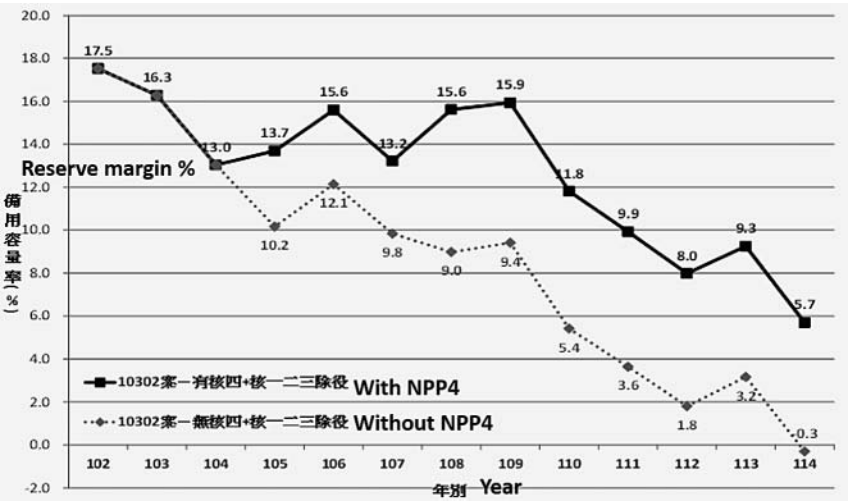


Fig. 1 Reserve margins forecasted by Taipower, the "bleak future" (Taipower 2014)

actors and the orchestrated practices of emphasizing power shortage at present, and economic prosperity in the future—if the current risk of power shortage is solved in a feasible way. The storylines exclusively emphasize supply-side measures and put much less attention on demand-side dynamics.[7] Adding more capacity to generation was believed the most pragmatic, if not the only, method to solve the risk of power shortage.[8] This combines an aspiration of nearly never-ending growth of GDP and electricity demand with a faith in pragmatist planning. It is continuously framed as a mission of pursuing the collective good as a state responsibility. It has to be established whether the state has the will and ability to provide its population with a prosperous future.[9] An endless supply of energy, in the nationalist-high modernist sense, is not only the means to an ever-growing economy but also symbolizes the determination to achieve an ever-evolving society: "Electricity is the cornerstone of modern life and the driving force behind the industrial development of both traditional industry and emerging high-tech industry. In the past sixty years, Taipower has provided sufficient electricity for the need of developing people's livelihoods and the economy. The transmission and

[7] When facing the proposal of Zero Electricity Demand Growth advocated by activists in 2012, the BOE's reply stressed the premise of a "persistent and favourable economic growth" and a "pragmatic" approach in terms of energy-saving and energy-efficiency.

[8] While more reserve margin does bring higher system reliability, it is not the only way to ensure a sufficient supply. After all, the figure of reserve margins depends on multiple factors such as the frequency of unplanned generator outage (supply side) and the ability of accurate demand forecast (demand side). Official prediction of economic growth historically tends to be too optimistic. To predict a lower and even negative economic growth seems to be hard enough for the Nationalist administration to swallow. Additionally, the delays of overhaul schedules and unplanned outages can be left in ambiguity. The consequence is that a large and arguably wasteful reserve margin is "required." Also see nn. 14 and 19.

[9] One of the Nationalist administration's key political pledge, the "Liùsānsān zhèngcè" 六三三政策 633 policy, is to achieve a continuous annual 6 percent GDP growth and the goal of US$30,000 GDP per capita. Sufficient power provision and no power rationing are their main concerns.

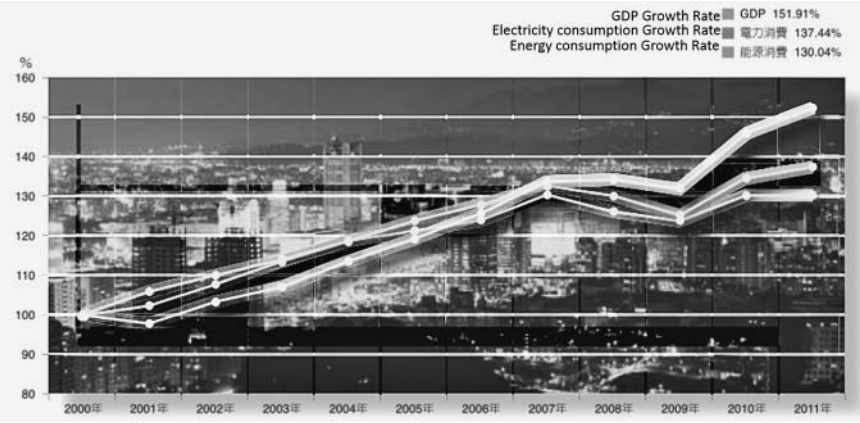


Fig. 2 The relation among energy, electricity consumption, and growth (MOEA 2014b: 6)

distribution lines of Taipower have grown to every corner of Taiwan. Taipower lives with 23 million fellow citizens every day" (Taipower 2015a).[10]

A similar metaphor was used in the chairman's opening speech at the seventieth anniversary ceremony of Taipower: "For 70 years . . . the development of Taiwan's industry and economy has taken off swiftly, riding on the wings of electricity" (Taipower 2016: 22). The same trope can also be found in 1940s and 1950s United States; as Leslie White argued, "The degree of civilization of any epoch, people, or group of peoples, is measured by ability to utilize energy for human advancement or needs" (quoted in Nye 2010: 77). This view connotes a technological determinism, as if the "development" of culture and society is correlated with economic growth and the consumption of energy. Additionally, in the Cold War era, a limitless supply generated by atomic power was also imagined in the United States and infinite energy abundance was presented as the "natural" and "developed" condition, in contrast to the "undeveloped" and "dark" parts of the world (Nye 2010).

Here, the presentation of a never-ending growth of economy and an ever-advancing development of people's livelihood is a legacy of postwar high modernism and relies heavily on particular visualizations showing an apparently inherent relation between ever-growing electricity consumption and the growth of national GDP (see Figs. 2 and 3).

The statist gaze on the relation between electricity demand and GDP growth is not only underpinned by a vision of a "glorious past" but also the schematic comparison with other countries. The period of negative growth of Taiwanese electricity demand in 2008 to 2010 (Fig. 3) is regarded as the consequence of negative economic growth that results from social unrest, the financial crisis, the European debt crisis, and the Jasmine Revolution. In an official report written by the BOE, the United Kingdom and Demark were singled out as examples of lower or negative electricity demand growth and

[10] The promised state citizenship of electricity accessibility would create a new identity: the electricity-desiring citizen with the basic human right to electricity. Like the high-energy American way described by Nye 2010, electricity and its consumption gradually have become an infrastructure of modern life in urbanized areas. It is the new normality.

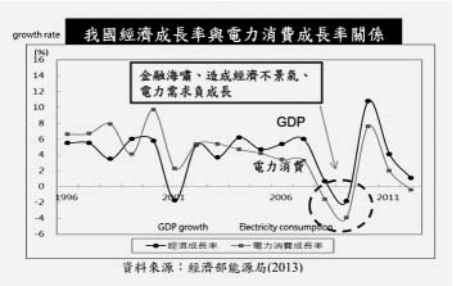


Fig. 3 The relation between electricity consumption and growth (MOEA 2014a: 6)

conceived as a departure from the "trajectory of economic growth." It was argued that once the economies of these countries return to a trajectory of growth, the demand will go up again (MOEA 2014a: 21, 24).

However, the strong desire for continuous growth and development does not only involve imagining an affluent society in the future; it also constructs a current scarcity. Turning current scarcity into future affluence constitutes the main rhythm of nationalist-pragmatist storylines. The manifestation of affluence in the future can only be secured by conquering the current imperfection constituted by impending power shortage—that is, by making a pragmatic and feasible technical choice. As we will demonstrate below, the use of nuclear power, as an incumbent source of generation, was repeatedly enacted as a mature and feasible technology to solve this scarcity. As suggested by Scott, high modernism often seeks to establish the reality of an undesirable current circumstance; here, it is imminent power shortage. Breaking apart from the unbearable current quagmire is always the rationale for sacrifice and great change. To do that, the message of power shortage needs to be convincingly demonstrated to the general public. The perennial warning of power shortage in late summer and early autumn—the traditional peak season in Taiwan—has to be comprehended in this sense.

We argue that this agenda is advanced implicitly through the arrangement of technical terminology. To understand how the claim of power shortage is formed and reenacted on an annual basis, we need to review the discursive practices as well as the institutional practices through which it gets reified and routinized. It is often assumed that in a subtropical country like Taiwan high temperature and electricity demand have an inseparable relation, even when the exact relation between temperature and demand is never fully explained. When mentioning high temperature, it is assumed that the consequence must be higher demand and therefore increased risk of power shortage. This is a naturalistic construction of the problem because higher temperatures do not necessarily lead to power shortage and power disconnection thanks to the system-balancing measures to which electricity operators can resort.

On the one hand, while the government's discourses mostly refer to *xiàn diàn* 限電 (power rationing), the term *quē diàn* 缺電 (power shortage), which implies *tíng diàn* 停電 (power disconnection), is a more salient term in public discourse. Even worse, the ambiguity between the terms *power shortage*, *power rationing*, and *immediate power disconnection* is exacerbated by their indiscriminate use in mass media either by

reporters or officials. The different implications of the three terms do not get highlighted in the government's discourse, which means that the questions of how long, how often, and how likely the public will be disconnected are rarely clarified, leaving an inchoate fear of power disconnection pervasive in society.

On the other hand, what have contributed to the firmly established alarming image of power shortage are the institutional practices of power rationing. One of these is the executive order "Diànyuán bùzú shíqí xiànzhì yòng diàn bànfǎ" 電源不足時期限制用電辦法 (Measures to Power Rationing during the Period of Power Shortage).[11] Under this order, power shortage is categorized into four different levels of action reacting to the levels of power shortage: *línshí xìng jiǎnshǎo yòng diàn cuòshī* 臨時性減少用電措施 (temporary demand reduction measure), *qítā jǐnjí yīnyìng cuòshī* 其他緊急因應措施 (other emergency reaction measures), *xiàn diàn* 限電 (industrial sector power rationing), and *tíng diàn* 停電 (planned power disconnection) (MOEA 2006; Taipower Hsinchu Office 2015). In this executive order the legal term *power rationing* is used strictly, referring only to the situation when all other possible mitigation measures including temporary demand-reduction measures and other emergency measures have been exhausted, and the industrial sector starts to receive capped power provision.

However, Taipower has a different, managerial conceptualization of power rationing (see Fig. 4). On its disclosure webpage and publicly accessible documents, *emergency power rationing* refers to the totally unexpected and accidental loss of system balance where demand exceeds supply, for example, due to the system damage resulted from an earthquake. In this situation, the responsible division is the electricity dispatching unit. *Planned power rationing* refers to the situation when the measures are expected to be implemented the day after the decision is made by the operations unit (Taipower Hsinchu Office 2015; Taipower 2015b, 2015e), and this would include all four levels of the action listed in the executive order. Importantly, the key question is whether voluntary measures of demand reduction and emergency reaction measures are regarded as part of the ordinary system-balancing measures available to operators to avoid power rationing (as according to the executive order) or as types of power rationing, and thus extraordinary, according to Taipower. This is the key point that generates ambiguity in the whole debate.

The current usage of the term *power rationing* can be problematized. Industrial sector power rationing and planned power disconnection means that non-voluntary measures are imposed, while temporary demand-reduction measures and other emergency reaction measures are simply options available to the operator to balance the system. The need for this clarification is due to the fact that the "system operator can use mitigation actions to manage supply shortfalls, with little or no impact on customers in most cases" (OFGEM 2014: 23). More important, mitigation measures involve voluntary reductions or temporal displacement of demand. The electricity operator "can implement mitigation actions to solve capacity adequacy problems without disconnecting any customers" (OFGEM 2014: 28). In other words, mitigation measures are the available means of balancing the grid, which demonstrates the operator's resilience.

[11] An executive order does not need to be approved by the parliament, but is issued directly by the competent authority—in this case, the MOEA.

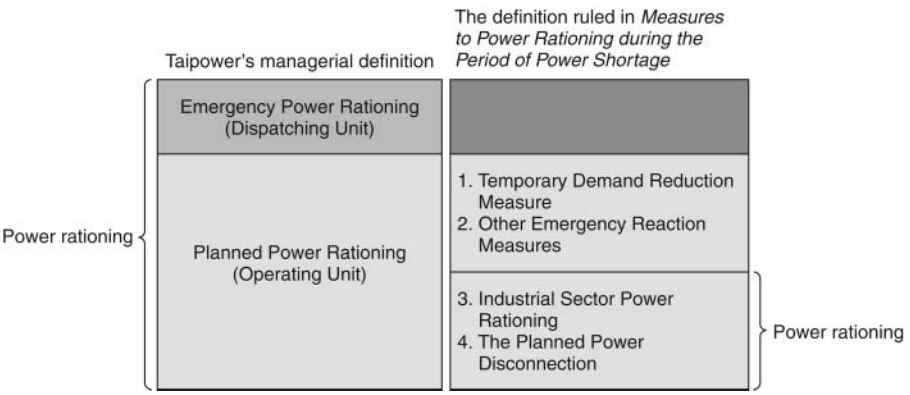


Fig. 4 Different definitions of the key concept of power rationing (MOEA 2006; Taipower Hsinchu Office 2015; Taipower 2015b, 2015e)

On the demand side, electricity operators have the ability to maneuver peak demand by implementing demand-side management measures. On the supply side, the generators can be kept in operation during peak time by implementing a well-performed work schedule of overhaul procedures. *Power shortage* for electricity operators simply means the tightening buffer zone that can be used to undertake system balancing; it does not necessarily mean that the ultimate measure of client disconnection must be done immediately so as to protect the system (OFGEM 2014). However, this point was not clarified by Taipower or the MOEA at the time.

Although the press release from the MOEA stressed that some forms of demand-reduction and mitigation measures would be implemented first before adopting more serious actions (MOEA 2015), these mitigation measures are still often referred to as "power rationing measures."[12] The ambiguity created here has political strength, especially when it comes to the asserted commitment to "no power rationing" pledged by the Nationalist administration, and the MOEA's clear preference for solving this predicament by adding more generation capacity through the construction and operation of the NPP4. For the engineers in the dispatching room, this ambiguity is created when a technical term travels from the dispatching room to the planners' office and thence to the public.

> Load restriction is the technical terminology of power rationing . . . the outside world probably won't tell the difference between emergency load restriction and planned load restriction. For them, they are both called power rationing. It is hard to ask the outsiders to share our perspectives, the perspectives of engineers. (Interviewee D2, 25 January 2016)

The term *power rationing* has strong political implications. Consciously or unconsciously, actively or passively, the bureaucratic planners bridging the two groups—the

[12] "After implementing power rationing measures, 1100MW peak demand can be curbed. This can add 3 percent more operating reserves to the system" (MOEA 2015).

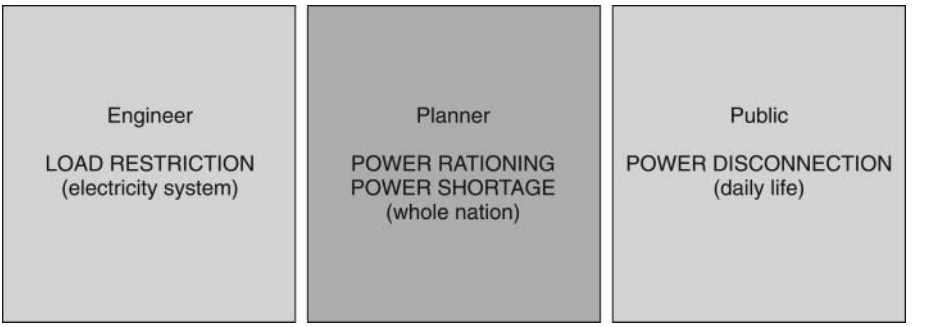


Fig. 5 Different concerns among Taipower engineers, governmental planners, and the general public regarding power restriction

dispatching engineers and the public—fail to highlight the different concerns embroiled in the different terms (see Fig. 5).[13]

As we noted above, nationalist high modernism as the dominant sociotechnical imaginary in the Taiwanese electricity sector can influence what is regarded as an accepted value, what is reasonable, and what is relevant—what is "the rationality" that we ought to follow. In this sense, it is inherently normative in its prioritization of adding more generation capacity to meet the nation's need and of declaring power shortage, instead of reinforcing the measures of demand-side response and mitigation. This is an implicit attempt to define what is salient and to be prioritized in energy politics in Taiwan. Now, any attempt to curb and maneuver power demand is framed as the declaration of power shortage, the most fearful and stressful scenario in the national predicament.

5 Making It Observable: The Public Witnessing of Operating Reserves

Being able to be observed is another crucial element of the nationalist-pragmatist storylines. The obsessive concern with the idea of power shortage in the nationalist-pragmatist storylines is also reinforced by the creation of observable indicators and objective figures—*bèizhuǎn róngliàng* 備轉容量 (operating reserves). When society transforms from an autocratic regime to a liberal-democratic government, the condition of the power supply should be directly witnessed by the public. Citizens, after all, are the primary targets for whom state enacts its scientific and technological demonstrations.

The inherent rule laid down by liberal-democratic politics is the possibility of knowing other people and of understanding and judging their actions, which requires the belief that true representation is achievable and that political agents can be held accountable by the public. "This faith has been upheld in the liberal-democratic

[13] As we clearly argued, by treating science and technology as a cultural enterprise does not mean that we are seeking the creator or the instructor of a sociotechnical culture. A culture is accumulated across time and (re)performed by numerous actors and materials, consciously or inadvertently, who may have different interests. However, we do think that the planners who have an engineering background and are at the position of bridging the two different concerns possess the key power of—implicitly or otherwise—making choices and elevating agendas.

Operating reserves level	≥ 10%	10%～6%	≤ 6%	Under 900,000 kW	Under 500,000 kW
Diagnosis and action	Ample	Tightening	More risk of power rationing	Power rationing alarm	Power rationing preparation

Fig. 6 The Precautionary Light Signal of Power Provision. The definition of each signal is explained in the following table (Taipower 2015d).

tradition by an optimistic political epistemology, according to which politics consists of actions or events that are observable and reportable as public facts" (Ezrahi 1990: 67). Technical-instrumental terms are constructed with the aim of externalizing and objectifying political actions in the visual space of publicly perceived facts (Ezrahi 1990). In this respect, the observable indicator of operating reserves presents an instrumental, immediate, real-time situation of national power provision. Operating reserve is the meter reading that can be obtained from the dispatcher's control panel. Compared to the probabilistic index such as loss of load expectation (LOLE; e.g., number of hours in one year), it is, in the words of one of Taipower's dispatchers, more "real and concrete" (Cheng 2011). Operating reserve shows in real time how many megawatts or how much capacity (percent) can be used for balancing purposes.

The idea is that the real situation should be visible to the general public. The figures showing how much operating reserve is available in real-time were put online because of public pressure. This information was regarded as internal data and was not released to the public (Cheng 2011) until 2013. One year after its release, the indicator scheme was online. This is the indicator scheme called Diànlì gōngyìng yùjǐng dēnghào 電力供應預警燈號 (Precautionary Light Signal of Power Provision). After a series of "warnings" of power shortage observed in June 2015, the classification was expanded even further (see Fig. 6). It was stated that when the operating reserve is under 500,000 kW, then "industrial sector power rationing" will be initiated. It was said that the expansion is to urge the public to "gòng tǐ shíjiān" 共體時艱 (make sacrifices on the basis of understanding and appreciation) to decrease the risk of power shortage (MOEA 2015).

Although the indicator scheme of operating reserves represents as "matters of fact" how much capacity is left for dispatching, it fails to capture the complexity of the "matters of concern" (Latour 2005) entangled in the institutionalized practices performed by Taipower. The meaning and diagnosis of every signal are not as static and mechanically rigid as the indicator scheme suggests. As suggested by interviewees W8 and D2:

> I guess [the handling of] operating reserve largely depends on dispatchers' experience. So there isn't a rigid quantitative mechanism behind the handing—it is decided by the conclusion of their internal meetings. Through the interaction with the dispatching office, I gradually realized that there are no fancy quantitative models like I assumed. Lots of things are based on their rule of thumb. (Interviewee W8, 28 January 2016)

> Power rationing often results from the unplanned outage of high-capacity generators. . . . This is why the dispatching unit needs to, in convention, prepare at least the equivalent operating capacity of the highest capacity generator [in the system] to react to the emergency situation. This can also be half the capacity of the highest capacity generator. The more operating reserve, the more provision stability—but it also means no economic efficiency. . . . In the isolated electricity grid like Taiwan, dispatchers [naturally] want more operating reserve. . . . I think this indicator scheme is invented on the basis of [the current dispatchers'] experience. In my opinion, it [the diagnosis of signals presented here] is slightly conservative. (Interviewee D2, 25 January 2016)

The launching of the indicator scheme should be understood as an effort to make the engineer's managerial figures into public facts through collective witness (Shapin and Schaffer 1985), while denying the need to examine the technical conventions that lie behind them. Through the collective witness of objective figures, the flexibility of the interpretation of operating reserves is diminished to an extent that the relevant experience and context is deleted and made into static rules. Power shortage as a political metaphor comprises a social amplification of what happens on the engineer's control panel; suddenly the meter reading of operating reserves becomes the most nerve-wracking fact for the whole nation.

6 Habituated Expertise in Electricity Planning: Net Peaking Factors

Over the years, the calculation of reserve margins (*bèiyòng róngliàng* 備用容量) and operating reserves (*bèizhuǎn róngliàng* 備轉容量) has come to dominate the public debate over electricity. The "proper understanding" of these two concepts is considered by different factions to be the crucial, if not the only, eligibility to take part in the debate. To an extent, they are seen as the only sensible way to discuss power shortage and electricity provision. Taipower has always argued that the concept of reserve margins is the most important factor that can be used to evaluate the stability of provision in electricity planning. Before going on, a short comparison between operating reserves and reserve margins can be helpful to exploring further the intricacy in Taipower's electricity planning. The term *reserve margins* is mainly used for long-term planning of system capacity, whereas the concept of *operating reserves* is used for measuring system resilience during day-to-day operation. They can both be represented as follows:[14]

[14] Mindful readers may have noticed that exactly the same equation is used for both reserve margins and operating reserves. This may result from Taipower's high modernist belief in making "factual certainty" that we are going to discuss at the end of this article. This peculiar situation indeed raises a deep question: How

$$\text{total available capacity} - \text{peak demand (in MW)}$$

$$\frac{\text{total available capacity} - \text{peak demand}}{\text{peak demand}} \times 100 \text{ (in \%)}.$$

The main difference between reserve margin and operating reserve can be summarized as below (Taipower 2015c, 2015d; Prada 1999) (see also Fig. 7).

Both reserve margin and operating reserve are predicted figures; however, they are based on very different time scales. The reserve margin is the estimated available extra capacity over one year and therefore is an estimated figure that does not take account of any reductions due to annual repair, temporary repair, unplanned outage, and other factors that interfere with the maximum power production of the total installed capacity. In contrast, operating reserve is the estimated available capacity on a specific day, which takes account of "recognized factors" in that day, such as annual repair, temporary repair, and unplanned outages, which are therefore itemized separately. Furthermore, Taipower's definition of the total availability in the calculation of reserve margins is regarded as "net peaking capacity in planning," defined as

$$\text{the nameplate capacity} \times \textit{net peaking factor}.$$

Net peaking factor (NPF) is a factor specific to different power generation technologies, decided by Taipower on the basis of certain assumed conditions. For gas or coal plants, it is (Taipower 2015b)

$$\frac{\text{installed nameplate capacity} - \text{power station internal consumption}}{\text{nameplate capacity}}.$$

For the hydro plants, it is

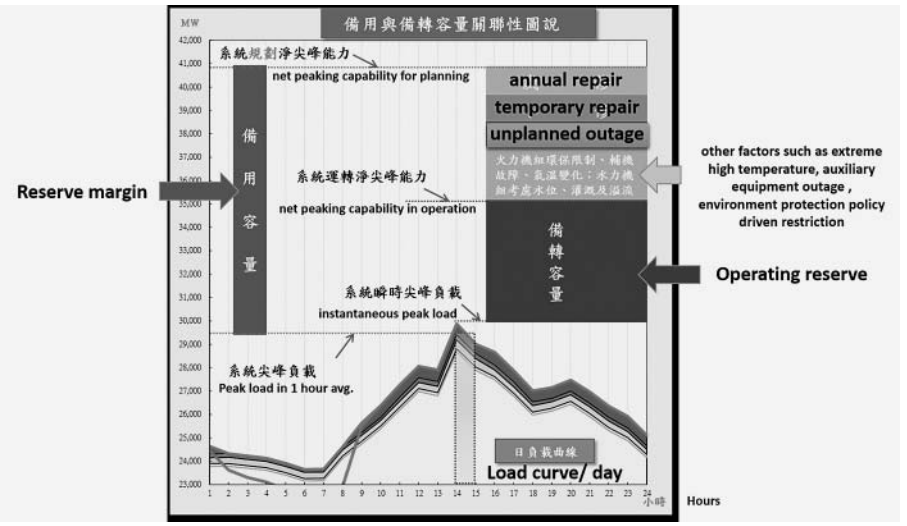
$$\frac{(\text{the maximum output with the water level in the dry season})}{\text{nameplate capacity}}.$$

For renewable energy technologies such as solar, wind, and biomass, technologies comparatively new to Taipower, the NPFs are simply "set" as assumed figures. The NPFs are summarized in Table 1 (Sun and Ge 2013).

NPFs are probably calculated not on the current actual output but simply by assuming the "right figures"—figures that are habituated in Taipower's institutional practices and are not regularly reviewed and checked. Interviewee D2 recognizes the inadequacy of the operating experience of renewable energy in Taipower, which contributes to the lack of checking and correcting the NPFs of renewable energy:

> Taipower currently has inadequate actual records of renewable energy generation. The accumulation of data is not enough; neither is the coverage of data. They [NPFs of renewables] should be revised accordingly in the future. As for

does one make sense at all of the difference between reserve margin (as a matter of the planned) and operating reserve (as a matter of fact), which is unrecognized uncertainties such as unplanned outages and delayed overhauls? We believe the answer is surprisingly simple: they are left in ambiguity (Wynne 1992). Also see n. 19.



Reserve margin	Operating reserve
The long-term ability of the system to meet the forecasted/expected demand.	The short-term ability to meet a given load.
In the long term, there is more uncertainty in planned construction of power plants and demand forecasts.	In the short term, there is less uncertainty about load forecast and capacity.
It is mainly used for *power development planning* purposes and is only released as one figure per year.	It is mainly used for *daily dispatching operation* and released as one figure per day.
The "total available capacity" is referred as "net peaking capacity *in planning* 系統規劃淨尖峰能力." This is total available capacity that *does not* recognise the unavailability caused by annual repair 歲修, temporary repair 小修, and unplanned outage 故障機組.	The "total available capacity" here is referred as "net peaking capacity *in operation* 系統運轉淨尖峰能力." It is a reduced figure that takes account of the unavailability caused by annual repair 歲修, temporary repair 小修, unplanned outage 故障機組, and other factors such as extreme high temperature 高溫, auxiliary equipment outage 輔機故障, and environment protection policy driven restriction 環保法規限制.

Fig. 7 The breakdown and comparison of reserve margins and operating reserve

> the operating reserve forecasted by the dispatching unit . . . it can always be forecasted on the basis of the recent actual generation results and the last year results. It [the forecast] should not be as conservative as it is in the power development unit. (25 January 2016)

The NPFs of renewable energy are habituated expertise in Taipower's electricity planning and treated as the "figures of consensuses," to be used instead of figures that would reflect the latest actual results of the newly constructed renewable installations. Yet they are used as facts in the internal discussion:

Table 1. The values of NPFs

Net peaking factor	
Nuclear	94%
Coal	94%
Gas	97.8%
Biomass	50%
Hydro	85.78%–40.15%
Solar	20%
Wind	6%

According to the American National Renewable Energy Laboratory, the value for solar should be in the range of 50–80 percent. For wind power, according to the Pacific Northwest National Laboratory it is 25 percent, which is close to the figure of 17–24 percent given by the Royal Engineering Academy. This information is based on the discussion documents available from the 2014 National Energy Convention, panel No. 2-1-8-3, "Renewable Energy Power Grid Integration Technology and Strategy" Zàishēng néngyuán diànlì xìtǒng bìng wǎng jìshù yǔ cèlüè 再生能源電力系統併網技術與策略 which can be accessed at http://2014energy.tw/image/download/area/2-1.pdf

> These figures are used to discuss the impact that the installation of renewables would bring to the national grid during an internal conference. The dispatcher referred to these figures to perceive the possible instability renewables bring when they are connected to the grid—can they support the huge demand in Taiwan? . . . These figures are the consensus in the group of people who engage in energy development. I visited the Institute of Nuclear Energy Research—they also use these figures. (Interviewee W8, 28 January 2016)

Interviewee W8 later told us that these NPFs are understood as "the average performance benchmark of a particular technology" (28 January 2016). It would not be challenged until a "new technology" or a "new generation" of a technology emerges. This implies that these figures are seen as not needing to be checked and reviewed against the latest actual generation results. This thought is echoed by the reply we received from the Power Development Office:

> It [net peaking capacity] is used for the purpose of calculating reserve margin and future power development. . . . The particular output of a renewable installation (solar or the wind) is influenced by the local weather conditions on that day, and therefore, the actual output/nameplate capacity ratio of the same type of renewable energy installations [in different places] on the same day would not be identical. The net peaking capacities of the solar and the wind power are calculated on the basis of the national average of output, not on the particular installation. (Interviewee P1, 28 January 2016)

This argument implies that, although renewables can vary greatly in their outputs, when they are included in the calculation of reserve margins, their contributing capacity is deemed a static—and low—figure. For the purpose of power development, these variations and irregularities need to be simplified to the extent that they do not affect the validity of the planning system. Precisely because their outputs can fluctuate hugely depending on where and when they are generating, a rigorous and up-to-date figure is

needed to reflect their possible contribution during peak times and seasons. Despite this being known, planning processes still mostly follow the convention and consensus, and deem the positive side of this variability irrelevant. The anchored expertise and planning culture can seriously restrict the emergence of new forms of planning order and of new ideas about how their conceptualization may be better founded to accommodate the transformation of the generation system. In fact, Taipower does have a definition on how to define an NPF of renewable energy calculated on the basis of actual generation results. According to the definition, for solar power it is as follows (Taipower, Power Development Office 2015: 2–4):

> Based on the output recorded from 10 hours to 17 hours every day in a year, the maximum power a generator can supply during this specific period for at least 85% of the time is defined as its net peaking capacity, that is, about 20% of the nameplate capacity.

For wind power,

> based on the output recorded every day in a year, the maximum power a generator can supply during this specific period for at least 85% of the time is defined as its net peaking capacity, that is, about 6% of the nameplate capacity.

Two key implications need to be highlighted in terms of the technical choice made by Taipower here: The first, the standard of "the capacity available in the 85 percent of the time" can be considered as strict, especially for intermittent generation technologies like renewables. According to a report commissioned by Taipower in 1996, this is a standard originally designed for coal-fired technology because it can always produce stable output throughout a year. Under this standard, the contribution of renewables to the total net peaking capacity (the total availability in reserve margin calculation) is significantly underestimated, and therefore, the standard should be set as the capacity available in 50 percent of the time instead of 85 percent of the time to avoid the "zero contribution" scenario of solar power (Wang 1996). Taipower since has made a revision to the definition; however, the 85 percent standard originating from the incumbent coal-fired generation is proving to be a convention too firmly rooted in institutional practice to be easily changed.

The second and most important reason to calculate "net peaking capacity for planning (the total availability/supply)" is to examine whether during peak time the supply can meet the demand. While taking account of the whole output record for a year is quite sensible for the incumbent generation technologies like nuclear, coal-fired, and gas-fired power because they can always produce stable output, this rule becomes problematic for renewables—it may be seen as discrimination against renewable energy.[15] The output of renewables can fluctuate quite remarkably depending on weather conditions, meaning that the weather patterns in different seasons are a crucial factor that should not be neglected. Summer and early autumn are the traditional peak time in Taiwan energy use, due to the wide use of air conditioning, and fortunately

[15] According to the British government's *Electricity Market Reform Delivery Plan*, the calculation of derated margin only takes account of the output records during the peak season—that is, the winter season in the United Kingdom. The policy document can be accessed at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268221/181213_2013_EMR_Delivery_Plan_FINAL.pdf.

photovoltaics can produce much higher output at this time than in winter. In this scenario, the renewable is meant not to replace "base load" generation but to help meet peak demand during the year.

To summarize this section, NPFs have their politics and are a concentrated form of implicit social meaning making: correct knowledge makes normativity. Presented as facts grounded in consensus and objectivity, they are enacted as measures of the inherent technical capacity of generation technologies, a part of habituated technical know-how, the "correct" understanding of which is a qualification for engaging in debates about electricity planning.[16]

7 Ordering the Future: The Creation of Factual Certainty

While the concept of reserve margins is so established in the debate that it is treated as a common language crossing different competing factions, the question of whether it is a reasonable and sufficient reserve margin produces no fertile outcome and fails to generate a reflection on the presumed rationality in current electricity planning. A comparison between reserve margins and its British counterpart can bring out the different rationalities that are enmeshed in the technicality of electricity planning in the two countries. In the British electricity industry, the total availability when calculating reserve margins is clearly treated as a rough, imprecise, and hypothetical figure, as it only shows the designed capacity in an ideal environment such as a laboratory. As explained by the Royal Academy of Engineering (2013: 9), "Traditionally, total available capacity was taken as the sum of full *theoretical* or *nameplate* capacities of all plant on the system." The definition stresses its "gross" attribution of listed capacity; therefore, it can also be called as "gross capacity" (Royal Academy of Engineering 2013). This total availability registers an ideal situation that indicates the desirable future the electricity development planners are aiming for; however, it is also marked clearly as an indicative target for its own institutional purposes.[17]

However, for Taipower, the use of reserve margins is, without a doubt, more than a purely hypothetical and indicative figure. It is the figure used in planning an energy future for the whole nation, a part of statecraft that simplifies or even ignores uncertainty such as unplanned outages and delayed overhauls, as they are not itemized separately. It is not hard to comprehend why Taipower's conceptualization of reserve margins relies heavily on making factual certainty. For Taipower engineers to

[16] Habituated know-how, expertise (e.g., NPFs), and the deemed legitimate technical qualifications are all constitutive components of what Thomas P. Hughes (1987) calls "technological momentum." However, as has been demonstrated by our interviewees, the momentum in this case study is best described as having been "passed through peers without facing challenges," rather than being created for a particular purpose. If we trace back to the point when this scheme of margins was created, we may find that its creation is a part of the pragmatic problem solving that engineers do on a daily basis, and which bears no clear wider intention. We argue this is exactly how technopolitics are "in-the-making" and may reflect a distinctive feature of technopolitics, that it is not necessarily done with a clear self-explanation.

[17] "In the past, the CEGB [Central Electricity Generating Board] would typically have planned the system on the basis of maintaining a 20 percent gross capacity margin" (Royal Academy of Engineering 2013: 9). However, regarding the forecasted margins, such as in OFGEM 2014, they are treated as highly constructed scenarios and therefore, indicative and suggestive futures. This point is clearly stated by OFGEM.

comprehend the more-than-complicated indeterminacy of both supply and demand sides and fulfill their collectivist responsibility, indeterminacy must be reduced to certainty. In this sense, adding more capacity, even more than the recognized unavailability, is the most pragmatic way to secure "sufficient" provision and a potent national economy.[18] Factual certainty is required and used in public persuasion, which thus demands authoritative commitment in public authority. Uncertainty has to be ruled out. The hypothesis on the engineers' paper needs to become established reality.

Last but not least, while in the British electricity industry the obsolescence of reserve margins is gradually recognized due to the rising contribution of renewable energy in the generation system, Taipower has no intention to follow suit.[19] For them, the incumbent generation technologies such as nuclear, coal-fired, and gas-fired can provide high controllable availability for planning tasks, while the renewables give no clear guarantee on how much capacity can be assured as available. Judged by the standard of proving controllable availability and stability, the renewables are seen as truly "immature" as they can merely provide as low as 6 percent availability in wind power when traditional generation technology can provide as high as 94–97.8 percent. The entrenched planning practices originating from the incumbent generation technologies keep enacting the renewables as "immature" technology. The characteristics of an intermittent generation of renewable technologies bring a huge challenge to institutionalized convention and therefore to Taipower's planners. The lack of controllable availability and stability of renewable energy perceived by the Taipower engineers creates huge irregularity for their high modernist statecraft. The so-called immaturity of renewable energy does indeed reveal the incompatibility of renewables with the incumbent planning conventions.[20] The habituated expertise of incumbent generation technology that emerged from Taiwan's authoritative and high modernist past is hindering the line of sight to a new energy system.

8 Conclusion: The Rationality of Authoritarian Developmental Planning and Beyond

The nationalist high modernist commitment to a better future for the whole nation and society constitutes the backbone of the nationalist high modernist storylines in

[18] The idea of a buffer zone (the reserve margins) is quite common and understandable. However, if the operator always expects unplanned outages and delayed overhauls and does not seek the reasons why they happen and where possible reduce them, then a huge buffer zone would be indeed "required." Also see nn. 8 and 14.

[19] Derated capacity/margin is a concept enjoying increasing preference and replacing reserve margins as the main concept of electricity planning task in the United Kingdom. The preference for derated margins comes from the growing contribution made by renewables in the generation system, which makes the concept of reserve margin obsolescent. Under this concept, the nameplate capacity is derated by "a factor which reflects the statistically expected level of reliable availability from that plant type during a given season" (Royal Academy of Engineering 2013: 9). This gives renewables and traditional generation technologies equal footing, as the available capacity of both technologies are now equally evaluated through historical records of availability in the peak season.

[20] Drawing on the experience of the British electricity industry, it is possible to treat renewable energy as a stable source of provision. The emergence of the concept of "equivalent firm capacity" of renewable energy is a good example. Of course, it will still depend on an auxiliary power storage system.

Taiwanese energy politics. The technical choices involved in putting exclusive emphasis on supply-side measures and much less attention on demand-side dynamics, the intensified public testimony of operating reserves, and the obvious preference for creating factual certainty can only be comprehended through taking the larger historical-cultural and institutional context into account. We would argue that in Taipower's imaginary, the engineers, as pragmatic doers and foresighted planners, are expected to orchestrate materials and social order to validate their blueprint for society and public authority: a prosperous energy future is prescribed by Taipower's engineers, and society should follow the prescribed path to it. This is the underlying vision of developmental planning that was born in the postwar era when an authoritarian state-society relationship was firmly in place. This involves a rationality of authoritarian developmental planning, the tendency to merge broad and rich social meanings into a simplified logic of planning, with the effect of reinforcing the unstated authoritarian commitment and suppressing alternatives. Although Taiwanese politics and society are largely liberalized and democratized since the lifting of martial law in 1987 after a thirty-eight-year-long White Terror, and despite the fact that policy discourses can shift rather quickly following a democratic election and the ensuring change of government, we believe these technically formed agendas and institutionalized practices do not change overnight.[21] They are where a specific sociotechnical imaginary gains its durability.

The fertile social and environmental movements since the 1970s have paved the way and provided momentum for democratization and the shakeup of the nationalist high modernist imaginary. The people no longer act as a passive audience of the demonstration of high modernist statecraft; instead, the people started to actively express their feelings, claiming "body sovereignty" and social legitimacy, and on the basis of these asserting their political and legal rights (Lii and Lin 2000, 2003). This alternative imaginary focuses on local issues, Xiāngtǔ 鄉土 (native soils) attached memory, and directly voiced concerns (Lii and Lin 2000, 2003; Hsiau 2005, 2010; Wu and Lii 2005; Ho and Lin 2011). In this very different dreamscape of modernity, the people are imbued with memories, emotions, and local experiences. For them, modernity requires participatory democracy (Lii 2009). Following this trajectory, the anti-nuclear (NPP4) movement initiated in the 1980s certainly played an indispensable role in redefining nuclear energy as a hybrid of US hegemony, nationalist autocracy, and technocracy and at the same time foregrounding the Democratic Progressive Party as the vanguard of political reform (Tsui 2011).

Notwithstanding, since the beginning of the 1990s, this imaginary (which we tentatively call a "indigenist-reformist rationality") was, bit by bit, transformed by the

[21] Through the long history of the anti-NPP4 movement, Taipower came under serious criticism from several "outsider" experts, such as Mo-Shing Chen 陳謨星 (IEEE Fellow, a doctor of electrical engineering), Li-Wei Ho 賀立維 (a doctor of nuclear engineering), and Ming-Hui Peng 彭明輝 (a doctor of control engineering) for its electricity planning decisions; however, these criticisms were rejected and deemed as fallacious by Taipower and had only minimal impact. The Chinese Institute of Engineers (Taiwan) mostly stayed outside the debate while dismissing public fears of nuclear power as based on ignorance. This illustrates how Taipower's planning decisions and practices are mainly sheltered from critique. Despite many changes being made to the Electricity Act in 2016, since which the prediction of reserve margins is not announced to the public and the procedure of power rationing has been explained thoroughly by the MOEA in the latest development in August 2017, this does not mean that the whole regime of incumbent power development has been examined and reformed.

expansion of the expertise-based advisory scheme (Lii and Lin 2003; Ho 2003) losing its grassroots vitality (Tsui 2011). The most broadly documented case is the scheme of the environmental impact assessment; consciously or inadvertently, it operates as a very practical (often developmental) problem-solving process dominated by experts, who are seen as having been a "virtual commission" by the public to give advice to the government.[22] The environmental impact assessment demonstrates the tendency of "solving expertise problems by bringing in even more expertise" (Tang and Chiu 2010; Tu 2012). A developmental Leviathan, as obscure as it may be, still hovers over the institutionalized conventions and habituated expertise of Taiwanese society. With the new wave of civil movements surging from the late 2000s, the milestones of the 2014 Sunflower Movement, the NPP4 mothballed in 2015, and the new initiatives of renewable energy usage and installation (Chiu 2014; Yang 2015), how can we STS researchers help society go further by scrutinizing the admixture of the rationality of developmental planning, expertise, and technopolitics?

The role of knowledge and expertise in policy making should not be simply seen as unproblematic or obvious. It should be considered as a situated cultural enterprise which expresses values, preferences, and beliefs in the forms of both policy discourses and material arrangements. Clearly, the ways of doing electricity planning we investigated here are far from being, as is claimed, purely instrumental and unpolitical; the power of technopolitics can only be understood and fully explored when we take the larger historical-cultural and institutional context into account and shift our research focus from identifying interests to revealing the dominant and often hegemonic imaginary. It has been a key element of our account that "democratic participation" in modernizing Taiwan of the late twentieth/early twenty-first centuries remains underarticulated and emergent.[23] However, we also suggest that this case study of political contestation over imagined energy futures for Taiwan and over their corresponding imaginaries of Taiwan's social-political future is one of the main historical vehicles for whatever form(s) a more democratically developed Taiwan will take. When we consider the issue of how experts of the kind we have described in the Taiwanese energy case imagine their publics, an issue with a growing literature in Western societies (Rommetveit and Wynne 2017), the conclusion has to be that "the public" that the powerful expert culture has imagined or recognized is weakly articulated. The changes since the new government was voted in in 2016 appear to reflect an imaginary of a public that is able to respond to a more flexible and less centrally managed energy system, and one that does not require the supposed security of a paternalistic nuclear technopolitical culture.

Finally, developmental high modernism in East Asia is characterized by the authoritarian reflex of planning rationality, which is by definition monolithic and thus with no imaginary of complex multiplicity. This rationality gives paramount political weight to a particular imaginary of a collectivist public good that is crafted through performative technicality in constructing the impartiality and objectivity of public authority.

[22] In a liberal democracy, when encountering more and more critiques, the instinct of high modernists is often to intensify their high modernity, deploying yet more mathematical equations and formulas. The renewable energy's FITs (feed-in tariffs) committee is a good example.

[23] This is not to assume any teleological dynamic of inevitable progress toward a democratic ideal in the absence of effective countervailing factors.

All of this posits a critical question: How can we disagree with the salient call for public welfare found in such statist technoscientific programs and authoritative past, while still agreeing that the "public good" as the underlying generic imaginary in democratic society is still very relevant for guiding the ways in which technologies are imagined and materially enacted? The interpretation of the concerns and ontologies that we have attempted in this case study of energy in Taiwan and their articulation and material enactment in public processes could be a next step for future research; however, as yet, public mobilization in this case remains weak, and thus the public issue itself remains to be more fully articulated. At this point, sociological research would begin to merge with political action.

References

Amsden, Alice H. (2001). *The Rise of the Rest: Challenges to the West from Late-Industrialization Economies*. Oxford: Oxford University Press.

Callon, Michel (1987). "Society in the Making: The Study of Technology as a Tool for Sociological Analysis." In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, edited by Wiebe E. Bijker, Thomas Parke Hughes, and Trevor Pinch, 83–104. Cambridge, MA: MIT Press.

Chang, Kuo-Hui (2013). "The Leviathan That Nationalism Longed For: The Chinese Background of Taiwan's Technocracy." *Journal of National Development Studies* 12, no. 2: 73–132.

Cheng, Chin-Lung (2011). "On Reserve Margin and Operating Reserves." 9 June. https://gordoncheng.wordpress.com/2011/06/09/.

Chen, Dung-Sheng (2015). "We Have Never Been Latecomers: A Critical Review of High-Tech Industry and Social Studies of Technology in Taiwan." *East Asian Science, Technology and Society* 9, no. 4: 381–96.

Chen, Liang-Chih (2012). "The Evolving Roles of the State and Public Research Institutes in the Technological Upgrading Process of Industries: The Case of Taiwan's Machine Tool Industry." *Journal of Social Sciences and Philosophy* 24, no. 1: 19–50.

Chiu, Hua-Mei (2014). "New Ideas for Energy Use: Small Is Beautiful." In *Sociology at the Street Corner*, edited by Hong-Zen Wang, 234–40. Taipei: Common Master Press.

Chu, Wan-Wen (2007). "Inquiries into the Causes of Taiwan's Postwar Economic Development." *Taiwan: A Radical Quarterly in Social Studies* 200703, no. 65: 1–33.

Chu, Wan-Wen (2010). "First-Generation Industrial Entrepreneurs in Postwar Taiwan." *Taiwan Historical Research* 17, no. 2: 39–84.

Chu, Wan-Wen (2011). "Democratization and Economic Development: The Unsuccessful Transformation of Taiwan's Developmental State." *Taiwan: A Radical Quarterly in Social Studies* 201109, no. 84: 243–88.

Cumings, Bruce (1999). *Parallax Visions: Making Sense of American-East Asian Relations at the End of the Century.* Durham, NC: Duke University Press.

Dore, Ronald (1990). "Reflections on Culture and Social Change." In *Manufacturing Miracles: Paths of Industrialization in Latin America and East Asia*, edited by Gary Gereffi and Donald Wyman, 353–67. Princeton, NJ: Princeton University Press.

Eisenstadt, Shmuel (2000). "Multiple Modernities." *Daedalus* 129, no. 1: 1–30.

Ezrahi, Yaron (1990). *The Descent of Icarus: Science and the Transformation of Contemporary Democracy.* Cambridge, MA: Harvard University Press.

Greene, J. Megan (2008). *The Origins of the Developmental State in Taiwan: Science Policy and the Quest for Modernization*. Cambridge, MA: Harvard University Press.

Hajer, Maarten (2006). "Doing Discourse Analysis: Coalitions, Practices, Meaning." In *Words Matter in Policy and Planning: Discourse Theory and Method in the Social Sciences*, edited by Margo Brink and Tamara Metze, 65–74. Utrecht: Netherlands Graduate School of Urban and Regional Research.

Hecht, Gabrielle (1998). *The Radiance of France: Nuclear Power and National Identity after World War II.* Cambridge, MA: MIT Press.

Ho, Ming-Sho (2003). "Political Democratisation and Institutionalisation of Environmental Movement in Taiwan (1993–1999)." *Taiwan: A Radical Quarterly in Social Studies* 200306, no. 50: 217–75.

Ho, Ming-Sho, and Hsiu-Hsin Lin, eds. (2011). *The Era of Social Movements: Taiwan's Social Activism in the Past Two Decades*. Taipei: Socio.

Hsiau, A-Chin (2005). "Generational Identity and Historical Narrative: The Emergence of the 'Back-to-Reality' Generation in 1970s Taiwan." *Taiwanese Sociology* 200506, no. 9: 1–58.

Hsiau, A-Chin (2010). "A 'Generation in-Itself': Authoritarian Rule, Exilic Mentality, and the Postwar Generation of Intellectuals in 1960s Taiwan." *Sixties* 3, no. 1: 1–31.

Hsiau, A-Chin (2013). "The Emergence of De-exile: Cultural Politics and the Postwar Generation in Taiwan." *Oriens Extremus* 52: 173–214.

Hughes, Thomas P. (1987). "The Evolution of Large Technological Systems" In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, edited by Wiebe E. Bijker, Thomas Parke Hughes, and Trevor Pinch, 51–82. Cambridge, MA: MIT Press.

Ichijo, Atsuko (2013). *Nationalism and Multiple Modernities: Europe and Beyond*. London: Palgrave Macmillan.

Jacobs, J. Bruce (2012). *Democratizing Taiwan*. Leiden: Brill.

Jacobs, J. Bruce (2013). "Whither Taiwanization? The Colonization, Democratization, and Taiwanization of Taiwan." *Japanese Journal of Political Science* 14, no. 4: 567–86.

Jasanoff, Sheila (1996). "Beyond Epistemology: Relativism and Engagement in the Politics of Science." *Social Studies of Science* 26, no. 2: 393–418.

Jasanoff, Sheila (2004). "Ordering Knowledge, Ordering Society." In *States of Knowledge: The Co-production of Science and the Social Order*, edited by Sheila Jasanoff, 25–98. London: Routledge.

Jasanoff, Sheila (2005). *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton, NJ: Princeton University Press.

Jasanoff, Sheila (2015). "Future Imperfect: Science, Technology, and the Imaginations of Modernity." In *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*, edited by Sheila Jasanoff and Sang-Hyun Kim, 1–33. Chicago: University of Chicago Press.

Jasanoff, Sheila, and Sang-Hyun Kim (2009). "Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea." *Review of Science, Learning and Policy* 47, no. 2: 119–46.

Kim, Sang-Hyun (2013). "The Politics of Human Embryonic Stem Cell Research in South Korea: Contesting National Sociotechnical Imaginaries." *Science as Culture* 23, no. 3: 1–27.

Kim, Sang-Hyun (2015). "Social Movements and Contested Sociotechnical Imaginaries in South Korea." In *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*, edited by Sheila Jasanoff and Sang-Hyun Kim, 152–73. Chicago: University of Chicago Press.

Kirby, William C. (1990). "Continuity and Change in Modern China: Economic Planning on the Mainland and on Taiwan, 1943–1958." *Australian Journal of Chinese Affairs* 199007, no. 24: 121–41.

Latour, Bruno (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Li, Kwoh-Ting (1987). *Work and Faith—Witness of Taiwan's Economic and Social Development*. Taipei: Economic and Life Publishing (Commonwealth Publishing).

Lii, Ding-Tzann (2009). "How Is Democracy Possible: The Review of 20-Year Democratization in Taiwan." *Reflexion* 200903, no. 11: 133–39.

Lii, Ding-Tzann, and Wen-Yuan Lin (2000). "The Cultural Origins of Social Forces: The Historical Formation of Perception of Environmental Rights in Taiwan 1970-86." *Taiwan: A Radical Quarterly in Social Studies* 200006, no. 38: 133–206.

Lii, Ding-Tzann, and Wen-Yuan Lin (2003). "The Transformation of Social Forces: Organizational Techniques in Taiwan's Environmental Protests." *Taiwan: A Radical Quarterly in Social Studies* 200312, no. 52: 57–119.

Lin, Lan-Fang (2013). "The National Resources Commission's Takeover of Taiwan Power Company in the Early Post-war Period (1945–1952): Technology and Engineers." *Bulletin of the Institute of Modern History Academia Sinica* 201303, no. 79: 87–135.

MOEA (Ministry of Economic Affairs) (2006). *Diànyuán bùzú shíqí xiànzhì yòng diàn bànfǎ* 電源不足時期限制用電辦法 (*Measures to Power Rationing during the Power Shortage Period*). Executive Order 09500658170. Taipei: Ministry of Economic Affairs.

MOEA (Ministry of Economic Affairs), Bureau of Energy (2012). *Xīn néngyuán zhèngcè yǔ jiénéng jiǎn tàn pèitào cuòshī* 新能源政策與節能減碳配套措施 (*New Energy Deal and Carbon Reduction Action Plan*). Taipei: Ministry of Economic Affairs.

MOEA (Ministry of Economic Affairs), Bureau of Energy (2014a). *Wǒguó diànlì xūqiú líng chéngzhǎng pínggū bàogào* 我國電力需求零成長評估報告 (*The Assessment Report on the Possibility of Zero Electricity Demand Growth*). Taipei: Ministry of Economic Affairs.

MOEA (Ministry of Economic Affairs), Bureau of Energy (2014b). *Diànlì jīngyíng kěkào wěndìng* 電力經營可靠穩定 (*Operating Electricity: Reliability and Stability*). Taipei: Bureau of Energy.

MOEA (Ministry of Economic Affairs), Bureau of Energy (2015). "The Soaring Temperature This Summer Creates Tension in Electricity Provision Service." Jīnnián xiàjì qìwēn biāo gāo gōngdiàn chījǐn 今年夏季氣溫飆高供電吃緊 http://www.moea.gov.tw/MNS/populace/news/News.aspx?kind=1&menu_id=40&news_id=43088.

Moore, Aaron Stephen (2014). "Japanese Development Consultancies and Postcolonial Power in Southeast Asia: The Case of Burma's Balu Chaung Hydropower Project." *East Asian Science, Technology and Society: An International Journal* 8, no. 3: 297–322.

Nye, David E. (2010). *When the Lights Went Out: A History of Blackouts in America*. Cambridge, MA: MIT Press.

OFGEM (Office of Gas and Electricity Markets) (2014). *Electricity Capacity Assessment Report 2014.* London: Ofgem E-serve.

Porter, Theodore M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. Princeton, NJ: Princeton University Press.

Prada, José Fernando (1999). *The Value of Reliability in Power Systems-Pricing Operating Reserves.* Cambridge, MA: Energy Laboratory of MIT.

Rommetveit, Kjetil, and Brian Wynne (2017). "Technoscience, Imagined Publics and Public Imaginations." *Public Understanding of Science* 26, no. 2: 133–47.

Royal Academy of Engineering (2013). *GB Electricity Capacity Margin.* London: Royal Academy of Engineering.

Scott, James C. (1998). *Seeing like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, CT: Yale University Press.

Shapin, Steven, and Simon Schaffer (1985). *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton, NJ: Princeton University Press.

Smith, Anthony (1983). *Theories of Nationalism*. New York: Holmes and Meier.

Sun, Ting-Rui, and Fu-Guang Ge (2013). *The Introduction of Capacity and Net Peaking Factors in Power Generation.* Taoyuan: Nuclear Energy Institute, Atomic Energy Council.

Taipower (2014). "Táidiàn chángqí diànyuán kāifā fāng'àn" 台電長期電源開發方案 (Taipower's Long-Term Power Development Plan [10302]) (https://fmaw.itri.org.tw/PGSRAIS/images/4-1-4.pdf).

Taipower (2015a). "Lìshǐ yǔ fāzhǎn" 歷史與發展 (Development and History) (http://www.taipower.com.tw/content/about/about01.aspx).

Taipower (2015b). *Diànlì xiǎo cídiǎn* 電力小辭典 (*The Electricity Dictionary*) (http://info.taipower.com.tw/left_bar/45453err/Electric_dictionary.htm).

Taipower (2015c). "Bèiyòng róngliàng zhī shuōmíng" 備用容量之說明 (The Introduction to Reserve Margin) (http://www.taipower.com.tw/content/new_info/new_info-33.aspx?LinkID=13).

Taipower (2015d). "Jīnrì diànlì zīxùn (Jīnrì bèi zhuǎn róngliàng lǜ)" 今日電力資訊 (今日備轉容量率) (Today's Power Condition [Today's Operating Reserves]) (http://www.taipower.com.tw/content/new_info/new_info_in.aspx?LinkID=26).

Taipower (2015e). "Xiàn diàn de zhǒnglèi" 限電的種類 (The Types of Power Rationing) (http://www.taipower.com.tw/content/new_info/new_info-d23.aspx?LinkID=23).

Taipower (2016). "Táidiàn 70 wèi nǐ ér zài; gōngsī chénglì 70 zhōunián qìngzhù dàhuì dǒngshì zhǎng zhìcí" 台電 70 為你而在; 公司成立 70 周年慶祝大會董事長致詞 (Taipower Is Here for You, 70 Years On—The Speech by the Chairman at the Seventieth Anniversary Ceremony) (http://tpcjournal.taipower.com.tw/article/index/id/392).

Taipower Hsinchu Office (2015). "Gōngyè yònghù xiàn diàn jí fēnqū lúnliú tíngdiàn" 工業用戶限電及分區輪流停電 (Industrial Sector Power Rationing and Planned Power Disconnection). Hsinchu: Taipower Hsinchu Operation Office (www.asip.org.tw/userfiles/file/2015/Hsinchu/1040512e2.pdf).

Taipower, Power Development Office (2015). *104 Nián chángqí diànyuán kāifā fāng'àn* 104 年長期電源開發方案 (*2015 Long-Term Power Development*). Taipei: Power Development Office.

Tang, Ching-Ping, and Chung-Yuan Chiu (2010). "Professionalism and Democracy: The Operation and Adaptation of Environmental Impact Assessment in Taiwan." *Journal of Public Administration* 201006, no. 35: 1–28.

Tsai, Wei-Hsien (2006). "The Analysis of Policy Process in Taiwan's IC Industry." PhD diss., Department of Political Science, Soochow University.

Tsui, Su-Hsin (2011). "The History and Tactics of Taiwan's Anti-nuclear Movement from the 1980s until 2011 (Taiwan Association for Human Rights)." Táiwān fǎnhé yùndòng de lìshǐ yǔ cèlüè, cóng 1980 zhì 2011(Táiwān rénquán cùjìn huì) 台灣反核運動的歷史與策略, 從 1980 至 2011 (臺灣人權促進會) https://www.tahr.org.tw/publication/113.

Tu, Wen-Ling (2012). "Expert Meetings in the Environmental Impact Assessment Process: The Framed Expert's Rationality." *Taiwan Journal of Democracy* 9, no. 3: 119–55.
Wang, Jenn-Hwan (2007). "From Technological Catch-up to Innovation-Based Economic Growth: South Korea, Taiwan, and China." *Taiwan: A Radical Quarterly in Social Studies* 200712, no. 12: 177–226.
Wang, Jenn-Hwan, and Ching-Jung Tsai (2009). "National Models of Technological Catching Up and Innovation: Patent Patterns of Taiwan and South Korea Compared." *Taiwan: A Radical Quarterly in Social Studies* 200903, no. 73: 39–76.
Wang, King-Min (1996). *The Assessment on the Criteria of Renewable Energy Efficiency.* Taipei: Chung-Hua Institution for Economic Research.
Welsh, Ian, and Brian Wynne (2013). "Science, Scientism, and Imaginaries of Publics in the UK: Passive Objects, Incipient Threats." *Science as Culture* 22, no. 4: 540–66.
Winner, Langdon (1980). "Do Artifacts Have Politics?" *Daedalus* 109, no. 1: 121–36.
Wu, Jieh-min, and Ding-tzann Lii (2005). "Channeling Sensus Communis: An Analysis of the Rhetorical Models in the Public Sphere of the Lin-He Community, Taiwan." *Taiwanese Sociology* 200506, no. 9: 119–63.
Wynne, Brian (1992). "Uncertainty and Environmental Learning: Reconceiving Science and Policy in the Preventive Paradigm." *Global Environmental Change* 2, no. 2: 111–27.
Wynne, Brian (1996a). "May the Sheep Safely Graze? A Reflexive View of the Expert-Lay Knowledge Divide." In *Risk, Environment, and Modernity: Towards a New Ecology*, edited by Scott Lash, Bronislaw Szerszynski, and Brian Wynne, 44–83. London: Sage.
Wynne, Brian (1996b). "SSK's Identity Parade: Signing-up, Off-and-on." *Social Studies of Science* 26, no. 2: 357–91.
Wynne, Brian (2008). "Elephants in the Rooms Where Publics Encounter 'Science'? A Response to Darrin Durant, 'Accounting for Expertise: Wynne and the Autonomy of the Lay Public.'" *Public Understanding of Science* 17, no. 1: 21–33.
Wynne, Brian (2010 [1982]). *Rationality and Ritual: Participation and Exclusion in Nuclear Decision-Making*: London: Earthscan.
Wynne, Brian (2011). "Lab Work Goes Social, and Vice Versa: Strategising Public Engagement Processes." *Science and Engineering Ethics* 17, no. 4: 791–800.
Wynne, Brian (2014). "Further Disorientation in the Hall of Mirrors." *Public Understanding of Science* 23, no. 1: 60–70.
Wynne, Brian, and Kerstin Dressel (2001). "Cultures of Uncertainty—Transboundary Risks and BSE in Europe." In *Transboundary Risk Management*, edited by Oanne Linnerooth-Bayer, Ragnar E. Lofstedt, and Gunnar Sjostedt, 121–54. London: Earthscan.
Yang, Hung-Jen (2015). "Reassembling Solar Farms, Reassembling the Social: A Case Study of Pingtung County in Southern Taiwan." *East Asian Science, Technology and Society: An International Journal* 9, no. 4: 359–79.

Chih-Yuan Yang has a PhD in sociology from Lancaster University, UK. The title of his thesis is "Socio-technical Imaginary and Rationality: Political Factuality and Public Authority in Taiwanese Energy Politics." He emphasizes the cumulative process of meaning-making and tacitly exerted power in the technoscientific knowledge "informed" policy-making. Observing the making-and-doing of mundanity and exploring different ontologies grounded in civil society, he seeks to enrich the democratic understanding of technoscience through STS research. His analytical approach includes anthropological-STS/SSK and interpretive policy analysis.

Bronislaw Szerszynski is a reader in sociology at Lancaster University, UK. His research combines approaches from the social and natural sciences, humanities, and the arts. He has researched and published on religion and technology, environmental movements and societal conflicts over biotechnology, food futures, and climate engineering. His recent work seeks to situate the changing relationship between humans, environment, and technology in the longer perspective of human and planetary history.

Brian Wynne is professor (emeritus) of science studies at Lancaster University, UK, and professor II of radioactivity and public risk at the Norwegian University of the Life Sciences. He has worked on the social construction of scientific knowledge as authority in public arenas where public issues involving scientific knowledge are mistakenly described as scientific issues. As he has described in many publications, a key arena where this is enacted is that of risk assessment, which has become a key domain where this ambiguity is often mistakenly scientized, with self-defeating consequences for the public authority of such science.