Nuclear Power in China: How it Really Works

By Xu Yi-chong

China is one of the few countries in the world firmly committed to rapidly expanding the use of nuclear power. In so doing it has adopted the formal trappings of international standards and regulations. Despite this, Xu Yi-chong argues that the corporate, governmental and regulatory framework in China remains confusing and captive to many entrenched interests that interfere with a clear and safe regulatory environment.

WHILE MUCH OF THE WORLD is debating the contentious question of whether to have a nuclear program, China has made up its mind. Indeed, 40 percent of the nuclear reactors under construction in the world (26 out of 63) are located in China, where a combination of rationales — energy security and diversity, climate change mitigation and building a "nuclear hedge" — have been used to endorse the drive to go nuclear.

China's official line is that nuclear energy is essential for the future because it is clean, can meet base-load demands in densely populated areas and represents state-of-the-art technology with positive spill-over effects that can enhance the productivity of capital, labor and other factors of production in the economy.

Even though the decision to start a civilian nuclear energy program began in the 1970s, a concerted effort to greatly expand nuclear energy capacity was made in the past decade. Between 2001 and 2005, eight units were planned, six started construction and six were connected to grids. In the following five years, 10 units were planned and all started construction, another four were hooked up to the grid. By 2010, 16 provinces, regions and municipalities had announced their intention to build nuclear power plants in the coming decade. Two state-owned corporations, the China National Nuclear Corporation (CNNC) and China Guangdong Nuclear Power Corporation (CGNPC) were licensed to own, operate and manage nuclear power plants; the China Power Investment Corporation (CPI) also was recently given the approval to own nuclear power stations.

Other utility companies were trying to get into the field too. The target set by the National Development and Reform Commission (NDRC) in 2007 to have 40GWe (gigawatt-electrical) online by 2020 was upgraded to 60-70GWe in 2009. Despite the concerns of many insiders that the pace of development might be too fast, the momentum seemed unstoppable.

Then there was the 2011 nuclear accident at the Fukushima Daiichi nuclear power plants in Japan, which put a temporary halt to the enthusiasm. Five days after the earthquake and tsunami, the State Council suspended approval of new nuclear projects and started conducting comprehensive safety inspections of all nuclear projects — those in operation as well as those under construction. It also decided to halt four approved projects due to start construction in 2011.

THE CHALLENGE OF SAFETY AND SECURITY

Despite Fukushima, it is a given that China will continue to expand its nuclear energy program, but what challenges does it face in doing so? Some are universal: financial demands, technical difficulties, spent fuel management, public acceptance, and so on. There is also a universal understanding among policy makers and the nuclear industry that there must be a guarantee of safety and security.

Nuclear security is often discussed in the context of proliferation, but it covers a wide range of issues, from design approval, siting and construction licensing to fuel management, technical standards, human capacity and regulation. Some issues cover both security and safety, such as unauthorized entry to nuclear power plants, sabotage or terrorist attacks. This paper only discusses the safety issues related to the development of China's nuclear energy program.

Even before Fukushima, frantic demands for new nuclear projects in China raised serious safety concerns. Despite the lack of a major accident, the head of the National Nuclear Safety Administration (NNSA) warned in a public speech in 2010, that minor incidents occurred frequently and about two-thirds of these were the result of human error. The challenges to safe development come from several directions — pressure to get new nuclear projects approved and started, the choice of reactor designs and a shortage of qualified nuclear engineers, scientists and skilled workers. There is also a paucity of good regulators and an inadequate regulatory environment in terms of both institutions and practices. All these issues need to be examined within the context of Chinese politics.

The nuclear industry in China emerged and has expanded in parallel with economic reform. It has benefited greatly from the opening to the outside world. From the beginning China sought international co-operation with multilateral and bilateral institutions such as the International Atomic Energy Agency (IAEA), nuclear regulatory agencies in the US and Canada and the nuclear industry including companies such as Framatome (later Areva), Westinghouse, Electricité de France (EDF), Atomic Energy of Canada Ltd. (AECL) and Siemens. China has introduced the most advanced reactors available and thousands of its technicians, engineers, operators and managers have been trained in the West. Its Regulations on Nuclear Safety, adopted in 1996, are literally a carbon copy of American nuclear regulatory standards. EDF even holds a 30 percent stake in a subsidiary of the China Guangdong Nuclear Power Corporation. In sum, the Chinese nuclear industry is part of the global nuclear industry.

External factors, of course, can help shape development, but cannot determine it. This extensive international collaboration has taken place within the Chinese political system, where fragmented central government institutions, provincial interests and the disparity between weak government agencies and powerful corporations have led to poor co-ordination, planning and management. No safe nuclear development can take place without consistent policies and effective regulation. Nuclear energy planning is highly cross-disciplinary and relates to numerous technical, economic and social issues. It can provide stable base-load electricity from relatively few large-scale sites, but its technology is enormously complex. It requires a highly skilled workforce and access to significant quantities of cooling water. It produces radioactive spent fuel and leaves a decommissioning legacy. All this means that consistent policies and effective regulations should be in place *before* a nuclear energy program is launched and regulators should have a thorough and informed appreciation of each aspect of a nuclear project. This article provides a brief discussion of the current development of the nuclear program in China, the safety concerns and core issues. It concludes with some cautionary analysis.

NUCLEAR STATE OF PLAY

Energy production and consumption has been rising rapidly in China. The 11th Five-Year Plan (2006-2010) set the total prime energy supply at 2,700 million tonnes of coal equivalent (mtce). By the end of 2010, it had reached 3,250 mtce, 20 percent more than was planned. China started its 11th Five-Year Plan with 517GW of installed generating capacity, which nearly doubled in the following years, reaching 966GW at the end of 2010 (equivalent to the total generating capacity of the European Union). In 2010 alone, China added 92GW capacity, which is about the current installed capacity in Spain. Between 2006 and 2011, the average annual growth rate of electricity generation was over 11 percent, supporting an average annual GDP growth of 11.2 percent.

Despite its nuclear push, China remains heavily dependent on coal for its electricity supply, and thermal accounts for 73.4 percent of total capacity. The rest is shared by hydro at 22.2 percent, nuclear (1.1 percent) and wind (3.2 percent). Also, thermal power plants have proved to be much more reliable than either hydro or wind. In the first decade of the 21st century, drought significantly reduced hydro power production, which was made up by thermal capacity. Nuclear and wind capacity grew faster than hydro and thermal. For example, in 2010, total installed capacity grew by 10.08 percent in total, but hydro grew only 8.7 percent and thermal 8.5 percent, while nuclear grew 19.2 percent. Wind capacity also expanded rapidly, from 2.7GW in 2006 to 31.1GW in 2010, but this has not been translated into electricity production (see Figure 1).

High reliance on coal presents two serious challenges. The first is the unequal allocation of coal supplies, meaning that provinces without coal reserves have greater difficulty securing energy. This is one of the reasons why nuclear power plants are located in provinces with limited energy resources, Zhejiang and Guangdong in particular. Coal-fired power plants also contribute more than half of the country's carbon emissions. According to some estimates, without its current 10.8GWe of nuclear generation capacity, China would have emitted an extra 67 million tonnes of CO_2, which is equivalent to the current CO_2 emissions of Chile. In 2009, the government set a target of reducing emissions per unit of GDP by 40-50 percent by 2020. It also set emission targets for each industry and province. These targets are among the main motivations for nuclear expansion.

In order to meet rising electricity demand and mitigate adverse climate change impacts, in the first decade of the 21st century the Chinese government decided to accelerate nuclear energy development. In 2005, the government changed its official line from "proper" to "active" nuclear development. To build 60-70GWe of nuclear capacity by 2020 is by any standard an ambitious plan. It means that China would have to build two or three reactors a year in an industry that is capital, technology and labor intensive.

More rapid development translates into higher risk as capital, technology, materials and human resources are all spread thin. It is not only a matter of paying for the plants but more importantly meeting the demand for human capital in building, operating and regulating nuclear power.

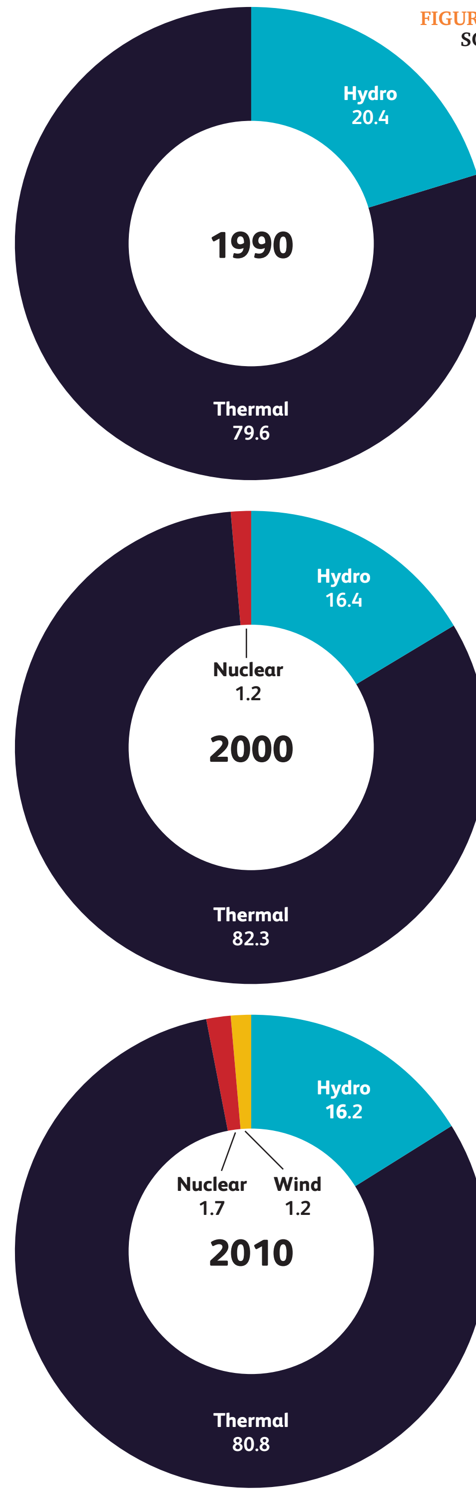

FIGURE 1 PERCENTAGE SHARE OF CHINA'S SOURCES OF ELECTRICITY PRODUCTION

Source: China Statistical Yearbook, various years

SAFE NUCLEAR DEVELOPMENT

The international community, mostly through the IAEA, has established an elaborate system to ensure that nuclear energy programs will develop safely and securely. The Convention on Nuclear Safety, adopted by the IAEA, China included, in 1994, covers "siting, design, construction, operation, the availability of adequate financial and human resources, the assessment and verification of safety, quality assurance and emergency preparedness." The following discusses some of these aspects but the issues involved cannot be understood without some appreciation of Chinese politics.

Siting: A Scramble for the Goodies

The IAEA lists general technical factors on siting, including earthquake risk, severe weather events, flooding, geotechnical hazards, political instability, population distribution, and uses of land and water in the region. How to ensure that technical merits are considered without political interference is a serious challenge in China. Zhejiang and Guangdong hosted the first two nuclear power plants partly because they have natural harbors that are close to water but relatively far from major population centers. Later, Shandong, Liaoning, Fujian, Hainan, Guangxi and Jiangsu were added to the list of possible sites. All are along the coast. Since the early 2000s, several inland provinces, Hunan, Hubei, Sichuan, Jiangxi and Henan have been pushing to build nuclear power plants. Scarce traditional energy sources are only one motivation. Other factors behind the local push for nuclear projects include jobs, infrastructure development, GDP growth and future revenues. Nuclear projects are attractive to many provincial and local leaders because before construction can begin, roads, water, electricity and other infrastructure facilities have to be put in place. These projects themselves are large and mean job creation for local people and GDP growth in general. These are commonly known as "edifice complex" activities because they also allow local officials to put their names on the various projects and thus carry on their legacy. GDP growth is also one criterion used by higher officials in considering promotions for local officials.

None of this is unique to China. The challenge is ensuring that local interests do not trump safety considerations in the selection of sites. A complicating factor is the time lag in any project. In China, basic supporting facilities have to be on site before feasibility studies can start, but the sites tend to be in areas with low population density where infrastructure is underdeveloped. This is the catch. Infrastructure must be built *in anticipation* of approval of a nuclear site. For example, Taohuajiang in Hunan province made a huge investment in roads, telecommunication, water and power grids from 2006 to 2011 ahead of a potential nuclear power station. The infrastructure construction took place as scientists were still debating whether China was ready to build nuclear plants in inland provinces and, if so, what type of technology should be adopted. Once the investment was made, the local government used it as a bargaining chip with the central authority for a final decision on the project. So far, the project has not been approved to start construction.

Designs: The Need for Neutral Judgment

One important component for safe nuclear development is to guarantee that "technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis," according to the Convention on Nuclear Safety. Reactor designs have improved significantly since the Three Mile Island accident in 1979, moving from what is known as Generation I+ to Generation II to II+ (with passive safety features) and to Generation III, represented by the Westinghouse AP1000 and Areva EPR1000+ designs. The nuclear industry and safety authorities around the world have been trying to build redundant safety systems and multiple barriers to protect against a large release of radiation into the environment. But in China, the safety of reactor designs has little to do with the design, per se. It has everything to do with how a particular design is selected and adopted.

China has so far adopted a variety of technologies — PWR (pressurized water reactors) from the US, France and Russia, PHWR (pressurized heavy water reactors) from Canada and Chinese-adapted-PWRs, which range from G-II to G-II+. It also has a fast-breeder reactor (FBR) that was connected to the power grid in 2011 and an experimental high-temperature gas-cooled reactor module (HTGR) to be constructed in Shandong. Among 27 reactors now under construction, 18 of them are CPR1000 reactors — a model based on the initial French M300, which itself was developed after adopting the Westinghouse PWR; three China Nuclear Power (CNP) series reactors developed by and large indigenously by CNNC; four are AP1000s and two are EPR1000s. This means six out of 27 reactors are Generation III, while the rest remain G-II or G-II+.

So far, the selection of reactor designs has been heavily influenced by politics, with inconsistent policies and bureaucratic bickering often behind the debate over the selection and licensing of reactor designs, rather than consideration of the technical merits of each model. China introduced the Russian VVER, a pressurized water reactor, not long after the Chernobyl disaster because Russia was isolated after 1989 and needed allies to do business with. Political pressures from France and Guangdong led to the adoption of the Areva EPR without proper international bidding.

Two decades into nuclear energy development, the Chinese government seemed to have decided that PWR would be the standard technology for its nuclear expansion. In 2005, the Chinese Communist Party Central Committee elevated the importance of China's "indigenous innovation to a strategic level." The National Development and Reform Commission, or NDRC, adopted the National Guideline on Medium- and Long-Term Program for Science and Technology Development (2006-2020), which gave priority to indigenous innovation in 11 industries. It identified new generation high-temperature gas-cooled reactors (HTGR) and fast-breeder reactors (FBR) as the next generation of technology. Less than two years later, in 2007, an agreement was signed with Westinghouse to transfer AP1000 technology, a PWR reactor, and this led the State Council to create the State Nuclear Power Technology Corporation to be responsible for introducing, adapting and indigenizing G-III technology.

With the inconsistent policies, debates have continued: some insist that G-III (AP1000 and EPR) reactors should be adopted because they have safety advantages over G-II+ models. Others argue that China should not be the guinea pig for Westinghouse or Areva to test their technologies, since no unit of either model is in operation anywhere. China should develop its own reliable CNP and CPR series, which are cheaper too, some argue. The core nuclear scientists at the China Institute of Atomic Energy and Tsinghua University believe resources should be concentrated on developing Generation IV reactors, which could recycle the fuel used in generating electricity. They argue and continue to lobby the government that small- and medium-sized G-IV reactors, especially HTGRs, should be used, particularly in inland provinces.

In addition, there is the ambition of the country's top leaders and its nuclear industry to become a global nuclear exporter. CNNC has already exported two CNP300 and 600 reactors to Pakistan and it wants to accumulate more operational experience of the CNP600 in order

Nuclear projects are attractive to many provincial and local leaders … They mean job creation for local people and GDP growth in general. These are commonly known as 'edifice complex' activities as they also allow local officials to put their names on the various projects and thus carry on their legacy.

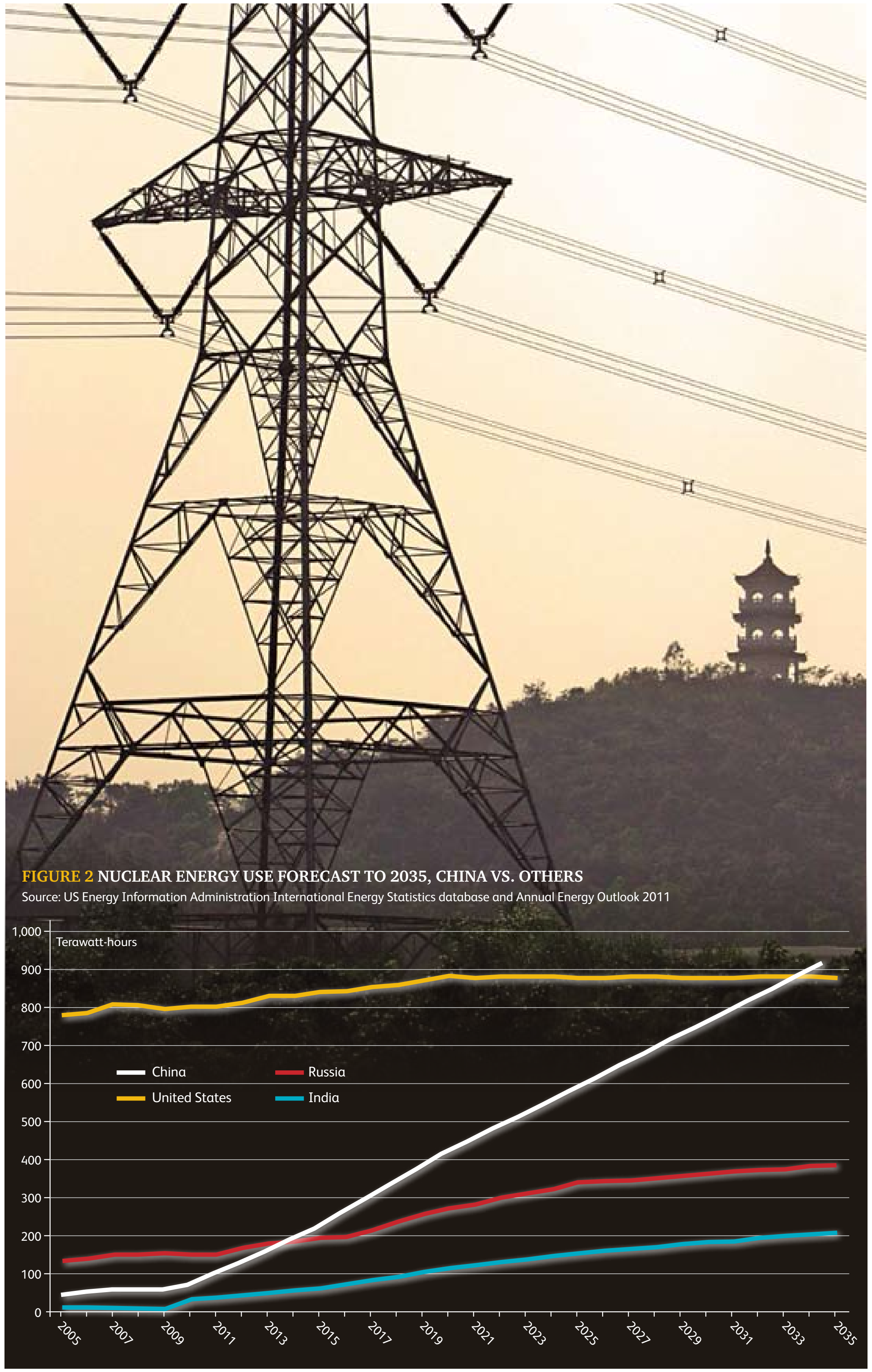

FIGURE 2 NUCLEAR ENERGY USE FORECAST TO 2035, CHINA VS. OTHERS
Source: US Energy Information Administration International Energy Statistics database and Annual Energy Outlook 2011

to export it to developing countries that may not need or cannot absorb a large-scale reactor. This means more CNP series reactors have to be built to get the necessary experience. Another major player, CGNPC, is working with EDF to expand the adoption of the CPR series. EDF, which holds a 30 percent stake in a CGNPC subsidiary, has reportedly argued that its EPR was too expensive and too large for many countries; it would work with CGNPC to build more CPR600 and CPR1000 units in China and other countries.

Two issues emerge from these design debates. First, competing interests are behind each argument as huge financial interests are involved in the adoption of a particular design. This is not unique to China and it is the very reason the Convention on Nuclear Safety emphasizes that countries should have independent regulatory agencies making design decisions based on technical merits not political considerations. In China, it remains to be seen how a truly independent regulatory regime can be created that would keep political and financial interests outside the door. Second, to ensure the safety of nuclear power plants, people who are responsible for approving and licensing reactors must have in-depth knowledge of the characteristics of each type of plant and pertinent information about safety and the human capacity needed to construct, operate and manage the plant. This means that the more reactor models in use, the more demanding it will be in terms of human capital and the more difficult it will be to develop one set of safety regulations.

Human Capital: Where to Find the Staff

China is facing a major dilemma in finding the skilled human resources needed for safe nuclear expansion. To accomplish its goals, China needs to train labor to build the plants to a proper standard, educate engineers in plant design, train operators to run the many plants it has planned and staff its regulatory agencies with qualified nuclear engineers and other experts. All nuclear companies operating in China, local as well as foreign, know that finding a qualified labor force is their most difficult challenge.

Enrollment in nuclear sciences and engineering programs at universities declined steadily and significantly in the 1990s. Science and engineering were traditionally the favorite fields for university students, while the social sciences were shunned because of the political risk — it was much easier to get into trouble with the Party and the government if one was a social scientist, a lawyer or a journalist rather than a scientist or an engineer.

But economic reforms opened up opportunities for students in finance, accounting, management, law and other social sciences. In addition, most university students enrolled in the 1990s onwards were only children, and few wanted to work in remote regions under the harsh conditions associated with the nuclear sector because China's nuclear weapons programs were almost all located in interior deserts. To make up for the shortage of qualified university graduates, the nuclear industry increased its investment in in-house or joint training programs with universities.

The foreign companies AECL and EDF in China sent a substantial number of Chinese to Canada, France and other developed countries for training, but this was far from sufficient to meet demand. According to an estimate by CGNPC, between 2008 and 2013, it would need 13,000 trained nuclear engineers, scientists and technicians — far less than universities would be able to provide. This manpower shortage is not limited only to construction, operation and management of nuclear power plants. It is also a major problem for regulation. The National Nuclear Safety Administration, as of early 2012, had only 300 people, in comparison with the US Nuclear Regulatory Commission (NRC), which has a $1 billion budget and 4,000 employees in five major locations. After the Fukushima accident, the State Council quickly promised to expand NNSA from 300 to 1,200 positions. The question is where to find qualified people.

Regulation: A Tangle of Competing Bodies

More than anything else, regulation is essential for safe development. There are three aspects of regulation — rules and laws, regulatory institutions and regulatory practices, e.g. licensing processes and practices. All three involve balancing the interests and demands of the public, environmentalists, regulators and companies. To complicate these interests is the fact that China is still in the process of creating an operational legal system that unifies the proliferation of rules, regulations and laws created under economic reform. In addition, of course, an operational legal system also requires a culture of individuals willing to obey the law.

First, there has to be clearly defined rules that cover siting, design selection, construction, operations and management, spent-fuel management and decommissioning. Increasingly, safety rules are global in nature as countries that are developing or expanding their nuclear energy programs borrow regulations from others. This was clearly the case when China adopted its "Safety Regulation of Nuclear Power Plants" in 1991 and "Regulation on Nuclear Safety" in 1996. Both were identical to those in the US, and their drafting received substantial help from the IAEA because at the time China had no experience in operating nuclear power plants. After the nuclear disaster in Chernobyl, the whole international community, including China, upgraded safety standards. Since then, however, especially with the frantic nuclear expansion after 2003, rulemaking in China has become more difficult as entrenched interests enter the fray. The Ministry of Environmental Protection (MEP) drafted a regulation on nuclear safety and prevention of radiation leakage. This proposed regulation, however, is still pending approval along with a revised version of the Mid- and Long-Term Nuclear Development Plan. The latter is controversial because there is no agreement on the pace, designs or players in nuclear development. The State Council twice rejected the proposed development plan because of concerns that the whole enterprise might be moving too fast and could jeopardise safe expansion.

Another unsolved dispute is over technology. It has been reported that initially many top leaders wanted to see the indigenous CPR and CNP series reactors as the backbone designs for nuclear expansion. But now some openly support the AP1000 or EPR models.

The Nuclear Safety Regulation drafted by the MEP cannot be approved until the State Council makes a final decision on (a) who can issue licenses to designs, (b) which companies will be allowed to enter the nuclear industry, and (c) who has the final authority to assess the licensing process. At the core of the regulatory debate is the question of who is doing what — the institutional question.

China is known for its fragmented institutions. Formally, three institutions are in charge of approving nuclear energy development: the National Development and Reform Commission, or NDRC, as the country's macroeconomic planner, is responsible for approving all large projects, including nuclear power stations. The National Energy Administration (NEA) is responsible for the country's energy strategy. The rationale is that nuclear development needs to fit into national economic development as well as energy development. In practice, the division of labor between the two is far from clear. The NEA was created in 2008 as part of the NDRC, with a higher rank than other departments. But the NEA was recently placed directly under the State Council, while its chairman remains the deputy minister of the NDRC. It is not clear who has the authority to approve what.

The issues facing safe nuclear development in China are more political than technical, and there is no quick fix … After three decades, China is still trying to 'reform' and create a real market system governed by the rule of law. In this environment, stiff challenges await as it tries to expand its nuclear capacity quickly.

Furthermore, some kind of approval is needed before feasibility studies can be done. This is, however, often an informal decision, leaving room for negotiation and bargaining among government agencies, and between the central and provincial governments. Finally, the NEA is responsible for energy policy planning, but in practice, this responsibility is shared by many other government agencies. Given that the NDRC and NEA do not always agree on broader energy policies or specific nuclear projects and that other institutions have their own interests to pursue, there is no transparent process whereby projects are assessed on their economic, technical and environmental merit. Given this tangle of competitive institutions, until now all nuclear projects were approved by the State Council directly on an ad hoc basis.

Licensing is at the core of regulation. Those who are in charge of issuing licenses need to have in-depth knowledge of all aspects of the nuclear industry and maintain their independence from both the nuclear industry and politicians. One major lesson from Fukushima is that those who regulate should not be responsible (even indirectly) for promoting the industry. In China, the National Nuclear Safety Administration (NNSA) of the Ministry of Environmental Protection (MEP) is responsible for drafting policies and regulations, issuing licenses for designs, installation, construction, operation, technology application, inspections, waste management (from transportation to disposal), emergency prevention and preparedness and a long list of other responsibilities. This means that the NNSA bears responsibility for both policy-making and regulation, which would inevitably bring other institutions into the process.

As a regulator, the NNSA issues licenses to companies and individuals. But that does not mean the process is transparent. Indeed, it is not clear how it works with another agency — the China Atomic Energy Authority (CAEA), which is under the Ministry of Industries and Information Technology (MIIT). CAEA represents China at the IAEA, which means that it is responsible for keeping track of nuclear materials, technology and the safety of civilian nuclear programs. The head of the CAEA is the deputy minister of the MIIT and often speaks on nuclear safety and security issues at IAEA meetings and elsewhere. The MEP, where the NNSA is located, tends to be cautious about safety standards.

COMPLEX INTERESTS

This is all overwhelmingly complicated. Many institutions with widely varying responsibilities are charged with ensuring nuclear safety, but these institutions all have different mandates and pursue different objectives. The NNSA under the environment ministry needs to look after the safety of nuclear development, and the ministry itself has been known to criticize the bad environmental practices of energy companies. It has raised alarms about the high speed of nuclear expansion. The NEA, now an economic planning agency under the State Council, has absorbed the nuclear power administration previously housed under a commission of the defence ministry, but it lacks sufficient manpower and expertise on nuclear issues. It pushes for nuclear expansion because electricity shortages remain a serious problem for the country. Moreover, all nuclear companies, whether operators or builders, are state-owned and therefore the State Asset Supervision and Administration Commission (SASAC), as the ultimate owner, is responsible for the performance of all state-owned corporations. With expansion a profitable activity, SASAC has a built-in tendency to support the growth of the industry.

Then there is the industry itself. State-ownership of nuclear companies is not unique to China. In most countries, the nuclear industry is in the hands of state-owned corporations. In China, one way to track the activity is to keep in mind that most large Chinese state-owned enterprises are derived from old government ministries. CNNC, for example, originated from the 2nd Ministry of Machine-Building, which was in charge of the country's nuclear weapons program, along with several defence agencies. In the late 1990s, the China National Nuclear Corporation, or CNNC, was spun off and now is among the group of elite state-owned corporations owned and supervised by SASAC. As with its counterparts in other sectors, CNNC inherited ministry personnel and colleagues from many government agencies.

In addition to these valuable connections, the chief officers of these large SOEs hold higher bureaucratic ranks than those who are supposed to regulate them. This is because in China the organization department of the communist party Central Committee maintains the power to appoint high-ranking officials both in government and in large SOEs. A few heads of large SOEs also serve as members of the CCP Central Committee and the People's Congress. The current president of CNNC, for example, was once deputy minister of the Commission for Science, Technology and Industry for National Defense, then head of CAEA and deputy minister of NEA before he took his current position. He is at the same rank as the current head of the chief regulator, the National Nuclear Safety Administration, or NNSA, but has had a longer career, more experience and enjoys better connections with relevant government agencies than his counterpart. This would not be a problem in a system with clear divisions of power and an independent regulatory regime, but in China there is a huge gap between what rules and regulations say and how they can be implemented in daily life.

In addition to CNNC, the other major state-owned nuclear company under SASAC is the China Guangdong Nuclear Power Corporation, or CGNPC, which was created through the joint efforts of the central and Guangdong governments at the end of the 1970s. Initially, the Ministry of Electric Power, Ministry of Nuclear Industry and Guangdong provincial government put resources together with the blessing of the central government. Since the electricity sector at the time saw nuclear as too costly to help alleviate electricity shortages, CGNPC quickly took on a life of its own.

The company has pursued the expansion of nuclear capacity through its own CPR model of adapted reactor designs, while CNNC is more interested in research and development related to the nuclear fuel cycle and fourth generation reactors that would be able to recycle nuclear fuel. CNNC argues that fast expansion of nuclear energy programs might undermine the resources that should be devoted to R&D for more advanced technologies.

Meanwhile, the five major state utility companies have all been doing what they can to get into nuclear, forming alliances with provinces and local governments to lobby the central government for nuclear expansion. Competition among major nuclear companies in China differs from the industry in most countries, where a close-knit nuclear community dominates the industry, like Japan's much-criticized "nuclear village." The competition among state-owned nuclear companies, which are often supported by different government agencies, often undermines the capacity of weak regulatory institutions.

POLITICS STILL IN COMMAND

The issues facing safe nuclear development in China are more political than technical, and there is no quick fix. Building an operational legal system, a set of independent regulatory agencies and the human capacity to ensure safe nuclear development will take time. After three decades, China is still trying to "reform" and create a real market system governed by the rule of law.

In this environment, stiff challenges await as the country tries to expand its nuclear capacity quickly. The good news is that the nuclear industry in China is very much part of the international industry, and those involved, from government agencies to nuclear companies, are willing to work with the international community. The major Chinese companies and their subsidiaries are members of the World Association of Nuclear Operators; China is a member of the IAEA and the World Nuclear Association. The IAEA and many OECD countries offer frequent training courses for Chinese personnel. China welcomes international inspectors to ensure the quality and safety of its nuclear power plants. In July 2010, for example, an IAEA team of 23 experts from 15 countries carried out a two-week Integrated Regulatory Review Service mission to review China's regulatory framework. The agency's list of suggestions and recommendations "provides important guidance in promoting the overall performance of China's regulatory system and safety culture development," according to the deputy industry minister, writing in his capacity as head of the China Atomic Energy Authority.

Yet all this international co-operation can bear fruit only when China gets its own house in order, changing the current system of bureaucratic rivalries, fragmented policy making and inadequate regulatory institutions into an independent and transparent system where standards can be decided and upheld fairly and on their own merits.

Xu Yi-chong is Professor in the School of Governance and International Relations, Griffith University, Australia.