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The security implications of China's nuclear energy expansion

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This Policy Brief is drawn from the author's CISSM Working Paper "China's Nuclear Energy Expansion and its Security Implications."

Executive summary

Nuclear energy is an integral part of China's energy strategy and will increasingly contribute to China's total energy supply. China has more than twenty civilian facilities, including power reactors, mines, and enrichment plants, to support its nuclear power program. As China operates more nuclear plants, more nuclear materials will be produced and stockpiled, and more nuclear facilities will be spread around the country. To ensure that this expanded network of nuclear facilities does not increase the risk that nuclear materials will be diverted or become the target of attack, China will need to develop more reliable domestic nuclear security strategies.

China is also poised to become a major exporter of nuclear energy technology. China has committed to keeping nuclear technologies out of the hands of dangerous states and/or sub-states, but in order to meet nonproliferation obligations, Chinese policy makers will need to strengthen nuclear export controls and practices. This brief examines and evaluates security measures at Chinese civilian nuclear power plants and facilities and suggests ways to improve them. These include updating Design Basis Threats (DBTs) and nuclear security regulations and guidelines, upgrading security at nuclear fuel cycle facilities, improving communications among nuclear facilities over nuclear security, maintaining international cooperation with the International Atomic Energy Agency (IAEA) and other nuclear countries. It also reviews current export control policies and systems, identifies likely challenges to the expanding nuclear sector, and proposes possible solutions.

Introduction

China has laid out plans to expand its nuclear energy generating capacity from 9.2 GWe to 40–60 GWe by 2020. The initial stages of this expansion foresee the construction and operation of pressurized water reactors (PWRs) fueled by low-enriched uranium, which will add to the country's current fleet of 11 PWRs. These reactors would not increase proliferation risks, but they would increase the opportunities for sabotage at plants, fuel-cycle facilities, and in transport, and the risk that radiological dispersal devices—so-called dirty bombs—might be used in China.

The larger potential security risks of China's nuclear expansion stem from its insistence on developing a closed fuel cycle and one day separating plutonium from reprocessed spent power reactor fuel. It is not clear when China will start reprocessing spent nuclear fuel. According to the National Development and Reform Commission's "Medium-Long Term Nuclear Power Development Plan," China plans to commercialize fast neutron reactors around 2035.[1] Before then, it intends to produce mixed oxide (MOX) fuel using separated uranium and plutonium for use in pressurized water reactors. When China begins reprocessing and transporting plutonium on a significant scale, this separated fissile material presents the risk that it could be stolen by insiders or terrorists. China needs to begin preparing for this complete spectrum of potential security threats now.

In addition, China's nuclear ambitions are likely to lead it to export its own nuclear technologies. China has improved its nuclear export controls during the past several decades by, for example, issuing new regulations to monitor dual-use nuclear technologies, yet the implementation and enforcement of current regulations is inadequate to prevent illegal nuclear exports. As an emerging nuclear supplier, China should work to strengthen its nuclear export control monitoring system and enforcement.

Material accounting and physical protection

China currently employs a range of material protection, control, and accounting (MPC&A) systems at its nuclear facilities that are based on two documents: the 1987 "Regulations on Nuclear Materials Control of the People's Republic of China" (HAF501) and the 1990 "Rules for Implementation of the Regulations on Nuclear Material Control of the People's Republic of China" (HAF501/01).[2] While China has traditionally protected its nuclear facilities and controlled its nuclear material through the use of the "three G's"—guards, guns, and gates—in recent years it has adopted new technological

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1. Mi Xu, chief engineer of the China experimental fast reactor, author interview (Beijing), March 2010.
2. HAF is an abbreviation from the Chinese for "nuclear safety regulations."

and managerial methods to increase facility security.[3] An overview of current practices at a range of facilities follows.

Nuclear power plants. Today, Chinese nuclear power plants use high-tech devices, such as microwave detectors, Doppler-infrared detectors, and tensile detectors, as well as more standard methods such as closed-circuit television for perimeter control. China has also strengthened its physical protection management system by implementing an integrated control system that allows safety personnel to monitor each component of the system and respond to potential intrusions. Training classes are offered to employees at some plants to strengthen the security culture. The many security improvements at nuclear power plants have already paid dividends. For example, once its security upgrades were completed, the Qinshan I plant officially met its regulatory and Design Basis Threat (DBT) requirements.

Yet, recent improvements to physical protection might not meet China's needs in the long run, despite being adopted from international regulations and standards. China lacks the necessary research and development capabilities and intentions to conduct studies, collect data, and perform simulations of potential security threats. In the meantime, current nuclear power plant physical protection systems lack the vulnerability assessment and system evaluation measures necessary to demonstrate their effectiveness. Elements of Chinese nuclear power plants' existing DBTs are unclear and ambiguous and need to be clarified and redefined.[4] Chinese rules and regulations for establishing and reviewing DBTs are also obsolete and need to be modernized.

Nuclear material transportation. In general, the transportation of spent fuel assemblies is more challenging than the transportation of fresh nuclear fuel assemblies, since spent fuel is much more radioactive. In June 2003, China issued the "Nuclear Reactor Spent Fuel Road Transport Management Interim guidelines" to strengthen its requirements for protecting nuclear spent fuel in transit.[5] The transport of nuclear material is not currently a crucial safety concern to Beijing, since the amount of material transported is relatively small and occurs infrequently. In China's short nuclear history, only spent fuel from the Daya Bay power plant has been transported off-site to the spent fuel pool at the nation's pilot reprocessing facility.

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[3] Nancy Hayden Prindle, "U.S. and China on Nuclear Arms Control and Nonproliferation: Building on Common Technical Interests," in James Town, ed., *Arms Control Issues for the Twenty-first Century* (Albuquerque, NM: Sandia National Laboratories, 1997), p. 322; Nathan Busch, "China's Fissile Material Protection, Control and Accounting: The Case for Renewed Collaboration," *The Nonproliferation Review*, vol. 9, Autumn 2002, p. 96.

[4] Yanhou Zou, "Preventing Nuclear Terrorism: A View from China," *The Nonproliferation Review*, vol. 13, July 2006, p. 253.

[5] CAEA, "Reactor Spent Fuel Road Transport Management Interim guidelines," 2003, available at http://www.caea.gov.cn/n16/n1178/45252.html.

Yet, as China boosts its installed nuclear capacity, the transport of nuclear material will increase tremendously.[6] The government-controlled system in place can secure the current number of transports, but it will not work for commercial transportation operations that move materials more frequently. Another potential challenge to the current transport system is that nuclear storage containers are not equipped with monitoring and tracking devices, which impede attempts to locate vehicles containing nuclear materials and potentially delay the time it takes to detect theft or sabotage.[7] In addition, when China starts reprocessing and manufacturing MOX fuel, the proliferation and terrorism risks associated with the transport of separated plutonium could be a significant concern.

Nuclear fuel cycle facilities. Little information is available about the MPC&A systems at China's fuel cycle facilities, because they are under military control and produce sensitive military materials. China has eight major uranium mining and metallurgy companies, two commercial enrichment facilities, two commercial fuel manufacturers, and one pilot reprocessing site. According to Nuclear Safety Research Association (NSRA) personnel, the nuclear fuel facilities should eventually comply with the same MCP&A regulations and guidelines as the reactor sites. Although the fuel cycle facilities' physical protection systems might not be as well-established as ones in commercial nuclear power plants, because, for instance, they are less profitable than the power plants, the facilities are working to improve them with government help. Currently, deployment of armed policemen is the major security measure. [8]

The expansion and maturation of China's nuclear energy generating capacity will lead to the growth of China's nuclear fuel cycle industry. For example, in support of its long-term goal to close its nuclear fuel cycle, China is likely to start reprocessing spent nuclear fuel at its pilot-scale reprocessing plant soon. Separated plutonium from this plant will be fabricated into MOX fuel for use in China's experimental fast reactor project. As China develops its reprocessing capability, it will need to upgrade MPC&A systems at fuel cycle facilities to ensure that its activities don't increase proliferation and terrorism risks.

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[6] Wan Zhihong, "Nuclear Power to Get a Big Boost," *China Daily*, December 20, 2008. Available at www.chinadaily.com.cn/bizchina/2008-12/20/content_7324967.htm.
[7] Safety personnel at the Qinshan Power Plant (names withheld by request), author interview (Haiyan), January 2008.
[8] Safety personnel at the NSRA (names withheld by request), author interviews (Beijing), March 2010.

Improving MPC&A systems

To begin the process of improving the MPC&A systems at all of its nuclear facilities, China should initiate a review of current procedures and requirements at all facilities. Changes in technology and the DBTs since the previous rules were established, necessitate revisions. Additionally, the NSRA and the Chinese Atomic Energy Authority (CAEA) should call for further revising nuclear facility DBTs. The threats addressed in the new DBTs should be updated and clarified, and new security arrangements should reflect each facility's specific needs.

To test the effectiveness of its new DBTs, power plant operators should run regular simulation exercises. All facilities should also offer regular training programs to ensure that staff understand and appreciate the necessity and importance of the systems. In general, nuclear power plant operators should be encouraged to share their experiences and work with each other to establish a safer and better MPC&A system.

To address concerns about the security of transportation networks, China should consider updating its tracking and monitoring system for nuclear material transportation. To improve the efficiency with which officials can notice material lost at enrichment, reprocessing, and fuel fabrication facilities, China should obtain advanced MPC&A technologies and accounting software from international organizations, such as the IAEA, and bilateral engagements, such as the lab-to-lab programs between China and the United States. Though cost is an obstacle to this type of modernization, the government should offer subsidies to support it.

Regular domestic workshops and seminars within China's nuclear industry would facilitate information-sharing about advanced MPC&A technologies and management concepts, but China also needs to continue collaborating internationally. Finally, it is extremely important for China to strengthen its domestic research capability in order to develop, among other things, its own MPC&A design requirements, databases, and software.

Improving export control and nonproliferation policies

During the 1980s and 1990s, China was one of eight major nuclear suppliers. China has exported its nuclear energy technology to a number of countries including non-nuclear states and states that are not signatories of the Nuclear Non-Proliferation Treaty (NPT). The most controversial exports involved nuclear trade and cooperation with Iran and Pakistan. Although Sino-Pakistani and Sino-Iranian nuclear projects were under IAEA safeguards, the deals led to disputes with Western countries, particularly the United

States, who saw such activities as indirect contributions to those countries' nuclear weapon programs. During the 2000s, China maintained close relations with Pakistan, and in 2009, it exported two additional nuclear reactors to its western neighbor.

While China has been an active nuclear supplier, it has also been an active participant in the international nuclear nonproliferation regime since the 1980s. As a sign of its commitment, it joined the Zangger Committee, and most recently, the Nuclear Suppliers Group (NSG). China's ascension to the NSG required it to apply formal, full-scope safeguards as a condition of supplying items on NSG control lists to non-nuclear weapon states.[9] China's commitment to nonproliferation is likely to increase its national strength, both economically and politically, and it has already opened the door to obtaining advanced nuclear technologies from the United States and other Western countries.

China's nuclear energy ambitions and its interest in building a sustainable domestic nuclear industry, however, are likely to lead China to export its own variations of nuclear technologies. Potential recipients of these exports include non-nuclear countries, especially countries that cannot afford to buy the technologies directly from Western countries or are prohibited from purchasing items for political reasons. Under these circumstances, nuclear exports could bring proliferation risks. The risks could stem from: 1) defense sector exports for financial profit; 2) civilian exports of dual-technology without awareness of the security and nonproliferation risks, and 3) individual criminal exports. Although China issued regulations on nuclear export control and an export control list of dual-use nuclear products and technologies in 1998, implementation and enforcement of these regulations has been inadequate, according to CAEA personnel.[10]

To cultivate nonproliferation awareness, the Chinese government needs to expand its outreach efforts to not only the defense sector, but also to civilian enterprises, and to ensure that all nuclear exporters are aware of potentially sensitive items or technologies that pose proliferation risks. The government should also provide regular educational and training programs to ensure that individuals and business are aware of proliferation risks. An even more effective way to eliminate risk would be to switch from an administrative system of export control policy to a law-based system, which would restrict nuclear exports by legislative means.

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[9] In January 1998, after China joined the Zangger Committee, President Bill Clinton certified China's nuclear nonproliferation policy and practices as part of the bilateral Nuclear Cooperation Agreement between the two countries. As a consequence, U.S. companies were permitted to supply nuclear technologies to China.

[10] Personnel at the CAEA (names withheld by request), author interviews (Beijing), March 2010.

China might also consider developing a framework to analyze and estimate the proliferation risks of potential export scenarios. The framework could include:

- a detailed understanding of a potential recipient government's political and economic background and its past and current nuclear programs;
- an analysis of the recipient government's rationale for wanting nuclear materials and technologies for energy or other civilian uses;
- an analysis of how nuclear exports would impact the partner government's nuclear program;
- an estimate of the potential proliferation risks associated with the exports;
- and strategies to minimize these proliferation risks.

In addition, China should establish a system to report potential proliferation risks to the IAEA and consult with the agency on related matters. China should also cooperate more with other nuclear states and nuclear suppliers on developing and employing dual-use items, such as uranium enrichment and reprocessing technologies.

About the author

Dr. Yun Zhou is a research fellow at the Belfer Center for Science and International Affairs, Harvard University, and a research scholar at the Center for International and Security Studies at Maryland. She received her Ph.D. in Nuclear Engineering from the University of California, Berkeley, and has published her work in various journals, including *Nuclear Engineering and Design* and *Energy Policy*.