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U.S. Defense Secretary Chuck Hagel joins Chinese Defense Minister Chang Wanquan to review an honor guard in Beijing (Source: Xinhua).

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In a Fortnight

CYBER TRANSPARENCY FOR THEE, BUT NOT FOR ME

In Beijing, a reminder for Hagel that the U.S. and China face divergent incentives on cyber policy

By Joe McReynolds

U.S. Secretary of Defense Chuck Hagel's latest trip to Beijing represented a new milestone in Sino-U.S. military-to-military information-sharing. According to media reports, the U.S. side laid out in detail the makeup of America's cyber forces, their command and control structures and U.S. policy regarding red lines and escalation in the network domain. Unfortunately, the Chinese haven't responded in kind. In his speech at National Defense University closing out the trip, Hagel reiterated his desire for mutual transparency, but the tone was one of palpable disappointment. Chinese media largely ignored this section of Hagel's remarks, with the only publications addressing it describing it as "hypocritical" in light of recent allegations regarding American cyber-spying and attacks on Huawei (Xinhua, April 9). Despite the Secretary's wishes, China is unlikely to acquiesce to a regime of symmetric cyber transparency in the foreseeable future.

Why is China so hesitant to join the United States in sharing information regarding its network warfare capabilities? At the risk of oversimplifying, there are three primary reasons. The first is that China operates a massive peacetime industrial espionage apparatus, and the Chinese military (the object of Hagel's desired transparency) plays a major role in providing the cyber-exploitation component of this capability. The second is that the leaks and accusations made by Edward

Snowden have improved China's diplomatic position in the context of any discussion of network warfare doctrine. The third is that Chinese military theoreticians' views regarding the inherent battle-space characteristics of the network domain predispose the Chinese toward attempting to retain a degree of uncertainty and ambiguity around China's offensive network warfare capabilities.

At this point, the rough outlines of China's cyber-enabled peacetime industrial espionage capabilities are well-known to all interested parties. As detailed in the comprehensive book *Chinese Industrial Espionage* and open-source reports such as last February's Mandiant Report on the peacetime espionage activities of PLA Unit 61398, PLA offensive cyber actors are aggressively gathering not only military but also industrial intelligence, which is then passed on to privileged Chinese corporations to impart a competitive advantage in international markets. The Chinese appear to view its unacknowledged industrial espionage operations as being every bit as deserving of secrecy as security-focused digital spycraft. The PLA's offensive cyber capabilities have such a central role in espionage beyond traditional military intelligence that even military-related disclosures could have negative repercussions for Chinese intelligence operations.

Edward Snowden's actions have also dramatically impacted America's ability to horse-trade information on cyber operations. Setting aside the unknown quantity of information that Chinese intelligence gained from Snowden during his stay in Hong Kong, Snowden has publicly leaked the un-redacted Presidential Decision Directive detailing America's cyber operations doctrine to the international media, published in *The Guardian* on June 7 last year. PLA leaders likely view briefings from Hagel's team on these topics as a bow to the reality that such information is already fully available to anyone with an Internet connection. If the United States has no important information to share that the Chinese do not already possess, there is little incentive for additional Chinese transparency. More broadly, at a time when the focus of international attention and criticism is on the United States' cyber-warfare capabilities, it is not in China's diplomatic interests to shift the discussion back to its own considerable forces.

Finally, dominant Chinese perceptions of both the inherent nature of the network domain and the present balance of power within it have influenced PLA leaders to err away from information-sharing with potential

adversaries (For a detailed examination of this topic, see Joe McReynolds, "Chinese Thinking on Deterrence and Compellence in the Network Domain," 2013 CAPS-RAND Conference on the PLA, Taipei, Taiwan). On a theoretical level, PLA academicians believe that the network domain is offense-dominant by nature due to the difficulty of attack attribution, the ongoing inadequacy of defensive technologies and the potential for adversaries to launch attacks that are high-speed, large-scale and low-cost (Zheng Lianqing, Liu Zengliang and Wu Yaoguang, eds., *Battlefield Network Warfare*, Beijing, China: Military Science Publishing House, PLA Internal Distribution, 2002). On a practical level, the PLA views the physical and operational control that the United States and its allies hold over the bulk of the Internet's core architecture as constituting a form of "network hegemony" (*wangluo baquan*) that constrains China's strategic options (*China Youth Daily*, July 19, 2013; *Qiusbi*, August 1, 2013).

These perceptions deeply influence China's strategic calculus. Transparency is helpful for preserving and stabilizing a "status quo" balance between two countries, but it can be harmful to the interests of an underdog reliant on the element of surprise in any hypothetical conflict against a more dominant power. China's leadership views the current cyberspace status quo vis-à-vis the United States with disdain; they see it as placing China in an intolerably weak position, and they believe that the network domain's characteristics are conducive to upsetting that balance with heavy investment in offensive capabilities that can be deployed in an asymmetric fashion. U.S. efforts at transparency, such as the 2011 release of the U.S. Department of Defense's Strategy for Operating in Cyberspace, are viewed through this lens not as an attempt at mutually beneficial transparency, but rather as part of America's deterrence posture (*Global Times*, March 13, 2013).

This is not to say that the Sino-U.S. cyberspace dialogue is destined to be entirely fruitless. Some limited cooperation and transparency initiatives may become possible as institutional understandings build over time between the two sides. The exchanges themselves may yield valuable informal information sharing even if no formal agreements are reached; information regarding the PLA's cyber operations organizational structures is more likely to be sketched out by a Chinese interlocutor on the back of a banquet cocktail napkin than conveyed in a formal presentation. At the end of the day, however, China is not

on a path to becoming a status quo power in cyberspace any time soon, and their approach to transparency reflects that reality.

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China's Penetration of the Canadian Energy Market

By John C. K. Daly

China's relentless global search for energy supplies has taken it from Central Asia to Sudan. But China imports oil from politically unstable nations such as inflation-ravaged Venezuela; Iran, constricted by international sanctions; and violence-ridden Iraq, the Democratic Republic of Congo and South Sudan, increasing the attractiveness of politically and economically stable exporters. More than half of China's investment in the overseas oil sector is currently in countries considered unstable.

Oil is China's second-largest energy source after coal, accounting for 18 percent of the country's total energy consumption. China's crude oil imports increased about 13 percent annually from 1994 to the 2008 global economic downturn, then slowly rose by 7 percent in 2012 and 4 percent in 2013, now standing at roughly 6.2 million barrels per day. As China's need for imports rises, it coincides with the energy policies of Canada's Conservative Prime Minister Stephen Harper. China's largest oil fields are mature and production has "peaked," leading companies to invest in techniques to sustain oil flows at the mature fields, while also focusing on developing largely untapped reserves in the western interior provinces and offshore fields. As China's domestic production is not only flat but entirely domestically consumed, imports become ever more important to feed the growing economy.

China is currently the world's fastest-growing major

economy, with annual gross domestic product growth rates averaging 10 percent for the past three decades. Energy demand in China has accelerated accordingly alongside the country's rapid industrialization, leading it to seek energy assets worldwide. In 2013 alone, the China National Petroleum Corporation (CNPC), Sinopec and the China National Offshore Oil Corporation (CNOOC) spent \$32 billion on overseas conventional oil and gas asset acquisitions, with Sinopec and CNOOC alone spending \$50 billion on overseas transactions since 2008 (*South China Morning Post [SCMP]*, August 7, 2013).

Seeking Reserves and Know-How

China is now the biggest foreign investor in Canada's energy sector. During 2007–2013, Canada's energy industry absorbed more than \$100 billion in foreign direct investment (FDI). China accounted for 28 percent, trailed by the United States with 19 percent.

The overall total for Chinese State Owned Enterprises' (SOEs) investments in Canadian energy assets from 2007 to the present is \$119 billion (*SCMP*, December 16, 2013). The table on the following page is a list of Chinese energy investments in Canada worth over \$C1 billion from 2008 to the present, which totals more than \$C35 billion (\$32 billion).

Another factor in turning China ever more towards Canada was the Arab Spring. When Libya fell into civil war in February 2011, China had to evacuate more than 35,000 workers and lost \$18 billion in investments in the process. The fracturing of Sudan into two nations, Sudan and South Sudan, in 2011 put an estimated \$20 billion in Chinese investment at risk. Following the countries' split, China has invested an additional \$8 billion in South Sudan following secession. During January–October 2013, China imported nearly 14 million barrels from South Sudan, twice as much as China imports from Nigeria annually, but the renewed fighting that erupted in early 2014 again put Chinese exports at risk, making Canada ever more attractive.

An added incentive for China in buying into Canadian energy firms is access to advanced technology such as oil sands extraction and hydraulic fracturing, where North American companies have a commanding lead.

This possibility was evident when in April 2005 the

Announcement Date	Canadian Dollar Equity	% Bought	Role	Parties
July 23, 2012	\$15,353,680,694	100%	Target Acquirer	Nexen Inc., CNOOC Ltd.
June 24, 2009	\$8,270,000,000	“	“	Addax Petroleum Corp., Sinopec
October 9, 2011	\$2,343,168,170	“	“	Daylight Energy Ltd, Sinopec
December 13, 2012	\$2,180,000,000	49.9%	Target Acquirer Vendor	Duvernay Holdings, Petrochina, Encana Corp.
October 31, 2008	\$2,000,000,000	100%	Target Acquirer	Tanganyika Oil Co., Sinopec
July 20, 2011	\$1,989,539,945	“	“	Opti Canada Inc., CNOOC
August 31, 2009	\$1,900,000,000	“	Target Acquirer Vendor	1487645 Albert Inc., Petrochina, Athabasca Oil Sands
October 31, 2011	\$1,000,000,000	“	“	Grande Cache Coal, Marubeni Corp., Winsay Coking Coal Holdings Ltd

Source: (*The Financial Post*, December 7, 2013)

state-owned CNOOC purchased a 16.69 percent stake in Calgary's MEG Energy oil sands company for \$C150 million. MEG held 100 percent ownership of oil sands leases in 52 contiguous sections, totaling 32,900 acres, in Alberta. CNOOC Chairman and CEO Fu Chengyu said, "The investment hits on our focus on long-term growth. At the same time, this move provides a good chance for us to exploit the advanced technology and expertise of oil sands development. These skills may help facilitate the exploitation of oil sands and shale in China, where large reserves of oil sands and shale were found in recent years" (CNOOC Press Release, 2005).

Unlike Canada or the United States, where shale gas is widely produced, China's shale gas reserves remain largely untapped. Most reserves in China are in remote areas that lack access to the large quantities of water needed to extract shale gas, and China lacks contractors with advanced technology that can drill for shale gas under modern safety standards. To develop China's own shale gas assets, Chinese companies are seeking access to Canadian firms' management skills and technical know-how for extracting heavy oil and shale. As China has a domestic shale reserve that is larger than both U.S. and Canadian reserves combined, Chinese energy companies will greatly benefit from their investments in Canada's advanced energy sector (*The Financial Post*, January 9, 2012).

Pursuing further diversification, China's Canadian energy spending spree gathered momentum in 2012, when PetroChina bought Canadian shale natural gas assets from Encana Corp. for \$1.2 billion, and a stake in Royal Dutch Shell Plc's Groundbirch project in British Columbia.

The U.S. Energy Information Agency reports that China's national oil companies (NOCs) anticipate that the Nexen deal and other overseas purchases will help them achieve an overall annual oil and gas production growth rate of 6-10 percent per year by 2015. The global recession is also assisting China's purchase of global acquisitions as it uses its vast foreign exchange reserves, estimated at \$3.3 trillion in 2012, to purchase equity or acquire stakes in energy companies. The CNPC Economics Technology Research Institute reports that since 2008, Chinese NOCs have purchased assets in the Middle East, North America, Latin America, Africa and Asia, and invested an estimated \$34 billion in overseas oil and gas assets in 2012 alone ("China—Analysis," U.S. Energy Information Agency, February 4).

Political Complications

There is some concern in the United States, the largest importer of Canadian oil, that Chinese companies could be buying up assets to send the oil and gas across the Pacific to fuel the nation's growing economy, to the possible detriment of U.S. purchases. A couple of years after becoming the world's largest energy consumer,

China has also become the world's largest importer of crude, leading some in Washington to frame China's increasing penetration of the Canadian energy sector as a possible security risk.

However, China, now the largest foreign investor in Canadian energy, is grappling with issues that have long plagued its North American rivals, including high costs, operational challenges, aboriginal issues related to possible environmental damage and volatile bitumen prices. Despite eager support from Canada's prime minister, these factors will limit, or at least delay, the development of natural gas exports to China.

In addition to investment, Canada has also attempted to use its energy relationship with China as a source of trade leverage in the North American market. In mid-February 2012, Canadian Prime Minister Harper, irritated with the slow progress on the Keystone XL pipeline in the United States, threatened to shift oil sands output to Asian markets, particularly China (Oilprice.com, February 21, 2012). However, the Northern Gateway pipeline needed to carry LNG from Alberta to Canada's west coast for export has also been delayed, by mounting opposition to both the oil sands and their attendant pipelines from Canadian First Nation Indian tribes.

On October 8, 2013 the Fort McKay First Nation of the Athabasca Wood Buffalo area in northern Alberta withdrew from federal-provincial Joint Oil Sands Monitoring (JOSM) program, established in 2012, because the First Nation's leadership felt they were not valued in the watchdog's consultation process, even though they were particularly interested in becoming involved in JOSM's technical details, such as monitoring air quality and contaminants (*First Nations Drum*, November 14, 2013). PetroChina is consequently struggling to expand in the oil sands because of a dispute with the influential Fort McKay First Nation. While 26 First Nations out of 45 in Northern Gateway's right of way support it and have agreed to become equity partners, a coalition of 130 First Nations has coalesced against to oil sands pipelines and tankers in British Columbia's offshore waters (*The Financial Post*, December 5, 2013).

Given the current lack of infrastructure, large scale energy exports from Western Canada to China remain far in the future. China already imports natural gas via pipelines

from Turkmenistan and Kazakhstan and LNG from Australia, Qatar and Yemen, which together accounted for almost a third of China's 2013 gas consumption, an increase of 25 percent over 2012, with consumption expected to rise another 11 percent this year. Given the long lead times and substantial costs necessary to build LNG liquefaction facilities, tankers and port facilities, China will continue to import the bulk of its natural gas needs via overland pipelines for the foreseeable future.

China's largest Canadian energy acquisition to date occurred five months after Harper's Keystone XL diatribe, when CNOOC succeeded with a \$15.1 billion (plus \$2.8 billion in net debt) buyout of Nexen Inc., a Calgary oil and gas company. The purchase was China's largest-yet overseas acquisition. In order to proceed, the contract had to be reviewed by the Canadian Parliament's Committee on Foreign Investment in consultation with the Canadian Security Intelligence Service under the government's Investment Canada Act, used to determine if the sale was a "net benefit" to Canada and did not pose a National Security Risk (*The Financial Post*, December 24, 2012). To put the acquisition in context, it was worth more than all of China's direct investment in Africa in 2011 (\$14.7 billion).

Whether the Harper administration will allow such mega-deals in the future is uncertain, as he faces political pressure both within Canada and from Washington to curtail such investment. Since Harper came to power in February 2006, the book value of foreign direct investment in Canada has increased by \$237 billion. Of the 10 largest Canadian takeovers by Chinese companies, nine have taken place during Harper's administration, leading to domestic criticism. The Canadian Security Intelligence Service also expressed unease over the strategic aspects of the Nexen deal, as a large China state firm bought heavily into a major Canadian energy company. This forced Harper to declare that the rising wave of takeovers of Canadian oilsands by foreign state-owned firms had gone far enough, and would not be allowed to continue except in "exceptional" circumstances (*The Star*, December 7, 2012).

Conclusion

The financial benefits of buying Canadian energy assets was clearly proven on April 22, when CNOOC posted

a 15.5 percent rise in 2014 first quarter output, with the rise primarily due to its purchase of Nexen (*The Globe and Mail*, April 22).

Barring a change of attitude in Ottawa, there is no indication that China's spending spree on Canadian energy assets will diminish anytime soon. Strengthening the investment legislative infrastructure, in September 2012 Canada and China signed a Foreign Investment Promotion and Protection Agreement. While China's acquiring Canadian energy assets makes perfect sense in Beijing, should such a pace continue, political pressure against further sales is likely to mount.

A further source of concern for Beijing is that while Canada is bereft of the political upheavals and terrorism infecting some of its other, more traditional crude suppliers such as Libya, Sudan and Iran, it is facing political risk of another kind—in addition to popular suspicion of Chinese state companies, the First Nations are turning to the courts to block what they see as wanton destruction of their environment, and have won some notable victories.

About the only certain thing about future Chinese acquisitions of Canadian energy assets is that the debates opened up during the Nexen deal will continue. When and whether significant volumes of Canadian oil and natural gas will flow to the West Coast for transshipment to China depends on a number of factors beyond Beijing's control, including First Nations political activism and the Canadian court system.

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China Pursues Ambitious, but Risky, Financial Reforms

By Sara Hsu

China's leadership has, in the past year, announced many reforms to the Chinese economy, and especially the country's financial system. Some are slated to be implemented over time, while some are already

in the process of being implemented. How can we distinguish between the two, and what should we expect in the coming months?

First, several major financial reforms have been announced and implemented in the past year. These include the July 2013 removal of controls on bank lending rates, the September 2013 announcement of the formal opening of the Shanghai Free Trade Zone, and the December 2013 issuance of negotiable certificates of deposit (PBOC "Notice on Furthering Market-Based Interest Rate Reform," July 22, 2013; "Framework Plan for the China (Shanghai) Pilot Free Trade Zone," September 2013; PBOC "Interim Measures for Interbank Deposits," December 8, 2013).

The July 2013 removal of controls on bank lending rates was announced by the People's Bank of China (PBOC) as a step toward full bank interest rate liberalization. PBOC Governor Zhou Xiaochuan later announced that deposit interest rate ceilings would be removed in the next one to two years (PBOC "Notice on Furthering Market-Based Interest Rate Reform," July 22, 2013; *Caijing*, March 11). This reform was made effective immediately but had little real impact on lending rates, as most lending rates were already at or above the benchmark rate of 6 percent. The move was considered symbolic progress toward further interest rate marketization.

The Shanghai Free Trade Zone began operations in September 2013, with the stated aim of experimenting with reforms in interest rates and capital account openness. The Zone has already welcomed consulting companies to help domestic and foreign companies set up businesses inside the zone, but little progress has been made in implementing the promised reforms, and it has failed to attract a significant number of foreign enterprises. However, the Zone has lifted deposit rates on foreign currency deposits under \$3 million, allowed cross-border RMB settlement to occur, and allowed the extension of overseas RMB loans, with certain restrictions. The Zone is a step toward liberalization of the exchange rate and capital account.

Issuance of negotiable certificates of deposit was also permitted as of December 2013; these instruments are traded on the interbank market and provide banks with another way to raise funds. Although less impactful than other reforms, this enhances the transparency of the interbank market.

Second, many economic and financial reforms were targeted at the Third Plenary Session of the 18th Communist Party Congress and the National People's Congress. This includes a very long list that reflects the broad scope of the 12th Five Year Plan. Although many of the economic reforms impact the financial sector, for the sake of limiting the discussion we focus on projected financial reforms (Xinhua, March 15). The financial reforms within this list include: Setting up small- and medium-sized private banks, implementing a deposit insurance system, enhancing the stock issuance process, continued deregulation of interest rates, improving the Internet banking sector, creating a market-based exchange rate system, increasing cross-border use of the RMB and increasing the capital account convertibility of the RMB. Closely related economic reforms include easing foreign investment in several sectors, including the banking sector; reducing barriers to international investment by Chinese enterprises; encouraging an increase in private investment; and reducing government investment in for-profit infrastructure projects.

The Chinese leadership generally keeps the details of the reform processes, including the timetable, private until they go live, but some officials have hinted about certain reforms, including the deposit insurance system, interest rate liberalization, creation of private banks, regulation of the Internet banking sector and currency reform in public appearances or communiqués. In his state-of-the-nation address at the National People's Congress, Premier Li Keqiang said that the deposit insurance system would be initiated and further interest rate liberalization carried out this year (Xinhua, March 14). The launch of pilot programs to set up five private banks in Tianjin, Shanghai, Zhejiang and Guangdong this year was announced by Chairman of the China Banking Regulatory Commission, Shang Fulin, at a press conference during the National People's Congress (Xinhua, March 11). The People's Bank of China has drafted some regulations to reduce risks in the Internet banking sector, to protect user information and data. Currency reform may already be beginning, as the People's Bank of China announced in mid-March a widening of the RMB-dollar trading band to 2 percent (PBOC "PBC Public Announcement [2014] No. 5," March 17). PBOC Governor Zhou Xiaochuan stated in November 2013 in a guidebook explaining Third Plenum decisions that the central bank would exit interventions in the currency market; completion of this process

is projected to happen by 2020 (Xinhua, November 15, 2013). What all of this means is that several major financial reforms are expected to be undertaken in 2014.

The most wide-reaching of both classes of reforms—those that were implemented this year, and those that were announced—are liberalization of interest rates and increased marketization of the exchange rate. These are fundamental, institutional reforms that will allow China to move closer (although certainly not completely) to a model of free market finance. Without these key changes, a continued move toward a market economy would be very difficult to pursue.

Lifting the lending rate floor was a symbolic move toward full interest rate liberalization, which will allow depositors to achieve higher returns on their deposits and discourage individuals from looking to riskier financial sectors for higher returns. Bank interest rates determined on the market as a result of interest rate liberalization will feed into the Shanghai Interbank Offer Rate, or SHIBOR, and improve the pricing of other financial instruments, such as corporate bonds. This will allow China's financial system to become less policy-driven and more interest rate-driven, especially as state owned enterprises are pushed by higher lending costs to increase the efficiency of their use of bank capital.

Increased marketization of the exchange rate will have a strong impact on trade, as export and import prices fluctuate within the liberalizing band. If the exchange rate liberalization eventually results in appreciation of the currency, as it is widely expected to do, this will force export-oriented industries to become more competitive and will allow households to purchase a larger basket of goods from abroad, boosting imports. Some critical industries may remain protected as they are exposed to increased foreign competition, but the manner in which they are protected is in debate. Subsidies to critical sectors like steel, for example, have already resulted in international outcry as overproduction has flooded global markets. The gradual removal of distortions imposed by the fixed exchange rate, guaranteed loans for inefficient investment and controlled interest rates will reduce the ability of the leadership to manage key sectors, and this issue will have to be addressed.

Elimination of government intervention in the currency market by 2020 will sharply reduce China's need to build up dollar reserves to maintain the value of the currency,

which will have large knock-on effects on American debt. A simultaneous increase in capital account convertibility of the RMB will provide a pressure valve on “hot money” flows; however, complete capital account convertibility, which is likely to be slower in coming, must be closely monitored to prevent too much “hot money” from entering or exiting the economy and setting the stage for financial crisis. This can sharply impact the real economy, as well as asset and commodity prices. Hence a balance in capital account convertibility is essential for the stability of both Chinese and global markets.

Thus far, the reforms that have been carried out have not had a significant impact on the business community, which has been more focused on events like the U.S. Federal Reserve’s tapering policy and the recent exchange rate depreciation of the RMB against the dollar. The reduction of uncertainty through the announcements of increased financial reform has on average bolstered global stock markets, while expectations on the ground regarding the reform process have been mixed. Some business analysts predict potentially strong and negative short-term impacts of financial reforms, particularly if the reforms are implemented rapidly and create clear losers, with long-term benefits of marketization. Others view the reforms as generally positive in terms of promoting productivity and efficiency among firms. At this point, however, there is no clear, unified reaction to these reforms within the business community.

China has some very large reforms on the agenda that address the very nature of its financial system, correcting fundamental distortions and increasing the presence of market forces. These reforms will affect many aspects of the Chinese financial and real economy, and, although they are positive moves toward more efficient allocation of capital, will have to be watched carefully for unexpected adverse effects. A focus on institutionalizing transparency and reducing related policy biases are essential to the success of these reform processes. Increased rebalancing of the economy toward new sources of profitability, such as consumption-related industries, can result in economic growth that will create an opportunity to reduce government intervention in the economy—but not a guarantee that state enterprises will not find ways to maintain their current standing.

Much is riding on the success of the Xi-Li administration’s reforms. Many elements of this ambitious agenda have been slated for implementation in the coming months,

yet, due to the complexity of realizing all of these changes, analysts wait with bated breath to measure their success. One can only hope that technocrats in Beijing are agile enough to respond to unforeseen consequences of their plan.

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Chinese 3rd Generation Nuclear Technology Development

By Clark Edward Barrett

Globally, 295 new nuclear power plants are under construction or planned by 2030. The total aggregate value of the total build is estimated at \$1.23 trillion, with international procurement worth approximately \$26bn per annum. [1] The size and prestige of this market has long been attractive to the Chinese leadership and China has recently unveiled its first 3rd generation nuclear reactor that possesses complete “indigenous property rights.” This step will enable it to compete in the international nuclear market, and will reduce China’s reliance on international firms for nuclear development, likely reducing access to what is likely to remain the world’s largest market for nuclear power.

Generation III reactors are defined as reactors incorporating evolutionary improvements from improved fuel technology, superior thermal efficiency, passive safety systems and standardized designs for reduced maintenance and capital costs compared to the fleet of reactors constructed prior to the year 2000 (known as generation II).

A key strategy employed by China in its nuclear development has been the extensive use of technology transfer agreements with companies such as Westinghouse (U.S.) and Areva (France). The evolution of these agreements is discussed in this article, followed by an assessment of the implications of Chinese nuclear development.

The Role of Westinghouse

In February 2006, the Chinese State Council issued the 2006–2020 National Medium- and Long-Term Program for Science and Technology Development, in which large scale advanced pressurized water reactor (PWR) technology was listed as a national development priority. [2] In September 2006, Chinese experts evaluating Generation III designs for adoption chose Westinghouse's AP1000 reactor to form the basis of the Chinese 3rd generation nuclear fleet citing its passive and simplified safety features, modular construction (allowing faster construction and better cost control) and smaller components allowing more ready equipment localization. [3]

On December 16, 2006, the then-head of the U.S. Department of Energy, Samuel Bodeman and Chinese development and reform commission chairman Ma Kai signed an advanced pressurized water nuclear reactor technology transfer memorandum of understanding under which China would introduce AP1000 reactor technology from Westinghouse and construct four reactor units in Zhejiangmen and Shandong's Haiyan, worth an estimated \$5–8 billion (Xinhua, July 24, 2007).

On July 24, 2007 the China National Nuclear Company (CNNC) Westinghouse and several other Chinese SOEs signed the “China 3rd generation nuclear self-reliance nuclear island equipment procurement and technology transfer” agreement in the Great Hall of the People in Beijing (Xinhua, May 22, 2007). According to Xinhua, the deal called for China to purchase four AP1000 units, and for Westinghouse to completely transfer AP1000 technologies covering main pumps, blast valves, containment and pressure vessels, closure heads, steam generators, supervision and other nuclear technologies (Xinhua July 25, 2007). The Chinese side would possess AP1000 improvements and developments of models outputting more than 1350 MW. Moreover, under the framework of the Sino-U.S. peaceful nuclear energy protocol, the Chinese party would possess export rights. [see reference 3] At the ceremony, central committee member, State Council vice premier and National Nuclear Independence Working Group leader Zeng Peiyan emphasized accelerating the introduction, digestion, absorption and re-innovation of nuclear technologies to realize independent Chinese design, manufacture, construction and operation strategy objectives to safeguard the energy needed for China's

economic development. “It is necessary to carefully organize, formulate and implement plans to tackle key technology research and development, develop domestic equipment manufacturing capabilities and strive to implement equipment indigenization goals to quickly develop indigenous trademarkable nuclear IP rights for large-scale advanced pressurized water reactors” (Xinhua, July 24, 2007).

To facilitate advanced nuclear reactor technology transfer and achieve a self-reliant nuclear power industry with independent trademark nuclear technology, a new central government-controlled state owned enterprise (SOE), the State Nuclear Power Technology Corporation, Ltd. (SNPTC) was officially launched in the Great Hall of the People in Beijing on May 22, 2007. SNPTC chairman Wang Binghua stated that the company would “accelerate the development process of self-reliance, industrialization and modernization of China's nuclear power industry.” A focus for the company is implementing the introduction, digestion, assimilation, research transfer applications and popularization of the Westinghouse AP1000 (Xinhua May 22, 2007). According to Wang, the nuclear independence strategy would proceed in three stages: The first stage would require complete reliance on outside assistance, while in the second China would begin to develop engineering plans, equipment manufacturing and construction in conjunction with Westinghouse. This process would culminate in the complete digestion and absorption of AP1000 technology and the completion of independent innovative designs. As stated by Xinhua: “Through introduction, digestion, absorption and re-innovation China will possess complete independent IP rights to trademark large-scale advanced pressurized water reactor technology which will allow the Chinese nuclear industry to go out and capture the world nuclear market” (Xinhua, February 27, 2008).

The SNPTC rapidly realized its objectives, on August 9, 2010, SNPTC vice-president Sun Hanhong reported that domestic AP1000 equipment manufacture had already reached 55 percent localization, with breakthroughs in key technologies allowing more than 40 domestic Chinese companies meeting international standards to supply AP1000 equipment (*People's Daily*, Aug, 9 2010). By December 2013, Xinhua reported that 80 percent of the components of the AP1000 had already been localized in China, and Chinese companies will seek opportunities in the spare parts export market (Xinhua, December 9,

2013).

In January 2012, the Chinese government announced that the SNPTC had achieved complete independent Chinese property rights for a 1400-1500 MW elaboration of AP1000/CAP1000 reactor designs (the CAP1400) developed between Westinghouse and the SNPTC. This development can be viewed as a significant milestone in the domestic development of pressurized water technology according to the State Council's 2006–2020 national medium and long-term program for science and technology, introduced previously. [4]

During an October 2013 visit to Beijing, U.S. Energy Secretary Ernest Moniz stated that the U.S. is committed to working with China on the development of new nuclear reactors and will encourage joint project bids. “What we are seeing is a very close relationship with SNPTC in the design and construction of generation three technology... Westinghouse and SNPTC are collaborating in developing both the U.S. and the Chinese supply chains for these nuclear projects” (Reuters, October 30, 2013).

The French Connection

In addition to the United States, China also has long-standing nuclear connections with France. On April 25, 2013 at a ceremony in Beijing attended by Xi Jinping and French President François Hollande, Areva, the CNNC and the CGN signed a number of agreements to advance Franco-Chinese strategic civil nuclear partnership. Also signed was a letter of intent between Areva and the CNNC to build a state of the art nuclear fuel reprocessing facility (Areva Press release, April 25, 2013).

In December 2013 during a state visit to China by French Prime Minister Jean-Marc Ayrault to mark the 30th anniversary of Sino-Franco nuclear cooperation, Areva and the CNNC signed a letter of intent to cooperate in front-end fuel cycle activities, including the formation of a joint venture to develop a facility to fabricate and convert up to 600 metric tonnes of zirconium alloy annually for the Chinese market by 2017. This follows a 50/50 joint venture between Areva and the CNNC in 2010 (CNNC–Areva Shanghai Tubing) to produce zirconium alloy cladding tubes for nuclear fuel assemblies (World Nuclear News, December 9, 2013).

French importance to Chinese nuclear development was reiterated by Chinese Premier Li Keqiang, who said that France and China would expand their cooperation and

jointly take advantage of third-party nuclear markets (Xinhua, December 9, 2013). According to the CGN's He Yu, the Sino-Franco partnership over the last 30 years is an example of Chinese nuclear cooperation with foreign nations evolving from a situation in which initially China acted in an ancillary role, to the current situation in which the Chinese lead and the French provide support through joint planning and construction of new units. “Thirty years ago, China unceasingly absorbed nuclear technology development from around the world, through continuous introduction, digestion, assimilation and independent innovation. China has already realized 1000 MW nuclear power station plans, independent manufacturing, independent construction and independent operation, fundamentally shaping a complete nuclear industrial system (Xinhua, December 9, 2013).”

Prior to the agreements made in 2013, in November 2011 Xinhua announced that CGN had successfully developed an advanced form of the CPR1000 reactor, which was an upgraded version of a French 900 MW design imported in the 1980s, over which Areva retained IP rights. The 3rd generation ACPR1000 design replaced all Areva intellectual property rights, achieving a model possessing complete Chinese IP ownership. Moreover, the ACPR1000 meets the regulatory standards for China, Europe and the United States markets (Xinhua, November 16, 2011). The CGN made the reactor available for local construction, and planned to independently market the ACPR-1000 for export from 2013. [see reference 3]

Implications of Chinese Nuclear Development

Developments in the domestic Chinese market have significant ramifications for the competitiveness of nuclear exporting countries. The acquisition of Chinese proprietary nuclear IP is clearly the first stage in a “going out” policy, which includes new nuclear construction in Pakistan and the UK (Xinhua, March 9).

The Chinese nuclear industry has benefited from the extensive use of technology transfer agreements and high-level government support for SOEs, including favourable financing, industrial coordination and support for manufacturers through localization requirements for domestic reactor construction, which the U.S. Department of Commerce has identified as impediments to U.S. small modular reactor competitiveness. [5]

The use of technology transfer agreements to “indigenize”

reactor designs appears to parallel the development of Chinese high-speed railway technology, during which Siemens and Kawasaki (Japan) were required to share high-speed rail technology with Chinese SOEs in order to access the Chinese market, at the cost of reduced long-term competitiveness and the establishment of domestic competitors. It is difficult to gauge Westinghouse's or Areva's reaction to Chinese nuclear technology "re-innovation" following technology transfer agreements even though such developments may have similar deleterious effects—the companies' limited public statements may be due to the sensitive diplomatic nature of nuclear accords.

Why would competitive companies be willing to enter into technology transfer agreements? This issue is multifaceted and industry variable. In this instance, Chinese SOEs, and therefore the Chinese government's, preponderance as the biggest buyer in the nuclear market allows it to dictate contract terms that include technology transfers. China will most likely retain this market dominance for the next 20–30 years, and hence its negotiating advantage will continue for some time.

Conclusion

On November 23, 2010, the *Financial Times* reported that Westinghouse had handed over more than 75,000 documents to the Chinese as the initial part of a technology transfer agreement relating to Sanmen and Haiyang reactors. According to the report, Westinghouse president for Asia Jack Allen stated: "We don't expect that we will walk away at the completion of these units and not participate in the [nuclear] programme, but there are no guarantees... Our experience has been in the past that you can't just give people drawings and manuals and they become proficient in a year or two years." Allen further asserted that technology transfer agreements are designed to prevent copying and that Westinghouse has a history of formulating such agreements with other countries (*Financial Times*, November 23, 2010). However, this assessment appears to be contradicted by Chinese media assertions regarding the "localization" and replacement of IP limited AP1000 technology to achieve independent trademark nuclear reactor models for export at a time when increasing number of countries are initiating new nuclear construction projects.

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Notes

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4. "Firmly Advance: A Report from the Forefront of 3rd Generation Nuclear Power Indigenization" (*Jianding tuijin: Laiqi sandai bedian zizhubua de qianyan baogao*), Central government portal, January 14, 2012 (retrieved February 2014).
5. "The commercial outlook for U.S. small modular nuclear reactors," U.S. Department of Commerce, International Trade Administration, February 2011.

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