

The nuclear capacity of the People's Republic of China is growing rapidly. For the longest time China was regarded as a younger brother by Russia. The Chinese have historically liked talking about the necessity of learning from others but the fact is that this situation is rapidly changing. One can easily distinguish between the Chinese approach towards nuclear power of ten years ago, when the country was eager to obtain any technology on any conditions, and today's approach characterized as Napoleonic in its size and scope. Starting with a domestic reactor technology of CNP-300 (Chinese Nuclear Power unit), now the country's strategic objective is to create a CAP-2100 (a reactor type with 2100 MW power capacity) on the basis of American advanced technologies within the next 10 years. The nuclear rise of the Chinese atomic dragon is obvious. The point for discussion lays in the ability of the other nuclear players around the world to wisely assess China's capabilities in the nuclear domain. The topic about the export intentions of the PRC is a subject of the greatest interest in Russia. What technology will be used by the Chinese in bidding for foreign contracts? What potential nuclear markets might PRC try to penetrate? What are the advantages of Chinese technologies in comparison to others? And of course there is the question of when will all this take off?

### Reactor technologies

In developing its nuclear industry, China's strategic objective was to make its first nuclear power plant themselves. This target was successfully achieved. The Qinshan-1 plant is built with Chinese technology, and the first power unit is equipped with CNP-300. This reactor originates from ex-submarine power reactor technology with increased power capacity. Through military-nuclear application, China was able to take its first nuclear step. The Chinese decided to develop their own technologies with the main goal of creating a 1000 MW nuclear power unit, which would form the basis not only for a domestic Chinese nuclear market but also provide the ability to export this technology. A second option was to import and acquire foreign nuclear technologies in order to accumulate experience and knowledge and on this basis grow their nuclear industry. In fact the Chinese pursued both approaches simultaneously. But the path to developing the CNP-1000 met a dead-end. They claim that their power 300 MW reactors are independently constructed by themselves with an 80% domestic technological input, whereas their 600 MW technology is available with 70% Chinese input. Concurrently their success with 1000 MW technology remains null and void.

Preference was then given to their second option, which counted on importing technologies

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Written by Artem V. Goncharuk

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from the world's top nuclear producers. These producers are AREVA (France), Westinghouse-Toshiba (USA-Japan), and Atomstroyexport (Russia). And what is the contribution of these companies and countries to a rise of nuclear power in China?

### France

France became the Peoples Republic of China's first partner in the nuclear sphere. It has assisted China in constructing their so-called CPR-1000 power reactor. For a long period of time this technology was seen as the basic reactor technology for the domestic Chinese market. Due to Chinese involvement, the price for constructing Chinese nuclear plants was significantly decreased. But there are two serious downsides in this concept. First, since AREVA supplied some of its key technological components the intellectual property rights to this technology remains French. There are absolutely no restrictions for the spread of this technology inside China but re-exporting French technology and know-how is different. Every contract on supplying CPR-1000 reactors abroad requires in principle approval from AREVA. Such approval is highly unlikely to be granted. For this reason CPR-1000 reactors are only planned for China's domestic market. The second crucial problem for the prospects of this reactor is Fukushima. CPR technology belongs to the second generation of power reactors, which implies that some characteristics do not meet optimal safety requirements. After the Japanese earthquake, nuclear safety was widely questioned, and all requirements for nuclear safety are increasing. Therefore one of the decisions adopted by the State Council of the PRC has been to revise the requirements for reactor technologies for future sites and concentrate on expanding China's nuclear industry with more advanced third generation power reactors. The prospects for future expansion of CPR-1000 reactors are quickly fading. .

French involvement in the rise of Chinese nuclear expansion is multifaceted. AREVA is developing some advanced technologies for its first EPR-1600 reactor presently under construction in Finland. However, considering that the Finnish EPR-1600 project has encountered some problems, China might turn out to become the first operator of the EPR-1600 reactor.

In 2005 China issued a call for tender for the development of several reactors in China. In real terms, this tender was designed to open competition for the whole of the Chinese market. AREVA, Westinghouse and Atomstroyexport put forward their bids. The key Chinese

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requirement on the transfer of imported nuclear technology was only met by the Americans. Despite its tender defeat, the French still managed to find a way to build a partnership with the Chinese. AREVA has since retracted its restrictions on the technology transfer issue and as a result, an 8 billion dollar contract for China's Taishan site was signed and a joint venture created with a 55% split between the China Guangdong Nuclear Power Group (CGNPG) while AREVA will retain a 45% ownership stake. Further details of the contract remain unknown.

Apart from technological cooperation, France has significantly contributed to the Chinese nuclear industry in another sphere. China is aiming at developing and supplying technologies for all phases of the nuclear fuel cycle. The industry is aimed at complete autonomy and independence in all aspects of this cycle. France has been invited to construct a fuel fabrication plant in Yinbin town and it is providing fuel assembly for all pressurized-water reactors in China.

### US-Japan

American presence on the Chinese nuclear market was limited for a long time, but over the last five years the situation changed dramatically. The 2005 tender competition showcased the highest level of American nuclear technologies. As mentioned the tender bid proposed by Westinghouse had no restrictions on the question of technological transfer, and this turned out to be crucial. The US proposed a new reactor the AP-1000. Currently there are two sites in China, in Sanmen and Haiyang, where these reactors are being constructed while many more sites are expected for development in the future. On this point the Fukushima nuclear crisis brought lots of positive momentum for the roll-out AP-1000 reactors on the Chinese market. The reactor is third generation technology, and its characteristics make it the most advanced reactor technology available anywhere at present, yet this reactor technology is not without its own problems. Most important is the price issue. The cost of the American reactor is way above Chinese CPR, CNP or even Russian VVER technologies which may present hurdles for further AP-1000 technology export to countries which are embarking on nuclear power in order to cut budgetary expenses. In China this problem might be solved through Chinese involvement and the introduction of Chinese technologies in order to reduce the overall cost of the reactor. Another hurdle is on safety which seems less than optimal. The main point here is the absence of a so-called "melting fuel trap" This is a trap located under the active zone of a reactor and serves as a last barrier for preventing contamination in the event of an accident. This question was widely debated in the UAE where South Korea's KEPCO enterprise is offering their own version of the American AP-1000 with similar design characteristics.

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Another risk the Chinese are facing is their lack of the operating experience. The AP-1000 is an absolutely new technology and China is the first importer of this reactor in the world. The first reactor, the Sanmen nuclear power plant (NPP), will even be built three years sooner than in the US. This absolute trust by the Chinese in US reactor technology surprises many experts. Recently Westinghouse admitted that the reactor's main circulation pumps are not working as expected. The technology requires additional testing and a delay on delivery is inevitable. Though Westinghouse claims the situation to be under control, it is the first sign of trouble that this new technology is bound to face.

So what are Chinese plans concerning AP-1000? The plans are really Napoleonic. First, China purchases several reactors from Westinghouse and monitors their construction which is what is happening now in Haiyang and Sanmen. Then Chinese specialists and American engineers through a concerted efforts work on improving the technology and increasing its power capacity. Lastly the Chinese are granted all the intellectual rights and operate the new reactor themselves. With regards to power capacity improvements, according to the terms of the signed Sino-American contract, the Chinese will have the intellectual property rights on any reactor type with power at the level of 1400 MW or more. Accordingly, as countries will seek greater capacity reactors the Chinese are busy in building their own export reactors, based on US technology, which will be on the world's nuclear market in the not too distant future.

## Russia

Involvement of the Russian Federation in China's nuclear market is restricted by its principal position on technology transfer. The first mutual Russia-China nuclear project was the Tianwan nuclear power plant with Russia's Atomstroyexport as a general contractor. The Chinese managed to take advantage of the poor state of the Russian nuclear industry during the 1990s when it invited Russia to build a new plant near Lianyungang city. For Russia the terms of the contract were less than optimal. The price was very low. China received credit for the project, and payment was to be made not in money but in exchange for Chinese goods. In the end, the entire project was unprofitable, yet for the industry it was salvation. It took Atomstroyexport around 15 years to complete the two power units with PWR reactors (VVER-1000) type. In matter of fact, Chinese interest in this Russian slow neutron technology was never very strong. Russia's position on the transfer of technology further created many problems. In fact the only reason the Tianwan-1 contract was signed was due to the uranium enrichment technology which was attached to the package agreement. Looking to sign a new contract on Tianwan-2 the Russians played a similar hand, in order to persuade the Chinese to compromise and

stimulate their interest in fast neutron reactors which were introduced into this contract.

As for uranium enrichment technologies, China is deeply interested in gas centrifugal enrichment. Russia is the world's leader in this technology; Russian facilities are already equipped with 8th generation centrifuges whereas China's are 6th generation technologies. All together Russia has already constructed four stages of a uranium enrichment plant in China and according to development plans more will be required. Anyway the contribution of the Russian Federation to another aspect of the Chinese nuclear industry is very serious.

### Fast neutrons

Russia occupies the leading position in the world in fast neutron technology. The only commercial fast neutron reactor is currently operating in the Russian Federation at the Beloyarskaya nuclear power plant and the first mutual fast neutron project in China was CEFR. This was a Chinese experimental fast neutron reactor, in which Russian specialists' assisted Chinese engineers during construction. But China's strategy goes way beyond simply introducing the technology. China's nuclear development is planned in conformity with the three steps suggested by Jiang Zemin. First, slow neutron energy is supposed to become the basis for China's nuclear energy sector; second fast neutron technology should be introduced and take the lead role; finally thermonuclear reactors are expected.

According to the plan, the fast neutron energy sector will only be developed after 2050. But in order to be ready for a major shift to fast neutron reactors the first steps are being taken now. So Russia has been invited to construct two power units with BN-800 reactors type (In Russian BN – Bustrye Neitroni- are Fast Neutrons). A technical contract was to be signed in November 2010, but the Chinese insisted on signing the contract and working on the project without any intergovernmental agreement which is seen by Russia as a way to obtain Russian advanced technologies. When the project will enter the next stage still remains uncertain.

### Growing a new rival

Russian specialists must take into account the possibility of future competition with China on the global nuclear market. Russia makes efforts at securing some of its top nuclear achievements. At the same time some experts suggest that competing for the niche in the Chinese market at the cost of selling some unique technologies is not reasonable. Yet Russia sticks to its policy of preventing the further transfer of its technologies and clearly some profitable contracts have been lost in order to keep these secrets. For instance, Russian Atomstroyexport (ASE) is currently involved in the Belorussian project on constructing a new nuclear power plant. At the same time the Chinese Guangdong Nuclear Power Corporation (CGNPC) developed great interest in this project and moreover stimulated Belorussian interest by offering very beneficial contractual terms. A joint venture between ASE and CGNPC was suggested. The Russian party considered the offer unacceptable; working on a technical project hand in hand with Chinese could result in leaking some of Russian know-how to the Chinese. In order to guard all its technological secrets ASE claimed that Russia is ready to withdraw from the construction in case the Belorussian side insists on Chinese involvement. Now it looks like this clash of interests' problem might be resolved through strictly dividing up areas of responsibility. China is likely to be in charge of constructing all the infrastructure elements, whereas the nuclear core is to be a Russian project.

At the same time there is another option for Russia and China to become involved in joint projects; the way forward for this was paved by the inclusion of a few clauses about working together in third countries which were added to the protocol of the 15th meeting of Sino-Russian Sub-committee on nuclear issues in September of this year.

As for the American attitude to the possibility of growing China as a new rival, their position is flexible. Westinghouse sees the Chinese rise of nuclear power as a possibility for trading new reactor technologies.

Since the US AP-1000 reactor, currently under construction in China, is the first of its kind, and is to be built three years before the American one, Westinghouse finds positive obtaining the operational experience for this technology basically being test-driven by the Chinese. Another interesting point for cooperation is that Westinghouse might secure its presence on the Chinese market through technological and scientific support for constructing additional AP-1000 reactors. It appears that China's rise as a nuclear exporter is not feared by the US nor is its technological progress a threat to America's technological nuclear capacity.

### Possible nuclear markets

In developing foreign export markets, China will face a number of hurdles. As mentioned the country is still unable to create its own 1000MW power unit. The Chinese are only able to work with small capacity reactors like the CNP-300 and the CNP-600. Of course there is some interest in these types of reactors in Africa for example. But demand remains limited and the Chinese are looking forward to becoming a much stronger player. Clearly they are aiming at supplying technologies on all stages of the nuclear fuel cycle as one strategy but this will be tough.

By the time China is ready to enter the global nuclear technology market, it will find the market already divided between the old, established players and it will have to make great efforts to build a niche for itself. There are actually two ways of cracking this nut. First, it may use its financial strength in providing extremely beneficial financing for an importing-country. This is the path South Korea's KEPCO took in the UAE. In order to persuade the Emirates KEPCO came up with very generous financial terms for their nuclear offer. The second option for entering the market is through political channels. This is pretty much the case of Russia's Atomstroyexport; currently all the nuclear projects led by the corporation were obtained on the basis of friendly relations with a country while, the technological level of equipment is considered almost optional. The Chinese like to develop their cooperation through so-called "guanxi" (personal relations), so some of the African regions, the countries from ASEAN and neighboring Pakistan might build nuclear partnerships without any tender competitions. China will most likely try every option available in order to conquer these markets. At first, it can be expected that Chinese corporations will be ready to construct anything and anywhere.

### Pakistan

As a nuclear exporter, China has already begun in neighboring Pakistan. For years Pakistan has been regarded as an instrument to deter Indian growth. Pakistan found some support in China in developing their nuclear weapons capability, and then turned to cooperation in peaceful atoms as well. Currently China manages the Chashma nuclear power project which has already been equipped with two CNP-300 reactors. The second unit was launched in July 2011. It is expected that altogether there will be 5 units supplied to the plant by the Chinese. Pakistan is a test case for China to gain experience in supplying nuclear technologies. The

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Pakistani market opened for world nuclear imports in 2008, but in the case of the Sino-Pakistani nuclear dialogue, this will not be subjected to uncomfortable restrictions for Pakistan by China and as a result this market will most likely be monopolized by China in the future.

### ASEAN

For China it has always been easier to do business with ASEAN nations than with others. Similarities in climate, culture, traditions and sometimes even language make it easier for China to seek and find compromise. Two main Asian rivals of China, Japan and South Korea, have the same comparative advantage as the Chinese. In the region there are several countries which seek to expand into nuclear. These include Vietnam, Thailand and Indonesia. With others the nuclear question is at different stages of discussion but because of Fukushima they will delay development. Laos, Brunei, Cambodia are unlikely to introduce any nuclear technology for awhile. Malaysia, Singapore, Burma and the Philippines are seriously considering the nuclear option. Most attention is drawn to Vietnam. The country proclaimed its course on diversifying into nuclear along the so-called Chinese way. The first stage of the power production will be constructed by the Russian Federation; the second is likely to be Japanese. All together there are 8 units planned for now, and there is serious competition between France, the US, South Korea, and China for future contracts. Recent focus is on the Fangchenggang nuclear plant which is being constructed near the Sino-Vietnamese border. It looks like at least one power unit will definitely originate from China.

### Iran

Sino-Iranian nuclear cooperation is a top secret. Nuclear partnership between these two countries is built on a long history of oil diplomacy. There are often some questionable facts about the illegal supply of centrifuges to Iran or cooperation on nuclear enrichment but both sides claim these allegations to be untrue. On the other hand, if sanctions imposed on Iran are lifted or at least softened, the dialogue between the parties will develop. Currently the Russian Federation is considering the possible extension of Bushehr for the second unit and within this



framework the question of a probable presence of other nuclear players is widely discussed. In case the Iranian market opens up, China will be among the competitors in this sphere.

### Africa

Africa is often called a Chinese colony. China invests huge sums of money into the region and supports many local governments. Chinese interest is mostly driven by the oil resources some African countries possess. And through oil diplomacy China has already settled deep and prospective partnerships with some of these countries. On this basis the nuclear dialogue is supported as well. The first project which has been discussed was a South African nuclear power plant. Before the recent economic crisis, the Republic of South Africa planned to introduce several plants into its energy sector and American and French technologies were under consideration. In spite of some serious budget cutbacks, the country still plans on developing its nuclear sector but on a sound economic basis. China is a possible partner in these developments and is ready to meet all of South Africa's demands but suffers from its comparatively smaller reactor technology. Another possibility for cooperation is on high temperature gas-cooled reactors (HTGC). HTGC is considered the most advanced reactor type in the world with a gas cooling system instead of water making it less dangerous and thereby enhancing plant safety by decreasing the possibility of contamination. China is planning to build a 200 MW demonstration unit, and for some time has had a mutual working group with South African specialists who are interested in this technology. But again due to limited funding, the African republic has suspended realization of this project.

In addition to South Africa recently another project has appeared – in Nigeria. Nigeria has declared its intentions to build a new nuclear power plant, and it sees the Russian Federation as its partner. However some other companies might find their own way into this market as well. The political, economic and overall stability situation of the country makes the Nigerian market risky. And in spite of the fact that Nigeria is almost the only country in Africa which has some available financing for such a project it still might face financial difficulties. Another issue is plant safety with risks posed by gangs local war-lords, and pirates which keep causing havoc for the government. Such risks pose problems for countries like the US and France. For China, these difficulties are optional, as are human rights' violations which China considers domestic issues of countries it trades with. As far as cost is concerned there is no doubt that the cheapest price would come from the PRC. Therefore in Russia, possible Chinese involvement in the Nigerian market is a very topical issue.

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In attempting to answer the question broached in the title of this article "Is China a competitor on the nuclear market?" there is no simple answer. At present Westinghouse, AREVA, Rosatom, TVEL, Tenex are the big serious players on the nuclear technologies market. They are hugely experienced; they provide the highest standards and are true brand names. We are incapable of saying the same about the Chinese. Their companies still have a long way to go. Currently we are witnessing many clashes of interest between the Chinese Atomic Energy Agency and other nuclear exporting countries and corporations. China is developing rapidly and will soon catch up with the world's top nuclear exporting powers. The situation will get tougher within 10 years as China gains operational experience with its new technologies. Market will see new nuclear offers coming forward from this nation. China is not satisfied to stand still; the rest of the world should take note.

*Contributor Artem V. Goncharuk is a Research Fellow, Atomstroyexport, Department of Constructing Nuclear Power Plants in China, National Research Nuclear University, "MEPhI" in the Russian Federation.*