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Russia's Nuclear Export Programme

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ABSTRACT

Since 2009, after a largely dormant period since the Chernobyl disaster, Russia, through Rosatom, has come to dominate the world reactor export market with a new design it claims achieves equivalent safety standards to the latest designs from other vendors. In this paper we examine the structure of the Russian nuclear industry and the technology offered and the political backing that has allowed it to achieve this dominance. We review construction and operation experience with new orders since Chernobyl. We then examine the status of the large number of orders Rosatom has won, the estimates of construction cost and how they compare with those of its competitors. We then examine whether Russia and Rosatom will have the financial and supply chain capability to fulfil more than a small proportion of its order book. Finally, we draw lessons for countries that have placed or are considering placing orders for Russian reactors.

1. Introduction

In 2007, after little activity in the previous two decades following Chernobyl, the Russian nuclear industry re-emerged with a new design, AES-2006, and ambitious sales targets. Initially, the Russian home market was expected to provide three reactor orders per year. However, these forecasts were quickly proved unrealistic and a combination of life extension of existing reactors, low electricity demand and shortage of finance mean that the home market is unlikely to provide a significant flow of orders. In Russia, between 2007 and 2017 construction on only seven reactors started including five using the AES-2006 and two used a pre-Chernobyl design. However, construction of one of the AES-2006s was suspended in 2013, a year after it started and is unlikely to restart and there has been no other construction starts since 2010. The projections in 2016 foresaw only 11 more reactors being built for the home market up to 2030 and those forecasts may prove too high (see Table 3).[1] However, Rosatom has been more successful in export markets and, by 2018, Russia was claiming firm orders for about 35 reactors in 10 countries with advanced negotiations in several other countries. In 2012, Rosatom claimed an order book worth US$50bn[2] but by March 2016, the Chief Executive of Rosatom, Sergey Kiriyenko, said Russia's reactor order book would be worth US$110bn over the following decade and more than US$300bn over the life of existing reactors.[3] If we look at the reactor export market from 2009, when Russia's export drive appeared to take off, to 2018, and count only firm orders with sites specified, Russia accounts for 23 of the 31 orders placed.[4] In this article we focus mainly on orders reported as firm but on which construction has yet to start or is at an early stage.[5] We assume that issues of finance and supply chain will have been largely resolved by the time construction starts and the risk of project abandonment is much lower. Other countries, such as Czechia and Uzbekistan are negotiating with Rosatom for further orders and Bulgaria is reported to be considering reviving the Belene project abandoned s few years ago. We cover the home market only where it gives context to the export effort. We review:

- What factors led to the sudden re-emergence of the Russian nuclear reactor industry;
- The technologies offered;
- The status of its export orders;
- Whether Russia can provide the finance and supply chain to fulfil these exports;
- Russia's nuclear industry's export strategy;
- Policy issues raised for countries considering importing Russian nuclear technology.

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1 For an account of the current state of the Russian home market, see http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx (Accessed April 15, 2016).

2 De Carbonnel, A. 2012. Russia Doubles Nuclear Exports despite Fukushima. Reuters, March 23. http://af.reuters.com/article/energyOilNews/idAFL6E8EN4WP20120323 (Accessed November 15, 2016).

3 Nuclear Intelligence Weekly 'Kiriyenko Argues Case for Russian Nuclear Expansionism' March 4, 2016, p 6.

4 The 23 Russian exports include 2 orders each for Jordan and Vietnam which appear unlikely now to go ahead.

5 Orders are regarded as firm when withdrawal by either party would incur penalty charges. It is not always easy to determine when orders are firm as press reports and press releases imply an order is firm when the agreement is no more than a Memorandum of Understanding which does not commit either side.

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Russia competes strongly in fuel cycle activities, but these are not covered.

2. Literature review

There are major problems in analysing Russia's nuclear industry because of the lack of up-to-date, independent and authoritative analysis. This article draws heavily on the trade press, especially nuclear newsletters with correspondents with good access to Russian sources. Pomper (2009) and Mukhatzhanova (2007) provide important political details about the sudden re-emergence of the Russian nuclear industry in 2007. Khlopkov (2016) reviews prospects for nuclear power in the Middle East focusing particularly on Russia's interests.

The damage the Chernobyl disaster did to the credibility of the Russian nuclear industry and rebuilding of the political institutions that followed the collapse of the Soviet Union mean that a temporary withdrawal from competing in the nuclear sector was understandable. The revitalisation of the Russian nuclear industry in 2007 with an aggressive pursuit of export markets is often seen as being closely related to the appointment in 2005 of Sergey Kiriyenko as the Chief Executive Officer (CEO) of the Federal Agency for Nuclear Energy in 2005, renamed Rosatom two years later (Mukhatzhanova, 2007). Kiriyenko had served briefly as Prime Minister of Russia under Boris Yeltsin in 1998 and was a close ally of the Russian President, Vladimir Putin. Mukhatzhanova (2007) argues that the appointment of Kiriyenko was part of a strategy to change the management of the Russian nuclear industry from inefficient government planning to corporate mode. Mukhatzhanova argues it was aimed at consolidating all the diverse elements of the Russian nuclear industry under one company controlled by the President.

3. Historical development

Prior to the 1986 Chernobyl disaster most of orders won by the Russian nuclear industry were for the Russian version of the most widely used reactor type, the Pressurised Water Reactor (PWR), known as the VVER[6] (see Table 1) (Mussapi et al., 1997). The first commercial orders were for a 440 MW design, while later orders used a 1000 MW reactor, most of which were the V-320 version.[7] This design was ordered for two reactors built at Rostov in Russian on which construction started in 2009/10.

In 1986, about 30 reactors of Russian design were under construction worldwide. Some were nearly complete and were brought on line soon after, for example, Paks 3 and 4 in Hungary; others were at an earlier stage and construction was halted before being restarted and completed sometimes without Russian assistance, for example Temelin in Czechia, while others were abandoned, for example, Zarnowiec in Poland.

After the Chernobyl disaster, winning new export orders did not seem to be a high priority for Russia until 2007 (see Table 2). Nevertheless, where strategic opportunities presented themselves, Russia did compete. For markets in Europe, this necessitated that the designs meet the standards required for European markets. A new design was developed for Finland in 1990 in cooperation with the Finnish utility, Fortum. The Finnish Parliament halted these plans in 1993 but the design work formed the basis for the AES-91 design exported to China. The AES-92 design was developed for the Belene project in Bulgaria, not proceeded with, and this design was sold to India.

The Bushehr nuclear power plant in Iran on which construction started in 1975 was for Siemens plants comprising two reactors each of

Table 1
Russia's nuclear power orders up to 1986.
Source: IAEA PRIS reactor data base: https://www.iaea.org/PRIS/home.aspx (Accessed September 8, 2016)

Country	Design	No of reactors	Completion date
Russia	VVER other	2	1964–68
Russia	VVER-440	6	1972–84
Russia	VVER-1000	10	1980–2012
Russia	RBMK-1000	11	1973–90
Russia	Breeder	1	1981
Armenia	VVER-440	2	1977–80
Bulgaria	VVER-440	4	1974–82
Bulgaria	VVER-1000	2	1988–93
Czech Rep	VVER-440	4	1985–87
Czech Rep	VVER-1000	2	2002–03
Finland	VVER-440	2	1977–81
German DR	VVER-440	5	1974–89
Hungary	VVER-440	4	1983–87
Lithuania	RBMK-1500	2	1985–87
Slovak Rep	VVER-440	8	1980-
Ukraine	VVER-440	2	1981–82
Ukraine	VVER-1000	15	1983-
Ukraine	RBMK-1000	4	1978–84

Notes: Includes only reactors with output of greater than 150 MW which were in service or under construction by end 1986 and were subsequently completed or are still under construction.

1200 MW. However, construction was suspended in 1978 at the time of the Iranian revolution. Russia agreed to complete one reactor and construction restarted in 1996 but commercial operation was not until 2013. The single reactor is a V-320 housed in the existing Siemens containment (Khlopkov and Lutkova, 2010).

3.1. The technologies

3.1.1. AES-91 and AES-92

These designs, developed for but not sold to European markets, were supplied to China (AES-91, Tianwan) and India (AES-92, Kudankulam). Construction of these started in 1999/2000 and 2002 respectively. Rosatom states these designs are essentially V-320 reactors with additional safety systems and changed plant lay-out. For example, Rosatom claims the AES-91 was the first reactor in service with a 'core-catcher'.[8]

AES-91 with the V-428 reactor was designed by the St Petersburg design office of Rosatom. It was chosen for Tianwan in 1997 and for this site, enhanced earthquake protection measures were included. An updated version (AES-91/99 with the V-466 reactor) was developed for the 1999 Finland reactor tender but the tender did not go ahead.

AES-92, using the V-412 reactor designed by the Moscow office, was destined for the Belene plant in Bulgaria. It was chosen for the Kudankulam project in 1997. While the AES-91 and AES-92 were superseded by the AES-2006, the designs are still being marketed, for example, AES-91 for China and AES-92 for India and Jordan.

3.1.2. AES-2006

New safety features developed for AES-91 and AES-92, including reliance on a combination of active and passive safety features and use of a core-catcher, were incorporated in the AES-2006. There was relatively little change to the nuclear steam supply system other than an increase in thermal power output from 3000MWth to 3200MWth. Rosatom's stated priority was to further increase safety in part through greater use of passive safety.

The St Petersburg version of the AES-2006 (using the V-491 reactor) was ordered for the Leningrad site in 2007, was subsequently chosen for

[6] VVER is the acronym for Vodo-Vodyanoi Energetichesky Reaktor. It is sometimes known as WWER.

[7] For an account of the different Russian VVER designs, see: http://www.rosatom.ru/en/resources/b6724a80447c36958cfface920d36ab1/brochure_the_vver_today.pdf (Accessed November 18, 2016).

[8] http://www.rosatom.ru/upload/iblock/0be/0be1220af25741375138ecd1afb18743.pdf (Accessed September 7, 2016).