Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

China's nuclear export drive: Trojan Horse or Marshall Plan?

Steve Thomas

Professor of Energy Policy, Public Services International Research Unit (PSIRU), Business School, University of Greenwich, 30 Park Row, London SE10 9LS, UK

HIGHLIGHTS

- China's nuclear industry expanded fast in the last decade and is targeting exports.
- Success in Europe would be a major boost to prospects elsewhere.
- National security concerns must be examined before investment decisions are taken.
- China's quality control and regulatory competence should be assessed.
- China's modern reactor designs are untested even in China.

ARTICLE INFO

Article history:
Received 28 January 2016
Received in revised form
12 September 2016
Accepted 14 September 2016

Keywords:
China
Nuclear power
Exports
Europe
National security

ABSTRACT

China's civil nuclear industry expanded strongly from 2008 onwards and nearly half of reactor construction starts worldwide since then are accounted for by the Chinese home market. Increasingly China is turning its attention to the export market using its own designs, which it claims emulate the safety standards of the latest designs of the established nuclear reactor vendors. Its export efforts would be greatly strengthened if it were to win an order from an established user of nuclear power and its best opportunity appears to be the UK where it is at the early stages of negotiating the construction of nuclear reactors. The financial collapse of the French nuclear company, Areva, gives it the opportunity to take a stake in the rescued companies giving it access to important fuel cycle technologies and perhaps the large French reactor service market. Its other export prospects in Europe are in Romania and Turkey. There are a number of issues European governments need to examine before committing to allow in Chinese nuclear companies. These include national security concerns about dependence on China for key infrastructure, issues of quality control and regulatory competence and the lack of construction experience with China's modern reactor designs.

1. Introduction

After a period of rapid expansion of nuclear capacity in China in the past decade, China is looking to use its expertise to spear-head an export drive for its nuclear reactors. It has a particular advantage over all other nuclear exporting countries, except Russia, through its ownership of the companies and its ability to marshal all aspects of the economy especially the financial sector to support its industries.

To be successful in this export drive, it needs credibility and for many potential markets the ability to provide low-cost finance. The prestige gained from exporting to a country with a strong existing nuclear capability would be valuable. Exports to USA, Japan and Russia appear implausible in the medium-term so Europe and, especially the UK, is a key market to crack. Importing reactors from China raises policy issues that must be addressed before any commitment is given. These include national security concerns, the safety of the designs and quality control of the components.

In this paper, we set out the history of the civil nuclear power programme in China, we review the main nuclear companies including their technologies, their ordering history, their target markets and their strategic alliances with European, Japanese and US nuclear companies. We then review the potential scale of the European market and the strategies these companies are pursuing in the European markets and finally we examine the main policy issues raised by China's attempts to export its nuclear technology to Europe. We pay particular attention to the UK and France as these are the markets which would carry most prestige and where efforts for Chinese companies to enter are most advanced.

2. Literature review

There are major problems in writing about China's nuclear industry because of the lack of up to date independent analysis.

E-mail address: stephen.thomas@gre.ac.uk

http://dx.doi.org/10.1016/j.enpol.2016.09.038
0301-4215/

Most of the detailed articles in journals and books, for example, Ramana and Saikawa (2011), Zhou et al. (2011), Zhou and Zhang (2010) and Yi-chong (2010) were written before the Fukushima disaster, which marked a major policy change in China and do not reflect the major technological and corporate changes to the Chinese nuclear industry that have occurred from 2013 onwards. King and Ramana (2015) provides useful and up to date analysis. This article draws heavily on the trade press, especially nuclear newsletters with correspondents based in China. China's nuclear export ambitions mean that senior officials in government and companies feel the need to provide reliable and honest answers to questions from such correspondents because the audience for such publications includes their potential customers.

3. China's civil nuclear programme and its industry structure

3.1. History of China's nuclear power programme

China carried out its first nuclear weapons test in 1964, but its exploitation of civil nuclear power came later.[1] Tables 1–3 summarise China's reactor programme. It was not until 1985 that construction work began on the first reactor, a small (300 MW) indigenous design of Pressurised Water Reactor (PWR)[2] designed by the Shanghai Nuclear Engineering Research and Design Institute (SNERDI), which was established in 1970. This was supplied by China National Nuclear Corporation (CNNC), a long established company with expertise in weapons and submarines as well as power reactors.[3] In 1978, China reached agreement with France to buy two reactors for the Daya Bay site but it was not till 1987 that their construction started. The reactors, each with an output of about 950 MW, were supplied by Framatome (renamed Areva NP in 2002) using its M310 design, with construction managed by the French national utility, Electricité de France (EDF). The Chinese partners became a new state-owned company, China Guangdong Nuclear (CGN)[4] in 1994.

Reactor ordering was slow in the period 1987–2007. CNNC produced a larger indigenous PWR design, the CNP-600, first construction start in 1996, and imported two heavy water reactors of Canadian design in 1998. Two more imported French reactors were built in 1997 in collaboration with CGN. However, both CNNC and CGN were building up their design expertise and in 2005, construction was started on a Chinese version of the M310, the CPR-1000.[5] In 2008, construction work took off with six reactors beginning construction (four CGN and two CNNC) based on the CPR-1000 design. In 2009 and 2010, ten more reactors of this design started construction.

The M310 design dates back to the 1960s, having been licensed by Framatome in the early 1970s from Westinghouse, and by 2006, the Chinese authorities acknowledged more modern designs were needed. Its plan was to select one of the advanced designs on offer importing a few reactors initially but progressively transferring the technology so it could be supplied by Chinese companies. Two technologies were seriously considered, the EPR supplied by Areva and the AP1000 supplied by Westinghouse, which was owned by Toshiba.[6] In 2007 the AP1000 was chosen with four reactors ordered and a new company created, State Nuclear Power Technology Company[7] (SNPTC), re-named State Power Investment Corporation (SPIC) in 2015 (see below), to indigenise the technology. SNERDI became a subsidiary of SNPTC giving it established expertise. In 2008 two orders were placed for EPRs with CGN partnering Areva and EDF for this project.

The Chinese vendors began to produce their own advanced designs using imported technology from their existing partners as the basis: CGN developing the ACPR-1000, CNNC the ACP-1000

Table 1
China's nuclear power plants in service.
Source: IAEA PRIS database https://www.iaea.org/PRIS/home.aspx

Technology	Supplier	No of units	Capacity (MW net)	Construction start	First power
CNP-300	CNNC	1	288	1985	1991
M310	Framatome/ CGN	4	3760	1987 – 1997	1993 – 2003
CNP-600	CNNC	6	3160	1996 – 2010	2002 – 2016
CANDU	AECL (Canada)	2	1354	1998	2002 – 2003
AES-91	Rosatom (Russia)	2	1980	1999 – 2000	2006 – 2007
CPR-1000	CGN	15	15229	2005 – 2010	2010 – 2016
CPR-1000	CNNC	5	6000	2008 – 2010	2014 – 2016
Total		**35**	**31771**		

Table 2
China's nuclear power plants under construction.
Source: IAEA PRIS database https://www.iaea.org/PRIS/home.aspx

Technology	Supplier	No of units	Capacity (MW net)	Construction start
AP1000	West/SPIC	4	4000	2009 – 2010
EPR	Areva/CGN	2	3320	2009 – 2010
CPR-1000	CNNC	3	3000	2012 – 16
CPR-1000	CGN	1	1000	2012
HTR-PM	Huaneng	1	200	2012
ACPR-1000	CGN	4	4000	2013 – 2015
HPR-1000	CNNC	2	2000	2015
HPR-1000	CGN	1	1000	2015
Total		**18**	**18520**	

Table 3
China's next new-build projects.
Source: Nuclear Intelligence Weekly 'Nine projects top priority list' May 16, 2016, p 5

Site/province	Capacity	Design	Owner	Approval expected
Rongcheng/ Shandong	2 × 1500	CAP1400	SPI	2016
Haiyang/Shandong	2 × 1250	AP1000	SPI	2016/17
Sanmen/Zhejiang	2 × 1250	AP1000	CNNC	2016/17
Lufeng/Guangdong	2 × 1250	AP1000	CGN	2016/17
Xudapu/Liaoning	2 × 1250	AP1000	CNNC/Datang	2016/17
Ningde/Fujian	2 × 1150	HPR-1000	CGN/Datang	2016/17
Zhangzhou/Fujian	2 × 1087	HPR-1000	CNNC/ Guodian	2017/18
Changjiang/Hainan	2 × 1087	HPR-1000	CNNC/ Huaneng	2018
Haixing/Hebei	2 × 1087	?	CNNC	2018

[1] Data on construction and operation of reactors are all taken from the International Atomic Energy Agency's PRIS data base. https://www.iaea.org/PRIS/home.aspx (accessed 12.08.16.).

[2] The PWR is the most widely used type of reactor worldwide accounting for about two thirds of the world's operating reactors.

[3] http://www.cnnc.com.cn/tabid/643/Default.aspx (accessed 15.12.15.).

[4] http://www.cgnpc.com.cn/n1500/index.html (accessed 15.12.15.).

[5] Both the CGN and CNNC versions of the M310 are designated CPR-1000 although there are differences between the two. The CNNC version of the M310 is also sometimes known as the M310+.

[6] Westinghouse's nuclear division was sold to the state-owned UK company, BNFL in 1999 for $1.1bn who in turn sold it to Toshiba in 2006 for $5.4bn. http://www.toshiba.co.uk/innovation/NEWSARCHIVE/archived_news_article.jsp?ID=0000006709 (accessed 14.07.16.).

[7] http://www.snptc.com.cn/en/(accessed 18.12.15.).