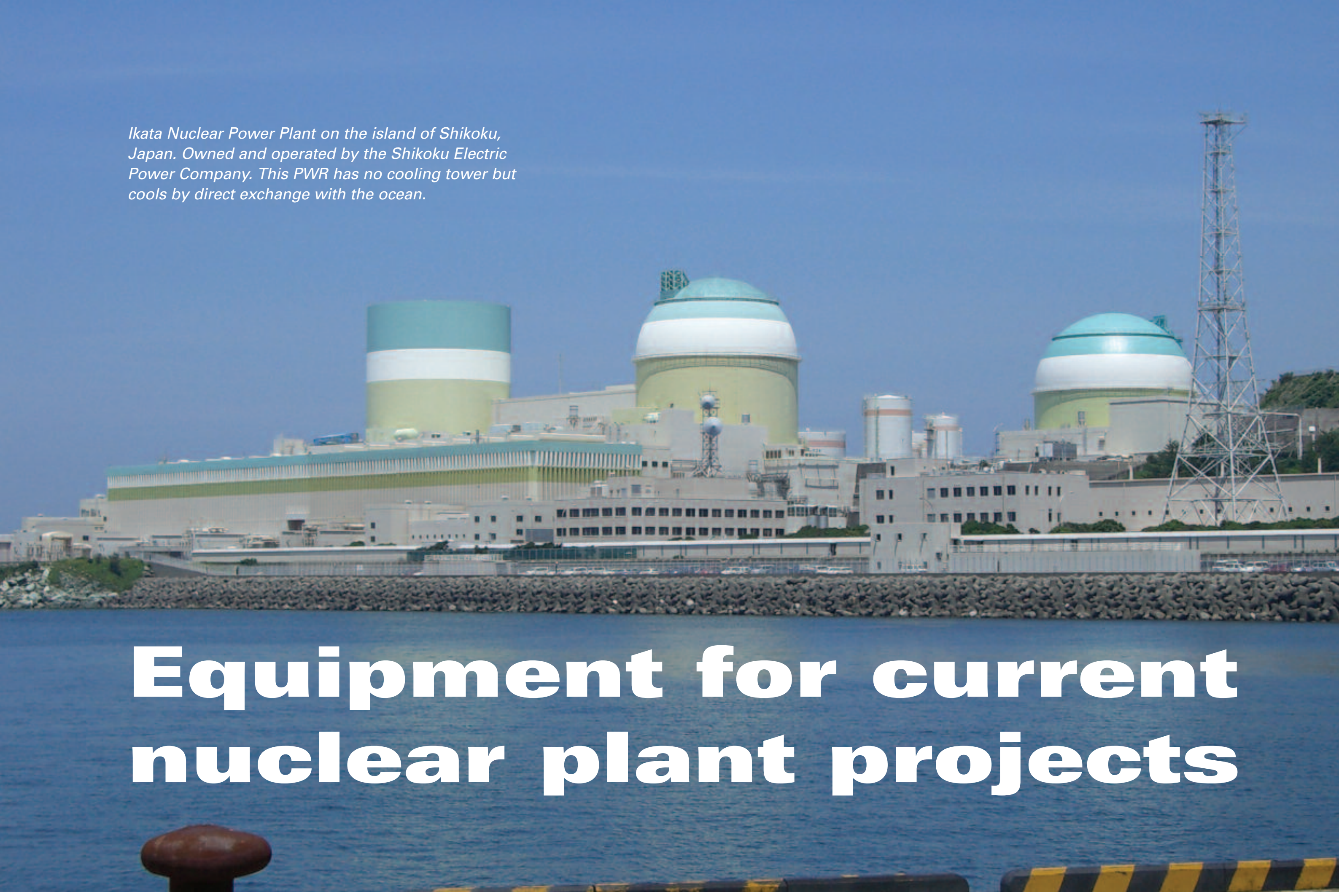

Ikata Nuclear Power Plant on the island of Shikoku, Japan. Owned and operated by the Shikoku Electric Power Company. This PWR has no cooling tower but cools by direct exchange with the ocean.

Equipment for current nuclear plant projects

The nuclear industry is undergoing a globalisation process. Companies like Westinghouse, GE, Areva and MHI are increasingly selling their expertise beyond their national borders; technology transfers and tie-ups are more frequent; plans are being laid to harness nuclear energy for desalinisation projects and - an industry first - for the manufacture of steel. Focus on Nuclear Power Generation surveys the scene, casting a particularly close eye on the role of suppliers in the slow but steady resurgence on the nuclear power industry.

By James Chater

The much talked about "nuclear renaissance" is happening, but progress is slow. It takes time to choose a location, ensure the investment funds are in place, seek the approvals, consult local communities and address the safety issues. And the market has several options to choose from: APWRs from Westinghouse, EPRs from Areva, ABWRs from GE or Toshiba, or ACRs from Canada's AECL, to name just a few of the current generation III reactor technologies (see table 1).

Energy scarcity

Supplies of gas will only become tighter and more prone to disruption and political manipulation; coal is an abundant but dirty alternative, and clean-coal technology needs to be commercialised much further; solar and wind power are increasingly rapidly, but progress around the globe is uneven and their share of the global energy market is still small. No wonder, then, that the construction of nuclear power stations is put forward as a way of plugging the energy gap - even though, if we are to believe critics of nuclear power, the new wave of power stations being planned will not be built in time to avert an energy shortage.

Energy security is increasingly on people's minds, then, and affects not only ordinary people struggling to pay escalating food and energy bills, but also industry, with all its repercussions for the standard of living.

Industry leaders are becoming more energy-conscious, not only out of environmental considerations, but also in order to keep costs down and remain competitive. This is why Outokumpu is aiming to increase its competitive advantage by forming a consortium of energy and steel companies to ensure a steady and affordable supply of nuclear power for the steel industry. In June 2007 the Finnish steel company announced it had teamed up with Sweden's Boliden, Rauman Energia, Katternoe and E.ON to form Fennovoima, which aims to construct a 1000-1800MW nuclear power plant in Finland. Power generation requires steel, especially stainless steel, but the converse is also true: steel production is highly energy-dependent, a fact that Outokumpu has taken fully on board.

Europe

Elsewhere in Europe, the UK is especially vulnerable to energy shortages because of the decline in North Sea gas and its aging fleet of nuclear power stations. After years of hesitations, flawed consultation processes and rumour, the Brown government has finally embraced nuclear power unequivocally, and a recent visit to the UK by France's President Sarkozy has fuelled speculation about a possible Anglo-French tie-up, with France's EDF said to be hoping to build four nuclear power stations in Britain, with reactors from Areva[1]. But the UK's regulators are also looking at three other designs: the ACR-1000 heavy water reactor from Canada's AECL, the ESBWR from GE-Hitachi Nuclear Energy and Westinghouse's AP1000. British Nuclear Fuels is refurbishing its reprocessing plant at Sellafield, for which it is using Sandvik's high-purity, 18/10/L, stainless steel tubes designed for nitric acid grade service. Sandvik is also supplying its SAF 2304 duplex stainless steel to a Swedish nuclear power station in order to replace carbon steel tubes, which failed frequently due to steam erosion.

Crossing the continents

European technology crossed the Atlantic in 2005, when France's Areva agreed to work with Constellation Energy to build an EPR together with Bechtel; a site has now been selected at Calvert Cliffs, Maryland. Areva along with MHI and other companies has formed the International Nuclear Recycling Alliance to build a nuclear fuel recycling centre and an advanced recycling reactor in the USA. Recently another trans-continental tie-up was announced: Japan's Toshiba (which now owns Westinghouse) will invest in NRG's Nuclear Innovation North America to build ABWRs in North America; two reactors are already being planned in South Texas. Meanwhile, TXU will scrap plans for eight coal-fired plants in Texas and build a nuclear plant instead. Both in Utah, USA, and in Alberta, Canada, plans exist to build their first nuclear power stations.
Westinghouse is completing Unit 2 of TVA's Watt's Bar power plant in Spring City, Tennessee, for which Curtiss-Wright is

Westinghouse AP1000 nuclear power plant

supplying four reactor coolant pumps, pump seals and drive rods. And on 9 April 2008 Toshiba announced that Westinghouse would supply two AP1000s for Southern Co. in the state of Georgia. This is Westinghouse's first nuclear new-build in the USA for about 30 years.
In anticipation of a surge in demand, Weir Valves & Controls has invested in a dedicated nuclear valve manufacturing facility in Ipswich, Massachusetts, complete with the latest welding, machining and testing equipment. Sulzer Pumps has also completed a new facility dedicated to nuclear pumps, servicing and upgrades, in Chattanooga, Tennessee. The building incorporates machine tools, pump rebuild facilities, including on-site tear down and inspection, machining, welding, balancing, reassembly and certification.
France is also exporting nuclear technology to Africa. Areva is offering technical assistance and training to Eskom, South Africa's utility company, and Libya has signed a deal with France to develop a nuclear reactor for water desalinisation.
Russia and eastern Europe are also stepping up the construction of power stations. Alstom and Atomenergomash, part of Rosatom, have agreed to work together on power plants incorporating Alstom's Arabelle half-speed turbine technology. Ukraine has been upgrading its nuclear fleet with technology from Weir Valves & Controls France, which in 2007 received its fourth order for relief valves for the Khmelnytsky nuclear plant in Ukraine. Romania has commissioned its second reactor at Cernavoda, using CANDU technology; two more reactors are planned at the same site.

Asia-Pacific region

The Asia-Pacific region's two most dynamic economies, India and China, are faced with a formidable supply-demand gap. In India, progress in developing a nuclear industry has probably been held up by the fact that the country has not signed the Nuclear Non-Proliferation Treaty. Nevertheless, the country is expected to have 20GW of nuclear capacity by 2020. It has produced a number of heavy water reactors, some with Canadian assistance, some on its own; it has also imported Russian VVER technology to build two reactors at Koodankulam in the southern state of Tamil Nadu; these are still under construction and are scheduled to begin commercial operation in December 2008 and June 2009. In February 2008 it was announced that India and Russia were close to a deal to build four more.
The nuclear industry in India is said to have a secretive culture and a poor safety record, even though no major accident has occurred. It has been alleged that back-up equipment has been part of the design but unavailable during operation, so that for example, back-up pumps for coolant circulation have been unavailable on failure of the operating pumps[2]. Clearly, there is an opportunity here for pump manufacturers to export products designed to improve safety and efficiency at Indian nuclear power stations.

Turbine deck inside the Diablo Canyon nuclear power plant. Photo: Jim Zimmerlin, Pacific Gas & Electric Company

Table 1. Selective list of reactors types in use, under construction or in design or planning stage

Generation	Abbreviation	Name	Description
II	AGR	Advanced gas-cooled reactor	Developed in UK from Magnox reactor. Uses graphite as neutron moderator and carbon dioxide as coolant.
	VVER		Russian design of PWR.
	PWR	Pressurized water reactor	Uses light water under high pressure as coolant and neutron moderator. Reactor type favoured by Westinghouse. Korea's KSNP, since renamed the OPR-1000, was developed from the PWR.
	BWR	Boiling water reactor	Designed by Allis-Chalmers and General Electric (GE) in the mid-1950s. Unlike with PWR, steam is produced in reactor core rather than in steam generators.
	CANDU	CANada Deuterium Uranium. A type of pressurised heavy water reactor (PHWR).	Developed in the late 1950s and 1960s by AECL in Canada. Used in Canada and exported to other countries.
III/III+	APWR	Advanced Pressurized Water Reactor	Improved PWR. Examples include Westinghouse's AP-600 and AP-1000, Mitsubishi's APWR and Doosan's APR-1400, designed for Korea Hydro Nuclear Power Company.
	EPR	European Pressurized Reactor. Name has since changed to "Evolutionary Power Reactor".	Improved PWR with standardized components designed and developed by Framatome (Areva) and Electricité de France (EDF) in France, and Siemens in Germany. The US-EPR is a design adapted for the USA.
	ABWR	Advanced Boiling Water Reactor	Designed by GE from its BWR. Went online in Japan in 1996. Design improved by internal recirculation pumps inside the reactor pressure vessel. Toshiba is also planning a new ABWR to be made commercially available by 2015.
	ACR	Advanced CANDU Reactor.	Light-water-cooled reactor that uses technologies of both pressurised heavy water reactors (PHWRs) and APWRs. Design is similar to Steam Generating Heavy Water Reactor (SGHWR). Developed from AECL's CANDU reactor.
	ATMEA 1	PWR	Reactor to be built by JV of Areva and MHI (JV formed in 2006).
	ESBWR	Economic Simplified Boiling Water Reactor	Developed by GE from its BWR. Passive design features include natural circulation with no recirculation pumps or associated piping.
	VK-300		Type of simplified BWR being developed by the Research and Development Institute of Power Engineering, Russia.
	SWR 1000	Siemens and Areva	Uses ABWR concept, with passive safety equipment and simplified plant systems. Developed at request of German electricity suppliers in co-operation with other European countries.
	ATES	Floating nuclear power station	Small, self-contained NPPs designed by Rosatom for use in Russia's remote north-east.
	IRIS	International Reactor Innovative and Secure	Smaller-scale PWR with steam generators, pressurizer, control rod drive mechanisms and reactor coolant pumps all located inside the reactor pressure vessel. Being developed by an international team co-ordinated by Westinghouse.

One such company is Flowserve, which opened a pump manufacturing facility in Coimbatore in April 2007. Another is Kirloskar Brothers Ltd, which has been associated with the nuclear power programme of India since 1971. According to Business Week (19 November 2007) Kirloskar is the premier pump maker in India, with a 24 per cent share of the market, and it has the ambition to expand rapidly by exploiting the nuclear and overseas markets. Indeed, India's pump export business in general is said to be expanding rapidly[3]. Kirloskar is supplying pumps for a 500MW prototype fast breeder reactor being built at Kalpakkam, near Chennai.

China is planning to raise nuclear's share of electrical power to 4 per cent by adding about 32 reactors in 15 years. A period of further rapid expansion is envisaged up to 2040. This provides plenty of opportunities for companies like Flowserve, which is contemplating a tie-up with China National Nuclear Corporation and SUFA Technology Industry to supply valves to the domestic nuclear market. Flowserve is also providing concrete volute pumps to China Nuclear Power Engineer for the first phases of nuclear power plants being built in Hongyanhe, Liaoning, NE China, and Ningde, Fujian province. (Both plants are built with China's newly acquired indigenous technology, the APR-1000.) Other suppliers to these two plants include Areva Dongfang, a subsidiary of Areva and Dongfang Electric Corp., which won a contract for 18 reactor coolant pumps; Clyde Pumps (formerly called Weir Pumps before being bought out by Clyde Blowers); and Hunan XD Changsha Pump Works Co. Ltd.

Among the most advanced nuclear power plants currently being built in China are the four using Westinghouse's AP1000 Generation III+ technology. Four plants of this type are being built in Sanmen (Zhejiang province) and Haiyang (Shandong province). For these plants, specially engineered valves are being supplied by SPX Corp. and reactor coolant pumps by Curtiss-Wright. And now Areva has entered the Chinese market in a big way: on 27 November 2007 China and France signed a deal worth 8 billion euros for the supply of EPRs along with about 10 years worth of fuel (from 2014 to 2026) after they are built. Areva is also planning a zirconium facility and is contemplating a nuclear reprocessing plant.

China has up to now been heavily dependent on foreign technology from the USA, France, Russia and Canada, but aims to develop its own technology. The CPR-1000 is the first step towards this goal.

In South Korea, 20 reactors provide about 40% of the country's electricity. The country has developed its technology from Westinghouse, becoming technologically independent in 1997. Korea's indigenous reactor design was called the KSNP and has since been renamed the OPR-1000 - of which four are currently under construction in S. Korea; the country has ambitions to export them to Indonesia and Vietnam. Also under construction are two generation III APR-1400 reactors - Shin Kori 3 & 4. They will be built by a consortium led by Hyundai, using technology developed by Doosan and Westinghouse. Doosan is also supplying the reactor vessels, steam generators and integrated head packages for the four AP1000s in China. Thermostatic valves for Shin Kori (APR-1400) and Shin Wolsung (OPR-1000) are being supplied by AMOT. ANCO is building a laboratory for severe thermal-hydraulic testing of safety-related pumps and valves for nuclear service.

In June 2007 Areva and Korean utility KHNP signed a contract for the supply of uranium enrichment services.

Japan was one of the earliest Asian countries to embrace nuclear power, and it plans to raise the nuclear share of electricity generation from 30 per cent (2005) to around 41 per cent in 2014 and 60 per cent in 2050. Up to now the favoured technologies have been the PWR from Westinghouse and the BWR from GE, but a number of generation III reactors - mostly ABWRs, with some APWRs - are under construction or are being planned. Now Areva has entered the Japanese market: it has formed a joint venture with MHI called ATMEA, to develop ATMEA 1, a new 1100MW reactor combining both companies' technologies.

Diablo Canyon Power Plant in San Luis Obispo County, California, USA has two Westinghouse-designed pressurized-water nuclear reactors and supplies power to over 2 million homes. The two reactors went online in 1984 and 1985

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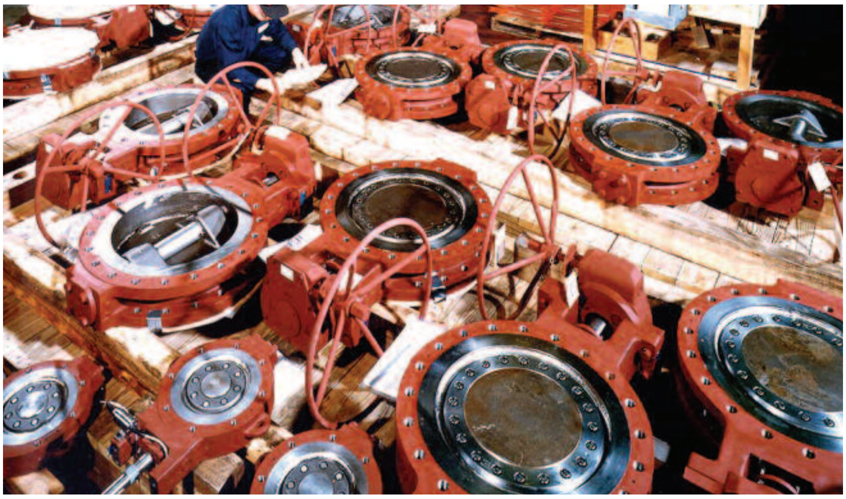

Weir Valves & Controls TRICENTRIC metal seated butterfly valves for service water applications in the Lungmen ABWR in Taiwan