

# The global renaissance continues: A review of the recent past and a look ahead

BY DICK KOVAN

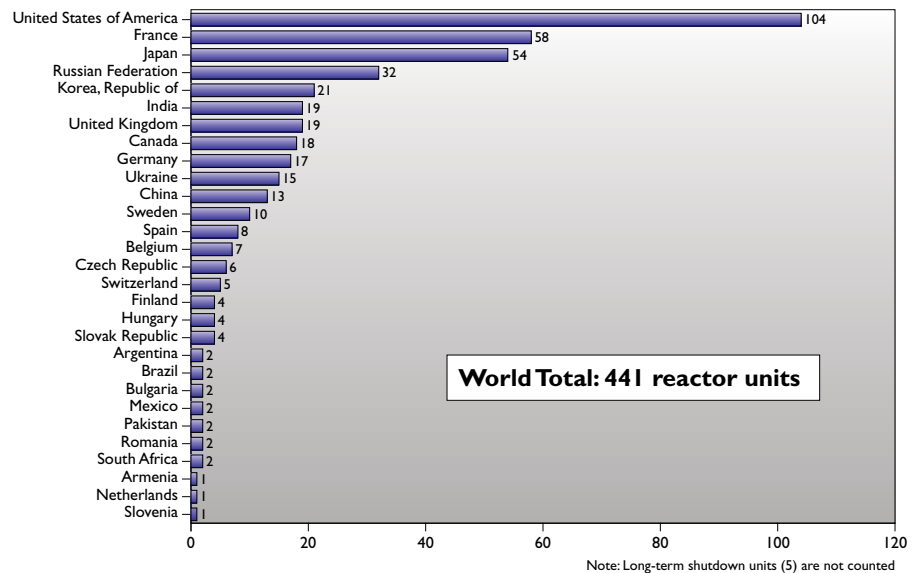
AS REPORTED A year ago in *Nuclear News* (NN, Jan. 2010, p. 43), the nuclear landscape continues to change as the driving forces move from North America and Europe toward the East, with countries such as China and India rapidly expanding their programs. With the contract for constructing four reactors in the United Arab Emirates (UAE) going to South Korea, and with China developing and building indigenous versions of the plants it purchased from Western companies, the industrial leadership would also seem to be shifting to the East.

The statistics show this quite clearly. According to the International Atomic Energy Agency, in 2010, the number of operating nuclear power reactors in the world rose from 436, as reported last year, to 441, with 66 reactors under construction. The five reactors that were connected to the grid during 2010 are Ling Ao-3 and Qinshan II-3, in China; Rajasthan-6, in India; Shin-Kori-1, in South Korea; and Rostov-2, in Russia. Of the 15 reactors on which construction began during the year, nine are in China, two in India, two in Russia, and one each in Brazil and Japan.

## Keeping the momentum

The recession, along with strong opposition from entrenched political interests and some sectors of the public, is making it difficult for European countries wanting to restart nuclear programs to move forward after decades of nuclear stagnation. But there have been many positive developments. Against stiff political opposition, the governments of Germany and Sweden passed promised legislation to abandon or defer nuclear phaseout laws. Proposals to build two new nuclear plants in Finland were approved by the government and the parliament, and while plans to build plants in Bulgaria (at Belene) and Lithuania (at

*In much of the world, nuclear power is either expanding already or the focus of government efforts to make expansion—or introduction—possible.*



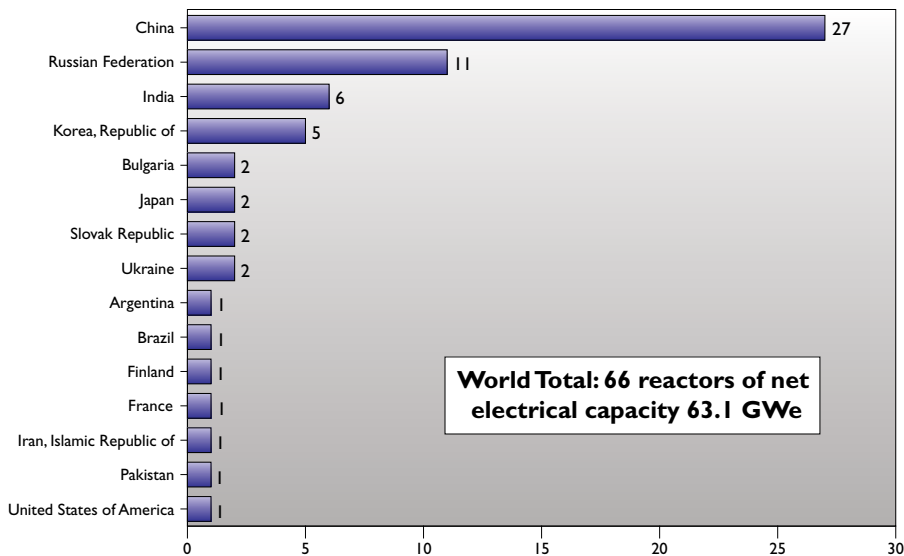
Reactors able to produce power as of the end of 2010 (the world total includes six reactors in operation in Taiwan, which is not displayed as a separate bar in the graph). (Graphs: IAEA/Power Reactor Information System) [Because of differences in criteria, data in the graphs on this and the facing page may not agree with data in the *Nuclear News* World List of Nuclear Power Plants, to be published in the March issue.]

Visaginas, near the Ignalina site) continue to be delayed, primarily because of financial problems, the governments are doing whatever they can to move the projects forward. Generally, there are no signs yet of an inclination to turn away from nuclear, although political parties opposed to nuclear could come into power in some European capitals as economic conditions make incumbent governments less likely to be reelected.

The following summaries provide updates of recent nuclear developments and plans for the future in European Union countries.

## Bulgaria

Although the start of construction in Bulgaria of two Russian-designed VVER-1000 pressurized water reactor units at Belene was officially launched in September 2008, only preliminary site work has been done owing to difficulties in funding the project. During 2009, the German utility RWE, which had been selected to take a 49 percent share in the project, decided to drop out, and the Bulgarian government also reduced its stake. Because of the need to attract other investors, Rosatom, Russia's atomic power company, and NEK, Bulgaria's National Electricity Company, at the



Reactors under construction as of the end of 2010 (the world total includes two reactors under construction in Taiwan, which is not displayed as a separate bar in the graph).

end of 2010 signed memorandums of understanding with the Finnish power company Fortum and Altran Technologies, a French consulting firm, to provide technical services for the project, with the possibility of also investing in it.

#### Czech Republic

In 2008, Czech utility ČEZ, a.s. announced that it would construct two new reactors at its Temelin site, and in August 2009 it began an open tendering process. In February 2010, ČEZ announced that it would begin discussions with three consortia, led, respectively, by Atomstroyexport (with Skoda JS), Westinghouse, and Areva. The tender includes an option for building as many as three new nuclear units in the Czech Republic or elsewhere in Europe. The possible sites being considered include Dukovany, where ČEZ operates four VVER-440 reactors, and Bohunice, in the Slovak Republic, where ČEZ has entered into a joint venture with the state-owned company JAVYS to build a reactor. Final bids are expected this year, and it is anticipated that a contract will be signed in 2012.

#### Finland

Following continuing construction delays, the third reactor being built at Finland's Olkiluoto site, which is owned and operated by Teollisuuden Voima Oyj (TVO), is now on course for commissioning in mid-2013, more than three years behind schedule. The plant is an EPR supplied by Areva, which is delivering the reactor plant, and Siemens, which is delivering the turbine plant.

In April 2010, the Finnish government announced preliminary approval for two nuclear new-build projects. Besides giving the go-ahead to TVO to construct a fourth unit at Olkiluoto, the government accepted the proposal of Fennovoima, a consortium of large energy users and power companies,

including Germany's E.ON AG, formed in 2007 specifically to construct a new nuclear power plant. Fennovoima is still considering two possible plant sites, and neither company has yet chosen a reactor design or vendor. The Finnish parliament ratified the government's decision in July, giving the companies five years to submit a construction application.

#### France

The construction of Electricité de France's (EDF) first Areva EPR unit at Flamanville is, like Olkiluoto-3, well behind schedule, with commercial operation not expected until late 2013 or 2014. In January 2009, French President Nicolas Sarkozy announced that the construction of another EPR will begin at Penly in 2012 for operation in 2017. In 2010, France's other major utility, GDF Suez, sought government approval to build an 1100-MWe ATMEA1 reactor, a design being developed by an Areva-Mitsubishi Heavy Industries' joint venture. This would be a reference plant for the design, providing a base for export sales.

In December 2010, the Nuclear Safety Authority extended the operating license of Tricastin-1 by 10 years, to 2020, following the reactor's third 10-year inspection. In July 2009, the regulator approved the safety case for the 40-year operation of the reactors in the 900-MWe range operated by EDF, based on a generic assessment. In July 2010, the company said that it was assessing the prospect of a 60-year lifetime for its reactors.

Faced with growing competition in the global nuclear market, Sarkozy ordered Areva and EDF to work together to ensure that the French industry competes effectively. The call for such action came after France lost a tender competition for the construction of four reactors in the United Arab Emirates, which France had expected to win, to a Korean-led consortium.

#### Germany

After winning the September 2009 election, Chancellor Angela Merkel and her new coalition government took more than a year to fulfill her promise to extend the lifetimes of the country's 17 remaining reactors, which had been limited to a maximum of about 32 years of production under existing nuclear phaseout legislation. Because there remains considerable public opposition to extending operation, even among some members of the coalition, the decision regarding how many more years to allow the plants to operate was not straightforward. Another difficult issue to resolve concerned the so-called windfall profits that power companies would reap from operating their plants longer. It was the government's aim to return more than half of these profits to the public coffers.

The solution reached in September 2010 was to give 14-year extensions (beyond the current 32-year limit) to the more modern nuclear plants—those built after 1980—and the older units an additional eight years. The last nuclear plants are now expected to close in 2036 instead of 2022, as set out under the previous law. In return, the nuclear operators must hand over more than half of the additional profits that are expected to be generated from the extended operation. The new measures introduced to put this plan in place were a mixture of new taxes and separate payments from the utilities to support renewables. These new arrangements were subsequently approved by both houses of parliament.

Faced with the German public's continued skepticism about nuclear power, Merkel defended the government's decision, noting that it will put Germany on track to having the most efficient and environmentally friendly energy supply in the world. She called nuclear power a bridging technology that is needed until renewables are developed to the point where they can become the main source of power.

#### Italy

Italy is now the only G-8 country without any nuclear electricity generating capacity, having shut down its nuclear plants following a referendum over 20 years ago. Consequently, it is also Europe's largest net importer of electricity. In May 2008, the new Italian government under President Silvio Berlusconi confirmed that it will commence building new nuclear power plants, with the aim of generating 25 percent of its electricity from nuclear power by 2030, which will require 8 to 10 large new reactors. In July 2009, the Italian Senate adopted legislation to reintroduce nuclear power to the country, which, among other measures, set out the basic requirements regarding nuclear safety, licensing, research, site selection, and decommissioning.

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In August 2009, Enel (Italy's largest power generator) and EDF formed a joint venture company with the aim of constructing at least four EPR units in Italy. The new company will initially undertake feasibility studies for the construction of new units, and the first EPR unit should come into operation by 2018. Enel, which holds a 12.5 percent share in the EPR being built by EDF at Flamanville, intends to take a share in France's second EPR at Penly.

#### *Lithuania*

At the end of 2010, a tendering procedure to construct a new nuclear plant in Lithuania failed when Korea Electric Power Corporation (KEPCO) dropped out of the process. Announcing the end of the procedure on December 3, Prime Minister Andrius Kubilius said that direct discussions with all potential investors in a nuclear project, including the South Koreans, would begin. With limited resources, Lithuania has moved forward as fast as possible to build a new nuclear plant to replace the Ignalina station, originally housing two RBMK reactors (like the units at Chernobyl), that was built when the country was part of the Soviet Union. The new plant, known as Visaginas, will be located next to the Ignalina plant.

Lithuania's aim is to develop a regional nuclear project in cooperation with its Baltic neighbors, Estonia and Latvia, along with Poland.

#### *The Netherlands*

In September 2010, Energy Resources Holding (ERH) announced that it was starting the procedure to license a new nuclear plant of up to 2500-MWe capacity at Borssele, the site of the Netherlands' only operating nuclear unit. In 2009, the utility Delta—which co-owns the Borssele plant with ERH—initiated a very similar plan, with a startup date of 2018. Both ERH and Delta are owned by provincial and municipal authorities and will need partners to develop a nuclear project. In November 2010, Delta signed a memorandum of understanding with EDF to collaborate on developing the project. The government had previously identified Borssele as a particularly suitable site for a new nuclear plant because it has the needed infrastructure, a plentiful supply of cooling water, and broad local and regional support.

#### *Sweden*

On June 17, 2010, by a margin of two votes (174–172), the Riksdag (the Swedish parliament) repealed the country's nuclear phaseout law, which had been introduced in 1980 following a national referendum. The new legislation, which took effect at the beginning of 2011, allows the construction of new reactors, but only to replace the 10 currently operating units at the three existing nuclear sites.

When coming into power following the September 2006 elections, the four-party Alliance for Sweden was still divided on the nuclear issue and agreed not to consider changes to the current phaseout policy during its term, although several major reactor upgrades were to be allowed. Growing concerns about energy supply and climate change led the two members of the four-party coalition that had been opposed to nuclear power to agree to the latest move. The main opposition party, the Social Democrats, remains opposed to the new policy and has promised to annul the new legislation if it returns to power.

#### *United Kingdom*

Following the United Kingdom's May 2010 elections, a two-party coalition took over from a government that had been working to establish a strong national nuclear power program. Although the Liberal Democrats, the smaller party in the coalition, had opposed the use of nuclear power, it finally agreed to support the continuation of the pronuclear policy.

After giving the go-ahead for a new-build nuclear program in January 2008, the previous administration had initiated a number of measures designed to remove potential barriers to undertaking new projects. This mainly involved streamlining nuclear licensing and planning (land-use) authorization procedures and identifying suitable sites for new plants. It also set out the generic design assessment (GDA) process, which is effectively a design certification scheme carried out by the nuclear regulators. The GDAs for two designs, Areva's EPR and Westinghouse's AP1000, should be completed by mid-2011, after which new-build applications will be submitted.

One notable change to the previous U.K. government's policy concerns a measure introduced to facilitate the authorization of nuclear power plants and other major infrastructure, such as airports, roads, and wind farms. Under the previous planning procedures, opponents of such projects were able to tie up the proceedings, sometimes for years. The new streamlined planning regime makes land-use authorization the responsibility of the independent Infrastructure Planning Commission (IPC) rather than of government ministers or local planning authorities. The IPC, however, would have to base its decision on an official government nuclear policy that had been approved by parliament. Believing that the

system lacked adequate accountability, the new coalition said that it will convert the IPC into an advisory body and give final decision-making power to the responsible

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government minister. What impact this will have on the project authorization process is not yet known.

So far, three utility groups have announced plans to build new nuclear plants. EDF Energy and Centrica, which now own British Energy, intend to build four EPRs, with the first unit to be sited at the Hinkley Point nuclear plant site for startup in 2017–2018. Horizon Nuclear Power, a joint venture formed by RWE and E.ON, plans to build some 6000 MWe of nuclear capacity. A third partnership, called NuGeneration, made up of Iberdrola, GDF Suez, and Scottish and Southern Energy, is planning to construct up to 3600 MWe of nuclear capacity, with work to begin in 2015.

#### **In the rest of the world . . .**

The following provides updates of nuclear developments in some of the main non-European Union countries.

#### *Argentina*

The country's nuclear utility, Nucleoeléctrica Argentina, currently operates two heavy-water reactors: Atucha-1, a 335-MWe pressurized heavy-water reactor (PHWR) supplied by Germany's Kraftwerk Union and put into operation in 1974, and Embalse, a 600-MWe CANDU 6 reactor supplied by Atomic Energy of Canada Limited that was connected to the grid in 1983.

Construction of a third reactor, Atucha-2, a larger version of the first unit, was started in 1981 but was suspended in 1994 when the reactor, designed by Siemens, was about 80 percent complete. In 2006, the government announced a strategic plan for the country's nuclear power sector involving the completion of the third plant and extending the life of the two operating reactors. Atucha-2 is now expected to start up in late 2011. Meanwhile, the construction of a fourth reactor has been approved, and over the past two years talks have been held with reactor ven-

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dors from China, France, Japan, Russia, South Korea, and the United States. The new plant, likely to be a pressurized water reactor, will be built at Atucha.

In October 2010, as part of the country's nuclear strategy, Argentine President Cristina Fernandez formally reactivated the country's gaseous diffusion enrichment plant, which had ceased production over two decades ago.

#### *Brazil*

Brazil operates two nuclear power plants. Angra-1 is a 626-MWe Westinghouse reactor that began commercial operation in 1985. Angra-2 was to have been the first of eight reactors to be supplied by Kraftwerk Union under a contract signed in 1975. Because of funding problems, however, only the first unit, Angra-2, entered commercial operation (in 2000), while the second, Angra-3, was left unfinished. In 2006, the government announced plans to complete the construction of Angra-3, and in December 2008, Eletronuclear, the plant operator, signed an industrial cooperation agreement with Areva to complete the plant and to possibly supply additional reactors. The construction license to restart work at Angra-3 was granted in May 2010. Commercial operation of the plant is expected at the end of 2015.

The government now envisages an additional eight nuclear units. At the end of 2009, Eletronuclear began initial siting studies at four potential locations in the northeast region of the country.

The country is also expanding its fuel cycle activities, with the aim of becoming self-sufficient by 2015. Besides increasing uranium ore production, Brazil plans to expand its commercial enrichment facility at Resende and is preparing to construct a conversion facility.

#### *Canada*

Plans for building new reactors have been put on hold by both of Ontario's nuclear operators, Ontario Power Generation (OPG) and Bruce Power, which are now focused on refurbishing their existing units. OPG's nuclear procurement process to select a vendor to construct two new reactors at its Darlington site was suspended in 2009 by the Ontario government, which owns OPG. Nevertheless, according to the November 2010 update to Ontario's 20-year energy plan, the provincial government remains committed to shutting down all coal-fired generating plants by 2014 and to maintaining nuclear power at approximately 50 percent of the province's electricity supply. In order to accomplish this, according to the plan, Ontario "will rebuild what it can, and replace what it can't." This includes refurbishing reactors at the Darlington and Bruce sites, as well as eventually building two new

nuclear units at Darlington.

NB Power's Point Lepreau plant remained shut down for another year, as the full fuel channel replacement refurbishment project, designed to extend the reactor's life by 25–30 years, is facing delays of about three years and will not be completed until 2012. The problems this project has encountered have led Hydro-Québec, which operates Gentilly-2, a sister CANDU 6 reactor, to delay its refurbishment project until the utility is confident that it can complete the work on time and on budget. Proposals to build nuclear plants in the provinces of Alberta and Saskatchewan have not progressed.

#### *China*

On the final day of 2010, the Fuqing-3 project, a CPR-1000 PWR in Fujian Province, became the ninth construction project to be launched in China during the year, bringing the total number of plants under construction in the country to 27. Two reactors were also connected to the grid for the first time during the year: Ling Ao-3 and Qinshan II-3. These achievements show how rapidly China's nuclear program is growing, particularly in comparison with the rest of the world.

The nine new construction projects include Haiyang-2, the last of the four Westinghouse AP1000s ordered in 2007, and Taishan-2, the second of two Areva EPRs also ordered in 2007. As the Westinghouse contract included technology transfer, the subsequent AP1000 projects will likely be contracted directly with Chinese firms.

China expects to build significant numbers of Generation-III/III+ reactors based on technology transfer and the experience gained from the AP1000 and EPR projects. A contract has also been signed to build two more Russian reactors at Tianwan. The acceleration of its program follows the initial slow buildup of experience in which China drew on foreign technology from Canada, France, and Russia. Until the decision was made to start an AP1000 program, China was developing an indigenous design capability based largely on French technology. The next-generation technologies being pursued at the moment are the high-temperature gas-cooled reactor and the fast reactor.

The CPR-1000 is based on the three-loop PWRs built by Framatome (now Areva) at Daya Bay. An advanced version is now being developed. Regarding the future of the AP1000, Westinghouse is working with Chinese organizations to develop a 1400-MWe version, which is referred to as CAP1400.

While only 13 nuclear power reactors are now in operation in China, this number will begin to rise substantially in a few years. The current capacity targets are 90 GWe by 2020, and 250 GWe by 2030. These nuclear

expansion targets, however, could go higher, as has happened on occasion over the past two years, driven by predictions of strong economic growth.

#### *India*

During 2010, two reactors—Rajasthan -5 and -6, which are both 202-MWe PHWRs—began commercial operation in India. This brings the number of operating reactors in the country to 19, with a total capacity of over 4100 MWe. The startup of both units was delayed because of a shortage of nuclear fuel, as India had not been able to import uranium while it was still under a nuclear trade embargo. In addition, besides Kaiga-4, which went critical in December 2010, Nuclear Power Corporation of India Limited (NPCIL) has six reactors under construction: the two Russian-designed VVER reactors at Kudankulam, and four 640-MWe PHWRs—Kakrapar-3 and -4 and Rajasthan-7 and -8. Pre-project activities are also under way for two more Russian units at Kudankulam.

According to the government's own energy targets, NPCIL is aiming to increase its nuclear capacity to 63 000 MWe by 2032. To realize such an ambitious goal, the company is working with both Indian concerns and foreign vendors. On the domestic front, NPCIL is forming joint ventures with the National Thermal Power Corporation (the country's largest power generator), the Indian Oil Corporation Limited, and the National Aluminum Company Limited to build nuclear plants, and is also in talks with other interested organizations, including the Steel Authority of India and Indian Railways. Discussions with foreign vendors are also under way. At the end of 2010, an initial agreement for the construction of two EPR units at Jaitapur was signed with Areva, and contracts for the construction of more Russian units at Kudankulam are also close to being signed.

Another important achievement was the passage of civil liability for nuclear damage legislation, which is designed to allow foreign companies to sign contracts to work on projects in India. Concerns remain among some Western organizations, however, that this will not provide adequate protection.

#### *Japan*

Japan, which imports some 80 percent of its energy requirements, operates 54 reactors that provide about 30 percent of the country's total electricity production. Over the past few years, the industry has been working to resolve a number of technical issues, and it achieved some successes in 2010.

Higashidori-1 is to be the first Japanese plant to extend its operating cycle beyond 13 months. Under nuclear inspection regulations introduced in 2009, a nuclear power plant's basic operating cycle—the time



interval between periodic inspections—can now extend to as long as 24 months, provided the plant complies with the new requirements that have been set out. This measure will help increase the load factors of Japanese nuclear plants, which remain well below international standards.

In December 2009, Kyushu Electric Power Company's Genkai-3 became the first Japanese nuclear power plant to operate commercially with mixed-oxide fuel. It was followed in 2010 by Fukushima-Daiichi-3 and Ikata-3.

The Monju prototype fast breeder reactor reached criticality in May 2010, more than 14 years after the sodium leak and fire that led to its shutdown in 1995. The reactor will undergo a staged program of performance testing over the next three years, with regular full-power operation anticipated beginning in 2013/2014.

New reactor construction is expected in Japan, perhaps this year, but some projects have been held up by concerns over local issues, and the national government has not recently announced firm commitments.

#### *Russian Federation*

With Rostov-2's start of commercial operation in 2010, Russia now operates 32 reactors at 10 sites. The fleet's installed capacity of about 22.7 GWe may double by 2020, according to Rosatom. Seven reactors are under construction, plus two 30-MWe reactors that will be aboard the country's first floating nuclear power plant. Significant investments are being made to extend reactor lifetimes beyond the initial 30 years of operation. Many of the older reactors, including the RBMKs (the Chernobyl-type reactors), are to be refurbished to operate for another 15 years, while the more modern units will be extended by 25 years.

On the commercial front, the Baltic nuclear plant planned for Kaliningrad is being designed to export electricity to the European Union. It is also to be the first Russian nuclear project open to private investors for up to 49 percent of the shares; the first unit is to be completed by 2016. In April 2010, Italian power company Enel signed with Rosatom subsidiary Inter RAO UES a memorandum of understanding that could see the Italian utility take a stake in the plant.

Rosatom's plans to build floating nuclear power plants are taking shape. The hull of the first plant, named *Academician Lomonosov*, was launched from the Baltic Shipyard in St. Petersburg at the end of June 2010. The completed plant is to be towed to a site at Vilyuchinsk, on the Kamchatka peninsula, in 2012, and grid connection is planned for 2013.

#### *South Korea*

South Korea is set to become a global nuclear exporting country after a consortium led by KEPCO won a \$20-billion contract

to supply four reactors to the UAE. During 2010, another Korean group, this one consisting of the Korea Atomic Energy Research Institute (KAERI) and Daewoo Engineering & Construction Company, signed a contract to build a 5-MW research reactor in Jordan.

Currently, South Korea operates 21 reactors that provide over 40 percent of the country's electricity. Of the seven reactors under construction, the most recent four are APR-1400s, the country's first Generation-III nuclear power plant design. The two Shin-Kori APR-1400s, which are the reference plants for the UAE project, should begin operation in 2013 and 2014. Shin-Ulchin-1 and -2 would follow in 2015 and 2016. South Korea is also developing the APR+, an advanced version of the design.

#### *South Africa*

During 2010, South Africa's government canceled the Pebble Bed Modular Reactor (PBMR) program due to its high costs and the failure of PBMR (Pty) Ltd. to attract enough investment or a major new customer for its reactors. The state-owned utility Eskom, which supplies about 95 percent of South Africa's electricity and operates the two-unit Koeberg nuclear plant, had already dropped plans to purchase a number of PBMRs. At the end of 2008, Eskom had also abandoned a procurement process to order several new nuclear plants because of financial difficulties. While the company later announced plans to restart a new but smaller nuclear construction program, the government took the matter into its own hands by deciding to develop a new national energy plan, which will include the future of nuclear power.

In October 2010, the Department of Energy released its draft Integrated Resource Plan (IRP) for the period 2010–2030 and began a public consultation. The IRP—which focuses only on electricity—seeks to develop an appropriate mix of power sources, taking into account various constraints, including cost, climate change, security of supply, and regional development. The draft plan envisions a future mix in which nuclear will provide 14 percent of the total electricity supply, with coal providing 48 percent, renewables 16 percent, peaking open-cycle gas turbines 9 percent, and peaking pump storage 6 percent, along with a few other sources.

#### *Switzerland*

Switzerland's five nuclear reactors produce some 40 percent of the country's elec-

tricity. In February 2007, the government adopted a new energy policy strategy that included replacing existing power reactors with new nuclear units to avoid a shortfall of as much as 25 percent of electricity demand by 2020 as the smaller reactors come to the end of their lives and the electricity import arrangement with France is phased out. This strategy calls for two new nuclear power plants to be ready for operation by about 2020.

Since that time, three Swiss utility groups have applied to the government for a general framework permission to build new reactors at three sites: Beznau, Gösgen, and Mühleberg. At the end of 2010, the three groups, Axpo, Alpiq, and BKW FMB Energy, announced that they would team up to develop all three projects jointly. A decision on whether all three of the plants will actually be built is expected to be made in mid-2012.

#### **Preparing for new nuclear**

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key, the United Arab Emirates, and Vietnam—have begun to move forward rather quickly.

#### *Jordan*

In March 2010, the Jordan Atomic Energy Commission (JAEC) signed a contract with a Korean consortium made up of KAERI and Daewoo Engineering & Construction to build the country's first research reactor. The 5-MW Jordan Research and Training Reactor, which is to be operational by 2015, will be built at the Jordan University for Science and Technology. The reactor, a smaller version of KAERI's High-flux Advanced Neutron Application Reactor, will become the focal point for a national nuclear science and technology center to educate and train future generations of Jordanian nuclear engineers and scientists.

The JAEC has also short-listed three reactor designs for Jordan's first nuclear power plant: Atomic Energy of Canada Limited's Enhanced CANDU-6 reactor (a 700-MWe class design); Atomstroyexport's AES-92 (a 1000-MWe design); and the ATMEA1 (an 1100-MWe design), which is

being developed under a joint venture between Areva and Mitsubishi Heavy Industries. A site near Aqaba has been chosen for the plant.

The commission is also working with various foreign mining organizations to exploit the country's uranium resources. For example, in early 2010, the JAEC signed a uranium mining agreement with Areva, granting the company the right to mine the deposits of central Jordan for 25 years. Areva is carrying out a feasibility study covering environmental, economic, and technical aspects of the project prior to starting production.

### *Egypt*

In March 2010, a new law setting out the framework for regulating nuclear installations and other activities involving radioactivity was passed by Egypt's parliament and ratified by President Hosni Mubarak, marking an important step in the country's ambitious plans to introduce nuclear power. Minister of Electricity Hassan Younis said this law paves the way for the establishment of a fully independent regulatory authority that would have all of the powers necessary to fulfill its nuclear responsibilities.

Several sites have been assessed for their suitability for the construction of a nuclear power plant, with El-Dabaa, on the Mediterranean coast, the most likely to be selected. International bidding to build a plant is expected this year. Egypt wants to build four nuclear units by 2025, with the first to start operating in 2019. The ministry has already invited several firms for project briefings, including Areva and Westinghouse, Younis said. Firms in South Korea, Japan, and Russia may also be considered as possible suppliers.

### *Turkey*

Following the failure of the reactor tendering process at the end of 2009, the Turkish authorities began direct discussions with Russia to come up with a deal. After several months, the two sides developed a build, own, and operate plan, whereby Rosatom, Russia's state atomic energy company, will set up a wholly owned project company to build and operate the plant, with the power to be sold at agreed-upon terms. Eventually, up to 49 percent of the project company will be sold to other investors, in Turkey and possibly in other countries. The plant, consisting of four 1200-MWe VVER-491 units, will be built at Akkuyu, on Turkey's Mediterranean coast, at a reported cost of about \$20 billion. The reactors are expected to enter service between 2019 and 2021. The countries' presidents signed an agreement in May 2010.

Turkey is also currently in talks with companies in Japan for the possible construction of a nuclear plant at Sinop, on the Black Sea coast.

### *United Arab Emirates*

In December 2009, the Emirates Nuclear Energy Corporation (ENEC) selected a bid from a South Korean consortium to supply the country with four APR-1400 reactors. One year later, ENEC submitted an application to the United Arab Emirates' Federal Authority of Nuclear Regulation (FANR) for a license to construct the first two units at Braka, on the Persian Gulf. The contract, which includes construction, commissioning, and supply of the fuel loads for four units, was valued at about \$20.4 billion. The first plant is to start up in 2017, and the fourth in 2020.

The Korean consortium is led by KEPCO and includes Samsung, Hyundai, and Doosan, as well as Westinghouse, owner of the System 80+ design originally developed by Combustion Engineering and certified in the United States. This design has been developed by the Koreans into the third-generation APR-1400 design.

The UAE's nuclear strategy was developed in close consultation with the IAEA. In April 2008, the government published a comprehensive policy on nuclear energy following an intensive assessment of energy options in which nuclear power emerged as "a proven, environmentally promising, and commercially competitive option which could make a significant baseload contribution to the UAE's economy and future energy security." In choosing a nuclear strategy, the UAE pledged to be transparent and to adopt all required international agreements for a nuclear power program. This approach was widely praised by the IAEA and the United States as a model for other countries that want to implement a nuclear power program, particularly in the Middle East.

In October 2009, the UAE adopted atomic energy legislation creating the legal infrastructure for implementing a nuclear program. The act provided for the establishment of FANR as a fully independent federal nuclear safety regulatory authority and set legal conditions for the licensing and control of nuclear material, including criminal penalties for its misuse. It also made it illegal to develop, construct, or operate uranium enrichment or spent fuel processing facilities within the country's borders.

### *Vietnam*

In June 2010, the Vietnamese government set out a master plan to implement a nuclear program to construct 15 GWe of nuclear capacity by 2030. This followed the approval in November 2009 by the country's National Assembly of an initial nuclear program and the government's decision to begin negotiations with Russia for the first two units, to be sited at Phuoc Dinh in Ninh Thuan province, for operation starting in 2020.

Throughout the year, Russian and Vietnamese negotiators worked to define the terms for a contract. By the time the high-level intergovernmental agreement was signed in October, all the key issues were agreed on, with only fine details, such as the specific financing arrangements, needing to be resolved before contracts could be signed.

At the same time, Vietnam agreed to begin discussions with Japan for developing another nuclear project. The government said it is also considering other vendors for subsequent reactors. Vietnam has signed nuclear cooperation agreements with several countries, including Canada, China, France, Japan, South Korea, and the United States.

### **Emerging nuclear countries**

The global interest in nuclear power is not only monitored by the IAEA, but also has a direct impact on its work. According to a recent IAEA document, *Rising Expectations for New Nuclear Power Programmes—NTR2010 Supplement*, more than 60 countries have approached the agency for support in assessing or actively planning for nuclear power. This renewed interest, the report says, is a response to growing energy demand, climate change concerns, and volatile fossil fuel prices. There is also a widespread view that nuclear power can fuel economic growth.

This level of interest is reflected in the agency's own projections of nuclear growth. While most new capacity will be built in countries that already have operating nuclear power plants, its low and high projections show that between 10 and 25 countries will commission their first nuclear power plants by 2030.

This is also reflected by a threefold increase in the number of IAEA Technical Cooperation projects (projects requested by member countries) related to nuclear power, rather than, as had been more typical in previous years, to nuclear technologies used in areas such as health, agriculture, training, and safety. The number of projects has grown from 13 in the agency's 2007–2008 program to 35 in its current program.

Referring to emerging nuclear countries or "nuclear newcomers," the report notes that some, such as Bangladesh, Egypt, and Vietnam, have been planning for nuclear power for some time. Others, such as Poland, are reviving the nuclear power option after plans had been curtailed, often due to public opposition, while countries such as Jordan, Mongolia, and Uruguay are considering nuclear power for the first time.

Countries introducing nuclear power now—as well as those wanting to restart programs that had stopped many years ago—face conditions different from those of the past, according to the report. While the construction of nuclear plants has continued in some regions, many nuclear countries have not experienced a new-build proj-

ect in decades. Besides its general negative impact on public opinion, the Chernobyl accident also led to a growing public demand for transparency and openness regarding nuclear power. In addition, challenges to the nonproliferation regime associated with the discovery of clandestine programs in Iraq, Iran, and North Korea have led to increased security concerns.

More recently, conditions have shifted in a more positive direction. Concerns about climate change have affected perceptions of nuclear power, and some prominent environmentalists now publicly support nuclear power, seeing it as an important contributor to meeting carbon emission limits and fueling development. Some countries now looking at nuclear are running out of options, the report says. Chile, for example, has recently experienced a “perfect storm,” when a major drought reduced output from hydropower at the same time that imports of natural gas were disrupted, and it has begun to study the viability of the nuclear power option. Bangladesh expects to use up its stores of natural gas within the coming decade and has few options to meet its base-load energy production.

Traditionally, nuclear power plants and other large-scale investment projects have required government involvement—for example, in providing financing guarantees. This is not feasible for many newcomer

STATUS OF IAEA COUNTRIES PLANNING FOR A FIRST NUCLEAR POWER PLANT

Not planning to introduce nuclear power, but interested in considering the issues associated with a nuclear power program	31
Considering a nuclear power program to meet identified energy needs, with a strong indication of intension to proceed	14
Active preparation for a possible nuclear power program, with no final decision	7
Decided to introduce nuclear power and started preparing the appropriate infrastructure	10
Invitation to bid to supply a nuclear power plant prepared	0
New nuclear power plant ordered	2
New nuclear power plant under construction	1

countries, and the new build, own, and operate approach to financing nuclear projects (starting with Turkey) is being borrowed from other parts of the energy sector where it is commonly used.

Regional approaches to nuclear power development are also being considered. The Gulf Cooperation Council countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE) have recently expressed interest in a regional approach and are working with the IAEA through a Technical Cooperation project to understand the issues. In Eastern Europe, Lithuania has invited Poland to join Estonia and Latvia in a regional approach to replacing the nuclear units shut down at its Ignalina site. Final agreement regarding the levels of investment and electricity off-take among the partners has not yet been reached.

A September 2010 report by the IAEA,

*International Status and Prospects of Nuclear Power*, said that about 65 countries without nuclear power plants “are expressing interest in, considering, or actively planning for nuclear power . . . after a gap of nearly 15 years,” during which time few countries showed a real interest in developing programs.

Although not naming the countries, the agency did provide the accompanying table indicating the seriousness of these 65 countries, noting that 31 of them are not currently planning to build reactors, and 17 of the 31 have grids of less than 5 GW, which is too small to accommodate most of the current reactor designs. The table also shows that one country has a plant under construction, two have each ordered a new nuclear power plant, and 10 have decided to build and are preparing the needed infrastructure. ■