PLATTS
McGRAW HILL FINANCIAL

NUCLEONICS WEEK
Volume 56 / Number 41 / October 8, 2015

US reactor vendors say they will move work overseas without Ex-Im Bank

US-based nuclear reactor companies are considering transferring work to other countries as a result of the prolonged lapse in authorization for the Export-Import Bank of the United States, officials said in interviews and speeches over the past month.

Congressional authorization for the bank, which provides loan guarantees to help finance international customer purchases of US-made goods, expired June 30. Opponents of the bank, Republicans who believe the program provides unneeded advantage to large companies, have blocked efforts to reauthorize the bank's charter.

The Ex-Im Bank has not been able to provide new financing since June 30, although it is able to support existing loan guarantees.

"It adds an element of market uncertainty to our efforts," said Jay Wileman, chief operating officer of GE Hitachi Nuclear Energy. "I'm very disappointed that our leadership didn't show leadership in getting this issue addressed," he said in an interview September 11 on the sidelines of the World Nuclear Association annual meeting in London.

General Electric has customers around the world and operations in dozens of countries, so it can move work around to where it is supported by an export credit agency, or ECA, Wileman said. "If I'm going to build a plant that needs ECA financing, I will bring in engineers [from] elsewhere, in France with [French ECA] Coface, or in Japan with

(continued on page 5)

Think tank warns of growing cyber attack danger at nuclear plants

A new report by the UK's Chatham House think tank warns that a combination of increased online activity by criminals, states and terrorist groups, combined with the relatively recent digitization of many nuclear installations, means that the danger of a cyber attack on a civilian nuclear facility has increased.

The October 5 report, "Cyber Security at Civil Nuclear Installations Understanding the Risks," said that "recent high-profile cyber attacks, including the deployment of the sophisticated 2010 Stuxnet worm, have raised new concerns about the cyber security vulnerabilities of nuclear facilities."

Stuxnet was a 2010 computer "worm," or malware program, that attacked Iranian computer software and was responsible for damaging a significant number of Iran's nuclear centrifuges, according to media reports at the time, which linked the program to the American and Israeli security services.

The Chatham House report said that "even a small-scale cyber security incident at a nuclear facility would be likely to have a disproportionate effect on public opinion and the future of the civil nuclear industry."

A spokeswoman for the UK's Office for Nuclear Regulation, or ONR, said in an October 7 email that "ONR recognises the thrust of the recommendations in the Chatham House report. As the nuclear safety and security regulator we licence sites and approve their security plans on the basis of a range of defence in depth measures, which includes cyber security."

The spokeswoman added that "cyber risks are always developing and no one can

(continued on page 6)

Japan fuel cycle plan may need review: analysts

The uncertain timing for restarting up to 18 Japanese LWRs that are planned to operate using partial cores of mixed-oxide, or MOX, fuel, could force the country to review its long-standing nuclear fuel cycle plan, known as the pluthermal program, analysts said.

The country's national fuel cycle strategy calls for the restart of LWRs in order to dispose of the country's stockpile of spent fuel and separated plutonium.

The "pluthermal" fuel cycle program, a word combining plutonium with thermal, was launched by the Federation of Electric Power Companies of Japan, or FEPC, in 2009, with the aim of having between 16 and 18 LWRs running on MOX fuel in Japan by 2015. MOX fuel is made from uranium and plutonium recovered from the reprocessing of spent fuel.

Four reactors -- Kansai Electric Power Co.'s Takahama-3, Shikoku Electric Power's Ikata-3, Kyushu Electric Power's Genkai-3 and Tokyo Electric Power's Fukushima I-3 — were using some MOX fuel before the 2011 Fukushima I accident, a spokesman for FEPC

INSIDE THIS ISSUE

Westinghouse says tests show new low-leak pump seals work 3

Experts recommend continued follow-up for Flamanville-3 vessel 3

New development model needed for Bulgarian unit: Westinghouse 5

Notes to Nucleonics Week's generating table for August 2015 7

said in an interview October 7. Some reactors have operated using MOX fuel assemblies comprising about 20% to 25% of their cores, according to an official at the PWR division of Nuclear Regulation Authority, or NRA.

The reuse of fissile material from spent nuclear fuel has been seen by the nuclear industry as an effective way to provide energy security in a country lacking abundant natural resources.

However, the extended shutdown of the country's reactors following the Fukushima I accident has raised questions about the fuel cycle plan, a former member of the Japan Atomic Energy Commission said.

"It could be almost impossible" for the 16 to 18 reactors intended to use MOX fuel to restart any time soon and for a fuel cycle program based on this strategy to work, Tatsujiro Suzuki, director of the Research Center for Nuclear Weapons Abolition at Nagasaki University and former vice chairman of the JAEC, said in an interviewOctober 7.

The government and nuclear industry should consider alternative plans such as halting the reprocessing of spent fuel and disposing of it directly, Suzuki suggested.

His comments come after FEPC Chairman Makoto Yagi said at a September 18 news conference that the utility industry should maintain a fuel cycle program based on loading MOX fuel in as many as 18 reactors.

Japanese power companies can use plutonium stored in and outside Japan to power those units, Yagi said.

"Operating those reactors would be behind schedule, but our policy of implementing a pluthermal program won't change," Yagi said. He did not elaborate on the timeframe for the implementation of the program.

All of the country's reactors that are proposed to use MOX fuel are currently under safety review by the NRA following the 2011 Fukushima I accident.

Almost all reactors in Japan shut immediately after the Fukushima I accident, with all being shut from September 2013 until Kyushu Electric Power Co.'s Sendai-1 became the first to restart in August.

The NRA has so far only allowed Sendai-1 to restart, more than two years after the power company submitted a safety review application to the regulator (NW, 13 Aug, 1).

The Rokkasho spent fuel reprocessing facility has produced separated plutonium in a test scale but has not operated commercially.

Japan Nuclear Fuel Ltd. plans to complete construction of the facility by March, but this timeframe represents the 22nd revised target date following a series of construction problems at the site. The Rokkasho facility has also been waiting for regulatory approval since January for commercial operations. It has been producing plutonium as part of an extended test run that began in 2006.

"The reality is, the [pluthermal] plan won't work and they [the government and the industry] will need to revise it," given that whether the country's 16 to 18 LWRs will restart is uncertain, Tetsuya Endo,

CORRECTION

Viacheslav Pershukov is Rosatom's head of innovation. His name was spelled incorrectly in the October 1 issue of Nucleonics Week.

PLATTS
McGRAW HILL FINANCIAL

NUCLEONICS WEEK
Volume 56 / Number 41 / October 8, 2015

ISSN: 0048-105X

Nucleonics Week is published 51 times yearly by Platts, a division of McGraw Hill Financial, registered office: Two Penn Plaza, 25th Floor, New York, N.Y. 10121-2298.

former vice chairman of the JAEC and senior adjunct fellow at the Japan Institute of International Affairs, said in an interview on September 28.

No current plans for policy review

Kenichiro Urakami, director of the nuclear energy policy planning division at Japan's Ministry of Economy, Trade and Industry, said on the sidelines of an October 6 news conference that the government has no plans to review the pluthermal policy "at the moment."

He did not, however, rule out the possibility of discussing a review of the country's fuel cycle program at future meetings between the government and the country's power companies.

Kansai's Takahama-3 and -4, which have either used or plan to use MOX fuel, have already met the NRA safety standard for restart, but the reactors are currently shut due to court order following a legal challenge to their restart by an anti-nuclear group. Some lawyers have said that ruling could be reversed based on rulings in similar cases (NW, 30 Apr, 5).

Electric Power Development Co., known as J-Power, plans to operate Japan's first nuclear reactor running solely on MOX fuel at its Ohma generating station, which is currently under construction.

The company, which had planned to complete the construction of the 1,383-MW ABWR by 2020, has pushed the plan back by one year to 2021, as a regulatory review for the reactor is taking longer than expected, a company spokesman said in an interview on October 6. The actual operation date for the newly built plant is uncertain, the spokesman added.

Tokyo Electric Power Co. has a plan to operate three to four reactors with some MOX fuel, a company spokeswoman said in an interview on October 7.

The Monju fast breeder reactor has used MOX fuel, but its operations also remain uncertain, a spokesman at Japan Atomic Energy Agency, which operates Monju, said in an interview on October 7. A series of incidents at Monju have resulted in the facility being shut for the last 20 years.

Monju, a sodium-cooled fast reactor in Fukui Prefecture, had been expected to play a key role in Japan's pluthermal project by using MOX fuel for operation.

— *Yuzo Yamaguchi, Tokyo*

Westinghouse says tests show new low-leak pump seals work

A new version of Westinghouse's lower-leakage reactor coolant pump seals, a component being used by some plants to show they meet new post-Fukushima safety standards, was successfully tested after operating for 18 months in a US reactor, the company said October 5.

An earlier version of the Shield-brand seals had not performed as expected, causing some plant operators to seek extensions of their dates of compliance with the NRC rules.

"This is great news for our customers and their plants," said David Howell, senior vice president of Westinghouse's operating plants business, in a statement October 5. Installing the seals will simplify the plant operator's response to the agency's order that power reactor licensees adopt mitigating strategies to protect against extreme external events, Westinghouse said.

The test had not been required by NRC, but Westinghouse had agreed to complete it and agency representatives observed the test, Westinghouse spokeswoman Sheila Holt said in an email October 6.

NRC endorsed a Westinghouse technical report submitted in March to support use of the new seals by licensees in their analyses of plans to comply with the post-Fukushima mitigating strategies order (Inside NRC, 16 June, 3). The technical report said the third-generation seals resolve problems in an earlier design by simplifying the seal, making it more resistant to friction and corrosion.

A second-generation low-leakage seal developed by Westinghouse failed to work as expected in post-operational tests and the reactor vendor said the seals would have to be redesigned.

The seals, which provide lower leakage rates than conventional seals used in reactor coolant pumps, are important because as many as 10 US nuclear plants relied on the low-leaking Westinghouse version in analyses conducted to show they meet the requirements of NRC's post-Fukushima order to ensure indefinite cooling of the reactor and spent fuel caused by extreme events.

One of the issues that must be addressed in meeting the mitigating strategies order is an analysis of the loss of reactor coolant inventory. A factor in that analysis is leaking of reactor coolant pump seals. Without cooling in a station blackout scenario, conventional seals would rapidly leak large amounts of coolant into containment, licensees said in their initial plans for meeting the order.

Several vendors, including Westinghouse, have developed lower-leakage seals to help licensees meet the new NRC requirements. The so-called shutdown seals are a key part of the strategy to meet the order's requirements, nuclear operators have said.

The third-generation seal was installed at FirstEnergy Nuclear Operating Co.'s Beaver Valley-2 for the operating cycle than began in the spring of 2014, the Westinghouse statement said. The seal was removed from service October 2 and tested October 4, with successful results, Holt said.

NRC continues to review a topical report from Westinghouse that would allow the use of the improved seals in plant probabilistic risk analyses that are used to assess options to meet fire protection and other requirements.

Six units at five sites asked NRC to extend by an additional refueling outage the time allowed to comply with the March 2012 mitigating strategies order because of problems with the earlier version of the low-leakage Westinghouse seals. Licensees were required to comply by the end of the second refueling outage after March 2012 or the end of 2016, whichever was sooner.

In all cases, the extensions sought by operators to meet the requirements of the NRC order were before the end of 2016.

— *William Freebairn, Washington*

Experts recommend continued follow-up for Flamanville-3 vessel

A group of experts, convened by French nuclear regulator ASN, has advised Areva to include potential operational measures on the future use of the upper and bottom head of the vessel at the Flamanville-3

EPR in a report to the regulator, ASN's Deputy Director General Julien Collet said in an interview October 6.

The GP ESPN, a permanent group of nuclear pressure equipment experts within ASN, said in a note released on ASN's website October 1 that Areva would need to propose measures that would enable a future operator to monitor the properties of the upper and bottom head of the vessel.

The expert group said it had judged "acceptable" Areva's methodology to demonstrate the sufficient fracture toughness of the upper and bottom heads of the Flamanville-3 reactor pressure vessel. However, the proposed method could "not restore the guarantee on the first level of defense-in-depth that a technical qualification consistent with current standards would have brought."

"If we cannot have all the necessary guarantees, then we would have to take measures on the operation" of the vessel, said Collet, referring to the expert group's conclusions. He suggested, as an example, that regular tests could be undertaken to monitor the integrity of upper and bottom head of the vessel.

Areva, EDF and ASN reported in April that chemical tests Areva performed in 2012 on steel similar to that in the reactor vessel top and bottom heads at Flamanville-3 showed a carbon content of 0.30%, higher than the 0.22% maximum limit set by French regulation (NW, 16 Apr, 1). The unit is under construction in France.

High carbon content in the vessel heads can reduce fracture toughness, which is the ability to withstand the propagation of cracks.

Mechanical tests on the vessel heads also revealed impact resistance values between 36 joules and 64 joules for an average of 52 joules, lower than the 60 joule minimum established by a 2005 French regulation on nuclear pressure equipment, known by its initials in French, ESPN. That regulation revised requirements for pressure vessels in nuclear reactors. A joule is a unit of measurement of energy applied to a mass or object.

The GP ESPN, in the note, said other manufacturing processes, "such as the one put in place for the heads of the EPR in Finland [Olkiluoto-3]," would have prevented the high carbon concentrations.

IRSN, the main technical support organization of ASN, reached a similar conclusion to the GP ESPN in a document published in April. It said the manufacturing process used for the upper and bottom vessel for the EPR vessel was in "technical regression," meaning using an older process, compared to the one used to make the components in the current operating fleet (NW, 16 Jul, 1).

The vessel head and bottom for the EPR were forged from a conventional ingot, the first time this has been done for a French reactor pressure vessel, according to IRSN. All of the country's 58 power reactors have vessel heads made using other methods, including using a "directional solidification ingot," known by the French acronym, LSD, that was developed to provide greater chemical, structural and mechanical homogeneity.

The upper and bottom head for Finland's Olkiluoto-3 EPR were manufactured by Japan Steel Works, or JSW. The heads for Flamanville-3 were manufactured by Creusot Forge, an Areva subsidiary.

Areva's proposed methodology, submitted to ASN in May, sought to justify the toughness of the upper and bottom heads by "other means" than compliance with toughness values required by regulation.

The methodology comprises three parts: calculating the level of toughness required to prevent any risk of the heads breaking, testing the minimum toughness in the part of the material with the high carbon concentrations, and finally, comparing the two test results. Areva has said that sufficient toughness of the heads would be demonstrated if the minimum toughness in the high carbon zones is greater than the level of toughness required to prevent a breaking of the heads.

The GP ESPN in its report said it considers this methodology "appropriate" and "acceptable" but also made four recommendations.

The first recommendation suggested additional testing of the bottom head of Flamanville-3 to demonstrate the absence of defects.

"All the controls that have been made so far have not shown defects [on the upper and bottom heads], but there is always a limit in testing," said Collet. Therefore, the group has suggested more tests to strengthen the confidence that the bottom head, which in a PWR is typically not a replaceable part, is free of defects.

The second recommendation outlines additional technical specifications to be made when Areva performs destructive testing on a similar components to demonstrate the minimum toughness values.

Areva said it would use the top and bottom head manufactured for EPR projects at Hinkley Point C in the UK and an unspecified US project as sacrifical parts. Sacrifical parts are used for destructive testing.

Finally, the third and fourth recommendations detail the best way for Areva to compare the results between the toughness values measured on the Flamanville-3 heads and the values measured with the sacrificial heads.

Collet said that there were several ways to compare the two results, with some that give better guarantees, but are more restrictive due to the higher safety margins they incorporate.

"Let's look at the scenario with the greatest guarantee and see if it works," said Collet. If that scenario doesn't work, the expert group suggested other methods to demonstrate the validity of the results.

ASN said September 30 it would make a final decision on Areva's proposed methodology "in the next few weeks."

EDF said in September it was "confident" that full results of tests of the top and bottom vessel heads would demonstrate their safety to ASN.

EDF is architect-engineer of Flamanville-3, while Areva is the plant supplier.

Areva declined to provide any comments on the GP ESPN note.

Pierre-Franck Chevet, ASN president, said during a Senate hearing in June that the ASN expects to make its decision during the first half of 2016 on whether the reactor vessel will be acceptable for use.

EDF announced in September that the commercial operation of Flamanville-3 would be delayed to the fourth quarter of 2018 with costs revised to Eur10.5 billion ($11.8 billion) from Eur8.5 billion.

Flamanville-3, the first Generation III reactor built in France, has had numerous setbacks associated with quality and design issues in both civil works and plant components since construction began in 2007.

EDF had said in 2012 that it expected the plant to start up in 2017.

When the project was started in 2005, the reactor was estimated to cost Eur3.3 billion and expected to generate its first electricity in the spring of 2012.

— Benjamin Leveau, London

New development model needed for Bulgarian unit: Westinghouse

While there is agreement about the long-term benefits of a new reactor at Bulgaria's Kozloduy plant, a new development model may need to be explored in order to secure a deal to build a new unit, a Westinghouse spokesman said in an October 6 email.

Hans Korteweg, a Brussels-based spokesman for the company, noted in the October 6 email that the shareholder agreement defining a period of exclusivity in negotiations between the Bulgarian government and Westinghouse for Kozloduy-7 "expired at the end of March 2015. But discussions are continuing on a new structure and timeline" for the construction of the unit.

Korteweg said that "the decision was made jointly by all parties with current conditions in Bulgaria to support an infrastructure project of this size."

However, he added that "while there is unanimity that the project is clearly attractive in the long-term, the parties believe that different models [new funding or shareholder arrangements] will need to be considered for deploying the AP1000 technology in the future."

A new unit at the plant has long been discussed. Westinghouse was in exclusive negotiations with the Bulgarian government about providing an AP1000 reactor for Kozloduy-7 for over 18 months (NW, 23 Apr, 6).

However, financing issues and the operating life extension for the existing Kozloduy-5 and -6, among other issues, have increasingly taken priority over new construction at the station, particularly as the Eastern European country remains a net exporter of electricity.

Asked about the reasons for delay in the new reactor project, Radoslav Mikov, an energy lawyer at the Wolf Theiss law firm in Sofia, said in an October 6 email that "the significant value of the expected investment, the lack of commitment for investment risk sharing and expectations for provision of state guarantees which are hardly to be currently provided hinders further commitments for the time being."

Mikov added that "the excess of electricity production in Bulgaria and the low electricity prices in the region" were also factors hindering progress on the Kozloduy expansion.

A spokesman for the Bulgarian government did not respond to requests for comment by press time.

However, the Bulgarian energy ministry in a September 25 email said that the Bulgarian government is looking for a strategic investor in the Kozloduy-7 project (NW, 1 Oct, 7).

The email added that "as a company with international experience, Westinghouse remains a strategic partner for the Bulgarian nuclear sector."

End of 2015 is a key date: Brachet

In comments at a Westinghouse press briefing held in conjunction with the World Nuclear Association Symposium September 11 in London, Yves Brachet, the company's president for Europe, the Middle East and Africa, cited the end of 2015 as being an important date for Westinghouse's continued involvement in the construction of Kozloduy-7.

Brachet said that the company is in the process of reviewing each step of its involvement in the project and that it could be ready to present its plans on the issue to the Bulgarian government by the end of 2015.

Mikov noted that it "seemed rather improbable" that the Bulgarian government could have a firm decision on Kozloduy-7 by the end of the year.

Mikov said that the government would not want, due to political sensitivities, to deal with the new unit at Kozloduy until local elections in October are completed.

He also noted that the Bulgarian government attached greater weight to other issues in the energy sector than Kozloduy's expansion. These included discussions with the owners of two lignite power stations in Bulgaria about power purchase agreements, he said.

— Oliver Adelman, London

Ex-Im Bank

...from page 1

JBIC," Japan Bank for International Cooperation. Both Coface and JBIC have a long history of financing nuclear plant project exports from their countries.

"The loss of the Export-Import Bank will have a big impact," David Howell, Westinghouse's senior vice president for operating plants, said during a conference October 1 in Pittsburgh underwritten by nuclear industry lobbying group Nuclear Matters.

"We as a business obviously will go on, but what that means is that we will go to other sources for financing our international projects. And usually those other sources of financing, coming from someplace like the Japanese equivalent of the Export-Import Bank or others, there's an expectation that jobs go to the country the financing goes through," he said.

"There are clearly decisions that have to be made" about where work will be completed for future nuclear plant contracts, Howell said.

Westinghouse has facilities in China and Europe, and its parent company has manufacturing capacity in Japan that could be used instead of US locations to support international contracts if the Ex-Im Bank remains shut, Howell said on the sidelines of the conference. "It's not something we want to do," he said.

In particular, upcoming opportunities to supply reactors in Bulgaria and other parts of eastern Europe will suffer from the lack of US export credit financing, Howell said.

"This is a key area for us to be competitive in the marketplace, because we are up against countries who do financing for these projects, many of them heavily financed by their governments. So without the Export-Import Bank to level the playing field, we are definitely at a disadvantage," Howell said.

The lapse in authorization has already cost power industry jobs, the Nuclear Energy Institute said in a September 24 statement. General Electric moved 500 natural gas turbine-related jobs to France after reaching agreement with Coface to support international projects, NEI said.

"A similar story could unfold in the nuclear industry if the bank is not reauthorized," NEI said.

A concern of NEI is that state-owned nuclear companies already have an advantage in leveraging government support. "Major nuclear exporting countries — armed with their own credit agencies — have signed nuclear deals worth billions of dollars in recent years," NEI said. Russian state nuclear company Rosatom "has been particularly aggressive in winning market share by offering favorable financing deals in many countries," NEI said.

Japan and France have also provided major financing for projects led by their nuclear industries, NEI said.

"In the civilian nuclear business, foreign customers require official export credit agency support as part of any major nuclear construction deal," Ted Jones, NEI director of supplier programs, said in the statement.

Reauthorization 'uncertain,' NEI says

Reauthorization is "very uncertain," NEI said in the statement.

There is no plan to vote on reauthorization in the US House of Representatives this month, even though a majority of members support bringing Ex-Im back, Representative Steny Hoyer, a Maryland Democrat who is the party's whip in the House, said in an October 1 statement. Hoyer called on Republican leaders to schedule a vote on a measure reauthorizing the bank.

The suspension of new work by the Export-Import Bank is hurting businesses all over the country, Gene Barr, president and CEO of the Pennsylvania Chamber of Business and Industry, said during the Nuclear Matters event October 1.

"Someone else once said, you can't unilaterally disarm, but we chose to unilaterally disarm in terms of an important economic program," he said. "You have Westinghouse, you have GE, you have Boeing … that have made use of" the export credit financing once offered by the Export-Import Bank, he said. "The Loss of Ex-Im is a real, real problem for this country."

— William Freebairn, Washington

Cyber

...from page 1

afford to be complacent. In addition to our robust inspection regime, ONR is constantly reinforcing the importance of cyber security to senior figures across the UK nuclear industry. We agree with the Chatham House report that significant attention must be paid to these issues now and in future."

NRC and US nuclear industry officials said that many of the report's criticisms do not apply to US nuclear power plants, which have in place robust cyber security measures and are adding more.

The report says that "the cyber security risk is growing as nuclear facilities become increasingly reliant on digital systems and make increasing use of commercial 'off-the-shelf' software, which offers considerable cost savings but increases vulnerability to hacking attacks."

Caroline Baylon, a cyber security expert at Chatham House and the report's lead author, said in an interview October 5 that there are seven cyber incidents at nuclear facilities cited in the report.

She added that there was "not a lot of incident disclosure" in the nuclear industry, but that "one of my sources has documented as many as 50 industrial control systems incidents at nuclear facilities."

Baylon said that recent digitization of nuclear plant systems is "basically an industry-wide trend. Digitalisation tended to happen later in the nuclear sector [compared to other industries] because of initial regulatory restrictions."

The report notes that the risks of cyber attack increase with the increased use of digital systems at generating stations, both because computer systems are more prone to cyber attack, but also because some stations are also increasingly using "off the shelf," or commercially available, software that is more vulnerable to attack.

While the report did not specifically list which plants have digital safety systems, Baylon emphasized that stations were generally more vulnerable to attack the more digitized they were. She cited the example of Russia, where the level of digitization was significantly lower and so the risk of cyber attack lower.

Baylon said that nuclear installations in developing countries are particularly at risk of cyber attack, because such installations "do not have access to best practices, it is difficult for them to tap into best practice areas."

However, Baylon also noted that nuclear installations in more advanced countries were also at risk, for different reasons.

"Advanced countries have more critical infrastructure connected to the internet," said Baylon. "Being modern is both good and bad."

Baylon said that the report was based on 30 interviews with sources in eight countries, but that the "majority of the interviews were with experts from the US, France, Japan, and UK."

Air gap a myth, report says

The report said that "the conventional belief that all nuclear facilities are 'air gapped' (isolated from the public internet) is a myth. The commercial benefits of internet connectivity mean that a number of nuclear facilities now have VPN connections installed, which facility operators are sometimes unaware of."

The report noted that "search engines can readily identify critical infrastructure components with such connections," adding that "even where facilities are air gapped, this safeguard can be breached with nothing more than a flash drive."

The report said that "supply chain vulnerabilities [at civilian nuclear installations] mean that equipment used at a nuclear facility risks compromise at any stage."

The report also said that a "lack of training, combined with communication breakdowns between engineers and security personnel, means that nuclear plant personnel often lack an understanding of key cyber security procedures."

Asked what would be the best way to improve cyber security internationally at civilian nuclear installations, Baylon noted that insurance against cyber attack was starting to be "more of a trend, it will create a greater following," adding that regulation in the area of cyber security at nuclear installations was "developing organically."

Report makes generalizations, NRC says

NRC spokesman David McIntyre said in an email October 6 that the Chatham House report "makes numerous questionable generalizations, and addresses the 'nuclear industry' globally, rather than by country. The NRC has been very forward-thinking in developing cyber security requirements for commercial nuclear facilities and we are confident that these requirements provide protection and flexibility to respond to evolving threats."

William Gross, senior project manager, engineering, at the Nuclear Energy Institute, said in an interview October 6 that the Chatham House report has "some very valid recommendations," but many of the concerns expressed in it are not security problems at nuclear power plants in the US.

The US nuclear industry implemented comprehensive cyber security programs in 2008, and regulatory requirements issued by NRC in 2009 are being implemented, Gross said. While some elements are still being implemented, "the key technology countermeasures are substantively in place," including controls on portable devices such as smart phones and portable media such as USB drives, he said.

Some of the security measures in place at US power reactors include data diodes, network hardware that allows data to be sent from a particular system but not received, effectively precluding cyber attacks on such assets, Gross said. So-called "air gaps," in which some systems are physically separated from networks connected to the internet, are also in widespread use, he said.

McIntyre said that, "[w]hile systems that perform safety functions at nuclear plants are required to be separated from the Internet, the NRC does not rely solely on such 'air gaps' for protection from cyber attacks. Air gaps are only one aspect of an effective cyber security program. NRC's requirements include defense in depth, with cyber security programs addressing all conceivable attack channels, including the supply chain, wireless, portable media such as discs and thumb-drives, or physical attack, as well as intrusion detection and response capability."

Also, Gross said, cyber security training is required for all personnel with access to US nuclear power plants, including contractors.

The US Department of Homeland Security's Office of Cyber and Infrastructure Analysis said in a paper dated October 6, provided by Gross, that "NRC does not direct industry on how to achieve the requisite security. Operators can find the approach most suitable for their plant."

The DHS office said: "Some cybersecurity experts have noted that each alternative approach to enforcing security among network security levels has its own limitation. The standard of care used in the commercial nuclear power industry is comparable to that used to protect U.S. Government classified networks. Thus, while it is not perfect, it represents the best known approach."

The DHS office concluded: "At this time, based on what has been implemented, the overall operational and regulatory requirements of the nuclear industry substantially avoid the possibility of a cybersecurity incident having a significant effect outside of the plant."

— Oliver Adelman, London; Steven Dolley, Washington

Notes to Nucleonics Week's generating table for August 2015

In the Czech Republic, Dukovany-1 shut August 28 for a planned two-month refueling; Temelin-1 shut July 11 for refueling, returning August 25.

Finland's Loviisa-2 shut August 30, returning September 15.

In France, Chinon-1 returned September 7 from refueling that began June 13; Cruas-1 shut March 28, returning September 23; Dampierre-1 was shut for refueling from June 27 to September 8; Dampierre-4 returned August 24 from refueling that began July 4; Gravelines-1 remained offline during August, returning September 1 from refueling that began May 23; Tricastin-1 shut July 11 for refueling that ended October 4.

In Germany, Gundremmingen C returned August 7 from refueling that began July 3; Isar-2 refueled from July 4 to August 13.

In Ukraine, Khmelnitski-1 shut August 8 for refueling, returning October 7; Rovno-4 returned September 13 from a refueling that began July 21; South Ukraine-2 shut May 10 for a planned 300-day overhaul; Zaporozhe-4 returned August 22 from refueling that began June 8; Zaporozhe-6 shut August 22 for refueling expected to last until October 13.

Long-term outages

In Belgium, Doel-3 and Tihange-2 were shut in March 2014, in advance of planned refueling and maintenance outages, to review results of testing on reactor pressure vessel material, and both units have remained offline. The operator said the units will be shut until at least November after initial test results were inconclusive.

Doel-1 shut in February after reaching the end of its 40-year permitted operating period, although the government has proposed extending operations to 2025. The operator and Belgium's nuclear regulator must agree on a plan for modifications to permit extended operation.

Japan had no nuclear generation from mid-September 2013, when the last of its 48 operational units shut for refueling and maintenance, until Sendai-1 connected to the grid August 14. The other operational units remain shut following the March 11, 2011 earthquake and tsunami that resulted in the permanent shutdowns of all six units at Fukushima I. Three of Japan's power reactors — Kashiwazaki-Kariwa-2, -3 and -4 — have been shut since a major earthquake in Niigata prefecture July 16, 2007.

In Switzerland, Beznau-1 shut for refueling March 13, with an expected return date of mid-July. After flaws were identified in the reactor pressure vessel, additional tests and analyses were ordered, and the operator has said the unit will remain offline until at least the end of February. Beznau-2 shut for refueling and inspections of its reactor pressure vessel August 13.

Taiwan's Chinshan-1 has been shut since December 10 for refueling, which was halted after a damaged fuel assembly was discovered. Investigation into a broken bolt in the assembly has continued, and a report to the legislature is pending.

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

Gross capacity of each unit listed hereunder is to the best of our knowledge the turbine nameplate rating unless we have evidence that some other figure more justly reflects our purpose of showing the unit s performance in relation to what the seller and buyer felt the unit was bought, designed, built, and intended to do.

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
ARGENTINA:						
Atucha	362	242,826	90.16	1,086,473	52.00	91,311,230
Embalse	648	0	0.00	355,471	9.41	134,361,431
Total. Argentina:	**1,010**	**242,826**		**1,441,944**		
ARMENIA:						
Metsamor-2 (#)	408	(a)		1,767,624	85.15	67,504,946
BELGIUM:						
Doel-1	454	0	0.00	410,832	15.52	127,432,359
Doel-2	454	336,528	99.63	2,485,231	93.88	124,803,630
Doel-3	1,056	0	0.00	0	0.00	236,603,769
Doel-4	1,090	715,933	88.28	6,235,350	98.11	235,457,218
Tihange-1	1,009	0	0.00	4,085,028	69.43	282,801,373
Tihange-2	1,055	0	0.00	0	0.00	232,857,756
Tihange-3	1,094	421,752	51.84	4,522,972	70.93	249,016,611
Total. Belgium:	**6,212**	**1,474,213**		**17,739,413**		
BRAZIL:						
Angra-1	640	429,036	90.10	2,325,342	62.30	90,645,279
Angra-2	1,350	935,856	93.18	7,911,423	100.49	148,097,159
Total. Brazil:	**1,990**	**1,364,892**		**10,236,765**		
BRITAIN:						
Dungeness B-1 (#)	625	NA				42,890,447
Dungeness B-2 (#)	625	NA				43,898,394
Hartlepool-1 (#)	650	NA				70,334,636
Hartlepool-2 (#)	650	NA				71,864,291
Heysham A-1 (#)	670	NA				72,157,250
Heysham A-2 (#)	670	NA				69,837,433
Heysham B-1 (#)	677	NA				70,921,020
Heysham B-2 (#)	677	NA				68,308,101
Hinkley Pt.B-1 (#)	460	NA				111,421,107
Hinkley Pt.B-2 (#)	480	NA				108,398,614
Hunterston B-1 (#)	495	NA				114,137,710
Hunterston B-2 (#)	495	NA				106,964,580
Sizewell B-1 (#)	1,250	NA				83,984,432
Torness-1 (#)	657	NA				70,826,321
Torness-2 (#)	662	NA				66,214,304
Wylfa-1 (#)	550	NA				148,349,535
Total. Britain:	**10,293**					
BULGARIA: (Lifetime only from May 1993)						
Kozloduy-5	1,000	742,287	99.77	4,873,151	83.56	66,545,769
Kozloduy-6	1,000	638,654	85.84	5,863,991	100.55	66,832,815
Total. Bulgaria:	**2,000**	**1,380,941**		**10,737,142**		
CANADA:						
Bruce-1 (#)	904	NA				100,745,474
Bruce-2 (#)	904	NA				80,852,078
Bruce-3 (#)	805	NA				152,933,281
Bruce-4 (#)	805	NA				147,809,379
Bruce-5 (#)	872	NA				174,080,993
Bruce-6 (#)	891	NA				170,022,252
Bruce-7 (#)	872	NA				167,181,306
Bruce-8 (#)	845	NA				156,441,261
Darlington-1	934	678,912	97.70	4,759,936	87.38	169,335,796
Darlington-2	934	674,560	97.07	5,281,664	96.96	163,124,005
Darlington-3	934	678,144	97.59	5,118,464	93.97	163,007,963
Darlington-4	934	684,160	98.46	5,347,968	98.18	159,166,734

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
Pickering-1	542	61,049	15.14	1,237,018	39.13	110,468,940
Pickering-4	542	325,626	80.75	2,993,783	94.71	115,775,091
Pickering-5	540	398,100	99.09	1,534,440	48.72	113,261,552
Pickering-6	540	394,890	98.29	2,961,870	94.05	118,431,720
Pickering-7	540	398,040	99.07	2,821,740	89.60	113,461,178
Pickering-8	540	391,940	97.56	2,956,470	93.88	106,924,765
Point Lepreau	680	0	0.00	0	0.00	123,941,586
Total. Canada:	**14,558**	**4,685,421**		**35,013,353**		
CHINA:						
Daya Bay-1 (#)	984	(b)		2,473,225	57.87	148,002,066
Daya Bay-2 (#)	984	(b)		4,189,318	98.03	146,831,541
Hongyanhe-1 (#)	1,119	NA				0
Hongyanhe-2 (#)	1,119	NA				0
Ling Ao I-1 (#)	990	(b)		4,268,883	99.29	65,890,643
Ling Ao I-2 (#)	990	(b)		3,563,912	82.89	65,917,069
Ling Ao I-3 (#)	1,080	(b)		3,721,579	79.34	37,277,112
Ling Ao I-4 (#)	1,080	(b)		3,753,810	80.03	31,807,530
Ningde-1 (#)	1,089	NA				0
Ningde-2 (#)	1,089	NA				0
Qinshan I (#)	310	NA				NA
Qinshan II (3 units) (#)	1,950	NA				NA
Qinshan III (2 units) (#)	1,456	NA				NA
Tianwan-1 (#)	1,000	NA				NA
Tianwan-2 (#)	1,000	NA				NA
Yangjiang-1 (#)	1,086	NA				0
Total. China:	**17,326**			**21,970,727**		
CZECH REPUBLIC:						
Dukovany-1	498	316,496	85.42	2,832,631	97.55	100,181,055
Dukovany-2	498	359,598	97.05	2,456,177	84.58	97,083,804
Dukovany-3	498	352,551	95.15	2,601,242	89.58	95,515,990
Dukovany-4	498	358,611	96.79	2,800,404	96.44	94,182,635
Temelin-1	1,013	107,527	14.27	5,039,310	85.31	87,849,593
Temelin-2	1,013	595,111	78.96	3,320,651	56.22	83,029,588
Total. Czech Republic:	**4,018**	**2,089,894**		**19,050,415**		
FINLAND:						
Loviisa-1	520	99,058	25.60	2,732,268	90.11	143,507,843
Loviisa-2	520	311,912	80.62	2,955,553	97.47	133,564,931
Olkiluoto-1	910	655,272	96.78	5,004,023	94.31	237,263,020
Olkiluoto-2	890	660,341	99.73	4,435,201	85.46	227,574,469
Total. Finland:	**2,840**	**1,726,583**		**15,127,045**		
FRANCE: (Note: EDF says capacity factor may not be the best measure of performance due to extensive load-following dictated by the national grid.)						
Belleville-1 (#)	1,363	NA				228,429,868
Belleville-2 (#)	1,363	NA				228,372,049
Blayais-1 (#)	951	NA				202,087,096
Blayais-2 (#)	951	NA				206,335,553
Blayais-3 (#)	951	NA				202,343,868
Blayais-4 (#)	951	NA				198,815,152
Bugey-2 (#)	945	NA				206,252,904
Bugey-3 (#)	945	NA				197,933,503
Bugey-4 (#)	917	NA				202,188,053
Bugey-5 (#)	917	NA				203,028,227
Cattenom-1 (#)	1,362	NA				235,351,806
Cattenom-2 (#)	1,362	NA				236,828,640
Cattenom-3 (#)	1,362	NA				215,217,578
Cattenom-4 (#)	1,362	NA				213,977,301
Chinon-B1 (#)	954	NA				192,227,786
Chinon-B2 (#)	954	NA				188,727,900
Chinon-B3 (#)	954	NA				173,840,581

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
Chinon-B4 (#)	954	NA				168,650,847
Chooz-B1 (#)	1,560	NA				154,806,893
Chooz-B2 (#)	1,560	NA				149,855,478
Civaux-1 (#)	1,561	NA				133,531,868
Civaux-2 (#)	1,561	NA				133,830,965
Cruas-1 (#)	956	NA				186,342,389
Cruas-2 (#)	956	NA				183,766,320
Cruas-3 (#)	956	NA				183,922,409
Cruas-4 (#)	956	NA				179,592,122
Dampierre-1 (#)	937	NA				205,187,678
Dampierre-2 (#)	937	NA				198,052,176
Dampierre-3 (#)	937	NA				205,091,711
Dampierre-4 (#)	937	NA				195,892,290
Fessenheim-1 (#)	920	NA				202,264,455
Fessenheim-2 (#)	920	NA				204,669,497
Flamanville-1 (#)	1,382	NA				242,098,146
Flamanville-2 (#)	1,382	NA				244,396,152
Golfech-1 (#)	1,363	NA				220,883,113
Golfech-2 (#)	1,363	NA				192,118,925
Gravelines-B1 (#)	951	NA				201,579,617
Gravelines-B2 (#)	951	NA				210,101,621
Gravelines-B3 (#)	951	NA				207,605,537
Gravelines-B4 (#)	951	NA				209,717,377
Gravelines-C5 (#)	951	NA				191,075,230
Gravelines-C6 (#)	951	NA				189,785,176
Nogent-1 (#)	1,363	NA				234,133,280
Nogent-2 (#)	1,363	NA				231,298,622
Paluel-1 (#)	1,382	NA				259,218,770
Paluel-2 (#)	1,382	NA				255,423,577
Paluel-3 (#)	1,382	NA				243,708,869
Paluel-4 (#)	1,382	NA				249,049,693
Penly-1 (#)	1,382	NA				223,669,193
Penly-2 (#)	1,382	NA				208,598,560
St.Alban/St.Maurice-1 (#)	1,381	NA				239,254,125
St.Alban/St.Maurice-2 (#)	1,381	NA				233,660,201
St.Laurent-des-Eaux B1 (#)	956	NA				195,403,881
St.Laurent-des-Eaux B2 (#)	956	NA				192,544,266
Tricastin-1 (#)	955	NA				211,559,906
Tricastin-2 (#)	955	NA				208,756,321
Tricastin-3 (#)	955	NA				213,145,047
Tricastin-4 (#)	955	NA				208,005,690
Total. France:	**65,880**					
GERMANY:						
Brokdorf (#)	1,480	NA		6,362,437	84.51	318,055,806
Emsland (#)	1,406	NA		5,875,311	82.15	307,746,200
Grafenrheinfeld (#)	1,345	NA		4,568,773	66.78	333,476,843
Grohnde (#)	1,430	NA		5,958,257	81.91	343,445,322
Gundremmingen-B (#)	1,344	NA		6,022,378	88.09	306,780,015
Gundremmingen-C (#)	1,344	NA		5,532,767	80.92	296,233,404
Isar-2 (#)	1,485	NA		6,179,756	81.81	313,168,112
Neckar-2 (#)	1,400	NA		6,967,728	97.84	293,957,209
Philippsburg-2 (#)	1,468	NA		5,921,619	79.30	331,527,482
Total. Germany:	**12,702**			**53,389,026**		
HUNGARY:						
Paks-1	500	365,175	98.17	2,143,624	73.53	116,400,150
Paks-2	500	83,621	22.48	2,668,434	91.53	106,055,884
Paks-3	500	361,941	97.30	2,905,605	99.66	102,824,095
Paks-4	500	357,950	96.22	2,608,560	89.47	102,639,721
Total. Hungary:	**2,000**	**1,168,687**		**10,326,223**		

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
INDIA:						
Kaiga-1	220	172,000	105.08	1,282,000	99.92	20,575,566
Kaiga-2	220	123,000	75.15	1,139,000	88.77	21,255,748
Kaiga-3	220	176,000	107.53	1,309,000	102.02	10,180,000
Kaiga-4	220	0	0.00	1,174,000	91.50	6,759,000
Kakrapar-1	220	165,000	100.81	1,080,000	84.18	27,753,941
Kakrapar-2	220	0	0.00	874,000	68.12	29,476,594
Kudankulam-1	1,000	0	0.00	3,503,000	60.07	3,503,000
Madras-1	220	168,000	102.64	1,218,000	94.93	31,528,243
Madras-2	220	134,000	81.87	1,032,000	80.43	30,986,103
Narora-1	220	150,000	91.64	1,175,000	91.58	26,939,290
Narora-2	220	157,000	95.92	1,263,000	98.44	26,612,164
Rajasthan-1	100	0	0.00	0	0.00	11,960,915
Rajasthan-2	200	146,000	98.12	943,000	80.85	36,698,785
Rajasthan-3	220	157,000	95.92	1,207,000	94.07	23,365,928
Rajasthan-4	220	103,000	62.93	1,174,000	91.50	22,833,972
Rajasthan-5	220	164,000	100.20	1,236,000	96.33	10,241,000
Rajasthan-6	220	135,000	82.48	969,000	75.52	8,294,000
Tarapur-1	160	0	0.00	0	0.00	44,823,775
Tarapur-2	160	86,000	72.24	749,000	80.27	46,479,928
Tarapur-3	540	399,000	99.31	2,917,000	92.62	31,617,000
Tarapur-4	540	398,000	99.06	2,616,000	83.07	30,189,265
Total. India:	**5,780**	**2,833,000**		**26,860,000**		
JAPAN:						
Fukushima II-1 (#)	1,100	NA				215,651,081
Fukushima II-2 (#)	1,100	NA				198,062,358
Fukushima II-3 (#)	1,100	NA				170,409,505
Fukushima II-4 (#)	1,100	NA				168,088,110
Genkai-2 (#)	559	NA				121,626,347
Genkai-3 (#)	1,180	NA				151,154,026
Genkai-4 (#)	1,180	NA				127,512,182
Hamaoka-3 (#)	1,100	NA				179,146,924
Hamaoka-4 (#)	1,137	NA				143,839,198
Hamaoka-5 (#)	1,380	NA				35,989,175
Higashidori-1 (#)	1,100	NA				41,030,051
Ikata-1 (#)	566	NA				133,878,051
Ikata-2 (#)	566	NA				123,152,439
Ikata-3 (#)	890	NA				112,457,800
Kashiwazaki-Kariwa-1 (#)	1,100	NA				167,491,230
Kashiwazaki-Kariwa-2 (#)	1,100	NA				125,113,550
Kashiwazaki-Kariwa-3 (#)	1,100	NA				104,978,640
Kashiwazaki-Kariwa-4 (#)	1,100	NA				93,439,420
Kashiwazaki-Kariwa-5 (#)	1,100	NA				142,874,170
Kashiwazaki-Kariwa-6 (#)	1,356	NA				133,976,546
Kashiwazaki-Kariwa-7 (#)	1,356	NA				117,915,082
Mihama-3 (#)	826	NA				180,298,068
Ohi-1 (#)	1,175	NA				224,416,241
Ohi-2 (#)	1,175	NA				244,534,111
Ohi-3 (#)	1,180	NA				177,165,820
Ohi-4 (#)	1,180	NA				179,150,712
Onagawa-1 (#)	524	NA				84,274,171
Onagawa-2 (#)	825	NA				82,855,326
Onagawa-3 (#)	825	NA				45,459,784
Sendai-1 (#)	890	NA				176,789,169
Sendai-2 (#)	890	NA				170,747,539
Shika-1 (#)	540	NA				61,466,824
Shika-2 (#)	1,206	NA				27,362,972
Shimane-2 (#)	820	NA				134,337,331
Takahama-1 (#)	826	NA				185,812,942
Takahama-2 (#)	826	NA				183,722,641

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
Takahama-3 (#)	870	NA				174,525,194
Takahama-4 (#)	870	NA				170,704,933
Tokai-2 (#)	1,100	NA				229,838,671
Tomari-1 (#)	579	NA				96,110,274
Tomari-2 (#)	579	NA				88,148,481
Tomari-3 (#)	912	NA				18,136,654
Tsuruga-2 (#)	1,160	NA				194,628,260
Total. Japan:	**42,048**					
MEXICO:						
Laguna Verde-1	810	509,337	84.52	4,054,586	85.85	118,191,645
Laguna Verde-2	810	580,632	96.35	4,389,906	92.95	101,261,031
Total. Mexico:	**1,620**	**1,089,969**		**8,444,492**		
NETHERLANDS:						
Borssele-1	515	373,302	97.43	2,581,597	85.97	150,008,789
PAKISTAN:						
Chasnupp-1	325	165,600	68.49	1,704,900	89.95	32,335,215
Chasnupp-2	325	36	0.01	1,644,014	86.74	8,808,158
Kanupp	137	55,360	54.31	326,530	40.87	15,109,404
Total. Pakistan:	**787**	**220,996**		**3,675,444**		
ROMANIA:						
Cernavoda-1 (#)	706	(a)		3,458,549	96.30	104,246,893
Cernavoda-2 (#)	706	(a)		3,108,107	86.54	44,907,175
Total. Romania:	**1,412**			**6,566,656**		
RUSSIA: (Lifetime only from March 1993)						
Balakovo-1	1,000	770,570	103.57	6,095,740	104.54	144,403,990
Balakovo-2	1,000	0	0.00	4,851,910	83.21	137,157,380
Balakovo-3	1,000	763,320	102.60	5,660,440	97.07	145,246,950
Balakovo-4	1,000	782,980	105.24	6,110,510	104.79	150,968,240
Beloyarsk-3	600	457,440	102.47	2,918,930	83.43	86,634,820
Bilibino-1	12	2,140	23.97	36,290	51.86	948,965
Bilibino-2	12	4,220	47.27	28,380	40.56	994,730
Bilibino-3	12	6,730	75.38	50,820	72.63	996,900
Bilibino-4	12	5,820	65.19	28,520	40.76	919,050
Kalinin-1	1,000	797,550	107.20	5,348,340	91.72	145,590,593
Kalinin-2	1,000	797,420	107.18	6,192,380	106.20	150,671,260
Kalinin-3	1,000	666,810	89.63	5,228,770	89.67	75,685,929
Kalinin-4	1,000	767,180	103.12	5,597,810	96.00	25,844,612
Kola-1	440	231,750	70.79	1,562,670	60.91	49,534,680
Kola-2	440	0	0.00	972,810	37.92	48,978,120
Kola-3	440	290,490	88.74	1,649,450	64.29	53,580,460
Kola-4	440	44,720	13.66	1,846,980	71.99	56,766,476
Kursk-1	1,000	679,480	91.33	4,903,240	84.09	107,910,550
Kursk-2	1,000	687,330	92.38	4,126,690	70.77	116,683,250
Kursk-3	1,000	703,680	94.58	4,960,880	85.08	140,365,710
Kursk-4	1,000	637,690	85.71	5,765,600	98.88	145,442,920
Leningrad-1	1,000	686,190	92.23	2,959,940	50.76	123,697,960
Leningrad-2	1,000	677,540	91.07	5,658,660	97.04	136,345,500
Leningrad-3	1,000	0	0.00	4,884,410	83.77	124,747,280
Leningrad-4	1,000	613,930	82.52	4,376,540	75.06	127,915,490
Novovoronezh-3	417	301,380	97.14	2,077,710	85.45	55,103,052
Novovoronezh-4	417	299,830	96.64	2,421,760	99.60	61,310,750
Novovoronezh-5	1,000	0	0.00	4,015,170	68.86	122,785,190
Smolensk-1	1,000	733,730	98.62	4,508,130	77.31	136,062,368
Smolensk-2	1,000	737,080	99.07	5,975,800	102.48	138,263,018
Smolensk-3	1,000	750,230	100.84	5,640,960	96.74	151,711,800
Volgodonsk-1	1,000	657,000	88.31	5,704,770	97.84	111,755,910
Volgodonsk-2	1,000	708,020	95.16	4,793,500	82.21	39,611,193
Total. Russia:	**25,242**	**15,262,250**		**126,954,510**		

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
SLOVAKIA:(Slovenske Electrarne s new owner - ENEL Company - has temporarily declined to provide monthly generation data.)						
Bohunice-3 (#)	505	NA				73,571,995
Bohunice-4 (#)	505	NA				72,119,430
Mochovce-1 (#)	470	NA				33,763,932
Mochovce-2 (#)	470	NA				32,654,261
Total. Slovakia:	**1,950**					
SLOVENIA:						
Krsko	727	531,662	98.29	3,512,877	82.87	164,681,224
SOUTH AFRICA:						
Koeberg-1	970	721,518	99.98	2,735,908	48.36	185,226,760
Koeberg-2	940	577,135	82.52	5,477,644	99.92	180,977,733
Total. South Africa:	**1,910**	**1,298,653**		**8,213,552**		
SOUTH KOREA: (Note: Kepco has applied a new reference unit power rating which reflects the three year average output as of Jan. 2011.)						
Hanbit-1 (formerly Yonggwang-1) (#)	1,035	(a)		3,701,329	70.64	219,978,733
Hanbit-2 (formerly Yonggwang-2) (#)	1,025	(a)		5,024,370	96.45	207,954,965
Hanbit-3 (formerly Yonggwang-3) (#)	1,047	(a)		1,446,180	27.14	158,145,388
Hanbit-4 (formerly Yonggwang-4) (#)	1,049	(a)		5,236,268	98.11	159,761,788
Hanbit-5 (formerly Yonggwang-5) (#)	1,053	(a)		5,353,702	99.93	106,252,554
Hanbit-6 (formerly Yonggwang-6) (#)	1,052	(a)		5,342,451	99.81	104,030,773
Hanul-1 (formerly Ulchin-1) (#)	1,007	(a)		4,075,783	79.57	200,627,147
Hanul-2 (formerly Ulchin-2) (#)	1,012	(a)		5,168,346	100.40	196,696,544
Hanul-3 (formerly Ulchin-3) (#)	1,050	(a)		5,342,510	100.00	137,253,305
Hanul-4 (formerly Ulchin-4) (#)	1,054	(a)		3,866,898	72.12	114,731,941
Hanul-5 (formerly Ulchin-5) (#)	1,051	(a)		5,309,852	99.31	93,195,371
Hanul-6 (formerly Ulchin-6) (#)	1,050	(a)		5,347,592	100.10	87,988,387
Kori-1 (#)	607	(a)		2,160,076	69.92	146,429,855
Kori-2 (#)	680	(a)		2,196,779	63.49	160,705,958
Kori-3 (#)	1,043	(a)		4,816,911	90.78	225,613,890
Kori-4 (#)	1,044	(a)		5,329,016	100.35	225,012,248
Shin Kori-1 (#)	1,049	(a)		5,058,613	94.78	30,397,008
Shin Kori-2 (#)	1,046	(a)		3,960,218	74.39	20,498,758
Shin Wolsong-1 (#)	1,049	(a)		2,749,491	51.54	19,012,984
Wolsong-1 (#)	685	(a)		662,805	19.02	141,725,124
Wolsong-2 (#)	730	(a)		3,453,498	92.98	104,799,095
Wolsong-3 (#)	729	(a)		3,536,335	95.34	100,896,308
Wolsong-4 (#)	730	(a)		3,559,249	95.83	94,087,078
Total. South Korea:	**21,877**			**92,698,272**		
SPAIN:						
Almaraz-1	1,049	762,901	97.71	5,972,111	97.60	239,405,476
Almaraz-2	1,044	765,475	98.51	5,007,414	82.22	234,279,329
Asco-1	1,032	679,710	88.48	5,919,630	98.32	230,645,241
Asco-2	1,027	666,770	87.25	5,759,270	96.15	223,080,823
Cofrentes	1,092	760,855	93.65	5,922,198	93.01	243,744,554
Garona	466	0	0.00	0	0.00	133,198,907
Trillo	1,066	788,355	99.40	5,346,039	86.01	218,966,529
Vandellos-2	1,087	782,044	96.69	4,652,578	73.40	208,217,493
Total. Spain:	**7,865**	**5,206,110**		**38,579,240**		
SWEDEN:						
Forsmark-1	1,022	636,700	83.74	3,912,735	65.66	247,740,897
Forsmark-2	1,158	783,289	90.92	5,893,315	87.28	241,631,793
Forsmark-3	1,208	21,567	2.40	5,652,339	80.25	266,051,858
Oskarshamn-1	492	177,950	48.61	1,622,584	56.56	108,958,120
Oskarshamn-2	661	0	0.00	0	0.00	161,289,332
Oskarshamn-3	1,450	932,070	86.40	6,545,497	77.42	252,757,071
Ringhals-1	916	571,065	83.79	3,364,417	62.99	196,023,075
Ringhals-2 (#)	910	(a)		85	0.00	206,945,011
Ringhals-3	1,128	689,817	82.20	5,156,892	78.40	228,517,764

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
Ringhals-4	1,180	270,704	30.83	5,094,285	74.04	218,168,335
Total. Sweden:	**10,125**	**4,083,162**		**37,242,149**		
SWITZERLAND:						
Beznau-1 (#)	380	NA				124,075,784
Beznau-2 (#)	380	NA				122,946,081
Goesgen (#)	1,035	NA				278,795,885
Leibstadt (#)	1,245	NA				258,575,970
Muehleberg (#)	390	NA				115,000,437
Total. Switzerland:	**3,430**					
TAIWAN:						
Chinshan-1	636	0	0.00	0	0.00	162,548,453
Chinshan-2	636	447,888	94.65	3,706,210	99.92	166,388,186
Kuosheng-1	985	715,159	97.59	4,938,410	85.97	236,154,593
Kuosheng-2	985	731,856	99.87	5,901,545	102.73	231,142,466
Maanshan-1	980	679,321	93.17	4,962,425	86.83	208,249,855
Maanshan-2	980	728,250	99.88	5,287,198	92.51	211,278,553
Total. Taiwan:	**5,202**	**3,302,474**		**24,795,788**		
UKRAINE: (Only plant level data provided divided evenly across each unit; Lifetime only from March 1993.)						
Khmelnitski-1 (#)	1,000	NA				118,877,006
Khmelnitski-2 (#)	1,000	NA				45,852,430
Rovno-1 (#)	420	NA				50,588,628
Rovno-2 (#)	415	NA				50,573,544
Rovno-3 (#)	1,000	NA				106,706,950
Rovno-4 (#)	1,000	NA				38,746,346
South Ukraine-1 (#)	1,000	NA				113,630,925
South Ukraine-2 (#)	1,000	NA				106,703,625
South Ukraine-3 (#)	1,000	NA				117,592,263
Zaporozhe-1 (#)	1,000	NA				109,265,174
Zaporozhe-2 (#)	1,000	NA				116,630,991
Zaporozhe-3 (#)	1,000	NA				115,126,945
Zaporozhe-4 (#)	1,000	NA				118,808,702
Zaporozhe-5 (#)	1,000	NA				122,277,328
Zaporozhe-6 (#)	1,000	NA				107,493,762
Total. Ukraine:	**13,835**					
US:						
Arkansas Nuclear I-1 (#)	903	(a)		3,669,024	79.87	228,551,976
Arkansas Nuclear I-2 (#)	1,065	(a)		5,283,791	97.53	235,146,031
Beaver Valley-1	1,011	724,231	96.31	4,805,442	81.54	221,551,210
Beaver Valley-2	1,008	717,633	95.69	5,660,527	96.31	185,834,292
Braidwood-1 (#)	1,320	(c)		3,972,084	83.06	249,695,083
Braidwood-2 (#)	1,295	(c)		4,479,415	95.47	250,306,191
Browns Ferry-1	1,155	807,697	93.99	6,486,803	96.32	130,381,110
Browns Ferry-2	1,155	813,815	94.70	5,675,000	84.26	263,641,231
Browns Ferry-3	1,155	812,759	94.58	6,503,965	96.57	223,648,541
Brunswick-1	998	712,873	96.01	5,669,208	97.42	218,342,336
Brunswick-2	980	707,731	97.07	4,497,107	78.70	216,307,425
Byron-1	1,268	926,102	98.17	7,081,655	95.78	264,461,609
Byron-2	1,241	903,063	97.78	7,113,965	98.28	255,483,164
Callaway	1,279	877,222	92.20	7,161,872	96.05	285,784,221
Calvert Cliffs-1 (#)	890	(b)		4,013,980	103.85	196,635,720
Calvert Cliffs-2 (#)	880	(b)		3,311,620	86.65	190,321,283
Catawba-1	1,305	892,086	91.88	7,062,254	92.81	270,306,607
Catawba-2	1,305	884,349	91.08	6,000,279	78.85	262,931,279
Clinton *	1,098	(n)				
Columbia	1,173	869,330	99.61	5,030,160	73.54	231,340,393
Comanche Peak-1	1,250	934,498	100.48	7,356,323	100.93	232,582,808
Comanche Peak-2	1,241	931,044	100.84	7,360,379	101.72	211,706,825
Cook-1 *	1,131	(n)				

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
Cook-2 *	1,151	(n)				
Cooper	836	592,330	95.29	4,633,130	95.10	211,505,145
Davis-Besse	971	709,862	98.26	5,500,691	97.15	210,853,827
Diablo Canyon-1	1,197	882,794	99.13	6,840,571	98.01	264,166,190
Diablo Canyon-2	1,197	859,742	96.54	6,869,258	98.42	259,887,657
Dresden-2 (#)	925	(a)		4,677,051	99.36	240,262,053
Dresden-3 (#)	920	(a)		4,843,257	103.52	231,638,789
Duane Arnold	647	469,957	97.61	3,664,342	97.11	158,715,528
Farley-1	918	683,831	100.12	4,287,173	80.09	242,067,134
Farley-2	928	686,693	99.46	5,409,612	99.97	229,373,539
Fermi-2	1,205	862,925	96.25	6,392,733	90.98	207,552,156
FitzPatrick (#)	849	(a)		4,449,336	103.02	220,281,931
Fort Calhoun *	526	(n)				
Ginna (#)	597	(c)		2,201,672	101.79	172,106,861
Grand Gulf-1 (#)	1,498	(a)		6,956,387	91.29	290,665,289
Hatch-1	911	677,250	99.92	5,215,880	98.19	236,053,362
Hatch-2	921	656,434	95.80	4,512,736	84.03	220,845,196
Hope Creek *	1,240	(n)				
Indian Point-2 (#)	1,067	(a)		5,353,310	98.63	259,824,290
Indian Point-3 (#)	1,080	(a)		4,268,227	77.69	242,852,931
LaSalle-1 (#)	1,207	(a)		6,099,995	99.35	243,048,645
LaSalle-2 (#)	1,207	(a)		4,747,529	77.32	236,465,949
Limerick-1 (#)	1,246	(a)		5,989,700	94.50	263,002,965
Limerick-2 (#)	1,246	(a)		5,088,720	80.28	240,444,220
McGuire-1	1,305	899,093	92.60	6,948,600	91.32	277,131,772
McGuire-2	1,305	819,323	84.39	7,002,133	92.02	278,857,543
Millstone-2	918	669,970	98.15	5,255,004	98.23	214,254,337
Millstone-3	1,276	942,446	99.27	7,367,707	99.02	242,079,548
Monticello	691	499,853	97.19	3,001,025	74.45	179,324,045
Nine Mile Point-1 *	640	(n)				
Nine Mile Point-2 *	1,362	(n)				
North Anna-1	998	744,218	100.23	5,208,927	89.51	252,618,712
North Anna-2	994	745,206	100.77	5,922,596	102.18	246,011,418
Oconee-1	934	650,730	93.64	5,189,509	95.29	259,051,798
Oconee-2	934	655,074	94.27	5,202,097	95.52	261,499,972
Oconee-3	934	661,892	95.25	5,232,325	96.07	258,291,972
Oyster Creek (#)	670	NA				174,016,616
Palisades (#)	845	(a)		4,293,601	99.89	199,078,187
Palo Verde-1	1,402	1,029,198	98.67	8,139,823	99.57	273,719,089
Palo Verde-2	1,406	1,034,212	98.87	8,179,711	99.77	282,057,066
Palo Verde-3	1,405	1,027,110	98.26	6,999,874	85.44	272,512,519
Peach Bottom-2	1,182	946,792	107.66	7,264,490	105.40	304,320,701
Peach Bottom-3	1,182	793,075	90.18	6,769,170	98.21	302,056,372
Perry	1,319	973,530	99.20	5,981,143	77.77	246,345,908
Pilgrim (#)	728	(a)		2,674,289	72.21	182,165,541
Point Beach-1 *	640	(n)				
Point Beach-2 *	640	(n)				
Prairie Island-1 *	590	(n)				
Prairie Island-2 *	585	(n)				
Quad Cities-1 *	912	(n)				
Quad Cities-2 *	994	(n)				
River Bend (#)	992	(a)		3,884,801	76.98	212,423,563
Robinson-2	820	579,377	94.97	3,829,352	80.09	219,941,306
Salem-1 *	1,254	(n)				
Salem-2 *	1,232	(n)				
Seabrook *	1,296	(n)				
Sequoyah-1	1,186	652,453	73.94	5,180,427	74.91	261,811,835
Sequoyah-2	1,181	866,547	98.62	6,670,643	96.87	260,312,606
Shearon-Harris	1,031	739,369	96.39	4,781,948	79.54	205,741,222
South Texas-1	1,312	1,008,836	103.35	8,054,862	105.29	261,160,324

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Gross	MWH Gross in Aug	Capacity Factor Aug	Total MWH Gross in 2015	Capacity Factor 2015	Lifetime Total MWH Gross
South Texas-2	1,312	1,007,761	103.24	6,624,118	86.59	251,030,974
St. Lucie-1 *	1,078	(n)				
St. Lucie-2 *	1,135	(n)				
Summer (#)	1,006	752,780	100.63	5,203,150	101.25	230,473,904
Surry-1	880	657,837	100.48	4,071,141	79.34	238,205,805
Surry-2	880	661,334	101.01	5,017,561	97.78	237,425,069
Susquehanna-1 *	1,330	(n)				
Susquehanna-2 *	1,330	(n)				
Three Mile Island-1 (#)	890	NA				211,580,149
Turkey Point-3 *	885	(n)				
Turkey Point-4 *	885	(n)				
Vogtle-1	1,205	901,688	100.58	7,145,825	101.70	267,792,848
Vogtle-2	1,205	901,534	100.56	6,992,547	99.52	250,646,531
Waterford-3 (#)	1,222	(a)		5,986,586	96.30	262,002,239
Watts Bar-1	1,210	874,758	97.17	6,681,379	94.70	180,738,758
Wolf Creek	1,249	913,317	98.28	5,246,413	72.04	268,689,208
Total. U.S.:	**105,392**	**43,205,564**		**418,198,940**		

NUCLEAR ELECTRICITY GENERATION FOR AUGUST 2015

NATION: Plant	Capacity MW Net	MWH Net in Aug	Capacity Factor Aug	Total MWH Net in 2015	Capacity Factor 2015
Clinton (#)	1,062	(b)		3,343,654	72.49
Cook-1 (#)	1,084	(b)		3,911,243	83.08
Cook-2 (#)	1,107	(b)		3,875,230	80.60
Fort Calhoun (#)	502	(b)		1,434,046	65.78
Hope Creek (#)	1,228	(b)		4,302,209	80.66
Nine Mile Point-1 (#)	613	(b)		2,253,407	84.64
Nine Mile Point-2 (#)	1,300	(b)		5,447,732	96.50
Point Beach-1 (#)	615	(b)		2,606,759	97.60
Point Beach-2 (#)	615	(b)		2,607,248	97.62
Prairie Island-1 (#)	557	(b)		1,608,227	66.48
Prairie Island-2 (#)	557	(b)		1,924,334	79.55
Quad Cities-1 (#)	866	(b)		3,454,297	91.84
Quad Cities-2 (#)	957	(b)		4,023,737	96.78
Salem-1 (#)	1,169	(b)		4,683,170	92.24
Salem-2 (#)	1,181	(b)		5,067,944	98.81
Seabrook (#)	1,248	(b)		5,415,374	99.91
St. Lucie-1 (#)	1,062	(b)		3,507,685	76.05
St. Lucie-2 (#)	1,074	(b)		4,007,402	85.91
Susquehanna-1 (#)	1,287	(b)		5,562,240	99.51
Susquehanna-2 (#)	1,287	(b)		4,146,245	74.18
Turkey Point-3 (#)	831	(b)		3,383,942	93.76
Turkey Point-4 (#)	840	(b)		3,420,105	93.75
Total U.S:	**21,042**			**79,986,233**	

Footnotes:
* Capacity factor calculated using DER Net MW Rating
** Unit came online during the year
*** Unit was shut down during the year
(a) one-month data missing
(b) two-months data missing
(c) Three-months data missing
(d) Four-months data missing
(e) Five-months data missing
(f) Six-months data missing
(#) Yearly generation totals calculated based on existing generation data
(n) only net and time being provided quarterly, see Net Generation Chart

NA Data not currently available