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State, federal support for nuclear power sought, NEI's Korsnick says

- Market-based solution is needed
- SMRs, microreactors getting boost

The Nuclear Energy Institute sees the need for additional federal and state support for nuclear plants as well as a modernization of the regulatory process and legislation friendly to small modular reactors and microreactors this year, Maria Korsnick, the group's president and CEO, said in an interview this week.

The prospect for more large, light water reactors to be built in the US is slim given power demand and current electricity market conditions, she added.

State-level solutions implemented in recent years to support the continued operation of some nuclear plants may be expanded this year, Korsnick said January 7 during an interview at NEI offices in Washington. Ohio and Pennsylvania may consider some form of financial support for nuclear plants, although the measures are not guaranteed to pass and may not cover all reactors in those states, Korsnick said.

A federal solution is needed and could be boosted by the incoming new Congress's likely focus on climate and clean energy, Korsnick said. She conceded that national-level legislation may not come in calendar 2019, but said she expects the issue to be debated by lawmakers this year.

The new Congress is expected to focus on climate, clean energy, infrastructure and national security, all issues for which nuclear power is a potential solution, she added.

A national system of support for nuclear

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Senator welcomes DOE's planned $115 million high-assay LEU demonstration

US Senator Rob Portman of Ohio welcomed the US Department of Energy's announcement January 7 that it would contract with a Centrus Energy subsidiary for a 16-centrifuge cascade in his state to demonstrate the production of high-assay low-enriched uranium, or HALEU, needed for the development of advanced reactor fuels.

DOE's investment of $115 million over three years into the deployment of the cascade could initially result in 60 jobs, Portman, a Republican, said in a statement that day. He said the cascade would be built at the former American Centrifuge Plant, a Centrus uranium enrichment demonstration project at the site of DOE's Portsmouth gaseous diffusion uranium enrichment plant in Piketon, Ohio that was shuttered in 2001.

The ACP was home to a 120-centrifuge demonstration cascade until the Obama administration dismantled that program in 2015.

The notice DOE issued January 7 on the Federal Business Opportunities website reported the department plans to issue a no-bid, also known as a sole-source, contract to American Centrifuge Operating LLC, or ACO.

The value of Centrus stock climbed 19% on the NYSE American exchange January 7, closing at $2.16 a share. On the previous trading day, January 4, it closed at $1.81 per share. On January 8 shares closed at $2.14.

"ACO is the only source capable of executing the contract activities to meet the requirements of the HALEU Demonstration Program," the DOE notice stated.

(continued on page 7)

Trade group seeks US Supreme Court review of ZECs

- Main point is federal versus state jurisdiction
- Supreme Court review unlikely, some say

The trade group Electric Power Supply Association filed petitions with the US Supreme Court January 8 seeking review of lower court rulings that upheld New York and Illinois nuclear subsidy programs, but an analyst and two legal specialists said high court review was unlikely.

"There is no greater issue today than the question of federal versus state jurisdiction over these out-of-market payments," John Shelk, EPSA's president and CEO, said in an interview January 8.

Shelk said the Supreme Court in 2016 ruled against a Maryland power market program, known as the Hughes case, because it crossed that jurisdictional boundary and the 2nd Circuit US Federal Appeals Court ruled New York's nuclear subsidy program came close to that line.

"So what did the [Supreme] court mean in Hughes," Shelk asked, likening the filing of petitions for certiorari to seek review from the instant replay booth when a close call occurs during a sporting event.

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NUCLEAR FACILITIES RECEIVING ZECS

Source: S&P Global Platts

The state legislatures in New York and Illinois have enacted zero-emission credit programs that provide funding collected from electric customer bills to nuclear power plants struggling to remain profitable amid historically lower wholesale power prices pulled down in recent years by lower natural gas prices and other factors.

In the second half of 2018, the 7th Circuit US Federal Appeals Court in Illinois and New York's 2nd circuit upheld the state ZEC programs, finding they did not infringe on the Federal Energy Regulatory Commission's authority to regulate electricity sold in wholesale markets. Both of the appeals courts held state laws that created the ZEC programs are not pre-empted by the Federal Power Act and do not violate the Commerce Clause of the US Constitution.

EPSA said in a statement that it "strongly disagrees" with the lower court rulings and their "narrow application of Hughes," so the trade association in conjunction with independent power producer NRG Energy filed the petitions for review late January 8 to give the Supreme Court an opportunity to have the final say.

EPSA recommended in the petitions that the Supreme Court use the 2nd Circuit case as the basis for review and hold the 7th Circuit petition on the Illinois program in abeyance, pending a decision on the 2nd Circuit case.

Some see long odds

Analysts and electricity law specialists said it is unlikely the high court will review the appeals court decisions.

"My view is that EPSA's jurisdictional theory confuses Congress's broad delegation of authority to FERC to set just and reasonable wholesale rates with imagined Congressional intent to usurp traditional state functions," Ari Peskoe, director of Harvard University's Electricity Law Initiative, said in an email January 8.

"It is inconsistent with precedent and would call into question longstanding FERC practice," Peskoe said. "Given the generally long odds against SCOTUS review, I would bet on the Court rejecting the petition," he added.

"I would estimate that the petitioners have less than a 10% chance of certiorari being granted, given the absence of any disagreement between the two appellate courts over the legality of the ZEC programs and the US government's position on preemption," Gordon

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Coffee, attorney with law firm Winston & Strawn, said in an email January 8.

Energy industry consulting firm Clearview Energy Partners in a client note January 8 also said Supreme Court review appears unlikely.

"We assign low odds to the prospect of the Supreme Court granting the petitions, given the unanimous agreement of the lower courts," as well as FERC's own position that it has sufficient jurisdiction to address the issues petitioners raised, the analysts said.

Nuclear subsidy legislation could soon come forward in Pennsylvania and Ohio, but these petitions are unlikely to impact those proceedings, Coffee said.

"Given those [long] odds, I would be surprised if the cert. petition had any significant impact on legislation in other states," Coffee said.

— *Jared Anderson, New York*

India reduces targets for nuclear capacity additions by 2021

India is aiming to have 15,700 MW of installed nuclear capacity by 2031 and by that year also complete 21 reactors now at various stages of construction, Atomic Energy Minister Jitendra Singh informed parliament in a written reply to a question January 3.

The 15,700-MW target is lower than an earlier target of 22,480 MW that was announced by the government in April. That target, in turn was lower than the original target of 63,000 MW set by the country's Integrated Energy Policy in 2006.

The country has current installed nuclear capacity of 6,780 MW.

On December 12, Singh had informed parliament that total nuclear power capacity by 2031 would reach 22,480 MW.

Last year, Singh had said that the scaling down of the target to 22,480 MW was because of the time needed for extensive pre-construction activities such as land acquisition, obtaining of statutory clearances and government approvals. No reason was given for the further reduction January 3.

There are nine reactors at various stages of construction in India, all targeted for completion by fiscal year 2024-25. A further 12 reactors were accorded administrative approval and financial support by the government in June 2017, Singh said January 3.

In addition, the minister told parliament that discussions are underway on finalization of project proposals to build large light-water reactors in collaboration with French utility EDF at Jaitapur in Maharashtra and with US-based Westinghouse at the Kovvada site in Andhra Pradesh.

Construction of these reactors will be started after administrative approval and financial support by the Indian government, Singh said.

He also said that there is a proposal to construct four new fast breeder reactors of 600 MW each. Of these, two are planned for Kalpakkam in Tamil Nadu, southern India and their construction is likely to start by 2021. The location for the other two planned fast breeders is yet to be selected.

The 500-MW prototype fast breeder reactor at Kalpakkam is yet to be commissioned after having experienced a series of delays. There is no definitive schedule yet, although the government in August 2018 said that it would be commissioned in about a year.

— *Sapna Dogra, New Delhi*

Millstone, Seabrook bids accepted in Connecticut power procurement auction

Bids from Dominion Energy's Millstone in Connecticut and NextEra Energy's Seabrook in New Hampshire, and bids from solar and wind energy producers, were accepted in Connecticut's recent solicitation for procurement of zero-carbon electricity, Connecticut Governor Daniel Malloy and state regulators announced late last month.

Under the Connecticut power procurement process, an existing generating resource such as the Millstone plant cannot be credited for its zero-carbon and other environmental attributes unless it is designated by state regulators after a review of its finances by the state's Public Utilities Regulatory Authority as being at risk of early closure. Dominion applied for that status for Millstone and received it in early December (NW, 13 Dec '18, 3).

With such a designation, a resource can be credited for such attributes and gain competitive advantages in the procurement process.

Under state law, up to 12 million MWh per year of "zero carbon energy" can be procured in state-run auctions for resale to utilities. That represents nearly 45% of the state's annual electric distribution company load.

"The approved selections will secure the at-risk Millstone Power Station, Connecticut's only nuclear plant," Malloy, a Democrat, and Connecticut's Department of Energy & Environmental Protection, known as DEEP, said in a joint statement December 28.

Dominion submitted "24 different bids for different terms lengths and quantities" of generating output from Millstone, according to the statement. Ultimately, "DEEP selected the 10-year bid for about 50 percent of the entire facility's output," it said.

"DEEP selected and treated this option as though it were two separate bids: one for the next several years when [Millstone is] not considered at risk due to their existing market commitments, and one for the latter years," the statement said.

In the latter years, Millstone will be treated as an at-risk generating asset, and Connecticut's electricity distribution companies, Eversource and United Illuminating, "are directed to negotiate for a price that reflects the costs and risks Dominion faces," the statement said.

However, Malloy and DEEP said in their statement that "Dominion has sought a rate of return that is not in the best interest of ratepayers." That rate of return was redacted from the public version of Dominion's bid.

The governor and regulator said that they had therefore directed Eversource and UI to "negotiate the price downwards to better reflect a reasonable rate of return for the plant's owner, Dominion Energy. A normal utility rate of return on equity is 9 percent, however, DEEP would consider 12 to 15 percent reasonable for a merchant power plant with a long-term contract."

The state has requested that those negotiations be concluded by March 31, the statement said.

NextEra had the option of bidding Seabrook into the auction as an at-risk asset but chose not to do so, the statement said. That utility's winning bid for Seabrook will result in a contract to sell 1.9 million MWh, beginning in 2022, it said.

Nine solar power generators and one offshore wind generator were

also selected as winning bidders, the statement said.

Paul Koonce, president and CEO of Dominion Energy Power Generation Group, said in a statement January 7 that the bidding results show that "Connecticut once again recognizes the significant environmental and economic benefits of Millstone Power Station to its citizens by selecting the maximum term allowed and a significant annual quantity."

Koonce said: "This is an important step in the process, but more work remains before contracts can be executed, particularly with regard to the short-term pricing. We look forward to resolving the remaining issues amicably to ensure that Millstone's benefits are available to Connecticut for the next decade."

Connecticut law directs PURA to approve or disapprove the resulting contracts within 180 days of their filing, ClearView Energy Partners, an energy consulting firm, said in a December 29 analysts note.

"Absent such a decision, the contracts are deemed approved," it said.

"While this suggests PURA could sign-off before the end of September 2019, our observations of prior PURA contract reviews suggest that its review may not take that long. We think PURA could approve timely submitted PPAs [power purchase agreements] allowing them to go into effect as early as [sometime in] 2019," ClearView said.

— *Steven Dolley, Washington*

Some academics question effectiveness of new Japan fast reactor plan

- Limited number of engineers with fast reactor experience an issue
- Fate of French-Japanese collaboration program uncertain

Japan's roadmap for developing a domestic fast reactor, approved by the country's ministers last month, provides few specifics on how the project will proceed, raising concerns among three professors that the plan may not result in deployment of a commercial fast reactor.

The plan was finalized by the trade and industry ministry December 3 and authorized by five ministers and six other Cabinet members involved in nuclear power December 21. Under it, a fast reactor is expected to start operation in the middle of this century and run at full capacity in the latter half of the century.

The outline of the project, however, did not provide details such as the design of the fast reactor envisioned and its anticipated output, as well as the exact timeline for the unit's development. The type of reactor — experimental, prototype, demonstration or commercial — also is not specified in the plan.

The roadmap indicates that the reactor technology will be defined after 2024, following a government assessment of a range of technologies expected to be proposed by Japanese vendors over the next five years. The plan noted, however, that the project may be reviewed for a possible change even after the technology is selected, depending on variables such as cost, safety regulations and the willingness of local governments to host the fast reactor, as well as the expansion of renewable power generation in Japan.

"The government seems reluctant to make details of a fast reactor plan clear and this explains why the prospects for the project are uncertain," Kazuya Idemitsu, a professor of engineering at Kyushu University, said in an interview December 25. He added that the project may be postponed or even fail.

The lack of details on the project, the limited number of fast reactor engineers due to a failure of the Monju fast reactor project and the scaled-backed French-Japanese joint development of a fast reactor have put the Japanese project into question, Idemitsu and other nuclear specialists said.

Under an agreement between Japan and France in 2014, the two countries will work jointly on a basic design of the Advanced Sodium Technological Reactor for Industrial Demonstration, or Astrid, until 2019. The Japanese government has not decided whether to remain involved in the French program because France has reduced the capacity of the proposed reactor.

"The biggest problem with the [fast reactor] development is human resources," Hiroshi Miyano, a professor at Hosei University's graduate school of nuclear engineering and a former nuclear engineer at Toshiba, said in an interview December 25. "Engineers involved in fast reactor work have or will retire and their expertise couldn't be passed down to new generations," making it harder for the project to advance, he added.

While Japanese utilities are keen to restart their existing reactors following the 2011 Fukushima I accident, none of them have operated a fast reactor.

The government decided in December 2016 to decommission the Monju fast breeder reactor. The 280-MW prototype unit, plagued with a series of problems such as a sodium coolant leak and fire, remained offline for more than two decades.

The trade and industry ministry moved to seek the development of a potential Monju successor in an effort to maintain Japan's program to reprocess spent fuel, close the fuel cycle and reduce its plutonium stockpiles amid criticism from outside the country about the large volume of Japan's plutonium holdings.

"We'll just pursue our fast reactor plan based on our energy policy," Yuta Tonegawa, deputy director of the trade and industry ministry's nuclear energy policy planning division, said in an interview January 8. He did not provide further comments on concerns raised by the professors about the fast reactor plan.

Muneo Morokuzu, a former Toshiba engineer who was involved in Monju's development, said in an interview December 28 that it is hard to apply technology used for the development of light water reactors, or LWRs, to a fast reactor, which could use sodium or another coolant. Given that, he added, bringing engineers from Japanese reactor vendors to the new fast reactor project following the Monju decommissioning will be a daunting task.

A fast reactor can use plutonium for power generation.

Japan had about 47.3 metric tons of separated plutonium at the end of 2017, up from 46.9 mt at the end of 2016, according to Japan Atomic Energy Commission.

Uncertain French-Japanese partnership

While the trade and industry ministry said it will look at some ongoing fast reactor projects outside Japan for the development of the country's plan, it made no mention in its project plan of France's joint fast reactor development program with Japan.

Whether the French-Japanese partnerships will continue is "unforeseeable," an official at the trade and industry ministry said in an

interview December 27. He spoke on the condition of anonymity as he is not authorized to speak to the media.

In June, CEA, the French nuclear regulator, announced that Astrid will have its capacity scaled down from the initially planned 600 MW to between 100 MW and 200 MW to reduce construction costs. Building a demonstration reactor was not urgent, given the state of the uranium market, CEA's program manager, Nicolas Devictor, said at that time (NW, 2 Aug '18, 5)

Even if Astrid's capacity is reduced, Japan could learn about the design and construction of a small fast reactor from France, which stands out in basic research, Toshikazu Takeda, a professor of nuclear engineering at University of Fukui, said in an interview December 26. Without such French support, he added, Japan may struggle to develop the technology from scratch because it has limited resources.

— *Yuzo Yamaguchi, Tokyo*

Nucleoelectrica Argentina's Embalse unit restarts after refurbishment

Nucleoelectrica Argentina SA restarted its Embalse heavy-water reactor January 4, ending the refurbishment process that will extend the life of the Candu reactor by 30 years and result in a power uprate.

Nucleoelectrica Argentina, also known as NA-SA, began loading fuel bundles November 22 at Embalse, which has been shut since December 2015 for the work. The unit will be connected to the grid shortly following a period of low-power testing, NA-SA said.

The $1 billion refurbishment included replacing all pressure tubes in the reactor as well as steam generators and process computers, the state-owned nuclear operator said. When the unit returns to service, its capacity will be increased to 683 MW from 648 MW, the company has said.

Criticality was recorded at 2 pm local time January 4, NA-SA said. The milestone is the most important one in the process of refurbishment, the company said.

"The investment made for the development of the nuclear industry is fully justified," NA-SA President Omar Semmoloni said in the statement.

The company said in a statement November 23 that 4,560 fuel elements had to be loaded at the unit. Loading of fuel takes two hours per channel and there are 380 fuel channels, the company said.

NA-SA said in October it successfully had completed pressure testing of the primary system at Embalse. The country's Nuclear Regulatory Authority subsequently authorized fuel loading, the company said.

The company had said when the unit shut that refurbishment would take 21 months. However, Candu reactor refurbishments are challenging projects and previous efforts have been delayed. Embalse is the third Candu6 reactor to undergo such a refurbishment after Point Lepreau in Canada and South Korea's Wolsong-1, NA-SA has said.

Bruce Power's Bruce-1 and -2, of a different Candu design, were refurbished from 2005 to 2012 at an estimated cost of C4.8 billion ($4.9 billion in 2012 dollars).

Embalse entered commercial operation in January 1984. The reactor was supplied by Atomic Energy of Canada Ltd., owned by Canada's government. In 2011, AECL won a contract, worth $444 million at the time, to do work on the refurbishment; other companies involved included Ansaldo Nucleare.

SNC-Lavalin acquired the Candu reactor business from AECL in 2011.

— *William Freebairn, Washington*

EDF Energy faces technical hurdles to life extension plans: academic

EDF Energy, the operator of the existing UK nuclear power fleet, faces a series of technical challenges to its plans to further extend the operating lifetimes of its advanced gas-cooled reactors, Paul Dorfman, an energy researcher at University College London, said in an email January 8.

"No one has a beef with continuing with the present reactors [the AGRs], if they are safe. The question is, are they? Basically, [with] the viability of any potential life extensions, there are key safety concerns involved," Dorfman said.

Dorfman, who has served as an advisor to the UK government and European Union on radiation risk from nuclear plants, cited the two-unit, 990-MW Hunterston B plant as facing potential challenges to additional operating life extensions. He noted that "significant uncertainties over the structural integrity and residual strength of the graphite moderator core" exist at the plant, as well as "potential cracking in the boiler spines, requiring inspections and repair."

The 495-MW Hunterston B-1 was shut for much of 2018 due to analysis and repair work on a series of graphite cracks in the unit's moderator core (NW, 10 May '18, 1). The cracking issue was experienced as early as 2014 at Hunterston B-1, as well as at the 1,300-MW Hartlepool and the 1,340-MW Heysham A plants.

Dorfman said that "aging UK AGRs have a history of technical problems including: insulation degradation; graphite oxidation; boiler spine cracking; boiler superheating cracking, and graphite cracking. The most important of these is the cracking of the graphite moderator."

He said "irradiation damage changes the structure of graphite, and this irradiation damage is part of the degradation of the core."

Dorfman added that "symptoms include graphite weight loss and brick cracking. As the number of cracked bricks increases and core distortion increases, the potential for the system to fail increases. This is because, if the core distorts too much, the control rods can't be lowered to control the nuclear reaction."

Sue Fletcher, a spokeswoman for EDF Energy, said in an email January 8 that "our lifetime strategy remains to seek life extensions for all our nuclear stations, where it is safe and commercially viable."

With respect to concerns about graphite cracking within the AGRs and its impact on EDF Energy's life extension policy, Fletcher said that "our life extension programme approach ensures that safety always remains at the forefront through significant additional investment to secure long term safety margins."

EDF Energy has said it has added articulated control rods to some reactors to reduce the risk that graphite cracking could constrain the entry of control rods to the core.

EDF Energy has already undertaken an extensive life extension program at its fleet of existing AGRs, which have a combined capacity of 8,493 MW. The company says on its website that it has added an average of over eight years per reactor to the life of its existing fleet

OPERATING PLANS FOR UK NUCLEAR FLEET

Plant	Dungeness B	Hartlepool	Heysham A	Heysham B	Hinkley Point B	Hunterston B	Sizewell B	Torness
Capacity (MW)	1,250	1,300	1,340	1,354	940	990	1,250	1,319
Original closure date	2016	2014	2014	2023	2016	2016	2035	2023
Extended closure date	2023	2024	2024	2030	2023	2023	N/A	2030

Sources: EDF Energy, S&P Global Platts

since 2008.

The current EDF Energy fleet of AGRs is expected to stop operating between 2023 and 2030, including all existing planned life extensions.

The 1,250-MW Sizewell B, the UK's only pressurized water reactor is expected to run until 2035.

Stephen Thomas, a professor of energy policy at the University of Greenwich in London, said in an email January 8 that "given the [graphite cracking] problems identified [in 2014] at one of the Hunterston reactors, getting to 2023 might not be feasible" for the plant.

Thomas noted that "I think you have to treat Hunterston and Hinkley separately to the other five" AGR plants. "These were brought on line in 1976 and in 2016 they completed their 4th 10-year review and were approved to continue in service. EDF said it would retire them in 2023 when it expected Hinkley C to be in service."

However, he said that "given that Hunterston and Hinkley are effectively twins, it would be surprising if the problems found at one Hunterston reactor were not also apparent at the other reactor and at Hinkley."

EDF Energy said in a statement in May that "inspections confirm that the graphite" at its Hinkley Point B plant is "behaving as experts predicted it would, underlining our confidence to operate Hinkley Point B to 2023 and beyond."

The UK's Office for Nuclear Regulation grants operating licenses for a 10-year period after undertaking a full inspection of the unit.

EDF Energy's planned 3,200-MW Hinkley Point C plant is under construction in western England. The plant had been due to be completed in 2023, but EDF Energy now says that it expects to have the first of two European pressurized reactors, or EPRs, connected to the power grid in 2025.

Dorfman also said that "the other issue [with UK life extensions] is one of cost," adding that it "may prove expensive" to undertake life extension work on the AGRs.

Dorfman noted that the proposed cost estimate for a series of life extensions to the existing French fleet of PWRs was Eur100 billion ($114.4 billion), although the "UK bill is much less than this."

— *Oliver Adelman, London*

Korsnick ...from page 1

power could be better than a series of state measures, she said. "In some ways it's a patchwork now … maybe that's not the best approach," Korsnick said.

Market-based solutions would be preferable, and ideally some approach that gives a market value to nuclear energy's attributes would come from the Federal Energy Regulatory Commmission, Korsnick said. FERC must review work done by regional transmission organization PJM Interconnection on the role of fuel security, for example, she said.

But FERC may be slowed in reviewing various issues such as its investigation into whether and how to value resiliency of the grid by the recent death of commissioner Kevin McIntyre, who passed away January 2, she said. Given the political gridlock in Congress, naming a replacement may be challenging and NEI hopes approving a replacement is a priority, she added.

'We really need to modernize the regulatory process'
—Maria Korsnick, president, CEO, Nuclear Energy Institute

Renewable standard to clean one

One of the state-level measures that may come up in 2019 is the reauthorization of renewable portfolio standards, which mandate a proportion of electricity be generated from renewable sources. Some of those standards could be revised to become clean energy standards that include nuclear energy, Korsnick said. This could happen "even in places that don't necessarily have a stressed asset," she added.

Other legislative priorities for 2019 include continued efforts to spur nuclear technology research and development, Korsnick said. "Advanced technology and development, we seem to get pretty strong bipartisan support for that," she said.

Legislation like Republican Senator Lisa Murkowski's proposal to promote nuclear technologies, which would permit federal agencies to sign longer-term power purchase agreements with a power plant operator, could spur deployment of new reactors, maybe small modular reactors, Korsnick said. That legislation was introduced in the last session by the Alaska senator with bipartisan support, but no action was taken. The bill, which also contains support for development of a fast neutron research reactor some advocates have said is needed to speed advanced reactor development, is likely to be reintroduced in the new session of Congress, Korsnick said.

The successful completion of the $28 billion Vogtle nuclear plant expansion in Georgia would be "huge" not only for US nuclear power, but also for the export potential of the reactor design, Westinghouse's AP1000, Korsnick said.

Georgia Power's Vogtle expansion is the sole remaining new reactor construction project in the US following the abandonment last year of the similar effort to add two AP1000 units at South Carolina Electric & Gas's Summer station. That project was canceled after cost overruns that nearly doubled the planned cost of the reactors, resulting in the bankruptcy reorganization of Westinghouse. Georgia Power's minority partners in the expansion agreed in September to a restructuring of the project which shifted some risk, as well as more control, of the project to the largest owner (NW, 4 Oct '18, 1).

Because the Vogtle and Summer expansions were the first new reactors to begin construction in 30 years in the US, they experienced first-of-a-kind issues, Korsnick said. Lessons from those projects

would mean additional reactors of that design could be built for less money and more quickly if they were started now, she said.

However, “you come back to, why do I need to build a large light-water reactor right now,” she said. Electricity demand would need to be greater to spur the development of a large LWR, she said.

Small, microreactors fill niche

Instead, small modular reactors, usually those smaller than 300 MW, or microreactors, those smaller than 15 MW, are more likely to meet the needs of customers in the US, she said. The grid of the future will have distributed generation and limited demand growth, a good match for SMRs or microreactors. “Quite frankly they fit a niche,” she said.

The recent announcement by the US Department of Energy that it would lease the first reactor in the planned NuScale SMR plant to be owned by the Utah Associated Municipal Power Systems and built at the Idaho National Laboratory (NW, 3 Jan, 2), is “a strong vote of confidence” in the smaller reactor category, Korsnick said.

“It’s precedent-setting, I think it opens a lot of doors,” including for the export of SMRs, she added. Many international customers would like to buy a US-designed SMR but do not want to be the first customer for one, Korsnick said.

Although UAMPS is a small organization composed of municipal power companies in several Western states, it could be an example of how smaller utilities can implement nuclear power, Korsnick said. “I’m optimistic … but it’s not going to be easy,” she said of the project.

The US Department of Defense has a growing interest in microreactors, which could provide power to military bases, Korsnick said. NEI has met with DOD officials to discuss microreactors, and the military is seeking an industry “roadmap” spelling out the steps needed for deployment of such reactors, she said.

Regulatory changes sought

"We really need to modernize the regulatory process," Korsnick said.

Rather than undertaking wide-ranging efforts to overhaul NRC regulatory processes, Korsnick suggested the establishment of what she called "off-ramps" in discussions between NRC staff and industry representatives of potential safety issues or their significance.

"If we get to the point where the conversation that we're having [with NRC staff] is of no safety value, [and the issue is of] no safety significance, now I'm beholden to this rigorous process. And I'm locked into following this path and spending time ... and we're arguing over things. At the end of the day it's like, 'Why are we even having this conversation?'"

Korsnick recommended development of such "process off-ramps" to focus NRC staff and industry alike on those issues with true safety significance. Introduction of a sort of "safety-significant filter" into NRC-industry discussions would help them achieve such focus, she said.

The significance determination process of NRC's reactor oversight process is one area such an improved dialog could be pursued, especially regarding so-called "white" inspection findings, that is, those held in the agency's color-coded process to be of "low to moderate" safety significance.

Costs to licensees to respond to and resolve NRC white findings run into the "millions of dollars," and the agency response to some lower-significance issues within that category could be modified, Korsnick noted.

Such a change would be "a win-win" for the agency and licensees, and could establish "a wonderful template" for handling such issues when they arise with new reactor designs, she said.

Export-Import Bank staffing

Other actions needed to spur the nuclear sector include full staffing of the Export-Import Bank of the US’s board of directors, Korsnick said. The bank has operated without a quorum for the past three years after criticism by Republicans who said its mandate of guaranteeing loans to support US exports represented excessive government interference in the economy. The bank plays a critical role in supporting US efforts to export nuclear plants and components, NEI has said.

“It’s a very necessary piece of this puzzle,” Korsnick said, referring to US company exports of nuclear plant technology.

— *William Freebairn and Steven Dolley, Washington*

HALEU ...from page 1

The use of existing US-origin enrichment technology and ACO's existing NRC license would "provide DOE with the capability to produce HALEU beginning in 2020," a DOE official said in a January 8 email. The official spoke on condition of anonymity to discuss information related to the potential contract. According to the notice DOE issued January 7, the department wants to begin producing HALEU by October 2020.

"The only U.S.-owned and U.S.-controlled firm known by the Department that can implement this program within the necessary schedule is Centrus," the DOE official said. "A sole-source contract meets the timeline for expected demand of HALEU," the official said.

HALEU is enriched to greater than 5% U-235 but less than 20%. Uranium enriched to 20% U-235 or greater is considered high-enriched uranium, or HEU, which is directly usable in nuclear weapons. According to surveys conducted by the US Nuclear Industry Council, an industry group that advocates for advanced reactor developers, HALEU is being considered as fuel for many, if not most, advanced reactor designs being developed in the US, and assurance of its availability for fuel development work is considered a top priority by the vendors (Nuclear Fuel, 4 Jun '18, 6).

“Demonstrating the capability of U.S.-origin enrichment technology for the production of HALEU is the objective because only U.S.-origin technology would be capable of producing HALEU for use in any type of advanced reactor application, civilian or defense related,” the DOE notice stated. ACO, it added, is the only US-owned and -controlled entity with an existing NRC license that would enable DOE to meet the 2020 target date.

Long-standing US policy and international treaties bar the use of foreign technology for national security purposes. That means, for example, that uranium in fuel used by reactors in the production of tritium must be enriched using US-origin technology. Tritium, a radioactive isotope of hydrogen, is used to enhance the explosive yield of nuclear weapons.

USEC, which was a US enricher and is known now as Centrus Energy, leased the Portsmouth facility from DOE and operated it before the plant permanently closed in 2001. Centrus, which did not have an enrichment facility of its own but was developing centrifuge technology, is now a supplier of enriched uranium.

The 120-centrifuge cascade at ACP has been dismantled and decommissioned, Centrus spokesman Jeremy Derryberry said in an email January 8. "That work was completed earlier this year," he said, noting those machines were disposed of as part of the company's work at the site.

"The buildings and infrastructure supporting the cascade are still in place though, as is our NRC license for the demonstration facility," he said.

The 16-centrifuge cascade DOE is calling for will be comprised of new machines, Derryberry said. He added that Centrus is comfortable with DOE's objective that a new cascade using US-origin technology produce HALEU by October 2020.

The DOE plan is "a very positive signal that the need for higher enrichment is coming," Nuclear Energy Institute President and CEO Maria Korsnick said in an interview January 7. The contract shows the government sees a future in HALEU demand and the reactors that will need it, she said.

The action also "sends signals that we're seriously in this business" of advanced reactors globally, Korsnick said.

The American Council for Capital Formation, or ACCF, a nonprofit, nonpartisan economic policy organization, noted in a statement January 7 that a HALEU demonstration program could help expand the US market for advanced small modular reactors.

"This is not only good for energy security, it's good for the environment," Drew Bond, ACCF senior fellow and director of energy innovation programs, said in the statement.

"The United States requires nuclear fuel to be produced by its own technology to fulfill national security objectives, including bolstering the readiness of its nuclear arsenal," ACCF Executive Vice President George David Banks said in the statement.

Urenco had its eye on HALEU

Melissa Mann, president of Urenco USA Inc., owner and operator of the only operating US uranium enrichment facility, told a House Energy and Commerce subcommittee in May that her company sees a need for HALEU and that the company's enrichment facility in New Mexico "is currently capable of producing … the full span of HALEU enrichments without further development or testing."

Only an amended NRC license would be needed to support a HALEU enrichment module, she said. "We estimate that if detailed design, site permitting and contractor selection were undertaken during the NRC review process, we could construct, commission and start-up such a module within 24 months of NRC licensing," she said.

"Centrus needs to prove the technology works," Mann said in a January 8 interview. When asked if her company would challenge any DOE award of a sole sourced HALEU contract to ACO, Mann responded that it was "looking at what its options are."

The Urenco Group is a nuclear fuel company that operates uranium enrichment plants in Germany, the Netherlands and UK, as well as the US plant — all using non-US technology. Urenco is one-third owned by the UK government, one-third by the Dutch government and one-third by German utilities.

— *Elaine Hiruo and William Freebairn, Washington*

Notes to Nucleonics Week's generating tables for November 2018

In France, Bugey-2 returned December 10 from refueling that began September 29; Bugey-5 shut for refueling July 28, returning November 26; Chinon-B2 returned December 7 from refueling that began August 11; Chinon-B3 refueled from October 20 to December 3; Civaux-1 returned November 5 from refueling that began September 22; Dampierre-3 shut for refueling October 6, returning November 29; Dampierre-4 returned December 25 from refueling that began June 9; Paluel-3 refueled from September 28 to January 1; St. Alban/St. Maurice-1 shut September 29 for refueling, returning December 2; St. Laurent-des-Eaux B2 returned December 14 from refueling that began September 1.

Germany's Neckar-2 returned November 8 after refueling that began September 1.

In Japan, Takahama-3 returned to service November 9 after refueling that began August 8.

In Spain, Asco-1 returned December 23 from refueling that began November 10.

In the US, Beaver Valley-2 shut October 21 for refueling, returning November 14; Braidwood-2 returned November 1 from refueling that began October 7; Cooper refueled from September 29 to November 17; Dresden-3 returned late November 12 from a 15-day refueling outage that began October 29; Ginna shut October 22 for refueling, returning late November 8; Millstone-2 refueled from September 27 to November 2; Oconee-1 returned November 14 from refueling that began October 20; Palisades refueled from October 13 until December 28; Palo Verde-2 shut October 5 for refueling, returning December 3; Robinson-2 shut early September 22 for refueling, returning November 26; Salem-2 returned November 13 from refueling that began October 11; Sequoyah refueled from November 3 to December 8; South Texas-1 shut for refueling October 5, returning November 11; Summer returned November 25 from refueling that began October 6; Surry-2 refueled from October 27 to December 6; Turkey Point-3 shut October 1 for refueling, returning November 9.

Long-term outages

Argentina's Embalse shut in December 2015 for an extended outage during which it will be refurbished to extend its operating life; the unit restarted January 4.

Belgium's reactor fleet had been largely shut after the discovery of concrete degradation in plant buildings resulted in the need for inspections and repairs. Doel-2, which shut May 22 for maintenance unrelated to the degradation, is to return to service in late January; Doel-4, which had been shut since August, returned to service December 13. Tihange-2 has been shut since March and is expected to be offline until March 2019 for concrete repairs. Tihange-3 shut August 19 and was offline until January 1 for similar work. Doel-1 has been shut since April 27 because of leaks to the primary coolant system; restart is planned in March.

India's Kakrapar-1 has been shut since March 2016 after a coolant channel failed.

Japan had no nuclear generation from mid-September 2013, when the last of its operational units shut for refueling and maintenance, until Sendai-1 connected to the grid in August 2015. Sendai-2 connected to the grid two months later. Takahama-3 restarted in February 2016 and Takahama-4 restarted in May 2017. Ikata-3 returned to service in August 2016 but shut for refueling in October 2017 and remained offline because of a court order that was lifted in September; the unit returned to service October 30. Ohi-3 returned to service March 16, and Ohi-4 resumed power generation May 11. Genkai-3 resumed operating March 25, and Genkai-4 returned to service June 19. The other operational units remain shut following the March 11, 2011, earthquake and tsunami that resulted in the permanent shutdown 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.

Taiwan's Chinshan-1 has been shut since December 2014 for refueling, which was halted after a damaged fuel assembly was discovered. Restart is not planned, and the unit may be retired at year-end. Chinshan-2 has been shut since June 2017 and has no storage space left in spent fuel pools, precluding its restart.

— *Staff*

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

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 Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Argentina						
Atucha-1	362	256,300	98.20	2,208,587	76.10	99,711,023
Atucha-2	745	148,413	27.63	4,509,544	75.50	15,712,979
Embalse	648	0	0.00	0	0.00	134,716,956
Total. Argentina	**1,755**	**404,713**		**6,718,131**		
Armenia						
Metsamor-2	408	196,025	66.64	1,787,196	54.64	75,311,964
Belgium						
Doel-1	454	0	0.00	1,229,714	33.79	135,441,704
Doel-2	454	0	0.00	1,549,672	42.58	133,807,553
Doel-3	1,056	778,160	102.35	3,158,438	37.31	254,256,321
Doel-4	1,090	0	0.00	5,638,811	64.54	260,183,174
Tihange-1	1,009	432,201	59.49	7,231,373	89.41	298,730,443
Tihange-2	1,055	0	0.00	5,702,395	67.43	255,346,696
Tihange-3	1,094	0	0.00	2,332,444	26.61	272,169,768
Total. Belgium	**6,212**	**1,210,361**		**26,842,847**		
Brazil						
Angra-1 (#)	640	(a)		4,589,565	98.29	106,403,969
Angra-2 (#)	1,350	(a)		8,709,050	88.42	181,905,746
Total. Brazil	**1,990**			**13,298,615**		
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
Total. Britain	**9,743**					
Bulgaria (Lifetime only from May 1993)						
Kozloduy-5	1,000	749,941	104.01	7,130,512	88.94	92,273,907
Kozloduy-6	1,000	750,085	104.03	7,441,597	92.82	91,640,083
Total. Bulgaria	**2,000**	**1,500,026**		**14,572,109**		
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	678,528	100.76	7,291,282	97.37	190,775,418
Darlington-2	934	0	0.00	0	0.00	170,800,293
Darlington-3	934	608,128	90.31	5,470,976	73.06	183,568,457
Darlington-4	934	676,992	100.53	6,764,434	90.34	181,806,734
Pickering-1	542	378,951	96.97	4,042,663	93.04	123,216,354

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Pickering-4	542	383,832	98.22	2,560,955	58.94	126,602,983
Pickering-5	540	369,450	94.89	4,096,020	94.61	126,552,852
Pickering-6	540	382,640	98.28	2,399,780	55.43	129,961,080
Pickering-7	540	354,360	91.02	4,205,110	97.13	126,155,278
Pickering-8	540	0	0.00	2,709,750	62.59	117,558,365
Point Lepreau	680	0	0.00	0	0.00	123,941,586
Total. Canada	**14,558**	**3,832,881**		**39,540,970**		
China						
Daya Bay-1 (#)	984	NA				148,002,066
Daya Bay-2 (#)	984	NA				146,831,541
Hongyanhe-1 (#)	1,119	NA				0
Hongyanhe-2 (#)	1,119	NA				0
Ling Ao I-1 (#)	990	NA				65,890,643
Ling Ao I-2 (#)	990	NA				65,917,069
Ling Ao I-3 (#)	1,080	NA				37,277,112
Ling Ao I-4 (#)	1,080	NA				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**					
Czech Republic						
Dukovany-1	498	287,626	80.22	3,236,345	81.07	110,050,778
Dukovany-2	498	357,357	99.66	3,241,111	81.19	106,351,848
Dukovany-3	498	346,763	96.71	3,805,576	95.33	105,055,874
Dukovany-4	498	145,306	40.52	2,794,998	70.02	104,315,724
Temelin-1	1,082	782,504	100.44	7,043,744	81.21	112,675,987
Temelin-2	1,080	788,355	101.38	6,939,945	80.16	106,346,695
Total. Czech Republic	**4,154**	**2,707,911**		**27,061,719**		
Finland						
Loviisa-1	531	379,714	99.32	3,834,311	90.08	157,195,296
Loviisa-2	531	382,787	100.12	3,569,722	84.59	146,975,258
Olkiluoto-1	910	664,826	101.47	6,320,040	86.64	260,974,213
Olkiluoto-2	890	647,514	101.05	6,910,878	96.87	251,209,852
Total. Finland	**2,862**	**2,074,841**		**20,634,951**		
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 NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	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	956,085	89.72	9,423,645	79.43	349,682,726
Emsland	1,406	1,018,214	100.58	10,488,388	93.06	345,751,664
Grohnde	1,430	983,443	95.52	9,933,236	86.66	376,305,242
Gundremmingen-C	1,344	952,292	98.41	9,356,368	86.85	329,603,997
Isar-2	1,485	1,070,654	100.14	11,042,736	92.77	352,577,139
Neckar-2	1,400	763,500	75.74	8,678,300	77.33	328,733,029
Philippsburg-2	1,468	989,567	93.62	9,925,255	84.34	364,856,211
Total. Germany	**10,013**	**6,733,755**		**68,847,928**		
Hungary						
Paks-1	509	376,715	102.87	4,024,907	98.72	129,634,583
Paks-2	504	240,054	66.13	3,425,380	84.75	118,923,418
Paks-3	500	378,289	105.08	3,124,092	77.95	115,496,440
Paks-4	500	371,133	103.09	3,930,074	98.06	116,029,546
Total. Hungary	**2,013**	**1,366,191**		**14,504,453**		
India						
Kaiga-1	220	148,000	93.30	1,764,000	100.01	26,629,566

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Kaiga-2	220	162,000	102.13	1,780,000	100.92	27,251,748
Kaiga-3	220	157,000	98.98	1,561,000	88.51	15,444,000
Kaiga-4	220	170,000	107.17	1,807,000	102.45	13,105,000
Kakrapar-1	220	0	0.00	0	0.00	28,770,941
Kakrapar-2	220	155,000	97.72	344,000	19.50	29,820,594
Kudankulam-1	1,000	13,000	1.80	4,730,000	59.00	17,774,000
Kudankulam-2	1,000	558,000	77.39	2,517,000	31.40	5,623,000
Madras-1	220	0	0.00	72,000	4.08	35,229,243
Madras-2	220	91,000	57.37	1,681,000	95.31	36,384,103
Narora-1	220	159,000	100.24	1,665,000	94.40	32,690,290
Narora-2	220	160,000	100.87	1,481,000	83.97	31,989,164
Rajasthan-1	100	0	0.00	0	0.00	11,960,915
Rajasthan-2	200	137,000	95.01	1,137,000	70.91	40,757,785
Rajasthan-3	220	0	0.00	1,449,000	82.15	28,944,928
Rajasthan-4	220	158,000	99.61	1,516,000	85.95	28,649,972
Rajasthan-5	220	170,000	107.17	1,572,000	89.13	16,215,000
Rajasthan-6	220	170,000	107.17	1,556,000	88.22	13,315,000
Tarapur-1	160	111,000	96.22	881,000	68.68	47,901,775
Tarapur-2	160	97,000	84.08	472,000	36.80	48,908,928
Tarapur-3	540	393,000	100.94	3,940,000	91.01	44,903,000
Tarapur-4	540	221,000	56.76	4,060,000	93.78	42,362,265
Total. India	**6,780**	**3,230,000**		**35,985,000**		
Japan						
Fukushima II-1	1,100	0	0.00	0	0.00	215,651,081
Fukushima II-2	1,100	0	0.00	0	0.00	198,062,358
Fukushima II-3	1,100	0	0.00	0	0.00	170,409,505
Fukushima II-4	1,100	0	0.00	0	0.00	168,088,110
Genkai-2	559	0	0.00	0	0.00	121,626,347
Genkai-3	1,180	866,605	101.86	6,554,199	69.28	157,708,225
Genkai-4	1,180	859,819	101.06	4,595,827	48.58	132,108,009
Hamaoka-3	1,100	0	0.00	0	0.00	179,146,924
Hamaoka-4	1,137	0	0.00	0	0.00	143,839,198
Hamaoka-5	1,380	0	0.00	0	0.00	35,989,175
Higashidori-1	1,100	0	0.00	0	0.00	41,030,051
Ikata-3	890	655,058	102.08	677,046	9.49	122,135,388
Kashiwazaki-Kariwa-1	1,100	0	0.00	0	0.00	167,491,230
Kashiwazaki-Kariwa-2	1,100	0	0.00	0	0.00	125,113,550
Kashiwazaki-Kariwa-3	1,100	0	0.00	0	0.00	104,978,640
Kashiwazaki-Kariwa-4	1,100	0	0.00	0	0.00	93,439,420
Kashiwazaki-Kariwa-5	1,100	0	0.00	0	0.00	142,874,170
Kashiwazaki-Kariwa-6	1,356	0	0.00	0	0.00	133,976,546
Kashiwazaki-Kariwa-7	1,356	0	0.00	0	0.00	117,915,082
Mihama-3	826	0	0.00	0	0.00	180,298,068
Ohi-3	1,180	874,151	102.75	7,479,137	79.06	184,644,957
Ohi-4	1,180	872,530	102.56	5,825,598	61.58	184,976,310
Onagawa-1	524	0	0.00	0	0.00	84,274,171
Onagawa-2	825	0	0.00	0	0.00	82,855,326
Onagawa-3	825	0	0.00	0	0.00	45,459,784
Sendai-1	890	686,693	107.01	4,678,673	65.57	199,497,537
Sendai-2	890	679,351	105.87	4,511,009	63.22	191,348,934
Shika-1	540	0	0.00	0	0.00	61,466,824
Shika-2	1,206	0	0.00	0	0.00	27,362,972
Shimane-2	820	0	0.00	0	0.00	134,337,331
Takahama-1	826	0	0.00	0	0.00	185,812,942
Takahama-2	826	0	0.00	0	0.00	183,722,641
Takahama-3	870	446,059	71.11	5,178,861	74.25	185,000,458
Takahama-4	870	657,993	104.90	4,948,668	70.95	180,513,375
Tokai-2	1,100	0	0.00	0	0.00	229,838,671
Tomari-1	579	0	0.00	0	0.00	96,110,274
Tomari-2	579	0	0.00	0	0.00	88,148,481

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Tomari-3	912	0	0.00	0	0.00	17,911,335
Tsuruga-2	1,160	0	0.00	0	0.00	194,628,260
Total. Japan	**38,566**	**6,598,259**		**44,449,018**		
Mexico						
Laguna Verde-1	810	572,694	98.06	6,098,353	93.92	135,457,594
Laguna Verde-2	810	571,560	97.87	6,297,406	96.99	120,717,185
Total. Mexico	**1,620**	**1,144,254**		**12,395,759**		
Netherlands						
Borssele-1	515	366,579	98.86	3,134,944	75.94	162,002,970
Pakistan						
Chasnupp-1	325	214,290	91.45	1,938,804	74.41	39,185,681
Chasnupp-2	325	22,232	9.49	1,821,154	69.90	16,847,071
Chasnupp-3	340	226,044	92.21	2,078,536	76.25	4,832,106
Chasnupp-4 **	340	224,100	91.42	2,310,966	93.45	2,310,966
Kanupp	137	0	0.00	346,190	31.52	16,466,094
Total. Pakistan	**1,467**	**686,666**		**8,495,650**		
Romania						
Cernavoda-1 (#)	706	(d)		2,899,797	80.74	120,865,722
Cernavoda-2 (#)	706	(d)		3,516,612	97.92	62,570,713
Total. Romania	**1,412**			**6,416,409**		
Russia (Lifetime only from March 1993)						
Balakovo-1	1,000	0	0.00	6,721,350	83.85	170,114,880
Balakovo-2	1,000	770,150	106.97	7,430,180	92.69	162,404,890
Balakovo-3	1,000	770,200	106.97	6,714,020	83.76	171,673,830
Balakovo-4	1,000	771,090	107.10	8,365,580	104.36	178,475,650
Beloyarsk-3	600	450,350	104.25	3,649,300	75.88	101,149,923
Bilibino-1	12	0	0.00	17,740	18.44	1,093,935
Bilibino-2	12	6,460	74.77	58,870	61.20	1,174,190
Bilibino-3	12	7,850	90.86	51,930	53.99	1,185,070
Bilibino-4	12	6,350	73.50	61,820	64.27	1,116,400
Kalinin-1	1,000	774,130	107.52	8,422,770	105.07	172,845,143
Kalinin-2	1,000	772,600	107.31	7,988,840	99.66	175,766,520
Kalinin-3	1,000	765,990	106.39	7,123,230	88.86	99,553,699
Kalinin-4	1,000	765,830	106.37	8,488,910	105.90	52,551,732
Kola-1	440	0	0.00	719,520	20.40	55,415,110
Kola-2	440	317,770	100.31	2,658,780	75.38	56,415,580
Kola-3	440	334,460	105.57	2,887,620	81.87	63,290,650
Kola-4	440	332,100	104.83	2,907,280	82.43	66,341,496
Kursk-1	1,000	740,600	102.86	4,318,200	53.87	127,688,250
Kursk-2	1,000	502,030	69.73	4,702,130	58.66	136,370,530
Kursk-3	1,000	504,960	70.13	6,156,340	76.80	165,112,040
Kursk-4	1,000	743,740	103.30	6,921,620	86.35	169,386,379
Leningrad-1	1,000	524,310	72.82	5,661,640	70.63	144,447,350
Leningrad-2	1,000	713,500	99.10	5,321,250	66.38	155,948,610
Leningrad-3	1,000	723,740	100.52	5,549,350	69.23	147,809,280
Leningrad-4	1,000	658,380	91.44	6,787,420	84.67	152,475,620
Novovoronezh-4	417	0	0.00	0	0.00	68,484,840
Novovoronezh-5	1,000	715,550	99.38	6,830,820	85.21	146,808,580
Novovoronezh-6	1,180	846,280	99.58	7,620,910	80.56	13,022,220
Smolensk-1	1,000	761,050	105.70	6,540,990	81.60	160,131,308
Smolensk-2	1,000	753,220	104.61	7,125,830	88.90	161,574,008
Smolensk-3	1,000	0	0.00	3,775,330	47.10	174,768,963
Volgodonsk-1	1,000	744,570	103.41	7,207,810	89.92	137,751,470
Volgodonsk-2	1,000	404,400	56.17	6,233,820	77.77	65,335,753
Volgodonsk-3	1,000	773,100	107.38	7,406,600	92.40	23,065,580
Total. Russia	**27,005**	**16,954,760**		**172,427,800**		

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	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	525,380	100.37	5,232,014	89.78	184,047,913
South Africa						
Koeberg-1	970	691,200	98.83	4,622,452	59.44	208,549,078
Koeberg-2	940	0	0.00	5,677,700	75.34	202,890,271
Total. South Africa	**1,910**	**691,200**		**10,300,152**		
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	0	0.00	5,632,043	67.88	242,667,954
Hanbit-2 (formerly Yonggwang-2)	1,028	0	0.00	4,831,021	58.62	226,048,836
Hanbit-3 (formerly Yonggwang-3)	1,047	0	0.00	3,239,001	38.59	181,641,865
Hanbit-4 (formerly Yonggwang-4)	1,049	0	0.00	0	0.00	172,511,759
Hanbit-5 (formerly Yonggwang-5)	1,054	151,370	19.92	6,916,557	81.85	131,483,277
Hanbit-6 (formerly Yonggwang-6)	1,050	758,358	100.17	7,635,589	90.71	127,675,869
Hanul-1 (formerly Ulchin-1)	1,008	0	0.00	5,811,030	71.91	223,974,177
Hanul-2 (formerly Ulchin-2)	1,012	728,047	99.78	4,523,787	55.76	220,483,302
Hanul-3 (formerly Ulchin-3)	1,050	758,007	100.13	5,411,804	64.29	159,863,481
Hanul-4 (formerly Ulchin-4)	1,053	758,795	99.94	6,298,536	74.61	139,159,520
Hanul-5 (formerly Ulchin-5)	1,051	754,186	99.53	6,567,132	77.94	117,873,833
Hanul-6 (formerly Ulchin-6)	1,051	748,929	98.83	7,743,468	91.90	113,647,443
Kori-2	681	491,668	100.14	2,353,626	43.11	175,542,126
Kori-3	1,043	753,992	100.26	5,022,207	60.06	242,834,603
Kori-4	1,044	753,972	100.17	5,761,609	68.84	244,526,964
Shin Kori-1	1,047	754,438	99.94	6,597,674	78.60	49,567,128
Shin Kori-2	1,046	751,892	99.70	6,451,522	76.93	46,918,759
Shin Kori-3	1,485	1,072,158	100.14	5,230,804	43.94	18,631,221
Shin Wolsong-1	1,048	756,164	100.07	6,597,327	78.52	46,240,499
Shin Wolsong-2	1,050	759,639	100.34	6,306,381	74.92	24,583,394
Wolsong-1	685	0	0.00	0	0.00	149,863,854
Wolsong-2	730	466,372	88.61	4,153,162	70.96	120,436,700
Wolsong-3	729	481,079	91.53	3,783,227	64.73	113,004,595
Wolsong-4	730	459,263	87.26	4,206,538	71.88	110,235,101
Total. South Korea	**23,806**	**12,158,329**		**121,074,045**		
Spain						
Almaraz-1	1,049	0	0.00	7,446,171	88.52	265,487,651
Almaraz-2	1,044	750,865	99.85	7,401,269	88.40	261,536,351
Asco-1	1,032	188,770	25.39	7,730,620	93.40	256,816,101
Asco-2	1,027	748,480	101.20	8,037,190	97.61	250,153,143
Cofrentes	1,092	785,129	99.86	8,330,429	95.17	270,766,749
Trillo	1,066	763,481	99.47	7,477,328	87.50	246,644,881
Vandellos-2	1,087	776,647	99.22	4,758,160	54.60	233,441,596
Total. Spain	**7,399**	**4,013,372**		**51,181,167**		
Sweden						
Forsmark-1	1,022	694,004	94.31	7,632,445	93.17	274,723,760
Forsmark-2	1,158	835,267	100.18	8,003,362	86.22	269,063,046
Forsmark-3	1,208	874,154	100.51	7,682,542	79.34	291,744,770
Oskarshamn-3	1,450	1,030,610	98.72	10,059,307	86.55	286,819,394
Ringhals-1	916	649,998	98.56	6,132,597	83.52	216,470,902
Ringhals-2	910	44,409	6.78	6,503,977	89.16	220,897,297
Ringhals-3	1,128	800,039	98.51	7,724,563	85.43	255,463,971
Ringhals-4	1,180	803,883	94.62	8,333,106	88.10	246,779,290
Total. Sweden	**8,972**	**5,732,364**		**62,071,899**		

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Switzerland						
Beznau-1	380	276,818	101.18	2,301,439	75.55	127,032,537
Beznau-2	380	275,293	100.62	2,900,460	95.22	134,168,924
Goesgen	1,035	767,570	103.00	7,886,369	95.06	312,349,727
Leibstadt	1,245	767,244	85.59	7,361,716	73.77	287,685,569
Muehleberg	390	276,440	98.45	2,782,300	89.00	127,032,977
Total. Switzerland	**3,430**	**2,363,365**		**23,232,284**		
Taiwan						
Chinshan-1	636	0	0.00	0	0.00	162,548,453
Chinshan-2	636	0	0.00	0	0.00	175,447,098
Kuosheng-1	985	0	0.00	6,824,400	86.42	258,653,307
Kuosheng-2	985	725,298	102.13	4,065,360	51.48	240,645,023
Maanshan-1	980	705,226	99.81	6,804,694	86.61	233,937,396
Maanshan-2	980	701,078	99.22	7,846,216	99.87	235,853,724
Total. Taiwan	**5,202**	**2,131,602**		**25,540,670**		
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				44,628,203
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**					
U.S.						
Arkansas Nuclear I-1	903	643,213	98.79	5,332,564	73.67	250,135,570
Arkansas Nuclear I-2	1,065	212,641	27.69	6,626,031	77.62	258,296,308
Beaver Valley-1 (#)	1,011	NA				235,084,423
Beaver Valley-2 (#)	1,008	NA				198,645,194
Braidwood-1 (#)	1,320	NA				249,695,083
Braidwood-2 (#)	1,295	NA				250,306,191
Browns Ferry-1	1,155	155,546	18.68	7,398,395	79.91	159,338,675
Browns Ferry-2	1,155	821,810	98.69	8,748,744	94.49	293,637,091
Browns Ferry-3	1,310	874,691	92.61	7,261,314	69.15	252,368,552
Brunswick-1	998	711,618	98.90	6,554,800	81.94	243,479,674
Brunswick-2	980	688,930	97.50	7,067,020	89.96	241,844,441
Byron-1 (#)	1,268	NA				264,821,799
Byron-2 (#)	1,241	NA				256,358,743
Callaway (#)	1,279	NA		1,822,780	100.66	309,907,689
Calvert Cliffs-1 (#)	890	NA				196,635,720
Calvert Cliffs-2 (#)	880	NA				190,321,283
Catawba-1	1,305	444,066	47.20	9,425,983	90.11	303,254,159
Catawba-2	1,305	884,807	94.04	8,851,874	84.62	295,870,273
Clinton *	1,098	(n)				
Columbia	1,207	868,810	99.83	9,206,070	95.15	262,417,773
Comanche Peak-1	1,250	920,654	102.15	10,167,897	101.48	266,858,805
Comanche Peak-2	1,241	910,414	101.75	9,982,188	100.35	242,744,082
Cook-1 *	1,131	(n)				
Cook-2 *	1,231	(n)				
Cooper (#)	836	NA				222,347,275
Davis-Besse (#)	971	NA				223,155,382

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Diablo Canyon-1	1,197	813,032	94.21	9,379,796	97.76	294,870,959
Diablo Canyon-2	1,197	837,090	96.99	8,175,574	85.21	290,950,915
Dresden-2 (#)	925	NA				240,262,053
Dresden-3 (#)	920	NA				231,638,789
Duane Arnold	647	467,562	100.21	4,700,727	90.62	175,788,793
Farley-1 (#)	918	NA				249,543,559
Farley-2 (#)	928	NA				235,899,351
Fermi-2	1,205	855,886	98.51	7,621,484	78.90	235,075,269
FitzPatrick (#)	849	NA				229,730,953
Ginna (#)	597	NA				172,106,861
Grand Gulf-1	1,498	1,046,832	96.92	6,441,652	53.64	316,260,202
Hatch-1 (#)	911	NA				242,630,197
Hatch-2 (#)	921	NA				228,120,616
Hope Creek *	1,250	(n)				
Indian Point-2	1,067	759,447	98.72	7,473,208	87.37	285,891,675
Indian Point-3	1,080	775,505	99.59	7,824,782	90.38	270,798,924
LaSalle-1 (#)	1,207	NA				243,048,645
LaSalle-2 (#)	1,207	NA				236,465,949
Limerick-1 (#)	1,246	NA				263,002,965
Limerick-2 (#)	1,246	NA				240,444,220
McGuire-1	1,305	891,463	94.75	9,795,665	93.64	310,373,865
McGuire-2	1,305	887,869	94.36	8,926,726	85.33	310,683,125
Millstone-2	918	4,047	0.61	5,738,238	78.02	236,575,054
Millstone-3	1,276	921,111	100.12	10,215,370	99.87	275,671,863
Monticello	691	426,392	85.55	5,336,569	96.30	197,708,701
Nine Mile Point-1 *	640	(n)				
Nine Mile Point-2 *	1,362	(n)				
North Anna-1	998	739,853	102.82	7,203,009	90.04	279,756,217
North Anna-2	994	742,586	103.62	8,095,920	101.61	272,998,883
Oconee-1	934	335,640	49.84	6,548,301	87.46	282,641,036
Oconee-2	934	652,030	96.82	7,232,093	96.60	285,904,020
Oconee-3	934	657,194	97.59	6,593,925	88.07	282,833,022
Palisades	845	0	0.00	5,659,881	83.56	220,857,898
Palo Verde-1	1,402	1,014,872	100.40	10,801,406	96.11	310,274,625
Palo Verde-2	1,406	0	0.00	9,162,321	81.29	317,564,630
Palo Verde-3	1,405	1,005,608	99.27	9,988,283	88.69	309,560,172
Peach Bottom-2	1,375	988,688	99.73	10,026,316	90.97	337,629,284
Peach Bottom-3	1,375	994,226	100.29	10,126,838	91.88	334,845,957
Perry (#)	1,319	NA				263,657,668
Pilgrim	728	465,768	88.74	4,089,515	70.08	199,616,366
Point Beach-1 *	640	(n)				
Point Beach-2 *	640	(n)				
Prairie Island-1 *	590	(n)				
Prairie Island-2 *	585	(n)				
Quad Cities-1 *	994	(n)				
Quad Cities-2 *	994	(n)				
River Bend	992	529,496	74.03	6,557,111	82.46	237,633,958
Robinson-2	820	14,408	2.44	4,902,461	74.58	239,846,277
Salem-1 *	1,254	(n)				
Salem-2 *	1,232	(n)				
Seabrook *	1,296	(n)				
Sequoyah-1	1,186	870,936	101.85	8,600,552	90.47	291,244,833
Sequoyah-2	1,181	38,907	4.57	8,484,480	89.62	290,361,380
Shearon Harris	1,037	763,025	102.01	7,279,435	87.54	232,661,122
South Texas-1	1,312	625,929	66.17	9,761,412	92.82	295,081,091
South Texas-2	1,312	1,002,296	105.96	9,894,569	94.08	287,899,563
St. Lucie-1 *	1,078	(n)				
St. Lucie-2 *	1,135	(n)				
Summer	1,006	78,818	10.87	6,901,723	85.63	255,026,056
Surry-1	880	660,932	104.17	6,198,918	87.88	261,616,914

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW gross	MWh gross in Nov	Capacity factor Nov	Total MWh gross in 2018	Capacity factor 2018	Lifetime total MWh gross
Surry-2	880	0	0.00	6,437,093	91.25	260,385,159
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	NA				276,627,641
Vogtle-2 (#)	1,205	NA				259,752,321
Waterford-3	1,222	884,532	100.39	9,810,653	100.15	293,867,140
Watts Bar-1	1,210	836,141	95.84	8,320,782	85.79	210,439,453
Watts Bar-2	1,210	892,677	102.32	9,119,316	94.02	17,469,460
Wolf Creek (#)	1,249	(a)		7,606,246	83.48	299,425,446
Total. U.S.	**106,159**	**31,617,998**		**395,478,010**		

NUCLEAR ELECTRICITY GENERATION FOR NOVEMBER 2018

NATION: Plant	Capacity MW net	MWh net in Nov	Capacity factor Nov	Total MWh net in 2018	Capacity factor 2018
Clinton (#)	1,062	(b)		6,270,336	90.13
Cook-1 (#)	1,084	(b)		6,928,562	97.57
Cook-2 (#)	1,194	(b)		5,640,653	72.11
Hope Creek (#)	1,237	(b)		6,889,146	85.01
Nine Mile Point-1 (#)	613	(b)		3,959,595	98.60
Nine Mile Point-2 (#)	1,300	(b)		7,246,824	85.10
Point Beach-1 (#)	615	(b)		3,924,430	97.41
Point Beach-2 (#)	615	(b)		3,940,243	97.80
Prairie Island-1 (#)	557	(b)		3,338,025	91.48
Prairie Island-2 (#)	557	(b)		3,563,876	97.67
Quad Cities-1 (#)	964	(b)		5,985,220	94.78
Quad Cities-2 (#)	957	(b)		5,368,163	85.60
Salem-1 (#)	1,169	(b)		7,624,345	99.56
Salem-2 (#)	1,181	(b)		7,240,262	93.58
Seabrook (#)	1,248	(b)		8,171,953	99.95
St. Lucie-1 (#)	1,062	(b)		5,761,918	82.82
St. Lucie-2 (#)	1,074	(b)		5,657,765	80.41
Susquehanna-1 (#)	1,287	(b)		6,752,555	80.09
Susquehanna-2 (#)	1,287	(b)		8,162,136	96.81
Turkey Point-3 (#)	831	(b)		5,393,663	99.08
Turkey Point-4 (#)	840	(b)		5,436,563	98.80
Total U.S.	**20,734**			**123,256,233**	

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

NUCLEAR ELECTRICITY GRID GENERATION FOR NOVEMBER 2018

The following data is grid generation collected by S&P Global Platts based on information from France's grid operator RTE. It represents net output from individual French reactors.

NATION: Plant	Capacity MW net	MWh grid in Nov	Capacity factor Nov	Total MWh grid in 2018	Capacity factor 2018
Belleville-1	1,310	203,186	21.54	9,144,416	87.08
Belleville-2	1,310	854,070	90.55	6,342,389	60.4
Blayais-1	910	599,499	91.5	5,499,101	75.39
Blayais-2	910	617,219	94.2	6,197,342	84.96
Blayais-3	910	592,499	90.43	5,632,526	77.22
Blayais-4	910	602,047	91.89	5,959,527	81.7
Bugey-2	910	0	0	5,624,423	77.1
Bugey-3	910	603,400	92.09	6,130,068	84.04
Bugey-4	880	585,284	92.37	4,820,055	68.33
Bugey-5	880	56,668	8.94	4,409,969	62.52
Cattenom-1	1,300	848,343	90.63	7,057,121	67.72
Cattenom-2	1,300	850,247	90.84	4,412,830	42.35
Cattenom-3	1,300	854,096	91.25	7,355,645	70.59
Cattenom-4	1,300	806,619	86.18	7,754,450	74.41
Chinon-B1	905	579,203	88.89	6,151,471	84.8
Chinon-B2	905	130,589	20.04	4,676,176	64.46
Chinon-B3	905	14,185	2.18	5,890,891	81.2
Chinon-B4	905	591,601	90.79	4,772,373	65.79
Chooz-B1	1,500	989,411	91.61	8,233,216	68.47
Chooz-B2	1,500	993,864	92.02	10,742,351	89.34
Civaux-1	1,495	861,849	80.07	9,557,399	79.75
Civaux-2	1,495	995,333	92.47	7,568,966	63.16
Cruas-1	915	475,743	72.21	5,547,138	75.63
Cruas-2	915	576,905	87.57	4,249,254	57.93
Cruas-3	915	4,720	0.72	5,502,916	75.03
Cruas-4	915	583,454	88.56	4,296,094	58.57
Dampierre-1	890	568,713	88.75	5,690,732	79.77
Dampierre-2	890	590,893	92.21	5,029,470	70.5
Dampierre-3	890	101,888	15.9	5,452,265	76.42
Dampierre-4	890	0	0	3,150,397	44.16
Fessenheim-1	880	567,355	89.54	6,304,441	89.37
Fessenheim-2	880	522,519	82.47	4,121,559	58.43
Flamanville-1	1,330	0	0	2,279,667	21.38
Flamanville-2	1,330	835,613	87.26	9,243,370	86.7
Golfech-1	1,310	812,443	86.14	8,175,715	77.86
Golfech-2	1,310	859,389	91.11	6,971,314	66.39
Gravelines-B1	910	571,821	87.27	5,782,262	79.27
Gravelines-B2	910	540,069	82.43	5,388,555	73.87
Gravelines-B3	910	4,128	0.63	4,815,350	66.01
Gravelines-B4	910	470,986	71.88	6,028,227	82.64
Gravelines-C5	910	594,652	90.76	5,497,470	75.36
Gravelines-C6	910	613,903	93.7	2,497,142	34.23
Nogent-1	1,310	465,447	49.35	6,785,251	64.62
Nogent-2	1,310	837,840	88.83	7,685,471	73.19
Paluel-1	1,330	772,095	80.63	7,905,193	74.15
Paluel-2	1,330	844,120	88.15	2,137,298	20.05
Paluel-3	1,330	0	0	8,137,130	76.32
Paluel-4	1,330	803,897	83.95	8,884,327	83.33
Penly-1	1,330	0	0	8,723,540	81.82
Penly-2	1,330	780,362	81.49	7,533,925	70.67
St.Alban/St.Maurice-1	1,335	0	0	7,107,264	66.41
St.Alban/St.Maurice-2	1,335	860,655	89.54	4,466,142	41.73
St.Laurent-des-Eaux B1	915	581,103	88.21	5,778,386	78.78
St.Laurent-des-Eaux B2	915	0	0	4,715,772	64.29
Tricastin-1	915	503,359	76.41	3,619,091	49.34
Tricastin-2	915	396,949	60.25	3,513,386	47.9
Tricastin-3	915	20,923	3.18	5,293,380	72.17
Tricastin-4	915	595,991	90.47	5,107,177	69.63
Total France	**63,130**	**19,987,147**		**347,348,776**	