NUCLEAR INTELLIGENCE WEEKLY®

September 28, 2018

UPI: $27.44/lb U3O8

Market Points

The Canadian Tax Court ruled in Cameco’s favor after nearly two years in a trial over a tax dispute with the Canada Revenue Agency involving the transfer of profits to Cameco’s Swiss-based subsidiary, Cameco Europe.

Nuclear Intelligence Weekly’s Uranium Price Panel reported an average spot price of $27.44 per pound U3O8 on Sep. 27, flat with last week’s price, in spite of Cameco collecting bids on its latest solicitation.

US utility Duke Energy issued a tender this week for up to 1.85 million lbs. U3O8 for delivery from 2021-27, while stipulating that the material “be legally imported into the US” and “legal for use in US reactors without the imposition of any tariffs, duties, or similar charges.”

WEEKLY ROUNDDUP

Beijing Silent After Sanmen-1 Commissioning

• It’s been a week since the start of commercial operation of the world’s first-of-a-kind AP1000 pressurized water reactor at China National Nuclear Corp.’s Sanmen plant, in China’s eastern province of Zhejiang. But so far there’s been no signal from government authorities in Beijing that they are ready to green light the start of construction of additional AP1000s or the demonstration CAP1400, a larger indigenous reactor based on the Westinghouse-designed AP1000. That’s kept executives at State Nuclear Power Technology Co., the State Power Investment Corp. subsidiary tasked with building China’s AP1000s and the CAP1400, on tenterhooks. For years, the expectation throughout China’s nuclear industry has been that once Sanmen-1 enters commercial operation, the State Council would approve the start of nuclear construction at the CAP1400 demonstration plant in Shandong as well as AP1000 projects in Shandong, Zhejiang, Guangdong and Liaoning (NIW Apr.27’18). It’s possible that government planners are simply waiting for operational data at Sanmen-1 to build up. Another possibility is that there are real concerns in Beijing over the economics of the AP1000 relative to other designs, such as the indigenous HPR1000 (the “Hualong-One”) or Russian-supplied VVERs (NIW Aug.10’18). A third possibility is most worrying to the Chinese and even the global nuclear industry: that there’s no longer a consensus among top decision-makers in Beijing on continuing with an ambitious expansion in nuclear power.

• There was better news for the AP1000 in the US, where the co-owners of the twin-unit AP1000 Vogtle newbuild in the state of Georgia struck a deal to move forward with the troubled project in a Sep. 27 vote, despite the latest $2.3 billion cost increase in the over-budget and behind-schedule project. The revised ownership agreement would “mitigate financial exposure” for minority owners Oglethorpe Power (30% owner), Municipal Electricity Authority of Georgia (Meag) Power (22.7%) and Dalton Utilities (1.6%), shifting a larger portion of financial responsibility for any future cost increases to 45.7% project-owner Georgia Power, a subsidiary of Southern. The new deal limits the ability of Vogtle’s three minority partners to exit the project but provides some opportunity for them to sell their project share. The new agreement followed intense last-minute negotiations after Oglethorpe threatened to back out of the project without a cap on future cost overruns. Southern last month recorded a $1.1 billion cost increase for its stake in the project (NIW Aug.10’18). That amounts to a total project cost increase of $2.3 billion that does not include financing.

• Israeli Prime Minister Benjamin Netanyahu told the UN General Assembly in New York this week that there was a “secret atomic warehouse” in Iran for storing up to “300 tons of nuclear-related equipment and material.” The site in the Turkuzabad district of Tehran is just three miles away from what Israel claimed in May was Iran’s “secret atomic archive” housing documents from the nuclear weaponization program that Iran appears to have abandoned in 2003. “The reason Iran didn’t destroy its atomic archive and its atomic warehouse is because it hasn’t abandoned its goal to develop nuclear weapons,” argued Netanyahu. “In fact, it planned to use both of these sites in a few years when the time would be right to break out to the atom bomb.” Iran quickly hit back at Netanyahu. “No arts & craft show will ever obfuscate that Israel is only regime in our region with a *secret* and *undeclared* nuclear weapons program - including an *actual atomic arsenal*,” Iranian Foreign Minister Javad Zarif said in a Sep. 27 tweet. “Time for Israel to fess up and open its illegal nuclear weapons program to international inspectors.”

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NUCLEAR FUEL MARKET

Camco Wins Tax Case, Collects Bids

The Canadian Tax Court ruled in favor of Camco this week, nearly two years after a trial began on Oct. 5, 2016, over a tax dispute with the Canada Revenue Agency (CRA) involving Camco’s Swiss-based subsidiary, Camco Europe Ltd. The ruling removes a huge potential liability that had been hanging over the uranium producer for years.

The CRA had argued that income attributed to the subsidiary should have been taxed in Canada. The dispute stems from a decision Saskatoon-based Camco made in 1999 to set up Camco Europe and sell uranium to the subsidiary through a 17-year deal. Camco was thus able to sell the commodity to the subsidiary at 1999-based prices and to declare the subsequent profits in Switzerland, which has lower corporate tax rates than in Canada.

So long as the ruling stands — and the CRA has until Oct. 26 to appeal it — Camco will avoid a tax bill of $1.7 billion and additional penalties of up to $1.3 billion (NIW Jun.27’14). The court directed the minister of national revenue to apply the ruling to the 2003, 2005 and 2006 tax years. Although “the decision is not legally binding for other tax years in dispute,” Camco said, “we believe there is nothing in the decision that would warrant a different outcome for the other tax years in question.”

Meanwhile, in Namibia, a government official confirmed to local media that “ongoing discussions” are in fact under way between Rio Tinto and state-owned China National Nuclear Corp. (CNNC) for the London-based miner to sell its majority stake in the Rossing uranium mine (NIW Sep.14’18). “In the absence of any agreement reached and the CNNC business model, the ministry has no information on the matter until the ministry has received an update,” Namibian Energy Minister Simeon Negumbo told the Namibian newspaper on Sep. 27. “This transaction will still need the approval of the minister [for the deal] to proceed.” If CNNC is successful it could mean that Rossing will remain in operation well beyond Rio Tinto’s planned 2025 shutdown.

Spot Price Plateaus

The uranium spot price was flat this week as Camco collected bids on its latest request for quotations (RFQ) (NIW Sep.21’18). Nuclear Intelligence Weekly’s Uranium Price Panel reported an average spot price of $27.44 per pound U3O8, flat with last week’s price. The failure of Camco’s tender to lift the price above $28 per pound might be an indication that without stronger demand from utilities, uninhibited by potential trade restrictions, a market resurgence still has much to overcome.

Cameco issued an RFQ on Sep. 20 for up to 1 million pounds of U3O8 and a minimum of 100,000 lbs. with delivery between Oct. 24 and Mar. 31 next year, and with a preference for delivery in November and December. Offers are due Sep. 28, with validity until Oct. 2. (NIW Aug.24’18). US utility Duke also issued an RFQ this week for up to 1.85 million lbs. U3O8 for delivery from 2021-27. Bids are due Oct. 15. Duke stipulated that the material “be legally imported into the US” and “legal for use in US reactors without the imposition of any tariffs, duties, or similar charges.”

Duke’s specification of origin on its U3O8 tender is an indication the utility expects some form of trade restrictions to result from the US Department of Commerce’s investigation into uranium imports. Commerce collected public comments on Sep. 25, after extending the deadline from Sep. 10 (NIW Jul.20’18; NIW Jul.20’18). In its comments, Cameco contends that its “uranium does not impair US national security interests and should not be subject to any form of import restriction in the United States.” Global Affairs Canada told NIW earlier this year that Article 907 of the Canada-US Free Trade Agreement exempts “Canadian energy products, including uranium, from national security-related trade restrictions, except under limited circumstances” (NIW Jul.20’18). A 1989 Commerce investigation into uranium imports determined that the bilateral free trade agreement “prohibits the use of Section 232 authority to limit Canadian uranium exported” for any purpose other than military use. But there’s no telling how stable relations between Washington and Ottawa will be when Commerce concludes its investigation and President Donald Trump makes his subsequent determination.

Cameco said the 25% quota on US-origin uranium proposed by the petitioners “could ultimately increase US dependence on state-controlled uranium supplied by the countries of concern as listed in the petition.” It is estimated that US producers would need to rapidly ramp up output from 2.4 million lbs. in 2017 to 12 million lbs. to meet the 25% quota. Cameco suggests that even with tariffs, production from the lowest-cost producer, Kazakh-run Kazatomprom, might still prove more economical than domestic sources or other non-state-owned suppliers. If Trump restricts the uranium trade but grants Canada an exemption, it might offer some impetus for Camco to reopen its own low-cost McArthur River mine and Key Lake mill in northern Saskatchewan, which produced 11.2 million lbs. U3O8 in 2017 (NIW Nov.10’17; NIW Nov.10’17). In late July, Cameco announced it would continue indefinitely the suspension of production at McArthur River and Key Lake (NIW Jul.27’18). *

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U R A N I U M P R I C E P A N E L

For the week ended September 27, 2018

<table>
<thead>
<tr>
<th>Weekly Spot Market Prices</th>
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<tr>
<td>Price ($/lb U3O8)</td>
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<tr>
<td>0.00</td>
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<td>26.41</td>
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- **Total Assesments**
- **% within 1 StdDev**
- **Low ($/lb U3O8)**
- **High ($/lb U3O8)**
- **Variability**

*This represents the value of the potential range of conceivable final averages that might result when random elimination is used to balance market positions within the panel.*
URANIUM

Denison Targets 2024
Production at Wheeler River

Toronto’s Denison Mines expects to produce up to 6 million pounds of U3O8 per year at less than $9 per pound U3O8 beginning in 2024 from its high-grade Phoenix deposit at its majority-owned Wheeler River uranium project in the Athabasca Basin in Saskatchewan, the Canadian junior revealed this week with the release of a recently completed prefeasibility study (NIW Jan.5’18). This would make the project economic at even the low uranium spot price of a year ago, and Denison appears to be committed to bringing Phoenix into production.

Toronto-based Denison now estimates the Phoenix deposit can be mined via an in situ recovery (ISR) process at a pretax all-in operating cost of $8.90/lb. U3O8 over a 10-year mine life. These latest results place the Phoenix deposit much lower on the uranium cost curve than Denison’s prior estimates, and even make the project competitive with the world’s lowest-cost uranium production in Kazakhstan. In 2016, Denison’s preliminary economic assessment estimated its Phoenix deposit would produce at a cash operating cost of $22.15/lb. U3O8 over a nine-year mine life (NIW Apr.15’16).

At Denison’s adjacent Gryphon deposit, also a part of the Wheeler River project, the company estimates a conventional underground mine all-in cost of $22/lb. U3O8 over 6½ years, compared with its estimated cash operating cost of $14.28/lb. U3O8 over seven years in 2016. As such, Denison does not expect to bring its Gryphon deposit into production until 2030, and unlike Phoenix Denison posits that Gryphon’s higher costs make it more “amenable to fixed-base escalated price contracts with nuclear utilities in order to reduce risk and justify development.”

Cheap ISR in the Heart of the Athabasca?

While the case to bring Gryphon into production, at an initial capital cost of $478 million (C$623.1 million), would clearly be predicated on higher demand, there’s seemingly little in the way of Phoenix entering production. At just under $9/lb. U3O8, the mine would be highly profitable at today’s low uranium prices near $27/lb. But Denison still has to raise $248 million (C$322.50 million) — its estimated pre-production capital cost to develop the Phoenix deposit.

Located in the infrastructure-rich eastern part of the Athabasca Basin, one of the benefits of the Wheeler River project has been the presence of the existing McClean Lake mill, of which Denison is a 22.5% owner alongside France’s Orano (NIW Apr.15’16). To serve the Gryphon deposit, the McClean Lake mill will require costly upgrades, estimated at $38 million, not including indirect costs and contingency. That’s still much cheaper than a new mill, which could cost half a billion dollars. But for the Phoenix deposit, Denison will instead rely on ISR for ore processing. The junior hopes that the relatively low initial capital requirements to develop the Phoenix deposit and an ISR plant, combined with the low operating cost, will attract sufficient debt and equity financing. In that respect Denison “may not require a book of long-term contracts to support a development decision” at Phoenix, the company said.

The junior miner hopes to begin construction at the Phoenix deposit in 2021. “It will take time to survey the market and put together a package of debt, equity, and other finance tools to raise the funds necessary to build Phoenix,” Denison CEO David Cates told Nuclear Intelligence Weekly. “This will be something that we would focus on in parallel to the permitting and feasibility study work in the next stage of project development.”

Permitting could take longer than expected. The use of the ISR mining method at a uranium deposit would be a first in Canada, and for the Canadian Nuclear Safety Commission (CNSC). ISR operations can have an impact on groundwater, but the CNSC failed to respond to NIW questions as to what sort of regulatory process it might put in place to regulate ISR. “The regulatory process can be unpredictable, so it is hard to provide any assurance on timelines,” Cates said. “We are planning for it to take three to four years.”

Denison is also increasing its ownership in the Wheeler project to up to 90%, after Cameco agreed in September to exchange its 24% interest in the Wheeler River joint venture for stock in Denison, valued at approximately $16 million, according to a Sep. 4 release by Denison. Canada’s JCU Exploration Company will keep its existing 10% of the Wheeler River project. With the resumed suspension of operations at its McArthur River mine and Key Lake mill, Cameco has scaled back its primary uranium production and focused more on trading (NIW Jul.27’18). “Given the conditions in the uranium market, we are focusing on preserving the value of our tier-one assets,” Cameco spokesperson Carey Hyndman told NIW. “When it comes to exploration, we have reduced our spending to focus on projects in the Athabasca where we have control. As a minority partner, Cameco could not control the timing or pace of development on the Wheeler River project. With this agreement Cameco will maintain exposure to Denison, and in particular, the Wheeler River project, without the need to contribute additional capital.”

Regarding the Gryphon deposit, Denison currently plans to begin development by 2026, with first production by 2030. Although, a “decision on development could be made on a deposit by deposit basis, but it is likely that Phoenix goes first and then a second decision is made on Gryphon — which is more sensitive to the pricing in the uranium market,” Cates said. Gryphon would benefit from the infra-

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**Denison’s Wheeler River Uranium Project**

<table>
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<tr>
<th>Deposit</th>
<th>Probable Reserves</th>
<th>Indicated Resources</th>
<th>Inferred Resources</th>
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<tr>
<td></td>
<td>Avg. Grade</td>
<td>Volume</td>
<td>Avg. Grade</td>
</tr>
<tr>
<td>Phoenix</td>
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<td>59.7 million</td>
<td>19.14%</td>
</tr>
<tr>
<td>Gryphon</td>
<td>1.80%</td>
<td>49.7 million</td>
<td>1.70%</td>
</tr>
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Source: Denison Wheeler Project Prefeasibility Study
structure at Phoenix and the existing McClean Lake mill. While Denison wouldn’t have to raise the capital to build a new mill, the miner would still have to negotiate a toll milling agreement with Orano-controlled McClean Lake exclusively for Gryphon. As partial owner of the mill, Denison would realize the “unique benefit” of recording a portion of revenue from its own toll milling contract, in proportion to its 22.5% interest in McClean.

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NEWBUILD

Jaitapur and Kovvada Deals
Unlikely Before 2021

Commercial contracts between Nuclear Power Corp. of India Ltd. (NPCIL) and EDF and Westinghouse, two key foreign reactor suppliers for separate nuclear newbuild projects in India, are unlikely before 2021. Both talks are tied to the successful operation of those reactors in their countries of origin. New Delhi appears in no rush to start work at the two sites: Jaitapur in Maharashtra, planned for six EDF-supplied EPRs, and the Kovvada site Andhra Pradesh, planned for six Westinghouse-supplied AP1000s. NPCIL is resolved not to start major work on either newbuild until, respectively, the first French EPR is commissioned at Flamanville-3 and the first US AP1000 is commissioned at Vogtle (p1).

“Approximately, we expect that these deals should be coming through somewhere around 21,” Sekhar Basu, head of the Indian Department of Atomic Energy that oversees NPCIL, told Nuclear Intelligence Weekly in a Sep. 20 interview in Vienna.

Basu explained that while there will be fully operational EPRs and AP1000s in China by the end of the year, this won’t be enough. “We know that the Chinese are going ahead, and that is also a good thing. It will help,” said Basu. “The point is that we don’t get the detailed information to satisfy our regulator” from the Chinese newbuilds — the EPRs in Guangdong and the AP1000s in Zhejiang and Shandong. Basu believes such information will be more available from the newbuilds in France and the US. Right now fuel loading at Flamanville-3 is targeted for the fourth quarter of 2019, which implies a commissioning in 2020 and real operational data as late as 2021 (NIW Jul.27’18).

Using the Delays

This schedule is dramatically different from that outlined by NPCIL and EDF only six months ago, when the two sides signed a framework agreement for Jaitapur and envisioned “producing a binding EDF tender toward the end of 2018” (NIW Mar.16’18). In that agreement New Delhi dropped its previous insistence that the foreign vendors act as a “single point of contact” in any newbuild, effectively adopting a full-scope engineering, procurement and construction role (NIW Oct.6’17).

“We wanted EDF to do the construction at least for the first two reactors, out of the six,” explained Basu. But EDF argued that “it should go the other way around. We should do all the things in the same way as in Russia model” — referring to Rosatom-supplied VVER-1000s at Kudankulam in Tamil Nadu, where NPCIL oversaw all on-site construction. That’s the model New Delhi eventually agreed to adopt at Jaitapur: “You get the blueprint drawings and the specifications, etc., etc., from them, and they supply the equipment. ... The entire work at site is done by us and entire work outside the site is done by them.”

Basu envisions the same project structure at Kovvada, and he warned both EDF and Westinghouse that they should ramp up to such newbuilds. “Over the next two years, they should get organized — EDF and Westinghouse — and we also should get organized.” Indeed, preparing for two major simultaneous foreign-supplied newbuild projects — on top of India’s ambitious program to build a new fleet of pressurized heavy water reactors (PHWRs), and the construction of additional Rosatom-supplied reactors in Tamil Nadu — means that NPCIL must seriously increase its industrial capabilities and manpower. “It means we have to expand NPCIL. We have to take more people. In India, there is no shortage of manpower, and in India we’re very used to training manpower in a big way. We’ll do that. But then some time is needed.”

Looking for Generous Financing

In the interim Basu views financing as the major issue to be overcome. “Unless the credit terms are attractive, and tariff matches with other options, we will not be able to sell this power,” he explained. According to one analyst Jaitapur is only viable if the tariff is below 6 rupees per kilowatt hour for the plant’s life, or at the very least in a range of 6 rupees-6.50 rupees (9€-10€)/KWh. That’s compared to tariffs on new renewable generation of 2.43 rupees-3 rupees/KWh (NIW Mar.9’18). Reactors including domestic PHWRs are almost inevitably above that rate, but they can’t be substantially more expensive.

The PHWRs are built “at about 60% cost of these EDF or Westinghouse reactors,” said Basu. “But then how do the economics work? It is very simple. In India we take the loan from Indian banks and the Indian financial system at a rate of over 8%.” But for the more expensive foreign-supplied reactors, New Delhi is looking for loans with interest rates at “3% or below.” Basu explained that he’s looking for loans indexed to the London Inter-bank Offered Rate (Libor). “Today I think Libor rate is 0.67%. And if you put in another 1.25% it will come to only 2% interest. So if we are able to get [a] loan on those terms and conditions, it will be fine.”

Indeed, most nuclear developers across the globe would love to secure cheap financing along those lines. But that doesn’t mean that export credit agencies in France or the US will prove willing to sign off on such loans. And indeed, it’s still not clear that either EDF or Westinghouse will accept New Delhi’s complex scheme to insure them against any liability exposure in the event of an accident at Jaitapur or Kovvada, given the 2010 nuclear liability law that avoided channeling all liability to the reactor operator (NIW Jun.29’18). This issue is likely particularly worrisome for Westinghouse, which only just came out of bankruptcy after being purchased by risk-averse Canadian private-equity firm Brookfield Business Partners (NIW Aug.3’18).

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CLOSED FUEL CYCLE
Russia’s Dream of Uniting Light-Water, Fast Reactors

In his remarks to the International Atomic Energy Agency’s general conference in Vienna last week Rosatom head Aleksei Likhachev repeated what has become an increasingly common pitch from Rosatom: the global nuclear industry’s dilemma of finding a long-term solution for the copious amounts of spent fuel around the world might best be solved via a so-called “duo-component” system of light-water and fast reactors working together in a closed fuel cycle. Russian nuclear planners argue that such a system will obviate the need for the country’s planned BN-1200 fast reactors to compete with the current generation of VVER-1200 pressurized water reactors in terms of construction and operating costs. But the economics of a duo-component system are questionable and the scientific challenges so daunting that if the approach is to be effective, Russia will have to accomplish enormous leaps in VVER technology.

The duo-component concept is relatively straightforward. A fleet of thermal VVER reactors will burn a mixture of enriched uranium, mixed-oxide (Mox) and plutonium fuels, which after reprocessing will feed a fleet of fast neutron reactors working in breeder mode. Spent fuel from the fast reactors will also be reprocessed, with the materials separated and returned to this intertwined fuel stream to supply both VVERs and fast reactors. Such a system, proponents argue, will reduce enormous stockpiles of used fuel that are only growing from year-to-year, vastly improve utilization of natural uranium, and minimize high-level radioactive nuclear waste by burning minor actinides found in the spent fuel.

Russia’s nuclear scientists have toyed with this concept for decades, but it wasn’t until 2016, after the commissioning of the BN-800 fast reactor and industrial production of Mox fuel that the idea threw down firm roots (NIW Aug.19’16). By now this approach has virtually become corporate dogma, and the goal of unifying VVERs and fast reactors in a seamless fuel chain using various types of fissile material is currently at the forefront of Rosatom’s long-term nuclear energy policy. “Duo-component” is more often heard in speeches and presentations by Rosatom officials, particularly from Rosenergoatom, the monopoly operator of Russia’s nuclear plants that will have to manage this potential system.

Competing Ratios?

It is not entirely clear what the ratio of VVER to fast reactor capacity might be in this duo-component system. Some have suggested that the reprocessed fuel from two 1,200 megawatt VVERs would be enough to feed to one 1,200 MW fast reactor, while others have proposed three to one if a high breeding ratio can be attained in the fast reactor. What is important is that, now that it is clear BN-1200s will work in conjunction with VVERs, Rosatom believes the need to justify the relatively high costs of building large fast reactors disappears. That’s what Mikhail Bakanov, head of Rosenergoatom’s New Platform department overseeing projects involving the closed fuel cycle, told Atominfo.ru news portal in a recent interview. Previously Rosatom had insisted that, prior to any final investment decision, the BN-1200 had to be able to compete with the VVER-1200 in terms of capital and operating expenditures, which many top officials believe is inherently impossible. This can be glossed over in a duo-component system.

The technological challenges ahead remain considerable. To name a few, Russia will need to build a large breeder and load it with Mox fuel, and the latest statements by Rosatom managers suggest the first BN-1200 might not be commissioned until 2031-32 (NIW Jun.30’17). Second, there is still a lot of work to be done on improving the technology and reducing costs of fuel reprocessing. Third, the duo-component system may require an advanced VVER not yet in operation or even under construction. That’s because the BN-1200 will likely operate with a conversion ratio of 1.2, meaning the reactor will produce 1.2 times as much usable fuel — after reprocessing — than it consumes. This contrasts to a conversion ratio of approximately 0.4 for a VVER-1200. Ideally, scientists say a closed fuel cycle system should set a conversion ratio of 1, meaning it would produce just as much fuel as it burns. But to get there, Russia will need to bring the VVER conversion ratio up to at least 0.8.

There are currently two advanced VVER options under consideration — a spectral VVER and a supercritical VVER — although there are no immediate plans to undertake either, even in terms of R&D. A VVER with a spectral core will dramatically change the neutron spectrum. This design would almost resemble a fast neutron reactor in which more natural uranium is utilized after converting to plutonium. Russian scientists have said the conversion ratio in a spectral VVER, largely seen as a stepping stone in the development of a closed fuel cycle, would be approximately 0.7. Meanwhile, a super-critical VVER would operate under extremely high pressure and could reach a conversion ratio of close to 1, which would be ideal for a closed fuel cycle system. However, this is an extremely challenging technology, requiring major breakthroughs in metallurgy and safety systems, and indeed it is one of six reactor technologies adopted by the Generation IV International Forum that Russia is participating in.

Finally, it is worth noting there are critics of the duo-component system in Russia, particularly among those scientists advocating a single component closed fuel cycle based on the lead-cooled reactor technology. The Brest-300, which Russia hopes to start building next year, is such a reactor; it will boast on-site fuel fabrication and reprocessing (NIW Jul.10’15). The conversion rate of this project, known as Breakthrough, is an even 1, so it will produce as much fissile material as it burns. Observers note that the duo- and single-component systems needn’t compete with each other since the VVERs Russia is building now at home will operate until the end of the century and can be included in a closed fuel system with fast reactors.

Gary Peach, recently in Moscow

DECOMMISSIONNING
TaiPower to Float Chinshan Tender

Taiwan Power (TaiPower) will soon float an open international tender for a consultant to oversee its first reactor decommissioning project: the retirement of the twin 635 megawatt boiling water reactors (BWRs) at the Chinshan plant on Taiwan’s northern tip, a senior TaiPower executive told Nuclear Intelligence Weekly.
The framework documents for the Chinshan decommissioning tender are now in the final stage of drafting, TaiPower Nuclear Power Division CEO Tsai Fu-feng told NIW. He added that the bid selection process would be treated under the Government Procurement Act as a “most advantageous tender” and not “minimum price tender” under Article 52 of the Government Procurement Law. This means that the state-owned utility will have the flexibility to choose the best bid to fit the needs of the decommissioning project instead of being obliged to accept the lowest-priced offer. “We expect to issue the tender at the latest by early next year,” said Tsai.

It’s been over a year since either reactor at the Chinshan site in Shihmen district, New Taipei City, has operated. Chinshan-1 has been off line since December 2014 after a break in a connecting rod in one of its fuel assemblies, and Chinshan-2 was shut down in June 2017 after a severe rainstorm triggered a mudslide that collapsed its main outgoing power line (NIW Jun.9’17). Since August 2017 both reactors as well as their adjacent fully saturated spent nuclear fuel pools have been covered with cooling water, while the lids of both reactor-containment vessels have been removed, TaiPower staff said.

According to TaiPower’s decommissioning plan approved in June 2017 by the Atomic Energy Council, the 25-year project will feature four stages, beginning with a transitional period for the cessation of power operations from 2018-26, reactor decommissioning and dismantling from 2026-38, plant decontamination and environmental radiation monitoring from 2038-41 and site restoration from 2041-43. Tsai told NIW that the initial contract would only cover the first stage of the decommissioning process. “We will evaluate whether we want to issue another similar contract, perhaps after the fuel is removed from the reactors and we enter the next stage.”

Tsai estimated the cost of the Chinshan decommissioning project at “over” NT$30 billion ($974 million), which would be funded by the official Nuclear Back-End Fund, which currently has NT$316.2 billion, through annual allocations approved by the Legislative Yuan, Taiwan’s parliament (NIW Mar.24’17).

“We aim to grant the tender to an experienced international consultant firm who can guide the first stages of our first decommissioning project and, preferably, work with a local partner,” Tsai said, adding that possibilities included government or semipublic agencies as well as private companies.

A Business Opportunity for TaiPower?

Tsai said that TaiPower aimed to use its accumulated experience in decommissioning Chinsan to enter into the international market for decommissioning operations, which he noted, “is certain to expand in the future.” The TaiPower executive made the remarks to NIW Sep. 14-15 during the course of a two-day emergency exercise focused on Chinshan and its surrounding eight kilometer radius emergency zone. He noted that the bidding process is taking place while the Environmental Protection Administration reviews TaiPower’s report assessing the project’s environmental impact assessment (EIA).

The Chinshan decommissioning EIA report is now in a “second phase” review and will likely not be approved until July 2019, although the utility had hoped it would be green-lighted by the end of the year. While that process is ongoing, TaiPower is moving ahead with decommissioning preliminaries as much as it can, including setting up 10 subcommittees at the Chinshan plant to prepare for launching various aspects of the decommissioning project.

Atomic Energy Commission Vice Chairman Chiou Syhtsong Chiou told NIW that the first major step in decommissioning would likely involve dismantling the turbine buildings in the plant’s southern corner to make room for an indoor dry storage facility big enough to house all the spent fuel from the two units, as well as other waste from the decommissioning project.

The dismantling of the BWRs cannot proceed until the fuel is removed from the reactor vessels and spent fuel pools, but this has been stymied by the refusal of the New Taipei City government to approve TaiPower’s soil and water conservation plans for using existing on-site outdoor dry storage facilities. This makes construction of an indoor facility — which may be less vulnerable to objections by the local authorities — all the more important to help avoid delay to the overall decommissioning process.

After Chinshan

Meanwhile, TaiPower is planning to submit draft decommissioning plans for its Kuosheng nuclear plant by the end of the year, in line with the deadline for submitting such plans at least three years before the scheduled retirement of a reactor. The two 985 MW BWRs at Kuosheng, also in New Taipei City’s Chinshan district, are scheduled to stop operations in December 2021 and March 2023, respectively. And the two 951 MW pressurized water reactors at the Maanshan plant in Pingtung County on Taiwan’s southern tip are slated for retirement in July 2024 and May 2025, respectively (NIW Jun.29’18).

TaiPower had asked the Ministry of Economic Affairs in 2016 whether the utility should submit a request for an extension of the operating lives of the Kuosheng reactors. Tsai said the ministry had advised the utility against doing so, given the Democratic Progressive Party government’s policy to phase out nuclear power by May 2025. Asked about the possibility of an extension for the Maanshan nuclear power plant, Tsai said the deadline for filing for an extension would be at the end of 2019.

Chiou told reporters that the two-day emergency drill at Chinshan “will probably be the last large-scale nuclear emergency exercise to be held for” the plant, adding that next year’s emergency review would focus on Maanshan.

Dennis Engbarth, Taipei City
The cost of power from EDF’s Hinkley Point C newbuild in Somerset, made the financing deal for the project desperately unpopular, even with strong supporters of nuclear power. As a result, the arrangements for follow-on newbuilds will have to appear very different, with a much lower expected price of power. The problem for nuclear projects is that if they are to be financeable, most of the financial risk must fall on the public, as either consumers or taxpayers, rather than on those providing the finance. This means that the primary way to get a lower price of power for EDF’s Sizewell C newbuild project in Suffolk than for Hinkley Point C is for the public to take on even more of the construction risk. Lowering the risk to financiers will reduce the cost of capital, and thereby significantly reduce the consumer cost of power — but only as long as things do not go wrong.

The plan for Sizewell C, and for most of the UK’s other prospective nuclear newbuild projects, now appears to be that it will be treated and regulated as if it was a monopoly facility, like a transmission line. Under this model construction and likely even operational risks will be largely covered by the “Regulated Asset Base” (Rab). This means the owners would earn a “fair” rate of return on the money invested as well as recovering their operating costs. This fair rate of return should be the rate of return earned by private-sector projects with a similar degree of risk and for network facilities is reassessed every five to eight years. Currently, monopoly energy companies are allowed to earn a real rate of return of about 6%.

The model cited by nuclear developers is the Tideway water project for London. This is a much smaller project, with an estimated cost of £4.2 billion (£5.5 billion), but rather than it being owned by the local water company, it will be owned by a consortium of institutional investors. A major advantage of this model for the nuclear sector is that it would mean developers like EDF would not have to finance and own a facility they cannot afford, while still increasing their order book. In EDF’s case an order for EPRs would be a boost for its Framatome reactor vendor business.

The Tideway project itself already has plenty of critics who doubt its worth. There is scope for costs to overrun with Tideway, but the record of large water projects is nowhere near as bad as recent nuclear projects. The output from newbuilds built using the Rab model would presumably be bought by the government’s Low Carbon Contracts Company set up to buy the power from Hinkley Point C, and while some indicative power costs would be given for the newbuild they would only be set in retrospect when costs and performance were known. Any arrangements for recovering the extra cost of power from consumers would have to be squared with the government’s promise from November 2017 that there would be “no new low carbon electricity levi es until the burden of such costs on energy bills is falling.”

A nuclear Rab model would be reminiscent of the period from 1990-96. Privatization of the UK electricity industry revealed a nuclear sector so uneconomic that income from selling power did not even cover reactor operating costs and the contribution to the funds needed to decommission the plants. A new publicly owned company, Nuclear Electric, was created in 1990. This was kept afloat by a consumer subsidy, the Fossil Fuel Levy (FFL), calculated as whatever was needed to keep the company solvent (in practice about 10% of consumer bills). A Non-Fossil Fuel Obligation required electricity retailers to buy all the nuclear output at cost. Of the £6 billion raised by the FFL, about half was used to finance the construction of the pressurized water reactor at Sizewell B. This regulated framework ended in 1996 when the UK’s newer reactors were privatized, essentially given away, as British Energy, meaning the FFL funds spent on Sizewell B were lost. British Energy went bankrupt in 2002 and required about £10 billion of public money to save it, after which it was eventually sold to EDF to become EDF Energy.

Could this be repeated? Under UK regulation of monopoly facilities, companies are allowed to start recovering their costs from consumers as soon as they start to invest. While this will be a major positive to investors, it places a major additional risk on consumers. One of the factors that allowed construction to start on the ill-conceived Vogtle and Summer AP1000 newbuild projects in the US was the allowance by regulators for the utilities to start recovering their costs from consumers even before construction started. Consumers will be lucky to get much of the money they have spent on these projects back. The obvious questions to ask are who will pay if construction cost is more than anticipated and who will pay if plant reliability and costs are worse than expected.

The UK government is now set to test the market with a nuclear Rab scheme, surveying institutional investors worldwide to see whether a project using this model is bankable, what the cost of finance will be and whether a reassessment of rate of return every five to eight years is acceptable. The details that have emerged so far are slim. If the market says no, or requires a rate of return that makes the power price too high, the government will have to move even more of the risk onto consumers or abandon its newbuild ambitions. The willingness of the UK government to take a substantial financial stake inHitachi’s Wylfa Newydd underlines its determination not to allow any of the nuclear projects to collapse.
BELGIUM
Engie revealed this week that outages at two of the seven reactors operated by Belgian subsidiary Electrabel will be extended for at least six months. Six Electrabel reactors are currently offline, and with the restart date at Tihange-2 extended from Oct. 31 to Jun. 11, 2019, and at Tihange-3 from Sep. 30 to Mar. 2, 2019, Engie will see an increase of €250 million in revenue shortfalls in 2018, bringing cumulative shortfalls for the year to €600 million. Doel-3, Electrabel’s only reactor currently running, was restarted Jul. 21 after repairs to degraded concrete ceilings in a storage bunker on the non-nuclear part of the plant. The discovery of those degraded ceilings led Electrabel to investigate comparable bunkers at Doel-4 and Tihange-2 and -3 — all second-generation plants like Doel-3. The repairs under way at Doel-4 since the reactor started a planned outage in August are on schedule, and the unit will be restarted Dec. 16. At the two Tihange units, however, recent inspections revealed far more bunker degradation than previously thought. Meanwhile, Doel-1 and -2 are both set to restart in December after outages that were extended by the need to repair leaky pipes. The availability of the Belgian fleet is now expected to be 52% in 2018 and 74% in 2019.

JAPAN
The Nuclear Regulation Authority (NRA) on Sep. 26 finalized a confirmation of conformity with its post-Fukushima safety standards for the idled 1,100 megawatt Tokai-2 boiling water reactor (BWR) operated by the Japan Atomic Power Co. (JAPC) in Ibaraki prefecture (NIW Jun.29’18). An expression of willingness by JAPC’s utility shareholders to provide financial support to JAPC, which reportedly invested 174 billion yen in safety upgrades, was a key factor in the decision, the Asahi Shimbun reported Sep.26 (NIW Apr.20’17). The decision marks the second time the NRA has issued safety confirmations for BWRs, after it affirmed the safety of two ABWRs at Tokyo Electric Power Co.’s Kashiwazaki-Kariwa nuclear plant in Niigata prefecture last December (NIW Jun.15’18). JAPC still needs to secure agreement from the NRA for a 20-year extension to Tokai-2’s operating license that expires on Nov. 27, as well as agreement from Ibaraki prefecture and six local municipalities under an accord signed in late March (NIW Aug.31’18). At least one city government is on record opposing the restart. To meet the NRA standards, JAPC needs to complete key structural improvements by March 2021. The Tokyo-based Citizens’ Nuclear Information Center issued a Sep. 26 statement arguing the heavy financial burden could perhaps double the retail rate for power generated by Tokai-2.

JAPAN
Shikoku Electric Power announced Sep. 25 that it would restart its 846 megawatt Ikata-3 pressurized water reactor (PWR) in Ehime prefecture on Oct. 27, after a panel of three Hiroshima High Court judges lifted an injunction against its operation imposed by the same court last December. The high court verdict was followed by another court decision on Sep. 28 rejecting a suit by four residents of nearby Oita prefecture for an injunction against Ikata-3 (NIW Aug.17’18). The court accepts that the plant’s safety is not compromised by possible volcanic activity from Mount Aso, over 120 kilometers away. The judges emphasized that plaintiffs had to provide highly credible evidence of such a risk, the Asahi Shimbun reported Sep. 25. Lawyers for the 164 plaintiffs said the verdict was “improper” and countered the court’s claim that the burden of proof should be on the plaintiffs; nuclear accidents are a “special type” of disaster that threaten an especially wide area, the plaintiffs argued. Shikoku President Hayato Saeki said that Ikata-3, which has been idled since last October, would soon resume its previous role as “a stable supply of low cost electric power” to the Shikoku region.

UNITED KINGDOM
Four industrial contractors this week launched a joint venture that will allow them to act as a single entity to “deliver the complex installation of cabling and pipework” across some 2,500 rooms in EDF’s Hinkley Point C newbuild in the UK, it was announced Sep. 27. Altrad, Balfour Beatty Bailey, Cavendish Nuclear and Doosan Babcock will form the MEH Joint Venture that will coordinate the delivery of all mechanical, electrical and HVAC (MEH) cabling and associated support services for the two EPRs. Separately, EDF said that more than 3,200 people are now at work on the project in Somerset (NIW Sep.7’18). “The project is on track for its next major milestone in 2019 — the completion of the 4,500 tonne concrete platform on which the reactor buildings sit,” EDF subsidiary EDF Energy announced Sep. 27. “This significant moment for the project is known as ‘J-0’ and has been underpinned by the successful completion of the final design for the work.”

UNITED STATES
BWX Technologies’ subsidiary Nuclear Fuel Services (NFS) announced this week it received a $505 million contract to downblend 20.2 tons of highly enriched uranium (HEU) to produce low-enriched uranium (LEU) as part of the US Department of Energy’s National Nuclear Security Administration’s (NNSA) nuclear weapons program. The NNSA last month entered a $750 million contract with the Tennessee Valley Authority (TVA) to oversee the downblending campaign. TVA has now contracted NFS to downblend the HEU into LEU to be fed into TVA’s Watts Bar-1 reactor for irradiation to produce tritium to replenish the nation’s nuclear warheads and bombs through 2040. For NFS, the work amounts to a contract renewal on its current contract that expires this year. The next batch of downblending will begin in early 2019 and run through mid-2025. “Under prior contracts, NFS has downblended about 70 metric tons of HEU for the NNSA,” NFS said in a statement. “The nation’s only commercial downblender and has been downblending HEU since 1995. In an Aug. 8 letter to the US Nuclear Regulatory Commission, NFS reported a spill of HEU on Jul. 11 at its downblending facility in Erwin, Tennessee (NIW Aug.31’18). The spill was reportedly contained and no chemical exposures occurred.

UNITED STATES
Several environmental and anti-nuclear groups have launched a campaign to raise opposition to the licensing application filed by Waste Control Specialists with the Nuclear Regulatory Commission (NRC) to receive a high-level radioactive waste at its existing low-level waste site in Andrews County, Texas (NIW Mar.16’18). Public Citizen, the Sustainable Energy & Economic Development (Seed) Coalition, the Nuclear Information and Resource Service (NIRS) and Beyond Nuclear said in a Sep. 27 statement that they have planned protests at various rail crossings across Texas where the waste might be shipped. And Public Citizen and the Seed Coalition are hosting town hall meetings in Houston, Dallas, El Paso, Midland and Andrews to encourage the public to intervene in the licensing proceeding. A similar coalition has also intervened in the NRC’s license application review for Holtec International’s planned consolidated interim storage facility near Carlsbad, New Mexico (NIW Mar.9’18). In addition to objecting to Holtec’s plans to store 173,000 tons of commercial irradiated fuel at that site, “more than twice what currently exists” in the US, the groups argue that Holtec “cannot provide reasonable assurances that it can obtain the necessary funds to cover the costs of construction, operation, maintenance, and decommissioning.” The coalition includes regional citizen and environmental groups.
ENERGY INTELLIGENCE URANIUM MARKET UPDATE

All prices as of Thursday, September 27, 2018

**UPP vs. Solactive Global Uranium Index**

($/lb U3O8) (Index)

<table>
<thead>
<tr>
<th>Year</th>
<th>Aug '17</th>
<th>Oct '17</th>
<th>Dec '17</th>
<th>Jan '18</th>
<th>Feb '18</th>
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*Solactive Global Uranium Total Return Index, created by Structured Solutions AG, tracks the price movements in shares of companies active in the uranium mining industry. Calculated as a total return index and published in USD, its composition is ordinarily adjusted twice a year.

**UPP vs. PowerShares DB Commodity Index**

($/lb U3O8) (Index)

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<th>Oct '17</th>
<th>Dec '17</th>
<th>Jan '18</th>
<th>Feb '18</th>
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<td>19.00</td>
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*The PowerShares DB Commodity Index Tracking Fund is designed to provide investors with a broadly diversified exposure to the returns on the commodities markets. It is based on the Deutsche Bank Liquid Commodity Index, which is composed of futures contracts on 14 of the most heavily traded and important physical commodities.

**Monthly Spot Market Prices**

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<tr>
<th>Uranium ($/lb U3O8)</th>
<th>Change</th>
<th>Aug</th>
<th>Jul</th>
<th>Jun</th>
<th>May</th>
<th>Apr</th>
<th>Mar</th>
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<th>Jan</th>
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<tr>
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<td>Conversion ($/kgU)</td>
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NWI monthly U6E, SWU and U3O8 prices rely on the general consensus of direct market participants and is informed by actual market transactions. This section was previously known as the Nukem Weekly Report and the Nukem Price Bulletin. The methodology for NIW’s weekly UPP price is different – more information about the methodology behind that price is available on page two.

**WNA Nuclear Stock Index vs. Dow Jones Industrial Average**

($k/Share) (Index)

<table>
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<th>Year</th>
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<th>Oct '17</th>
<th>Dec '17</th>
<th>Feb '18</th>
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<td>25.00</td>
<td>27.00</td>
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*Roughly two-thirds of the Dow Jones Industrial Average's 30 component companies are manufacturers of industrial and consumer goods. The others represent industries ranging from financial services to entertainment. Index relative to value of 1.0 on Jan. 1, 2002.

**Tepco Stock Price vs. WNA Nuclear Stock Index**

($/Share) (Index)

<table>
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<th>Year</th>
<th>Aug '17</th>
<th>Oct '17</th>
<th>Dec '17</th>
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*Maintained by the World Nuclear Association, the World Nuclear Association Nuclear Energy Index includes companies that build nuclear power facilities, design and service reactors, operate nuclear reactors, supply nuclear components, technology, and fuel. Index relative to value of 1.0 on Jan. 1, 2002.