

NUCLEAR INTELLIGENCE WEEKLY[®]

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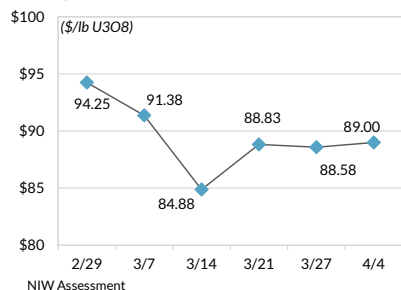
Market Points

Paladin Energy began commercial uranium production at Langer Heinrich this week, while Boss Energy expects to fill the first drum of uranium from Honeymoon in the next two weeks.

Sources say *Atlantic Navigator II*, a ship carrying Russian enriched uranium product intended for US utilities, could be held up in Germany for a few more weeks.

The Metropolis UF6 plant in Illinois is undergoing its first maintenance outage since the plant restarted operations last year.

UPP: \$89.00/LB U3O8



WEEKLY ROUNDUP

Bangladesh's Hasina Interested in Further New Nuclear

- Bangladesh is looking at building two further power reactors beyond the country's first two units under construction at Rooppur, Prime Minister Sheikh Hasina said during this week's meeting with Alexey Likhachev, director-general of Rooppur-supplier Rosatom. "We are interested in building another" nuclear power plant at Rooppur "if there is any scope to do so," Hasina said in an Apr. 2 statement released by Rosatom. "Technical survey needs to be conducted for setting up of two more power units. We need your support in constructing new power units after completion of the ongoing project." Nuclear construction of the first of the twin VVER-1200 reactors at Rooppur began in November 2017, and with a first core delivered on site in October, the physical start-up of that unit is scheduled to start "before the end of the year," said Likhachev. Bangladesh has long mooted additional units, and Hasina's statement will come as no surprise to analysts — the World Nuclear Association's nuclear fuel report released in September envisioned two further reactors being commissioned in 2038 and 2040 — but this appears to be Dhaka's most concrete statement on the matter.
- French nuclear giant EDF is slowly but surely adding new contracts to its nuclear production order book post-2025, when the current French regulation governing nuclear electricity prices is set to expire. There is not yet any new market regulation legally in place post-2025. EDF has now "signed 671 contracts for a volume of 5 terawatt hours of annual consumption, which is quite considerable, for durations of 4 to 5 years, so we are talking about 20 TWh" of contracts signed with companies, EDF Commercial Strategy Executive Director Marc Benayoun told an Apr. 3 Senate hearing. "We have also signed three letters of intent relative to nuclear allocation production contracts (Capns) for a total of 10 TWh" which "will result in contracts before the end of 2025." But there are signs that customers are still reluctant to agree to EDF's prices. Capns require an upfront payment from customers of up to a quarter of the contract's total value, and the French government has asked EDF to look into banks financing that advance payment to eliminate some of the risk for customers.
- GE Vernova, the former power and renewables division of GE that includes the nuclear business under a joint venture GE Hitachi, began trading this week as an independent company on the New York Stock Exchange. The company's nuclear business remains small — its \$800 million in revenue last year came almost entirely from servicing and fueling some of the 195 gigawatt global installed base of reactors using GE-derived boiling water reactors — but GE Vernova has high hopes for its BWRX-300 small modular reactors that will see first-of-a-kind deployment at Darlington, in Ontario. "I know there's a lot of work to be done to translate all this into more orders and more commercial contracts, but this is a huge opportunity for us," Mavi Zingoni, the CEO of GE Vernova's power division, told a Mar. 6 investor day event in New York. Zingoni added, "We are going to remain focused in a few markets."

NUCLEAR FUEL MARKET

Uranium Juniors Hit Production Milestones

Paladin Energy began commercial production at its Langer Heinrich uranium mine in Namibia this week, while Boss Energy expects to fill the first drum of uranium from its Honeymoon mine in Australia in the next two weeks. Langer Heinrich and Honeymoon are two of the largest uranium mines expected to come on line before 2025, but their respective targeted annual production rates of 6 million pounds U₃O₈ and 2.45 million lbs. U₃O₈ won't even make up for Kazatomprom lowering its 2024 production guidance by 9 million lbs., and both mines are similarly small potatoes compared to Cameco or Kazatomprom's larger projects. Both juniors have already also contracted large portions of their respective mine's production.

"I don't think they will have much in the way of direct impact to the market assuming that they meet their production commitments," said one mining source. But "it will provide more competition for the buyers to leverage when contracting."

Paladin announced Apr. 2 that it achieved commercial production at Langer Heinrich on Mar. 30. The Australian junior aims to produce 3.6 million lbs. U₃O₈ in 2024 before ramping up to 6 million lbs. per year. Boss announced Apr. 3 that it expects a first drum of uranium to be filled "in the next two weeks." While Boss' goal is to reach 2.45 million lbs. U₃O₈ annual production, that target is based on just 36 million lbs. of total project resources of 71.6 million lbs., leaving the Australian junior plenty of room to increase that capacity at a later date if all goes according to plan. "We'll be watching their production rates, their recovery rates, because this deposit is known to be a little bit harder to work with," said one market source.

Further up the nuclear fuel cycle, supply logistics remain an issue. Multiple sources say Atlantic Navigator II, a ship carrying Russian enriched uranium product intended for US utilities, could be held up at the port of Rostock, Germany, for a few more weeks. The ship has already been detained for a month because it is carrying EU-sanctioned timber. The ship is operated by Canadian shipping company CISN and its US vessel operator,

ARRC Line. "CISN and ARRC Line are working closely with German authorities on a positive resolution of the matter to ensure the Atlantic Navigator II is permitted to continue on her planned voyage to ports in the United States as soon as possible," a CISN spokesperson told Energy Intelligence.

The EU banned all imports of Russian timber in July 2022. "Customs especially checks the restrictions on foreign trade like the sanctions against Russia," a German Customs spokesperson told Energy Intelligence. "If there are restrictions and prohibitions, customs can start criminal measures."

When it comes to uranium conversion, there is still extremely limited supply through 2028 and there was no conversion activity at all during the month of March. The Metropolis UF₆ plant in Illinois is undergoing its first maintenance outage since the plant restarted operations last year, shutting down production during April and part of May. "If it goes well it could be a positive for production numbers" as "it's an opportunity to address a lot of the items that weren't necessarily anticipated upon restart," Nikko Collida, vice president of business development at ConverDyn, marketer of output from Metropolis, told Energy Intelligence. Historically, conversion facilities including Metropolis can struggle to get back to full production levels immediately after maintenance outages, but Collida stated that "we are confident the level of preparation that has gone into this outage will result in a positive outcome after restart."

Sprott Physical Uranium Trust purchased 100,000 lbs. U₃O₈ on Apr. 3, but no other deals took place this week. The fund has purchased just 550,000 lbs. U₃O₈ so far this year, down from 3.9 million lbs. in the first three months of last year. "Maybe investors are thinking that maybe \$80 [per pound U₃O₈], \$90 is the top of the market, some of them are getting out," speculated one trader. The average U₃O₈ price delivered by Energy Intelligence's Uranium Price Panel rose to \$89.00/lb. U₃O₈, up slightly from \$88.58/lb. last week.

Grace Symes, London

URANIUM PRICE PANEL

For the week ended April 4, 2024

| | Chg. | Weekly Spot Market Prices | | | | | | | | | | | | |
|--|--------|---------------------------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|
| | | Apr 4 | 27 | Mar | | | 29 | 22 | Feb | | Jan | | | |
| | | | | 21 | 14 | 7 | | | 15 | 8 | 1 | 25 | 18 | 11 |
| Price (\$/lb U ₃ O ₈) | 0.42 | 89.00 | 88.58 | 88.83 | 84.88 | 91.38 | 94.25 | 99.75 | 102.38 | 102.25 | 104.00 | 103.25 | 106.17 | 96.75 |
| Total Assessments | 1.00 | 10.00 | 9.00 | 7.00 | 6.00 | 7.00 | 9.00 | 7.00 | 8.00 | 8.00 | 8.00 | 9.00 | 7.00 | 7.00 |
| % within 1 StDev | -28.89 | 60.00 | 88.89 | 71.43 | 66.67 | 71.43 | 55.56 | 71.43 | 50.00 | 50.00 | 75.00 | 75.00 | 85.71 | 85.71 |
| Low (\$/lb U ₃ O ₈) | 1.00 | 88.00 | 87.00 | 88.50 | 83.00 | 90.00 | 94.00 | 98.50 | 101.50 | 100.00 | 101.00 | 100.00 | 106.00 | 93.50 |
| High (\$/lb U ₃ O ₈) | 1.00 | 90.00 | 89.00 | 89.00 | 88.00 | 94.00 | 96.00 | 100.00 | 103.00 | 105.00 | 107.00 | 106.00 | 108.00 | 100.00 |
| Variability* | 0.33 | 1.00 | 0.67 | 0.00 | 0.00 | 1.00 | 0.63 | 0.00 | 0.00 | 0.00 | 3.00 | 0.63 | 0.33 | 2.50 |

*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.

NEWBUILD

PacifiCorp Backs Away From Sodium Reactor Fleet

Even as advanced reactor developer Terrapower submitted its construction license application for its first-of-a-kind Sodium sodium-cooled fast reactor this week, prospective plant owner PacifiCorp walked back plans to build additional Sodium reactors beyond the demonstration plant planned for Kemmerer, Wyoming.

PacifiCorp subsidiary Rocky Mountain Power remains nominally committed to the Kemmerer first-of-a-kind Sodium in an update to PacifiCorp's 2023 Integrated Resource Plan (IRP) released Apr. 1, but PacifiCorp said that "additional advanced nuclear resources" beyond that demonstration plant "are not selected in this update." In the original 2023 IRP, released May 2023, PacifiCorp had modeled bringing the demonstration Sodium plant on line by 2030 (still the goal), and then two quick-follow subsequent reactors in 2032 and 2033, respectively.

A PacifiCorp spokesperson told Energy Intelligence that a joint PacifiCorp-Terrapower study on the feasibility of deploying up to five additional Sodium's in the PacifiCorp service area is "still in place." And while that joint study "hasn't gone as far forward as some folks expect, we still will work with Terrapower on considering" the deployment of further Sodium reactors "for the future." A Terrapower spokesperson added that it and PacifiCorp "will continue to work together to study the potential for Sodium units at sites through Rocky Mountain Power's service territory. TerraPower knows that the dispatchable, flexible energy Sodium provides will be critical in the coming years as the energy sector sees dynamic shifts in energy mix and exponential load growth."

For the moment, however, the IRP update is a major blow to Terrapower, which has no firm customer commitments to purchase Sodium reactors beyond the Kemmerer demonstration plant. In a way, Terrapower is now in the inverse of the situation faced by small modular reactor developer NuScale Power after plans for its first-of-a-kind plant in Idaho were canceled by the customer in November: While NuScale has other customers interested in its reactor but not willing to buy a first-of-a-kind plant, Terrapower now has a customer willing to buy a first-of-a-kind plant but nobody committed to buying further reactors. And as former Energy Secretary Ernest Moniz told a Terrapower official on a Mar. 19 nuclear panel at the CERWeek by S&P Global conference in Houston, "The idea of getting beyond a single project to a set of reactors is so important here." When asked about additional customers, the Terrapower spokesperson only pointed to a December memorandum of understanding with Abu Dhabi's nuclear champion, the Emirates Nuclear Energy Corp.

PacifiCorp's Policy Environment

The changes in the updated IRP are driven by state policies, and in particular, Wyoming and Utah policies over ozone transport rules that were newly enabled on the federal level; the US

Environmental Protection Agency (EPA) signed off on these rules in Wyoming, and a court stayed the EPA's disapproval of these rules in Utah. These policies remove limits on natural gas- and coal-fired generation in the summer, and effectively allowed Rocky Mountain Power to continue the operation of a fleet of coal plants longer than anticipated a year ago. This "deeply concerning" IRP update "is a sign" that Utah legislation making it hard for the state's public service commission (PSC) to approve the retirement of old coal plants "will significantly limit the near-term build-out of clean energy resources," Utah Clean Energy's government relations manager Josh Craft said in an Apr. 2 post.

Rocky Mountain Power is one of PacifiCorp's two regional utilities — it serves Utah, Wyoming and Idaho, while sister utility Pacific Power serves Oregon, Washington and northern California — and as a regulated utility, PacifiCorp must therefore seek approval for its plans across six PSCs. The company is, therefore, subject to a "push and pull" in any drive to decarbonize away from the fossil fuels currently responsible for 70%-75% of its 12 gigawatts of generation capacity, Rocky Mountain Power CEO Gary Hoogeveen told a nuclear finance conference in November. The "push" comes from the EPA and its rules regarding coal generation, while the "pull" comes from the state level. "Our states, and our regulators in our states, like the fact that we have very low-cost electricity, and to jeopardize low-cost and reliable electricity is becoming a very difficult issue, particularly in my three states" of Utah, Wyoming and Idaho, said Hoogeveen.

It's possible that the policy shift driving this IRP update could, in time, be reversed. The update to PacifiCorp's nuclear plans in its IRP "seems like normal IRP fluctuations to me," Brett Rampal, the director of nuclear and power strategy at energy investor Veriten, told Energy Intelligence. "I think it's hard to say what the policy environment around energy in Utah (and other western states) is going to look like next year, let alone in five to 10 years when the real progress on these types of projects would need to take place." Rampal would be "just as unsurprised" to see next year's IRP "swing back" to its nuclear fleet plans, "or for changes later in this decade once other policy changes happen or better pictures around load growth emerge."

For the moment, Terrapower is focused on its first-of-a-kind plant at Kemmerer. "TerraPower continues to advance the Sodium demonstration project in Kemmerer; this year will see major milestones including the start of on-site, non-nuclear construction, and last week we filed the construction permit application for nuclear-related activities with the US Nuclear Regulatory Commission," said the Terrapower spokesperson. The company is applying to the regulator for a construction permit under Part 50, a two-step process that involves applying for an operating license when construction is near completion. TerraPower hopes to bring the Kemmerer demonstration plant on line "within the decade."

Phil Chaffee, New York

UNITED STATES

Palisades Restart Still Faces Significant Hurdles

Holtec International's push for the restart of the Palisades pressurized water reactor in the US state of Michigan is the first-ever planned nuclear power reactor restart on US soil, with both the federal government and the state backing the effort, contingent on various provisional conditions. But numerous questions about restarting the retired 800-megawatt reactor remain unanswered, such as who will operate the plant and how or whether the company will address various aging problems while maintaining the plant's decommissioning trust fund, particularly as Holtec initially purchased the plant to decommission it.

Former operator and owner Entergy shut down Palisades on May 20, 2022, 11 days earlier than planned, due to leaks in the reactor reactivity controls, a problem that had plagued the reactor for decades. Palisades first came on line in 1971, and although it was licensed to operate through 2031 under a license extension granted in 2011, from December 2016 on, Entergy was committed to shuttering the plant early as it backed away from operating reactors in merchant markets. There was growing talk of continued operations at Palisades to meet decarbonization goals, but Entergy did in fact shutter the plant in 2022, as that's when a power purchase agreement (PPA) with former owner Consumers Energy expired. Entergy CEO Leo Denault also noted in an April 2022 earnings call that there were "significant technical and commercial hurdles to changing course," calling such a prospect "a really heavy lift" and "a lot of work." He added that Entergy had not "done the investigation into what that work would be because, as you might guess, we have been planning for five years to shut the plant down."

Not long after that call, in June 2022, Palisades was transferred from Entergy to Holtec subsidiary Holtec Decommissioning International (HDI) for decommissioning, but almost immediately — on Jul. 5, 2022 — Holtec submitted a 42 page application, obtained by Beyond Nuclear, to the US Department of Energy (DOE) Civil Nuclear Credit program seeking \$2 billion for the restart that it did not receive. Then on Sep. 9, 2022, the company and the Michigan governor announced a plan to restart Palisades. HDI subsequently created Holtec Palisades to manage that restart, currently targeted for August 2025, but that may be a little ambitious. "Repowering work includes extensive equipment and systems inspections and testing, preventative maintenance, modifications and replacements of existing equipment," Holtec spokesperson Nicholas Culp told Energy Intelligence. To that end, funding is "essential to support the hiring — and in many cases rehiring — of plant personnel across all disciplines, re-establish the plant's training program, purchase fuel and procure long-lead procurement items."

Holtec is particularly open to any and all government support. Last week, one of those efforts bore fruit: the DOE Loan Programs Office announced a conditional \$1.5 billion loan from its brand

new Energy Infrastructure Reinvestment program to restart Palisades, subject to due diligence and risk mitigation, among other legal and technical conditions. The process also involves a National Environmental Policy Act review, meaning it could take several months before the LPO approves the disbursement of the funds. Once those federal funds are disbursed, Holtec Palisades will be eligible to receive \$150 million allocated last year by Michigan lawmakers that is contingent on federal funding. Not to mention, Michigan Gov. Gretchen Whitmer in February requested lawmakers approve another \$150 million in the latest state budget for the restart. Holtec also announced in September a conditional long-term PPA with Wolverine Power Cooperative, a not-for-profit power generation cooperative based in Michigan. Holtec assumes a minimum of \$412.5 million in annual revenues from that PPA, according to Holtec's July 2022 application to DOE. Holtec maintains plans to partner with an operator for the restart, but has yet to announce one.

Holtec also has the responsibility of maintaining Palisades' decommissioning trust fund, which stood at about \$560 million as of Nov. 24, 2023, but with decommissioning costs last estimated at \$644 million. In a Feb. 20 inspection report, the US Nuclear Regulatory Commission (NRC) "identified several instances, totaling just over \$57,000, in which" Holtec used the funds "to pay for activities not considered legitimate decommissioning expenses." The majority of those funds went to reactor restart efforts. Holtec's Culp responded to the low-level violation saying the company has "already taken corrective actions to ensure the amount was restored to the trust fund, with interest, and that this issue does not recur."

In addition to restarting Palisades, Holtec is seeking up to \$7.4 billion in loan guarantees from the LPO to support a fleet of never-built Holtec-designed SMR-160 reactors potentially sited at Palisades, although currently the nuclear decommissioning vendor is mooting only two SMR-160s at the site.

Restarting Palisades

Despite Entergy's warnings about the technical challenges around Palisades' continued operation, Holtec's Culp told Energy Intelligence that Palisades "has been maintained in excellent material condition" and "the repower is akin to a broader, longer refueling and maintenance outage."

But skeptics are not convinced. "The list of construction problems that Holtec identifies is extraordinary and shows that the physical condition of the Palisades Plant deteriorated terribly while Entergy was the owner," Arnie Gundersen, chief engineer for Fairewinds Associates and a former industry executive, said in a December petition to intervene and request for a hearing filed in the Palisades restart docket at the NRC. Gundersen references an itemized list of expenses to support the Palisades restart included in Holtec's July 2022 application to the Civil Nuclear Credit program. In the application, Holtec also estimates a cost of \$510 million for steam generator "design, fabrication, replacement (includes reactor coolant system redesign, cold-hot-fuel testing),"

but Culp said this week that recent “expert testing and analysis has validated the integrity of our steam generators to support continued safe and reliable operation,” and the machines will not be replaced.

With regard to the “degrading seal” on the control rod mechanism drive that prompted Entergy to shut down Palisades 11 days early, Holtec said it amounted to “nothing uncommon” and “something that would routinely be fixed during a refuel outage or shutdown, which would have occurred had the plant had longer to run in 2022.”

Perhaps a more controversial characteristic of Palisades is the embrittlement of the reactor pressure vessel due to neutron bombardment. While common among aging reactors, the NRC in 2013 pegged Palisades as having the worst embrittlement in the country. Subsequently, Entergy convinced the NRC that this embrittlement would not lead to pressurized thermal shocks, and the NRC spokesperson told Energy Intelligence this week that the matter was therefore “addressed and verified through previous inspections while the plant was in operation.”

Holtec still has to clear a number of regulatory hurdles as well, having engaged with the NRC since March last year to set up a regulatory framework for authorization of the restart that essentially requires a litany of exemptions from licensing requirements, since the NRC has already terminated Palisades’ operating license.

In October last year, Holtec began the licensing process to restart the reactor, and the NRC estimates it could complete review of all the material submitted by the end of December as soon as Jan. 31, 2025. But Holtec submitted further material in February, and has yet to submit documents to support the reinstatement of a Palisades emergency plan, expected last month, or the security and quality assurance plans, expected this month. It’s therefore unclear how long any NRC review will ultimately be, particularly as the regulator will likely request additional information as it reviews all of these individual plans.

Jessica Sondgeroth, Washington

FINLAND

Grid Limitations Force Olkiluoto-3 to Curtail Output

Finland’s 1,650 megawatt Olkiluoto-3 nuclear reactor has had to curtail output more than a dozen times since it began regular electricity generation in April 2023 due to Finnish electric grid limitations, as well as low Finnish electricity prices and technical issues. While Olkiluoto-3 has itself helped to lower these prices, Finland’s electric system does not currently have enough resiliency to support such a large reactor, and transmission system operator Fingrid has had to take special measures to ensure that

the Olkiluoto-3 EPR can operate near capacity. These issues could call into question the rationale for building such a large reactor in the first place.

Olkiluoto-3 is the single largest nuclear reactor in Europe and accounted for about 13% of Finnish electricity generation in 2023. The reactor began regular electricity production on Apr. 16, 2023, 14 years behind schedule and nearly 18 years after the first concrete was poured for the EPR in August 2005. That huge delay meant that the electricity system Olkiluoto-3 began supplying in 2023 looked vastly different from 2005’s system. Since 2005, Finland’s installed wind capacity has jumped from just 82 MW to 6,946 MW at the end of 2023. Renewables overall accounted for 41.8% of energy generation in 2022, compared to 20.4% provided by nuclear, according to the Finnish treasury. Those figures don’t include Olkiluoto-3, which hadn’t yet begun operation. That huge increase in renewables resulted in lower, and sometimes negative, electricity prices and put pressure on Fingrid to build out transmission capacity.

Because renewables connect to the grid via power converters and traditional baseload, such as nuclear and thermal generators, connect via synchronous machines, when the proportion of renewables to baseload increases the inertia of the electricity system decreases. When this happens there is less stored energy available to mitigate a large power plant failure, and it “may be necessary to limit the power of the largest production or consumption units” such as Olkiluoto-3, according to Fingrid.

Given these difficulties, building another EPR reactor in Finland likely doesn’t look too attractive. Finnish energy company and nuclear operator Fortum, which holds a 25% stake in Olkiluoto-3, is currently undertaking a two-year new nuclear feasibility study looking at the deployment of both large and small modular reactors in Finland and Sweden. While Fortum could, in theory, reap the benefits of repetition if it chose to construct another EPR, it is likely watching closely a dispute over how to integrate Olkiluoto-3 into Finland’s electricity system, and it may opt for smaller options.

Work on Olkiluoto-3 “started almost a couple [of] decades ago in a very different system, so this plant is very big for the Finnish system,” Tampere University Climate Researcher Pami Aalto told Energy Intelligence. “If the planning were started maybe 10 years ago it wouldn’t be this big.”

It’s worth pointing out that TVO has also voluntarily curtailed Olkiluoto-3’s output due to low electricity prices at times. But the reactor itself has helped lower Finnish electricity prices. “On the electricity market, the mild weather at the start of the year and consumers’ electricity saving measures, the good hydrological situation that continued throughout the year and the regular electricity production that took off at Olkiluoto-3 in April caused the price of electricity to fall, as a whole,” read Fingrid’s 2023 annual report.

Fingrid vs. TVO

Olkiluoto 3’s role in Finland’s electrical grid is the center of an ongoing dispute between TVO and Fingrid. In May 2022 TVO asked Finland’s government-run Energy Authority, which regulates electricity and gas markets, to investigate system protection, or the mechanism which ensures stability of the grid in case Olkiluoto-3 is suddenly disconnected.

Typically system protection takes the form of reserve capacity: in Finland, Fingrid owns a number of reserve plants and leases others that can be called upon in an emergency to immediately replace the electricity large generators were producing prior to a disconnection. Fingrid can also purchase reserve capacity from power generators from Nordic and Estonian markets and can lower power consumption to maintain grid frequency. This mechanism is meant to deal with sudden unplanned outages from electricity generators, and not with any predictable weather-dependent hourly fluctuations from variable renewables.

Olkiluoto-3 is so large that it surpasses Fingrid’s maximum allowable change in power level of 1,300 MW, requiring a special mechanism for Olkiluoto-3 to operate at its full capacity of 1,600 MW (50 MW is used to sustain the reactor’s own operations). That 1,300 figure likely comes from a combination of Fingrid’s own plants — it operates 1,047 MW of its own and leased reserve power plants — and 300 MW of transmission capacity in interconnectors from Sweden to Finland that the Finnish transmission system operator has had to reserve specifically for Olkiluoto-3. Under the special system protection mechanism certain industrial energy users agree that, for a price, 350 MW of their consumption can be automatically taken offline in the case of an unexpected Olkiluoto-3 disconnection.

Fingrid had required TVO to pay much of the cost of this mechanism because it considered that the mechanism benefitted only TVO and not any other electricity producers or consumers, since no other plant in Finland is large enough to require the added protection. But in a January 2024 decision, the Energy Authority found that Fingrid should not have transferred these costs to TVO and it required Fingrid to submit “determination principles for fees related to system protection or a proposal for another mechanism” by Apr. 11.

“The current contract period for this system protection, it is up to [the] end of this year,” TVO Corporate Adviser Sami Jakonen told Energy Intelligence. “And now Fingrid is preparing for [a] quotation for the next one.”

With Fingrid now likely on the hook for this system protection cost, it’s now Finnish electricity ratepayers, rather than TVO’s shareholders, who will foot the bill – as Fingrid is allowed to pass its costs along to the ratepayers. TVO said in its statements to the Energy Authority that the cost of this system protection increased by 2023 to “tens of millions of euros per year,” from approximately one million euros/yr in the early 2000s. Fingrid has said it will appeal the Energy Authority’s decision.

TVO also argued that Fingrid should have established sufficient capacity to allow Olkiluoto-3 to operate at full capacity without a special mechanism given that Fingrid has known for two decades how large the plant would be. But the Authority found that Fingrid fulfilled its duties in relation to Olkiluoto-3. Fingrid says it has increased the electricity system’s maximum allowable change in power level by 40% since the Olkiluoto-3 project began.

“Fingrid should, as a matter of principle, strive to develop its network in such a way that the needs of the subscriber would be met and thus also possibly at some point the system protection could be waived specifically as a solution connected to OL3,” read the Energy Authority decision. But it added, “the further development of the network to eliminate system protection would also require other Nordic transmission system operators to take measures with regard to their own electricity systems.”

In other words, Olkiluoto-3 is so large that Fingrid alone cannot create sufficient system protection to allow it to operate at full capacity without a special mechanism. And the Finnish power system has changed so much since 2005 that the operation of Olkiluoto-3 in the electricity system is “significantly more challenging than previously assumed,” Fingrid said in a 2016 statement referenced in the Energy Authority decision.

Broader Impacts

The end result of this special system protection mechanism is that Olkiluoto-3’s output “has in recent months been reduced on several occasions because the protection operated by Fingrid has not been fully available,” TVO said in January. “This may occur, for example, when an industrial business that is a contractual party to the protection system is undergoing a maintenance outage.”

Olkiluoto-3 has also not operated above 1,570 MW since it began regular electricity production, but TVO and Fingrid dispute the reasons why. TVO says Fingrid has set a limit of 1,570 MW, but Fingrid says it has set no such limit and Olkiluoto-3 simply requires more electricity to sustain its own operations than initially predicted, lowering its net output below 1,600 MW.

Beyond TVO, the system protection dispute raises questions about nuclear’s role in increasingly renewables-heavy electricity systems, particularly in smaller grids. One of the key arguments for nuclear, despite its often astronomical price tags, is that including nuclear in an electricity system keeps system costs needed to connect renewables and compensate for their variability down.

But growth in renewables shows no sign of slowing, and this will lead to yet more demand for transmission lines and lower inertia in electric grids, which raises the likelihood of having to curtail the output of large nuclear reactors. The case of Olkiluoto-3, which will cost ratepayers tens of millions of euros per year for the foreseeable future in system costs, may cast doubt on the viability of

such large reactors being built as renewables penetration increases. It's not clear to what extent these costs may be counterbalanced in this case by the lowered power prices Fingrid acknowledged from Olkiluoto-3's generation in 2023.

Grace Symes, London

URANIUM

Rio Tinto Takes Over Ranger Rehabilitation

Rio Tinto is taking over the rehabilitation of its shuttered Ranger uranium mine in Australia's Northern Territory from its subsidiary Energy Resources of Australia (ERA) following years of cost and timeline increases, likely in an effort to avoid reputational damage. That news was welcomed by the Gundjeihmi Aboriginal Corporation, which represents the traditional owners of Ranger, the Mirarr, and that has long been critical of ERA's rehabilitation efforts. Regardless of its international expertise, due to Ranger's unique operating environment, Rio Tinto will likely have its work cut out for it to prevent further cost and timeline increases.

Ranger was once one of the largest uranium mines in the world, and over its 30 years of operation it produced 146,597 tons of uranium (381 million pounds U₃O₈), but Ranger ceased operations in December 2020 after the Mirarr refused to back an extension of ERA's authority to mine Ranger beyond January 2021. Since its closure, rehabilitation cost estimates for Ranger have ballooned from an initial projected A\$512 million (US\$337 million) to A\$1.2 billion (US\$791 million) in December 2023 and

A\$2.4 billion (US\$1.6 billion) in a December 2023 estimate. The rehabilitation, initially expected to be complete by 2026, is now forecast to finish in 2034. While environmental standards have tightened around the world since Ranger began operation in 1980, Ranger is required to meet far more stringent rehabilitation guidelines than almost any other mine in the world, contributing to ERA's rehabilitation difficulties. But ERA knew the standard it would have to meet when it released its initial mine closure plan and feasibility study, and it failed to adequately predict the time and money it would take to meet those requirements.

"A lot of it has to do with the fact that they have an almost impossible task to meet regulatory requirements" because regulations "require them to do things at that site that probably few others have had to do in rehabilitating any mining site in the world," one mining source told Energy Intelligence. But the source added that "it calls into question the quality of the studies they [ERA] did five or 10 years ago on what closure would cost," and "it was always known that they were dealing with an extremely difficult regulatory environment."

Rio to the Rescue

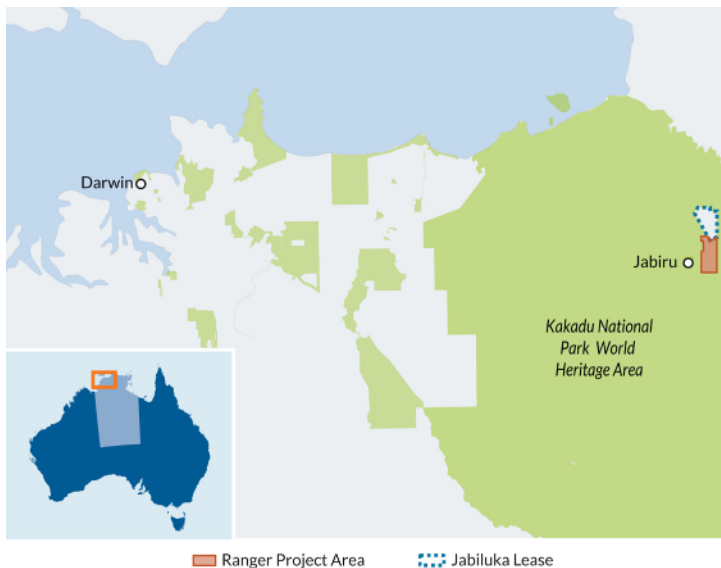
Among Rio Tinto's chief concerns when it comes to Ranger is its reputation in Australia and on indigenous issues. While Rio Tinto is active in 35 countries, its Western Australia iron ore operations are crucial to the company. Western Australia accounted for about 38% of global iron ore supply in 2022 and Rio Tinto produced about 35% of that. But despite employing more than 23,000 people in Australia, Rio Tinto took a huge blow to its reputation in 2020 when it blew up a 46,000-year-old sacred site at Juukan Gorge in Western Australia in order to expand an iron ore mine.

"It just would become a particularly difficult situation for Rio Tinto if they didn't demonstrate that they had control over the rehabilitation," said the mining source. "After the Juukan Gorge incident they have to be extremely sensitive to things that don't play well in the Australian press with regards to dealing with the local traditional owners and environmental cleanup."

Rio Tinto owns 86.3% of ERA's shares and would almost certainly take the blame if the rehabilitation failed. ERA currently only has enough capital to last it through the third quarter of 2024, and expects to raise further funds through an equity raise this year, according to ERA's 2023 annual report, released Mar. 13. Rio Tinto has previously stepped in directly to ensure sufficient funding, entering into a A\$100 million loan agreement in 2022 with ERA to provide "additional liquidity" for the rehabilitation and supplying A\$319 million out of a total A\$369 million ERA capital raise in April 2023.

Rio Tinto is now expected to take over all management aspects of Ranger's rehabilitation shortly, with a new management services agreement implemented in the second quarter of 2024, followed by a transition period of two to three months, accord-

RANGER URANIUM MINE



Source: Energy Resources of Australia

ing to an Apr. 3 ERA announcement. Rio Tinto has also agreed to provide the first 12 months of management team and internal technical expertise cost-free.

“Mirarr is pleased that the ERA independent board committee has finally admitted that ERA has lost control of the Ranger Rehabilitation Project and will hand over management of it to the major shareholder Rio Tinto,” said Gundjehmi CEO Thalia van den Boogaard.

The Mirarr and ERA continue to disagree, however, over the Jabiluka deposit near Ranger. On Mar. 20, ERA applied to extend the lease of Jabiluka, one of the world’s largest uranium deposits, even though there has been no plan to mine Jabiluka since its development was blocked by Mirarr-led activists in the 1990s. ERA claims that the lease renewal was simply a means of extending its Jabiluka arrangement with the Mirarr, which includes the right for the Mirarr to veto Jabiluka development. But an added motivation for ERA to extend the lease may be to keep open the possibility of developing Jabiluka in the long run and, therefore, preserve some value for the company. “What is the value of ERA without Jabiluka?” asked one source.

Problems on the Ground

It is by no means clear that Rio Tinto can get Ranger back on track, or even meet current deadlines and cost estimates. Ranger is situated in the middle of Kakadu National Park, which became a national park after mining began at Ranger. ERA is required to return Ranger to an environment similar to the rest of the national park so that it could be incorporated into the park in the future. To this end, tailings must be contained for 10,000 years and contaminants from tailings must not have detrimental environmental impacts for 10,000 years.

Meeting that high bar is taking longer than anticipated. Of ERA’s December 2023 cost leap, from A\$1.2 billion to A\$2.4 billion, 85% is attributable to post-2027 rehabilitation activities. Those costs come from a feasibility study completed in 2023, but ERA said further studies are still required and “activities post-2027 and estimates of their cost remain highly uncertain.” Meanwhile, certain rehabilitation criteria still have yet to be agreed upon by traditional owners or have not received ministerial approval.

Among the most significant and unique contributors to the cost and schedule increases is water management. “Overall long-term performance of the water treatment plant has been below the planned performance,” read ERA’s annual report. If ERA must install additional water treatment capacity, which is more likely if rainfall is higher than average, “the rehabilitation cost may increase further.”

Ranger is “right in the tropics; it’s the very top of Australia,” said another mining source. “In a big wet season you could have up to two meters of rainfall” and “some years you’re going to have more rain than you’re going to have evaporation.” Even as ERA is

cleaning up Ranger, “you’re still capturing a certain amount of water from what you haven’t cleaned up,” said the source. Area-average Northern Territory rainfall in 2023 was 624.3 mm, 14% above average and in 2022 was 613.2 mm, 12% above average, according to Australian government data.

Under Commonwealth government regulations, all rain that falls on uranium-bearing ore, including ore stockpiles that are below Ranger’s cut-off grade or contain similar levels of uranium to surrounding rock, has to be contained and treated until its uranium concentration meets national drinking water standards. “That’s where the issues started because they started to accumulate water,” said the mining source.

Water management is key not just to treat the water itself, but because “water is the pathway for contaminants ... to move off-site,” said ERA in its 2023 updated mine closure plan. Other cost escalation drivers include an increase in costs for bulk material movement and a schedule extension for the consolidation and then covering of tailings.

Grace Symes, London

FUEL CYCLE

Former US Officials Push Back on Reprocessing Plans

A bipartisan group of former senior US government officials and various nuclear experts this week urged President Joe Biden not to allow federal funding or regulatory approval for plans mooted by France’s Orano and prospective US fusion firm Shine Technologies to build a commercial nuclear fuel reprocessing facility in the US. There was no immediate response from the White House, but the intervention is a sign that the new industry momentum behind advanced fuel cycles will continue to receive pushback.

“We, the undersigned nuclear nonproliferation experts, write to express grave concern about a recently announced plan by the US company Shine to build a domestic, commercial pilot reprocessing plant that would extract annually enough nuclear-weapons-usable plutonium for more than 100 atomic bombs,” the 29 experts wrote in an Apr. 4 letter to the White House. Among the signatories were officials who had served under four previous presidents, including four from the Obama administration in which Biden was vice president, such as former Nuclear Regulatory Commission Chair Allison Macfarlane and Thomas Countryman, former assistant secretary of state for international security and nonproliferation. The proposed facility would “break a half-century US abstention from civilian reprocessing” and would “legitimize the building of reprocessing plants in other countries, thereby increasing risks of proliferation and nuclear terrorism.”

The letter came roughly a month after the Feb. 29 announcement from Orano and Shine of a memorandum of understanding to develop a US “pilot plant with commercial scale technology” for recycling spent nuclear fuel from light-water reactors. The plant will rely on basic design components and at least the initial stages of the process used at Orano’s La Hague reprocessing plant in France, but Shine hopes to lower proliferation risks via an aqueous process in the later stages that will not fully separate out the plutonium from uranium.

An Improved Technology?

“Our technology is designed to create a process that improves global safety, including proliferation resistance,” Shine said in a statement to Energy Intelligence. “The planned process will unlock a valuable fuel source for clean energy production that is unusable for nuclear weapons. Further, responsible recycling of spent fuel is the only known way to actually eliminate plutonium that has already been generated in fission reactors.”

Shine added that it is “actively engaged” with the US technical nonproliferation community “to conduct a thorough proliferation risk assessment and optimization of our technology, aligned with our mission to help create a safer, healthier and cleaner world. Through responsible recycling of spent fuel, we envision a future with higher nuclear security, and a fuel cycle where nuclear power becomes renewable.”

The letter signatories argue that in a 2009 study, the alternative reprocessing technology that underpins the Shine plans offers “minimal additional proliferation resistance” over the French technology used by Orano “when considering the potential for diversion, misuse and breakout scenarios.” They also point to the original 1976 decision by President Gerald Ford to halt commercial reprocessing, and argue to Biden that despite “policy fluctuations since then, commercial reprocessing has never restarted in this country and should not do so under your watch.”

Shifting Policies

In a Mar. 5 American Nuclear Society webinar, Shine noted that current federal policies and policy gaps “pose a hindrance” to commercial reprocessing plans, but pointed to Department of

Energy efforts to assess the changing landscape of nuclear fuel cycle technologies. This week’s letter, meanwhile, quotes from a March 2023 National Security Memorandum that it is US policy to focus civil nuclear research and development “on approaches that avoid producing and accumulating weapons-usable nuclear material and enable viable technologies to replace current civil uses of these materials.”

For its part, Orano has long argued that reprocessing need not be a proliferation threat. “Orano has operated its used nuclear fuel reprocessing and recycling facilities in France safely and securely in full compliance of nonproliferation oversight for more than 50 years,” the French state-owned company told Energy Intelligence in a statement. “We fully support and have intentionally integrated nonproliferation compliance in our plans for this recycling facility, which is a clear requirement by US government regulators. As part of the facility’s licensing process, federal nonproliferation experts will conduct a thorough review and analysis to verify the safeguards meet these established criteria.”

That’s unlikely to persuade the letter writers, who urged Biden to implement its nonproliferation policies by “making clear” the Biden Administration “will not support federal funding [including loan guarantees] or licensing for Shine’s proposed reprocessing plant or any other non-weapons facility that would increase the production and/or use of nuclear weapons-usable material.” But given how embryonic the Shine-Orano initiative is, it’s likely that Washington will not move quickly on this issue, and that any definitive re-articulation or shift in US reprocessing policy may come under whoever wins the presidential election in November.

Phil Chaffee, New York

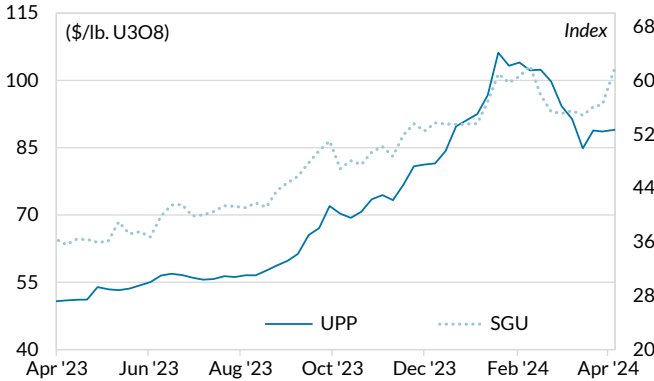
CORRECTION

In a Mar. 22 article, Energy Intelligence incorrectly reported that a request for information (RFI) from Google, Microsoft and steel producer Nucor Corp. is seeking responses from firms developing advanced clean generation technology under 50 megawatts. The RFI instead says that qualified technologies will “ideally” be over 50 MW.

URANIUM MARKET UPDATE

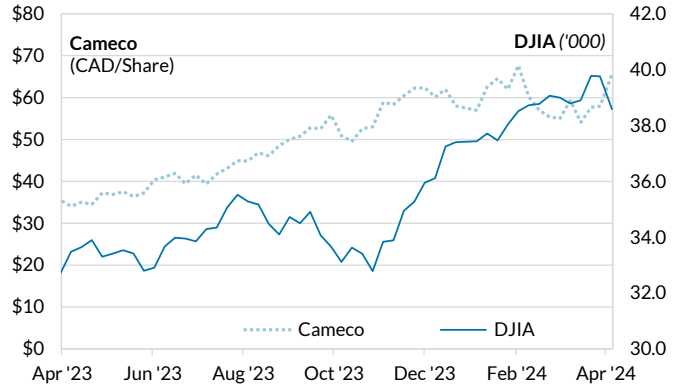
All prices as of Thursday, April 4, 2024

UPP VS SOLACTIVE GLOBAL URANIUM INDEX
(previous 52 weeks)



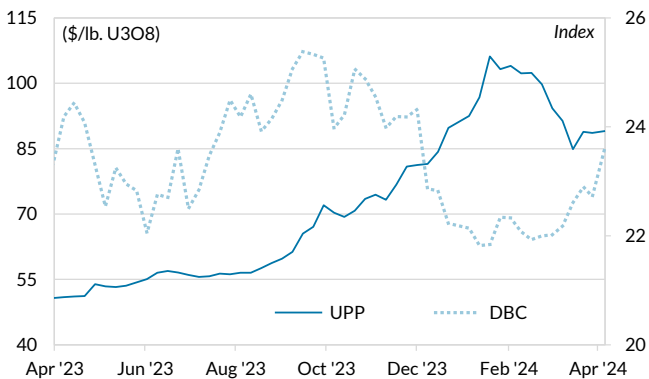
The Solactive Global Uranium Total Return Index, created by Structured Solutions AG, tracks the price movements in shares of companies active in the uranium mining industry. Calculated as a total return index and published in US\$, its composition is ordinarily adjusted twice a year.

CAMECO VS DOW JONES INDUSTRIAL AVERAGE
(previous 52 weeks)



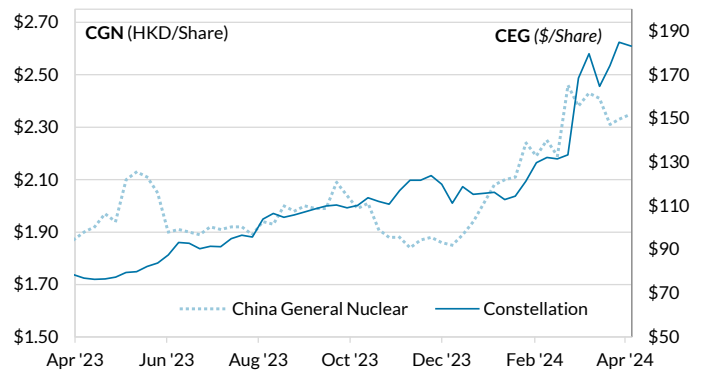
Canadian uranium miner Cameco's stock is valued in Canadian dollars compared with the US dollar on the Dow Jones Industrial Average (DJIA). Roughly two-thirds of DJIA's 30 component companies are manufacturers of industrial and consumer goods. The others represent industries ranging from financial services to entertainment.

UPP VS POWERSHARES DB COMMODITY INDEX
(previous 52 weeks)



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.

CONSTELLATION VS CHINA GENERAL NUCLEAR
(previous 52 weeks)



China General Nuclear (CGN) Power Co., a Chinese state-owned utility, is China's largest nuclear operator, while Nasdaq-listed Constellation Energy Corp. (CEG) is the largest nuclear operator in the US.

MONTHLY SPOT MARKET PRICES

| | Chg. | 2024 | | | | 2023 | | | | | | | |
|-----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | Mar | Feb | Jan | Dec | Nov | Oct | Sep | Aug | Jul | Jun | May | Apr |
| Uranium (\$/lb U3O8) | | | | | | | | | | | | | |
| Low | -11.00 | 83.00 | 94.00 | 92.00 | 91.50 | 82.00 | 69.00 | 61.10 | 56.25 | 55.40 | 54.75 | 53.25 | 51.00 |
| High | -13.00 | 94.00 | 107.00 | 108.00 | 81.00 | 72.50 | 75.00 | 74.00 | 61.75 | 57.00 | 58.00 | 55.50 | 53.95 |
| Conversion (\$/kgU) | | | | | | | | | | | | | |
| Low | +2.00 | 58.00 | 56.00 | 50.00 | 41.00 | 45.00 | 41.00 | 43.00 | 40.00 | 40.00 | 41.00 | 39.00 | 38.50 |
| High | +4.00 | 62.00 | 58.00 | 60.00 | 45.00 | 47.00 | 43.00 | 45.00 | 40.25 | 41.00 | 43.00 | 43.00 | 42.50 |
| Enrichment (\$/SWU) | | | | | | | | | | | | | |
| Low | +1.00 | 164.00 | 163.00 | 158.00 | 158.00 | 150.00 | 148.00 | 138.00 | 138.00 | 138.00 | 135.00 | 134.00 | 130.00 |
| High | -1.00 | 168.00 | 169.00 | 168.00 | 168.00 | 158.00 | 157.00 | 150.00 | 150.00 | 148.00 | 155.00 | 150.00 | 145.00 |

NIW monthly UF₆, 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.

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