

URANIUM OUTLOOK²

Uranium revival takes
off as reality hits on
energy, geopolitics



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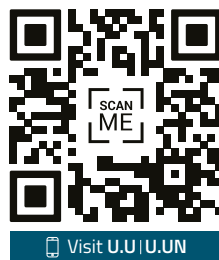
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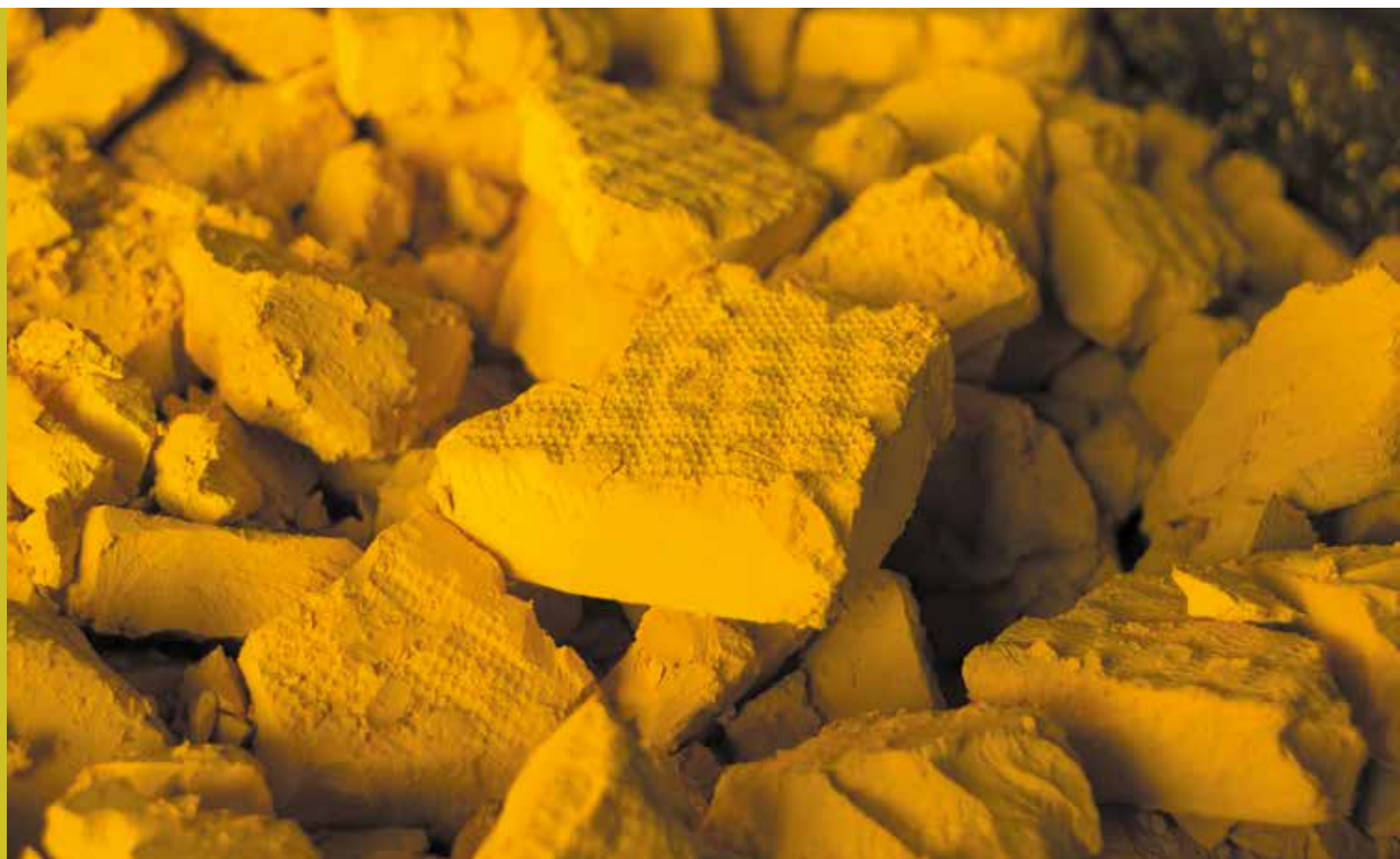
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Revival of nuclear power to spark uranium demand

Written off by developed economies after Fukushima, nuclear power is staging a revival as policymakers have come to acknowledge the role it can play in solving the world's energy crisis

In the United States, billions of dollars in funding and incentives have been committed to existing and new nuclear plants, and a similar story is unfolding in Canada. Even more surprising has been the path taken by the countries most opposed to nuclear, such as Japan, where a government panel will look into building next-generation reactors, and Germany and Belgium, which have extended the life of plants to ensure stable power supply.

The extent of the nuclear revival remains to be seen, and it typically takes around 10 years to construct a new reactor. Nevertheless, the market signals have been strong enough to send the long-term uranium price from the low \$30s to the low \$50s in just three years, with experts saying prices will need to go a lot higher to incentivise enough production to meet likely demand.

Against this backdrop, uranium companies around the world are announcing restarts of long-suspended operations and dusting off plans for greenfield projects. This report contains profiles of eight companies with projects in four jurisdictions. We also take a deep dive into the factors driving the uranium market – and what needs to happen for prices to move up even further.

“The long-term uranium price has risen from the low \$30s to the low \$50s in just three years, with experts saying prices will need to go a lot higher to incentivise enough production to meet likely demand.”

Nadav Shemer, *Mining Journal*

Denison eyes low-cost in-situ recovery in Canada's high-grade Athabasca Basin

The Eastern Athabasca Basin in Canada's Saskatchewan province is home to the world's two largest high-grade uranium mines – McArthur River and Cigar Lake – both majority owned by Cameco. The nearby Wheeler River project will soon be added to that list, if all continues to go to plan for majority owner Denison Mines

Denison completed a prefeasibility study for the project in 2018, which forecast that the flagship Phoenix deposit would produce 6Mlb of uranium oxide (U_3O_8) at 19.1% U_3O_8 across a 10-year mine life. Wheeler River also contains a second deposit called Gryphon, which – although regarded as a first-tier deposit by Denison – is expected to trail the expansion of Phoenix as part of a staged development plan.

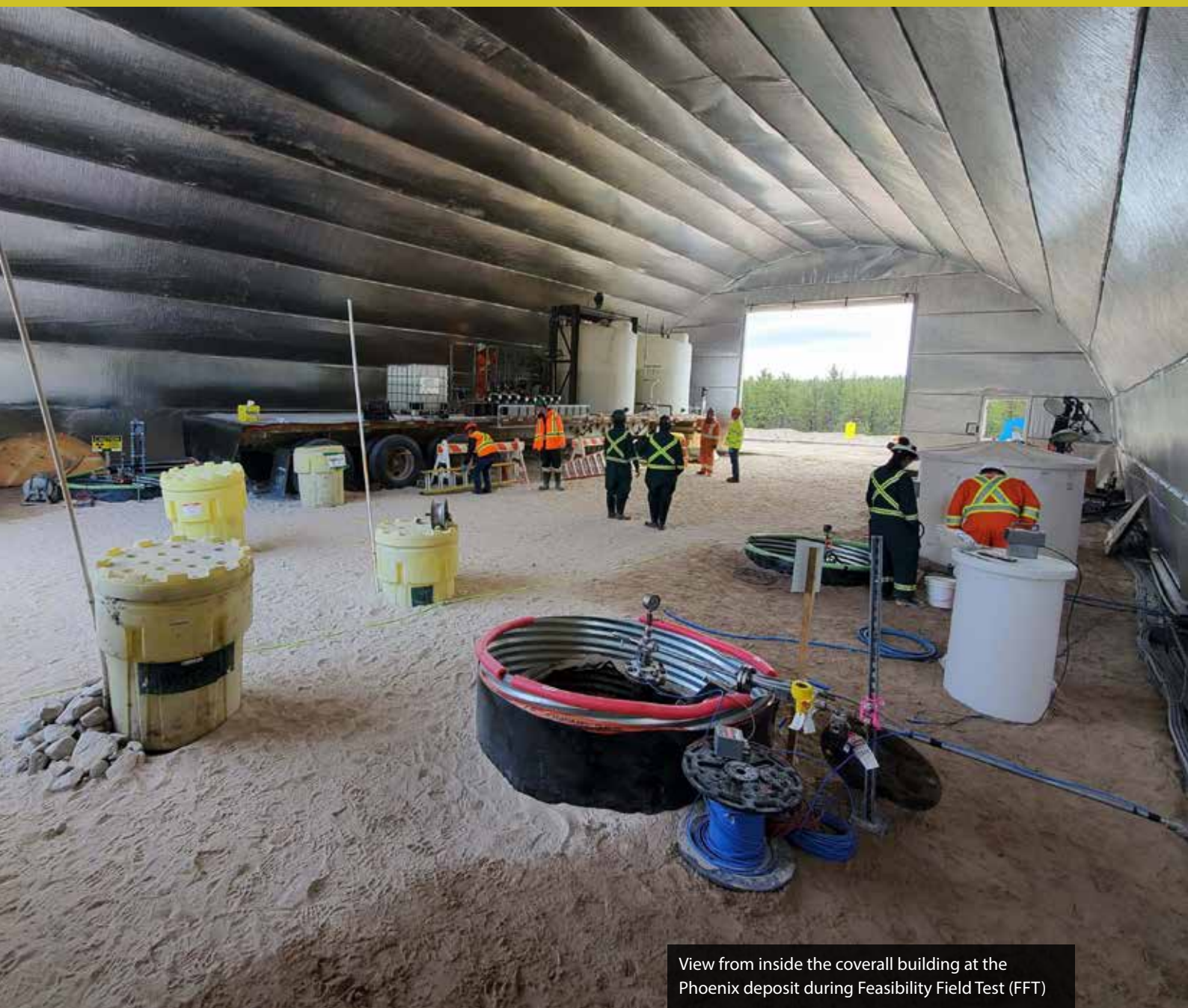
Denison, which owns 95% of Wheeler River, intends to mine Phoenix using in-situ recovery (ISR), a common uranium mining method which has been deployed in Kazakhstan, the United States and Australia but never before in Canada, according to David Cates, the company's president and CEO.

Evaluating the feasibility of the ISR method has been the subject of a multi-year process of field and laboratory testing, culminating in what Denison calls a Feasibility Field Test, or FFT – which involved the injection of an acidic mining solution into a previously installed ISR test pattern in the Phoenix deposit. Earlier this year, Denison reported receipt of regulatory approvals for the FFT from the province of Saskatchewan and the Canadian Nuclear Safety Commission, and on October 17, the

company announced the successful recovery of uranium-bearing solution from the field test. Cates called the accomplishment an “historic moment for uranium mining in Canada,” adding that the test showcased Denison's industry leadership in bringing the low-cost ISR mining method to the high-grade uranium deposits of the Athabasca Basin.



President and CEO, David Cates



View from inside the coverall building at the Phoenix deposit during Feasibility Field Test (FFT)

"In the last five years we've done significant technical work to prove this mining method will be successful at Phoenix. We have installed many hydrogeological testing wells into the deposit, as well as a full-scale five-spot commercial-scale well pattern located within our planned first production area. We have performed in-depth hydrogeologic testing using our test wells, to make sure our flow models reflect actual performance from the field. In 2021, we performed a tracer test to ensure that dissolved solids were travelling between wells as predicted by our models," Cates said.

The FFT consists of three phases. The first involved the injecting of lixiviant (mining solution) into the test area of the underground ore body. Given the successful results of the FFT, the injection has ceased, and Denison is now preparing to transition to the neutralisation phase, which it expects to complete before the end of 2022. This phase

involves the recovery of the remainder of the leached mineralised solution from the test area, with the purpose of demonstrating its ability to return the Phoenix deposit to acceptable environmental conditions. The final phase of the FFT, which is expected to commence in the first half of 2023, involves separating the recovered solution into mineralised precipitates and a neutralised treated solution.

In terms of other milestones, Denison recently announced the submission of a draft environmental impact statement (EIS), which is a critical milestone in the joint federal and provincial environmental assessment process Denison started for the project in 2019. Denison is also working on completing an update of the Wheeler River prefeasibility study – bringing the Phoenix deposit to a feasibility study level – during the first half of 2023.

“Based on our efforts to date, we continue to believe that a Phoenix ISR uranium mine will be positioned amongst the lowest cost uranium mines in the world”

“Based on our efforts to date, we continue to believe that a Phoenix ISR uranium mine will be positioned amongst the lowest cost uranium mines in the world – in competition with the lowest cost mines in Kazakhstan and the large and high-grade incumbent mines in the Athabasca Basin,” Cates said.

As for capital cost inflation, Cates acknowledged that this was a problem for the entire mining sector but expressed confidence that it wouldn't hold Denison back, as the project is expected to have comparatively low initial capital costs owing to the nature of the ISR mining method – which doesn't rely on costly and time – consuming shaft sinking or open pit excavation to reach the ore body, and has a simplified processing plant design without the need for conventional milling circuits or tailings disposal. He added that the company was well capitalised with more than C\$225 million (US\$165 million) in working capital and investments on the balance sheet, including more than C\$50 million cash and 2.5Mlb of yellowcake uranium inventory acquired at a low price in 2021 that has appreciated in value while in storage at two North American conversion facilities.

“We're bullish on the [uranium] price, obviously, and we believe our physical uranium could fund a significant portion of the capital cost for Phoenix when the time comes,” Cates said. “Whether or not we're selling the material into the open market, or placing it in utility contracts, or using it as collateral for debt financing, we're very pleased to have this item on our balance sheet as we approach a development decision”

“Phoenix's economics were favourable even at much lower uranium prices, so much so that we've been in active development since the 2018 prefeasibility study during a period of under-investment for much of the sector,” he added. “You can't buy time in our industry, so the ability to have advanced the project over the past several years is a tremendous competitive advantage for Denison.”

Aside from Wheeler River, Denison has a stake in three other projects at various stages of development in the Athabasca Basin. These are Waterbury (Denison 67.01%, Korea Waterbury Uranium Limited Partnership 32.99%), Midwest (Denison 25.17%, Orano Canada 74.83%) and McLean Lake (Denison 22.5%, Orano Canada 77.5%).

Denison has identified Waterbury's Tthe Heldeth Tuvé (THT) deposit as another potential candidate for ISR mining like Phoenix. This deposit used to be called the J Zone deposit, and was renamed in 2020 based on consultation with local indigenous groups. The deposit is also well known as the western extension of Rio Tinto's former Roughrider deposit. Speaking briefly about Waterbury, Cates noted that “previous thinking around THT was that it would be a natural fit for eventual co-development with Roughrider. Since we have advanced our efforts on ISR mining we have really changed our mind on THT and realise that it is actually the best part of the THT-Roughrider deposit in that it is the only part that is amenable to ISR mining, which has dramatically improved the economics of potential development.”

Building on the company's leadership in ISR mining in the basin, Denison is also working together with Orano Canada to evaluate the potential use of ISR at Midwest – a project which has an approved EIS for open pit mining but which was not previously advanced due to high costs.

In October 2022, Denison took another step forward in its Athabasca - region projects when it signed its third agreement with local First Nations and Indigenous communities in which it committed to advancing exploration activities in a manner that respects Indigenous rights, advancing reconciliation with Indigenous peoples, and providing economic opportunities and other benefits to the Athabasca communities.

Denison Mines – at a glance

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Market capitalisation

C\$1,300 million (as of June 29, 2022)

Quoted shares on issue

805 million

Canada's NexGen Energy eyes large-scale uranium production



NexGen Energy's Rook I project in Saskatchewan, Canada, has the potential to become a significant supplier of uranium to meet growing global demand

Located in the southwestern Athabasca Basin of Canada's Saskatchewan region, NexGen's Rook I uranium project has the potential to significantly boost Canada's uranium production for many years to come and help meet anticipated global demand growth, said the company's founder and CEO, Leigh R Curyer. And once developed, Rook I will be capable of producing up to 30Mlb/pa of uranium, which would be the equivalent of about a quarter of the world's total uranium production today, he added, meaning that Rook I can help replace production from Canadian mines that are coming offline between now and 2030.

Canada is one of the world's main producers of uranium, predominantly in the Saskatchewan region. And while small quantities of that uranium are supplied to domestic nuclear reactors, most is exported.

Australia-born Curyer, who founded Vancouver-based NexGen over 11 years ago, is not hiding his excitement about Rook I. "An enormous amount of work has gone into it," he said. "We have a strong team in place to take the project into construction."

NexGen, which bought the Rook I property from Toronto-based Mega Uranium in 2012, completed a feasibility study in 2021 and aims to complete front-end engineering design by the end of 2022. Permitting decisions are pending before a final investment decision can be taken.

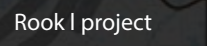
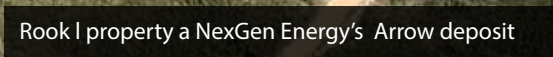
On June 21, 2022, NexGen announced it had submitted a draft environmental impact statement (EIS) to the Saskatchewan Ministry of Environment and the Canadian Nuclear Safety Commission (CNSC). The CNSC announced its acceptance of the draft EIS shortly after.

NexGen is continuing to advance the environmental assessment and licensing activities towards the submission of the final EIS and licence applications required from the provincial and federal regulators. The company also continues engagement with regulators and local communities. The public comment period closed on October 12.

Curyer said the company had a "fantastic relationship" with local communities including Indigenous groups in the area. The EIS submission included letters of support for the Rook I project from the Clearwater River Dene Nation, the Buffalo River Dene Nation, and the Buffalo Narrows



Founder and CEO,
Leigh R Curyer.



Dene Nation, all of whom have benefit agreements with NexGen that define the environmental, cultural, economic, employment, and other benefits to be provided to the communities in respect of the project.

If the development goes ahead, the permitting basis for the Rook I project is a 24-year operational period. Once production is up and running, the uranium will be exported to demand centres such as the US.

"The US is still the largest nuclear power producer in the world," said Curryer. "Then you have expansions and life extensions of reactors in countries like the UK and France. On top of that, China plans to build 159 new reactors over the next 10 years."

In other words, security of demand does not seem to be an issue.

The outlook for uranium consumption growth is “incredibly strong,” the CEO said. “On the one hand, electricity demand is on the rise globally. But there is also growing demand for energy from non-carbon resources in the wake of the Paris Agreement in 2015.

"There is as yet no alternative to nuclear for producing low-carbon baseload power," said Curyer. "There is hydropower, of course, but that is highly dependent on geographical location. It is an indisputable fact that if you want low-carbon baseload energy then nuclear is the answer. Wind and solar are still a long way off producing baseload power.

"I don't think there is a nuclear renaissance just in the West – it is in the entire world," he added. "You have China and India as well."



NexGen Energy's Rook I project

Curyer has over 20 years' experience from the resources sector and his project assessment experience with uranium has, in addition to Canada, been focused on assets in Australia, USA, Africa, Central Asia, and Europe. He was previously head of corporate development for Accord Nuclear Resource Management, where he assessed uranium projects around the world for First Reserve Corporation, a private investment firm with a focus on energy. Prior to that, he was the chief financial officer for Southern Cross Resources (now Uranium One).

Back in 2011 when he founded NexGen, Curyer noted, the appetite for uranium exploration was generally very low. The outlook for uranium demand was highly uncertain; the Fukushima disaster had cast doubts over plans for new reactors and the event prompted Germany to announce a total nuclear phase-out – something it has not yet fully completed.

Despite the headwinds for the industry at the time, Curyer remained optimistic. And in 2014, NexGen made the Arrow Deposit discovery, which is part of the Rook I property. The Arrow Deposit is currently the largest development-stage high-grade uranium deposit in Canada. The property consists of 32 contiguous mineral claims with a total area of 35,065ha. All claims are 100% owned by NexGen.

As with other deposits in Saskatchewan, the uranium in Arrow is incredibly high grade, said Curyer, up to 100 times the average in other parts of the world. Mineralisation is expected to occur 100m below the surface.

Rook I is expected to be capital-intensive but with high rewards. The total initial capital cost for Rook I is estimated at \$1.3 billion. Average annual after-tax net cash flow is estimated at more than \$1 billion for the first five years, while the average for the 11-year period is estimated at more than \$760 million per annum.

“On the one hand, electricity demand is on the rise globally. But there is also growing demand for energy from non-carbon resources in the wake of the Paris Agreement in 2015.”

Assuming uranium prices of \$50/lb, which is NexGen's base case, Rook I's after-tax net present value would be C\$3.45 billion while NPV would rise to C\$4.87 billion if uranium prices were to reach \$65/lb.

Uranium may currently be hovering around \$50/lb but prices have been volatile in recent months. However, Curyer said he is bullish on the outlook. Prices have crashed in the past after hitting around \$140/lb in 2007 and \$70/lb in 2011 but the recent upward trend is here to stay, he said. “The marginal cost of producing uranium requires prices far higher than where spot prices are today.”

NexGen Energy – at a glance

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Market capitalisation

\$2.11 billion (at November 2022)

Quoted shares on issue

480 million

Major shareholders

Ka Shing Li 6.18%

Sprinkle Ring Investment Ltd 4.30%

Global X Management Co. LLC 4.25%

Mega Uranium Ltd. 4%

Feasibility study imminent at Fission's high-grade, low-cost uranium project

A forthcoming feasibility study looks set to position Fission Uranium's PLS project as one of the standout uranium development projects in the Athabasca Basin, Canada

The 2012 discovery of the Triple R uranium deposit was a game changer for geologists' understanding of the Athabasca Basin. With 114.9 Mlb of indicated resource and a further 15.4 Mlb in the inferred category, it is the sixth largest deposit ever discovered in the Athabasca Basin, and stoked major exploration interest in the basin's southwestern fringe. With a feasibility study expected by the end of 2022 and with uranium price forecasts remaining bullish, Fission Uranium Corp, sole owner and operator of the PLS project which hosts Triple R, is moving steadily through development.

"It's been ten years since discovery to reaching the point where PLS is close to conclusively demonstrating that it is on track to become a major, low-cost producing asset," said Ross McElroy, the company's president and CEO. "I think the southwest side is rapidly becoming the next major mining focus of the Athabasca Basin."

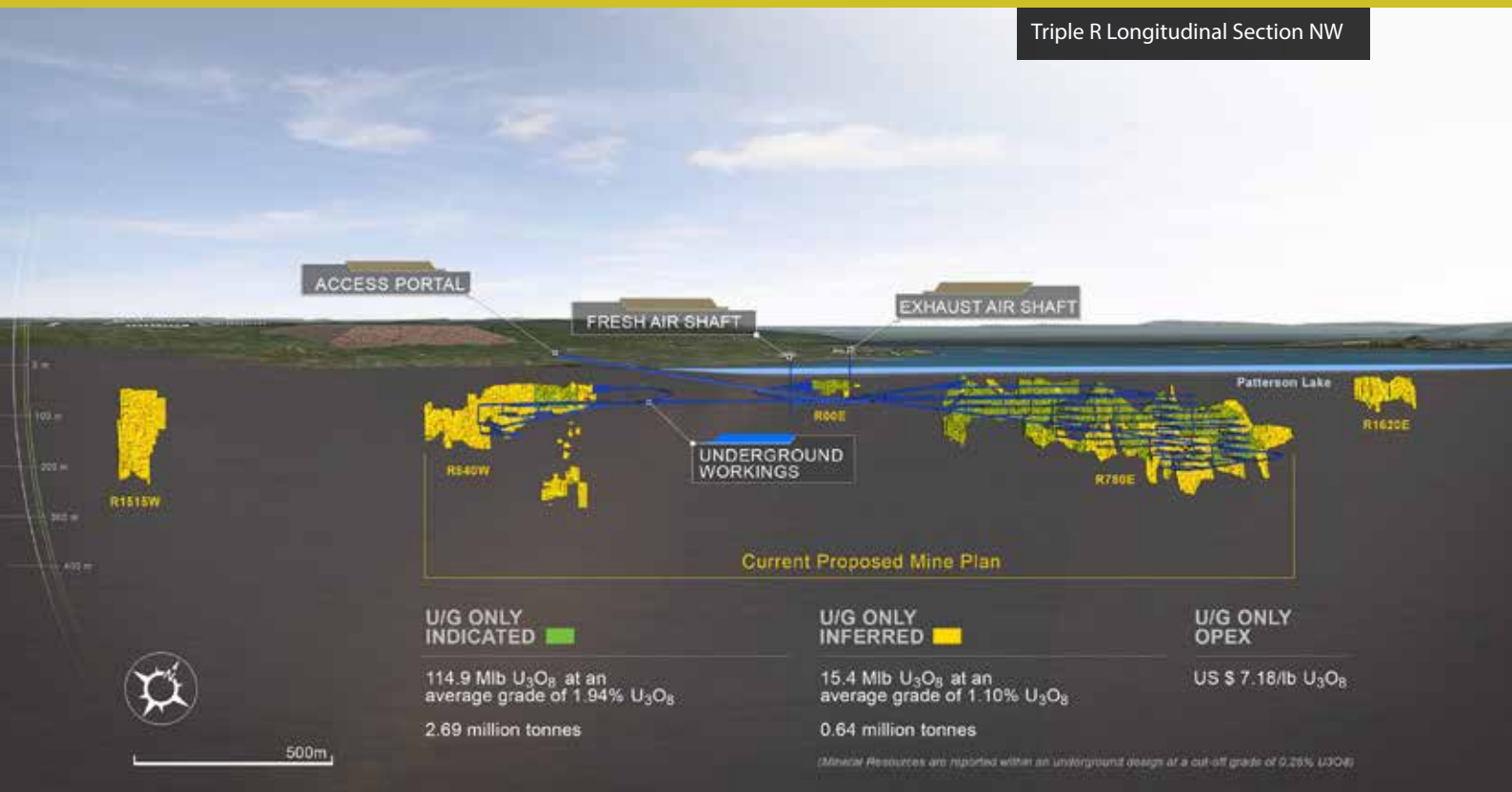
Few mining professionals can compete with McElroy's pedigree in the basin. In the mid-1980s he worked for the crown-run Saskatchewan Mining Development Corporation, which went on to become publicly-traded Cameco, and he was part of the team that discovered McArthur River, the world's largest high-grade uranium deposit. Having worked for junior mining firms during the uranium boom of 2004, he joined Fission Energy, as it was then called, in 2007 to direct exploration at its early-stage

projects. The first discovery made by the McElroy-led team, the J-Zone at Waterbury Lake, led to Fission Energy's acquisition by Denison Mines in March 2013, and the company's non-core assets being spun off into Fission Uranium.

Previously, major uranium deposits, including McArthur River and Cigar Lake, had been made in the unconformity, the region where the basin's crystalline basement rock and the sandstone on top of it meet. Triple R was discovered



President and CEO, Ross McElroy



in the basement rock outside the basin. The deposit is at shallow depths of 50-300m and the competent basement rock is less technically challenging to mine than sandstone, making for lower operating costs and technical risks. "This is the largest, near-surface, high-grade basement rock-only uranium project in the Athabasca Basin," McElroy said. "It's large, it's high grade, and it's economically viable."

Furthermore, the current resource estimate could be just scratching the surface of the project's potential. PLS sits on a land title of 31,000ha – five times the size of Manhattan Island – and the early discovery means that 90% of property has yet to be drilled as exploration efforts to date have centred around Triple R. "These deposits tend to occur in multiple frequencies along geological trends and we have all the markers and features for other areas that could become high-priority exploration targets," McElroy said. "I think further exploration will reveal the enormous potential of the property and we're seeing the right market conditions to justify this exploration in addition to advancing the deposit itself."

For now, however, the company's efforts are focused on its upcoming milestone announcement of a feasibility study. In September 2019, Fission Uranium released a pre feasibility study for an underground operation with seven years of mine life that would process 2.3Mt of ore from two of the project's five zones. With a capex of C\$1.18 billion, the 81.4Mlb of produced uranium were forecast at operating costs of US\$7.18/lb.

"The key to Triple R is that we can be a very low-cost

operator," McElroy said. "Kazakhstan dominates the industry because it has very low average operating costs of between \$10 and \$11 and we're clearly in that category. That's what basement rocks do, they have the potential to lower your operating costs and give you an advantage."

The feasibility study, due by the end of 2022, is expected to strengthen the economic argument, bringing new resources into the mine plan from the R840W zone, with corresponding increases in mine life and further production advantages. As part of reaching this goal, Fission conducted an infill drilling programme at R840W and, in September 2022, released an updated resource estimate that boosted uranium content by 12.3%. The company has also been heavily focused on geotechnical work, to develop a better understanding of rock mechanics at the project. Although primary access will be by a decline, the new plan is expected to call for a moderate increase in shaft size dimensions, which can be used for additional production access.

"The feasibility study will take into account a larger resource, with a new zone that allows for greater flexibility when combined with the current improved uranium prices," McElroy said.

In parallel, the company has been working towards permitting PLS and has been collecting environmental baseline data for nearly a decade, while working closely with local rights holders and stakeholders. The most important review, the environmental impact assessment, is expected to begin in the third quarter of 2023 and last 24-36 months. Local Indigenous communities

will continue to be consulted, and have a history of being supportive of such projects in the region. "The Saskatchewan government has a long-term vision on development," McElroy said. "There are no short cuts but there are no surprises, they don't change the rules on you. We've developed a team with permitting expertise from the best in the industry, people who've brought major uranium mines into production."

McElroy points out that the firm has the ability to develop it alone, while not discounting the possibility of future sales. "When you have a project with these phenomenal, robust economics, you can take several routes forward," he said. "It's a large enough deposit for us to keep going on our own path and as we get closer to production, we'll seek out strategic relationships if we feel they can build shareholder value. The number of potential buyers in the uranium space is small compared to copper or gold, but we've sold projects in the past and there is a strong M&A dynamic in the sector right now, much of it focused on the Athabasca Basin." Fission Uranium has already garnered strong interest from institutional investors who have grown their holdings from under 10% to almost half of the company's shareholders.

With the forthcoming feasibility study set to highlight PLS' clear path to production, the project stands well placed to provide investors with major upside as uranium prices continue to rise as a result of geopolitical pressures and growing efforts to convert to green sources of energy.

"Our PFS was forward projecting production based on \$50 uranium. That is where the spot market is right now. Most projections these days are significantly higher. I would not be surprised to see a doubling in price in the near future," McElroy said. "Development projects have a key role to play in providing clean energy to utility companies. PLS is in North America, it has strong economics and the case for the uranium sector keeps getting stronger and stronger."

Fission Uranium – at a glance

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Market capitalisation

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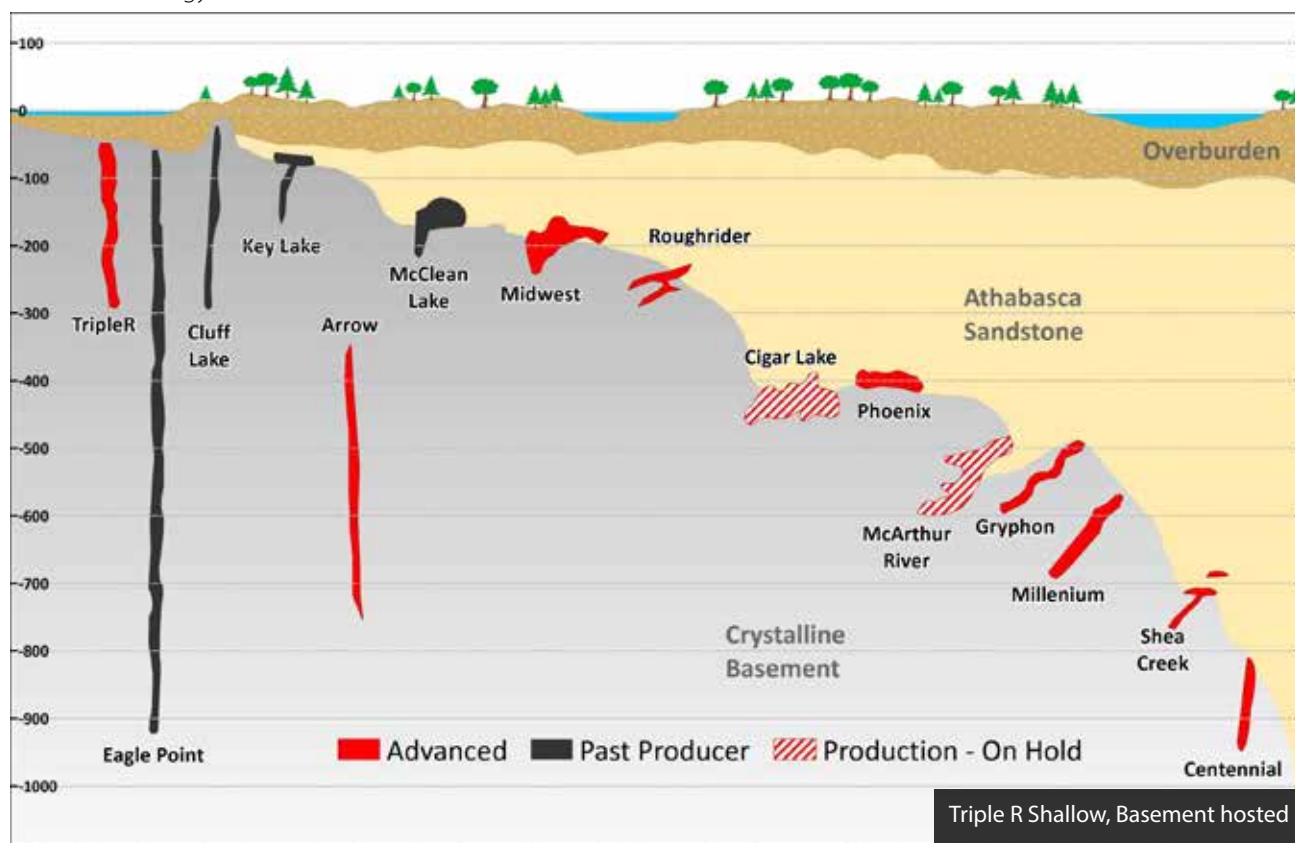
Quoted shares on issue

681.5 million

Major shareholders

Institutions (53.3%)

CGN (14.2%)



Purepoint Uranium Group well positioned to make next Athabasca discovery



An out-and-out exploration company, Purepoint has the land package, experience and partners to place it amongst the front-runners looking for major uranium deposits

Home to the world's highest-grade-producing uranium mines, the Athabasca Basin in Saskatchewan, Canada, continues to reveal the true scale of its resources, with four major discoveries in the last decade. Geopolitical tensions stoked by the Russian invasion of Ukraine have tightened supply of uranium and now a new wave of exploration, harnessing knowledge gained over the past 15 years, is set to begin in the basin.

"Development companies taking a resource through to production provide a clear value proposition, but over the last decade investors in uranium have made even larger returns on the discovery," said Purepoint Uranium Group president and CEO Chris Frostad. "Purepoint is unashamedly an exploration company and with our portfolio, our partners, and our experience in the region, if anyone is going to make a major new discovery in the Athabasca Basin, the odds are on us."

The company has a 20-year history in the region, following its 2002 formation. At that time, Frostad's brother, an exploration geologist working in Saskatchewan, alerted him to the untapped uranium potential in the basin. Purepoint went on to stake over 400,000 ha of mining titles and witnessed first hand the wave of exploration dollars and new techniques that flooded the sector following the uranium boom of 2004 to 2007, when prices reached US\$135/lb. But while most companies exited the sector following the global financial crisis and the 2011 Fukushima nuclear accident, Purepoint hunkered down.

"We were pretty much the last man standing," Frostad said. The company was able to keep hold of its acreage and

focus on exploring the Hook Lake project – in which it holds 21% and operator status – with majority financing coming from joint venture partners Cameco and Orano, two giants of the uranium space. Hook Lake remains the primary exploration focus, but the renewed interest in the sector from mining firms and financial groups has allowed Purepoint to make plans to bring the other properties to drill-ready status. "We were able to pull the sheet off another 11 projects that have been waiting for us, like a time capsule, and really get back to work," Frostad said.

Recent discoveries have reinforced the Athabasca Basin's reputation for high grade deposits and expanded the



Chris Frostad, Purepoint Uranium Group president and CEO



Red willow drilling

spectrum of exploration targets. In July 2022 IsoEnergy announced a resource estimate of 48.61 Mlb of uranium at an average grade of 34.5% on a property that Cameco had previously held for years. While most 20th century exploration had focused on the unconformity, where the basin's sandstone meets the underlying basement rock, major recent discoveries, such as Cameco's Millennium deposit, have been found well below that level.

"Exploration firms realised they were stopping short, we weren't drilling deep enough," Frostad said. "Over the last 10 or 15 years there's been so much more understanding and learning with regard to the nature of uranium deposits across the region."

At Hook Lake, on the southwest edge of the basin, Purepoint will begin a new drill campaign in January 2023. So far, efforts have focused on the Patterson corridor, a complex band of graphitic structures that run north-south through the property adjacent to and on strike with NexGen Energy's Arrow deposit, and Fission Uranium's Triple R deposit to the south, which collectively hold over 250 Mlb of uranium.

The company's deep understanding of this part of the basin has led Purepoint and its partners to focus on the Carter corridor, to the west of the Patterson corridor. The company looked over its first exploration programme on the property and found that the 14-year-old drill results at Carter demonstrated evidence of potential mineralisation much deeper in the basement rock.

"That's what's got us and our partners really hyped up," he said. "We're going back to the Carter corridor with a new roadmap to begin drilling in January. We now see

this as probably one of the best untested areas for a tier one deposit in the basin." In this flat region with many lakes, exploration is best undertaken in the winter when the land is frozen. The drill results are expected to come through in March 2023.

Meanwhile, exploration continues apace at the company's other properties to the east of the basin, with the Osprey Zone of the Red Willow property a particular focus.

"We drilled Osprey in early 2022 and the great results prompted us to return as soon as possible. We are back up there drilling right now," he said. Having tracked consistent quantities of uranium along the target zone, the company is using helicopter drill teams to see how far the mineralisation extends to the north. So far it stretches nearly a mile.

Current uranium price conditions make patient exploration possible. "I think we're in for a kinder, gentler ride this time," Frostad said. "I don't think we'll see a hockey stick in uranium prices like we saw during the last uranium bull market but over the next couple of years we should see it continue higher to around the \$75 mark." The firm has the current exploration funded and will choose the right moment to return to the capital markets.

Should Purepoint make a discovery, the obvious exit strategy is a sale to one of the existing well-established miners in the region such as Cameco or Orano. Relationships the company has built with the majors has helped them understand the sort of project that interests them. "The current producers, Cameco and Orano, require new resources to serve the demands of their existing facilities eight or ten years out and we look to deliver on that need," he said. "With the large amount of money coming into uranium exploration right now, I expect the basin will see one or two significant discoveries in the very near future."

Purepoint Uranium – at a glance

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Market capitalisation

C\$25.82 million (at press time)

Quoted shares on issue

368.89 million



Uranium enjoys renaissance as penny drops on energy supply, geopolitics

When Australia's John Howard returned from years in the political wilderness in the mid-1990s to become leader of the opposition and then prime minister for an 11-year tenure, he famously referred to his achievement as "like Lazarus with a triple bypass".

Nadav Shemer

The same could be said of nuclear power – and by extension, uranium – today. Written off in 1986 after Chernobyl and again in 2011 after Fukushima, nuclear is enjoying an unlikely renaissance as the one source of power capable of combatting both energy shortages and carbon emissions.

In last year's *Uranium Outlook*, we wrote that the uranium market was spluttering to life with stocks of companies in the sector seeing significant gains. While uranium stocks have fallen back in the past 12 months – a natural consequence of trading in an overall bear market – the political support for nuclear power's revival has well and truly arrived.

The most surprising recent headlines haven't been from the United States, where president Joe Biden recently signed a new law to provide investment and tax incentives for existing nuclear plants and new, advanced reactors, or Canada, which has committed C\$970 million (\$715 million) to finance the deployment of small modular reactor technology, or China, which has announced plans to build 150 new civilian nuclear reactors by 2035, but from countries that were headed for complete nuclear phase-outs.

In Japan, site of the Fukushima disaster, prime minister Fumio Kishida has directed a government panel to look into how "next-generation nuclear reactors equipped with new safety mechanisms" could help the country achieve carbon neutrality by 2050. And in Europe, countries that were on track to phase out nuclear power – including Germany and Belgium – have extended the life of nuclear plants to ensure stable power supply.

Energy policy U-turn

Nuclear power never disappeared altogether; in fact, it contributed around 10% of all global electricity production in 2020 and has produced a constant 19-20% of US electricity from 2000 to the present day. But up until very recently, it was on track to be phased out in much of the developed world (although not in major emerging economies such as China and India, which have been committed to nuclear power for many years and which together account for 29 of the 50 nuclear reactors currently in construction around the world).

Two key developments have driven the energy policy U-turn in developed economies, according to John Ciampaglia, CEO of Sprott Asset Management. The Sprott Physical Uranium Trust (SPUT) invests in uranium oxide in the form of U₃O₈ and is the largest physical uranium



Ikata nuclear power plant
(Ehime Prefecture), Japan

fund in the marketplace. SPUT has accumulated 59Mlbs of uranium since its launch in mid-2021, bolstering the spot uranium price.

The first development was the overloading of intermittent renewable power sources onto the grid, to the extent that “the grid is now unstable,” Ciampaglia said.

“We’ve spent trillions of dollars globally building solar and wind and hydroelectric [power plants] and all those things are vulnerable to weather conditions. How you offset the unpredictability of weather is you need reliable baseload energy creation. There are only three ways to do that: you can burn coal, you can burn natural gas, or you can use nuclear energy. The world is trying to move away from coal and natural gas in order to lower greenhouse gas emissions, and that’s where nuclear fits. It’s the perfect complement [to renewable energy] in terms of low greenhouse gas emissions but [provides] more reliable baseload power.”

The other development was Russia’s invasion of Ukraine, which showed how the energy security of a major economy such as Germany could be vulnerable to a single geopolitical event.

“When you think about nuclear energy, it’s about energy density and about being less susceptible to supply and price shocks,” Ciampaglia said.

“If you think about a natural gas plant where you’re getting your gas through a pipeline from Russia every day, you’re really beholden to that source of natural gas to operate that plant and generate electricity. If there is a disruption

to that gas, your plant turns off. If the price [of that natural gas] spikes, then the price of your electricity generation goes up exponentially, which you have to then pass on to your end users.”

“A nuclear power plant operates in a completely opposite fashion. When you load the fuel into a nuclear reactor – and that amount of fuel is literally the size of what you can put in one tractor trailer – it runs continuously for about 18 months. You have zero vulnerability from a price shock or from being cut off from the fuel. It’s the ultimate hedge against the just-in-time energy sources like natural gas and coal.”

By turning to nuclear power, Western policymakers and nuclear plant operators are now having to face up to another issue involving Russia: its influence over nuclear supply chains.

Russia only accounts for around 5% of global uranium mine production, with Kazakhstan producing 45% and Canada, Australia and Namibia combining for an additional 30%. But much like China in the battery metals space, Russia dominates the midstream and downstream segments of the nuclear value chain and owns a significant share of production in Kazakhstan via its state-owned mining company Uranium One.

Uranium leaves the mine as the concentrate of a stable oxide known as U_3O_8 or yellowcake. Prior to enrichment and fuel fabrication, U_3O_8 must be further refined and converted to uranium hexafluoride (UF_6), a process jointly referred to as conversion. Russia’s Rosatom facility accounts for 20% of global conversion nameplate capacity

World enrichment capacity – operational and planned		
Country	Company and plant	2020 capacity (thousand SWU/yr)
France	Areva, Georges Besse I & II	7500
Germany-Netherlands-UK	Urenco: Gronau, Germany; Almelo, Netherlands; Capenhurst, UK	13,700
USA	Urenco, New Mexico	4900
Russia	Tenex: Angarsk, Novouralsk, Zelenogorsk, Seversk	27,700
China	CNNC, Hanzhun & Lanzhou	6300
Other	Various: Argentina, Brazil, India, Pakistan, Iran	66
Total SWU/yr approx		60,166
Requirements (WNA reference scenario)		50,205

but – due to being the only conversion facility operating at near-100% capacity and the fact that the ConverDyn facility in the US has been closed pending market improvements – accounted for 38% of conversion services in 2020. Furthermore, Russian facilities account for 46% of world enrichment capacity, European (French, German, Dutch and British) facilities for 35%, Chinese for 10% and US facilities for only 8%. As a result, European countries with nuclear power variously source 25-100% of enriched uranium from Russia, while the US faces the question of how to ramp up its domestic nuclear capacity while the Russia suspension agreement – which mandates that Russian imports must not exceed more than 20% of US enrichment demand – remains in force.

But the above goes only some way to accounting for the interconnectedness between US and Western utilities on the one hand and Russian enrichment facilities on the other, as Jeff Geringer, director of commercial and corporate development at Canadian uranium project developer Denison Mines and a former utility nuclear fuel buyer, explained.

“Often, Western utilities only buy the enrichment component of enriched uranium from Russia. A typical contract sees the US utility pay cash for enrichment work and then deliver to the Russians – or their intermediary – equivalent natural uranium hexafluoride, which is sourced on the open market by that utility,” he said.

“Even when Russian companies sell uranium to export

markets, much of the yellowcake originates in other countries. Russia is an integral part of a global nuclear fuel market, importing uranium from Central Asia and exporting via enrichment contracts with foreign utilities. Deliveries haven’t ceased other than to a utility or two in Europe that have pulled the plug themselves. But obviously many fuel buyers can’t or won’t do new business with Russia now, and every day the war in Ukraine continues the more the nuclear industry expects that inevitably Russian supply will get officially cut off. The real question is when.”

Incentive price still needs to rise

The Biden administration launched a \$6 billion programme in April 2022 to keep open cash-strapped American nuclear plants. In a statement to mark the launch, US energy secretary Jennifer Granholm acknowledged that nuclear power plants contributed more than half the country’s carbon-free electricity and said the funding was part of the administration’s strategy to fight climate change.

Twenty of the 99 operating nuclear reactors in the United States were at risk of shutting down in the last decade before states stepped in to save them, according to the Nuclear Energy Institute (NEI). Moreover, one-quarter of the fleet was at risk of shutting down when the federal funding programme was announced earlier this year.

Cheap electricity prices have been a main cause of nuclear’s struggles, which was contributed to by federal

Estimated world primary conversion capacity 2020					
Company	Country	Location	Nameplate capacity (tU)	Capacity utilisation (%)	Capacity utilisation (tU)
Orano*	France	Pierrelatte & Malvézi	15,000	17%	2600
CNNC†	China	Lanzhou & Hengyang	15,000	53%	8000
Cameco	Canada	Port Hope	12,500	72%	9000
Rosatom	Russia	Seversk	12,500	96%	12,000
ConverDyn‡	USA	Metropolis	7000	0%	0
Total			62,000	51%	31,600

* Orano’s new conversion facility is still in the process of production ramp-up, which is expected to be finalized by 2023. † Estimated capacity according to the assumption that China will develop its conversion capacity to supply the needs of the domestic reactor fleet. ‡ ConverDyn reduced capacity of its Metropolis plant in 2016 then closed it down pending market improvement in 2017. In January 2021 it announced that it plans to restart the plant after refurbishment in 2023.

and state policies to subsidise wind and solar power sources, according to the NEI.

Looking forward, it is the message as much as the funding that will give utilities the confidence to extend the lives of nuclear power plants or build new ones—and to go out and sign long-term contracts with uranium producers.

The energy policy U-turns have, to quote Ciampaglia, given nuclear plants “a new lease on life.”

“The utilities now can make long-term investments and capital decisions,” he said. “As they have greater confidence that they’re actually going to be operating five, 10 or 20 years down the road, they’re going back to market and they’re contracting more uranium. This is really healthy for the sector because we always believed that the price needed to reset to ensure long-term supply for utilities. As the price has gone from \$20 [per pound] to \$40 to \$45 to \$50, what you’ve seen is that all of the mines that were put on care and maintenance in the downturn are slowly coming back online. It will take one to two years to bring them back online but it’s absolutely critical that they come back online to meet the supply gap”.

While substantial supply gaps are being forecast for critical metals such as copper, nickel and lithium, the supply gap in uranium is already a reality. Miners produced 48,332t (roughly 107Mlb) of uranium in 2021, meeting about 77% of global demand of about 63,000t (approximately 139Mlb), according to the World Nuclear Association

(WNA). Mines supplied an average of 78% of global demand from 2018-21, compared to 93% from 2012-17, according to the WNA, with the shortfall being bridged by secondary sources including stockpiled uranium as well as by underfeeding at enrichment plants. But those inventories have been drawn down and the supply shortfall is projected to be a real problem.

The WNA’s upper demand scenario has uranium demand reaching around 65,000t (145Mlb) in 2022, 100,000t (220Mlb) in 2030 and more than 150,000t (330Mlb) in 2040, resulting in deficits of roughly 10,000t (22Mlb) in 2022, 20,000t (44Mlb) in 2030 and 80,000t (176Mlb) in 2040 that would need to be met by mines not yet in production, development or planning. A similarly bullish scenario from UxC, one of the nuclear industry’s leading market research companies, has uranium demand reaching roughly 82,000t (180Mlb) in 2022, 95,000t (210Mlb) in 2030, and 107,000t (235Mlb) in 2035, resulting in deficits of around 23,000t (50Mlb) in 2022 and 2030 respectively and 48,000t (105Mlb) in 2035.

Although many operators have announced plans to bring uranium mines out of care and maintenance, Ciampaglia said the uranium price would need to rise substantially from its current point of a little more than \$50/lb for supply to meet demand.

“At \$50/lb, we’ve seen that price signal as an incentive to allow the companies with mines on care and maintenance to have the confidence to say they’re going to reopen



Rossing Uranium Mine, Namibia

after being closed for four to five years. But that's not the pricing you need to develop a greenfield project, where the massive upfront capex means the price you need to get that project off the ground is probably \$70, \$80, \$90 or even \$100, depending on where the mine is located, its local cost structure, the complexity to get the permits, the availability of labour, etc," he said.

Mine restarts come under varying degrees of pressure from costs and grades, he said, noting that while restarts have been announced in Canada, Australia and Namibia, not a single one has been announced in the United States.

"The US has a very high cost structure because labour has been very tight there. Go and try to find a truck driver down there. When you think about having to hire in some cases hundreds of people to restart a mothballed project, it's quite daunting. Even when the price of uranium briefly hit \$60 in April [2022], you didn't hear any US companies say they were restarting production there," he said.

"I think that reinforces this idea that the high-grade mines can come back online in the \$50-\$58 ranges – they're probably contracting in the high fifties, but some of the other deposits are clearly going to need \$65, \$70, \$75 and so on. We think more supply response will come with higher prices."

Previous long-term uranium commitments have also had an impact on producers, as Denison's Geringer explained.

"Many long-term uranium contracts have a fixed-price component or price ceiling that is in some way reflective of the uranium price at the time the contracts were sold. This means that the realised price that producers receive from contracts tends to lag the market, in some cases by several years. So we have had tremendous recovery in the uranium price, but many of the pounds being delivered into the market today reflect pre-2021 pricing. So not everyone is fully realising these higher prices. Especially with significant mining cost inflation, that is putting pressure on producers and their sales books and potentially increasing the value of the remaining pounds they have for sale."

Who are the next producers?

While long-term uranium prices have hovered around the \$50-\$52 mark since early 2022, enough activity has returned to the nuclear sector to generate confidence among uranium miners and project developers.

Nowhere was this more evident than in the October 2022 announcement that Cameco – the world's second-largest uranium producer and an operator of refining, conversion and fuel fabrication facilities in Canada – had teamed up with private equity firm Brookfield Renewable Partners to acquire Westinghouse Electric, one of the world's leading providers of nuclear power technology, for \$7.9 billion.



As Tim Gitzel, chief executive of Cameco, said in a statement announcing the deal, "We're witnessing some of the best market fundamentals we've ever seen in the nuclear energy sector."

Cameco operations produced 12.2Mlbs U₃O₈ on a 100% basis in 2021, all from the company's majority-owned Cigar Lake mine in the high-grade Athabasca Basin in Canada's Saskatchewan province. But what is more notable is how many pounds Cameco *didn't* produce. Cigar Lake operated below capacity due to the COVID-19 pandemic and is expected to produce 15Mlbs in 2022. Moreover, long-running production suspensions continued at the McArthur River mine and adjoining Key Lake Mill in Saskatchewan and at several lower grade mines in the United States, keeping about 23Mlbs out of the market. At time of writing, Cameco expected to resume production at McArthur River and Key Lake by the end of 2022.

Cameco is currently the only uranium pureplay that is not state-owned or controlled. But that could soon change, as positive market fundamentals have prompted at least two smaller publicly-traded uranium companies to restart long-suspended operations.

The same market fundamentals that prompted the company to decide to restart McArthur River have had the same effect on at least two smaller publicly-traded uranium companies.

Paladin Energy confirmed in July 2022 that the Langer Heinrich mine in Namibia would return to production after going on care and maintenance in 2018. The Australian-listed company completed an institutional placement for around A\$200 million (\$130 million) several months before the confirmation which, together with existing funds,

“We have had tremendous recovery in the uranium price, but many of the pounds being delivered into the market today reflect pre-2021 pricing”

should cover all of the recently updated project capital expenditure of \$118 million. It is targeting production in the March quarter of 2024, and expects a 17-year mine life at an average of 4.6Mlbs per year.

Also on the ASX, Boss Energy made a final investment decision in June 2022 to develop the Honeymoon in-situ recovery project in South Australia, which last saw production in 2015 under previous ownership. Boss is targeting first production in the December quarter of 2023, with an expected ramp up to 2.45Mlbs of U₃O₈ within three years. It successfully raised A\$120 million in March 2022 and recently received state government approval for its updated environmental protection and rehabilitation programme.

As for greenfield mine developments, there are two of note in the high-grade Athabasca Basin.

NexGen successfully completed a feasibility study for its Rook I project's Arrow deposit in 2021 and is now in the front-end engineering and design stage. The feasibility study outlined average annual production of 28.8Mlbs U₃O₈ for the first five years and 21.7Mlb average annual production at a grade of 2.37% across an initial 11-year mine life, which would make it the world's largest uranium mine. The study also outlined an average annual operating cost of C\$7.58/lb U₃O₈, which would make it one of the world's lowest-cost uranium mines. NexGen is funded for the estimated \$158 million of early works capital but will need to secure financing for the estimated \$1.14 billion in project execution capital costs.

Another Athabasca resident is Denison Mines, which expects to complete a feasibility study at its Wheeler River project's Phoenix Deposit by mid-2023. A 2018 prefeasibility study outlined a 10-year mine life consisting of average annual production of 6Mlbs U₃O₈ at a grade of 19.1%. The study outlined initial capital costs of \$323 million and average annual operating costs of C\$4.33/lb U₃O₈. Denison believes the feasibility study will prove the

project is bankable, even with the obvious impact of cost inflation.

In addition to Rook I, at least five other greenfield projects have checked off both feasibility studies and mining permits:

- TSX-listed Forsys Metals' Norasa project in Namibia's highly-regarded uranium district is looking at 5.2Mlbs average annual production over a 15-year mine life.
- Another TSX company, Global Atomic, has outlined an initial phase of 3.8Mlbs annual production over a 15-year mine life at its high-grade Dasa project in the Republic of Niger.
- ASX-listed Deep Yellow's Mulga Rock project in Western Australia is undergoing a revised definitive feasibility study after a previous DFS confirmed a project with around 3.5Mlbs production over a 15-year mine life.
- Fellow ASX-listed company Peninsula Energy recently completed an update to the DFS for its Lance project in Wyoming, USA, which outlined annual average production of 1Mlbs over a 14-year mine life.
- And ASX-listed Aura Energy's Tiris project in Mauritania is targeting 1Mlbs annual production in a “fast-track” first phase that it expects to begin in the second half of 2024, followed by a ramp up to 3-5Mlbs within five years of first production. It expects to make a final investment decision in the January quarter of 2023.

This could be just the beginning

Rising uranium prices, investor enthusiasm and political support are all evidence of a genuine – and potentially long-term – revival in the uranium sector.

But while a lot of capital has come into the sector in the past 18 or so months, uranium bulls such as Ciampaglia believe this story is still in its early stages.

“While the price has gone from \$28/lb to \$52/lb, I would say that's largely been on the back of a small subset of institutional investors getting positioned in the sector. The sector is still too small in terms of its market capitalisation and liquidity for many larger institutions to even get started,” he said.

“You would think that when a price moves, it would attract a very large amount of capital and the trade becomes crowded, so to speak, but we just don't see that at all. We speak with a lot of institutions that tell us they're very intrigued by this but it's very hard for them to get positioned in this sector because there aren't a lot of options. I think that as the sector continues to grow and becomes re-capitalised, that naturally will bring in more investment and create a snowball effect.”

Global Atomic homes in on Dasa financing

Toronto-listed Global Atomic Corporation has enjoyed a strong 2022, culminating in the recent sign-up of a second major Western utility for volumes from its Dasa uranium project in Niger. With steady progress being made on the ground, company president and CEO Stephen Roman hopes to wrap up project financing shortly as his team vies to bring what is Africa's largest highest-grade uranium project online in a little over two years from now

Several pieces must fall into place in order for that to happen, but favourable uranium market conditions, a highly promising deposit, and a stellar team mean Roman is unphased. On the financing front, the CEO told *Mining Journal* he expected to have word on banking terms by the end of the year, which should give guidance on what additional equity capital might be needed.

Solving the funding equation – total capex is slated at US\$208 million – would cap an impressive run for the industry veteran. In the last six months alone, Roman has already overseen, among other things, an initial offtake agreement, a successful negotiation with the government of Niger – which saw Niger double its stake in the project to 20% – and delivery of an impressive drilling programme.

For now, building out the customer base is a key priority. In addition to the two utilities already onboard, Roman said he had “a number of other discussions on the go” and was looking to sign up “a few more”.



Global Atomic Corporation president and CEO Stephen Roman

"We need to sell at least 1.5Mlb/pa to cover all our costs and our bank requirements," Roman explained. "This mine, at 1,000t/d, is capable of processing and producing about 4.5Mlb/pa. Based on recent discussions with nuclear utilities, I think as we complete some of these milestones, you'll see more of these utilities sign on with us".

A 2021 feasibility study for Dasa outlined an initial phase one mine development over 12 years, producing 45.4Mlb and an after-tax NPV8% of US\$157 million and an IRR of 22.7%, using a base case uranium price of US\$35/lb.

With all-in sustaining costs slated at US\$22/lb and OPEX costs already in the region of US\$18-19/lb, Roman believes the company's recently expanded drilling programme will see OPEX costs fall even further.

"The feasibility study took into account developing the ore body along a 2km strike length. We don't need to develop those outlying areas right now – they are areas you could develop 30-40 years from now," Roman said. "Right now, the areas that our drill programme targeted were inferred resources around our phase one area, which will allow us to mine in that area for many more years, decreasing the underground development required and lowering our cost."

The project's numbers look significantly better in the current price environment, just north of US\$50/lb. Not that Roman thinks the bull run is anything like finished. On the contrary, he believes the forecast build-out of the global nuclear fleet, coupled with additional demand from small modular reactors (SMRs), could create a price

"The current reactor fleet is already in a 60-80Mlb/pa deficit. So if you double the reactor fleet, where are you going to get the fuel?"

spike on a par with 2007, when prices briefly touched US\$140/lb.

"The current reactor fleet is already in a 60-80Mlb/pa deficit. So if you double the reactor fleet, where are you going to get the fuel? Even if all the mines that are known today come on stream, their projected uranium supply doesn't handle the fuel requirement," Roman said.

This shortfall has been exacerbated by the Ukraine war, presenting Roman's company with an unexpected opportunity. "A lot of countries that were previously getting supplies from Russia are now speaking with us – they want a diversification of supply," he added.

While Global Atomic has undoubtedly benefited from the recent buzz surrounding uranium, it was in a better position to capitalise on the favourable market



Camp expansion in progress to accommodate up to 150 workers



Solar panels

conditions than many of its rivals. That is largely because, in the fallow years following the Fukushima disaster in 2011 when many juniors fell all but dormant, Roman's company took proactive steps to prepare for an uptick in prices. "A lot of people wait for markets to improve before they start doing their work," he said. "We did not wait. So that's why right now we're ahead of the game. And we're actually in construction currently to build the Dasa mine and definitely be one of the first producers out there in 2025 to take advantage of a better uranium market."

The sheer quality of Dasa certainly gives Global Atomic a significant leg up on the competition. The Tim Mersoï Basin, in which Dasa is located, shares many characteristics with Canada's Athabasca Basin, the world's leading source of high-grade uranium. In both instances, the uranium is contained in sandstone host rocks, much softer and easier to handle than, say, the granite mined until recently by Rio Tinto at Rossing in Namibia.

"We've been blessed with a fabulous large high-grade deposit that doesn't have a lot of metallurgical issues," Roman said. "It's basically a standard crush, grind, acid leach and precipitate, which a lot of other uranium projects use. However, based on what kind of rock they're found in, you could have many more issues recovering the uranium and processing it. We really don't have any big issues on our project."

As for the 'Africa factor', Roman believes the strong American military presence – the US has its largest base in Africa just south of Dasa in Agadez – together

with government buy-in should help soothe investors' nerves. "[The Niger government] very intently secures that area, as uranium production constitutes a very large portion of Niger's export revenues," he explained. "The government makes sure that companies can operate there, and that they can continue producing revenue for the country."

Global Atomic Corporation – at a glance

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Market capitalisation

\$716 million (at October 31, 2022)

Quoted shares on issue

180.4 million

Major shareholders

Management & board (20%)

Retail investors (45%)

Institutional investors (40%)



Blue Sky's big ambitions for Patagonia's uranium resources

Blue Sky Uranium is advancing a portfolio of uranium-vanadium projects in southern Argentina to the pre-feasibility study stage

Argentina has the potential to produce enough uranium domestically to wean itself off expensive imports for electricity generation in the near future, said Nikolaos Cacos, CEO of Vancouver-based Blue Sky Uranium.

Despite its huge potential, Argentina's mining industry remains underdeveloped, claimed Blue Sky Uranium CEO Nikolaos Cacos. And he should know. Cacos has worked with Grosso Group Management Ltd since 1993, when the mining sector in Argentina was first opened to foreign investment. Grosso Group, a private company that provides management services to Blue Sky, is headed by Joseph Grosso, one of the early pioneers of the mining sector in Argentina, who had previously made gold, silver and zinc discoveries with junior companies in Argentina. However, in 2006 he became aware of the country's nuclear potential and along with the other principals of Grosso Group co-founded Blue Sky to explore for uranium in the country. "I always tell my investors that if they want to establish a nuclear company, there is no better place than Argentina," Cacos said.

Argentina has three nuclear reactors, generating about 7% of its electricity, according to BP statistics. The country is also planning to build two additional reactors. But all uranium is imported from Kazakhstan and Canada, which adds to the cost of producing electricity.

"Argentina is a nuclear country," Cacos said. "They have been in the nuclear business since the 1950s, almost as long as the US. Argentina is involved in every facet of the nuclear industry – apart from uranium production."

He notes that Argentina has the eighth largest landmass in the world and that the investment framework for mining has improved over the years, from state ownership of

resources in the past to a much more liberalised regime now. "The Argentinian government understands nuclear and the uranium industries," he said. "The government is very supportive. Argentina is an underappreciated country in which to do business. They are of course interested in revenues from mining, including uranium."

Of particular interest to Blue Sky is the Rio Negro province in Patagonia, southern Argentina, where the company is advancing the Amarillo Grande Uranium-Vanadium project, which was discovered following exploration work between 2007 and 2012. The project encompasses the Ivana deposit, which has an estimated 22.7Mlb of uranium in place and 11.5Mlb of vanadium, used to make steel alloys, for use in, for example, nuclear reactors.



Nikolaos Cacos, CEO of Blue Sky Uranium



AGP Exploration at Ivana North

“What we discovered in Rio Negro is not just a project but a district. It is 145km in length, it is enormous,” Cacos said. “The area has the same geological characteristics as Kazakhstan, which hosts some of the world’s largest uranium deposits.”

According to a preliminary economic assessment, as the production costs associated with Ivana are estimated to be relatively modest, the deposit could potentially be profitable with uranium prices as low as US\$20/lb, according to Cacos. “The financial viability is there even at US\$20/lb and right now prices are around US\$50/lb,” he said.

“The deposit is located 25m from the surface so it is not deep,” he explained. “It is also unconsolidated ground and not very hard. That means you don’t need to carry out crushing or blasting, which is expensive.”

If developed, Ivana could produce uranium for an estimated 13 years. Pre-production capital cost is estimated at about US\$128 million, while the Life of Mine sustaining capital cost is estimated at US\$35.46 million. After-tax Net Present Value is calculated at US\$135.2 million.

Blue Sky’s next step is to publish a new resource estimate and then commence a prefeasibility study for Ivana, which will take about 10 months to conclude. The completion of the PFS would bring the company to the stage where a production decision could be made, most likely about autumn 2023. If the project goes ahead it is expected to take about three years before production can start, Cacos said.

But the company is not planning to go it alone. “We would likely want to team up with an experienced producer,” he said.

As for sales, the primary market would be Argentina, to supply its nuclear reactors. Preliminary assessments however suggest that Ivana could produce 1.4Mlb/pa of uranium, which is more than enough to satisfy Argentina’s

needs, allowing for the possibility of exports.

“Argentina pays almost double the current global spot prices for its uranium,” he explained. “We could sell at very competitive prices. And being so dependent on Kazakhstan – as part of the FSU a geopolitically risky region – is a concern. Domestic uranium production would boost security of supply”.

Patagonia, which spans Argentina and Chile, is a vast area known for its natural beauty. Rio Negro, in Argentinian Northern Patagonia, boasts glacial lakes and the snow-capped Andes mountains. Consequently, the environmental footprint of uranium production is of great concern. “Although this is a very sparsely populated area, we go to great lengths to ensure that local communities are informed of our activities and are on board with what we are doing,” he said.

Cacos believes the world is seeing a nuclear renaissance after falling out of favour post-Fukushima. “I am sensing a real shift towards nuclear power,” he said. “There has been a U-turn from many environmental groups in terms of support. Nuclear energy is becoming more and more accepted. It is the best way to decarbonise energy. The new reactors are also safer and cheaper, especially the Small Modular Reactors”.

And with more reactors being built, the outlook for uranium prices is bullish, Cacos said. “A lot of financial players, including hedge funds and banks, are buying uranium and storing it. They obviously believe prices will go up.”

In total, the company has more than 4,000sq.km (400,000ha) of prospective tenements for uranium and vanadium in Argentina. “Can we find more? Of course we can,” Cacos said. “That is what Blue Sky is about. We want to find another Ivana.”

Blue Sky Uranium – at a glance

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Directors

Joseph Grosso, Nikolaos Cacos, David A Terry

Main shareholders

Joseph Grosso (52%)

Nikolaos Cacos (1.40%)

David A Terry (0.51%)

Aura picks up the pace on its pathway to uranium production at Tiris

Portfolio offers globally significant uranium and energy metal potential

Dual-listed near-term developer Aura Energy is poised to capitalise on the momentum of green energy as it approaches a final investment decision for its low-cost Tiris uranium-vanadium project in Mauritania.

A resource update is imminent, along with key government negotiations in Mauritania and advancing additional finance and offtake discussions.

An anticipated 300% rise in the world's electricity demand by 2030 is expected to see uranium demand grow three-fold, with nuclear power forecast to increasingly replace coal as a baseload, near-zero carbon emissions energy source in the global shift towards decarbonisation.

Tiris is described as one of the lowest capex, lowest operating cost uranium projects slated for development.

However, Aura is not only relying on its uranium credentials and is positioning as a new energy company, thanks to the significant vanadium content at Tiris and its complementary Häggån high-grade vanadium and battery metals project in Sweden.

"The importance of Tiris and the other Aura projects will play an important role in the security and stability of energy supply globally," said David Woodall, who joined Aura in September as managing director and CEO.

His mining and corporate experience is seen as vital to fast-tracking Aura towards production and rounds out the

refreshed board, which includes former Rio Tinto executive Phil Mitchell, prominent advisor Warren Mundine and experienced uranium mining executive Patrick Mutz.

Chief operating officer Dr Will Goodall, who brings technical expertise, said Aura now had a very strong team to take Tiris forward.

"We're definitely setting up to not just be an 800,000lb/pa producer, we see ourselves as a lot bigger than that and being around for a long time," he said.



Aura Energy COO Dr Will Goodall



Aura Energy is fast tracking to uranium production at the Tiris uranium-vanadium project in Mauritania

Top Tiris

Aura Energy has deliberately set out to establish an expandable operation at Tiris, which has a 56Mlb U₃O₈ resource grading 270ppm.

The company is planning to initially produce 800,000lb/pa, with just 20% of the resource used in the phase one mine plan.

Aura is targeting a 2-4Mlb/pa operation within five years by unlocking additional value from the current resources and progressing exploration in the under-explored region of Northern Mauritania.

A resource upgrade drilling and logging programme finished in mid-October, with final results expected by year-end, along with a FEED study which together will provide key considerations for the FID slated for the first quarter of 2023.

A feasibility study updated last year outlined a modest price-tag of less than US\$75 million for the 85%-owned project.

The study put the C1 operating cost at \$25.43/lb U₃O₈, well below the current uranium spot price around \$50/lb.

Aura doesn't need higher prices to incentivise production, Goodall said, saying the economic metrics already stacked up at Tiris.

He pointed to current contract pricing around \$55-\$60/lb and anticipated the coming supply crunch would put upwards pressure on the spot price.

Aura has taken a number of steps to de-risk development, including reaching a US\$10 million offtake financing agreement with Curzon Resources, covering 15% of production over seven years, which includes a further \$10

million facility. Goodall said Tiris was a unique asset. "It has been described as a case of pure geological luck," he said.

The near-surface deposit is simple to mine, with free-dig ore that can be upgraded significantly, with 90% of the uranium remaining in the separated 20% of material, according to recent pilot plant testing. "That's very unique," Goodall said. "Getting a 500-600% upgrade is something you dream of but we managed to do it – and it keeps everything much simpler.

"It means a smaller processing circuit, which keeps your capital down, your operating costs down, the fact we don't have crushing or grinding circuits keeps power costs down and that keeps our emissions low – so there are a lot of positives that flow out of that mineralisation."

He said the jurisdiction was another positive, saying Mauritania had an established mining code and a supportive government which has already set up its regulatory environment for uranium mining.

"We still have to do all of the same things we would've done in Australia, we're just not finding quite as much red tape," he said.

Vanadium advantage

Tiris has an 18.4Mib vanadium resource and Aura has work underway with ANSTO Minerals, assessing a new circuit to recover vanadium pentoxide as a by-product, which could significantly lower operating costs.

Vanadium by-product recovery has been explored in several other operations with similar mineralogy to Tiris, including Paladin Energy's Langer Heinrich operation in Namibia.

Aura also has a huge 15.1 billion pound vanadium resource at its polymetallic Häggån project in Sweden.

Häggån contains a high-grade vanadium zone, of 124Mt at 0.43% V₂O₅ for 1.1 billion pounds.

The project also contains sulphate of potash, plus nickel, molybdenum and zinc credits – and 800Mlb U₃O₈, which could have been seen as problematic given Sweden's ban on uranium mining.

However Aura intends to develop Häggån as a vanadium and battery metals hub.

"We'll continue to work with the Swedish government around the uranium mining ban just to give the optionality," Goodall said.

"But we want to move the project forward as a vanadium project, and we're working on a scoping study at the moment.

"If Sweden then decides to roll back the uranium mining ban, that wouldn't necessarily trigger us to put uranium back in the project, that decision will be driven by the community.

"As it stands, it could produce a reasonably significant proportion of Sweden's domestic requirements for uranium, so there are some real positives from an energy security point of view. More importantly, the production of vanadium pentoxide in the European market could be a real positive for energy security, through use in vanadium redox flow batteries.

"But Häggån will be a battery metals hub, essentially, rather than just a mine ... to make sure that it's fully supporting the green industrialisation strategies that Sweden has."

Green goals

As well as empowering the green energy transition, Aura is committed to a net-zero pathway at Tiris.

The initial net zero emissions baseline study calculated phase one would produce a low 16,600t of carbon dioxide-equivalent per annum, representing about 0.15% of the entire country's annual greenhouse gas emissions.

Aura intends to expand renewable energy sources as Tiris expands, potentially including vanadium flow batteries.

"Anything you can do to reduce your emissions is going to have a positive economic impact," Goodall said.

"It's a good opportunity to make it a real positive across the board for the project, from an investment point of view, a returns point of view and a humanity point of view."

Aura also has gold optionality up its sleeve in the highly prospective Tasiast South project in Mauritania,

near Kinross Gold's Tasiast mine which is expected to produce 600,000 ounces gold-equivalent in 2022.

However Aura Energy's prime focus is achieving production at Tiris in 2024 and shipping its first yellowcake in 2025.

A near-term catalyst is the looming resource upgrade, which is expected to support the case for expanded production and allow Aura to include the full project in updated economics.

"It looks like a small project at the moment ... but it's a modular design, set up to expand and it'll be a very capital efficient expansion," Goodall said.

"We hope that will be a real re-rating event for Aura.

"We see it as a real opportunity for us to catch up with our peers in the uranium market."

He said the focus on near-term production was a key differentiator for Aura, in addition to the unique resource at Tiris, its expansion potential and the company's growth pathway utilising Häggån in Sweden.

"We're on a pathway to production which will put us in that first crop of greenfields developers ... and that definitely sets us apart from other uranium hopefuls," he said.

Aura Energy – at a glance

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Directors

Phil Mitchell, David Woodall, Patrick Mutz, Warren Mundine, Bryan Dixon

Quoted shares on issue

530 million

Market cap

(ASX: AEE: A\$145.9 million (at October 26, 2022))

Major shareholders

Citicorp Nominees (17.14%)

BNP Paribas Nominees (11.47%)

Computershare Clearing (7.82%)

Woodross Nominees (7.74%)

John Langley Hancock (4.96%)

Game-changing winds for Aurora's uranium, lithium

As readers view this report, the drill rigs will have begun hammering away at Aurora Energy Metals uranium and lithium advanced exploration project in southeast Oregon in the United States

While the company is firmly focused on the uranium component of the AEMP (Aurora Energy Metals Project) in the short term, the current drill programme will also test the potential extent of the lithium-bearing sediments which overlay the uranium mineralisation.

The latest drill campaign, announced on October 19, is a follow up to extensive exploration at the project since its discovery in the late 1970s. The uranium mineralisation, which lies within a volcanic-hosted deposit, is very well-defined with more than 600 drillholes completed, the most recent in 2011.

The campaign involves 17 reverse circulation holes for about 3400m, targeting both lithium and uranium, initially in the north-western part of the project area where the company believes there may be an extension to proven mineralisation.

Aurora already has well-defined uranium mineral resource of 69.3 million tonnes at 248 parts per million uranium

oxide equivalent for 37.9 million pounds of U_3O_8 , along with confirmed lithium hosted in shallow lakebed sediments above and surrounding the uranium deposit.

The company's vision is to supply minerals that are critical to the energy transition, an aspect about which managing director Greg Cochran is extremely upbeat.

Aurora has only been listed on the Australian Securities Exchange since May this year and Cochran sincerely believes the plans his company has for the US project could make it a "mine of the future".



Greg Cochran,
managing director
Aurora Energy Metals

The deposit is near surface with a flat-lying geometry amenable to very low strip ratio open-pit mining. Low-cost mining is possible due to the free-dig nature of the lake sediment overburden. Most of the uranium mineralisation is contained within a fine fraction, amenable to low-cost scrubbing and screening upgrades.

The project is served by excellent infrastructure with the town of McDermitt, sealed roads and hydro-generated power nearby.

Mining engineer Cochran, who had his first association with uranium in his uni days in the 1980s, makes four points about Aurora and the AEMP, which he is keen to see the market recognising when comparing it to other uranium projects elsewhere in the world.

The first point Cochran makes is that the AEMP, with nearly 40Mlb of U₃O₈, has the scale to become a credible uranium mine, with the potential to produce at least 1.5Mlb.

He points out that scale is important because in the past, upwards of 350 uranium mines in the US were producing between 40Mlb and 45Mlb, leading to huge environmental legacies.

“At around 1.5Mlb, you’re at a level where you can develop a fully integrated, standalone operation.

“In the old days, ore was trucked from mines to selected regional plants over great distances. Those mines were

“At around 1.5 million pounds per annum, you’re at a level where you can develop a fully integrated, standalone operation.

often left abandoned. At the scale we’re talking about, you can afford to build a plant to take the uranium through to at least the point of loaded resin. That is a product that you can afford to safely truck great distances.” Loaded resin is the penultimate step in the process which precedes stripping and finally precipitation of uranium.

“That is a proven model in the US and probably what we will consider doing. Scale and quality of the deposit in one single location is what works today, not producing ore from a multitude of smaller deposits that are miles apart.”

Cochran’s second point is about the level of resource definition. “We are not at an early stage of exploration, touting our first intercepts or surface samples which are telling us this or that.



Exploration taking place in the evening at the AEMP in October 2022



A drill team on site at the AEMP in October 2022

"The deposit is over 95% in the indicated category, and we are in the process of converting part of that resource to measured, which is a very high standard of definition. This gives people confidence in our understanding of the geology and our ability to mine the resource. There are more than 600 holes drilled, most of them into the deposit and we are about to put some more into it to generate material for further metallurgical testwork.

"The drill campaign currently taking place will start by testing the north-west corner for a potential extension, which we think there is. And when you look at the intersections we have from the last campaign 10 years ago, any uranium exploration company would love results like that. In that area they are generally thick, high grade and shallow in what is already a close to 40Mlb well-defined deposit. It is all real upside, those intersections were not 150 or 200ppm from 100 to 200m deep, they were all generally close to surface, and frequently well north of 500ppm," Cochran said.

The third point Cochran makes about the AEMP is its location. "While I believe the market has not yet realised the value of our uranium, the lithium gives us huge blue sky potential, as we are 10km from the US's second largest lithium deposit. And we are just 25km from the country's largest lithium deposit, it is all in the same geological sequence."

Anecdotally, Cochran says that each time he and the team visit site, arriving in Reno, Nevada, they pass Elon Musk's Tesla Gigafactory in the Storey County of that state.

"Given the high-value nature of lithium, it is a product which can be transported right across the country, to the east coast where many gigafactories are being developed. Transport is not an issue, but US domestic supply is. And that is why it is great to be where we are."

Still on the theme of location, Cochran says that Aurora's recent acquisition of private land in Nevada on the Oregon border is a game-changer. He explains that while Oregon is a good jurisdiction in which to work, it does not have the robust mining history of Nevada to the southeast.

That means that while the mining operation will be permitted in Oregon, plant and tailings could be established in Nevada, a state which has well-proven permitting processes for what you do after digging of the dirt.

"It is a lot simpler to permit a mine without a process plant in Oregon and that is a major benefit as when it comes to the plant, we will be dealing with regulators in Nevada who have extensive industry experience and who understand mining. In addition, private land is easier to work on, provided of course your approach is environmentally sound and you put a lot of effort into consultation with local communities. This strategy just ticks so many boxes."

Also linked to the subject of location, Cochran points out the favourable price of power in Oregon.

"We have hydropower which costs six-and-a-half cents per kilowatt hour, which is the average price of power in Oregon this year to date. There are not many places in

“There is a growing groundswell of support for nuclear power and now, within the context of climate change, it has political bipartisan support.”

the world which have that kind of pricing. And because it is hydropower, you can immediately begin to envisage a ‘mine of the future’ there.

“This enables you to have a low-impact, low-carbon-footprint mining operation. After mining, the ore can be part-processed in an in-pit crusher, then put on a conveyor belt which takes it to your plant which is about 10km away in Nevada, all done with cheap, reliable, clean power. A pipeline to transport the ore as a slurry is also an option that could be considered.

“Trucks would be used to move waste rock, but ore would be taken out of the pit on a conveyor or in a pipeline. We are already talking to companies that can do amazing things with belts, and I am so excited about that aspect of the project. A ‘mine of the future’ is the way in which we characterise the plans we already have, despite the fact we have only been listed for six months now [May 2022].”

Cochran, a seasoned operator who loved his time with uranium company Deep Yellow and before that with Uranium One, points to the depth of skills and experience within the board and management team, all of whom have experience in geology, processing, finance – and, most importantly – they all know what it takes to develop and deliver a successful operation. “We have all the skills in the right places,” he said.

The fourth point Cochran makes is all about the current environment in the US and globally on the subject of nuclear power and battery minerals.

“The tailwinds in the US supporting production of these commodities are as they have never been seen before. The need, especially in the wake of Russia’s invasion of Ukraine, for significant domestic supply uranium, is strongly recognised.

“There is a growing groundswell of support for nuclear

power and now, within the context of climate change, it has political bipartisan support. The building blocks are already in place and support battery minerals and nuclear power is increasing. And now there is price protection for nuclear power, although it’s not a blunt subsidy, like those that have been handed out to solar and other renewables with questionable success.

“Historically, renewables were given priority access to the grid over nuclear. So effectively the largest, most reliable source of emissions-free electricity was blocked at times from selling into the grid, which rendered them uneconomic. But now, at least, that has changed and there is legitimate price support, though I stress, it is not a giveaway subsidy. There is no doubt that in the US the political tailwinds are behind uranium and lithium mining and Aurora stands to benefit from that,” Cochran said.

In a philosophical sense, Cochran concluded: “There are so many things in our favour, we really are exceptionally well positioned to advance the project.

“And when it comes to the uranium right now, it is about focusing on project development. However, on the lithium side we recognise there is a longer way to go because as it’s still somewhat early-stage exploration and it’s something we must prove up over time. But if you look at the size of the two lithium deposits on our doorstep, the lithium has the potential to outshine uranium as the AEMP has the potential to also be a very large deposit.”

Aurora Energy Metals – at a glance

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Key executives

Peter Lester, Greg Cochran, Alasdair Cooke, Steven Jackson

Shares on issue

142.6 million

Market capitalisation

\$27 million

Major shareholders:

Directors (15%)

Management (13%)

Institutional shareholders (10%)

Balance of top 20 (14%)

Balance of register (48%)



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**URANIUM
OUTLOOK²**

Uranium revival takes
off as reality hits on
energy, geopolitics

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