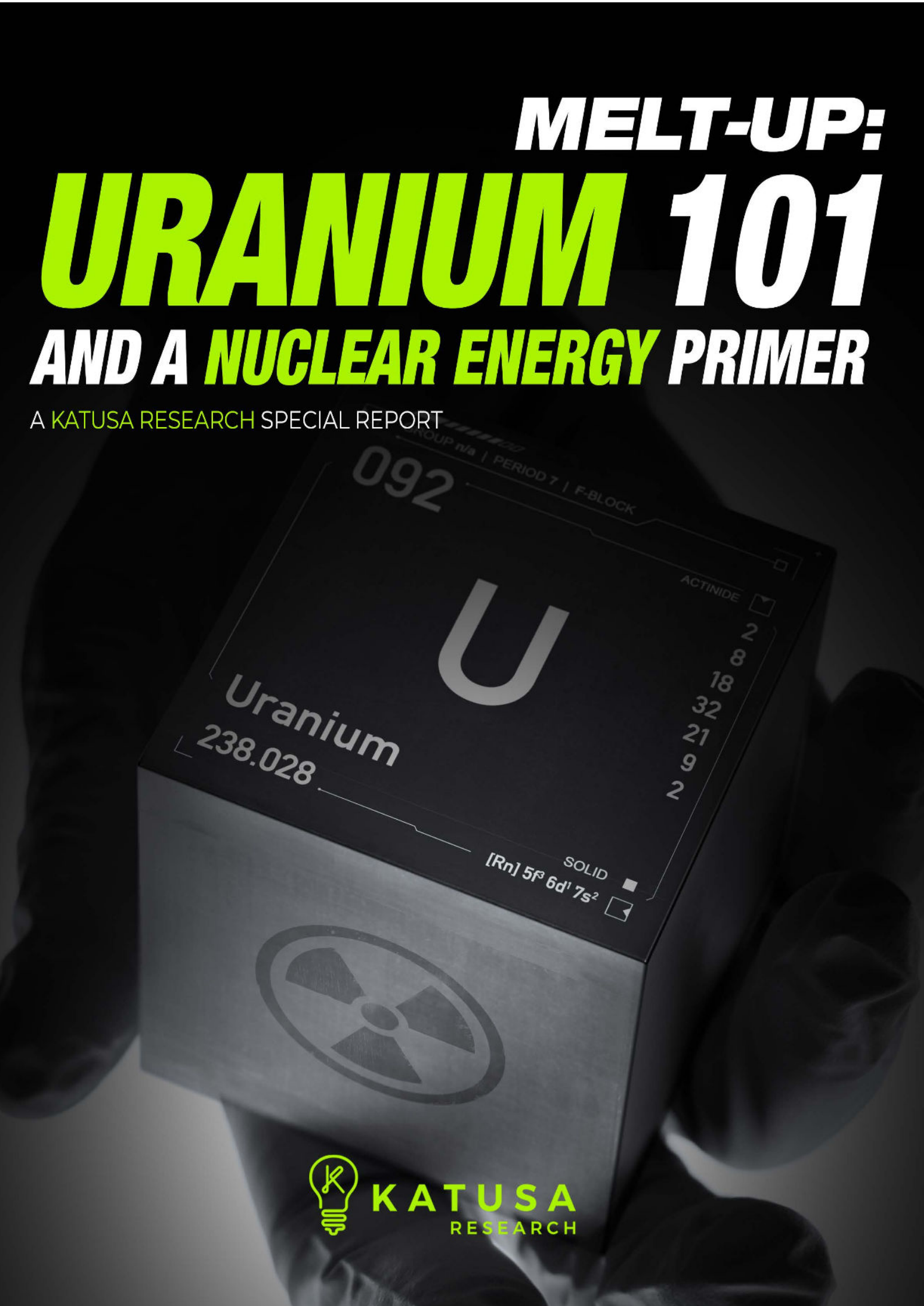
MELT-UP:
URANIUM 101
AND A NUCLEAR ENERGY PRIMER

A KATUSA RESEARCH SPECIAL REPORT



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Investing in equities is high-risk and you could lose your entire investment.

You May Have Noticed a Nuclear Sentiment Shift…

It wasn't widely shared or reported, but it should've been.

Because in 2022, there was major news in the nuclear sector that marked a major shift in sentiment

The U.S. Department of Energy (DOE) announced the achievement of **fusion ignition** at Lawrence Livermore National Laboratory.

This is significant.

Fusion was considered science fiction and wishful thinking until very recently. And now there's scientific proof of a successful reaction.

From the release:

> *"On Dec. 5, a team at LLNL's National Ignition Facility (NIF) conducted the first controlled fusion experiment in history to reach this milestone, also known as scientific energy breakeven, meaning it produced more energy from fusion than the laser energy used to drive it."*

This is a major step to reliable, cost-effective, and stable baseload power for the world. Not to mention, ultra-low in emissions. Bravo and congratulations to all those involved.

When it comes to Nuclear energy, investors must watch Russia and China.

They're planning massive nuclear reactor capacity which will have major impacts on uranium demand.

However, don't forget to keep an eye on Europe…It will be the center of the policy and sentiment shift. It should come as no surprise that European nations are reversing their *'anti-nuclear'* agendas as electricity prices explode.

For instance:

1. Germany has pushed to extend 3 nuclear power plants running.
2. Swiss politicians are now launching a petition to revise the country's anti-nuclear policies.
3. And even Italy is beginning to rethink their long-standing no-nuclear stance

Suddenly, Nuclear is Cool Again. Why?

Simple, nuclear energy is carbon neutral.

Right now, it powers 1 in 5 homes in America and is the cheapest operating source of baseload power in the USA.

For example, 11 nuclear plants in Illinois and Pennsylvania produced more power than all solar in the U.S. in 2021. (Source: EIA)

- **If the U.S. invests about $1 trillion into nuclear energy by 2050, it could supply more than 3,500TWh of energy per year.**

In that scenario, nuclear would provide 85% of current energy consumption.

Oh, and all carbon-free, for less than half of the CARES Act stimulus. Net Zero Solved. You're welcome.

No Brainer: Affordable Net Zero Power

On top of this, the push for zero-carbon energy (aka energy that emits zero emissions) is growing sharply. Things like coal and crude oil production are taboo.

So, there's increasing demand for both cheaper *and* zero-carbon energy sources. This is where nuclear comes in… Putting it simply, you can't hit consistent zero-carbon pledges *without* using nuclear energy. It's just not possible.

That's because nuclear energy is a highly efficient, zero-emission, and clean energy source. Forbes wrote that:

> *"To reach net-zero by 2050, the US would need to deploy* ***one new nuclear power plant worth of carbon-free energy about every six days, starting this week*** *[this was written in September 2019],* ***and continue until 2050…"***

Contrary to the belief of many, new nuclear reactors are incredibly safe. Especially the Small Modular Reactors (SMRs). Some of which are being developed by a company backed by Bill Gates and others supported by the Department of Defense.

Green
Cleaner Tech

The Pentagon Is Helping Bring the Next Generation of Nuclear Technology to Life

The first small modular reactor commissioned by the Defense Department could roll off the assembly line of a Virginia-based factory in just two years.

BWX Technology's large vacuum furnace is being used in a variety of manufacturing and testing applications on Project Pele. *Photographer: Photo courtesy BWX Technology*

These reactors are smaller, meaning they can be placed more strategically near demand centers and are meltdown proof. Yet they can provide the same massive amount of zero carbon electricity to consumers.

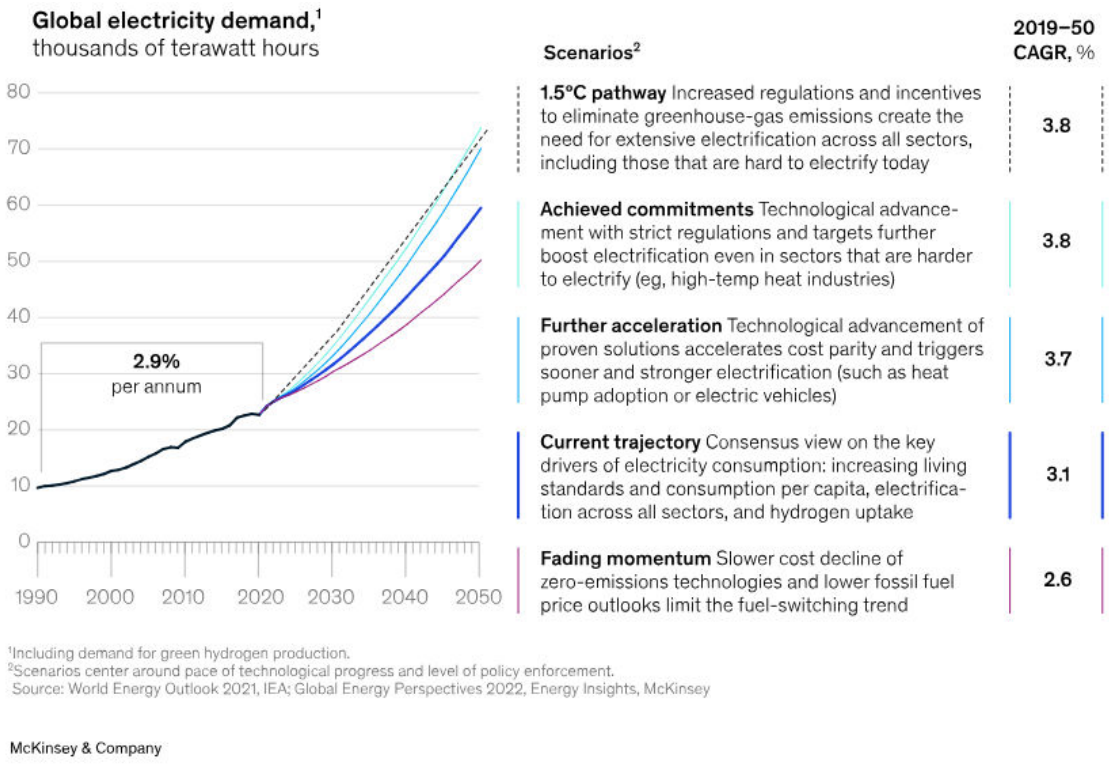
The Perfect Storm for Uranium

Over the past 30 years, global electricity generation has doubled.

As populations continue to grow and nations continue to develop, it's not a question of "if" the world will electrify, it's a question of "how much".

Layer on global decarbonization of the electricity grid and suddenly there is a massive tailwind for new low carbon electricity generation.

The chart below from global powerhouse McKinsey shows that global electricity demand is forecast to grow somewhere between 125%-250% over the next 30 years.



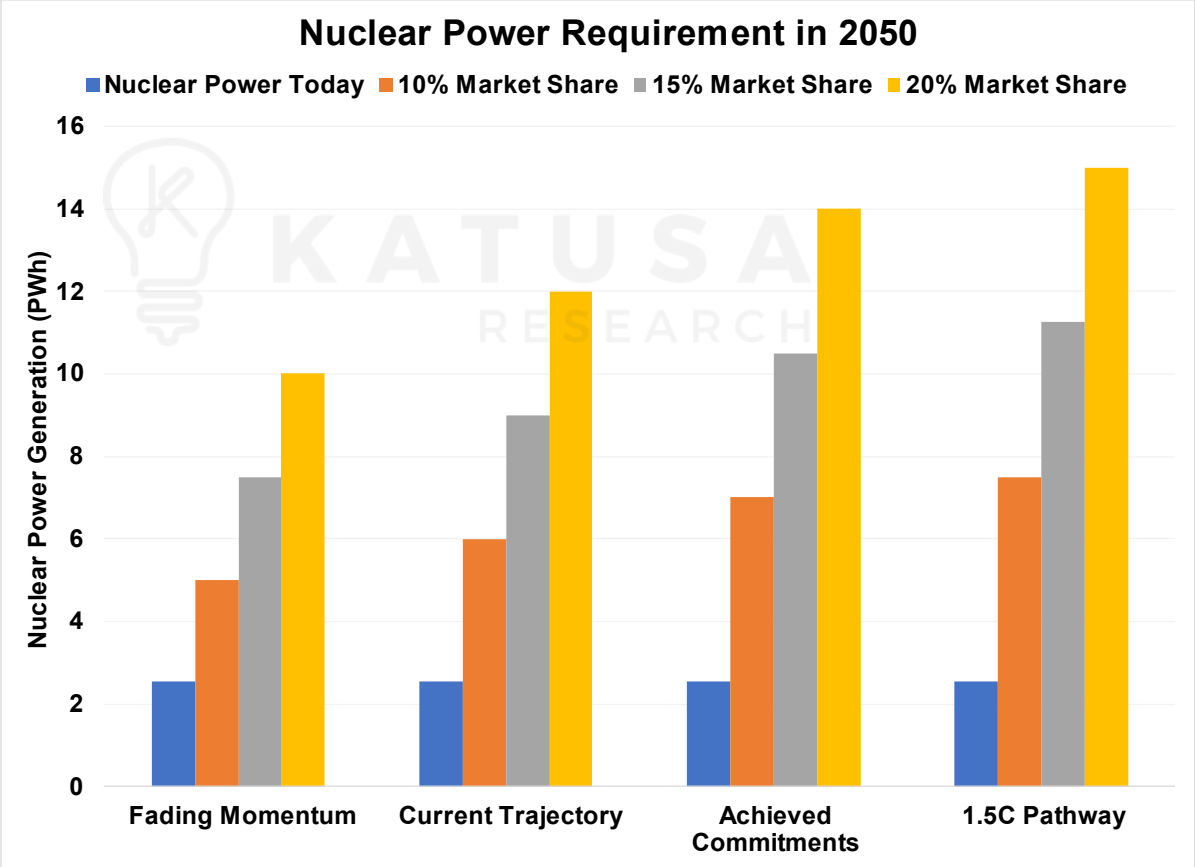
Today, nuclear power accounts for roughly 10% of electricity generation Worldwide.

Given the trajectory of electricity demand over the coming decades, it should be crystal clear the world is going to need more capacity.

- And in the global push to decarbonize, there are only really only a few electricity generation options for near-zero emissions.

Moreso, if you remove intermittent renewables such as wind and solar from the equation, nuclear power stands to be a true cornerstone of global electricity supply.

Based on the McKinsey electricity forecast, the amount of nuclear power generation required is staggering.



- **At the very minimum <u>we are looking at a double in nuclear reactors required</u>.**

- **If nuclear leads the charge, <u>we are looking at nearly a 6x in nuclear reactors</u>.**

The opportunity for nuclear is simply enormous, it just comes down to execution and governments are finally starting to get onboard. In fact, billions of dollars are currently being allocated…

Nuclear power and renewables are essential to proceed with a green transformation. Russia's invasion changed the global energy situation."
– Prime Minister Fumio Kishida, August 24, 2022

Uranium is creeping closer to its final inflection point.

- **In July 2022, the EU stated that nuclear power would qualify as a green investment beginning in 2023.**

That's a monumental statement. It paves the way for a plethora of tax and policy incentives to build out nuclear power plants.

Keeping the momentum going…

In January 2023, GE Hitachi, Ontario Power Generation and SNC Lavalin signed a contract for deployment for the first grid scale Small Modular Reactor in North America.

The US Department of Energy plans to award $3 billion towards the development of two large advanced reactors known as Gen-IV reactors through the Advanced Reactor Program, plus an additional $1.4 billion to a new Small Modular Reactor development.

In a major policy shift, Japan just announced it's going to restart several nuclear reactors over the next 12 months.

The market for uranium stocks went bananas on the news.

Most companies were up double-digit percentage points.

Understandably, the scars from Fukushima run deep in Japan.

It was a horrific event and a major black eye for the uranium sector.

The Big Deal: Japan's Nuclear About-Face

Japan is the world's third-largest economy and fifth-largest greenhouse gas emitter.

It has been stretching its power grid to the max since the Fukushima meltdown in 2011.

- **Prior to Fukushima, 30% of Japanese electricity was produced by nuclear power.**

After Fukushima, Japan immediately shut down all 54 of its reactors.

Today, nuclear power produces roughly 7% of Japan's electricity.

However, an earthquake recently knocked out power and stretched the remaining power lines beyond the max.

This is the second major power crunch felt by Japan, which could have been avoided if the country was running a full power grid.

Their politicians are left with few other options than to return to nuclear as a key source of baseload power.

Japan Pledged to Become Carbon Neutral by 2050

To meet its global climate commitments, the country will need to restart almost EVERY nuclear reactor it shuttered in the aftermath of the 2011 meltdowns.

And then build more.

- **It's forecast that to meet the Paris goals, Japanese nuclear power needs to make up 20% to 22% of its energy mix by 2030.**

That's a 3-fold increase from levels today!

With carbon prices in the EU making record highs in 2022, Japan's pivot will be critical in the country's energy policy.

Going Green Means Going Nuclear

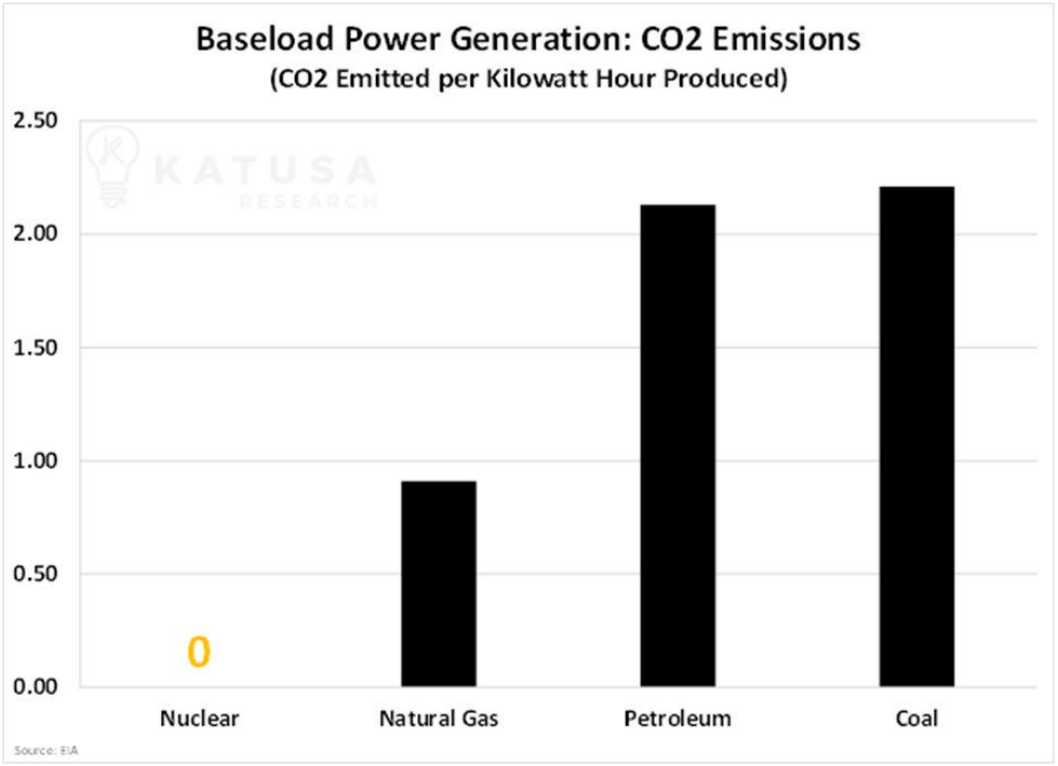
Whether you believe in climate change or not, nations around the world are on a massive regime shift and decarbonization is the focal point.

Decarbonization means reducing greenhouse gas emissions.

And one of the largest sources of greenhouse gases is electricity, making it a key target in the political agenda.

Put plainly, nuclear power is the only baseload electricity source that doesn't emit greenhouse gases. So, if you want to go green, you must go nuclear.

Below is a chart which compares the emissions levels across current baseload electricity generation types.



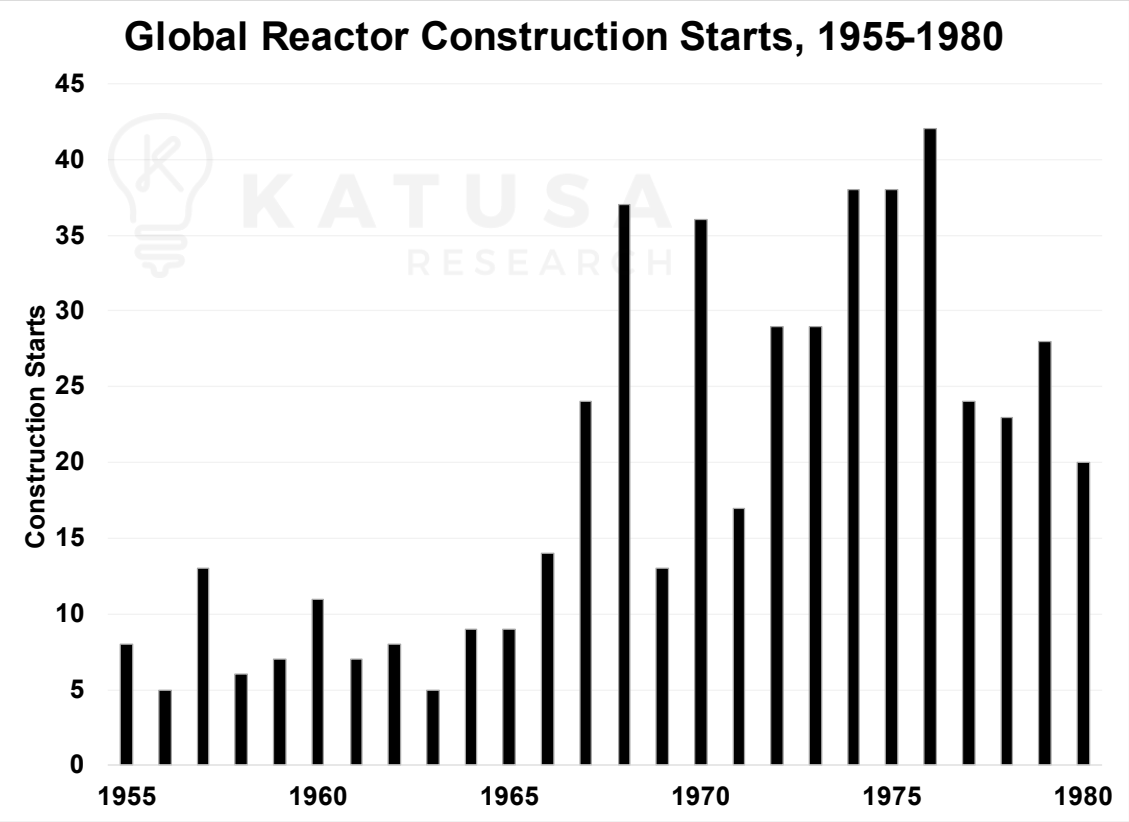
As the chart shows, if the world wants to get serious about lowering emissions from electricity sources, nuclear power must be a fundamental part of the game plan.

Nuclear (Reactor) Superpowers: For Uranium, *Third Time's the Charm*

Twice in the past fifty years, the price of uranium has shot up **600 percent**.

And it could be happening a third time—*right now*.

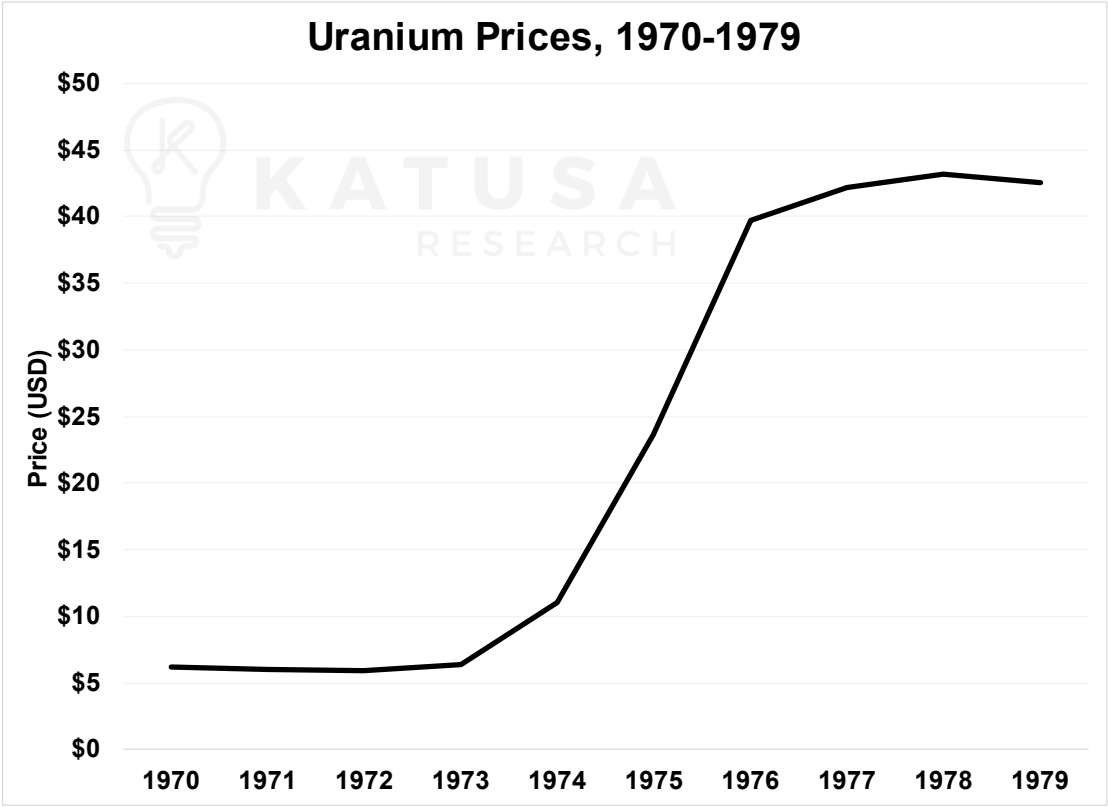
The first rapid increase was in the mid '70s, when the global nuclear reactor buildout began in earnest.



Nuclear reactors require lots of uranium to start up and operate, and it can take more than a decade to get a new uranium deposit into production.

So utility companies became extremely concerned that they wouldn't be able to actually *run* their new reactors when they were finished.

In just four years, the incredible demand took uranium from $6/lb. to $42/lb. Adjusted for inflation, in the late 70's uranium peaked at over $200/lb. in today's dollars.



Of course, every boom has a bust—which is exactly what the Three Mile Island accident did to the uranium market.

Sentiment toward nuclear changed, new construction dried up, and the price of uranium fell...

and fell… and fell some more.

By 1990, it was sitting back at $7/lb., and utilities were sitting on huge stockpiles of uranium.

It would take until 2006 for the price of uranium to finally break free once more. All it took was a single broken pipe at Cigar Lake, an unfinished uranium mine in central Canada.

The Wrench Twist Heard ‘Round the World

Cigar Lake holds the largest reserve of high-grade uranium—*at 100x average grade*—anywhere in the world.

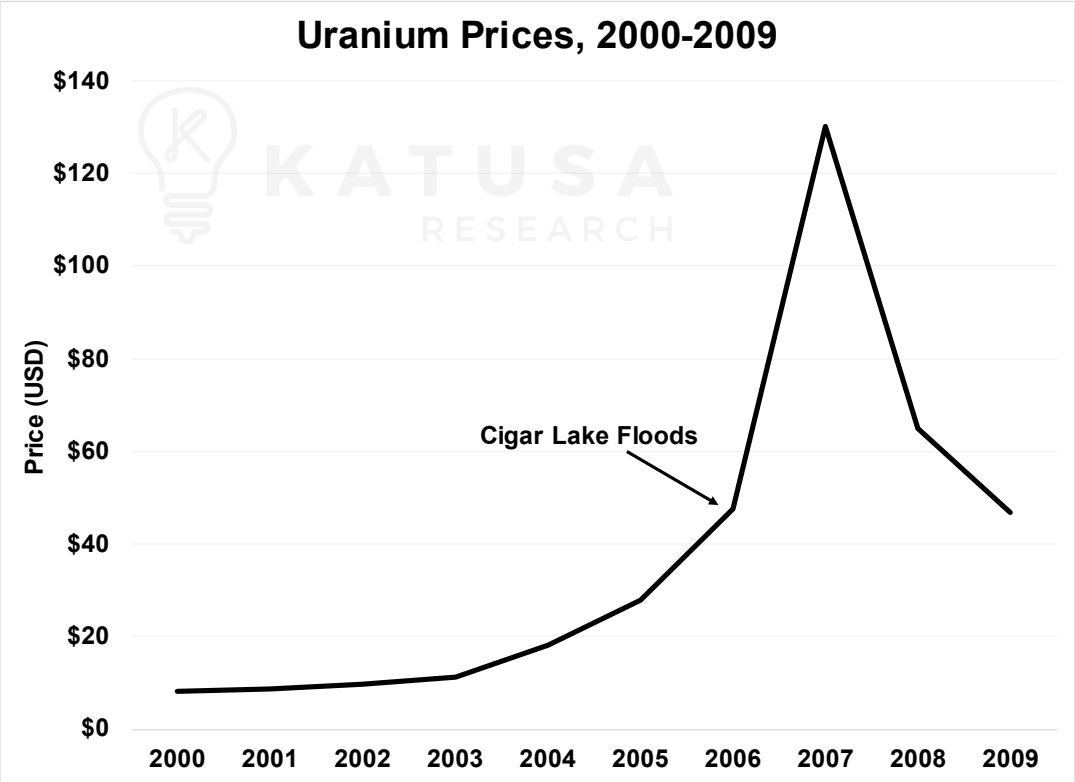
And at the time it was supposed to be completed, it would have produced more than 10 percent of the world’s supply.

But when a small standpipe in Shaft No. 2 sprang a leak, two workers trying to fix it accidentally broke a valve completely off.

The gush of water couldn’t be stopped, and the mine flooded—several times. Mine development couldn’t resume for *four years.*

The mere possibility of a tighter supply, combined with planned nuclear construction around the world, sent shockwaves through the entire uranium market.

Spot prices spiked from $20/lb. to $140/lb. in early 2007—**a second 600 percent gain**.



Cameco, the company that owns Cigar Lake, couldn't have been happier with the payout.

Despite its largest project—by far—having just been delayed by nearly a decade, Cameco's stock *rose* by 300 percent from 2005–2007.

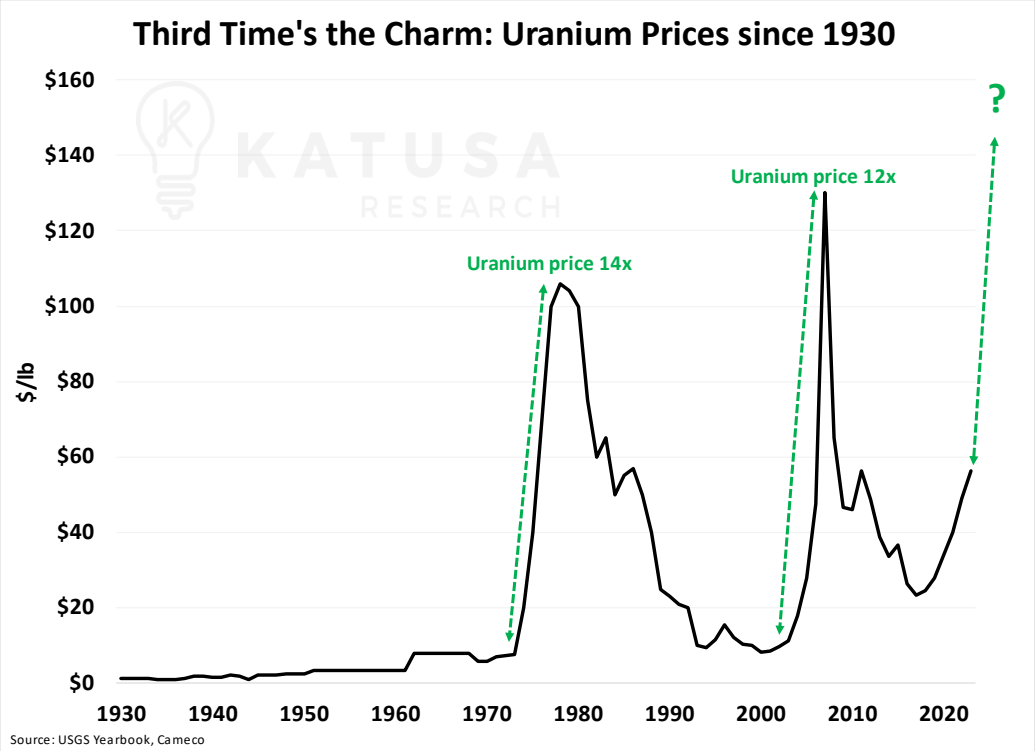
But ultra-high uranium prices led to historically high exploration and production... and the price began to return to normal.

Then Fukushima happened in 2011, and it was Three Mile Island all over again.

As a result, the price fell to one of the lowest inflation-adjusted levels in history. And it stayed there.

The low price forced hundreds of mining companies out of business. The number of uranium companies listed on the ASX and TSX cratered—from 585 to about 50. And more than 70 percent of the market value of major listed producers was completely erased.

Over a decade later, however, and uranium prices are once again starting to show signs of life, breaking out of the previous lows they had settled into:

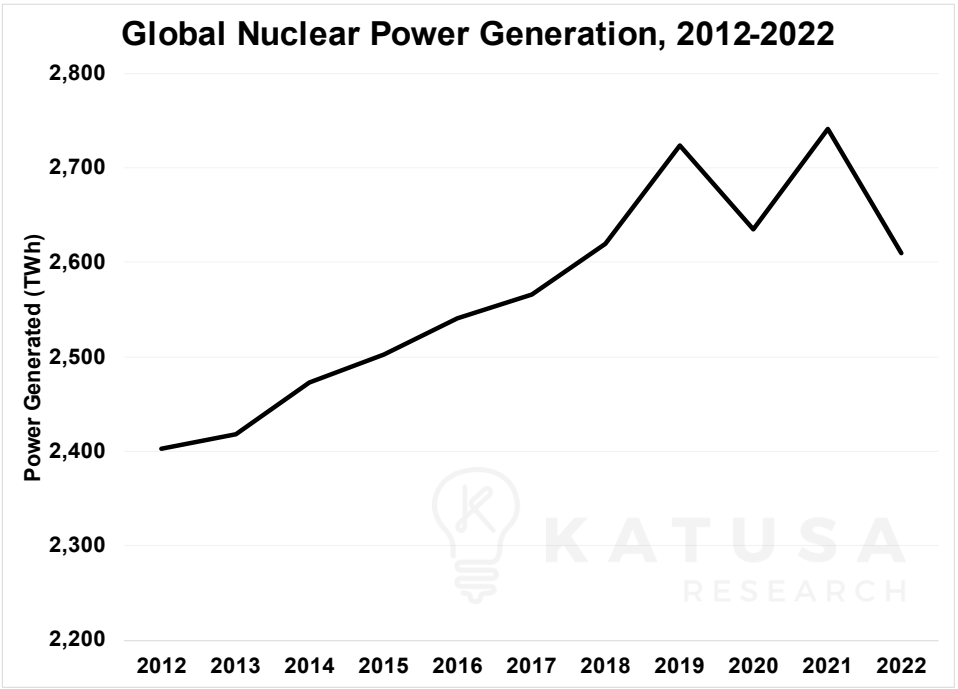


Now, each previous run-up in uranium prices has had a story behind it, and this one is no different… Because there's no better time than now to go nuclear.

When Nuclear Goes Thermonuclear

Analysts have long predicted a steep decline in uranium demand—*only it's never arrived*. Why? Because those predictions are flat-out *wrong*.

Here's why: Even though the number of reactors in the world has declined in the past decade, the total electricity generated by nuclear has actually grown:



Not only that, but reactors are running for far, far longer than uranium demand models ever predicted.

- **The concept of "Long-Term Operations" means that nuclear plants that were originally licensed for only forty years are now capable of running for *up to a century*.**

And governments around the world are providing subsidies to keep them pumping out carbon-free energy for long past their original license period.

- **All of that has led to a 15 percent increase in uranium demand in just two years—from 59,200 tons to 68,200 tons—unaccounted for by analysts.**

But it's nothing compared to what's coming…

> "*World annual reactor-related uranium requirements are projected to rise to... **100,225 tonnes by 2040***."
>
> – Nuclear Energy Agency and International Atomic Energy Agency 2020 report

That's another nearly 50 percent increase. And it comes *before* the major nuclear buildout announcements of the past two years.

Because a decade after Fukushima, countries are quickly discovering that nuclear is the best, if only, way to meet their decarbonization requirements.

So, the announcement and construction of new reactors is picking up again—particularly in Asia.

More Reactors, More Uranium

Currently, 4.6 percent of China's electricity comes from their 48 nuclear reactors. They want to get to 20 percent—which will take another 150 reactors.

That's why China is now expected to grow nuclear capacity from 51 GW to 150 GW by the end of 2030.

China alone will increase the uranium demand by 33 percent annually by 2030.

- **By 2035, East Asia is expected to demand more uranium than all of North America and the EU combined—currently more than 60 percent of global demand.**

And by 2050, China plans to ramp up nuclear energy production to 400 GW.

- **That alone would require approximately 97,500 tonnes of uranium annually—*or about 130% of current global demand*.**

But perhaps the greatest impact on demand for uranium is the number of new reactors that are *planned or anticipated.*

You see, first-load fuel requirements for all these new reactors are about *three times as much* uranium as plants that are in operation.

That's why, when China announced plans to expand nuclear in 2010, the spot price immediately began to rally.

Now, the new reactor announcements are coming in fast and furious…

1. India is building nine new reactors.
2. Japan is accelerating restarting its fleet—and considering rebuilding its decommissioned nuclear reactors.
3. France is building up to fourteen new reactors.
4. Pakistan, Russia, Iran, and Turkey all have reactors being commissioned.

In all, more than 90 reactors are on order or planned—and more than 300 additional reactors have been proposed.

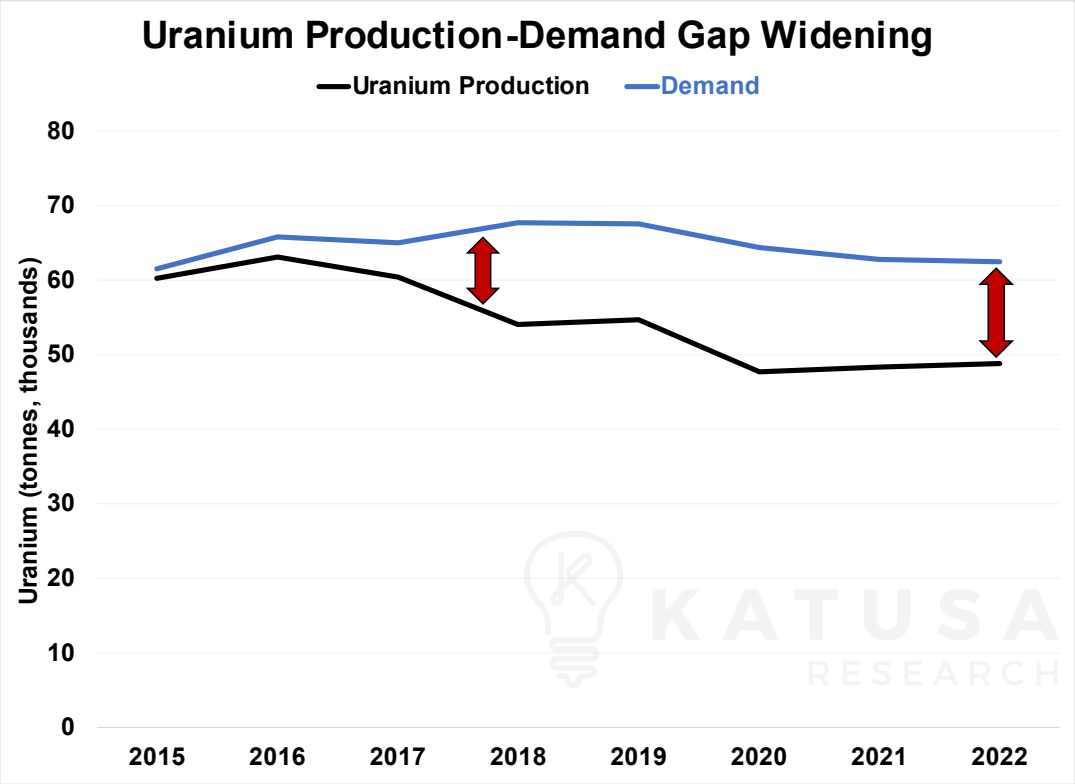
Every one of these needs fuel for the next 80+ years…

But the uranium supply simply just isn't there.

A Run on the Uranium Bank Has Begun

For nearly a decade, uranium mining has been in freefall.

The gap between what miners produce and what reactors need continues to widen rapidly:



Yet mines are *still* slowing production and even shutting down entirely.

In 2022, the demand for uranium was roughly 62,500 tonnes.

Mined supply? 48,888 tonnes.

That's only 78 percent of demand—**just off another record low**.

And that doesn't include high demand from companies that buy up pounds in the spot market for investment purposes nor does it include countries acquiring pounds for their own strategic reserves..

Even if everything from the supply chain to global geopolitics goes perfectly, the uranium market is setting itself up for *severe* deficits in the years to come.

How severe?

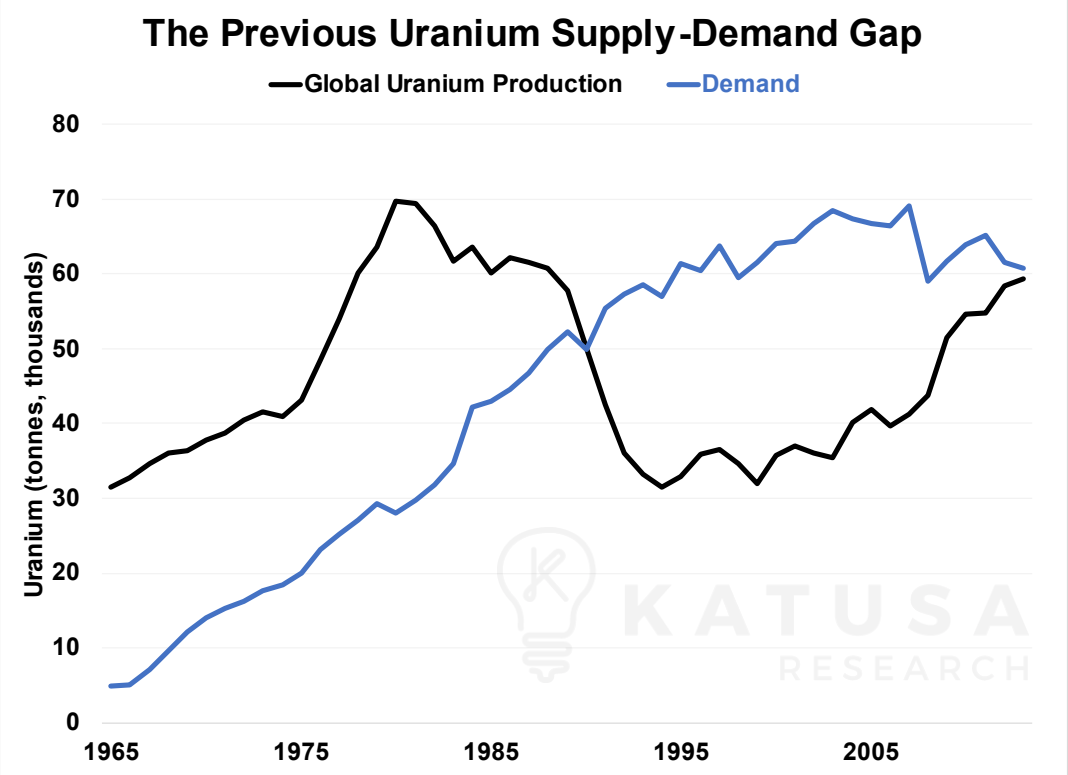
"Planned capability from all existing and committed production centers is projected to cover... about 44 percent of high case requirements through 2040."

– Nuclear Energy Agency and the International Atomic Energy Agency joint report

Over the past decade, operating uranium mines have averaged about 80 percent capacity.

That means only about 35 percent of uranium demand will be covered in 2040.

The last time uranium hit a supply/demand gap this big, in the early 1990s, another source of uranium filled in the gap: secondary supply.



Secondary supply is just miscellaneous uranium inventory held by utilities, fuel cycle companies, and governments. It could be reprocessed nuclear fuel... uranium from depleted uranium stockpiles... or recycled nuclear weapons.

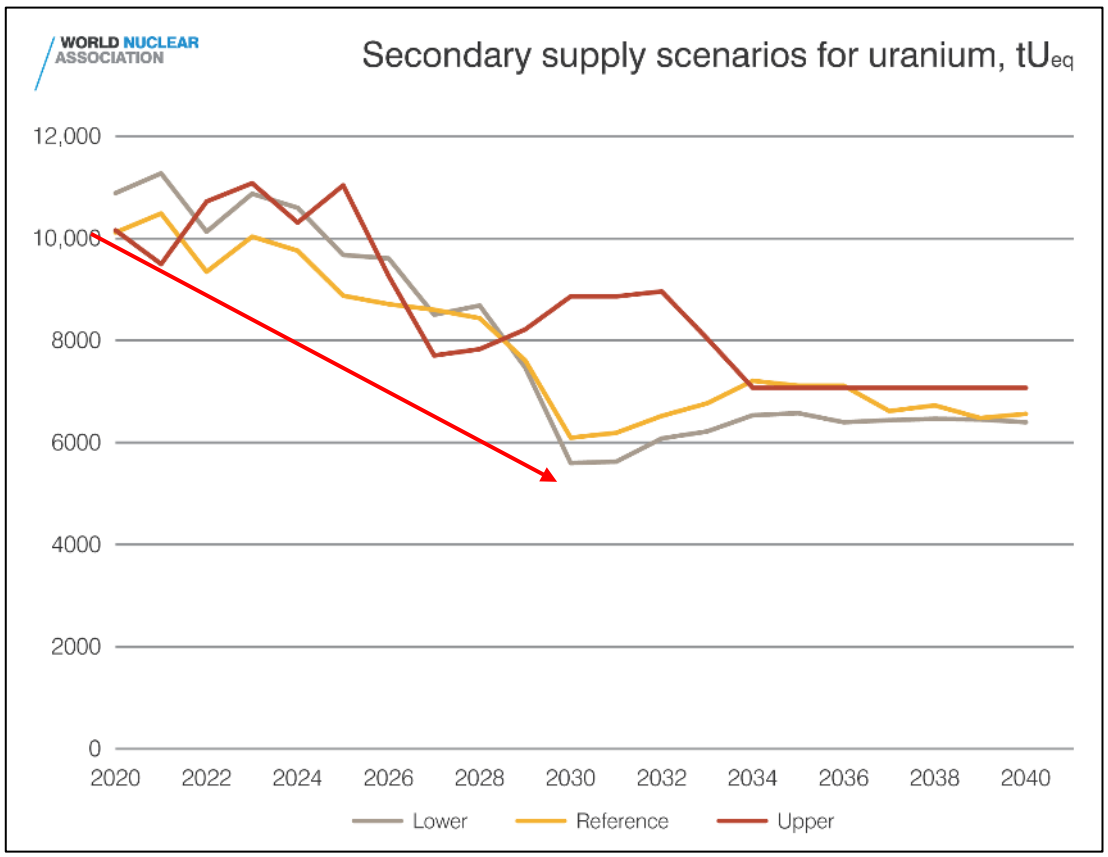
The former largest source of secondary supply was the "**Megatons to Megawatts**" program, which started in 1993.

The program converted Soviet-era warheads into usable nuclear fuel.

- At its peak, the program was fueling nearly half of all nuclear power in the United States.

But no one is making Soviet-era warheads anymore, and the program ended in 2013. All other secondary supply (except reprocessed fuel) is finite—once it's gone, *it's gone.*

As a result, secondary supply has dropped precipitously. It's down to 10,000 tonnes a year and is expected to drop another 40 percent by 2030.



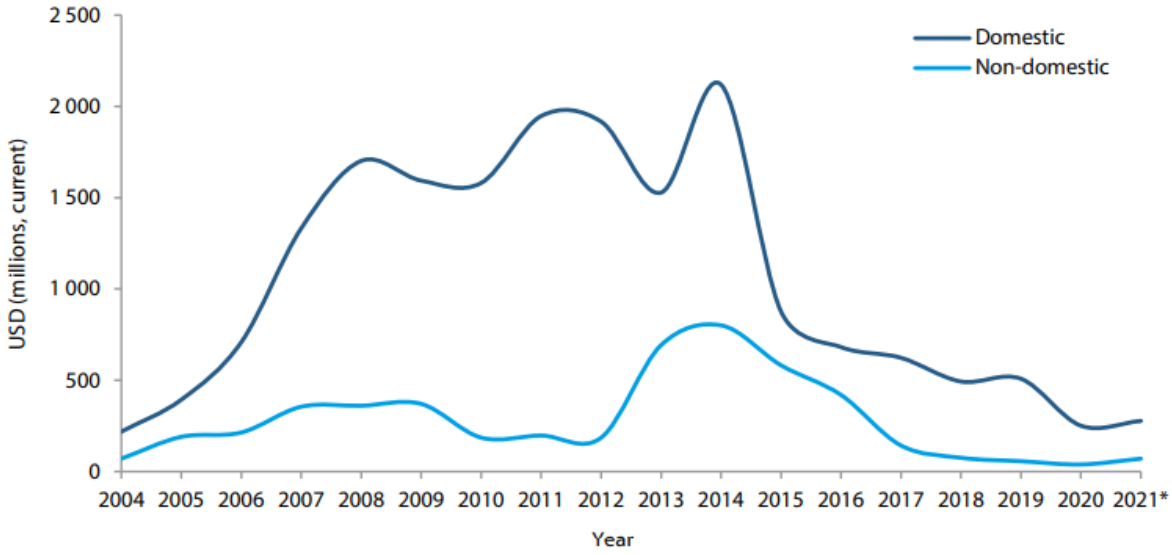
Without secondary supply, the tiniest bump to the uranium market could make it go BOOM. It gets worse...

Help Isn't on the Way

With little income from shuttered mines, and the price of uranium in the basement, **miners have stopped investing in finding new uranium altogether.**

Exploration expenditures dropped from over $2 billion in 2014 to under $300 million in 2019.

Figure 1.4. **Trends in exploration and development expenditures**



* 2021 values are estimates.

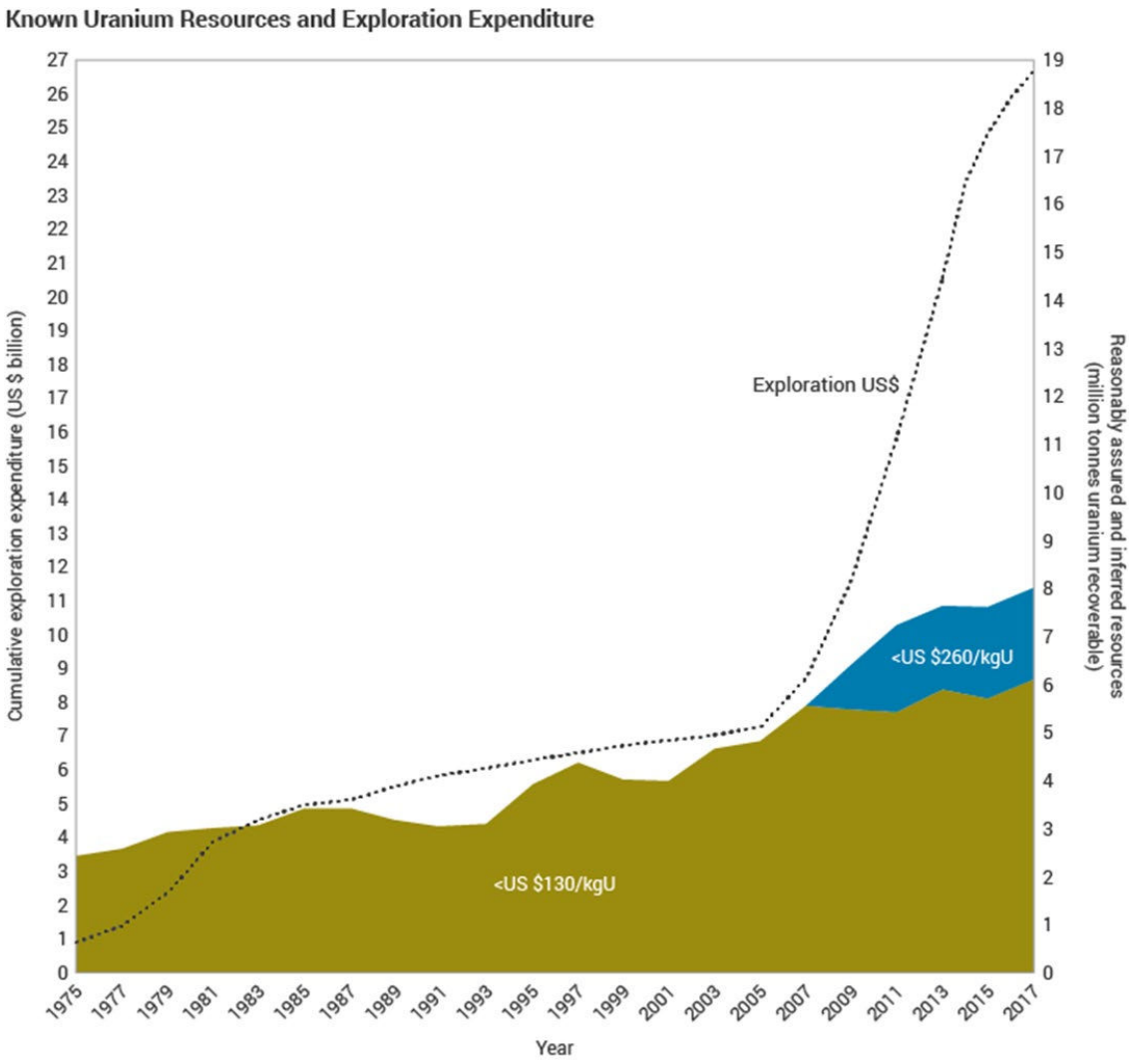
(Note: **China** and **India** comprised 75 percent of exploration spending in 2019.)

Low exploration spending means that total identified recoverable resources **only increased by 1 percent** from 2017 through 2020.

- **By 2030, low investment in new mines is projected to cut uranium supply in *half*.**

The money that was invested in exploration barely paid off. More than $8 billion was spent on exploration from 2006–2016.

Yet the amount of uranium extractable below current prices barely budged…



"*Intense development of new projects will be needed... to avoid potential supply disruptions*." – World Nuclear Association report

According to that same report, there needs to be a *doubling* in the development pipeline for new projects to meet demand.

Even then if those mines are found, developing a uranium mine takes a long time—about fifteen years from first discovery to production.

After that, it takes years for the fuel to be mined, milled, converted, enriched, and fabricated into fuel.

In other words, the uranium supply/demand gap has already been locked into place through 2030.

Utilities and governments are starting to realize what that means for their access to uranium...

Particularly those in the United States.

No U for the USA

- **98 percent of uranium production comes from just eight countries:**

Three of those are Russia or its former Soviet States, over which it exercises heavy control.

One is China.

And two are in Africa, where China has all but taken over.

Together, those countries control 74 percent of global uranium—and they are not keen to share with Western utilities.

In late 2022, Xi Jinping traveled first to Kazakhstan, then Uzbekistan to meet with Vladimir Putin.

During their meetings, they agreed on a "no-limits" friendship, saying that China and Russia should take on the role of "great powers."

The Chinese-Russian alliance will stop at nothing from achieving dominance over uranium supply—and thus, a stranglehold on the energy security of every nuclear country.

That leaves only two possible sources of supply for Western nations: Canada and Australia.

That's less than 25 percent of global production—about 12,000 tonnes of "safe" uranium.

The United States alone needs more than twice that.

Out of the top ten producing mines, only three are in Canada or Australia.

Mine	Country	Main Owner	Production (MM lbs.)	% of World
Cigar Lake	Canada	Cameco/Orano	15.3M	14%
Husab	Namibia	Swakop Uranium (CGN)	7.4M	7%
Inkai 1-3	Kazakhstan	Kazatomprom/Cameco	7.1M	7%
Olympic Dam	Australia	BHP Billiton	6.2M	6%
Karatau	Kazakhstan	Uranium One/Kazatomprom	5.6M	5%
Rössing	Namibia	CNNC	5.0M	5%
SOMAIR	Niger	Orano	4.5M	4%
Four Mile	Australia	Quasar	3.8M	3%
Central Mynkuduk	Kazakhstan	Ortalyk	3.6M	3%
South Inkai 4	Kazakhstan	Uranium One/Kazatomprom	3.5M	3%
Top 10 total			**62.0M**	**57%**

Over its entire lifetime, the Four Mile mine in Australia will produce barely enough uranium for the U.S. for *one year.*

And both Four Mile and Cigar Lake (in Canada) are expected to be depleted by 2030.

The U.S. needs two-thirds of all the uranium produced by the top ten mines in the world.

And it's on the verge of having access to only *one mine*—Olympic Dam.

That's why Thomas Neff, a researcher at MIT, says that the U.S. could be the "last one to buy, and it could pay the highest prices, *if it can get uranium at all*."

Right now, the United States is moving fast to cut reliance on Russian and Chinese uranium.

And to do so, it's going to restore domestic dominance in uranium mining—at any cost necessary.

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