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Sujet traité : Énergie nucléaire aux US : Domination décroissante / US Nuclear Energy : Decaying Dominance

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Special Report

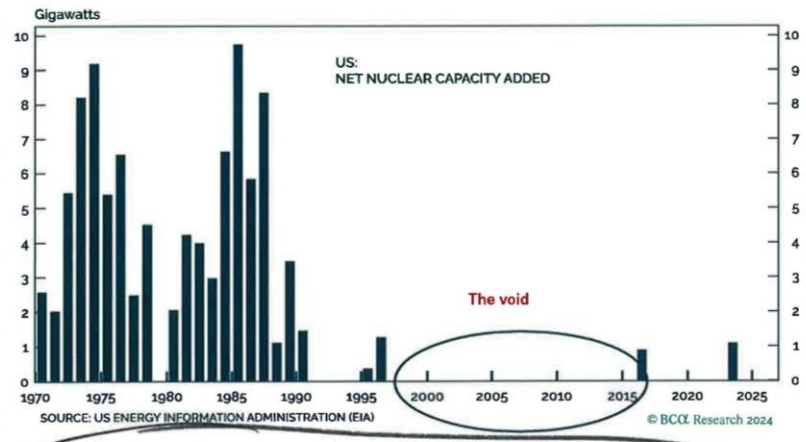
US Nuclear Energy: Decaying Dominance

In this Issue

Executive Summary

- Nuclear energy remains a significant component of the country's energy mix, and the US industry is at least good at one thing; efficiently generating energy.
- Public opinion has turned and is a tail wind for change. But utility companies still face a harsh truth: nuclear energy is expensive and requires significant upfront investment.
- Achieving greater standardization will require collaboration between industry stakeholders, regulators, and policymakers, a feat we do not foresee occurring soon.
- Vogtle's journey should serve as a cautionary tale for US nuclear going forward, although it seems Westinghouse is more interested in opportunities outside of the US.
- Nuclear energy is also geopolitical, and the US needs to increasingly diversify its uranium supply, and more broadly its nuclear fuel cycle, to bolster nuclear energy security.
- The rivalry between the US and China will have significant implications for global energy markets, technological innovation, and international power dynamics, adding further to geopolitical risk between the two largest economies.

From Zero To Hero, And Back To Zero



Bottom Line: US nuclear energy dominance is decaying. Though still the world's leader in generation and capacity, the US will not hold the mantle indefinitely given high industry inefficiencies, costs, and fast scaling competition from countries like China and South Korea. For once in recent history, the US may not be the preferred market to invest in. There are pockets of opportunity lying in wait, especially given a lack of investable global alternatives – which limits our downside view.

US Nuclear Energy: Decaying Dominance

Welcome back to our special series on the nuclear renaissance. If you are new here, we encourage you to read our prior research on the science of nuclear energy, how to invest in it, nuclear friendly mega-trends, and the uranium bull market. With summer mostly behind in the Northern Hemisphere, it is time to start heating up the core of this special series. In a fitting ascension through nuclear energy, we now assess the situation in different parts of the world, starting with the world's largest nuclear energy producer; the United States (US).

Come take a journey through the annals of atomic history, tracing the rise and the decay of nuclear energy in the land of opportunity. Picture the heyday of the 20th century, when nuclear plants dotted the landscape, symbols of progress and power, standing tall against the backdrop of uncertainty. Fast forward to today and we are met with a different scene – a landscape peppered with decommissioned reactors and stalled, costly projects – decaying dominance has set in.

But this is not a eulogy for US atomic energy. Instead, it is a candid examination discussing challenges and opportunities that lie ahead, from the lack of industry standardization, high costs, and the complexities of policy and regulation to the investment implications for US nuclear energy.

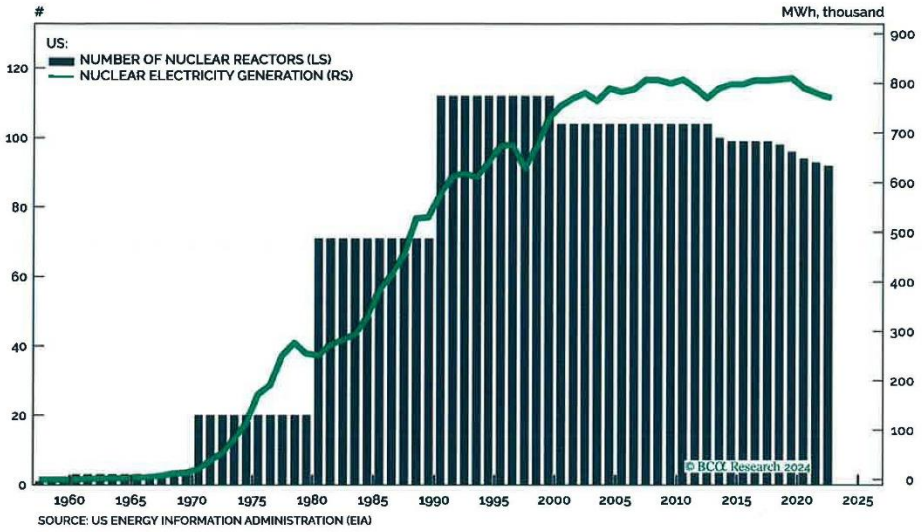
Sneak Peak: US nuclear energy dominance is decaying. Though still the world's leader in generation and capacity, the US will not hold the mantle indefinitely given high industry inefficiencies, costs, and fast scaling competition from countries like China and South Korea. For once in recent history, the US may not be the preferred market to invest in.

80 Years In The Making

1940s: The US was in a race against then Nazi Germany to create the world's first atomic bomb during World War II, in fear that the latter would deploy and drop nuclear arms on the US and its allies. The Manhattan Project was devised and resulted in the successful testing of the first atomic bombs in 1945, which were later dropped on the Japanese cities of Hiroshima and Nagasaki. These events marked a turning point in military history, and also changed the global geopolitical landscape as it initiated the nuclear arms race during the Cold War.

1950s: President Eisenhower's Atoms for Peace initiative birthed the commercial application of nuclear energy. In 1951, the world's first electricity-generating nuclear power plant was operated in Idaho. This milestone paved the way for the construction of the Shippingport Atomic Power Station in Pennsylvania, which became the first commercial nuclear power plant to supply electricity to the US grid in 1957.

CHART 1
Nuclear Energy Rose To Stardom In The 70s...



SOURCE: US ENERGY INFORMATION ADMINISTRATION (EIA)

1960s: In 1963, General Electric built a low-cost light-water reactor at Oyster Creek, New Jersey. As more reactors were being built in the late 1960s, overnight construction costs dropped to between $600 - $900/kW in 2016 dollars – cheaper than modern gas plants in the 21st century. Atomic energy was on a roll.

1970s: Government investment and private sector innovation fueled rapid industry expansion. Nuclear plant construction surged; dozens of reactors came online to meet the nation's growing energy demands (**Chart 1**).

Government policy favored the industry too. It was President Nixon who famously introduced Project Independence in reaction to the OPEC oil embargo and the resulting 1973 oil crisis. The goal - achieve energy self-sufficiency by constructing 1000 nuclear power plants by 2000.

But, as utility operators ordered more nuclear reactors, supply chains and skilled labor became stressed. Delays ensued, and costs began to rise. Regulatory requirements were also constantly shifting through the construction phase of a nuclear plant adding further delay. By the mid-1970s, new build nuclear construction costs had risen to $1 800 - $2 500/kW in 2016 dollars – more than double just a decade ago.

Then came Three Mile Island, a mortal blow after the much publicized (**but nonfatal**) meltdown in 1979. All reactors under construction at the time – 51 in total – faced major regulatory delays, changes

in safety procedures, and new retrofit requirements. Construction times doubled; costs skyrocketed, past $7 000/kW for some reactors.

1980s - 2000s: After Three Mile Island, nuclear power in the US was moribund. Utility operators canceled more than 120 nuclear reactor orders. Utility deregulation, that started in the 1970s, also came to the fore, disfavoring large, expensive energy producing plants. Government policy also encouraged competition in the electricity market, like the Clinton Administration's Energy Policy Act in 1994, which reduced monopoly power of utilities by encouraging the rise of independent power producers.

Nuclear fell out of favor, fast.

It took more than three decades for a reprieve - the Nuclear Regulatory Commission (NRC) received its first application for a new nuclear reactor build in 2007, interest in nuclear power was back?! In part, the Energy Policy Act of 2005 was a significant helping hand, providing incentives like loan guarantees and production tax credits for new builds. But, around the same time, the NRC introduced the Air Impact Assessment (AIA) following the 9/11 events, which required nuclear power plants to guarantee the integrity of the reactor core and the spent fuel pool under the impact of a large, commercial aircraft. The AIA drove up costs and complexity for new nuclear. Renewed interest stalled.

In the end, no new reactors were commissioned for construction until 2013, a very long hiatus in the US nuclear industry **(Chart 2)**.

CHART 2
...But Lost Its Shine Quickly

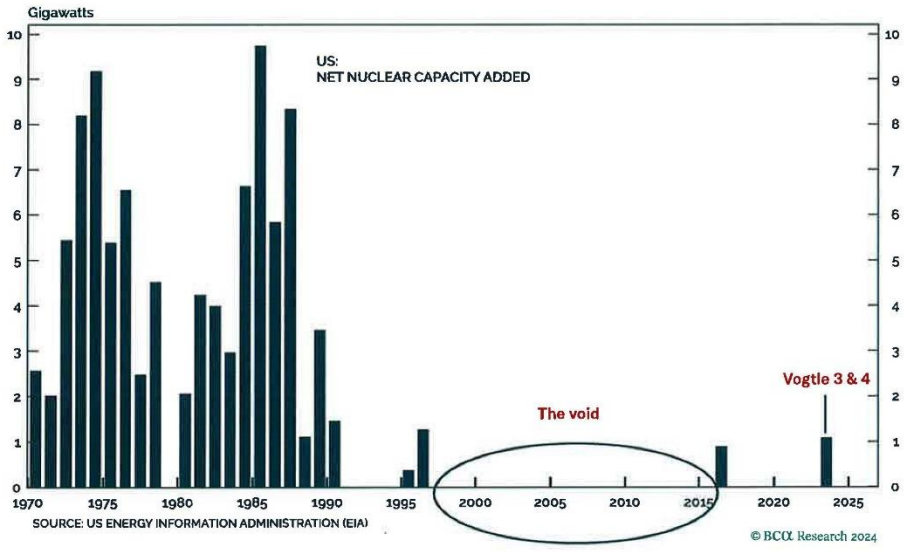
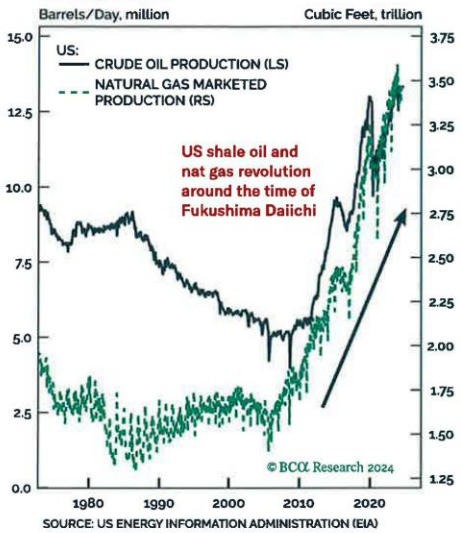
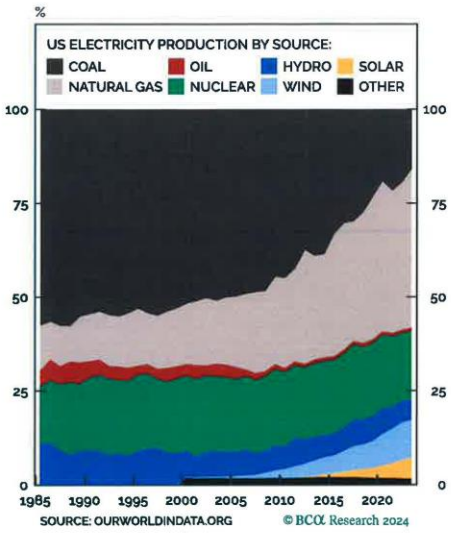


CHART 3
Fossil Fuel Competition Also Slowed A 21st Century Revival



SOURCE: US ENERGY INFORMATION ADMINISTRATION (EIA)

CHART 4
But Nuclear Is Still Key For The US



SOURCE: OURWORLDINDATA.ORG © BCA Research 2024

Enter Vogtle units 3 and 4 at the Vogtle nuclear power plant in Georgia. In 2010, President Obama's administration announced loan guarantees for the construction of new reactors at the Vogtle Electric Generating Plant in Georgia, marking the first new reactors to be built in the US in over 30 years.

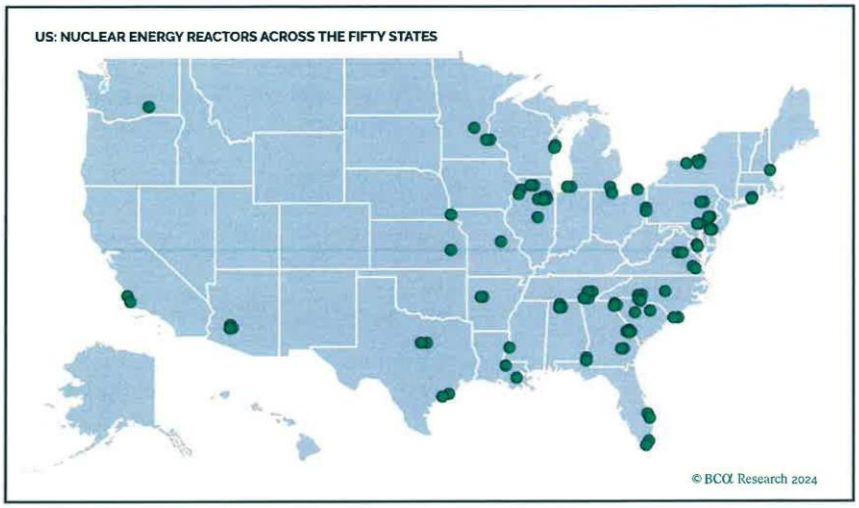
But like with Three Mile Island and Chernobyl, the Fukushima Daiichi nuclear disaster in Japan had a profound impact on the US nuclear industry, leading to increased safety reviews and regulatory scrutiny, Construction delays and costs rose again, like in the 1970s, for new reactor builds like Vogtle 3 and 4.

Inconveniently for nuclear, a US shale oil and natural gas revolution began when Vogtle was expanding too. Energy prices fell sharply as production soared (**Chart 3**). Lobby groups also ensured that fossil fuel energies remained as primary energy sources in the US, influencing government agencies and policies to make resource extraction easier. Cheap, easily accessible fossil fuel cast a shadow of renewed interest in nuclear.

Nuclear Energy Today

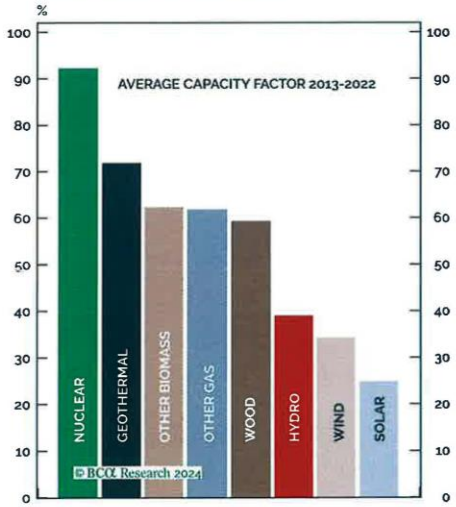
Nuclear energy remains a significant component of the country's energy mix, accounting for 20% of electricity generation (**Chart 4**). The industry is at least good at one thing, efficiently generating energy. US nuclear plants are also mostly concentrated

FIGURE 1
Nuclear Calls The East Cost "Home"



SOURCE: US ENERGY INFORMATION ADMINISTRATION

CHART 5
Its All About That Base(load)

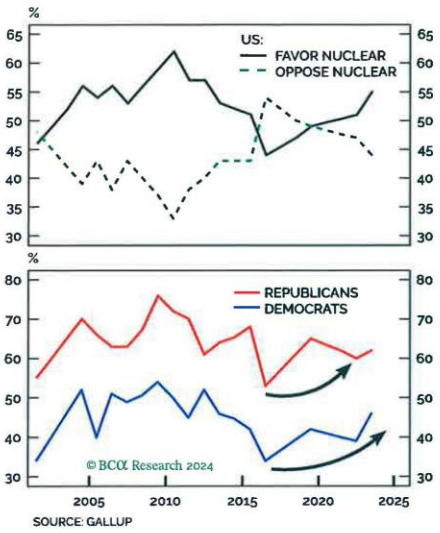


SOURCE: US ENERGY INFORMATION ADMINISTRATION (EIA)

along the east coast, with 93 commercial reactors operating in 28 states, with an average age of 42 years (**Figure 1**). Locality is mostly to do with nearby water sources (for reactor cooling). Legacy reactor builders like Westinghouse, are also located along the east coast.

Although several reactors have retired in recent years, and the average age of the reactor fleet is high, commercial and political interest in nuclear energy is on the rise again, in a bid to help reduce the country's carbon footprint and maintain its energy independence. Nuclear energy produces no CO_2 emissions and provides essential baseload power that would otherwise largely come from coal and natural gas-fired plants (**Chart 5**).

CHART 6
Public Opinion Is Warming



SOURCE: GALLUP

Public opinion on nuclear energy is starting to warm again too, as climate and energy security concerns stay top of mind (**Chart 6, top panel**). This change has fostered bipartisan support too, which increasingly favors nuclear (**Chart 6, bottom panel**). But there may be more behind this shift in support than just climate and energy risks. Nuclear energy is a job creator, more than other sources of energy (**Chart 7**). The construction and operation of a new nuclear power plant creates more jobs on site, pays a higher median industry wage, and is highly beneficial for local communities. It is no wonder that politicians are turning more positive on nuclear energy.

But at this tail wind blows, will it be able to pick up speed and change the course of decay?

For now, no.

CHART 7
Hard To Ignore The Economic Impact

GENERATION TYPE	PERMANENT JOBS ON SITE, JOBS/GW	INDUSTRY WAGE MEDIAN, $/HR	BENEFITS CONCENTRATED IN LOCAL COMMUNITY?
NUCLEAR	237 (~500)	41	✓
COAL		34	✓
NATURAL GAS		34	✓
WIND	80	26	✗
SOLAR		24	✗
OIL GENERATION	Variable	24	✓
OTHER RENEWABLE GENERATION	Variable	18	✗

SOURCE: US ENERGY INFORMATION AGENCY (EIA)

Nuclear energy is often viewed as a utility killer due to its prohibitive costs and complex regulatory hurdles. The construction of nuclear power plants requires substantial upfront investment and can take over a decade to finish, leading to financial strain on utility companies– which also fund most of their operations, including expansion, via debt financing.

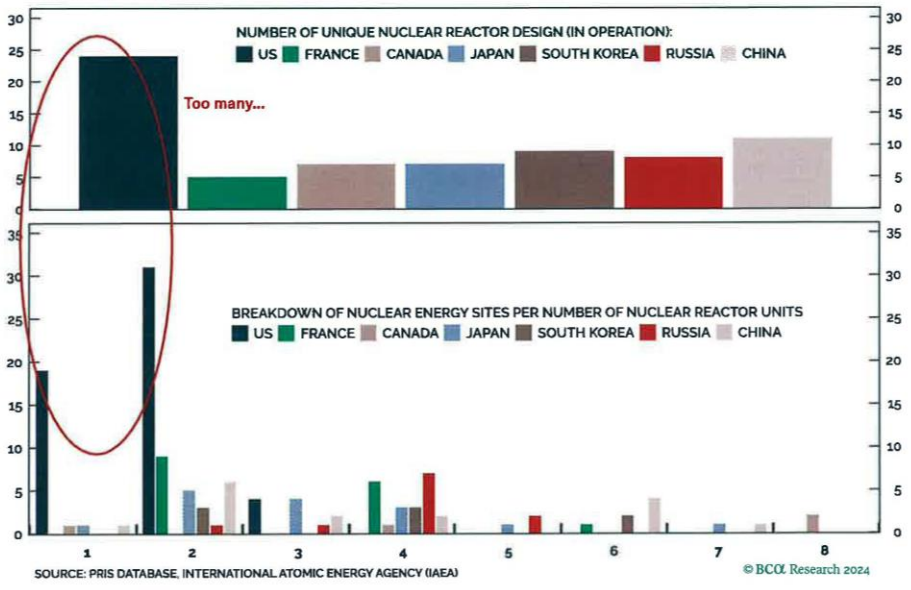
As renewable energy sources become increasingly competitive, financial and operational challenges make nuclear power a less attractive option for utility companies, potentially undermining their economic stability and making it harder to compete in a rapidly evolving energy market. Instead, utility companies, for current and future operations, will continue favoring coal or natural gas-powered energy plants. They are quicker to construct, cheaper to maintain, and easier to establish and comply with regulatory oversight.

Bottom Line: Public opinion has turned and is a tail wind for change. But utility companies still face a harsh truth: nuclear energy is expensive and requires significant upfront investment.

Standardization: Not So Standard Practice

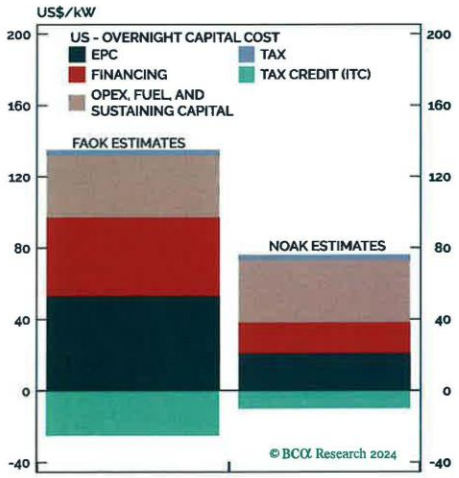
The lack of standardization is the greatest driver of high industry costs, among others. Unlike other industries that benefit from standardized processes and components, for example, coal or shale gas, US nuclear energy is characterized by a patchwork of designs, regulations, and operating procedures.

CHART 8
Too Many Designs Are A Bottleneck



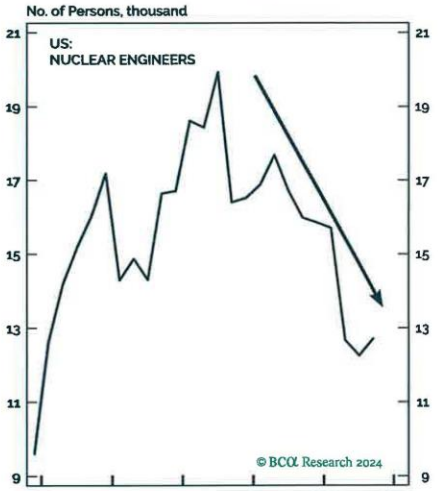
- **Reactors**: There are too many designs each with their own set of engineering specifications, safety features, and operational requirements **(Chart 8, top panel)**. There are also too few reactors per a site – the US tends to commission single large reactors per a site, while other countries commission several per a site **(Chart 8, bottom panel)**. Countries like France, Japan, and China have standardized reactor designs to streamline licensing and construction processes, greatly lowering costs. Too many designs are also expensive. First of kind reactors cost more to build, finance, and operate, than several iterations of the same design **(Chart 9)**.
- **Utility companies**: Because there are so many, they operate differently from one another, and hence operate different nuclear reactor designs. In some cases, two different nuclear reactor designs were commissioned at the same plant – think Florida Power and Light, Turkey Point nuclear plant. In France, there is a single utility (EDF) and single reactor builder (Areva, before EDF took it over) that produce and repeatedly build standardized designs. This is the case in other countries like Japan too.
- **Human capital**: Plant operators, maintenance, and repair workers are trained on specific operational procedures for the type of reactor installed at the location they work. This limits skill transferability from one plant to another since reactor designs differ so much. Industry labor has also aged given a lack of new plant builds in past decades, while skilled industry labor is in low supply **(Chart 10)**.

CHART 9
And Expensive Vs. Tried And Tested



SOURCE: EIA ANNUAL ENERGY OUTLOOK 2022
NOTE: FOAK STANDS FOR "FIRST OF A KIND" AND NOAK STANDS FOR "Nth OF A KIND"

CHART 10
Skilled Labor Needs A Supply Boost



SOURCE: US BUREAU OF LABOR STATISTICS (BLS)

- **Funding**: Is capitalism a weakness? In the US, funding for new reactors is primarily driven by the private sector, which is cyclical, generally requires a high rate of return, and is privy to meeting certain investment criteria related to each project. Government funding exists, but has mostly been allocated to research, especially on new reactor designs, which the US could use less of.

Bottom Line: Achieving greater standardization will require collaboration between industry stakeholders, regulators, and policymakers, a feat we do not foresee occurring soon.

Vogtle 3 & 4: A Testament Of Will Power

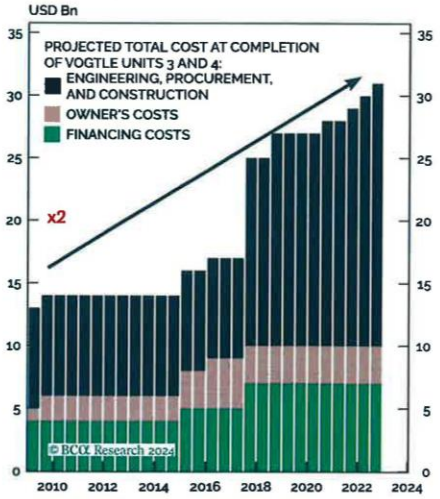
Initially touted as a flagship project for nuclear renaissance in the US, the Vogtle 3 and 4 reactors at the Vogtle nuclear power plant in Georgia have been mired in a host of challenges since their planned construction.

Originally slated for completion in 2016, the project's timeline had been repeatedly pushed back, exacerbating concerns about its feasibility and economic viability. Delays were attributed to a multitude of factors, including design changes, regulatory scrutiny, and workforce shortages. The Covid pandemic did not help either.

Cost overruns were notable too, amplifying financial strains and intensifying scrutiny from stakeholders. The initial price tag was around $14 billion, but the final bill surpassed $30 billion (**Chart 11**). The project even claimed the scalp of legacy reactor designer and builder, Westinghouse, which filed for chapter 11 bankruptcy in 2017. Though Westinghouse has since made a comeback after being bought by Brookfield Business Partners, the company was in some way, its own worst enemy.

Westinghouse's hiatus from building new nuclear reactors had a notable impact on its ability to produce the AP1000 reactor series, which are running in Vogtle 3 and 4. This led to significant time and cost overruns. The new design was also supposed to aid in modularity, allowing for prefabricated components to be manufactured off-site and assembled on-site – construction time and costs would fall. However, these benefits were hindered by an unprepared local supply chain. Many suppliers lacked the capability to produce the specialized parts required, delays and costs rose instead.

CHART 11
Vogtle: Expensive And Timely



SOURCE: GEORGIA PUBLIC SERVICES COMMISSION'S VOGTLE CONSTRUCTION MONITORING REPORTS

The NRC was also a thorn in the side. The gap in recent experience and technological advancement, coupled with the most stringent global and continuously evolving regulatory requirements by the NRC, rose the complexity of modern reactor designs like the AP1000.

But the woes of the AP1000 were not just experienced in the US. Plants like Sanmen and Haiyang in China, which also house the AP1000, experienced similar issues to Vogtle 3 and 4. To resolve future bottlenecks, Westinghouse and others need to position closer to local industry to help it keep pace with modern reactor designs. But that alone would not solve the industry's shortcomings.

Ironically, Westinghouse is increasingly looking outside of the US for opportunities, since almost none exist locally. Westinghouse is becoming an exporter of nuclear reactors. The company has been on a world tour, racking up technical and equipment agreements in countries like Bulgaria, the Netherlands, Ukraine, and more recently, Sweden and Finland – in partnership with Hyundai. Westinghouse is also contracted to deliver six AP1000 reactors at a new plant build in Poland. Part of the local supply chain will benefit, but the industry will lag on putting modern reactors like the AP1000 into commission regularly and smoothly. This will be a detriment to an industry renaissance that may be in the making.

That said, Vogtle's journey serves as a cautionary tale for US nuclear going forward. However, the fact that Vogtle 3 and 4 were ultimately finished and put into commercial operation is testament to what the industry could achieve, if it can decisively address its shortcomings and provide more funding and policy support.

BOX 1
Palo Verde: An Oasis In The Dessert

The Palo Verde Nuclear Generating Station is a remarkable success story. The largest plant in the US, constructed in the 1970s, it was essentially built in the middle of the desert in Arizona. Unusually, it is not situated near a large body of water, but instead relies on treated sewage water for cooling. It was a full NRC design from a regulatory standpoint, which streamlined its construction.

Palo Verde consistently demonstrates high performance in safety, reliability, and efficiency. Its three units have consistently operated at high-capacity factors, often exceeding 90%, making it one of the most productive nuclear energy facilities in the world.

Overall, Palo Verde Nuclear Generating Station exemplifies the potential of US nuclear energy. Its success underscores the importance of effective standardization, technological innovation, and operational excellence.

The difficulty lies in replicating Palo Verde's success at scale – a tough ask for an industry that is plagued by low standardization, high regulatory demands, and high upfront investment cost.

Nuclear Is Also Geopolitical

Nuclear energy influences global power dynamics through technology leadership, energy security, and international trade. Nations with advanced nuclear capabilities can assert influence, secure energy resources, and form strategic alliances, while others may depend on or compete with these countries for technology and fuel.

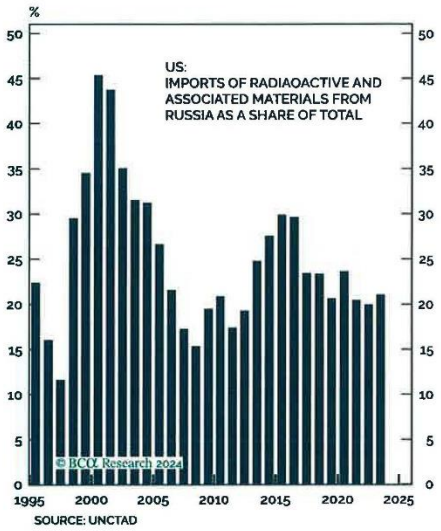
Diversify Uranium Supply

Energy security has been a multi-decade priority for the US, tracing its roots back to the Cold War-era. Policymakers are increasingly realizing nuclear is an asset in ensuring a stable and reliable energy supply. Russia's invasion of Ukraine in 2022 highlighted this. Germany's dependency on Russian natural gas was exposed. And when Russia closed the taps on Nordstrom, Germany scrambled for alternatives. Old coal-fired plants were restarted as temporary measures. If only they had kept their nuclear reactor fleet going.

Though US energy security is not under threat today, the fuel supply that powers the country's fleet of nuclear reactors is. The US is heavily dependent on enriched uranium from Russia. In 2023, like in past decades – Russia provided almost a quarter or more of the nuclear fuel used in America's commercial reactor fleet (**Chart 12**).

Dependency rose because the US failed to address slowing domestic production and enrichment of uranium, starting from when the cold war ended. Global supply of enriched uranium rose sharply, drastically lowering prices. Without policy support, domestic facilities struggled to compete.

CHART 12
Russian Uranium Is Still A Prized Import

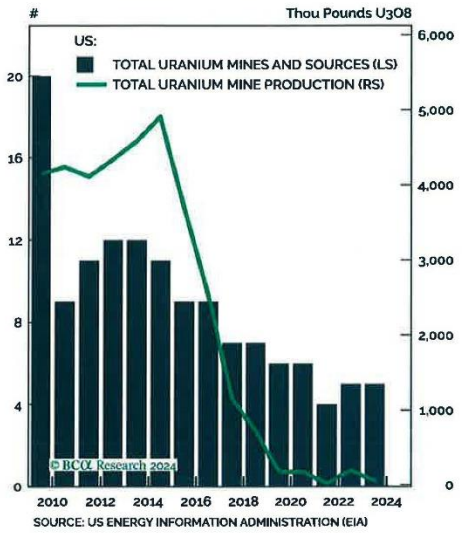


SOURCE: UNCTAD

Regulation was burdensome, adding to production costs, while foreign policy shifted to favoring foreign uranium supply. In the 1990s, the number of uranium mines stood at 50. By 2009, this number dropped to 20, and by 2023, to just five (**Chart 13**). Decades of "laissez-aller" crippled the US uranium industry.

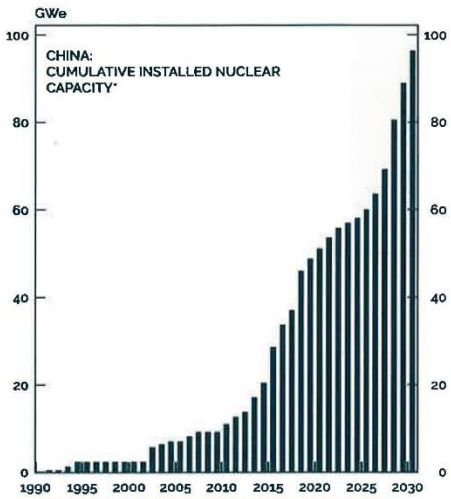
But this will change, albeit slowly. Uranium production is being revived, especially across the Arizona and Utah border, a first in eight years. Companies such as Energy Fuels Inc. and Ur-Energy are increasing their production abilities. This has been supported by government plans to establish a strategic uranium reserve and ramp up funding for domestic uranium enrichment, as provisioned for in the Inflation Reduction Act of 2021.

CHART 13
The US Cannot Rely On Itself



SOURCE: US ENERGY INFORMATION ADMINISTRATION (EIA)

CHART 14
China Is Hot On The Heels Of The US



* SOURCE: BNEF, US ENERGY INFORMATION ADMINISTRATION
NOTE: SHADING DENOTES PROJECTIONS

The US is also actively diversifying its uranium supply. Utility companies are increasingly turning to Canadian uranium suppliers like Cameco, which now supply 19% of US uranium. Canada, a global leader in uranium production, is more reliable and politically stable. Other US suppliers include Kazakhstan, though geopolitical risk is more elevated here given its ties to Russia.

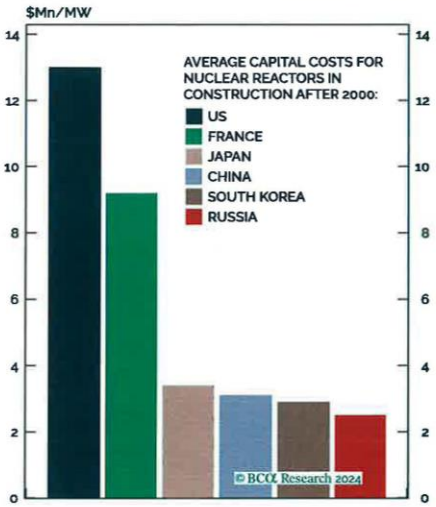
Bottom Line: The US needs to increasingly diversify its uranium supply to bolster nuclear energy security.

Battle For Nuclear Energy Supremacy: Enter China

China's aggressive nuclear expansion aligns with its broader geopolitical strategy of securing energy resources and asserting global leadership through constructing and selling nuclear plants globally. Installed capacity over the past ten years stands at 53 GW, more than half of installed US capacity (**Chart 14**).

China's ability to rapidly deploy new reactors and focus on cost-effective, large-scale projects contrasts with the US focus on developing advanced technologies and improving safety standards. China's streamlined regulatory environment and state-backed funding enable it to scale projects quicker and cheaper. China will outpace US advancements going forward (**Chart 15**). Testament to this is that there are 23 new reactors under construction, while the US has no new reactors under construction, and just 13 proposed – it also took the US 40 years to add the same installed capacity as China did in ten years.

CHART 15
Nuclear Is Cheaper Out East Than In The West



SOURCE: BloombergNEF

For the US, the strategic response involves enhancing domestic nuclear technology, reducing reliance on foreign components, and increasing investment in next-generation reactors. These efforts aim to maintain technological leadership and counteract China's growing global influence.

However, the US must address challenges like the lack of industry standardization, policy support, and regulatory burden to remain competitive – all which will take a long time to change.

Bottom Line: The rivalry between the US and China will have significant implications for global energy markets, technological innovation, and international power dynamics, adding further to geopolitical risk between the two largest economies.

Nuclear Renaissance Threatened In The US

The US nuclear energy industry faces significant challenges as it contends with cost overruns, lack of standardization, de-risking of its nuclear fuel supply chain, and increasing global competition. Historically, nuclear power offered a stable, low-carbon energy source, but recent challenges have eroded its dominance. While there is a slight tailwind from renewed public support and government interest, it is not strong enough to correct a structural breakdown that is decades old.

High construction and regulatory costs have plagued new nuclear projects, making them less competitive compared to cheaper, faster-to-deploy energy sources like natural gas and renewables. Investors may view nuclear projects as high-risk due to these financial uncertainties.

Meanwhile, the absence of standardized reactor designs contributes to inefficiencies and increased costs. Developing and deploying a new reactor often involves bespoke designs, which can lead to delays and cost overruns. Standardized designs, such as those being developed for Small Modular Reactors could mitigate these issues, but they are still in the early stages of development and deployment.

Whilst the industry decays, countries like China are rapidly advancing their nuclear capabilities with aggressive investment and streamlined regulatory processes. China's focus on expanding its nuclear fleet and advancing reactor technologies is outpacing the US. China, as a global market share, will look to disrupt US energy policy.

Investment Implications

For once, the investment case for the US – albeit in the nuclear industry – is not a promising one long term. Opportunities lie across the supply chain of the global industry, as we have previously highlighted, but are lacking in the US.

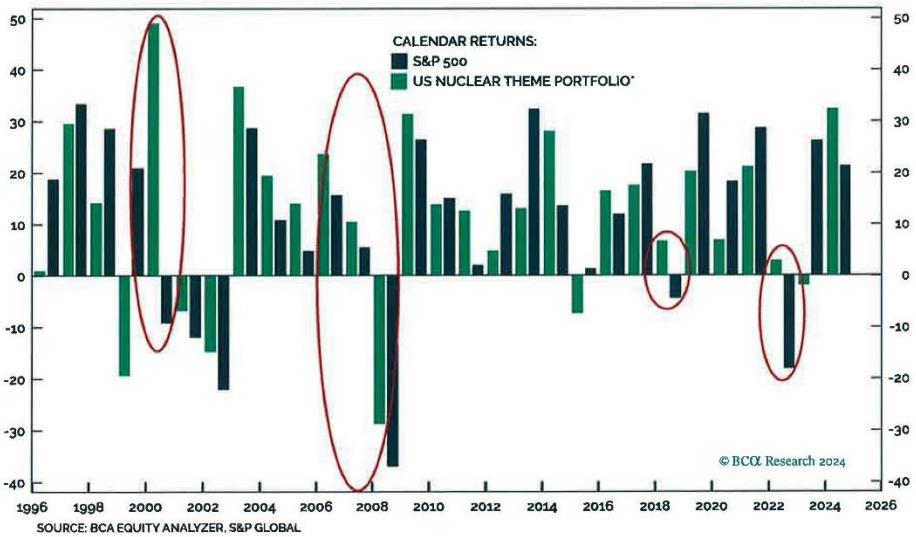
Notably, our equally weighted US nuclear theme portfolio constructed using BCA's Equity Analyzer[1] offers better downside protection than the broad market during periods of uncertainty (**Chart 16**). This is because 32 of 35 constituents are utilities, an excellent defensive.

Going forward, the US themed portfolio will outperform further for two reasons: 1) utility companies are an excellent defensive given BCA Research's expectations of a US recession penned for the end of 2024 or in early 2025. YTD, the utility sector is up 23.5%. 2) utility companies will continue to benefit from energy demand tailwinds, like GAI and green manufacturing (**Chart 17**). Meanwhile, increasing exports of nuclear reactors, like the AP1000, will support part of the local industry supply chain.

Longer term, the unfolding nuclear renaissance theme will be a positive for the US nuclear industry, but not supportive enough to affect wide-sweeping change and slow down its decay. Avoid exposure to large-scale US nuclear energy projects until standardization improves, and policy turns more supportive – both will lower costs.

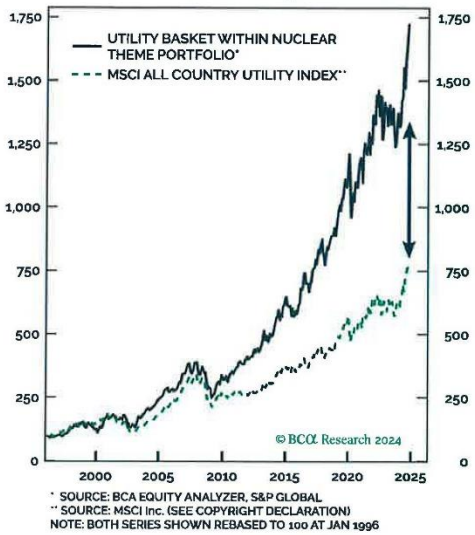
[1] For clients who do not have access to BCA's Equity Analyzer platform, a bottom up, quantitative, systematic stock picking tool, please reach out to your account manager for trial access.

CHART 16
Nuclear Exposed Stocks Offer Strong Downside Protection...



SOURCE: BCA EQUITY ANALYZER, S&P GLOBAL

CHART 17
And Are Set For Further Outperformance



* SOURCE: BCA EQUITY ANALYZER, S&P GLOBAL
** SOURCE: MSCI Inc. (SEE COPYRIGHT DECLARATION)
NOTE: BOTH SERIES SHOWN REBASED TO 100 AT JAN 1996

Overall, we are bearish on US nuclear energy, but not overly so. As we have pointed out, there are pockets of opportunity lying in wait, especially given a lack of investable global alternatives – which limits our downside view.

Bottom Line: The US nuclear industry is experiencing decaying dominance. Lack of industry standardization has contributed to high costs, too many reactor designs, and the inability to complete new builds in a timely manner – eroding competitiveness. The lack of policy support compared to other energy sources, as well as high startup costs, have deterred investors and commercial uptake further. Competition has caught up, and countries like China are moving toward top spot in the global nuclear energy industry.

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