Floating Nuclear Pòwer Plant with Flash Ironmaking Technology Proposal for Philippine Steel:

Prolog:

- Floating nuclear power plants offer a cleaner and more efficient alternative to traditional energy sources.
- The *Liberty Project* by Core Power aims to create a fleet of versatile FNPPs stationed along the coast and offshore.
- Molten salt reactors utilize salt as both fuel and coolant, minimizing risks associated with traditional water cooling.
- The revival of this innovative technology with *Redstar's Aqueous Homogeneous Reactor* marks a significant step in the global quest toward sustainable and affordable solutions.
- Apr 11, 2025 - Global breakthrough agreement to tackle shipping emissions this changes everything for Floating Nuclear Power Plants/ propulsion systems (***see last pages for full article***)

In an era where energy demands are soaring, a groundbreaking concept is emerging on the horizon: floating nuclear power plants (FNPPs) powered by molten salt reactors. This innovative approach promises to revolutionize how we think about energy production, offering a cleaner and more efficient alternative to traditional methods. As the world grapples with the urgent need to reduce greenhouse gas emissions, these floating marvels could pave the way for a sustainable future. However, the journey to realizing this vision is fraught with challenges and opportunities. At the heart of this innovation lies the molten salt reactor, a technology first conceived in the 1960s. Unlike conventional nuclear reactors that rely on uranium-235 rods and water as a coolant, molten salt reactors utilize a unique combination of salt and powdered uranium oxide. This fusion not only serves as fuel but also as a coolant, eliminating the risk of evaporation. The high boiling point of salt offers a significant advantage, allowing reactors to operate at extreme temperatures without the need for thick-walled steel.

Intro-
Aligning Economic & Sustainable Goals of Asia Through Nuclear Energy

Nuclear energy can help align The Philippines and Thailand’s sustainable development goals with its commitment to achieve net-zero emissions by 2065, and solve its dire energy shortfalls, an expert says. Currently, about 60% of the Philippines electricity comes from dirty and deadly coal (455k deaths in big coal- run towns- see NIH coal death study below); and, 60% of Thailand's electricity comes from natural gas, according to the Ministry of Natural Resources and Environment.

While renewable energy (RE) accounts for 20% of both nation's total power generation, the experts are highlighting the significant challenges which hinder its long-term sustainability, including unstable power generation and high investment and lack of grid storage make adding renewables exponentially harder with each kW. 65% of California's and 55% of Texas's RE is curtailed! Patti Boonyasukanon, vice president of public affairs at Global Power Synergy Public Company Limited (GPSC), said last week that the company is exploring the use of Small Modular Reactors (SMRs) to generate nuclear power and ensure long-term energy security. Each SMR has a maximum capacity of 300MW(e), with one-third of the output of conventional nuclear reactors, according to Mr Patti.The SMR's modular design allows for factory assembly and easy transportation to installation sites, he said, adding the reactors use nuclear fission to generate heat and produce electricity with enhanced operational safety features. Meanwhile, Redstar is resurrecting the only nuclear design by a Nobel Prize winning physicist that's the best system to produce radioisotopes and power at installed cost of $500 per kW; and, 33 x's less expensive per kW than ***Westinghouse's***; and, 39 x's less than ***Nuscale's*** reactors. Redstar will build and manufacture these SMRs called *Aqueous Homogeneous Reactor*s- *AHR*, tested 5 years by *ORNL*, with full Feasibility Study by *ORNL*, and backed by *Lloyd's Syndicate Insurance. Each Redstar power plant features* exclusive patented *Red Sun* **wireless amplifier***,* **transformer** *and* **amplifier** *of 6 MW* (120 MWh) to *32 MW* (*360 MWh*, *1000 tons* of *equivalent 1000°C coal steam*) *thermal batteries* (*6.5* to *26 tons* respectively, the second patent is Non- Combustion Brayton Cycle, to run big turbines 2.5 MW to 54 ***MW*** **Siemens by replacing cannula with two shell heat exchanger heated by 1850°C** molten nickel iron alloy in seven steel and refractory layers, running ***Siemens 13*** to **54 MW turbines** (see ***Use***. ***Of Funds*** in ***Red Sun***- ***AHR- Power Plant***- ***Executive Summary***) and/or gensets and/ or retrofitting all diesels to run ships trains and all ith carbon fiber pipe - connected thermal power wireless solid state analog high - heat 80 MW - 330 MW floating power plants. The ***Red Sun Nuclear Renaissance*** is here, and this is the future of shipping and power for SE Asia according to *Maersk*, *Lloyd's Register* and the *IMO*: https://youtube.com/shorts/SYpQ1YEdqnk?si=J5hiDLPokcuER36P.

Why is Southeast Asia turning to nuclear power?

Governments across Southeast Asia are eyeing nuclear energy to fuel rapid growth while also meeting ambitious climate goals. But critics say they should instead be focusing on exploiting abundant renewable sources. https://p.dw.com/p/4sXit. The Bataan Nuclear Power Plant was built in the 1970s; but has never produced a single watt of energy. Southeast Asia's only nuclear power plant is located in the province of Bataan in the Philippines, around 40 miles (64 kilometers) from the capital, Manila. Built in the 1970s, the Bataan facility was mothballed before it ever opened amid the political instability of the end of the Ferdinand Marcos Dictatorship— and in the wake of the 1986 disaster at Ukraine'st,Chernobyl, which killed at least 30 people and spewed radioactive fallout over much of the Northern Hemisphere. But now, under the government of the late dictator's son, Ferdinand "Bongbong" Marcos Jr., the Philippines is turning to nuclear power as one solution to satisfying the country's rapidly growing energy demand, and as a way of reducing its reliance on fossil fuels and thereby curbing harmful greenhouse gas (GHG) emissions. In February, Philippine Energy Secretary Raphael Lotilla said his country was "paving the way for a safe, sustainable, and responsible nuclear energy program that will secure our nation's energy future."

Why nuclear power?

The Philippines and Indo**nesia** are leading the surge in coal dependency in Southeast Asia, according to London-based energy think tank Ember, which pointed out that the Philippines was Southeast Asia's most coal-dependent country in 2023. The Philippines is aiming to gradually phase in nuclear power as part of [6] resource which must be mined and then shipped — all of which entails carbon emissions, Derek Cabe of the Nuclear and Coal-Free Bataan Movement, told DW. "The 'clean narrative' is false. It's a pretense, […] nuclear energy is a diversion," said Cabe. She believes renewable energy— primarily solar, hydro and wind power— is the best solution for the archipelagic nation, where sun, water and wind are abundant. Cabe pointed to the lack of political will from the government and the misallocation of budget funds as the main "hindrance to fully tapping renewable energy." Entrenched corporate interests and much higher profit margins in fossil fuel industries are also a major obstacle. "We do not have that political will to really prioritize renewable energy because of the push or the pull of the corporate business," she said.

Southeast Asia's nuclear ambitions Embracing nuclear energy is not unique to Manila. Most of Southeast Asia is increasingly turning to nuclear energy, both for its power generation potential and because it is seen as a way of achieving the target of "net zero" emissions by 2050. Over the next 15 years, Indonesia aims to derive 75% of its power generated from "clean" energy sources, including nuclear. But these plans are still very much in their nascent phase: Construction of a plant is planned to start in 2032, and a nuclear regulatory framework is still not in place. For Grita Anindarini, senior strategist at the Indonesian Center for Environmental Law, focusing on nuclear plants — which are expensive and time consuming to build— at the expense of renewable sources would be a mistake, especially for sun-drenched, archipelagic countries like Indonesia and the Philippines that are also vulnerable to earthquakes and other natural disasters. "How could we deal with radioactive and other highly toxic waste that could pose serious risks to human health and the environment? [...] Why do we need to invest in high-risk activity where we have safer and more environmentally friendly options?" Anindarini asked DW. Are smaller reactors a better solution?

Authorities in Vietnam, which have been considering nuclear power for nearly two decades and have sought expertise from Russia and the United States, have also introduced plans to build a plant in the southeastern province of Ninh Thuan by 2030. But according to Thuy Le, a professor at San Jose University and a nuclear policy adviser to the Vietnamese government, those plans and the short timeline are far too ambitious and "will fail." He told DW that Vietnam should focus instead on more modern Small Modular Reactors (SMRs) as a way to safely and realistically integrate nuclear energy. "Start with the SMR, or even the microreactor, and go step by step," Thuy Le said. SMRs and microreactors are much smaller than traditional plants, meaning they can be used in coastal, densely populated locations. They are also far simpler and cheaper to build, compared to the hugely ambitious, yearslong construction projects needed for large plants. Their smaller size also means some of the inherent risks associated with nuclear energy generation can be mitigated, despite unresolved safety risks, particularly in the event of severe natural calamities. They could also be an option for Singapore in the coming years, according to Alvin Chew of Singapore's Nanyang Technological University (NTU), who explained that building "a large conventional nuclear power plant isn't feasible" for the small island country.

Meralco, **France energy giant** -**EDF-to explore nuclear power dev't in Philippines for €42,000/kW for EPR2 installed vs. Redstar's AHR at $500/kW**
https://www.pna.gov.ph/articles/1248017

The EPR2 reactor is 1,650 MW and cost €67.1 bn
Output of 1,600 MW net, which equates to €42,000 per kW.

This is 84 x's x 1.075 USD/EUR = 95 x's more expensive than the cost of the *Aqueous Homogeneous Reactor* -AHR-, at $500 USD/kW installed:

EPR2

Operates at 77 bars, or 7,720 kPa

AHR
And, except for pumps, operates at 1 to 2 bar, 38+ x's less pressure, so can't explode!

Convincing a hesitant Southeast Asian public About Nuclear.

Another challenge facing governments in the region is convincing the public that going nuclear is the right choice. A study by the NTU found generally low public support for the development of nuclear energy in Southeast Asia, largely due to the technology's perceived risks. The disasters at Chernobyl and Fukushima in Japan and the legacy of World War II have corroborated those concerns, Chew told DW, adding that the "region has no experience in regulating the safe operation of nuclear power plants." Convincing the public in Singapore and elsewhere in the region will require "a paradigm shift to destigmatize the negative perception of nuclear energy," Chew said. These concerns were also highlighted by anti-nuclear activist Derek Cabe in Bataan, the site of the region's only existing nuclear plant, which she pointed out "is sitting on top of a volcano." "If there is a problem [with the plant], those of us on the front lines will be the ones who will be affected first and foremost," she said. Redstar Combines Flash Ironmaking & Flash Ni & Cu Smelting - A 3600 x's More Efficient Metal Making Method with Lowest Cost Energy.

This powerful combination is ready now as China unveils a method to produce steel 3600x faster— without coal. In a world where industries are under mounting pressure to go green, China has just thrown down a game-changing gauntlet. After a decade of meticulous research, a team of Chinese scientists has developed a groundbreaking method to produce steel without coal—and not just faster, but an eye-popping 3,600 times faster than traditional techniques. The potential impacts on both the environment and the global steel market are hard to overstate. The Old Way: Slow, Dirty, and Carbon-Heavy! For centuries, making steel has followed a well-worn, if somewhat environmentally damaging, path. It begins with iron ore, which is crushed and processed, then cooked at searing temperatures above 1,300°C in blast furnaces fueled by coke—a derivative of coal. This coke isn't just a heat source; it's also essential for the chemical reaction that extracts iron from the ore. But here's the catch: the process takes hours (five to six, typically) and comes with a hefty side order of carbon dioxide emissions. In fact, steelmaking has long been one of the industrial world's worst climate offenders, responsible for roughly 7-9% of global CO_2 emissions, according to the World Steel Association.

Steel in Six Seconds

Steel in Six Seconds: The New Chinese Method: Now, enter China's radical new approach. Professor Zhang Wenhai and his team have figured out how to sidestep coal entirely and crank out steel in just three to six seconds—yes, seconds, not hours. Their secret sauce? It's all about injecting ultra-fine iron ore powder into a furnace using a vortex lance. Imagine blasting this powder into a superheated environment where, instead of a long, energy-draining process, a rapid-fire chemical reaction takes place almost instantly. The iron melts into droplets that fall to the furnace's base, ready to be transformed into high-quality steel. What's more, the technique isn't picky. It works with both low-grade and high-grade iron ore, which is especially important for China. Historically, the country has leaned heavily on imports from resource-rich nations like Australia, Brazil, and various African countries to meet its need for high-grade ore. This breakthrough could shift that balance, allowing China to rely more on its own lower-grade reserves. A Win for Industry and the Planet This isn't just a speed record—it's a sustainability milestone. By removing coal from the process entirely, the method is projected to slash energy consumption by up to one-third. That dovetails perfectly with China's broader push toward carbon neutrality, a goal it's set to reach by 2060. Meanwhile, everyone is trying to produce green steel, with costs actually tripling due to the very high cost of hydrogen and green electricity. Hydnum Steel plans to invest €1.65bn into the project, which is scheduled to begin operations next year financed through an order from Thyssenkrupp. German steelmaker Thyssenkrupp's material processing subsidiary has signed a strategic agreement to buy 100,000 tonnes of green hydrogen-derived flat steel from Hydnum Steel's flagship steel production scheme in Spain, for the first seven years of the project's operations. Hydnum Steel has previously estimated that the Puertollano project will start operations of its first phase in 2026, using green hydrogen to extract iron from ore and an electric arc furnace to produce up to 1.5 million tonnes of rolled steel per year. ● In a bold move, Rostadom is building 8 RITM-200 floating nuclear power plants (NFPP) in the Antarctic. + 90 MW RITM 400:

- This is to power icebreakers along the Northern Sea route;
- These reactors enhance efficiency by reducing shipping time between northern Europe and Asia by half;
- The RiTM- 200 is used in both FNPP and land based reactors:

China is already the heavyweight champion of global steel production, contributing more than half of the world's supply. But this innovation could tip the scales even further. Imagine a future where China not only produces steel more efficiently but also leads the charge in creating a low-carbon steel industry. The ripple effect across sectors like construction, automotive manufacturing, and infrastructure could be monumental. And here's the broader question: if this technology scales successfully, could it prompt a global domino effect? Could other nations adopt similar methods and finally begin untangling steel production from its carbon-heavy past? Definitely now is the time with most steel making plants pumping out red ink, while carbon credits are slated to reach $150tCO2!

Core Power, a leading nuclear innovation company based in the U.K., is spearheading the development of floating nuclear power plants under its Liberty program. This ambitious initiative aims to create a fleet of smaller FNPPs that can be stationed near the coast or further out in the ocean. The versatility of these floating plants offers numerous advantages, including mobility and reduced land footprint, making them less intrusive to local communities.

The Liberty Project envisions a future where FNPPs form the largest floating power plant network in the United States. A central shipyard will oversee construction, maintenance, and refueling, ensuring the seamless operation of these plants. While the exact location for the initial FNPPs is yet to be announced, the potential impact of this project is undeniable. *By harnessing the power of the ocean and cutting-edge nuclear technology, the Liberty Project aims to deliver clean, reliable energy on an unprecedented scale..*

The concept of floating nuclear power plants offers several distinct advantages. By placing reactors on industrial barges, these plants become more mobile and less problematic for communities. The construction and presence of a nuclear power plant on land can often be a contentious issue, but a floating version alleviates many of these concerns. Additionally, a network of FNPPs can generate more power than a single site on land, increasing transmission capabilities.

Future applications for molten salt reactors extend beyond just energy production. Portable versions could supply energy to remote sites or military bases, reducing the need for fuel transportation—a significant source of casualties for the military. With the potential to deliver electricity at a competitive price, FNPPs could become a cornerstone of energy infrastructure. The success of these floating power plants will depend on the ability of reactor vendors to meet the demands of this innovative technology.

A Glimpse of Steel's Greener Future.

This breakthrough stands as more than just a technical marvel—it's a signal. A reminder that even the world's most entrenched, energy-intensive industries can adapt, evolve, and innovate when the stakes are high enough. Of course, scaling this method and integrating it into existing production lines won't happen overnight. There will be economic, logistical, and regulatory hurdles. But if history has taught us anything, it's that game-changing ideas often start with bold steps, and right now, China seems to be leading that charge—one molten droplet at a time. Modern-day direct reduction of iron first developed as a small-scale, low capital and operating cost alternative to the blast furnace. Since commercialization of continuous DR technology in the late 1960s, the market for the products of direct reduction was more than 74 million tonnes in 2012. The advantages of DR plants over BF facilities have grown over the years, for several reasons, including the increased size of DR modules, lower energy and emissions (particularly CO2), along with the flexibility to use a number of different reductants. The development of DR technology over the past forty years will be emphasized in this presentation, including recent developments that 7allow for even more direct sustainability comparisons with the iron blast furnace — and even combine the two technologies for improved synergies. Also briefly discussed will be the possibilities of using direct reduction for non-ferrous ores. the flash ironmaking method includes: mixing pulverized, pure oxygen and steam in the pulverized coal gasifier to obtain a crude coal gas containing carbon monoxide and hydrogen; drying and pre-reducing wet iron ore and block coal in the drying pre-reduction kiln to obtain pre-reduced iron ore; feeding the pre-reduced iron into the furnace…Flash ironmaking involves rapidly reducing fine iron ore concentrates in a high-temperature reactor using a reducing gas stream, producing molten iron in seconds, bypassing traditional methods like pelletization and coke-making. Here's a breakdown of the process:

Fine Ore Preparation:
Iron ore is pulverized into a fine powder.

Reducing Gas Generation:
A reducing gas stream (e.g., natural gas or hydrogen) is generated by partially oxidizing a fuel gas with oxygen.

High-Temperature Reactor:
The fine iron ore powder is injected into a high-temperature reactor along with the reducing gas stream.
Rapid Reduction:
The iron oxides in the ore are rapidly reduced to metallic iron within seconds, resulting in molten iron droplets.
Molten Iron Collection:
The molten iron is collected at the bottom of the reactor and is ready for immediate use in casting or steelmaking.
Advantages:
Flash ironmaking offers advantages such as: **Increased Efficiency**:
The process is significantly faster than traditional methods, reducing production time. Reduced Emissions:
Using natural gas or hydrogen as reducing agents can lead to lower carbon emissions. **Cost Savings**:
The ability to use fine ore concentrates and bypass pelletization or sintering steps can lead to cost savings.
Use of Low-Yield Ores:
Flash ironmaking can effectively utilize low or medium-yield iron ores, which are abundant in some regions. The process can be operated at lower temperatures to produce iron in solid state, which can then be fed to downstream steelmaking processes. Flash ironmaking system and method - Changing a Century of Steelmaking in a Flash. The development of a novel steel making technology which if commercially feasible could radically change the way steel is made. Chinese scientists just developed a revolutionary iron making technique that results in a massive boost in productivity and cost savings. The process would use inexpensive, abundant natural gas to both heat the ore in the furnace and to remove oxygen and make a higher purity iron. The process would use inexpensive, abundant natural gas (or hydrogen) to both heat the ore in the furnace and to remove oxygen, converting the ore to iron ...Flash Ironmaking Process is a concept first proposed by H. Y. Sohn in the 1970's..The ironmaking process mostly consisting of coke plant, sintering plant and blast furnace accounts for about 80 % of total CO2 emission from steel plants. **Flash ironmaking steps**: This innovative process allows for the direct utilization of fine iron oxide particles without requiring additional pre-and posttreatment, ...The flash ironmaking technology is an innovative process that uses iron ore concentrate directly without further treatment. Flash Ironmaking: 3600x Faster with **Near-Zero Emissions**.
Flash Ironmaking is an innovative process that directly reduces iron ore concentrates into metallic iron using gaseous reductants like natural gas or hydrogen. Flash smelting involves rapidly reacting fine iron ore in a hot gaseous environment and is distinct from a fluidised bed by: (a) the particles falling through the furnace.

The Case Of India Steel Vs. **Eu**: India's steel sector, heavily reliant on coal, faces significant financial penalties from the EU's Carbon Border Adjustment Mechanism (CBAM) unless it rapidly adopts low-carbon technologies. .

●Indian steel producers, including major players like Tata Steel and JSW Steel, are implementing initiatives such as renewable energy integration and carbon capture to reduce emissions and meet evolving global standards.
●Despite efforts, India's steel industry needs to accelerate its decarbonization efforts to remain competitive in the European market and avoid substantial carbon costs, which could reach up to $116 per tonne by 2034.
●**The Indian steel sector**—the world's second-largest —faces a critical challenge in 2025 as the European Union (EU) tightens its environmental standards, intensifying its focus on carbon neutrality. With Europe being a key customer for Indian steel, accounting for 25% of exports, India must urgently comply with stricter carbon regulations to avoid steep financial penalties that could undermine its global position in the steel market.

●Rystad Energy's research suggests that by 2034, India and Russia could face some of the highest carbon costs in steel production, potentially incurring levies of up to $397 per tonne, even if carbon prices remain stable. Key policy shifts, such as the EU's Carbon Border Adjustment Mechanism (CBAM), which will take full effect by 2034 but begins next year, will assign a carbon cost to imports, including steel, based on embedded carbon emissions.
● According to the EU's *Joint Research Centre* (*JRC*), India's steel production is more carbon-intensive than most of its global competitors. As a result, this policy could impose a potential surcharge of up to $80 per tonne by 2030 unless cleaner technologies are adopted in India. These rising costs threaten to undermine the country's competitiveness in the European market, making its steel less attractive compared to lower-emission alternatives. South Korea and Turkey are well- positioned to benefit from this shift and could potentially displace India from the top three producers.*In the coming years, reducing carbon emissions could extend beyond regulatory compliance and become a competitive necessity as buyer sentiment continues to evolve. Governments and industries are increasing support for low-carbon technologies, and companies that fail to adapt risk falling behind. In India, where steelmaking remains heavily reliant on coal, transitioning to low-carbon alternatives such as natural gas-based ironmaking or green hydrogen will require substantial investment and innovation. However, with limited time for transition, India must confront the carbon cost challenge in front of them, as early adopters of greener production methods could gain a stronger competitive edge in global markets.* In response to these policy shifts, the Indian government and its biggest steel players are tweaking their approaches to adapt to their external environment. The Indian government introduced a green steel classification system under the Production Linked Incentive (PLI) scheme in December 2024. Under this framework, steel producing less than 2.2 tonnes of carbon dioxide (CO?) per tonne of finished steel qualifies as 'green,' while steel with emissions below 1.6 tonnes per tonne earns a five-star rating. The initiative aims to incentivize Indian steelmakers to cut emissions and adopt cleaner technologies. Discussions are also under way to mandate green steel in public sector projects, potentially reshaping domestic demand. The nation's top five largest steel producers – namely Tata Steel, JSW Steel, Jindal Steel & Power (JSPL), Steel Authority of India (SAIL) and AM/NS India – collectively account for more than 50% of the nation's steel output and have made changes with some setting net-zero carbon goals as early as 2045. To curb emissions, these producers are also adopting a mix of renewable energy integration, process

optimization and circular economy initiatives.Tata Steel, for instance, will commission a 0.75 million tonne per annum (Mtpa) electric arc furnace (EAF) plant in Ludhiana by March for low-carbon steel production. ●The company has also invested in a carbon capture plant in Jamshedpur and is securing 379 megawatts (MW) of captive renewable power for its operations. Meanwhile, JSW Steel, targeting net-zero emissions by 2050, has raised $500 million through sustainability-linked bonds and is expanding production using low-carbon technologies. The company has also committed $1 billion to decarbonization and is incorporating biomass and hydrogen into its processes for steel making. In addition, these domestic giants are also planning major capacity expansions, with total production projected to reach 189 Mtpa by 2035. While this growth is essential to meet both domestic and global demand, it must be carefully balanced with emission reductions if decarbonization and scale are to advance in tandem. ●Currently, these companies are on track to cut emissions by only 43% in the next decade—well below the levels needed to comply with stringent EU standards and mitigate CBAM-related costs. Furthermore, if this trajectory continues Indian steelmakers could face carbon costs of up to $116 per tonne by 2034, assuming a carbon price of $100 per tonne. This slow progress leaves Indian steelmakers vulnerable to significant carbon taxes, potentially $116 per tonne by 2034, and jeopardizes their competitiveness in the EU due to rising carbon prices.

Nickel Flash Smelting:

The two commercial classes of nickel ore (sulfide ores and silicate oxides) are produced in the highest quantities in Canada and Russia which equates to approximately 20-25% of the world's production.

Using nickel flash smelting technology it is possible to process sulfide nickel concentrate and produce nickel matte and slag in a relatively efficient process. Any materials resulting as smelting and converting slags are recirculated in the electric furnace and recovered where possible as nickel matte.

Nickel: Nickel (Ni) is a silvery-white, hard metal. Although it forms compounds in several oxidation states, the divalent ion seems to be the most important for both organic and inorganic substances, but the trivalent form may be generated by redox reactions in the cell. Nickel compounds that are practically insoluble in water include carbonate, sulfides (the main forms being amorphous or crystalline monosulfide, NiS, and subsulfide Ni_3S_2) and oxides (NiO, Ni_2O_3). Water-insoluble nickel compounds may dissolve in biological fluids. Particles of the same chemical entity (oxides and sulfides) have different biological activity depending on crystalline structure and surface properties. **●NICKEL MATTE AVERAGED $10,744 PER TON IN 2023**. ●There are two commercial classes of nickel ore, the sulfide ores (pentlandite and pyrrhotite) and silicate-oxide. Most nickel is produced from the sulfide ores, and the two largest producers, Canada and the Russian Federation, account for 20–25% each of total annual production, which was 784.82 thousand tones in 1988. ●In Nickel Flash Smelting technology, sulfide nickel concentrate is processed in the Outotec® Flash Smelting Furnace to produce nickel matte and slag. The matte is transported to the Peirce-Smith converters where it is blown to high-grade matte. The metal values in the smelting and converting slags are recovered in the electric furnace as nickel matte. The matte is then circulated to the Peirce-Smith converters. **The dried feed mixture**: ●Oxygen-enriched process air and distribution air are mixed in the concentrate burner to assure an even distribution of the feed in the reaction shaft suspension. As the dried charge flows downwards in the reaction shaft, the concentrate particles dissociate, ignite and undergo controlled partial oxidation generating a large amount of heat, which results in the melting of the material into fine droplets. In the settler, the immiscible slag and matte phases separate and form two layers according to their specific densities. ●The process gas flows upward through the uptake shaft and then to a heat recovery boiler for cooling. Part of the flue dust is separated from the gas stream in the boiler. The gas flows onward to an electrostatic precipitator where the remaining fine dust is recovered. The dust collected under the boiler and precipitator is returned back to the furnace. ●The produced slag is tapped from the Flash Furnace and directed along with the converter slag into an electric slag cleaning furnace before being granulated and discarded. Reduction is carried out batch-wise using coke as a reducing agent. During the settling period, reduced metal droplets and mechanically trapped matte droplets are settled through the slag layer to the bottom of the electric furnace to form the matte layer. Immiscible slag components with a much lower density stay at the top of the bath and form the cleaned slag layer. ●The mattes obtained from the flash smelting furnace and from the electric *Outotec® Slag Cleaning Furnace* are converted in Peirce-Smith converters with oxygen-enriched air, which is blown through tuyeres into the converter. For slag forming purposes, some silica flux is added. The produced high-grade matte is granulated and further treated in the refinery. The waste slag is also granulated and transferred to the slag disposal area. ●A typical flash smelting furnace is shown schematically in Figure 1. The refractory-lined furnace vessel is composed of three sections: reaction shaft, settler and uptake shaft. In the flash smelting process, a sulfidic feed mixture is distributed through the top of the reaction shaft by a concentrate burner, where the correct design is vital to furnace operation. The concentrate burner consists of several concentric ducts through which the process gas and the concentrate are blown and mixed in the furnace. The main task of the burner is to produce an optimal suspension of solid particles and oxygen-enriched process air in the reaction shaft. ●Individual particles heat up as they fly about in the furnace and after ignition they start to combust with oxygen in the process gas. The combustion reactions with fine (<100μm) sulfides are very rapid and a substantial amount of heat is released, which leads to the complete melting of the combusting particles, as well as that of the other materials introduced in the feed mixture. The molten particles flow downstream and they are collected in the settler, where silicate slag and sulfidic matte layers are separated. The off-gas (mainly an SO_2-N_2 mixture) flows through the uptake to the waste heat boiler, where it is cooled down and its heat content is recovered as steam

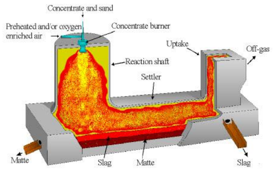


Figure 1: Flash smelting furnace with its main sections and material flows. ●***Metso*** & ***Outotec*** Flash Smelting.

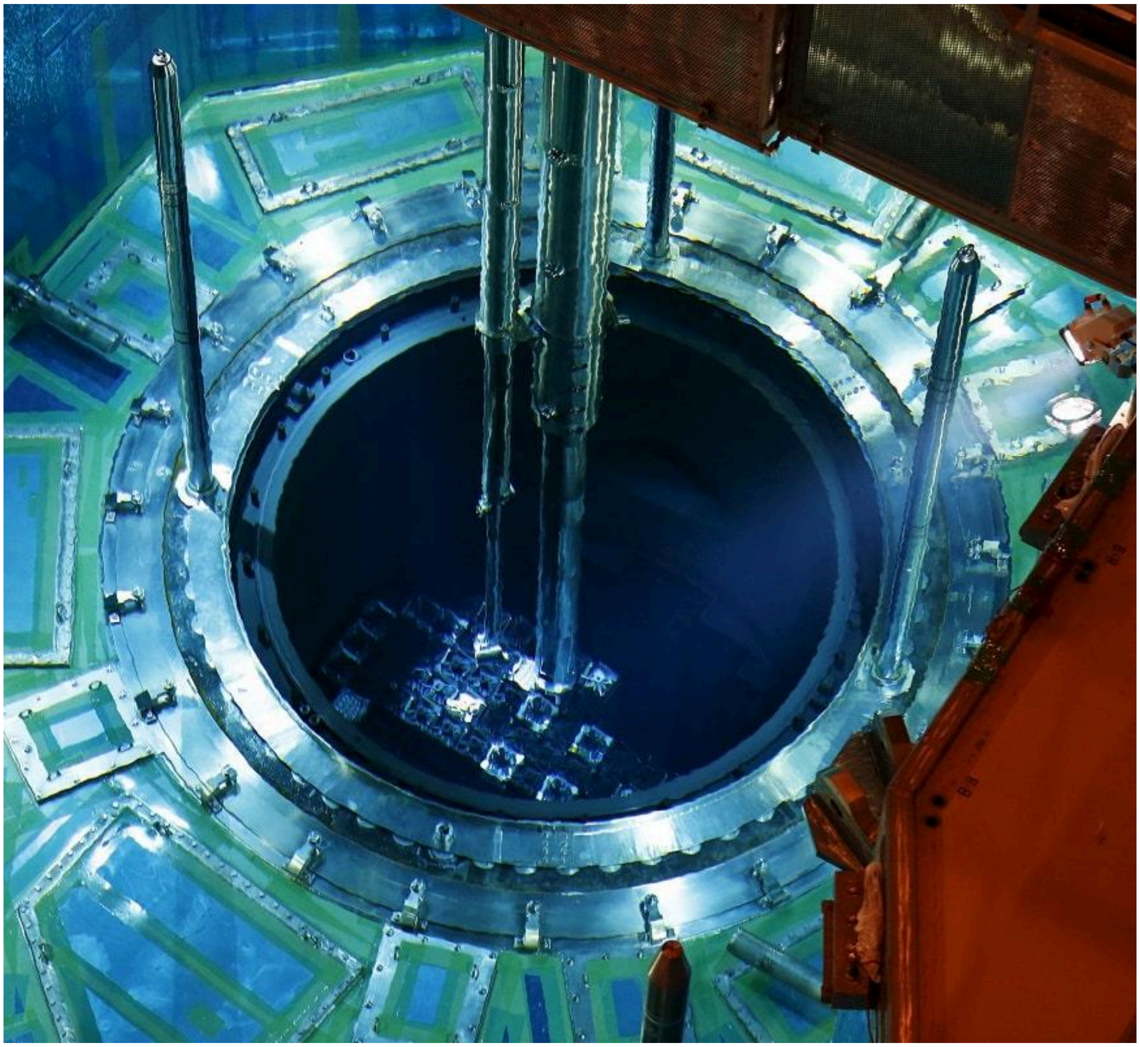
Red Sun Thermal Battery Run Smelting & Refining Summary Conclusions:

The recent ban of induction crucibles (also in Thailand, Indonesia, Malaysia, Taiwan and China) for refining steel and matte is a boon for Red Sun smelting furnace systems and 5 different heat transfer methods capitalising on the 1850°C to 2000°C Red Sun molten nickel iron alloy battery and carbon fiber pipes that deliver automatically, at the speed of sound, from the hotter battery to furnace at the speed of sound, i.e , the 300°C cooler heat.exchanger, steam generator or combustion chamber of diesels and turbines. To run smelter furnace we blow air in through battery heat exchanger at 650° and sulfides in ore are solid oxide fuel that take it to 1600°C, giving 75% of the energy;
2. Plus, using a 2000°C battery to directly heat ladle itself to 1700 - 1850° using carbon fiber pipes.
3. Using heated acid leaching broth for gold and Ni/ Cu metals before floatation;
4. Blowing hot air through molten slag to run 38.5 MW HE LM 2500 with 6 MW thermal battery to hold and return heat in continuous 24 hr cycle, with each 1 m3 of slag running one LM 2500;
5. Magnetically stirring slag using above number 4 to remove gold and platinum/ Pd from slag, with second electrowinning to separate metals 99%;
6. Using our high H2 catalyst (calcined at 2000°C with Red Sun battery) and connect ***Redstar EGG Algae to H2*** pyrolysis to make H2, CO and biochar reducing agents, which are piped into top and middle of matte furnace;
7. Also; waste heat from LM 2500 38 MW and from thermal battery and radiative heat from heat run from 1850°C Red Sun 6 MW thermal battery (120 MWh) to run heat exchanger plus steam generator run from battery to run ore roasting ovens at 900 °C.
https://www.gmanetwork.com/news/topstories/nation/942176/dost-changes-ph-steel-materials-manufacturing-the-big-one-quake/story

https://youtu.be/hLEldWy3KeI?si=PX5chAC_Ybs0beLh https://youtu.be/YrJ1J2txL14?si=iPhz7NQz8Z9WUOTN

SMR firms race to build a nuclear fuel supply chain.

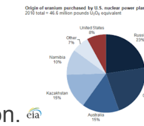
Intro To Small Modular Reactors:



The development of molten salt reactors marks a significant departure from traditional nuclear technology. As Core Power CEO Mikal Bøe points out, the shift from fossil fuels to cleaner energy sources is crucial in the fight against climate change. **Molten salt reactors** have the potential to generate around 175 GWh of clean electricity annually, making a substantial contribution to reducing global greenhouse gas emissions. With energy production accounting for a significant portion of these emissions, the adoption of such innovative technologies is more important than ever.

Small modular reactor (SMR) developers in the U.S. have announced a string of deals and investments to secure steady supplies of HALEU nuclear fuel amid fears that the lack of a domestic nuclear fuel supply chain could delay the industry. ●Thyssenkrupp has put its tender for green hydrogen aside due to significantly higher prices for its $3 bn steel plant; ●Redstar's ORNL certified Aqueous Homogeneous Reactor makes 66 liters of hydrogen per micro unit- although scaling up to 80 MW would produce over 10,000 litres per minute (STP) for reducing iron, nickel and copper ores at only $0.28/kg of hydrogen from AHR through radiolysis of water with neutrons.
●SMRs could help meet an expected surge in U.S. electricity and even hydrogen demand coming from the expansion of power-hungry data centers but they are still in the development stage and unlikely to become commercially available until at least the end of the decade. As well as investing billions of dollars to develop this technology ahead of their rivals, SMR companies need to secure supplies of nuclear fuel. ●Redstar has a 5 year headstart testing and prototyping the AHR thanks to Oak Ridge National Labs and developer/ inventor Nobel Prize winning Glenn Seaborg. Thus, Redstar will develop on ships before 2030 the first commercially viable SMRs and “will always going to have the advantage,” said Jeffrey Bonner, editor at Nuclear Insights, a data analytics service by the American Fuel Resources, but their success will largely depend on their ability to "build out the supply chain in reverse.” ●“If you are looking at the dollar to megawatt equation, Nuscale, Westinghouse, Oklo, Terrestrial Energy, Terra Power and other newer SMRs will be very expensive, initially, because they have to start from scratch with testing, prototyping and licensing; and, because you have to build out the supply chain for solid and various protected and layered elaborate fuel systems, rather than AHRs liquid cheap nitrate or sulfate aqueous homogeneous flexible mixes that enable recycling others’ solid fuels or even atomic bombs- greatly lowering op costs. ●Many leading SMR companies such as Oklo, X-energy, TerraPower and kairos Power plan to use high assay low enriched

uranium (HALEU)-based fuels that are currently being produced through an electromechanical process to extract uranium from used nuclear fuel that is then mixed with lower enriched uranium. ● The U.S. Department of Energy (DOE) estimates the domestic demand for HALEU could reach 50 metric tons per year by 2035, with additional amounts required each year. However, Centrus Energy, currently the only U.S. maker of the fuel, aimed to produce 900 kilograms in 2024. The U.S. cannot import HALEU from Russia, the only global supplier of the fuel,



because the Biden administration banned uranium imports from Russia following the Ukraine invasion. **CHART**: U.S. uranium supply to commercial nuclear reactors (1950-2023). Million pounds total. Source: U.S. Energy Information Administration (January 2025) ●The HALEU supply chain needs to grow rapidly in order to meet future demand from SMRs, which will typically need to refuel every five to seven years. To tackle the looming deficit, the DOE in October awarded a total of ten contracts with companies such as Westinghouse, BWXT, Framatome, GE Vernova, Urenco, Centrus, and Orano to provide enrichment services that will help establish and build out a U.S. supply of HALEU and low-enriched uranium (LEU), and for deconversion services. ●The 10-year contracts will each offer a minimum of $2 million, with up to $3.4 billion available from the 2022 Inflation Reduction Act (IRA). The inflation act set aside some $700 million for the nuclear industry, with $500 million of that for HALEU production, $100 million to start a HALEU transportation system, and another $100 million for research, development, demonstration, and commercial use. In addition, SMR companies have signed several deals and announced investments to secure a steady supply of HALEU. ●The latest such agreement was signed by Sam Altman-backed Oklo, which in January announced a Memorandum of Understanding with advanced nuclear fuel company Lightbridge to co-locate their commercial fuel fabrication facilities. ●The *partnership could potentially reduce capital expenditures and operating costs, the companies said, giving Oklo an advantage over rivals. Also, Oklo has secured 14 GW in orders, including a non-binding agreement in December to supply data center company Switch for 12 GW from future* Aurora reactors through 2044. **Competitive advantages**: U.S. power demand from data centers is forecast to double within five years, rising from 176 TWh in 2023 to between 325 and 580 TWh in 2028, government data shows. ●Big tech companies are teaming up with firms operating traditional water-cooled fission reactors, such as Constellation and Talen Energy, as well as SMR developers to secure a steady supply of nuclear power for their data centers. Amazon is among a consortium investing $500 million in X-energy with the aim of installing 5 GW of SMR capacity in the U.S. by 2034.
●SMRs are expected to help meet an expected surge in U.S. electricity demand coming from the expansion of power-hungry data centers but they are still in the development stage and unlikely to become commercially available until at least the end of the decade. As well as investing billions of dollars to develop this technology ahead of their rivals, SMR companies need to secure supplies of nuclear fuel. The company that develops the first commercially viable SMR "is always going to have the advantage," said Jeffrey Bonner, editor at Nuclear Insights, a data analytics service by the American Fuel Resources, but their success will largely depend on their ability to "build out the supply chain in reverse." ●"If you are looking at the dollar to megawatt equation, newer SMRs will be very expensive, initially, Westinghouse is $16500 per kW and Newscale is 19,450 per kW. X- energy is at $5500 per kW, on par with coal plants at 6500 per kW. Then you have to build out the solid fuel supply chain," (for most *of these 3rd gen SMRs that use solid fuel* pellets, embedded kernals, or golf ball shaped fuel systems that are mostly light water or gas cooled reactors; and most still need water for cooling of up to 564 gal per MWh), Bonner told Reuters Events. This is where the AHR has a double advantage of 33 x's less cost per kW over Westinghouse, plus, already tested for 5 years and certified by ORNL. Redstar will easily win the first mover race and licensing/ commission! Also, since AHR uses spent fuel or HALEU, it has the ultimate flexibility and lowest Capex and Opex..
●Furthermore; many leading SMR companies such as Oklo, X-energy, TerraPower and Kairos also plan to use high assay low enriched uranium (HALEU)-based fuels that are currently being produced through an electromechanical process to extract uranium from used nuclear fuel that is then mixed with lower enriched uranium. Thus, Redstar could share a centralized fuel reprocessing facility to greatly lower costs. ●The global nuclear energy sector is experiencing a renaissance with increased interest and expansion plans, but faces the challenge of high water consumption for reactor cooling for Light Water reactor designs (Westinghouse, Nuscale, and all the boiling water designs or PWRs).. ● Advancements in nuclear technology, including small modular reactors and future designs using gas or air cooling, offer potential solutions to reduce water dependency, but concerns about increased nuclear waste persist.
● However, next-generation nuclear does have some key drawbacks as well. For one, studies have shown that SMRs will create more nuclear waste than traditional models. This presents a tricky and expensive problem, as the highly radioactive waste material remains hazardous for thousands of years in the best of scenarios. For another, nuclear energy is an extremely thirsty form of power production, requiring huge quantities of water to cool down the reactors for optimal particle speed for fission, as well as to generate steam to create electricity. According to Dave Sweeney, a nuclear policy analyst at the Australian Conservation Foundation, nuclear power uses more water than coal, and "massively more than renewables" on a per-kilowatt basis. Sweeney was speaking with the Guardian in reference to a recent conflict between political parties in Australia over planned nuclear expansion and water scarcity. A report commissioned by the organization Liberals Against Nuclear found that a whopping 90% of the nuclear generation capacity proposed by the opposing Coalition party lacks sufficient access to water for safe operations. "Half of the proposed nuclear capacity was already unfeasible given insufficient water, while a further 40% of the capacity would need to be curtailed during dry seasons," the Guardian reported this week based on the findings. And luckily, according to the Breakthrough Institute, "nuclear reactors don't need to be so thirsty." In order to support the expansion of nuclear

power, more strict guidelines are needed for water recycling processes at power plants. Moreover, nuclear reactor design is continuing to evolve, and some future reactors will rely on gas instead of steam, while others will use salt cooling.

FLOATING NUCLEAR POWER PLANTS: How can we provide a reliable supply of energy far out to sea, or on an island, or in a coastal community? The typical answer is by using fossil-fuelled generators. But as efforts to decarbonize global energy systems expand, one of the answers could be to use a floating nuclear power plant (FNPP). Interest is growing in installing small modular reactors (SMRs) on floating barges or platforms to provide clean electricity and heat for remote coastal locations, to decarbonize offshore oil and gas or mining activities, or even to provide grid scale electricity production, unlocking cost reductions through serial production in shipyards. At an IAEA symposium on floating nuclear power plants that took place from 14-15 November 2023 in Vienna, legal experts, nuclear and maritime regulators, and industry leaders discussed the benefits and challenges of FNPPs and exactly what role they could play in the fight against climate change and the transition to Net Zero. Opening the meeting, IAEA Director General Rafael Mariano Grossi said that in many countries “there is active consideration of floating nuclear power plants”. However, as part of discussions about their viability and potential applications, the Director General said that safeguards and the international legal and regulatory implications needed to be thoroughly analysed. Nuclear energy has already been in use for about 60 years in naval ships and icebreakers propulsion. However, FNPPs are different since they will produce low-carbon power and heat for different applications, including district heating, desalination and hydrogen production. Floating NPPs can be built in a factory, assembled in a shipyard and transported to a site, all of which may help to speed up construction and keep costs down. Canada, China, Denmark, South Korea, Russia and the USA are each working on marine small modular reactor designs, some are in advanced development, and Russia even has one FNPP, the Akademik Lomonosov, in commercial operation in the far east of the country. The Akademik Lomonosov FNPP has been in operation, producing electricity and district heating, since 2020. It has replaced the shut down Bilibino NPP and the aging Chaunsk coal power plant. However, it is the very mobility of these FNPPs that raises new questions, particularly when they move across international borders or operate in international, rather than territorial, waters. For example, how does the licensing and regulation process work when a FNPP is built and fuelled in one country’s jurisdiction, and then transported to another jurisdiction? “The IAEA is working with our Member States to determine what further guidance and standards might be needed to ensure the safety of floating nuclear power plants", IAEA Deputy Director General and Head of the Department of Nuclear Safety and Security, Lydie Evrard, said. "The IAEA’s safety standards serve as the global reference for protecting people and the environment from the harmful effects of ionizing radiation. There are also considerable legal and regulatory challenges that must be addressed if a truly international floating nuclear power market is to emerge,” she said. Topan Setiadipura, the Co-Chair of the Symposium and Head of the Research Centre for Nuclear Reactor Technology (BRIN) in Indonesia said, “to some extent, floating NPPs are an interesting option for Indonesia as many power or utilities companies have floating diesel power plants or floating gas power plants”. However, acquiring more information and knowledge is essential to understanding whether embarking countries like Indonesia could use FNPPs in the future to replace fossil-fuelled floating power plants, he said. During the symposium, discussions focused on current and future designs of FNPPs and their uses, including, for example, as a floating offshore installation for production of clean hydrogen to be converted into green ammonia for use in agriculture or as a low carbon shipping fuel. Participants also examined the specific challenges that the movability of FNPPs pose for their licensing, regulation, transportation and application of safeguards. Nuclear safety and security were discussed, including the extent to which the current standards and practices can, or cannot, be applied to FNPPs. The symposium’s concluding session identified the next possible steps to enable the deployment of floating nuclear power plants, including the establishment of a mechanism to improve communication between the nuclear and maritime industry on one hand, and regulators on the other, with focus on application of security and safeguards by design. “Getting to Net Zero requires the use of all clean energies available,” Mikhail Chudakov, IAEA Deputy Director General and Head of the Department of Nuclear Energy, told the gathering. “Floating nuclear power plants are not in competition with land-based SMRs but extend the use and potential of such nuclear technology to reach our Net Zero targets.” TYPES OF **FLOATING PLANTS**. **LNG Floating Power Plants**:

These plants utilize Liquified Natural Gas (LNG) as fuel and are designed to be towed to the desired location and moored for power generation.

●Example: Kawasaki Heavy Industries has developed an LNG floating power plant with high-efficiency power generation equipment. ●Easier ship access ●Advantages: Faster construction, lower environmental impact compared to coal or heavy oil, and flexibility in location. ●Lower port fees. **Floating Solar Power Plants**:

These plants utilize floating photovoltaic (PV) panels on bodies of water (lakes, reservoirs, etc.) to generate electricity. ●Advantages:

Utilizes water bodies, reducing land usage, and can be integrated with hydroelectric power plants. ●**Relatively flat and homogeneous**.. **Floating Nuclear Power Plants**:

These plants feature nuclear reactors on a floating platform, providing a compact and potentially reliable power source. ●Example: The Russian design for floating nuclear power plants ÍNTPC Renewable Energy:

Won the bidding for an 80 MW floating solar project at Omkareshwar Reservoir in Khandwa, Madhya Pradesh. Hybrid Plants:

In Türkiye, some hybrid power plants have 80 MW of secondary installed solar capacity, like the Aşağı Kaleköy Hydroelectric Power Plant.

SeaFloat:

SeaFloat's first order for a floating platform will be equipped with two SGT-800 gas turbines, which could be placed by the end of 2018 and commissioned as early as the beginning of 2020. Modular Power Barges:

A modular, medium-speed engine 80-MW to 180-MW power barge design has received Approval in Principle (AIP). Faster Deployment:

Floating power plants can be deployed much faster than traditional land-based plants, potentially addressing electricity shortages quickly. Flexibility:

They can be moved to different locations as needed, offering flexibility in power supply. Reduced Land Usage:

Floating plants can utilize water bodies, freeing up land for other uses. Environmental Advantages:

LNG-based floating plants can reduce emissions compared to coal or heavy oil-fired plants. Potential for Hybrid Systems:

Floating platforms can be designed to integrate multiple renewable energy sources, like wind, solar, and wave power. Floating Power Plant Benefits: Thus, for Redstar, floating power plants, including those with 80 MW capacity, offer advantages like faster deployment and flexibility in addressing electricity demand, particularly in remote areas or those with limited land for traditional power plants. Furthermore, with a fleet of 6W (120 MWh) to 32 MW (360 MWh) thermal batteries operating wirelessly, it makes no difference if the plant is on land or at sea, and/ or in the harbour.

Novel Floating Power Plants on the Horizon For decades, floating power plants have been used widely as a source of flexible, decentralized power generation for several reasons. Among them are that they can be built cost-effectively and rapidly; they are mobile, which means they can be relocated or traded; and because they do not require a large site and sometimes have no land footprint, they can be deployed even in the most remote locations and under challenging ambient conditions, both for temporary or permanent power. Some experts suggest that more than 75 floating power plants are installed worldwide. But historically, floating power plant (or vessel-mounted power plant) fleets have relied on diesel, gas, or dual-fuel engines that can run various types of liquid and gaseous fuels. For example, of the more than 20 floating power barges that Finnish power plant equipment provider Wärtsilä has launched since the late 1990s in places like Bangladesh, Jamaica, and Papua New Guinea, most are fueled by heavy fuel oil. Owing to demand for low-cost flexibility, floating power plants are seeing a resurgence. But developments on the horizon suggest the future fleet could be far more diverse and include nuclear plants, combined cycle gas turbines, and liquefied natural gas (LNG) facilities. Floating Nuclear. On November 5, the first of two 35-MW KLT-40S reactor units aboard Russia’s Academik Lomonosov reportedly sustained chain reactions for the first time. According to Russian state-owned nuclear company, Rosatom, comprehensive testing of the reactor will begin in a few days. The plant’s second reactor will also be started soon. Construction of the floating plant, which began in 2009 at the Baltic shipyard in St. Petersburg, wrapped up this April, and it was towed without nuclear fuel 4,000 kilometers (through four seas—the Baltic, Northern, Norwegian, and Barents) to Murmansk, where it arrived in May. Fuel loading began in July and wrapped up on

October 2. After testing is concluded, it will be towed to its permanent base at Pevek in Russia's Far East region of Chukotka in the summer of 2019. At Pevek, it will replace the 48-MW Bilibino nuclear power plant and 35-MW Chaunskaya thermal power plant, projects Rosatom said are "technologically outdated," and it will become the most northerly nuclear power plant in the world (Figure 1).

1. A mobile nuclear plant. The Akademik Lomonosov, which could begin providing power to Russia's remote Chukotka region next summer, is one of the world's first floating nuclear plants. The two-reactor plant is 144 meters long and 30 meters wide. This image shows the barge leaving the shipyard in April 2018. *Courtesy: Rosatom*

Rosatom noted the plant is the main project in a series of mobile transportable power units of low power. China, meanwhile, is also developing an offshore nuclear power station, and suggested the first plant of its fleet—which is expected to include floating and submarine designs—could be delivered by 2020. Details of the fleet aren't fully known, but experts suggest at least two designs are under development, both of which are small pressurized water reactors. The Nuclear Power Institute of China, a subsidiary of the China National Nuclear Corp. (CNNC), has signed an agreement with UK-based Lloyd Register to support development of a barge that could use CNNC's ACP1000S, while China General Nuclear Power Group in 2016 started development of its ACPR50S floating plant. CNNC has also reportedly set up a joint venture that would have one billion yuan in registered capital to develop and produce small, floating nuclear power plants. Experts, however, noted multiple technological difficulties must be overcome, such as licensing, safety, radiation protection, and waste disposal.

Floating Gas Turbines. While gas turbines installed on ships and oil platforms aren't new, their power output has been limited owing to space and fuel availability constraints. Siemens hopes to change that. Following the devastating tsunami in Japan in 2011, the company's SeaFloat team has been actively developing and marketing floating platforms and ships that can be equipped with varying gas turbine models. The concept, which it offers for lease or purchase, seeks to meet what it says is surging demand from energy providers in developing nations or companies looking for flexibility in industrialized countries. SeaFloat's first order for a floating platform will be equipped with two SGT-800 gas turbines, and it could be placed by the end of 2018 and commissioned as early as the beginning of 2020, it said. However, Siemens also offers floating plants equipped with the smaller quick-start SGT-A65 aeroderivative gas turbine.

"Even the large Siemens SGT-8000 H-class gas turbines will be made seaworthy in the future," the company said, noting that for combined cycle gas turbine (CCGT) power plants, outputs of up to 1.3 GW "are possible" (Figure 2).

2. Floating a heavy-duty gas plant. Siemens' SCC5-8000H SeaFloat power plant, pictured in this artistic rendering, has an SGT-8000H gas turbine on board. It could deliver up to 1.3 GW with a plant efficiency of more than 61% in a two-unit combined cycle configuration. *Courtesy: Siemens*

This August, the company said its SeaFloat team has developed the heavy-duty concept "to the point of readiness for series production." Because a CCGT on board a barge at sea exposes turbines to increased stress due to the swell, engineers took a "wide variety of measures to adapt supports, bearings, and other components that would dampen these wave-induced movements," it said. Engineers also considered standards that can vary from country to country and harbor to harbor.

"Once a power plant is docked, the simplest option is to supply it with natural gas from land. If the facility is located further offshore, it can also be supplied with [LNG] from ships. To make this possible, additional platforms have to be set up where ships can dock. These platforms would be equipped with the technology that is needed to convert the liquid fuel into a gaseous one," Siemens said.

Floating LNG Power Plants. While several prototypes for floating LNG power plants have been launched over the years, no commercial floating LNG-powered plants have yet set sail. However, recent advances in floating storage and regasification technologies are now making floating LNG power plants more operationally viable.

Notably, Malaysia's state-owned oil and gas firm Petronas in April 2017 launched a new era in gas production when it began operating the world's first floating liquefied natural gas (FLNG) platform—a facility that floats above an offshore natural gas field and produces, liquefies, stores, and transfers LNG to a carrier ship. Keppel's Hilli Episeyo in March 2018 became the second FLNG vessel to begin production, and Shell is nearing completion of its massive and much-watched Prelude FLNG facility offshore in Western Australia. Experts say the developments promise to broaden fuel availability and catalyze the movement toward gas-to-power projects at remote sites.

But they also note these FLNG breakthroughs are accompanied by the operational start of more floating storage and regasification units (FSRUs). Since 2005, when the first FSRU began operation in the U.S., at least 28 are now operational—three came online in 2017, and five were scheduled for delivery in 2018. In step with that trend, various power plant equipment makers have unveiled innovative designs for FLNG power vessels. As Mitsubishi Heavy Industries noted, key reasons for resurgent interest in FLNG power generation is the marked increase in global gas supply, a surge in environmental consciousness, the drive for flexibility, and most importantly, lower costs. LNG "power ships," it noted, can cut utility charges by a third compared to diesel.

Projects awarded an approval in principle (AIP) over the past year by the American Bureau of Shipping include the 100-MW Hudong-Zhonghua Shipbuilding's LNG Power Supply Vessel, which integrates an LNG receiver, storage, and regasification. The ship features GE's modular Combined Gas Turbine, Electric and Steam power trains. Last year, Japan's Chiyoda also got the marine classification society's AIP for its concept, which is based on existing LNG carriers and range from 72 MW to 400 MW, and Houston-based Power Barge Corp. won an AIP for its modular, medium-speed engine 80-MW to 180-MW power barge design. Meanwhile, approvals may be forthcoming for a project jointly developed by Lloyd's Register and Hyundai Heavy Industries for a 221-MW barge-mounted power plant running 13 HiMSEN dual-fuel engines. Samsung in 2017 also unveiled its "all-in-one-solution," a 500-MW FLNG power plant that integrates a CCGT, an LNG containment system, and a regasification unit.

New York City to Get Eight Floating Aeroderivative Gas Turbines

Floating Nuclear Power Buoyant on New Prospects

In July 1968, the U.S. Army sent the world's first floating nuclear power plant, the Sturgis, to the Panama Canal to help overcome a regional hydroelectric power plant shortage, which was driven by a severe drought and worsened by increased ship traffic through the Canal zone. The Sturgis (Figure 1) featured a 45-MWth/10-MWe MH-IA pressurized water reactor (PWR)—the last reactor the Army fashioned—and it operated until 1976, five years longer than initially anticipated. It produced 356 GWh until the military withdrew it from the area amid concerns that acts of violence might damage it during treaty negotiations between the U.S. and Panama.

1. The Sturgis, a former World War II Liberty ship, was converted into the first floating nuclear power plant in the 1960s. Before being shut down in 1976, the Sturgis' nuclear reactor, MH-1A, was used to generate electricity for military and civilian use in the Panama Canal. The very complex and unique MH-1A decommissioning project was ultimately completed in 2018. Source: U.S. Army Corps of Engineers

While the Sturgis demonstrated crucial attributes of floating nuclear power—including reliability and resilience—it wasn't readily replicated, despite emphatic efforts by industry, such as Westinghouse's 1970s "Offshore Power Systems" initiative and Public Service Electric and Gas Co.'s 4.6-GW Atlantic Nuclear Power Plant. But buoyed by a global urgency to add new nuclear capacity to address modern power challenges, interest in floating nuclear power plants appears to be perking up.

A Key Selling Point: Flexibility

Floating nuclear's key selling point is fixated on flexibility. Industry observers suggest emerging designs could accelerate the shift of the established paradigm for nuclear, which today is exclusively based on large centralized plants, toward distributed generation to satisfy multiple energy consumption needs beyond electricity, including heat, desalination, and production of hydrogen and ammonia.

In addition, experts note that nuclear mobility has been long established— and even predates the commercial nuclear industry—and fabrication methods already exist at scale at commercial shipyards. And, as the Electric

Power Research Institute (EPRI) noted in a recent report, regulatory precedent has also been established by the 1970s Atlantic Nuclear Power Plant. “As part of this effort, the environmental and regulatory review processes for commercial offshore applications were exercised and demonstrated to the point of authorization of plant fabrication,” EPRI noted.
“Throughout the 1970s, a private- sector venture pursued state and federal regulatory review for the Offshore Power Systems proposal, which entailed multiple factory- manufactured floating reactors to be sited off the east coast of the United States,” it said. In the U.S., the regulatory review “was generally positive and resulted in a final environmental statement that included a recommendation for issuance of a license to remotely fabricate the nuclear plants in a purpose-built shipyard-like facility.”

Today, however, only one other floating nuclear power plant has been completed and deployed: Rosatom’s barge-mounted Akademik Lomonosov plant, which began supplying electricity and heat at Pevek, a remote mining site on the north coast of Siberia in May 2020. The plant includes coastal infrastructure and a floating power plant unit outfitted with two 35-MW KLT-40S thermal neutron spectrum PWRs.

However, more Russian projects are already on the horizon. Chinese shipyard Wison Heavy Industries in August 2022 kicked off construction for the first of four floating plants for offshore operation near Cape Nagleynyn in the Chukotka Autonomous Region. The project, which is slated to be moored in the Russian Arctic by 2027, will feature two Atomenergomash Group RITM-200S PWRs—a combined 105 MWe—mounted on a 140-meter-long barge.

“This project is special for us for several reasons: for the first time ever Atomenergomash establishes [itself] as supplier of the final product— floating power units, for which we are responsible from start to finish. Second, I can say that this is the start of the history of a whole [floating nuclear power plant unit] family, with a whole capacity and purpose range—Arctic and Tropic versions,” said Andrey Nikipelov, director general of Atomenergomash.
In North America, ***NuScale Power*** and ***Prodigy Clean Energy***, a Canadian designer of small modular reactor marine power plants, in October 2022 announced a new conceptual design for their “transportable and marine-based small modular reactor (SMR) power generating facility,” which is based on ***NuScale’s*** terrestrial ***77 MW VOYAGER*** power plant offering. The milestone marks the next pivotal step under a MOU the two companies signed in 2018 to bring “a competitive North American SMR marine facility to market.”

2. An artistic rendition of NuScale Power and Prodigy Clean Energy’s Marine Power Station. The companies in October 2022 said an updated concept would be used for engagements with utilities, regulators, and shipyard manufacturers. Courtesy: Prodigy Clean Energy

Prodigy said its SMR Marine Power Station (MPS, Figure 2) can house from one to 12 NuScale Power Modules, for a total output of 924 MWe. “Compared to terrestrial deployments, the benefits of using Prodigy’s technologies to deploy the *NuScale VOYGR SMR power plant* begins with manufacturing and outfitting of the entire marine facility in a shipyard, enabling expedited delivery,” it added.
“Further advantages include a significantly reduced capital expenditure; accelerated project schedule; minimized site preparation; reduced environmental impact; unlocked project financing structures that are not typically available to conventional site-constructed nuclear plants; and simplified and expedited decommissioning and site recovery. The marine facility’s design is standardized to allow for deployment at a wide variety of sites and for serial manufacturing.”
Floating a Platform for Molten Salt Reactors Development is kicking up for barge-mounted advanced reactor concepts, too, mostly in Asia. In December 2022, Bureau Veritas (BV), a certification body and also a nuclear power technology developer, announced it entered into an agreement with *ThorCon (my cousin Lars Jorgenson*

is CEO) for the technology qualification and "subsequent development" of a 500-MW molten salt nuclear power barge for operations in Indonesia.

The concept integrates a molten salt power plant within a floating barge hull, which will be towed to a shallow water site before being ballasted to rest on the seabed. "Experts from Bureau Veritas' Nuclear Certification Department and from the Marine & Offshore Division will collaborate throughout the process," BV said. "A key area of work will be to identify the applicable standards, codes and Class Rules, potential gaps with those currently available and the development if needed of new guidance notes and rules." BV anticipates the technology qualification process will take a minimum of three years. If successful, the deployment phase would require another two years. For ThorCon, which will focus on Southeast Asia as its primary market for its fourth-generation advanced nuclear design, technology qualification marks an important step. The company said it has entered into discussions with the Indonesian province of Bangka-Belitung, Indonesia's state electricity company PLN, and the country's nuclear energy regulatory agency BAPETEN regarding potential sites for the demonstration and the final installation of a 500-MW power plant. "Unlike current nuclear reactors, the ThorCon reactor operates at low pressure and uses liquid fuel. The liquid fuel enables much higher operating temperatures, leading to greater efficiency while also enabling completely passive safety (requiring no action from the operator nor intervention on the power source to stop the reaction)," it said.

Another floating nuclear liquid fuel concept separately making similar headway is spearheaded by South Korea's Samsung Heavy Industries (SHI) and Danish technology firm *Seaborg Technologies*. In early January, SHI reported it had garnered Approval in Principle (AIP) from the *American Bureau of Shipping* for its Compact Molten Salt Reactor (CMSR) power barge. The AIP from ABS marks an essential milestone in a technology qualification process overseen by the global provider of classification and technical advisory services, essentially confirming that the proposed early concept complies with required industry codes and standards.

*3. Danish company **Seaborg** has partnered with **Samsung Heavy Industries** to develop the Compact Molten Salt Reactor (CMSR) Power Barge. "The **CMSR Power Barge** is designed to be cost-competitive, whether it's delivering process heat for industrial purposes, electricity into the grid of an existing coal port, or power the production of hydrogen and ammonia," Seaborg said. Courtesy: Seaborg*

The CMSR concept (Figure 3), which Seaborg launched in 2017, is a 250-MWth/100-MWe molten salt reactor designed for use in modular floating nuclear power barges. The concept derives from Seaborg's first reactor design effort, the Molten Salt Thermal Waste Burner (MSTW), a terrestrial 270-MWth/115-MWe molten fluoride salt reactor, which features a graphite moderator.

"In these reactors, the molten salt is both the liquid nuclear fuel and the coolant that continuously circulates in a closed-loop primary system operating at or near atmospheric pressure. The reactor core is formed by an array of fuel/coolant pipes that pass through the moderator inside the reactor vessel," Seaborg explained.

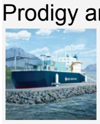
The CMSR, however, uses a "proprietary liquid moderator that enables the reactor core to be about 1/8 the size of a graphite-moderated core with a comparable power rating, such as the MSTW." The scale is well-suited for marine applications, but so are the design's inherent safety and refueling features, Seaborg noted. "Molten salt reactors are designed to be refueled online by periodically adjusting the amount of enriched uranium fluoride salt in the molten fuel/coolant to sustain near-term power operations. In an emergency, the entire inventory of molten fuel/coolant can be discharged from the primary system into criticality-safe drain tanks under the reactor," it said.

“In contrast, civilian marine PWRs contain enough enriched uranium to sustain operating cycles lasting from several years to a decade between refuelings. Marine PWRs severe accident phenomena may include hydrogen generation in the reactor core (from hot zirconium-water reaction) and core melt. These accident phenomena cannot occur in the CMSR.”

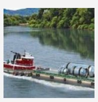
Seaborg’s concept is designed to be mounted on a flat bottom, unpropelled barge comprised of at least three modular sections: a bow, a power module housing two to eight CMSRs, and an “accommodation/control section.” Seaborg in April 2022 sealed a key partnership with SHI to manufacture and sell turnkey power plants “ready to be moored at industrial harbors and connected to the electric grid onshore.” The partners also launched an effort to develop hydrogen production and ammonia plants powered by CMSRs. However, they noted the design of these units “will be optimized for efficient serial construction at SHI’s shipyards.”
As a modular floating power plant design, the CMSR could deliver up to 800 MWe for a 24-year lifetime to developing countries strapped for power. “The site selection and facility constraints are relatively less demanding, the construction period is as short as about two years, and the cost is low,” the company claims. For now, SHI plans to commercialize the CMSR power barge by 2028, after completing the detailed design of all its power-generating facilities. Serial production could begin in 2030, it noted. The companies acknowledge that the timeline may be optimistic, given a lack of mature regulations that adequately address nuclear safety issues for the novel marine reactor design.

Seaborg Floating nuclear thoriumMolten salt reactors. Russia Ammonia Hydrogen Marine powerplant design nuclear reactor

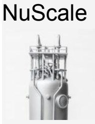
Prodigy and Westinghouse Targeting Launch of eVinci Floating Nuclear Plant in Canada by 2030



South Korean Companies Snap Up Opportunities to Advance Floating Nuclear, Nuclear Hydrogen, SMRs



NuScale Exploring Marine-Deployed SMR Power Plant



Poland Secures NuScale SMR as Urgency for Nuclear Energy Ramps Up Across Central, Eastern Europe

- Tech and Industry Giants Pledge to Triple Global Nuclear Power by 2050
  A coalition of large energy users—including Google, Amazon, Meta, Occidental, and Dow—have pledged their support

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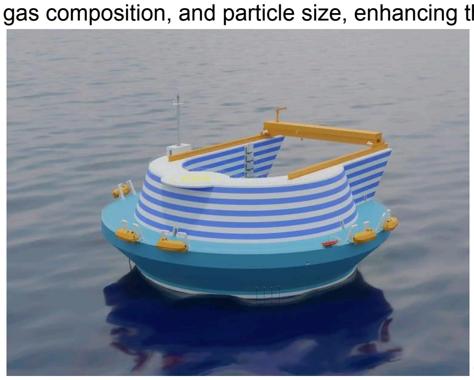
FLASH IRONMAKING:

Considering the two most important issues the ironmaking industry faces today, i.e., energy consumption and greenhouse gas emissions, it would be advantageous to utilize the concentrate-size raw materials directly without pelletizing or sintering, especially without the use of coke. The solution is the Flash Ironmaking Technology (FIT) and the other is a moving-bed process for continuous ironmaking with gaseous reduction of iron ore concentrate (MBIT). These technologies are designed to produce iron directly from iron concentrate without requiring pelletization/sintering and cokemaking in two significantly different temperature ranges. They take advantage of the high reactivity of the concentrate particles and will considerably reduce energy consumption and carbon dioxide emissions compared with the current processes. The process of the development from the conception of the idea, to kinetic feasibility establishment, to laboratory flash furnace, and finally to the operation of a prototype facility for the development of the FIT is discussed. The development of the MBIT also started with the formulation of the process concept, followed by kinetics feasibility establishment, and the design of a potential industrial reactor. The results of economic analyses on the FIT are briefly described. That's $12.75 million per km There is a flash ironmaking process worked out by US DOE and is 3500 x's more efficient in one step using ground up ores and pig iron.   Works by H2 plasma.   Ninety nine percent of the universe is plasma, as is molten metals, and they are the most energy conserving form in the universe; and helps to explain why after a year, the Red Sun loses only 300°C to 1550°C (from 1850°C) and still run turbines at 1350°C and diesels at 950°C. And so using plasma in Flash Ironmaking and smelting works Super efficiently using hydrogen plasma,using only 3% of the hydrogen of other hydrogen reduction methods; making steel alloy with iron and nickels that can go directly in Red Sun molten metal in 6 seconds! Takes grinding ores to fine powder 1st - but takes poor quality Iron ore oxides and nickel laterites. Replaces blast furnace with efficient H2 plasma laser. Revolutionizing Steel Production: The Promise of Flash Ironmaking and Its Impact on CNC Technology The steel industry serves as a vital pillar of the global economy, with over 90% of iron traditionally produced through blast furnace smelting processes. Despite numerous advantages, such as technological maturity and high energy efficiency, the significant carbon emissions associated with this method have become increasingly problematic amidst growing concerns over global climate change. Reports indicate that the steel industry is responsible for 5-6% of global carbon emissions, with traditional blast furnace ironmaking accounting for approximately 70% of those emissions. Therefore, reducing emissions in this sector is a critical step toward achieving broader climate goals.

Advancements in Ironmaking Technology. In response to these challenges, researchers and industry leaders worldwide have been actively developing innovative ironmaking technologies. These efforts focus primarily on two strategies: 1). Optimization and Upgrading of Blast **Furnace Processes**: 2.). Development of Alternative Ironmaking Technologies: Flash **Ironmaking**: **A Promising Solution**: ●Amid these developments, flash ironmaking technology has emerged as a particularly promising solution. Pioneered by the Institute of Metal Research at the Chinese Academy of Sciences in collaboration with Ansteel Group, this method adapts the mature flash smelting techniques from the non-ferrous industry to iron production. Key benefits of this approach include: **Rapid Processing:** By using iron ore fines and eliminating the need for sintering and coking, flash ironmaking can convert ore to molten iron in just 3-6 seconds, compared to the several hours required by traditional methods. Environmental Advantages: The process uses hydrogen as a reducing agent, significantly reducing carbon emissions and aligning with global sustainability goals. **Resource Efficiency**: The method is adaptable to various grades of iron ore, enhancing resource efficiency and reducing reliance on high-grade ores. ●Studies by Professor Hong Yong Sohn's team at the University of Utah demonstrated over 90% reduction rates for iron ore fines using hydrogen or natural gas. ●Comprehensive kinetic models have been developed to optimize key process parameters, such as temperature, gas composition, and particle size, enhancing the overall efficiency and feasibility of the process.



Core Power These Floating Nuclear Reactors—Powered by Salt—Could Supercharge America's Electrical Grid ●The small nuclear power plants will use molten salt in their fuel, making them safer and more versatile and portable than traditional nuclear power plants. ●Nuclear power is leveling up, with plans for an entire floating power plant fueled by something you'd least expect to find in a reactor— table salt. ●By the mid-2030s, a fleet of smaller floating nuclear power plants (FNPPs) that use "molten salt reactors" could form the largest floating power plant in the U.S. Nuclear innovation company Core Power, based in the U.K., dreamed up the design, and its Liberty program will oversee construction of the plant. A central shipyard will manage the build, keeping up with tasks such as maintenance and refueling. Some of the FNPPs in the fleet can be stationed near the coast, while others will be further out in the ocean. A definite location for the FNPP has not yet been announced. ●Rather than the typical fuel powering a nuclear reactor, uranium-235 rods, these reactors will be using salt and powdered uranium oxide melted together. Instead of the water used in traditional generators, salt will also be used as a coolant, virtually eliminating the risk of evaporation. ●The Liberty Project's network of mass-produced FNPPs is expected to generate around 175 GWh of clean electricity per year. That is an enormous shift from fossil fuels, which have been warming the planet and wreaking havoc with the climate worldwide over the last 150 years. While efforts in more eco-friendly energy sources like wind and solar have been gaining momentum, energy production still makes up about three-quarters of total greenhouse gas emissions globally, according to the International Energy Agency. ●"We have an opportunity to use energy differently," said Core Power CEO Mikal Bøe at a recent summit in London. "The output [of fossil fuels] is exhaust gases, and those are the heart of the decarbonization debate. In a sense, the challenge here is if we're going to solve decarbonization." ●Molten salt reactors were first conceived in the 1960s by scientists at Oak Ridge National Laboratory who came up with the Molten Salt Reactor Experiment. The brainchild of nuclear physicist Alvin Weinberg, it was the first nuclear reactor to use molten salt as both a coolant for fuel and a component of the fuel itself. It was also the first reactor ever to run on uranium-233 or U-233. Though it ran at full power for more than 13,000 hours from 1965 through 1969, the Department of Energy eventually lost interest in the project and shut down operations. Then things were pretty much silent until research resumed in the early 2000s. ●"It wasn't until the 2010s or so when there started to be interest on the industry side, with people thinking this might be a viable technology for smaller reactors," Oak Ridge lab physicist Ted Besmann, Ph.D., told Popular Mechanics. "There began to arise small companies inspired by the MSRE that began to take an interest in molten salt reactors." ●The original Oak Ridge lab's nuclear salt reactor used U-233 atoms that experienced nuclear fission when bombarded with neutrons. The U-235 that Core Power is planning to use in its reactors is slightly more powerful at 200 MeV—or 200 million electron volts—which releases 1.8 million more times the energy of the same mass of diesel. Besmann sees more advantages than just more energy output. The problem with water as a coolant is its volatility, or evaporation at high temperatures. Pressure in these types of reactors needs to be so high that the water would evaporate without thick-walled steel vessels to keep it contained. If that pressure is lost, so is the water, and without a coolant, the reactor fuel will overheat and radioactive sludge could ooze out, causing a highly dangerous situation. ●Molten salt reactors that use salt as a coolant have an advantage because the boiling point of salt is much higher. Even at extreme temperatures, the molten salt will still be far below its boiling point, so it only needs a thin vessel to contain it. If things do overheat, coolant salt circulating around the reactor will expand and stop the fission reaction inside. ●"There are also potential advantages in that you can refuel the reactor while it's operating," said Besmann. "You can reprocess the fuel and continue to run the reactor. These are potential advantages nobody has ever demonstrated, but it's one of the possibilities that add to the attractiveness of this kind of reactor.

."Core Power ●This illustration depicts the offshore production of energy using a floating nuclear power plant. ●Core Power's concept of a floating nuclear power plant has advantages of its own. Putting FNPPs on industrial barges instead of building them on land not only makes them more mobile, but less problematic, because the construction and imposing presence of the plant won't take over an entire neighborhood. Nobody really wants to live next to a nuclear power plant. It's also possible for a floating network of power plants to generate more power than at just one site on land, and with an immense amount of power comes a huge amount of transmission. A single FNPP on a grid can deliver power to any point on that grid. ●Future applications for molten salt reactors could extend to portable versions that supply energy to remote sites or military bases, as Besmann sees it. Trucking fuel to bases has been one of the largest sources of casualties for the military, but a small nuclear plant could solve that issue. For now, he thinks the Core technology looks promising. "I think their broad thinking about providing large-scale amounts of power from sea-based systems has a lot to recommend it," he said. "Success will probably hinge less on the sea-based concept and more on the ability for reactor vendors to supply plants that can deliver electricity at a competitive price."

Industrial Application and Economic Insights: The path to industrializing flash ironmaking appears promising, with pilot tests revealing favorable economic and technical outcomes:
Energy Consumption: Comprehensive energy consumption is estimated at about 450 kgce per ton of iron, or 4 MWh/ ton of iron, comparable to traditional blast furnace methods.
Material Recycling and Efficiency: The incorporation of efficient off-gas treatment and heat recovery systems maximizes resource utilization and minimizes waste, contributing to the method's economic viability.
Implications for the CNC Industry. For the CNC sector, advancements in steel production through processes like flash ironmaking present exciting new opportunities: **Access to Sustainable Materials**: As steel production technologies evolve to become more sustainable, CNC manufacturers can benefit from more environmentally friendly material options. **Cost and Efficiency Improvements**: Enhanced ironmaking processes may lead to cost savings in raw materials, which can positively impact CNC machining operations. In conclusion, staying informed about these technological advancements in steel production is crucial for those in the CNC industry. These innovations not only offer potential improvements in material sourcing and cost efficiency but also inspire broader consideration of sustainability and technological advancement within. China makes new progress in flash ironmaking tech. China has achieved breakthroughs in flash ironmaking technology, a process capable of boosting ironmaking efficiency by up to 3,600 times, according to a recent study published by a researcher of the Chinese Academy of Engineering (CAE) in Nonferrous Metals (a leading technical journal in the nonferrous metals industry in China). Flash smelting involves injecting metal concentrates and reducing gases such as hydrogen or natural gas into a furnace, where the wide dispersion of concs creates optimal conditions for chemical reactions, enabling the rapid production of high-purity metals, according to the study paper. This method has been widely used in Jinnan.
Development of a Novel Flash Ironmaking Technology with Greatly Reduced Energy Consumption Despite the dominance of the blast furnace ironmaking process, increasing attention is being paid to the development of new technologies with lower energy consumption and CO_2 emissions. At the University of Utah, a novel flash ironmaking technology to meet these demands is under development. This technology eliminates the highly problematic cokemaking and pelletization/sintering steps by directly utilizing iron ore concentrate, which is currently produced in large quantities in North America and elsewhere. This transformative technology is expected to allow significant energy saving and reduced CO_2 emissions compared with the blast furnace process. It has been demonstrated that iron of more than 95 % metallization can be obtained by reduction with hydrogen

or a mixture of carbon monoxide and hydrogen in 2–7 s at temperatures of 1473–1823 K. The development of the technology has gone through the stages of proof-of-concept and small laboratory flash reactor tests. A large prototype bench reactor that has most of the features of an eventual industrial reactor has been built in China and is operating successfully.. Introduction to Flash Ironmaking Technology: new high power lines cost $12.75 million per km At $2.5 bn for 196 km in Australia, and 1000 miles of transmission lines blew out to $ 13.9 bn AUS- $13.9 million per mile! Thus Red Sun has a defacto monopoly transporting 360 MWh by truck, train and ship in 29 ton shipping containers! Also, Red Sun thermal wireless batteries are needed to build smelters as the cost of blue, turquoise and green hydrogen is too expensive, causing green steel projects to be halved in 2024, and even Fortesque quit his green steel project in Aus. Thus, smelters metal refineries, and manufacturing can het half or quarter- priced heat amd 1000°process heat and stem through Red Sun, plus delivered from RE off-sites and delivered to plants everyday- buying discount power at night and plugging into existing diesel and turbine cogens or ships and trains; of course after retrofitting/ remodelling or upgrading them.
● There is a flash ironmaking program worked out by US DOE and is 3500 x's more efficient in one step using ground up ores and pig iron. **Works by H2 plasma**. Super efficiently makes steel alloy with iron and nickels that can go directly in Red Sun molten metal in 6 seconds! Takes grinding ores to fine powder 1st - but takes poor quality Iron ore oxides and nickel laterites. Replaces bladt furnace with efficient H2 plasma lasers Revolutionizing Steel Production: The Promise of Flash Ironmaking and Its Impact on CNC Technology The steel industry serves as a vital pillar of the global economy, with over 90% of iron traditionally produced through blast furnace smelting processes. Despite numerous advantages, such as technological maturity and high energy efficiency, the significant carbon emissions associated with this method have become increasingly problematic amidst growing concerns over global climate change. Reports indicate that the steel industry is responsible for 5-6% of global carbon emissions, with traditional blast furnace ironmaking accounting for approximately 70% of those emissions. Therefore, reducing emissions in this sector is a critical step toward achieving broader climate goals. **Advancements in Ironmaking Technology**.
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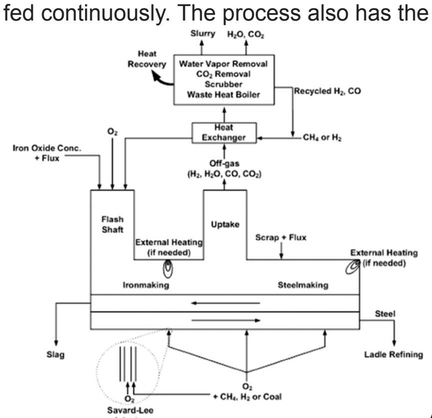
Optimization and Upgrading of Blast Furnace Processes & Development of Alternative Ironmaking Technologies: Flash Ironmaking: A Promising Solution. Amid these developments, flash ironmaking technology has emerged as a particularly promising solution. Pioneered by the Institute of Metal Research at the Chinese Academy of Sciences in collaboration with Ansteel Group, this method adapts the mature flash smelting techniques from the non-ferrous industry to iron production. Key benefits of this approach include:. **Rapid Processing**: By using iron ore fines and eliminating the need for sintering and coking, flash ironmaking can convert ore to molten iron in just 3-6 seconds, compared to the several hours required by traditional methods.. Environmental Advantages: The process uses hydrogen as a reducing agent, significantly reducing carbon emissions and aligning with global sustainability goals..
Resource Efficiency ●The method is adaptable to various grades of iron ore, enhancing resource efficiency and reducing reliance on high-grade ores. Significant research efforts have been undertaken to explore the potential of flash ironmaking: Studies by Professor Hong Yong Sohn's team at the University of Utah demonstrated over 90% reduction rates for iron ore fines using hydrogen or natural gas. Comprehensive kinetic models have been developed to optimize key process parameters, such as temperature, gas composition, and particle size, enhancing the overall efficiency and feasibility of the process. Industrial Application and Economic Insights The path to industrializing flash ironmaking appears promising, with pilot tests revealing favorable economic and technical outcomes:. **Energy Consumption**: ●Comprehensive energy consumption is estimated at about 450 kgce per ton of iron, comparable to traditional blast furnace methods that use 4 MWh energy per ton.. **Material Recycling and Efficiency**: ●The incorporation of efficient off-gas treatment and heat recovery systems maximizes resource utilization and minimizes waste, contributing to the method's economic viability Implications for the CNC Industry:
●For the CNC sector, advancements in steel production through processes like flash ironmaking present exciting new opportunities: Access to Sustainable Materials: ●As steel production technologies evolve to become more sustainable, CNC manufacturers can benefit from more environmentally friendly material options.. **Cost and Efficiency Improvements**: ●Enhanced ironmaking processes may lead to cost savings in raw materials, which can positively impact CNC machining operations. In conclusion, moving forward is essential for steelmaking to be affordable, sustainable and competitive. ●These technological advancements in steel production are crucial for those in the CNC industry. These innovations not only offer potential improvements in material sourcing and cost efficiency but also inspire broader consideration of sustainability and technological advancement within . **China makes new progress in flash ironmaking technology**: ●China has achieved breakthroughs in flash ironmaking technology, a process capable of boosting ironmaking efficiency by up to 3,600 times, according to a recent study published by a researcher of the Chinese Academy of Engineering (CAE) in Nonferrous Metals (a leading technical journal in the nonferrous metals industry in China). Flash smelting involves injecting metal concentrates and reducing gases such as hydrogen or natural gas into a furnace, where the wide dispersion of concs creates optimal conditions for chemical reactions, enabling the rapid production of high-purity metals, according to the study paper. This method has been widely used in Jinnan. **Development of a Novel Flash** Ironmaking Technology with Greatly Reduced Energy Consumption: ●Despite the dominance of the blast furnace ironmaking process, increasing attention is being paid to the development of new technologies with lower energy consumption and CO_2 emissions. At the University of Utah, a novel flash ironmaking technology to meet these demands is under development. This technology eliminates the highly problematic

cokemaking and pelletization/sintering steps by directly utilizing iron ore concentrate, which is currently produced in large quantities in North America and elsewhere. This transformative technology is expected to allow significant energy saving and reduced CO_2 emissions compared with the blast furnace process. It has been demonstrated that iron of more than 95 % metallization can be obtained by reduction with hydrogen or a mixture of carbon monoxide and hydrogen in 2–7 s at temperatures of 1473–1823 K. The development of the technology has gone through the stages of proof-of-concept and small laboratory flash reactor tests. **Development of Ironmaking Technology:** By the Fash Direct Reduction of finely- ground Iron Concentrate: ●Considering the two most important issues the ironmaking industry faces today, i.e., energy consumption and greenhouse gas emissions, it would be advantageous to utilize the concentrate-size raw materials directly without pelletizing or sintering, especially without the use of coke. This plenary lecture describes two such processes developed at the University of Utah. One is the Flash Ironmaking Technology (FIT) and the other is a moving-bed process for continuous ironmaking with gaseous reduction of iron ore concentrate (MBIT). These technologies are designed to produce iron directly from iron concentrate without requiring pelletization/sintering and cokemaking in two significantly different temperature ranges. They take advantage of the high reactivity of the concentrate particles and will considerably reduce energy consumption and carbon dioxide emissions compared with the current processes. The process of the development from the conception of the idea, to kinetic feasibility establishment, to laboratory flash furnace, and finally to the operation of a prototype facility for the development of the FIT is discussed. The development of the MBIT also started with the formulation of the process concept, followed by kinetics feasibility establishment, and the design of a potential industrial reactor. The results of economic analyses on the FIT are briefly described. ●Despite the dominance of the blast furnace ironmaking process, increasing attention is being paid to the development of new technologies with lower energy consumption and CO_2 emissions. It should also require much less capital investment than the blast furnace/coke oven combination. At the University of Utah, an alternative technology to meet these demands, called the flash ironmaking technology (FIT), has been under development [1–7]. This novel technology eliminates the highly problematic cokemaking and pelletization/sintering steps by directly utilizing iron ore concentrate, which is currently produced in large quantities in North America and elsewhere. In this article, recent advances on this work are discussed. The FIT is an innovative process that uses iron ore concentrate directly without further treatment. The fineness of the concentrate particles allows a very rapid reaction rate, thus requiring residence times measured in seconds instead of the minutes and hours it takes to reduce pellets and even iron ore fines. Other processes for the gaseous reduction of iron oxide can be grouped into two broad types: (1) shaft furnaces (Midrex [8] and Energiron [9]), and (2) fluidized-bed reactors (FINMET and the earlier FIOR [10], CIRCORED Process [11], and SPIREX [12]). Shaft furnaces require pellets or sinter, which are of 10–12-mm size and require minutes or even hours to be fully reduced. The fluid-bed processes use “iron ore fines,” i.e., particles in the range of +0.1 mm to −10 mm. These processes are slow because the larger pellets and particles react slowly, and the process cannot be operated at high temperatures, under which they suffer the problems of sticking and fusion of particles. Processes that can replace the blast furnace must be sufficiently intensive to meet the large production rates required for economic competitiveness. The FIT reduces iron ore concentrates of <100-μm sizes, which are smaller than fines by one or two orders of magnitude. Historically, fluidized-bed processes using iron ore fines have been less than successful. Compared with concentrate particles, even ore ‘fines’ used in a fluidized-bed process take much longer time to reduce than the time available in a typical flash reduction process. The FIT removes many of the limitations associated with the other processes discussed above. Specifically, (1) it uses iron oxide concentrates directly without the need for pelletization or sintering; (2) coke ovens are not required; (3) high temperatures can be used because there will be little particle sticking or fusion problems (and thus, the process can be operated at high temperatures); (4) it is possible to produce either solid or molten iron; and (5) the raw materials can be fed continuously. The process also has the possibility of direct steelmaking in a single unit, as depicted in Fig. 1..



A schematic diagram of a possible direct steelmaking process based on the Flash Ironmaking Technology (FIT) [6. major progresses made so far on the Flash Ironmaking research, especially the kinetics of the reduction process, the chemistry of the slag, and the economic and environmental aspects of the process. **Reduction Kinetics**: ●Previous research on the gaseous reduction of iron oxide has typically involved samples larger than concentrate particles, such as ore fines and pellets as well as temperature ranges substantially lower than in the new flash ironmaking process. Ray and Kundu [13] reduced hematite in CO–N_2 mixtures in the temperature range 1073–1273 K (800–1000 °C) and determined an activation energy of 90 kJ/mol. Edstrom [14] studied the reduction of natural hematite crystals by hydrogen below 1273 K (1000 °C) and found that the hematite crystal swelled at first, but shrunk during the later stages when reduced by hydrogen. Hematite particles of 105–140-μm sizes were reduced by hydrogen in a silica-tube fluidized-bed reactor by Srinivasan and Sheasby [15] in the temperature range of 923–1173 K (650–900 °C). They found that a pore-free magnetite layer was formed adjacent to the hematite phase, but the magnetite layer developed porosity with further reduction. Piotrowski et al. [16] reduced hematite particles of 91-μm average size to wustite by carbon monoxide at 973–1173 K (700–900 °C). The nucleation-and-growth kinetic model was applied to the initial stages of the reduction process, which gradually shifted to diffusion control as reduction proceeded. They determined activation energy to be 58 kJ/mol. Sturn et al. [17] found that the phase boundary reaction was the most likely rate-controlling step for the reduction of hematite particle of 177-μm diameter by hydrogen in the temperature range 673–803 K (400–530 °C). Fruehan et al. [18] investigated the reduction of hematite particles of 180–250-μm size by hydrogen in the temperature range 873–1273 K (600–1000 °C) and found that a shell of dense iron formed around the wustite grains that significantly slowed the reduction rate, limited by the diffusion of oxygen atoms through solid iron when the grains were larger than 2 μm. ●Recently, Monazam et al. Despite the dominance of the blast furnace ironmaking process, increasing attention is being paid to the development of new technologies with lower energy consumption and CO_2 emissions. It should also require much less capital investment than the blast furnace/coke oven combination. At the University of Utah, an alternative technology to meet these demands, called the flash ironmaking technology (FIT), has been under development [1–7]. 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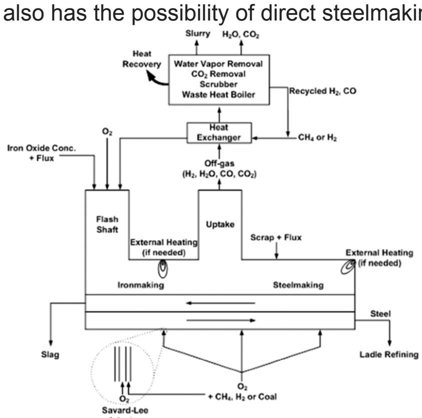


A schematic diagram of a possible direct steelmaking process based on the Flash Ironmaking Technology (FIT) [61] and kinetics of the reduction process, the chemistry of the slag, and the economic and environmental aspects of the process. Reduction Kinetics: ●Previous research on the gaseous reduction of iron oxide has typically involved samples larger than concentrate particles, such as ore fines and pellets as well as temperature ranges substantially lower than in the new flash ironmaking process. Ray and Kundu [13] reduced hematite in $CO–N_2$ mixtures in the temperature range 1073–1273 K (800–1000 °C) and determined an activation energy of 90 kJ/mol. Edstrom [14] studied the reduction of natural hematite crystals by hydrogen below 1273 K (1000 °C) and found that the hematite crystal swelled at first, but shrunk during the later stages when reduced by hydrogen. Hematite particles of 105–140-μm sizes were reduced by hydrogen in a silica-tube fluidized-bed reactor by Srinivasan and Sheasby [15] in the temperature range of 923–1173 K (650–900 °C). They found that a pore-free magnetite layer was formed adjacent to the hematite phase, but the magnetite layer developed porosity with further reduction. Piotrowski et al. [16] reduced hematite particles of 91-μm average size to wustite by carbon monoxide at 973–1173 K (700–900 °C). The nucleation-and-growth kinetic model was applied to the initial stages of the reduction process, which gradually shifted to diffusion control as reduction proceeded. They determined activation energy to be 58 kJ/mol. Sturn et al. [17] found that the phase boundary reaction was the most likely rate-controlling step for the reduction of hematite particle of 177-μm diameter by hydrogen in the temperature range 673–803 K (400–530 °C). Fruehan et al. [18] investigated the reduction of hematite particles of 180–250-μm size by hydrogen in the temperature range 873–1273 K (600–1000 °C) and found that a shell of dense iron formed around the wustite grains that significantly slowed the reduction rate, limited by the diffusion of oxygen atoms through solid iron when the grains were larger than 2 μm. Recently, Monazam et al.

If We Don't Hurry & Build Nuclear Power, Dirty Coal Will Forever Trump Clean Atomic Power: ●Drought in developing countries fuels spike in demand for new coal-fired power stations. ●An energy crisis in Zambia and Zimbabwe caused by lack of rain has led to plans for a rapid increase in coal power – most backed with money from Chinese firms. ●The Kariba Dam hydroelectric plant, whose record low waters prompted Zambia and Zimbabwe to propose new coal-fired power stations *(AP)* A drought-fuelled energy crisis in ***Zambia*** and ***Zimbabwe*** led to growth in demand for new **coal-fired** power in 2024, reaching its highest annual total in eight years. ●Both countries were gripped by energy shortages for much of the past year as the Kariba Dam hydroelectric plant, which supplies them with the majority of their electricity, faced record-low water levels due to a severe drought. ●Newly proposed coal production would create an extra 2.8 gigawatts (GW) of power, according to data produced by research organisation Global Energy Monitor (GEM). A power plant with a capacity of 1 GW can provide the energy needs for around one million US homes. ●The 40 per cent of Zambians with grid electricity suffered their "**worst blackouts in memory**" as the country's six hydroelectric turbines generated less than 10 per cent of normal electricity output in the latter part of last year. In **Zimbabwe**, meanwhile, blackouts became so severe that finance minister Mthuli Ncube was plunged into darkness in the middle of his budget speech in November, in which he also warned that the agricultural sector would contract by 15 per cent due to the country's low rainfall. Also in Mindanao's main city Cagayan de Oro we had a brownout Friday midday, Apr 11th, 2025. ●Though seasonal rainfall has now returned, last year's drought was caused by a particularly severe El Niño weather pattern, which was exacerbated by climate change, experts have suggested. In response to the crisis, Zambia has proposed building a $900m, 0.6 GW coal-fired power plant, with support from the Wonderful Group, a Chinese-owned company that manufactures ceramics and fertiliser. ●In **Zimbabwe**, some 1.8 GW of new coal capacity was announced at the Hwange power station, the country's largest power plant, which was backed by the China-based Shandong Dingneng New Energy, and the India-based Jindal Steel. A number of other new plants were also proposed in Zimbabwe with the backing of Chinese money, according to GEM, taking the total to 2.2 GW of power. "The situation unfolding in Zimbabwe is a tragic example of the vicious cycle created by fossil fuel dependency," Farai Maguwu, executive director at the Zimbabwe-based Centre for Natural Resource Governance (CNRG), told *The Independent.* ●"The country's decision to expand coal at a time when the climate crisis – exacerbated by fossil fuel use – is already wreaking havoc through extreme droughts is both counterproductive and deeply concerning," he said. Zimbabwe should be "prioritising a just transition towards renewable energy" rather than "locking in" more coal, Maguwu added. ●There is also a new proposal for a coal mine in the country's Hwange National Park, a biodiversity and tourist hotspot, which is backed by another Chinese company Sunny Yi Feng, and which CNRG has been lobbying against. "A full cost accounting of any coal development must be cognisant of the rights of future generations," the CNRG wrote in a recent letter to the Mining Affairs Board, seen by *The Independent*. "It appears the considerations above in relation to damaging aspects of the Sunny Yi Feng are not yet being considered." Lucy Hummer, senior analyst on GEM's coal plant tracker team, added that coal-fired power itself requires "significant water supplies" to function, and therefore is not a smart solution for drought-stricken countries. ●"Instead, investments are needed in resilient, renewable energy sources rather than the refurbishment of ageing coal infrastructure," she told *the Independent*. "Rich countries that emit the most must step up with climate finance to support a just transition for Southern African countries that seek to alleviate acute energy crises with short-term solutions." "While coal projects are often promoted as drivers of economic growth and energy security, their environmental and social costs are significant," added Marina Agortimevor, coordinator at the Africa Just Transition Network. ●"Their impacts not only exacerbate the ongoing climate crisis but also contribute to the severe droughts currently affecting Southern African countries." Beyond newly proposed power plants, last year was also a bumper year for coal plant construction starts in Zambia and Zimbabwe, with some 1.5 GW of new capacity breaking ground, according to GEM. The majority of that total was due to the 1.2 GW Prestige power station breaking ground in Zimbabwe, which is being built by China's Xintai Resources at a cost of £1.2bn in order to power a new metal processing special economic zone.
●China's support for these facilities comes despite a **high-profile pledge** at the 2021 ***UN General Assembly*** from President ***Xi Jinping*** to stop financing overseas coal. Many of the new China-backed proposals exploit an apparent loophole in the pledge, which allows for "captive power plants" – or power stations built to power specific industrial facilities. However, not all of the new proposals appear to fall into that category, according to GEM. China has for many years been the biggest global financier of coal under its Belt and Road Initiative, which supports large infrastructure with international aid as well as foreign direct investment and B to B. ●Despite coal's resurgence in Zambia and Zimbabwe, prospects for the fuel remain broadly negative across the rest of Africa, with 16 countries reducing or eliminating their pipeline of proposed coal over the past decade, with only three countries marginally breaking that trend. Globally, the 44 GW of new coal that came online last year was the

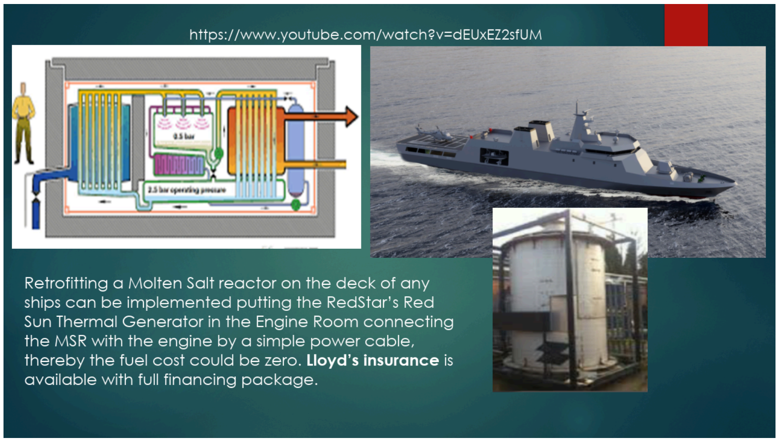
lowest level in 20 years, reported GEM. However, while retirements of coal plants in the EU increased fourfold in 2023, and the **UK** phased out **coal** for good, China recorded its highest year for construction starts since 2015, with 94 GW of capacity breaking ground. ●Coal plant retirements in the US also fell to 4.7 GW in 2024. While nearly half of the remaining US coal power capacity is due to retire by 2035, power utilities including PacifiCorp, Duke Energy, and Georgia Power have more recently said that they are planning to withdraw or delay retirements, according to GEM. "Last year was a harbinger of things to come for coal as the clean energy transition moves full speed ahead," said Christine Shearer, senior analyst on GEM's coal plant tracker team. "But work is still needed to ensure coal power is phased out in line with the Paris climate agreement, particularly in the world's wealthiest nations. ●Deaths associated with pollution from coal power plants A careful analysis found that air pollution from coal power plants is associated with greater mortality than previously thought. ●It also found that such deaths have decreased due to air pollution regulations and coal power plant retirements. ●The findings highlight the health benefits of continuing to reduce coal emissions. .

●Understanding the effects of air pollution from individual power plants could help in designing more targeted policies to improve people's health. ●Coal-burning power plants are a major source of fine particulate matter ($PM_{2.5}$) air pollution. Exposure to $PM_{2.5}$ is associated with increased risk of death. To judge the success of measures to improve air quality, we need to estimate the health impacts, including death, associated with specific air pollution sources. Previous attempts to do so have assumed that $PM_{2.5}$ from all sources is equally toxic. But coal $PM_{2.5}$ is rich in sulfur dioxide, black carbon, and metals. ●Recent evidence suggests that such emissions may be more deadly than $PM_{2.5}$ from other sources. A team of researchers led by Dr. Lucas Henneman at George Mason University, the Harvard School of Public Health, and UT Austin set out to estimate the number of deaths nationwide associated with $PM_{2.5}$ from coal power plants. They analyzed a vast dataset of Medicare death records dating from 1999. They then modeled where air currents carried emissions from 480 individual coal power plants. This allowed them to estimate coal $PM_{2.5}$ exposure where the people lived and died. Results appeared in *Science* on November 23, 2023. ●The researchers calculated that for every 1 $\mu g/m^3$ increase in coal $PM_{2.5}$, mortality increased by 1.12%. This is more than twice the risk that was previously associated with general $PM_{2.5}$ exposure from all air pollution sources. ●The team estimated that between 1999 and 2020, 460,000 deaths would not have occurred in the absence of emission from the coal power plants. ●There was a notable decline in the number of deaths from coal $PM_{2.5}$ during the period studied. ●From 2000 to 2008, deaths associated with coal $PM_{2.5}$ were 25% of all $PM_{2.5}$-related deaths in the Medicare population. From 2013 to 2016, coal $PM_{2.5}$ deaths were only 7% of all $PM_{2.5}$-related deaths. This was likely due to coal power plant retirements and air pollution regulations that reduced emissions. ●About 140 coal power plants were each associated with more than 1,000 excess deaths during the study period. Ten plants, all located east of the Mississippi River, were associated with more than 5,000 deaths. ●When a plant installed pollution control technology (called emissions scrubbers) or shut down, the number of associated deaths declined. For example, the Keystone facility in Pennsylvania was one of the deadliest power plants over the period studied. It was associated with more than 600 deaths per year on average before installing emissions scrubbers. After scrubber installation, that number dropped to 80 per year. "$PM_{2.5}$ from coal has been treated as if it's just another air pollutant. ●But it's much more harmful than we thought, and its mortality burden has been seriously underestimated," Henneman explains. ●But the decline in mortality over time highlights the success of emissions reductions at improving health. "I see this as a success story," says senior author Dr. Corwin Zigler of UT Austin. ●"Coal power plants were this major burden that U.S. policies have already significantly reduced." This approach to pinpoint the effects of individual power plants might be used to design more targeted policies to further reduce the health impacts of air pollution sources. 6

Conclusions. The journey of both AHR and molten salt reactors from their inception to their reemergence as a viable technology is a testament to the power of innovation. Conceived at Oak Ridge National Laboratory by nuclear physicist Alvin Weinberg, the original Molten Salt Reactor Experiment (MSRE) demonstrated the potential of this technology. Despite their early success, the projects were shelved in 1965 and 72 respectively, until renewed interest in the early 2000s reignited research efforts on molten salt reactors and recent interest in the AHR by Redstar.Today, companies like Core Power are building on the legacy of the MSRE, exploring the potential of molten salt reactors for smaller, more efficient applications. As Oak Ridge lab physicist Ted Besmann notes, the ability to refuel and reprocess the reactor while it's operating adds to its attractiveness. **The revival of molten salt reactors** represents a new chapter in the quest for clean energy, offering a promising solution to the challenges of decarbonization.As the world stands at the crossroads of energy innovation, floating nuclear power plants powered by molten salt reactors offer a glimpse into a sustainable future. With the potential to revolutionize energy production and reduce greenhouse gas emissions, these floating marvels could play a pivotal role in addressing the challenges of climate change. But as we embark on this journey, one question remains: How will societies adapt to and embrace this transformative technology?

Countries have agreed a global deal to tackle shipping emissions, after nearly ten years of negotiations. **Global breakthrough agreement** to **tackle shipping emissions**- **full compliance**. This changes everything for Floating Nuclear Power Plants/ propulsion systems! The agreement covers the vast majority of the world's commercial shipping and means that starting in 2028, ship owners will have to use increasingly cleaner fuels or face fines. The deal was nearly derailed after Saudi Arabia forced a last minute vote and the US pulled out of talks in London – but it eventually passed on Friday. Small island states and environmental groups were angry that a blanket tax was not agreed to and called the deal "unfit for purpose". **Shipping agrees net-zero goal** but critics unmoved Clean energy's share of world's electricity reaches 40%, report says Shipping accounts for around 3% of global emissions. But unlike many other sectors it has struggled to reduce its carbon footprint over the last decade and is reliant on fossil fuels like diesel. But the agreement means it is now the first industry in the world with internationally mandated targets to reduce emissions. The agreement was passed at the UN's International Maritime Organisation (IMO) meeting. It will require owners of large international vessels to increase their use of less carbon intensive fuels or face a penalty of up to $380 per tonne of carbon dioxide emissions they emit from burning fuel. Although the final agreement was passed, it had to be put to a vote - an unusual move for UN bodies that usually agree measures by consensus..

There have been moves to improve the efficiency of ships, but emissions have continued to increase in line with global trade - 90% of which is carried by ships. The most effective measure would be to switch ships away from fossil fuels to green fuels, but that would be very expensive. "There is no fuel as cheap as diesel that ships use today because when we take crude oil out of the ground, we take out all the nice bits, that's the kerosene for aviation, diesel and petrol for cars," said Faig Abbasov, programme director for maritime transport at think tank Transport and Environment. "Whatever is left at the bottom, that's what ships burn. So no fuel will be as cheap as this because not much energy goes into its production," he said. In comparison, the most environmentally friendly fuels like e-kerosene and ammonia are created from initially splitting water atoms to obtain hydrogen, which is a very energy-intensive and costly process. Figures vary depending on the fuel type but the World Economic Forum estimates that these green fuels are 3-4 times more expensive to produce. "There's still a huge cost gap between the fossil fuels and the zero emission fuels ($700/ton ***Bunker C*** - ***Diesel 2*** at $430 LCOE/ MWh and $1200 /MWh- ***Green HYDROGEN*** at $1600/ton) ***Ammonia*** = $2400/MWh) and we need to close this gap. So you need carrots and sticks and in shipping the stick is not that big yet to use sustainable fuels," said Refke Gunnewijk, program manager for sustainable transport at the Port of Rotterdam. Nearly 90% of the world's goods are moved via ship and the industry continues to grow in line with trade volumes (Reuters).



"Let us be clear about who has abandoned 1.5°C. Saudi Arabia, the US and fossil fuel allies pushed down the numbers to an untenable level and blocked progress at every turn," said Ralph Regenvanu, minister of energy and climate change for Vanuatu. Their disappointment was shared by environmental groups. "This week, IMO member states squandered a golden opportunity for the global shipping sector to show the world how it can turn the tide on catastrophic climate heating, putting their own goals out of reach", said Delaine McCullough, president of the Clean Shipping Coalition.

It is estimated that the agreement could achieve an 8% reduction in emissions for the sector by 2030, according to the maritime consultancy UMAS. This would be short of the IMO's target agreed two years ago to cut emissions by 20% by the end of the decade. But China and Brazil had previously raised concerns that a levy could result in a significant price increase for basic goods like food. Both countries backed the final deal. Jesse Fahnestock, director of decarbonisation at the Global Maritime Forum, said that the deal was a compromise. "It is a difficult set of decisions, but it is the first regulation of its kind and that is to be celebrated," he said. Fahnestock added it was unclear if the penalties were enough to close the cost gap between the fuel types. "You may have incentivised shipowners to prepare a bit for the future fuels but whether the signal is strong enough to get the billions of dollars of investment into the production facilities for these fuels - I don't think these regulations will overcome that. I think more will need to be done," he said. Any money raised from the penalties will be put into a "Net Zero" fund, with money spent on scaling up greener fuels and supporting developing countries. It is this "redistribution" that prompted the US delegation to pull out of the talks on Tuesday night. A letter was sent by the US to all countries at the IMO negotiations saying any levy would cause inflation and if it was passed then "reciprocal measures" would be taken. Although the US move was at odds with its long-held position at the IMO, it was in keeping with President Trump's push back on climate action seen over the last few months - such as withdrawing the US from the Paris Climate

Now the committee have agreed the measure, it is expected to be formally adopted in October.

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- Air Pollution Linked to Dementia Cases
- Drop In Coal Power Plant Emissions Associated with Asthma Improvements
- Air Pollution Associated with Worsening Emphysema
- Air Pollution Associated with Increase in NICU Admissions
- Asthma Cases Dropped When Air Pollution Declined
- Air Pollution Linked to Risk of Premature Death
- Cleaner Air Tied to Healthier Lungs in Kids
- Breathe Easier
- Air Pollution and Your Health References: Mortality risk from United States coal electricity generation. Henneman L, Choirat C, Dedoussi I, Dominici F, Roberts J, Zigler C. *Science*. 2023