We Affirm, “Resolved: The United States federal government should substantially increase its investment in domestic nuclear energy.”

Contention 1 is Space

Nuclear energy is key to space colonization, but more investment is needed.

Nguyen 20 [Tien Nguyen, Ph.D. in Organic Chemistry & B.S in Chemistry with Minor in Physics, 5-15-2020, Why NASA thinks nuclear reactors could supply power for human colonies in space, Chemical & Engineering News, https://cen.acs.org/energy/nuclear-power/NASA-thinks-nuclear-reactors-supply/98/i19, Willie T.] **brackets in original**

The astronauts pass their days in darkness. After several months of living on the moon, they’re still adjusting to the endless night. The crew’s habitat at the lunar south pole sits in a shadowed crater—chosen for its promise of ice—that has not been touched by a single ray of sun for billions of years. Fortunately, the nearby nuclear reactor is unfazed by the lack of light. Connected to the astronauts’ base camp by a kilometer of cables cautiously tracing the lunar surface, the reactor provides an uninterrupted supply of electricity for recharging rovers, running scientific instruments, and most importantly, powering the air and heating systems that keep the astronauts alive. This is one vision of what human exploration could look like on the moon. In fact, NASA has plans to make some versions of this scene a reality—and soon. The agency aims to send a human mission to the moon by 2024 in an effort named the Artemis project. Congress has allocated more than $6 billion of NASA’s 2020 fiscal budget for space exploration programs including the Space Launch System rocket, the Orion spacecraft, exploration ground systems, and research and development. The agency estimates that it will cost $35 billion to land a crew on the lunar surface, including the first woman to step foot on the moon. After 2024, NASA hopes to move to launching one human mission each year and reach sustainable operations on the moon by 2028. The lessons learned in that phase will be crucial in preparing for future trips to Mars. One major effort will involve figuring out which power systems—including ones that have never been tested on the lunar surface, such as nuclear power—would best support future settlements. Whether the necessary materials can be brought safely to the moon and whether systems such as nuclear fission can run reliably under such harsh conditions are central questions that must be answered as engineers weigh their options. Going nuclear Choosing a power source depends on the particular mission’s needs, says Michelle A. Rucker, an engineer at NASA’s Lyndon B. Johnson Space Center who has researched possible architectures for space settlements. Electricity may come from nuclear reactors, solar panels, batteries, fuel cells, or some combination of these technologies connected in a power grid, she says. “I’m a big fan of all the types of power.” But each power source has distinct pros and cons to consider. Solar arrays have reliably delivered renewable power in space for decades but are useless in places that never get any light, like the potentially resource-rich craters on the moon. And on the windy, dusty surface of Mars, solar panels may struggle to collect enough light, making them a risky option for powering life support systems, Rucker says. Batteries and fuel cells have limited lifetimes for now, relegating them to supplementary power sources at best. One type of nuclear device that has been used to power spacecraft is a radioisotope thermoelectric generator, which runs on the heat produced by the decay of plutonium-238. These generators have been used since the 1960s in Mars rovers and space probes sent to the outer edges of the solar system, such as the Voyager spacecraft and Cassini. Despite being the workhorses of scientific missions, the generators provide only several hundred watts of power, just enough to send radio signals back to Earth or power a camera. On Earth, the nuclear technology used by power plants is nuclear fission, which splits uranium-235 atoms via bombardment with neutrons to generate heat that’s captured to produce electricity. Nuclear fission holds the potential to provide a continuous, reliable source of power for a small space settlement designed to last for several years. In the 1960s, many scientists thought fission reactors for space would follow on the heels of radioisotope generators. In 1965, the US launched a small nuclear fission–powered satellite named SNAP-10A, but electrical issues caused it to fail a mere 43 days after launch; it's still in orbit, now just another piece of space junk. The Soviet Union launched 31 nuclear fission–powered satellites over the next 2 decades. But the development of new nuclear fission reactors for space stalled during that time because of design problems and ballooning budgets. Engineers wanted advanced performance from these systems right away, which led to complicated and expensive designs, says David Poston, a nuclear engineer at Los Alamos National Laboratory. He and Patrick McClure, who specializes in reactor safety at Los Alamos, have worked at the lab for the past 25 years and recall the days when nuclear fission had fallen out of favor. "Pat and I were sitting around just kind of demoralized," Poston says, "because we had gotten to the point where NASA wasn't really interested anymore because the impression was that it was going to be too expensive and too hard to develop a fission reactor." But the pair were convinced their team could come up with a design to dispel the funk that had settled around fission power for space. In the early 2010s, they got their chance: researchers at Los Alamos and in later the NASA Glenn Research Center and the US Department of Energy began work on a joint project called Kilopower, now renamed the Nuclear Fission Power Project. The goal is to develop a new nuclear fission power system for space that would be capable of producing 10 kW of electrical energy. Designing the reactor Four of these reactors could easily provide the 40 kW of power that Rucker estimates a six-member crew would need to live on Mars. The team's modular, compact design is lightweight enough for space exploration, in which every kilogram counts. Previous hypothetical fission-power concepts required a payload of 12–14 metric tons (a 6–7 t reactor plus a backup), whereas a single Kilopower reactor would weigh an estimated 1.5 t, she says. The team decided to approach the reactor design anew, putting one priority above all: simplicity. This meant not only maintaining a simple mechanical design but also looking for opportunities to simplify safety approvals and project management. As an example, McClure says, the team made a conscious choice to limit the size of the nuclear core to a container already being used to test nuclear materials instead of fabricating a new one. "I hate to call it an innovation because it's not that complicated. But it's an innovation that we said, 'Why don't we just do it the simple way that we know is going to work?' " Poston says. "We knew it was going to work, but the world didn't." The nuclear core, which is about the size of a paper towel roll and weighs 28 kg, comprises a solid alloy of about 8% molybdenum and 92% highly enriched uranium. The nuclear material is surrounded by a beryllium oxide reflector that bounces neutrons into the core to drive the fission reaction. Lodged inside the core is a rod of pure boron carbide that absorbs neutrons, quenching fission reactions. When the boron carbide rod is slowly removed, neutrons start to strike uranium atoms, occasionally splitting them, creating more neutrons and releasing energy as heat. Once the number of neutrons lost equals the number of neutrons being produced, the reactor becomes self-sustaining. The fission-generated heat travels through sodium-filled heat pipes to a set of Stirling engines. Designed in the early 1800s, these simple piston-driven engines convert heat to electricity. Finally, the team's reactor design includes a radiator to remove the excess heat, sloughing it off into space. "We wanted to show not only the world but ourselves that we can still do something real because we had gotten away from actually testing real fission systems," Poston says. In a proof-of-concept test called DUFF, the team showed that the hardware worked to produce electricity. Then, in 2018, the team successfully tested a prototype of the reactor at the Nevada National Security Site. During the months-long KRUSTY experiment, researchers tested each of the reactor's components and its ability to withstand various failures. (The experiment names were inspired by The Simpsons TV show.) The reactor also successfully passed a 28 h test, in which it ramped up to full power, peaking at about 5 kW, operated at a steady state, and then shut down safely. The team hopes that with more optimization, such as by increasing the size of the nuclear core, it can meet its goal of producing 10 kW per reactor. Of course, some people look at highly enriched uranium with skepticism, given its potential to harm humans and its role as a material for nuclear weapons. But McClure says transporting uranium to the moon and working alongside a reactor can be done safely. Uranium emits weak α particles, which can't penetrate a piece of paper or skin, so the shielding that surrounds the nuclear core would prevent astronauts from any radiation exposure. Burying the reactor a few meters into the ground or putting it behind a big rock feature could also help keep astronauts safe from radiation when the reactor is on. Once the reactor has run its course, the radioactive waste will likely be shielded and left alone. The worst-case scenario for such a system would involve the entire reactor blowing up midlaunch, aerosolizing and dispersing uranium particles. Even then, a person a kilometer away might receive a dose in the millirem range—less than the dose you get from solar radiation when you take a plane flight, McClure says. Ultimately, the fission reactor's future will depend on not only technical success but also sufficient funding. Dionne Hernández-Lugo of the NASA Glenn Research Center and deputy project manager of the Nuclear Fission Power Project says the proposed budget puts the team "on the path to build and send a surface power system to the moon." "It'll be really exciting to test [the reactor] on the moon and get some experience under our belts before we go to Mars," Rucker says. "On the moon, you're close to home, so if something fails, it's a fairly close trip to get back home, whereas on Mars, your system better be working."

Furthermore, fusion advancements are the single most important emerging technology for space colonization. David 22

Leonard David; December 15 2022; Award-winning space journalist who has been reporting on space activities for more than 50 years, Interviewing multiple physicists and scientists; Space, "Nuclear fusion breakthrough: What does it mean for space exploration?" https://www.space.com/nuclear-fusion-breakthrough-spacetravel //recut rchen

The nuclear fusion feat has broad implications, fueling hopes of clean, limitless energy. As for space exploration, one upshot from the landmark research is attaining the long-held dream of future rocketsthat are driven by fusion propulsion. But is that prospect still a pipe dream or is it now deemed reachable? If so, how much of a future are we looking at? Data points The fusion breakthrough is welcomed and exciting news for physicist Fatima Ebrahimi at the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory in New Jersey. Ebrahimi said the NIF success is extraordinary. "Any data points obtained showing fusion energy science achievement is fantastic! Fusion energy gain of greater than one is quite an achievement," Ebrahimi said. However, engineering innovations are still requisite for NIF to be commercially viable as a fusion reactor, she added. Ebrahimi is studying how best to propel humans at greater speeds out to Mars and beyond. The work involves a new concept for a rocket thruster, one that exploits the mechanism behind solar flares. The idea is to accelerate particles using "magnetic reconnection," a process found throughout the universe, including the surface of the sun. It's when magnetic field lines converge, suddenly separate, and then join together again, producing loads of energy. By using more electromagnets and more magnetic fields, Ebrahimi envisions the ability to create, in effect, a knob-turning way to fine-tune velocity. As for the NIF victory impacting space exploration, Ebrahimi said for space applications, compact fusion concepts are still needed. "Heavy components for space applications are not favorable," she said. Necessary precursor Similar in thought is Paul Gilster, writer/editor of the informative Centauri Dreams website. "Naturally I celebrate the NIF's accomplishment of producing more energy than was initially put into the fusion experiment. It's a necessary precursor toward getting fusion into the game as a source of power," Gilster told Space.com. Building upon the notable breakthrough is going to take time, he said. "Where we go as this evolves, and this seems to be several decades away, is toward actual fusion power plants here on Earth. But as to space exploration, we then have to consider how to reduce working fusion into something that can fit the size and weight constraints of a spacecraft," said Gilster. There's no doubtin Gilster's mind that fusion can be managed for space exploration purposes, but he suspects that's still more than a few decades in the future. "This work is heartening, then, but it should not diminish our research into alternatives like beamed energy as we consider missions beyond the solar system," said Gilster. Exhaust speeds Richard Dinan is the founder of Pulsar Fusion in the United Kingdom. He's also the author of the book "The Fusion Age: Modern Nuclear Fusion Reactors." "Fusion propulsion is a much simpler technology to apply than fusion for energy. If fusion is achievable, which at last the people are starting see it is, then both fusion energy and propulsion are inevitable," Dinan said. "One gives us the ability to power our planet indefinitely, the other the ability to leave our solar system. It's a big deal, really." Exhaust speeds generated from a fusion plasma, Dinan said, are calculated to be roughly one-thousand times that of a Hall Effect Thruster, electric propulsion hardware that makes use of electric and magnetic fields to create and eject a plasma. "The financial implicationsthat go with that make fusion propulsion, in our opinion,the single most important emerging technology in the space economy," Dinan said. Pulsar Fusion has been busy working on a direct fusion drive initiative, a steady state fusion propulsion concept that's based on a compact fusion reactor. According to the group's website, Pulsar Fusion has proceeded to a Phase 3 task, manufacturing an initial test unit. Static tests are slated to occur next year, followed by an in-orbit demonstration of the technology in 2027. Aspirational glow "The net energy gain reported in the press is certainly a significant milestone," said Ralph McNutt, a physicist and chief scientist for space science at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "As more comes out, it will be interesting to see what the turning point was that pushed this achievement past the previous unsuccessful attempts," he said.

But Investors are required for the development of fusion. Windridge 23

Melanie Windridge; April 13 2023; PhD plasma physicist and science communicator best known for her book Aurora: In Search of the Northern Lights and her educational work on fusion energy with the Institute of Physics and the Ogden Trust; Forbes, "Investors Hold The Key To Fusion And Our Clean Energy Future," https://www.forbes.com/sites/melaniewindridge/2023/04/13/investors-hold-the-key-to-fusion-and-our-clean-energy-future/ //rchen

Why **investors are key** Investors are in an interesting position. They **have the potential to** be a huge part of the solution to our climate/energy woes by making the **accelerate**d development of **fusion** possible. Legal & General Group, one of the UK's leading financial services groups and a major global investor, is up front about the power of investors to address climate change through investment, influence and operations. The Group's alternative asset platform, Legal & General Capital (LGC), plays a significant role in developing and deploying technologies that help to tackle climate change, such as electric charging infrastructure in the UK, super-efficient solar panels, offshore wind farms and also fusion energy, where they have been investing in Tokamak Energy for several years. John Bromley, Managing Director Clean Energy Strategy & Investments at Legal & General Capital, says: "Climate is not only the most urgent issue, but also the biggest investment opportunity of our lifetime. Investors who are focused on the challenges of decarbonising our economy, and can take a long term view, have a crucial role to play in the accelerated development of fusion energy." He continues: "As an energy transition investor, Legal & General Capital supports the growth of a new generation of clean energy technology and infrastructure providers, and innovative companies whose work will support the transition to net zero." Some consider that the **financing risk is** the **biggest risk to fusion**, so investors are critical to success. Getting in on the action Investors also have the chance to win big on fusion, a market that Bloomberg has predicted could reach $40 trillion. Why is fusion so attractive? As John Bromley says, "Renewables will certainly be a large and important part of a decarbonised economy, but we will also require dispatchable zero carbon energy sources to end fossil fuel reliance. Fusion energy holds the potential to achieve and sustain a significant reduction in global emissions." There's no doubt that funding fusion is challenging, involving high upfront costs, long timescales and high uncertainty. Yet investment in fusion has been increasing. Just last month, Breakthrough Energy Ventures (Bill Gates' investment firm seeking to finance, launch, and scale companies that will eliminate greenhouse gas emissions throughout the global economy—an investor in Commonwealth Fusion Systems and Zap Energy) invested in another fusion company, Type One Energy. Behind the scenes, more conventional investors, like pension funds, insurance companies and sovereign wealth funds, have quietly been investing in fusion. The mainstreaming of fusion among capital-providers has begun. What investors need Yet getting into fusion investment requires a steep learning curve. Fusion is a big and complex subject. Increasingly investors, investment banks or other financial players are enquiring wanting to learn about fusion, taking that first step into getting familiar with a new industry. Financing fusion is so critical to the mission that advocates of fusion should be asking how we can accelerate this mainstreaming of fusion and draw new capital to the table. Investors need access to opportunity, they need insight from industry insiders and existing investors, they need community and relationships. This is why events that bring all these things together can be so important. But **investors** also **need gov**ernment **support and certainty**. That's one reason why the U.K. is currently in a strong position for fusion energy development, because they have outlined their plans for a regulatory framework for fusion while other countries are still in discussion. It goes further than technology regulation, however.**Policy and incentives will be required** in the financial services industry **to drive** the effective **reallocation of capital**. Michelle Scrimgeour, Chief Executive of Legal & General Investment Management, gave evidence to a 2022 U.K. parliamentary inquiry entitled 'The financial sector and the U.K.'s net zero transition'. Scrimgeour said: "A successful transition to a decarbonised economy, consistent with less than 1.5 degrees warming, will require a substantial change in capital allocation. Several trillion dollars a year of incremental capital will need to be invested into low carbon energy, energy infrastructure and energy efficiency. For this capital allocation to occur, a financial services industry that is aligned with net zero outcomes will be crucial. Equally, this requires global policy action at international governmental level, particularly on an effective regulatory structure to price carbon and other greenhouse gases." So while investors hold the key to the success of fusion and our clean energy future, it's not just down to investors—government policy will be **crucial in enabling investors** to drive the change.

Current funding is insufficient. Disregard doubt on fusion. Any risk that we prove federal investment is enough to make fusion possible AND faster means it's try or die. Risch 25

James Risch, Maria Cantwell, Ylli Bajraktari, Risch is an American lawyer and politician who has served as the junior United States senator from Idaho since 2009, Cantwell is an American politician who has been the junior United States senator from Washington since 2001, Bajraktari is the President and CEO of the Special Competitive Studies Project February 24 2025, "Fusion Power Enabling 21st Century American Dominance" No Publication,

https://www.scsp.ai/wp-content/uploads/2025/02/Final-Fusion-Power_-Enabling-21st-Century-American-Dominance.pdf //rchen

Thanks to decades of federal investment in basic research, American **scientists have** now **proven** that **fusion is possible**. Growing power demands, **recent tech**nological **breakthroughs**, and the shifting market dynamics of energy create a unique opportunity for fusion to finally see its time in the Sun. A big bet on fusion could **secure America's position** as a technological superpower for decades to come. The Global Fusion Race The U.S. Fusion Landscape America has led the world in fusion energy sciences since the days of the Manhattan Project.12 U.S. universities have consistently attracted the world's best talent, many of whom created today's leading fusion companies. Our National Labs beat the world in demonstrating fusion's scientific feasibility. **Yet** despite this legacy of scientific excellence, the **U**nited **S**tates finds itself **underprepared** for fusion's transition from experimental science to commercial reality.**Achieving fusion** energy on a competition-relevant timeline will **require** more than just tackling key scientific hurdles. It calls for an entirely different posture than the current U.S. approach, one that prioritizes commercialization and optimizes **U.S. spending on fusion.** Though progress has been made in strategy, infrastructure, and **investment** in recent years, it is not sufficient to compete and harness fusion energy's full potential. An assessment of the U.S. fusion landscape reveals: Strategy: Stemming from the 2022 Bold Decadal Vision, recent U.S. strategic initiatives have laudably sought to push fusion toward commercialization, but have **fallen short** in translating ambitious goals into urgent, concrete, actionable policies **and** programs.13 The Department of Energy's (DOE) 2024 Fusion Energy Strategy focuses on three pillars: bridging technological gaps for a pilot plant, enabling sustainable deployment, and forging external partnerships.14 The Milestone-Based Fusion Development Program, modeled after NASA's Commercial Orbital Transportation Services (COTS) program, seeks to reduce investment risk by setting discrete technical milestones that unlock government funds. Other programs include the Fusion Innovation Research Engine (FIRE) Collaboratives, which provide testing infrastructure that private firms can **not** develop on their own,15 the Innovation Network for Fusion Energy (INFUSE), which provides access to technical and financial support,16 and most recently the Private Facilities Research (PFR) program, which will enable public research at private fusion facilities.17 However, appropriations for these programs have been less than **Congressionally authorized** levels.18 The **failure to implement** many critical **recommendations** made by strategic documents, such as DOE's Fusion Long-Range Plan, has **left** an **incomplete ecosystem** that China is racing to complete itself.19 Scientific Breakthroughs: In December 2022, after a decade of diligent work, scientists at the U.S. National Ignition Facility (NIF) achieved the long-sought milestone of producing more energy in a fusion reaction than the laser energy used to create it (Q > 1).20 Indeed, the fusion process itself became the primary source of heat for the fusion fuel, signifying true ignition. NIF scientists have reproduced ignition multiple times since, while no other machine has yet to replicate it.21 The NIF's breakthrough marked the starting gun for the commercial fusion race, but there are a number of scientific and engineering challenges on the road ahead.22 The scientific community has identified a suite of R&D infrastructure that—with **an upfront investment**—would help **solve** these **challenges and unlock fusion**'s economic potential.23 The key hurdles involve sustaining and stabilizing a burning plasma, increased energy gain, developing components that can handle radiation and extreme heat, and breeding and recycling tritium to fuel the reaction.24 In addition to hardware and infrastructure, significant progress has been made, largely in the United States, in the computer simulation of plasmas.25 Simulation has driven the invention of new concepts, such as the Spherical Tokamak NSTX-U at the Princeton Plasma Physics Laboratory (PPPL).26 The United States is also applying AI across multiple fusion fronts, including PPPL's AI platforms predicting and preventing plasma instabilities in real time.27 The combination of advanced simulations and

AI is poised to further accelerate the development of optimized fusion designs, **significantly expediting the path to** practical **fusion energy**.

And Investment secures fusion propulsion deployment by 2030.

Prisco 4-3-**25** (Jacob Prisco is a London-based producer and writer for CNN International) CNN Science, 04/03/2025, "Nuclear-powered rocket concept could cut journey time to Mars in half" https://www.cnn.com/science/nuclear-powered-rocket-pulsar-space-spc/index.html (Accessed: 04/03/2025) //jjoy

The dream of nuclear fusion has been chased by some of the world's brightest minds for decades. It's easy to see why — replicating the inner workings of stars here on Earth would mean virtually unlimited clean energy. Despite a long history of attempts, and several breakthroughs, the dream hasn't turned to reality yet, and we're likely many years away from seeing a fusion power plant anywhere on the planet. Carrying out the process in space might sound like adding an extra layer of complexity to an already complex technology, but it could theoretically happen sooner than on Earth. And it could help spacecraft achieve speeds of up to 500,000 miles (805,000 kilometers) per hour — more than the fastest object ever built, NASA's Parker Solar Probe, which peaked at 430,000 miles (692,000 kilometers) per hour. With funding from the UK Space Agency, British startup Pulsar Fusion has unveiled Sunbird, a space rocket concept designed to meet spacecraft in orbit, attach to them, and carry them to their destination at breakneck speed using nuclear fusion. "It's very unnatural to do fusion on Earth," says Richard Dinan, founder and CEO of Pulsar. "Fusion doesn't want to work in an atmosphere. Space is a far more logical, sensible place to do fusion, because that's where it wants to happen anyway." For now, Sunbird is in the very early stages of construction and it has exceptional engineering challenges to overcome, but Pulsar says it hopes to achieve fusion in orbit for the first time in 2027. If the rocket ever becomes operational, it could one day cut the journey time of a potential mission to Mars in half. Just grams of fuel Nuclear fusion is different from nuclear fission, which is what powers current nuclear power plants. Fission works by splitting heavy, radioactive elements like uranium into lighter ones, using neutrons. The vast amount of energy released in this process is used to make electricity. Fusion does the opposite: it combines very light elements like hydrogen into heavier ones, using high temperature and pressure. "The sun and the stars are all fusion reactors," says Dinan. "They are element cookers — cooking hydrogen into helium — and then as they die, they create the heavy elements that make up everything. Ultimately the universe is mostly hydrogen and helium, and everything else was cooked in a star by fusion." Fusion is sought after because it releases four times more energy than fission, and four million times more energy than fossil fuels. But unlike fission, fusion doesn't require dangerous radioactive materials — instead, fusion reactors would use deuterium and tritium, heavy hydrogen atoms that have extra neutrons. They would work on minute quantities of fuel and produce no dangerous waste. However, fusion requires a lot of energy to start, because conditions similar to the core of a star must be created — extremely high temperature and pressure, along with effective confinement to keep the reaction going. The challenge on Earth has been to create more energy from fusion than is put in to start, but so far we've barely broken even. But if power generation is not the goal, things become less complicated, Dinan says — only the simpler goal of creating a faster exhaust speed. The reactions that power nuclear fusion take place inside a plasma — a hot, electrically charged gas. Just like proposed reactors on Earth, Sunbird would use strong magnets to heat up a plasma and create the conditions for the fuel — which would be in the order of grams — to smash together and fuse. But while on Earth reactors are circular, to prevent particles from escaping, on Sunbird they would be linear – because the escaping particles would propel the spacecraft. Lastly, it would not produce neutrons from the fusion reaction, which reactors on Earth use to generate heat; Sunbird would instead use a more expensive type of fuel called helium-3 to make protons, which can be used as a "nuclear exhaust" to provide propulsion. The Sunbird process would be expensive and unsuitable for energy production on Earth, Dinan says, but because the objective is not to make energy, the process can be inefficient and expensive, but still be valuable because it would save fuel costs, reduce the weight of spacecraft and get it to its destination much faster. Cutting journey times Sunbirds would operate similarly to city bikes at docking stations, according to Dinan: "We launch them into space, and we would have a charging station where they could sit and then meet your ship," he says. "You turn off your inefficient combustion engines, and use nuclear fusion for the greater part of your journey. Ideally, you'd have a station somewhere near Mars, and you'd have a station on low Earth orbit, and the (Sunbirds) would just go back and forth." Some components will have an orbit demonstration this year. "They're basically circuit boards that go up to be tested, to make sure they work. Not very exciting, because there's no fusion, but we have to do it," says Dinan. "Then, in 2027, we're going to send a small part of Sunbird in orbit, just to check that the physics is working as the computer assumes it's working. That's our first in-orbit demonstration, where we hope to do fusion in space. And we hope that Pulsar will be the first company to actually achieve that." That prototype will cost about $70 million, according to Dinan, and it won't be a full Sunbird, but rather a "linear fusion experiment" to prove the concept. The first functional Sunbird will be ready four to five years later, he says, provided the necessary funding is secured. Initially, the Sunbirds will be offered for shuttling satellites in orbit, but their true potential would come into play with interplanetary missions. The company illustrates a few examples of the missions that Sunbird could unlock, such as delivering up to 2,000 kilograms (4,400 pounds) of cargo to Mars in under six months, deploying probes to Jupiter or Saturn in two to four years (NASA's Europa Clipper, launched in 2024 towards one of Jupiter's moons, will arrive after 5.5 years), and an asteroid mining mission that would complete a round trip to a near-Earth asteroid in one to two years instead of three. Other companies are working on nuclear fusion engines for space propulsion, including Pasadena-based Helicity Space, which received investment from aerospace giant Lockheed Martin in 2024. San Diego-based General Atomics and NASA are working on another type of nuclear reactor – based on fission rather than fusion – which they plan to test in space in 2027. It is also meant as a more efficient propulsion system for a crewed mission to Mars compared to current options. According to Aaron Knoll, a senior lecturer in the field of plasma propulsion for spacecraft at Imperial College London, who's not involved with Pulsar Fusion, there is a huge potential for harnessing fusion power for spacecraft propulsion. "While we are still some years away from making fusion energy a viable technology for power generation on Earth, we don't need to wait to start using this power source for spacecraft propulsion," he says. The reason, he adds, is that to generate power on Earth, the amount of energy output needs to be greater than the energy input. But when using fusion power on a spacecraft to generate thrust, any energy output is useful — even if it's less than the energy being supplied. All of that combined energy, coming from the external power supply and the fusion reactions together, will act to increase the thrust and efficiency of the propulsion system. However, he adds, there are significant technical hurdles in making fusion technology in space a reality. "Current fusion reactor designs on Earth are large and heavy systems, requiring an infrastructure of supporting equipment, like energy storage, power supplies, gas delivery systems, magnets and vacuum pumping equipment," he says. "Miniaturizing these systems and making them lightweight is a considerable engineering challenge." Bhuvana Srinivasan, a professor of Aeronautics & Astronautics at the University of Washington, who's also not involved with Pulsar, agrees that nuclear fusion propulsion holds a substantial promise for spaceflight: "It would be extremely beneficial even for a trip to the Moon, because it could provide the means to deploy an entire lunar base with crew in a single mission. If successful, it would outperform existing propulsion technologies not just incrementally but dramatically," she says. However, she also points out the difficulties in making it compact and lightweight, an added engineering challenge which is a lesser consideration for terrestrial energy. Unlocking fusion propulsion, according to Srinivasan, would not only allow humans to travel farther in space, but be a game-changer for uncrewed missions, for example to gather resources like helium-3, a fusion fuel that is rare on Earth and must be created artificially, but may be abundant on the Moon: "If we can build a lunar base that could be a launching point for deep space exploration, having access to a potential helium-3 reserve could be invaluable," she says. "Exploration of planets, moons, and solar systems farther away is fundamental to our curious and exploratory nature as humans while also potentially leading to substantial financial and societal benefit in ways that we may not yet realize."

And US progress specifically is crucial.

Harrison 24 [Todd Harrison, Senior fellow at American Enterprise Institute 5-8-2024, Building an Enduring Advantage in the Third Space Age, American Enterprise Institute - AEI, https://www.aei.org/research-products/report/building-an-enduring-advantage-in-the-third-space-age/, Willie T.]

Executive Summary The United States is leading the world into a new era of space activity known as the third space age. Unlike the militarization and exploration of the first space age (1957–90) and the diversification and stagnation of the second space age (1991–2015), the third space age (2016–present) is defined by rapid commercialization and proliferation. In this new era, US space capabilities and capacity are second to none, but China, Russia, and other nations are actively working to erode this advantage. This report provides quantitative insights and analysis of the trends in space launch, satellites, and space debris and makes recommendations for how to build an enduring advantage for the United States in space. The global annual launch rate hit an all-time high of 211 successful orbital launches in 2023, driven mainly by the **United States** and China, which each logged their highest launch rate ever at **103** and 66 **launches**, respectively. The US lead is even more stark considering that it comprised **81 percent of global effective launch capacity** in 2023—**four times the rest of the world combined**. The introduction of much **larger US launch vehicles**, **particularly SpaceX's Starship** and Blue Origin's New Glenn, and the higher **degree of reusability these** vehicles employ **will further increase the US lead**. These disruptive changes will give the United States a **unique ability to launch much larger payloads** at much **lower costs**, enabling new generations of satellites with designs unconstrained by size, weight, and power. The US **advantage in space also extends to satellite capabilities** and **production capacity**. Globally, more satellites were launched in the past five years (2019–23) than in all previous years combined. In 2023, 78 percent of satellites launched were US satellites, driven mainly by the deployment of SpaceX's Starlink constellation. Commercial satellites comprise 84 percent of all satellites launched in the third space age, and market projections indicate that the satellite launch rate will remain high for the foreseeable future, driven by the deployment of highly proliferated commercial constellations, such as **Starlink and Amazon**'s Kuiper.

And this access to space is key to solving inevitable extinction. Multiple scenarios - Kovic 21 Concludes…

Marko Kovic; February 2021; PhD from the University of Zurich, co-founder and CEO of the consulting firm Ars Cognitionis, the president of the nonprofit think tank ZIPAR, and the former president of the Swiss Skeptics association for critical thinking; Futures, "Risks of space colonization"; Vol. 126 https://www.sciencedirect.com/science/article/abs/pii/S0016328720301270 https://sci-hub.se/https://doi.org/10.1016/j.futures.2020.102638 //recut rchen

Second, engaging in space colonization represents a strategy for mitigating existential risks. Existential risks are risks that could result in the extinction of humankind or in the permanent curtailing of humankind's potential for future development [6]. In a more technical sense, existential risks can be thought of as risks that could cause the permanent loss of a large fraction of humankind's future moral expected value [7]. There are two main categories of existential risks: Natural and anthropogenic. Natural existential risks are risks that are not caused by human decisions and actions. If, for example, a giant asteroid or meteor were to crash into Earth and exterminate human life, humans would not be to blame for their demise (just as the dinosaurs weren't to blame for theirs). Anthropogenic existential risks, on the other hand, are [hu]man-made in that they are the direct or indirect consequence of the technological progress of our civilization. Some examples of anthropogenic existential risks are global nuclear winter caused by nuclear war, catastrophic global warming [8, 9], or uncontrollable misaligned superintelligent artificial intelligence [10, 11]. As humankind continues to develop [s] technologically, the number of existential risks is likely to increase, making the issue of existential risks ever more pressing. Conceptually, every existential risk has a very low probability of resulting in a catastrophic outcome at any given time (their adverse outcomes are low- probability, high-impact scenarios), but they still represent a major moral concern, both because so much is at stake (the expected value of humankind's future is enormous), and because the cumulative probability of a catastrophic outcome is bound to be non-trivial in the long run2 In practical terms, space colonization is therefore an important hedge against existential risks [13, 14]. Colonizing space means making sure that not all of our existential eggs are in the same basket, which ceteris paribus increases the probability of avoiding the worst outcomes.

Contention 2 is Climate

SMR development is being hampered by lack of investment.

Waleed '25 Hammad Waleed (Research Associate at Strategic Vision Institute), 03-13-2025, "Nuclear's Next Chapter: Can Small Modular Reactors Succeed?," SVI - Strategic Vision Institute - Strategic Vision Institute, https://thesvi.org/nuclears-next-chapter-can-small-modular-reactors-succeed/, accessed 3-31-2025 //RP

In the vast chessboard of global energy, a new player is making its move—a promise wrapped in steel and uranium, heralded as the saviour of both the climate crisis and the nuclear industry itself. **Small Modular Reactors (SMRs) are being hailed as the future of clean energy, a technology that could redefine power generation as we know it**. **Compact, factory-built, and supposedly safer, faster, and cheaper,** SMRs have been cast as the solution to nuclear energy's greatest pitfalls. SMRs are marketed as a nuclear breakthrough—smaller, safer, and scalable—but their **high costs and lack of investment slow progress**. Yet, for all the fanfare, the revolution has yet to arrive. Over 80 different SMR projects have been proposed in recent decades, yet **only two have been designed and put into commercial operation .** The Western world, despite its enthusiasm, is struggling to make SMRs a reality. **Meanwhile, the East—led by Russia and China—is racing ahead, proving that when it comes to nuclear energy, state-backed ambition often trumps free-market hesitation**. Not too long ago , nuclear energy was the great hope of modern civilization. It was the power of the future, promising limitless energy without the environmental scars of coal and oil. But then came Chernobyl. Three Mile Island. Fukushima. One disaster after another shattered public confidence, turning nuclear into a relic of a more naive era. Now, as the world plummets toward climate catastrophe, **nuclear power is finding its way back into the mainstream energy discourse .** The International Energy Agency (IEA) has stated, unequivocally, that **nuclear capacity must double by 2050 if we are to meet global net-zero targets.** But here's the problem—**traditional nuclear plants are too expensive, too slow to build, and too politically fraught**(something that politicians dependant upon five year election cycles would consider too costly and politically less rewarding) **Enter SMRs, the golden compromise. They're small. They're scalable. They can be mass-produced in factories like airplanes instead of being built from scratch on-site. They take up a**

fraction of the space required by wind and solar farms. In theory, they're a silver bullet. In practice? Not so much. **China and Russia lead the SMR race, using state-backed funding, streamlined regulation, and full-service nuclear deals to outpace the West**. The logic behind **SMRs is simple: make them smaller, make them safer, and make them modular. Instead of sprawling mega-facilities that take decades to construct, SMRs could be produced assembly-line style and shipped to wherever they're needed**. They could power remote towns, support industrial manufacturing, and even serve as a replacement for decommissioned coal plants. More importantly,**they are designed with passive safety features—instead of relying on external power and human intervention, many SMRs cool themselves naturally. No pumps, no backup generators—just physics doing its job**. The nuclear industry argues that this makes them inherently safer than their predecessors, ensuring that a **Fukushima-style meltdown would be nearly impossible.**

Climate change is worsening – most recent studies confirm we're on the brink of irreversibility and the next 20 years are key.

Martina **Igini**, **02-**11-20**25**, "Breaching 1.5C Threshold Could Come 'Earlier Than Expected'", Earth.Org, https://earth.org/paris-agreements-1-5c-threshold-breach-could-come-earlier-than-expected-scientists-warn/ [Martina holds two BA degrees - in Translation Studies and Journalism - and an MA in International Development from the University of Vienna.] DOA: 3/10/2025 //RRM

Two **new** studies indicate that we might have already **crossed a key threshold** to limit global warming in line with the **Paris Agreement**, after 2024 became the first calendar year where global temperatures surpassed 1.5C. – **The planet might be on track to breach a key global warming threshold "earlier than expected," two new papers warned on Monday. The studies, published in Nature Climate Change, follow the hottest year on record and the first in which global temperatures reached 1.5C for the entire year**. This has left scientists wondering what this means for warming trends, as it puts us closer to a temperature limit we have pledged to do everything we can to avoid crossing. EO Movement Become an EO Member today and join a growing movement of people determined to make a change. JOIN EARTH.ORG Whether the planet has breached the Paris Agreement 1.5C warming target or not is measured over a 20-year retrospective average, meaning last year does not signal a permanent breach. **What the new studies investigated, however, is whether we have already entered the 20-year period above 1.5C.** Both concluded we have. One study, authored by Alex Cannon, a research scientist with Environment and Climate Change Canada, concluded that if 1.5C anomalies continue beyond 18 months, "breaching the Paris Agreement threshold is virtually certain." **Meanwhile, Emanuele Bevacqua, a climate scientist at the Helmholtz Centre for Environmental Research in Germany, and colleagues put the odds of 2024 being the first year of a 20-year period reaching the 1.5C warming level at "likely" to "virtually certain."** The Paris deal was drafted in 2015 to strengthen the global response to the growing threat of climate change. It set out a framework for limiting global warming to below 1.5C or "well below 2C" above pre-industrial levels by the end of the century. **Beyond this limit, experts warn that critical tipping points will be breached, leading to devastating and potentially irreversible consequences for several vital Earth systems that sustain a hospitable planet.** The United Nations had already estimated that current emissions reduction pledges put the planet on track for a temperature increase of 2.6-3.1C over the course of this century. The only way to avoid this is do drastically reduce greenhouse gas emissions, the primary driver of global warming as they trap heat in the atmosphere, raising Earth's surface temperature. Scientists are not optimistic either. A survey of 380 IPCC scientists conducted by the Guardian last May revealed that 77% of them believe humanity is headed for at least 2.5C of warming. And on Monday, renowned climatologist James Hansen said even the 2C target "is dead" after his latest paper concluded that Earth's climate is more sensitive to rising greenhouse gas emissions than previously thought. The former top NASA climate scientist famously announced to the US Congress in 1988 that global warming was underway. Warming Continues Hopes that the recent warming trend would subside with the arrival of a cooling weather pattern known as La Niña were dashed last month, as January turned out to be the hottest January ever recorded. Surface air temperature anomaly for January 2025 relative to the January average for the period 1991-2020. Data source: ERA5. Surface air temperature anomaly for January 2025 relative to the January average for the period 1991-2020. Image: C3S/ECMWF. "[M]any of us expect that 2025 will be cooler than both 2023 and 2024, and is unlikely to be the warmest year in the instrumental record," climatologist Zeke Hausfather wrote in a blog post on Monday. Their expectations were not met, he went on to say, describing how last beat the prior record set in January 2024 "by a sizable margin." "January 2025 stands out as anomalous even by the standards of the last two years," Hausfather wrote. "[A]t least at the start of the year nature seems not to be following our expectations."

Fortunately, nuclear energy offers an effective solution.

Hansen '13 confirms [James E. Hansen; PhD, American adjunct professor; Pushker A. Kharecha; PhD, Climate scientist; 03-15-2013; "Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power"; ACS; https://pubs.acs.org/doi/10.1021/es3051197; accessed 03-10-2025] leon

In the aftermath of the March 2011 accident at Japan's Fukushima Daiichi nuclear power plant, the future contribution of nuclear power to the global energy supply has become somewhat uncertain. Because nuclear power is an abundant, low-carbon source of base-load power, it could make a large contribution to mitigation of global climate change and air pollution. **Using historical production data, we calculate that global nuclear power has prevented an average of 1.84 million air pollution-related deaths and 64 gigatonnes of CO2-equivalent** (GtCO2-eq) **greenhouse gas** (GHG) **emissions that would have resulted from fossil fuel burning**. On the basis of global projection data that **take into account the effects of the Fukushima accident, we find that nuclear power could additionally prevent an average of 420 000–7.04 million deaths** and 80–240 GtCO2-eq emissions due to fossil fuels by midcentury, depending on which fuel it replaces. By contrast, we assess that **large-scale expansion of unconstrained natural gas use would not mitigate the climate problem and would cause far more deaths than expansion of nuclear power**.

Nuclear energy is key for climate goals. Matthew 22 continues…

Matthew 22 [M.D. Matthew, Professor @ Saintgits College of Engineering (India), January 2022, Nuclear energy: A pathway towards mitigation of global warming, Progress in Nuclear Energy, https://aben.com.br/wp-content/uploads/2022/02/Nuclear-energy-a-pathway-towards-mitigation-of-global-warming.pdf] sumzom

The clean energy transition means shifting from fossil energy to energy resources that **release little or no greenhouse gases** such as nuclear power, hydro, wind and solar. About a **third of the world's carbonfree electricity** comes from **nuclear energy.**

Nuclear power has a **great potential** to contribute to the 1.5 ◦C Paris climate change target. Nuclear power plants produce **no greenhouse gas** emissions during their operation; only very low emissions are produced over their full life cycle. Even after accounting for the entire life cycle from mining of nuclear fuel to spent fuel waste management, nuclear power is proven to be a low carbon electricity source. During operation and maintenance, nuclear power plants produce different levels of solid and liquid waste and are **treated and disposed-off safely**. While conventional fossil-fueled power plants cause emissions almost exclusively from the plant site, the majority of greenhouse gas emissions in the nuclear fuel cycle are caused in processing stages upstream (exploration and processing of the uranium ore, fuel fabrication etc.), and downstream from the plant (fuel reprocessing, spent fuel storage etc.). Over the course of its life-cycle, the amount of CO2-equivalent emissions per unit of electricity produced by nuclear power plants is comparable with that of wind power, and **only one-third of** the emissions by solar. The greenhouse gas emissions correspond to 10–15 gm of CO2 per kilowatt hour electricity produced in comparison with the emission from a fossil fueled plant of 600–900 gm, 15–25 gm from wind turbines and hydroelectricity, and around 90 g from solar power plants (Fig. 8) (Carbon Dioxide Emissions, 2021).

Nuclear power delivers reliable, affordable and clean energy to support economic growth and social development. **Without a larger role for nuclear energy, it would not be possible to combat climate change.**

Nuclear power can be **deployed on a large scale**. So, nuclear power plants can directly replace fossil fueled power plants. As of end December 2020, global nuclear power capacity was 393 GW(e) and accounted for around 11% of the world's electricity and around 33% of global low carbon electricity. Currently, there are 442 nuclear power reactors in operation in 32 countries. There are 54 reactors under construction in 19 countries, including 4 countries that are building their first nuclear reactors according to the IAEA reports (Nuclear Power Proves its, 2021; Climate Change and Nuclea, 2020a, 2020b). Nuclear power is reducing CO2 emissions by about **two gigatons per year**. Therefore, nuclear power will be imperative for achieving the low carbon future. In France, nuclear power plants accounted for 70.6% of the total electricity generation in 2019, the largest nuclear share for any industrialized country. About 90% of France's electricity comes from low carbon sources (nuclear and renewable combined). Nuclear power contributes 20% of electricity generation in the United States over the past two decades and it remains the single largest contributor of non-greenhouse-gas-emitting electric power generation out of 1,117, 475 MWe total electricity generating capacity of which 60% is from fossil fuel.

The second-largest source of low carbon energy in use today is nuclear power, after hydropower. Nuclear power plants provide **continuous and stable** energy to the grid whereas solar and wind energy require back-up power during their output gaps, such as at night or when the wind stops blowing. The International Panel on Climate Change (IPCC) has proposed at least doubling of nuclear power generation by 2050 to meet the Paris agreement. Nuclear power has compensated about 60 Gt of CO2 emissions over the past 50 years, nearly equal to **2 years** of global energy-related CO2 emissions and can help to conquer the challenges of climate change.

Existing reactors and future advanced nuclear technologies, like Small Modular Reactors (SMRs), can meet base load power needs and also **operate flexibly** to accommodate renewables and respond to demand. SMRs are a recent concept to accelerate the construction and commissioning of large nuclear power projects. By adopting the concept of modular manufacture of components, significant reduction in on-site construction time can be achieved. This can also help in reducing the capital costs. Several types of SMRs are currently under development and these offer improved economics, operational flexibility, enhanced safety, a wider range of plant sizes and the ability to meet the emerging needs of sustainable energy systems. Some of these reactors are designed to operate up to 700–950 ◦C (for gas cooled reactors) compared to LWRs, which operate at 280–325 ◦C. The electrical efficiency is higher and it can supply high temperature heat to industrial processes. High temperature SMRs can generate hydrogen through more energy efficient processes such as high temperature steam electrolysis or thermochemical cycles. Their smaller size and easier siting are expected to be a better fit for most non-electric applications, which require an energy output below 300 MWe.

Transition now solves before the brink

Stiglitz 21, (Joseph E. Stiglitz [Economics Nobel laureate, Professor of Economics at Columbia University, Ph.D., Massachusetts Institute of Technology], "The Cost of Inaction on Climate Change," United States Senate Committee on the Budget, 4-xx-2021, https://www.budget.senate.gov/imo/media/doc/Joseph%20Stiglitz%20-%20Testimony%20-%20U.S.%20 Senate%20Budget%20Committee%20Hearing.pdf)//Shwillett

Risks Let me spend a few moments discussing the real risks our economy and society face if we do not take stronger actions than we have so far. We have been treating truly **scarce** resources, our **environment**, our water, our air, as if they **were free**. But economics teaches us that there is no such thing as a free lunch. We will have to pay the check someday. And **delay** is **costly**. Taking carbon out of the atmosphere is far more expensive than not putting it into the atmosphere. A smooth **transition** is far **less costly** than the one we will surely **face** if we do not take action **urgently**. In 2008 we saw the financial destruction that came about as a result of the sudden readjustment in the pricing of one part of our housing market. The failure there would have brought down our financial system if governments had not acted forcefully. A full accounting of the costs to our societies over the succeeding years suggests that they were in the trillions of dollars. There will be a **repricing** of carbon **assets**. This I firmly believe. Carbon assets, such as those associated with **coal** and **oil** companies, **do not** today adequately **reflect** the realities of **climate change**. The **longer** we **delay** dealing with **climate change**, the **larger** the necessary **adjustments** will be, and the **greater** the potential for **huge** economic **disruption**—an **economic** disruption that could **make** the **2008** Great Recession **look like child's play** by comparison.6 The **danger** of a **crash** is **particularly acute** for the **U.S.** economy, given that large **U.S. banks** are the largest **financiers** of fossil fuel.7 The insurance industry is heavily exposed, too. Over time, I would expect that they will be more careful in providing coverage—and that means more Americans will have to manage these risks on their own. And ultimately, we know what that means: When large calamities occur, as seems inevitable, the government will pick up the bill. This is a huge hidden liability on the government's balance sheet. Opportunities Economics has, for good reason, been called the dismal science. The scenario of doom and gloom that I have painted is, unfortunately, all too real. But I want to end on a sunnier note. Doing something about climate change could be a real boon for the economy. Too often, critics of taking action point to the job losses. **Change** is **costly**. But change provides **opportunity**. I am also firmly convinced that the **opportunities afforded** by addressing climate change are **enormous**. The number of jobs that will be lost in the old fossil fuel industries are dwarfed by those that will be created in the new industries. The **value** created in the **new industries** will also **dwarf** the **value** of the **stranded assets** in the fossil fuel and related sectors. As just two examples: the number of **installers** of solar panels already is a **mbultiple** of the number of **coal miners**; the auto company with the **highest valuation** today is **Tesla**. The current focus on changing to a green economy is already stimulating enormous innovation, innovation that holds out the promise of significant increases in standards of living. The price of renewable energy has been plummeting, and in many areas outcompetes fossil fuels. The drive for a greener society is stimulating the design of new buildings and new ways of doing agriculture, which turn out actually to save resources, particularly if we value them appropriately. Our country especially has much to gain, because innovation is a key comparative advantage. If we are ahead of the game—rather than a laggard—we will develop technology that will be in demand around the world. If we are behind the game, we will pay a high price. It is almost inevitable that other countries will demand cross-border adjustments that will put our companies at a disadvantage. Government has an important role in enabling, facilitating, and encouraging the transition to a green economy. One might say we are in good luck: The deficiencies in public investment over the past decades has made it imperative that we undertake such investments now; and we can make those investments "green" investments. The investments themselves will create an enormous number of jobs, stimulating the economy and banishing to the past discussions of secular stagnation that have abounded for the past two decades. They will also crowd-in private investment. Basic research and technology investments by government, for instance, provide the foundations for investments by the private sector. We saw that in the case of the internet; we saw that in the case of the vaccines that were produced with such rapidity in response to Covid-19. And we will see it with these green investments as well. More To Be Done There is much more to be done to protect the economy from the risks I have described.8 For instance, we need immediately to end fossil fuel subsidies and require full disclosure of climate risks—both the risks of physical damage and the financial risks. Markets on their own don't provide adequate disclosure, necessary both for the efficient allocation of scarce capital and for protecting investors. We need to change statutes governing fiduciary responsibility to mandate looking at these long-run risks, and especially where government is at risk, as in government insurance pension schemes. When the government is providing insurance or finance—whether it's through FDIC or through Fannie Mae—we as taxpayers need to be apprised of all these risks; or more pointedly, we shouldn't be taking on these risks. We shouldn't be insuring banks that make loans that put our planet at risk. We also know that when all is said and done, the government will pick up the pieces when there is systemic financial fragility—and that's why it's imperative that we start assessing, and regulating, systemic climate risk. We have long been aware that in certain key areas there may be deficiencies in the provision of adequate finance. Economists have explained why that's the case, and governments around the world have stepped into the breach. There is, I believe, the need for the founding of a national infrastructure bank and for seeding the creation of community, state, and regional banks to facilitate green investments. We should never again allow the deficiency in infrastructure, which I referred to earlier, to be built up. Social Cost of Carbon Within the **economy**, within **companies**, and within **government**, prices help **guide decisions**. That's why assigning a **near-zero** price to resources that are scarce is such a bad **mistake**, and leads to such **bad outcomes**. We need to **be aware** of the social **cost** of carbon. Unfortunately, the **interim** social **cost** of carbon that was arrived at was much, **much too low.** If used as a **basis** for guiding the economy, it would **result** in temperature increases of 3.5 to **4 degrees** C.— temperatures we have not seen in millions of years, with untold risks that the international community has rightly shied away from.9 We need to **employ** a significantly **high** social **cost** of carbon, accompanied by regulations, and public investments that will **enable us** to deal **with risks** that have rightly been called **existential.**10

And this is crucial , as failure to address climate change is existential. Specktor '19…

Brandon **Specktor 19**, 6-4-2019, "Civilization could crumble by 2050 if we don't stop climate change now, new paper says," NBC News, https://www.nbcnews.com/mach/science/civilization-could-crumble-2050-if-we-don-t-stop-climate-ncna1013701 || DOA 9/6/2023 BRP

It seems every week there's a scary new report about how man-made climate change is going to cause the collapse of the world's ice sheets, result in the extinction of up to 1 million animal species and — if that wasn't bad enough — make our beer very, very expensive. This week, a new policy paper from an Australian think tank claims that those other reports are slightly off; the risks of climate change are actually much, much worse than anyone can imagine. According to the paper, climate change poses a "near- to mid-term existential threat to human civilization," and there's a good chance society could collapse as soon as 2050 if serious mitigation actions aren't taken in the next decade. Published by the Breakthrough National Centre for Climate Restoration in Melbourne (an independent think tank focused on climate policy) and authored by a climate researcher and a former fossil fuel executive, the paper's central thesis is that climate scientists are too restrained in their predictions of how climate change will affect the planet in the near future. [Top 9 Ways the World Could End] The current climate crisis, they say, is larger and more complex than any humans have ever dealt with before. General climate models — like the one that the United Nations' Panel on Climate Change (IPCC) used in 2018 to predict that a global temperature increase of 3.6 degrees Fahrenheit (2 degrees Celsius) could put hundreds of millions of people at risk — fail to account for the sheer complexity of Earth's many interlinked geological processes; as such, they fail to adequately predict the scale of the potential consequences. The truth, the authors wrote, is probably far worse than any models can fathom. How the world ends What might an accurate worst-case picture of the planet's climate-addled future actually look like, then? The authors provide one particularly grim scenario that begins with world governments "politely ignoring" the advice of scientists and the will of the public to decarbonize the economy (finding alternative energy sources), resulting in a global temperature increase [of] 5.4 F (3 C) by the year 2050. At this point, the world's ice sheets vanish; brutal droughts kill many of the trees in the Amazon rainforest (removing one of the world's largest carbon offsets); and the planet plunges into a feedback loop of ever-hotter, ever-deadlier conditions. "Thirty-five percent of the global land area, and 55 percent of the global population, are subject to more than 20 days a year of lethal heat conditions, beyond the threshold of human survivability," the authors hypothesized. Meanwhile, droughts, floods and wildfires regularly ravage the land. Nearly one-third of the world's land surface turns to desert. Entire ecosystems collapse, beginning with the planet's coral reefs, the rainforest and the Arctic ice sheets. The world's tropics are hit hardest by these new climate extremes, destroying the region's agriculture and turning more than 1 billion people into refugees. This mass movement of refugees — coupled with shrinking coastlines and severe drops in food and water availability — begin to stress the fabric of the world's largest nations, including the United States. Armed conflicts over resources, perhaps culminating in nuclear war, are likely. The result, according to the new paper, is "outright chaos" and perhaps "the end of human global civilization as we know it." How can this catastrophic vision of the future be prevented? Only with the people of the world accepting climate change for the emergency it is and getting to work — immediately. According to the paper's authors, the human race has about one decade left to mount a global movement to transition the world economy to a zero-carbon-emissions system. (Achieving zero-carbon emissions requires either not emitting carbon or balancing carbon emissions with carbon removal.) The effort required to do so "would be akin in scale to the World War II emergency mobilization," the authors wrote. The new policy paper was endorsed with a foreword by Adm. Chris Barrie, a retired Australian defense chief and senior royal navy commander who has testified before the Australian Senate about the devastating possibilities climate change poses to national security and overall human well-being. "I told the [Senate] Inquiry that, after nuclear war, human-induced global warming is the greatest threat to human life on the planet," Barrie wrote in the new paper. "Human life on Earth may be on the way to extinction, in the most horrible way."

Thus, we urge you to affirm

Rebuttal

NQ - Collapse is inevitable.

Bohdanov '25 [Yurii; Writer @ the Euromaidan Press; January 17; Euromaidan Press; "Why Russia's collapse is inevitable — and what comes next," https://euromaidanpress.com/2025/01/17/why-russias-collapse-is-inevitable-and-what-comes-next/; DOA: 3-26-2025] tristan

The war is breaking Russia's economy

War accelerates the economic collapse of authoritarian regimes – Putin's Russia is no exception. His power has always rested on resource centralization, strict state control of key assets, and, in the past decade, escalating violence against society.

Long before the war, Russia's economy suffered from "Dutch disease," where raw material exports strangled other sectors, leading to stagnation since 2012. Now sanctions cut off access to Western technology, crippling the raw materials sector, while the civilian economy withers as resources feed the war machine.

The growing imbalance between military and civilian spending has created a classic "mobilization" economy. For Putin, war isn't just strategy – it's a means of maintaining power. Yet paradoxically, it undermines the regime's economic foundation through systemic overheating.

Economic overheating occurs when growth exceeds sustainable capacity. In dictatorships, war accelerates this process as resources are squandered unproductively, leading to:

Rapid inflation. Military and defense spending drive up prices. Russia has already experienced this in rising food costs and goods shortages.

Labor shortage. War takes people to the front and military factories, reducing economic productivity. Labor quality falls due to migration and loss of the working-age population.

Growing budget deficit. The state finances war through monetary emission, undermining ruble stability and pushing the economy toward collapse.

The pattern is familiar: short-term "growth" masks slow stagnation and loss of competitiveness—exactly as in the USSR of the 1970s and 80s. While a war economy can briefly show growth, it ultimately collapses under military spending and technological isolation.

Russia today follows the same path. Military spending has already become a key factor in the growing budget deficit, and sanctions block most attempts to restore technological chains. Oil and gas sales to India and China provide life support but cannot overcome demographic collapse and fundamental economic weakness in such a vast country.

Even "freezing" the war in Ukraine will not solve Russia's economic problems. Companies leaving Russia now signal deep market distrust, and a freeze only delays the inevitable collapse. Even partial sanctions lifting isn't enough without substantial external investment, which requires major institutional changes.

Institutional degradation is inevitable because any meaningful reforms would threaten the dictatorship's grip on power. Sanctions have only accelerated this decline, while corruption, negative selection, and manual control continue eroding Russian institutions' effectiveness. The institutional decay runs too deep for even a "frozen" conflict to enable recovery.

The overheated economy won't stabilize without reducing military spending, yet this remains impossible under the current "besieged fortress" model. Like the USSR before, the Russian regime faces an inevitable economic collapse – it's only a question of timing.

Elite clashes and social decay are tearing Russia apart

Beyond economics, the social model is also collapsing. And again, even hypothetical "freezing" won't save Putin here.

The 2023 rebellion by Yevgeny Prigozhin— the leader of the Wagner mercenary group who marched his forces toward Moscow—revealed how quickly elite loyalty can shatter. Throughout 2024, elite conflicts intensified within Putin's inner circle. Ramzan Kadyrov, head of the Chechen Republic, accused Suleiman Kerimov, a billionaire senator from Dagestan, of plotting an assassination. This remains unresolved as Kadyrov builds up his "pocket" troops. Anton Vaino, Chief of Staff of the Presidential Executive Office, is also involved in these disputes.

Inside Putin's government, a battle rages over Russia's future. Central Bank Governor Nabiullina and Finance Minister Siluanov fight for economic stability, while Rostec CEO Chemezov pushes for ever-higher military spending. This isn't just a policy debate—it's a fight for Russia's direction.

Conflicts between elites are becoming open clashes, and the Kremlin no longer has sufficient authority to control them. Putin's system has created a toxic environment where demobilized soldiers, embittered elites, and a demotivated population form a dangerous cocktail.

No chance of nuclear use and Putin shifts inwards.

Snyder '23 [Timothy; Professor of History @ Yale University, Best Selling Author, Permanent Fellow @ Institute for Human Sciences in Vienna, Member @ Council of Foreign Relations, DPhil @ Oxford University, BA @ Brown University, 2003 American Historical Association's George Louis Beer Award, 2013 Hannah Arendt Prize, 2015 VIZE 97 Prize; February 8; "Nuclear war!," https://snyder.substack.com/p/nuclear-war; DOA: 3-25-2025] tristan

Rather than just listening to Ukrainians about their evaluation of risk of local nuclear use, we sometimes seek Putin's inner thoughts. When people imagine the use of Russian nuclear weapons in Ukraine, a certain weird empathy comes into play: Putin will feel that his back is against the wall, that he has no choice.

If we treat that as a hypothesis, we see that it has been disproven. Russia lost the battles of Kyiv, Kharkiv, and Kherson without using nuclear weapons. Russia has suffered almost a year of surprising defeats of various kinds, not least the collapse of its entire war plan, which involved overthrowing the Ukrainian government and controlling the entire country. And yet: no nuclear weapon use. Instead, each defeat generates stories about how Russia was not actually defeated. That is worth noting. The escalation one actually sees is narrative. It takes more and more work for Russians to explain defeat as victory. But so far they have been up to the task.

Wars end when the political power of rulers is threatened, and we have not yet reached that point. When we do, Putin will feel the threat in Moscow, not in Ukraine. In such a situation, using nuclear weapons in Ukraine will not help him. Withdrawing conventional forces from Ukraine for a power struggle in Russia might. During that power struggle, no Russian struggling for control of the Kremlin will admit that the war in Ukraine was lost. Instead, contenders for power will compete with their stories of how grand the victory actually was. My expectation is that the next Russian leader (or Putin if he remains) will claim that Russia won an extraordinary victory over NATO by eliminating NATO forces in Ukraine before they had a chance to cross into Russian territory.

In both the global and the Ukrainian settings, the Russian calculation is that nuclear talk will induce Europeans and North Americans to deter themselves from sending weapons. But deploying talk is very different from deploying weapons. Indeed, it is an alternative to doing so. We too easily assume that the word must be the antecedent to the deed. But the word is the deed. When deploying nuclear talk is the policy, then actually deploying a nuclear weapon undoes the policy. The implied threat is no longer available, once used. And the Russian leadership knows that the Americans and everyone else would send more far, far weapons to Ukraine were Russia to use a battlefield nuclear weapon.

The use of a nuclear weapon on the Ukrainian battlefield would have far greater costs than this for Russia: in the moment, and for years and decades down the line. Moscow would lose even what tentative support it has around the world. It would forfeit its ability to present itself as a victim in international relations. Its leaders would know that they would be remembered as criminals and pariahs. And that is not even to mention what would usually be mentioned first: direct deterrence. Should Russia break the taboo of nuclear use, its own status as a military power would be dramatically compromised by the military response of others.

Nuclear weapons are symbolic, for different people in different ways. I want to close on the question of status, from the Russian point of view. People sometimes say that a nuclear power cannot lose a war. This that makes historians cry into their pillows. The United States is a nuclear power that loses wars on a regular basis. The Soviet Union lost in Afghanistan, Russia lost the first Chechen war. The French nuclear test in 1960 did not save it from defeat in Algeria, any more than British nuclear weapons preserved the Empire. The use of a battlefield nuclear weapon will not win the war for Russia in Ukraine, but it would be a tremendous blow to Russian status, which is something that Russian leaders do care about.

NQ - No Russia internal instability

Stratfor 16 (Strategic Forecasting, Inc., American publisher and global intelligence company, provides strategic analysis and forecasting, "Putin's Russia Is More Stable Than It Seems", 1/23/16, Accessed 2/29/16) SSN

While it is tempting (and for some, emotionally satisfying) **to predict** the beginning of the end for Putin, or at least **a** slow **downward spiral that might result in political change in Russia, such theories suffer from a pervasive problem in reporting and analysis of Russia: They analyze** Putin, the Kremlin and events in **Russia from an overly Western perspective.** In fact, Putin's hold on power in Russia and his command over the Russian people remains strong, despite circumstances that would normally spell disaster for a Western leader. **Ultimately, significant instability in Russia is unlikely.** The trick to more accurately predicting unrest there is to get past Western assumptions and premises that simply do not hold true in Russia. Leaving Behind the Western Perspective The first flawed assumption people usually make is that Putin is actually very concerned about what the Russian population thinks or does. It is worth remembering that Putin's power does not emanate from the people he governs in the way of

Western democracies. **Putin relies** much more (albeit not exclusively) **on coercive measures** to control his country. Some pundits overemphasize the importance of Putin's former career with the KGB, and it is certainly true that there is much more to Putin than simply his background in Russian intelligence. But being a member of the KGB, or its successor organization, the FSB, or any of the previous iterations of the security organs of Russia, does carry with it a certain view of the world. Current and former members of what Russians refer to as "the special services" consider themselves Chekists, that is, in the direct lineage of the Cheka, the secret police created by Lenin. This worldview fully embraces the use of coercive measures against one's own population when needed. **Both Putin and the Russian citizenry understand this, and it frees Putin from having to be overly concerned about popular uprisings** over the price of food or other commodities. The second assumption follows from the first, namely, that Putin is concerned about how Russians express their displeasure, such as demonstrations, protests, riots and the like, and that such expressions have an effect on his decisions. **Western** commentators and **reporters** sometimes **allude to protests in Russia as harbingers of change or barometers of discontent, but it is important to remember how carefully protests in Russia are monitored, and how much** work by **the security services goes into controlling, penetrating and extracting information on the organizers** for later use. (**Witness the immense presence of the security apparatus during the BolotnayaSquare protests** in 2011.) **Putin understands it is highly unlikely that protests will reach a level that his security services (or**, in a more serious scenario, **the Russian military) can no longer control. In fact, Putin actually sees value in allowing some protests, since it enables him to paint a picture of a democratic Russia, a place where opposition forces are allowed to manifest.** This can be useful in international forums such as the United Nations, the European Union and so forth. **The final assumption is that if economic conditions continue to deteriorate in Russia, the Russian people will finally reach the point of a significant uprising that would threaten the current status quo.** While such a premise is completely reasonable in the West, most **Russians do not view scarcity the same way Westerners do. Russians take great pride in suffering** (an interesting trait that extends to other Slavic cultures but is less prominent elsewhere). **When the Russian government** explains economic hardship in a nationalistic fashion and **blames external forces** such as the European Union or the United States, **tolerating scarcity becomes** almost a national sport, and certainly **a matter of great national pride.** It is another way for Russians to stand up to an international community portrayed by the Kremlin as fundamentally anti-Russian. This explains some of Putin's actions that confound Western economists, such as Russia enacting counter-sanctions against Western trading partners, which actually creates more suffering for the average Russian family.

Putin controls the state – Elites can't act

Olga **Khvostunova 22**, 7-22-2022, Writer for FPRI, "Why Russian Elites Are Standing By Putin," Foreign Policy Research Institute, https://www.fpri.org/article/2022/07/why-russian-elites-are-hanging-together-for-now/ //mac

A **few members of Russia's elite publicly condemned the war or signaled that they disagreed with Putin's decision to launch it.** Among them were the head of the International Chess Federation and former Vice Prime Minister Arkady Dvorkovich, Russian diplomat Boris Bondarev, billionaires Oleg Tinkov, Mikhail Fridman, and Oleg Deripaska. Roman Abramovich, although did not explicitly condemn the war, has been helping peace negotiations with Ukraine. Russia's climate envoy Anatoly Chubais was even more inconspicuous in his dissent: he quietly resigned and left the country.

Some **elite** member**s confessed their shock and horror to the media on condition of anonymity**: "No one is rejoicing. Many understand that this is a mistake," a top Russian official described the mood in the Kremlin in the first days of the war. "It's paranoia that has reached the point of absurdity," said another about Putin. **Yet, three weeks later, interviews with the same interlocutors yielded different messages**: "Now that they [the West] imposed sanctions on us … we're going to f*ck them all." Others, like most **members** of the State Duma and Federations Council, **demonstrated their full support for Putin's "special military operation**." But the majority appeared to remain silent. The reality of the elites' attitudes and behavior is a complex issue, which requires careful study.

The appearance of **a monolithic façade does not signify elites' cohesion based on common values and beliefs—a factor that could hold them together in the long term. Putin**'s initial efforts to consolidate elites were only partially successful, as various elite groups continued to pursue divergent interests, and feud for influence and resources while demonstrating loyalty to Putin regardless of their actual views. But as the Russian economic pie started to shrink following the 2014 Ukraine sanctions, the Russian president **has increasingly relied on a combination of ressentiment, ultraconservative ideology, targeted repressions, and the general atmosphere of fear to strengthen his grip on power and rein the elites in.** Today, **Russian elites**, unless they are true supporters of Putin's war in Ukraine, **find themselves largely paralyzed by the high cost**s **of** dissent or **defection—both in Russia and in the West—opting for the status quo, which adds to the growing internal tensions and creates more risks for the regime in the future.**

IL NL - No Russian strikes.

Daryl G. **Kimball 21**, Executive Director, Arms Control Association, B.A. in Political Science and Foreign Affairs from Miami University, "Enough Already: No New ICBMs," Arms Control Association, March 2021, https://www.armscontrol.org/act/2021-03/focus/enough-already-no-new-icbms]

Even veteran lawmakers such as Senate Armed Services Committee Chairman Jack Reed (D-R.I.) seem to accept this bizarre nuclear war-fighting theology. "**They can't risk a 'first strike' against us unless they take those out**," Reed told Bloomberg last month.

Such arguments do not hold up. Why would Russia or China deliberately launch a bolt-from-the-blue nuclear first strike against U.S. ICBM fields **if**, as is the case, **this would assure their own annihilation? With or without ICBMs, the United States could still launch a devastating nuclear retaliatory strike from just** a portion of its invulnerable fleet of **12 strategic submarines and dispersed bomber-based weapons** that can be **distributed before the hypothetical adversary nuclear attack.**

Just one U.S. nuclear-armed submarine, carrying 160 thermonuclear warheads, each with an explosive yield of 100 kilotons or greater, **could devastate a large country** and kill tens of millions of people. The reality is that a nuclear war cannot be won and must never be fought.

Imp. NL - No escalation.

Isabel Van **Brugen 22**, 11/25/2022, Author for NewsWeek, Putin Too 'Scared' To Order Nuclear Strike, Leaked FSB Letters Reveal,

https://www.newsweek.com/putin-nuclear-weapons-war-leaked-fsb-letters-1762233)// JZ

White House national security advisor Jake Sullivan said that Washington and Moscow have held talks aimed at toning down rhetoric around Russia's potential use of nuclear weapons and talk of nuclear strikes has been less noticeable in recent weeks.

The whistleblower suggested that "there a possibility of a localized nuclear strike" but not for any military objectives.

"Such a weapon won't help with the breach of the defenses. But with a goal of scaring everyone else (the West)," they wrote.

The March 4 letter also details three reasons why the FSB agent believes Putin will not use nuclear weapons.

Kremlin's Chain of Command

The Wind of Change suggested that a chain of command within the Kremlin would block Putin should he ever attempt to order a nuclear strike.

"I don't believe that Putin will press the red button to destroy the entire world. First, it's not one person that decides, and someone will refuse. There are lots of people there and there is no single 'red' button,'" the whistleblower wrote.

Putin's Nuclear Arsenal

The agent also said there are concerns within the FSB about the effectiveness of Russia's nuclear weapons.

"Second, there are certain doubts that [Russia's nuclear arsenal] actually functions properly," they wrote. "Experience shows that the more transparent the control procedures, the easier it is to identify problems."

"And where it's murky [whether] as to who controls what and how, but always reports full of bravado, is where there are always problems. I am not sure that the 'red button' system functions according to the declared data. Besides, plutonium fuel must be changed every 10 years."

Putin's 'Fear of Death'

According to the FSB agent, Putin's fear of death will ultimately prevent him from pushing the "red button."

"Third, and this is the most disgusting and sad, I personally do not believe in Putin's will to sacrifice himself when he does not even allow his closest ministers and advisers to be in his vicinity," they wrote.

"Whether it's due to his fear of COVID or a possible assassination is irrelevant. If you are scared for the most trusted people to be near you, then how could you possibly choose to destroy yourself and those dearest to you."

T - Both fossil fuels and traditional renewable energy are unsustainable. Only modernized nuclear power solves.

[Thomas **Rehm**; March **2023**; Ph.D. in chemical engineering from Northwestern University; Current Opinion in Chemical Engineering, "Advanced Nuclear Energy: The Safest and Most Renewable Clean Energy," https://www.sciencedirect.com/science/article/abs/pii/S2211339822000880] rchen Are solar and wind renewable? **Solar** and **wind** have renewability **problems due to** planetary **mineral** resource **limits**[8], the **social impact of mining** those resources[18], and **mineral recycling** challenges at end of equipment useful life [19] We are disingenuous if we do not look at least 200 years into the future. Psychologists say that a human is sincerely concerned with his/her children, grandchildren, and great-grandchildren. Beyond those three generations, most humans do not care what happens to distant progeny. I may have great-grandchildren born as far out as my 100th birthday in 2050, and they might live 100 years. Our action plan must be at least 200 years out. Owing to the variability of solar and wind, 100% 'renewable' plans depend on energy storage. Battery storage is the hope. Lucas Bergkamp, Editor of Road to EU Climate Neutrality by 2050, does not hold that view. "You cannot, in the near future at least, have an energy storage system that will allow you to power a whole country through batteries," he told EURACTIV, saying another energy source, such as nuclear or fossil fuels, will be needed to provide baseload electricity [20]. Solar is challenged in far northern latitudes. Earth's 'center of population' latitude is 25.92 degrees north. At that latitude, solar irradiation on the winter solstice is reduced by 35%. One-fourth of Earth's population lives above 36.37 degrees north latitude, corresponding to a reduction of solar irradiation by 50% on the winter solstice [21], [22]. Sunlit hours also drop with increasing latitude. As the earth heats up, the population will undoubtedly shift farther north, exacerbating the solar energy 'solution'. Fewer people will live in areas that are good for solar generation of electricity. A nuclear plant can operate anywhere. But is not nuclear too costly? Nuclear is a better choice than solar and wind on both a land requirement basis and a consumer cost basis [20]. Overly optimistic views of solar and wind, coupled with an

unfounded fear of nuclear, are leading many to shutter legacy nuclear plants. The United States currently has 296 GW of nuclear energy capacity. If we do not keep these plants open through license renewals, we will lose 50 GW of nuclear capacity by 2030, 150 GW by 2040, and nearly all of it by 2050 [23]. We must not shut down legacy nuclear plants. Advanced nuclear energy

is truly renewable Although proven uranium reserves only give legacy technology 90 more years. **advanced tech**nology is good for thousands of years. Uranium ore contains 100 times more U238 than U235. Advanced nuclear can theoretically **provide 9000 years of** renewable **energy** from those reserves at today's energy demand, and that is not taking into account the legacy nuclear **'waste'** now safely

stored, which **can become fuel** for advanced reactors. **Advanced tech**nology can be **commercially**

viable in the United States by the 2030s. In 2001, nine nations formed the Generation IV2 International Forum (GIF) [24] to develop sustainable, economic, safe, reliable, proliferation-resistant, and physically protected nuclear reactors. Founding GIF countries include Argentina, Brazil, Canada, France, Japan, the Republic of Korea, the Republic of South Africa, the United Kingdom, and the United States. Subsequently, Switzerland (2002), Euratom (2003), the People's Republic of China (2006), the Russian Federation (2006), and Australia (2016) became members. There are now two operational advanced reactors, one in Russia and one in China. The Russian BN-800 reactor, a sodium-cooled fast breeder reactor, in Zarechny, was connected to the grid in December 2015 [25]. China's high-temperature pebble-bed modular reactor HTR-PM was connected to the grid in December 2021 [26]. The United States is lagging, but work is underway to catch up. US Department of Energy (DOE) made two awards to build advanced reactors by 2027 [27], one to TerraPower [28] on Natrium technology, and the other to X-energy [29]. TerraPower is working to commercialize three technologies, the molten chloride reactor, the Traveling Wave Reactor, and the Natrium reactor that is a sodium fast reactor incorporating the design features of the Traveling Wave Reactor. Natrium is its premier technology, which will be demonstrated at the Naughton coal-fired power plant in Kemmerer, Wyoming, which is retiring in 2025. X-energy has a moving pebble-bed high-temperature gas reactor (HTGR) design that will have 220 000 graphite pebbles with TRIstructural-ISOtropic (TRISO) particle fuel. They expect a 60-year operational life [30]. How about thorium? Per the Thorium Energy Alliance [31]: Because liquid fluoride thorium reactors (LFTRs) burn virtually all of their fuel, 83% of the waste products are safe within ten years and the remaining 17% become safe after 300 years. LFTRs can be used to burn legacy nuclear 'waste'. Thorium is the 36th most plentiful element in the earth's crust. It is four times as common as uranium. LFTRs have no refueling outages. They are continually refueled and continually remove waste product. LFTRs can be factory-produced, allowing for lower costs and shorter commissioning timetables. Kirk Sorensen, Founder of Flibe Energy, details the many LFTR benefits in a short video, those benefits being safety, a 100-fold decrease in waste generated, and immense quantities of thorium on the planet [1]. China is a leader in thorium. Experts say that China could be the first to commercialize thorium technology. An experimental thorium reactor in Wuwei could result in an operational 300 + MW thorium reactor by 2030 [32]. Centrus Energy Corporation and Clean Core Thorium Energy are working on an advanced nuclear fuel that combines thorium with high-assay, low-enriched uranium (HALEU). The new fuel is called Advanced Nuclear Energy for Enriched Life (ANEEL). ANEEL has less than 20% U238, compared with more than 94% in LWR fuel. HALEU is itself enriched to between 5% and 20% U235 [33]. In May 2022, the Norway-based marine group Ulstein announced a concept design for cruise ships using a thorium Molten Salt Reactor [34]. There are significant advantages of molten salt reactors and hot-salt storage. A molten salt reactor has its nuclear fuel dissolved in fluoride salt or chloride salt. The Terrapower/Southern fast reactor is molten chloride. The Moltex design is a molten chloride fast reactor. Kairos Power has a fluoride salt reactor design. Flibe's salt is Li2BeF4 salt that has a melting point of 459 °C and a normal boiling point of 1430 °C [35]. Molten salt allows a design with a secondary hot-salt loop with storage and a separate 'power block' cycle to produce power-on-demand from the stored hot salt, allowing load following functionality as delivery of heat is controlled by a hot-salt pump. As the power block is not coupled to the reactor, it can be built to non-nuclear standards. The salt in the loop is a nitrate salt in common use in concentrated solar power plants [36]. Although molten salt reactors hold much promise, there are challenges, the most significant being the risk of corrosion in reactor structural materials from high-temperature molten salt. A considerable amount of development work remains to be done on salt redox potential measurement and control tools in order to limit the corrosion rate [37]. Advantages of small modular reactors Small modular reactors (SMRs) are nuclear plants of 300 MWe or less. SMRs have several advantages over large nuclear plants.Onsite construction of large nuclear plants can take many years and have associated cost overruns. SMRs will be factory-built and moved to the site by truck, railcar, or barge. SMRs employ economies of mass production rather than economies of scale. Advanced technology SMRs are now operational. Two Russian SMRs (Pressurized Water Reactor, type KLT-40S) have been in operation in Port Pevek, Russia, since December of 2019 [25], [38], and two Chinese helium-cooled pebble-bed reactors (HTR-PM) were connected to the grid in December 2021 [26]. Advanced technology SMRs could be **deployed in** very **large numbers** in the next decade, in time **to meet 2050** **net-zero** goals. The emergency planning zone around a large legacy plant is typically 10 miles. The DOE 'strongly supports' an NRC proposal to apply risk-based emergency preparedness requirements for SMRs, which will significantly reduce the size of this zone [39]. Gen III+ water-moderated/cooled SMRs have a design advantage over legacy technology. Even though the reactor is designed at 2000 psig, its small size allows for ease of containment manufacture compared with a large legacy reactor. For example, each 3 m-wide NuScale reactor nestles into its own 4.6 m-wide steel containment vessel [40]. Argentina, China, and the Russian Federation are on course to begin commissioning SMRs. North America will likely be the next to deploy an SMR, as the United States is looking at 2027 for the start of operations. Canada also expects to start-up demonstration reactors in 2027 [41]. The HTGR is a moving 'pebble bed' SMR design with an exit temperature of 750 °C or higher, ideal for providing industrial process heat. The Japanese HTGR Development Program achieved 50 days of continuous 950 °C operation in a test reactor in 2010 [42]. A major DOE/Industrial program is underway to commercialize HTGRs for industrial applications, being led by Dow Chemical [17]. Each pebble is TRISO coated and is about the size of a tennis ball. Each pebble is its own nuclear reactor, the outer shell being its containment vessel. Each reactor is cooled down by passive natural circulation, usually a gas such as helium, making it impossible for an accident such as Fukushima to occur. TRISO fuels are fabricated by BWX Technologies Nuclear Operations Group (Lynchburg, Virginia) [43]. In 2017, Neutron Bytes reported that China is an HTGR leader. China is actively promoting its HTGR technology in Saudi Arabia, South Africa, the United Arab Emirates, and Indonesia [44]. China is building an HTGR demonstration plant that will have two reactor modules. The objective is a full-scale power plant with eighteen 210 MWe units. In March 2020, China announced that the reactors, steam generator, and hot gas ductwork of the demonstration plant were connected [45]. Penultimate Power in the United Kingdom has partnered with the Japanese Atomic Energy Agency to develop plans for HTGR technology to be operational in Britain by 2029 [46]. Establishment of safety regulations associated with SMRs are not yet resolved. However, the Nuclear Regulatory Commission is working to resolve policy questions such as SMR siting, offsite emergency planning, and security and safeguards [47], [48], which are strongly supported by the U.S. Department of Energy [39]. Uranium and thorium reserves At current global nuclear capacities, we have about 90 years of proven uranium reserves. There also is uranium in our oceans at a concentration of 3.3 micrograms per liter, which could provide tens of thousands of years of uranium [49]. Scientists from Oak Ridge National Laboratory have demonstrated a material that can adsorb 6 g of uranium for every kilogram of adsorbent material [50]. Rainfall runoff from land masses will renewably replenish any uranium we remove from seawater. There are about 6.4 million tonnes of thorium reserves. India leads with 846 000 tonnes, and has made utilization of thorium a major goal in its nuclear power program. The United States has the 3rd largest reserves at 595 000 tonnes. Russia and China lag considerably behind the United States with 155 000 tonnes and 100 000 tonnes, respectively. The United States can be a leader in thorium advanced reactor technology [51]. Replacing crude oil: large-scale nuclear biorefineries Crude oil and natural gas provide about 85% of the feedstocks in chemical manufacturing [52]. More than 500 million tonnes of oil-equivalent feedstock are consumed each year to make nearly 1 billion tonnes of chemical products [53]. If we are to decarbonize, we must figure out how to end our dependency on fossil fuels for chemical feedstocks. This can be done. A nuclear biorefining initiative is being led by MIT and INL. Highlights of this effort [54].3. Replacing liquid hydrocarbons will be extremely difficult. In the United States, about 18 million barrels/day of petroleum products are produced. To achieve the scale of biorefining capacity necessary to replace fossil fuels, three technologies are needed: Consolidation of biomass into energy-dense, anaerobically stored, economically shippable commodities that are available year-round. Biorefineries at the scale of 250 000 barrels per day. Nuclear energy providing electricity, process heat, and hydrogen to the biorefinery. In the United States, one billion tons of biomass will be required each year to match current consumption of refining products. The DOE and the USDA estimate that 1.4 billion tons could be produced, but that number could be tripled if (a) we pay farmers more; (b) we use 10% of semi-arid lands to plant opuntia (prickly pear cactus); (c) we use double-cropping extensively; (d) we integrate food/feed/fuel production; (e) we improve pasture/energy crop productivity; and (f) we rehabilitate saline, retired, and degraded lands. Nuclear biofuels could be deployed at scale in 20 years.

Conclusions We must transition to carbon-neutral energy. Solar and wind are not truly renewable. Advanced nuclear is far more renewable with promises of many thousands of years of clean energy. It is also the safest form of electricity generation. Industry fatalities per TWe-year are less than 0.01 for legacy nuclear energy, one to three orders of magnitude lower than solar or wind. Most of those legacy fatalities were from plants designed with high-pressure Generation-II technology. Generation-III technology is safer, having its primary focus on safety. Generation-IV advanced nuclear technology is safer yet. Fear of catastrophic nuclear accidents is driving us away from the best chance we have of solving global warming. That fear is unfounded. Some say that we must reduce energy consumption! They say we must reduce the planet's population that will help reduce energy consumption. Wishful thinking will not get us out of this mess. About 1–3 billion people on our planet either have no electricity or have very meager/unreliable electricity. They will burn oil and gas, dung, or anything they can get their hands on, to produce energy. We must figure out a way to replace fossil fuels for firm baseload. Energy demand will likely double during this century, regardless of wishful thinking. **Advanced nuclear energy is the only viable option for rapidly replacing fossil fuels** as firm baseload. Do not be swayed by the argument that nuclear cannot possibly ramp up in time to accomplish this objective. We can achieve major increases in nuclear energy capacity by 2040 if we put our minds and money to it.

T- Renewables cost more

Snyder '23 writes [Van Snyder; Spent 53 years as a mathematician, Engineer at Caltech; 03-16-2023; "Five Myths About Nuclear Power"; Substack; https://vsnyder.substack.com/p/five-myths-about-nuclear-power; accessed 02-19-2025] leon

A 2009 MIT study concluded that nuclear power plants could be built for $4 per watt, and produce electricity for 6¢ per kWh. Reactors under construction in Finland and Sweden cost about $7.50 per watt; ones in China cost $1.50 per watt. Delays due to lawsuits, difficulty certifying a new reactor, and licensing in an ever-changing regulatory environment add significant cost, especially interest on capital. It would be helpful if the Nuclear Regulatory Commission were to adopt the French system of licensing reactor designs, instead of individual reactors. **The operating cost of a reactor is quite low because fuel cost is low**. Using $30/lb for uranium ore and 4.5% enrichment, **the contribution of the cost of uranium to the price of electricity is 0.116¢ per kilowatt hour** (kWh). This was the origin of Lewis Strauss's infamous '"too cheap to meter" quip, which ignored all other costs. **Reducing oxide to metal, enriching the concentration of the fissile isotope (U-235) from the natural state of 0.7%, to 5%, and fabricating fuel assemblies, increase the fuel price to 0.5¢ per kilowatt hour**. Economic details are explained in Chapter 13 of Plentiful Energy. <<TEXT CONDENSED NONE OMITTED>> The lowest-cost electricity in California, 5¢ per kWh, is produced by the Diablo Canyon Nuclear Generating Station. Fixed cost amortization over the life of the facility contributes 74%, or 3.7¢ per kWh. Labor and other non-fuel recurring costs are 0.8¢ per kWh. The average California delivered electricity price is 30¢ per kWh. The 3.3 GWe Palo Verde nuclear generating station in Arizona was constructed for $1.79 per watt. Its delivered price for electricity is 4.3¢ per kWh. It is the most profitable electric utility in the U.S. Waste disposal is incorrectly cited as a social cost not internalized in the pricing structure. Since 1981, utilities had been paying 0.1¢ per kWh into the Federal Nuclear Waste Disposal Fund for this purpose, until a Federal court ruled in 2013 they no longer needed to pay because the Department of Energy had reneged on its legal responsibility to take custody of spent fuel. It was included in the rate customers paid. The fund now stands at $43 billion. Nuclear power is the only industry that fully internalizes all costs! Another factor sometimes cited is subsidies. Federal subsidies for light-water reactors are larger than subsidies for gas or hydro generation, but substantially less than for wind or solar photovoltaic (PV). State and local subsidies vary. The additional California solar PV subsidy is 40% of the Federal subsidy. The first full-scale instance of any new system is always expensive, but both construction and operating costs always decrease with experience. A 300 MWe IFR-type reactor could be built for less than $8 per watt. A GE/Hitachi consortium estimates they could build 380 MWe modular instances called S-PRISM (Super Power Reactor Innovative Small Modular) for less than $2 per watt, if they were to have a stream of orders that is sufficiently secure to justify a factory to construct essentially identical ones, instead of building each one, subtly different from any other, on site. In Conceptual Design of a Pilot-Scale Pyroprocessing Facility, Argonne National Laboratory and Merrick & Company proposed a forty hectare $398 million pilot-scale pyroelectric refining facility to process 100 tonnes per year of any type of spent fuel, a small fraction of the cost of a PUREX facility. Operating cost would be 0.05¢/kWh. Because utilities paid into the Federal Nuclear Waste Disposal Fund, and because Yucca Mountain has been canceled, this facility and similar larger-scale facilities ought to be constructed using those funds, not funded as part of the construction of new reactors, and not from the general fund of the Federal treasury — but the Nuclear Waste Disposal Act prohibits using the funds for reprocessing. If the goal of modernizing the energy sector is to reduce or eliminate carbon dioxide (CO_2) emissions, comparison to fossil fuels is irrelevant. Several scientists calculated that the only renewable source that can in principle provide all current energy usage is solar. Wind cannot provide more than about 15% of current total energy usage, which will surely increase (and wind won't). Conservation and all other schemes, alone or together, are inadequate to close the gap between wind supply and energy demand. <<LINE BREAKS CONTINUE>>

Solar PV panels cost about $3 per peak installed watt of label capacity. Setting aside their inability to destroy spent nuclear fuel, it seems attention ought to focus on them instead of new designs of nuclear reactors. **The amount of electricity produced in a year, divided by the amount that would be produced if the system ran continuously at full label power output, is the capacity factor**. **The Department of Energy reported that the 2018 national average capacity factor for solar PV was 25%**. **Nuclear generating stations averaged 92.5%**. **With a 25% capacity factor, the cost of a solar panel**, at $3 per peak watt, **is $12 per average watt, about six times the expected cost of S-PRISM modules**. Solar panels last about 25 years, but must operate more than four years to repay the energy invested in their fabrication, deployment, and recycling. The capital cost of $12 per average watt, amortized over twenty-five years at 5%, deducting the four-plus year energy payback period, is $26.61 per watt of average capacity. The capital cost for solar PV panels does not include operating and maintenance costs, electricity storage, significant grid changes necessary to exploit diffuse sources, and recycling. Several independent studies have determined that **renewable sources would need 390-800 watt-hours' storage per average watt of demand to provide firm power**, for which the industry definition is 99.97% availability. In Adequate Storage for Renewable Energy is Not Possible, using twelve years of data for California, I calculated that more than 2,800 watt-hours' storage per watt of average demand would be necessary. Using five years of nationwide data, more than 800 watt-hours' storage per watt of average demand is necessary. The May 2020 price for Tesla PowerWall 2 batteries was $0.543, not including installation. The warranty period is ten years. For 800 watt-hours, **the total cost would be more than 3.8 times total USA GDP every year**, for batteries alone, or "only" $49,000 per month for each of America's 128 million households. **These amounts of storage will be entirely inadequate the next time Mount Tambora erupts and produces another** "**year without a summer**" such as 1816. This or something similar will happen again. The only question is "when?" **These sorts of calculations never appear in arguments that renewable electricity is less expensive than nuclear power**. <<TEXT CONDENSED NONE OMITTED>> It leads to nuclear weapons proliferation (no it doesn't) In a March 2017 Scientific American interview, John Holdren, President Obama's Science Advisor, said "… breeder reactors… [require] what amounts to a plutonium economy… and trafficking in large quantities of weapons-usable material." A plutonium economy unrelated to breeder reactors already exists. The often-repeated hyperbole "trafficking in large quantities of weapons-usable material" is nonsense. Spent fuel from a British municipal reactor was used to make a nuclear explosion. The yield was a fraction of the Hiroshima weapon, which was a much simpler uranium device. The British remarked "We will not try that again." If plutonium is less than 93% isotopically and chemically pure Pu-239, explosive yield decreases rapidly. In an IFR-type system, plutonium in spent fuel never contains more than 54% Pu-239, and is never more than 40% chemically pure. Separating isotopically pure Pu-239 from spent fuel presents a much more difficult problem than for uranium. Plutonium isotopes in spent fuel, other than Pu-239, emit 50 times more heat, 5,000 times more neutrons, and 100 times more gamma radiation. This could damage a weapon or cause predetonation, and makes maintenance of fine mechanical tolerances difficult. Expensive remote assembly is mandatory. A 1994 Lawrence Livermore National Laboratory study stated "spent IFR fuel cannot be used to make a nuclear weapon without significant further processing." No one makes weapons from spent fuel because it is the most difficult substance from which to do so. Producing isotopically pure plutonium directly in a reactor requires controlling the neutron energy more precisely than is practical in a municipal reactor, and irradiating the fuel for durations far shorter than would be economical. Even the most rudimentary inspection regime would detect this. If an inspection regime is not practical in rogue states, don't sell them reactors, spent fuel, or means to reprocess fuel. Even if truly "weapons-ready" material existed, the proliferation argument is a red herring. No country's nuclear power stations or fuel reprocessing affect any other country's desires, decisions, or ability to acquire nuclear weapons. On-site reprocessing implies very few opportunities for diversion or theft. Plutonium in spent fuel in an IFR-type system is in a highly-radioactive and therefore easily monitored state. Advanced industrial economies already have nuclear weapons, or have the means to make them much more effectively than from spent municipal reactor fuel. Only a fast-neutron reactor can consume all fissionable metals in spent fuel and decommissioned weapons. There isn't enough uranium (there's plenty) The Australian Uranium Association estimated that it is economically feasible at current prices to recover about 4.5 million tonnes of uranium. Known or projected reserves of lower quality increase the estimate to 18.5 million tonnes. Activists insist an all-electric Earth would demand about 15,000 GWe. Using the one tonne per GWe-year rule of thumb, 18.5 million tonnes is enough to satisfy this demand, if it were used with 100% efficiency, for only about 1,200 years. But today's reactors use only 0.6% of the energy in mined uranium, so this fuel would last less than ten years. The situation isn't nearly so bleak, however. In the United States, there are about 90,000 tonnes of 5%-used fuel, and about 900,000 tonnes of depleted uranium left over from enriching mined uranium. A 1,700 GWe all-electric U.S. energy economy could be powered by this "waste" in fast-neutron reactors for 525 years, or longer depending upon use of renewable sources, without mining, milling, refining, enriching, or importing one gram of new uranium. Spent fuel is significantly more radiotoxic than depleted uranium, so it should be consumed first. Every country that has nuclear reactors has stocks of spent fuel and depleted uranium. IFR-type reactors extract 99.99% of the energy immanent in mined uranium but today's reactors extract only 0.6%. The price of uranium would contribute the same amount to the delivered electricity price from IFR-type reactors if it were to increase 167 fold. Uranium could be economically extracted from lower quality ores, or from seawater, where there is estimated to be at least a thousand times more than could be extracted from land. Another low-quality ore is coal-fired power plant waste, which contains nineteen times more energy in the form of uranium and thorium than was extracted by burning the coal. Thorium, four times more common than uranium, can be converted to fissile fuel by neutron transmutation in a fast-spectrum reactor. Nuclear fission is an effectively inexhaustible source of energy. It is possible to breed about 5% more fuel from uranium than is consumed, but only about 1% more from thorium. If the goal is to deploy a fleet of new breeder reactors fueled only by recycled fuel, thorium should not be used before sufficient reactors are in service. The first two goals of the IFR project were safety and waste mitigation. The third was fuel economy. The system problem Most energy discussions focus only on components — wind turbines and solar panels. Electricity production and distribution is a system problem, not simply a component problem. In Burden of Proof: A comprehensive review of the feasibility of 100% renewable-electricity systems, Renewable and Sustainable Energy Reviews 76, Elsevier (2017), pp 1122-1133, Ben Heard et al described an analysis of 24 studies that claimed to explain how to construct and operate regional, national, or continental-scale electricity systems. None of the studies described systems that were physically feasible. Heard et al concluded there was no point to study economic viability. <<LINE BREAKS CONTINUE>> **A more serious system problem is that the Earth does not have sufficient materials to build the** "**technology units**" **that the International Energy Agency** (IEA) **demands be built to provide all energy from renewable sources**. To stay out of the weeds, here is just one problem: **Five times more copper is needed than is known to exist on the Earth in forms that can be recovered**.

T - Renewables worse – destroy farmland

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U.S. Senators Jon Tester (D-MT) and Mike Rounds (R-SD) recently introduced a bill to bar foreign adversaries—namely, China, Iran, North Korea, and Russia—from buying American farmland. The act was triggered by concerns over Chinese investment in U.S. farmland, although China currently owns less than 1 percent of U.S. foreign-held farmland (Canadian investors hold the largest share -nearly one third - of U.S. foreign-held farmland). Preventing adversaries from investing in U.S. farmland is a necessary but insufficient action. **As the United States progresses with its net-zero transition, the public and private sectors should maximize land efficiency for renewable energy sources. If not appropriately managed, electricity production from renewables to meet decarbonization goals could drive up land use and land-cover change, threatening biodiversity and food security and challenging other environmental and social priorities.** According to Bloomberg, the United States currently uses eighty-one million acresto power its economy, about the size of Iowa and Missouri combined and covering roughly 4 percent of the contiguous United States. If**the U.S. government and energy industry fail to maximize land efficiency in the energy transition process, replacing less land-intensive fossil fuels with more land intensive clean energy sources will dramatically drive up demand for land. Intensified competition for land use risks exacerbating farmland loss.** For example, according to a 2020 Brookings report, electricity generation by wind and solar is at least ten times more land-intensive than coal- or natural gas-fired power plants. A different study, using data from 1,400 real-world observations covering nine electricity sources across 73 countries and 45 U.S. states, also showed that wind and solar are far more land intensive than fossil fuels, and biomass is the least land-efficient source of electricity. To achieve President Joe Biden's pledge to create a carbon-free economy by 2050**, the United States would need the equivalent of four additional South Dakotas to generate sufficient clean power to meet its electricity demand**, according to Princeton University estimates and Bloomberg analysis. The Biden administration has demonstrated a firm commitment to promoting clean energy development in the United States through landmark legislation, such as the infrastructure bill and the Inflation Reduction Act. Policy measures such as subsidies and tax credits make it more lucrative for owners of farms and ranches to lease their land for solar and wind farms in exchange for annual royalty payments. In parts of the country, such as Colorado, solar and wind farms have become the new cash crop, driving a frenzied land rush for renewable energy that has irrevocably altered the landscape. Converting prime agricultural land into clean energy farms has also raised significant concerns and encountered local resistance in rural communities in states such as Texas. **The United States needs a more land-efficient approach. That will require restoring American leadership in nuclear power research, development, and deployment. Researchers have found that nuclear power is by far the most land efficient for electricity generation compared to other energy sources: to generate the same amount of electricity, it needs twenty-seven times less land than coal, eighteen times less than hydropower plants, and thirty-four times less than solar. However, developing nuclear energy has not been a priority in the U.S. energy agenda for decades**. Between 2013 and 2021, at least twelve [PDF] U.S. nuclear reactors were shut down (representing 9,436 megawatts of electricity generation capacity) due to rising security costs, competition from wind and solar, and power generated by cheap natural gas, leaving just 92 nuclear reactors operating nationwide. Not until the recent disruption in global energy markets triggered by Russia's invasion of Ukraine did the U.S. government step up support for its nuclear energy sector. The Biden administration has correctly recognized that maintaining and expanding nuclear power as a source of carbon-free electricity is crucial for reaching its climate commitment. To that end, the Biden administration recently offered $1.2 billion in aid to extend the life of distressed nuclear power plants. The funding is also available for recently closed plants, marking the first time such support has become available. The challenges of the energy transition to a clean and sustainable future extend beyond monetary costs. **The transition requires careful consideration of land use intensity between competing interests and demands. The U.S. government needs to revitalize the domestic nuclear power industry to drive the decarbonized American economy while protecting farmland and food security.**