

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 rockets that 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 doubt in 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 implications that 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 **accelerated 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 government 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.scsdp.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 technological 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 United States 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.” Bhuwana 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, 02-11-2025, "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 to 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, [//Shwilllett">https://www.budget.senate.gov/imo/media/doc/Joseph%20Stiglitz%20-%20Testimony%20-%20U.S.%20Senate%20Budget%20Committee%20Hearing.pdf">//Shwilllett](https://www.budget.senate.gov/imo/media/doc/Joseph%20Stiglitz%20-%20Testimony%20-%20U.S.%20Senate%20Budget%20Committee%20Hearing.pdf)

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 multiple 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-added 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

Renewables

Renewables aren't enough and all implantation plans of a renewable grid are idealistic with flaws. Clack 17

Clack CTM, Qvist SA, Apt J, Bazilian M, Brandt AR, Caldeira K, Davis SJ, Diakov V, Handschy MA, Hines PDH, Jaramillo P, Kammen DM, Long JCS, Morgan MG, Reed A, Sivaram V, Sweeney J, Tynan GR, Victor DG, Weyant JP, Whitacre JF. Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar. Proc Natl Acad Sci U S A. 2017 Jun 27;114(26):6722-6727. doi: 10.1073/pnas.1610381114. Epub 2017 Jun 19. PMID: 28630353; PMCID: PMC5495221.

Number of studies, including a study by one of us, have concluded that an 80% decarbonization of the US electric grid could be achieved at reasonable cost (1, 2). The high level of decarbonization is facilitated by an optimally configured continental high-voltage transmission network. There seems to be some consensus that substantial amounts of greenhouse gas (GHG) emissions could be avoided with widespread deployment of solar and wind electric generation technologies along with supporting infrastructure. Furthermore, it is not in question that it would be theoretically possible to build a reliable energy system excluding all bioenergy, nuclear energy, and fossil fuel sources. Given unlimited resources to build variable energy production facilities, while expanding the transmission grid and accompanying energy storage capacity enormously, one would eventually be able to meet any conceivable load. However, in developing a strategy to effectively mitigate global energy-related CO₂ emissions, it is critical that the scope of the

challenge to achieve this in the real world is accurately defined and clearly communicated. **Wind and solar are variable energy sources, and some way must be found to address the issue of how to provide energy if their immediate output cannot continuously meet instantaneous demand.** The main options are to (i) curtail load (i.e., modify or fail to satisfy demand) at times when energy is not available, (ii) deploy very large amounts of energy storage, or (iii) provide supplemental energy sources that can be dispatched when needed. It is not yet clear how much it is possible to curtail loads, especially over long durations, without incurring large economic costs. There are no electric storage systems available today that can affordably and dependably store the vast amounts of energy needed over weeks to reliably satisfy demand using expanded wind and solar power generation alone. These facts have led many US and global energy system analyses (1–10) to

recognize the importance of a broad portfolio of electricity generation technologies, including sources that can be dispatched when needed. **Faults with the Jacobson et al. Analyses** Jacobson et al. (11) along with additional colleagues in a companion article (12) attempt to show the feasibility of supplying all energy end uses (in the continental United States) with almost exclusively wind, water, and solar (WWS) power (no coal, natural gas, bioenergy, or nuclear power), while meeting all loads, at reasonable cost.

Ref. 11 does include 1.5% generation from geothermal, tidal, and wave energy. Throughout the remainder of the paper, we denote the scenarios in ref. 11 as 100% wind, solar, and hydroelectric power for simplicity. Such a scenario may be a useful way to explore the hypothesis that it is possible to meet the challenges associated with reliably supplying energy across all sectors almost exclusively with large quantities of a narrow range of variable energy resources. However, there is a difference between presenting such visions as thought experiments and asserting, as the authors do, that rapid and complete conversion to an almost 100% wind, solar, and hydroelectric power system is feasible with little downside (12). It is important to understand the distinction between physical possibility and feasibility in the real world. To be clear, the specific aim of the work by Jacobson et al. (11) is to provide "low-cost

solutions to the grid reliability problem with 100% penetration of WWS [wind, water and solar power] across all energy sectors in the continental United States between 2050 and 2055." **Relying on 100% wind, solar, and hydroelectric power could make climate mitigation more difficult and more expensive than it needs to be. For example, the analyses by Jacobson et al. (11, 12) exclude from consideration several commercially available technologies, such as nuclear and bioenergy, that could potentially contribute to decarbonization of the global energy system, while also helping assure high levels of reliability in the power grid. Furthermore, Jacobson et al. (11, 12) exclude carbon capture and storage technologies for fossil fuel generation.** An additional option not considered in the 100% wind, solar, and hydroelectric studies is bioenergy coupled with carbon capture and

storage to create negative emissions within the system, which could help with emissio

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 Berghamp, 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 EUNACTIV, 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 [25]. 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 technology 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 technology can be commercially**

viable in the United States by the 2030s. In 2001, nine nations formed the Generation IV 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), Euronorm (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 Zarechinsk, was connected to the grid in December 2015 [25]. China’s high-temperature pebble-bed modular reactor HTGR-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 Thorium-triOxide (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 (LFRs) 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. LFRs 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. LFRs have no refueling outages. They are continually refueled and continually remove waste products. LFRs can be factory-produced, allowing for lower costs and shorter commissioning timetables. Kirk Sorensen, Founder of Flibe Energy, details the many LFR 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 technologies. An experimental thorium reactor in Wuwei could result in an operational 300 - MW thorium reactor by 2030 [32]. Centrus Energy Corporation and Clever 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 UOX fuel. HALEU is itself enriched to between 5% and 20% U235 [33]. In May 2022, the Norway-based marine group Uthman 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 Molten design is a molten chloride fast reactor. Kairos Power has a fluoride salt reactor design. Flibe’s salt is U235F4 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 functionally as a 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-40B) have been in operation in a Port Povey, Russia, since December of 2019 [25], [38], and two Chinese helium-cooled pebble-bed reactors (HTGR-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 Nuclear 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 RWX Technologies Nuclear Operations Group (Richmond, Virginia) [43]. In 2017, Nestor Byer 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]. Peninsular 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 is a 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 third largest reserves at 395 000 tonnes. Russia and China have the United States with 153 000 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 alternatives Crude oil and natural gas provide about 85% of the feedstocks in chemical manufacturing [52]. More than 100 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 brending initiative is being led by MIT and INEL. Highlights of this effort [54]. 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 bioengineering 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. Bioethanol at the scale of 250 000 barrels per day. Nuclear energy providing electricity, process heat, and hydrogen to the bioeconomy. In the United States, one billion tons of biomass will be required each year to match current consumption of refining products. The DOE and 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 corn and beans to plant sorghum (richly pest resistant), (c) we integrate food/feed/fuel production, (d) we integrate food/feed/energy crop productivity, and (e) we improve pasture/energy crop productivity, and (f) we rehabilitate saline, retired, and degraded lands. Nuclear biofuels could be deployed at scale in 30 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.

Renewables don't live up to their expected performance AND nuclear better than fossil fuels

Department of Energy 25 [U.S. Department of Energy, "What is Generation Capacity", March 30, 2025, U.S. Department of Energy, <https://fortune.com/2022/03/29/us-energy-independence-uranium-nuclear-power/>]

Capacity factors allow energy buffs to examine the reliability of various power plants. It basically **measures how often a plant is running at maximum power**. A plant with a capacity factor of 100% means it's producing power all of the time. **Nuclear has the highest capacity factor of any other energy source—producing reliable and secure power more than 92% of the time** in 2024. **That's nearly twice as much as a coal (42.36%) or natural gas (59.9%)** plant that are used more flexibly to meet changing grid demands and almost **3 times more often than wind (34.3%) and solar (23.4%) plants**.

Cards that nuclear can't keep up with our energy sector or that it takes too long are projected with a lack of investment, investment solves – we become faster and have a greater quantity

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 (CO2) 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,

T - Renewables worse – destroy farmland

Liu 23 (Zongyuan Zoe Liu is Maurice R. Greenberg senior fellow for China studies at the Council on Foreign Relations (CFR). Her work focuses on international political economy, global financial markets, sovereign wealth funds, supply chains of critical minerals, development finance, emerging markets, energy and climate change policy, and East Asia-Middle East relations. Dr. Liu's regional expertise is in East Asia, specifically China and Japan, and the Middle East, specifically Gulf Cooperation Council countries. 3/23/23, "Going Green Pits Renewables Against Farmland. Nuclear Energy Can Help", CFR, <https://www.cfr.org/blog/going-green-pits-renewables-against-farmland-nuclear-energy-can-help> // DOA: 3/10/25)JDE

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 acres** to 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.

T - Renewable energy production threatens biod

ESC 23 [Endangered Species Coalition, March 17, 2023 "How Renewable Energy Impacts Biodiversity"
<https://www.endangered.org/how-renewable-energy-impacts-biodiversity/> /Accessed 4/7/25] //JS

Renewable energy production often destroys habitats and hurts wildlife.

NL/T - Nuclear is better:

A. Emissions.

Oracle '22 [Change Oracle, 7-20-2022, "Nuclear Power Versus Renewable Energy", Change Oracle
<https://changeoracle.com/2022/07/20/nuclear-power-versus-renewable-energy/>, doa 4-2-2025] //ALuo

Nuclear energy has advantages over renewables in terms of reliability, GHG emissions, land use and waste. Nuclear is far more reliable (dispatchable) than renewables like wind and solar. Nuclear plants keep churning out energy even when the wind is not blowing, and the sun is not shining. Nuclear is also one of the cleanest sources of energy. Recent research published in the Journal of Cleaner Production found that the emission of GHGs and natural resource use associated with nuclear power generation was similar to that of renewable energy. An analysis by the European Commission indicates that in terms of full-cycle production, the emissions from nuclear are around the same as wind. Other studies have concluded that nuclear may be even cleaner than solar. Orano claims that nuclear power generates four times fewer GHGs than solar.

B. Waste.

Oracle '22 [Change Oracle, 7-20-2022, "Nuclear Power Versus Renewable Energy", Change Oracle
<https://changeoracle.com/2022/07/20/nuclear-power-versus-renewable-energy/>, doa 4-2-2025] //ALuo

While there are valid concerns about nuclear waste, there are also legitimate issues with renewable waste. Wind and solar generate a litany of chemical wastes including toxic heavy metals like cadmium, arsenic, chromium, and lead. While nuclear waste can remain radioactive for thousands of years, waste metals associated with renewables remain dangerous forever. Perhaps most importantly, the volume of nuclear waste is a tiny fraction of renewable waste. Nuclear w

Even if you believe renewables are better, declining government budgets make tradeoffs inevitable---even if its not all their links, it proves their impact is inevitable.

Schleicher 23 [David Schleicher is a professor at Yale Law School. He is the author of the book In a Bad State: Responding to State and Local Budget Crises.; "The Era of Flush State Budgets Is Over"; The Atlantic; June 4, 2023;
<https://www.theatlantic.com/ideas/archive/2023/06/state-budgets-federal-funding-california-new-york/674264/>]/eleanor

As part of the deal to extend the debt limit, President Joe Biden and Congress agreed to rescind about \$30 billion that had originally been allocated in 2021's American Rescue Plan, some of which was going to be sent to state and local governments for a variety of projects. The amount isn't that large, at least by federal-budget standards, but it is indicative of a huge change in policy. The federal response to COVID-19 included enormous amounts of mostly unconditional fiscal aid to states, cities, and other local governments. But this era of huge federal aid, and the flush state and local budgets it helped create, is over.

In its place will be a period of state fiscal retrenchment. Between the huge buckets of federal aid and the strong economy of the past few years, state budgets have never been healthier. Some states and cities have used this time to address long-standing fiscal problems and to sock away significant "rainy day" funds, which will ease the coming crunch. But others have not, instead using the money to build out new government programs or cut taxes, policies that will prove hard to reverse even when budgets get tighter.

And they are getting tighter. Across the country, state and local tax and other revenues are declining, and the outcome will be particularly bad for transit agencies dependent on farebox revenue where many fewer people are riding transit and for cities reliant on downtown commercial property taxes where more people are working from home. When the flow of federal money to state and local budgets runs out, some jurisdictions—including California, Illinois, and New York City—will face enormous budget gaps.

People have become used to the state and local politics that were ushered in by the full budgets written amid the growing economy of the late 2010s, and the boom in state revenue around COVID. During these flush years, even some liberal politicians supported tax cuts and even some conservative ones supported increasing pay for teachers. The next few years will not look like that. Rather than new programs and tax reductions, we are going to see a number of states and localities forced to cut back. Police departments will be partially defunded not because of political preferences but because of fiscal necessity, despite worries about crime; class sizes in public schools will increase because fewer teachers will be hired. Federal efforts to encourage green infrastructure will be partially frustrated by declining state and local investment. Some places will raise taxes. And, in the medium term, we are likely to see severe fiscal crises in at least a few jurisdictions, like what we saw in Detroit in 2013.

The central lesson of the past few years is that although federal aid to state and local governments can be extremely useful in heading off economic crises, it should be paired with conditions that encourage states and cities to budget responsibly. Congress could still encourage some changes in state and local fiscal policy. Achieving these reforms would have been much easier when federal money was flowing; now, however, we'll be able to see the need for them more clearly.

Federal aid for states and cities came in several packages in 2020 and 2021 and was crucial in ensuring that the economic shock of COVID didn't turn into a giant recession. One reason the post-2007 Great Recession was so big was that it led to a huge downturn in state and local employment, substantially extending the economic decline. States and cities ended up hiding a lot of their lost revenue in underfunded public-pension systems, and the consequences persist to this day. During the Great Recession, interest rates were low and unemployment was high, which should have led to massive investment in new infrastructure, but states and cities used their borrowing capacity to accrue pension debt (ask yourself, where are the infrastructural wonders of the past 20 years?). Some jurisdictions, notably Detroit and Puerto Rico, were forced to default on their debts.

Cyber attacks

They provide no time-frame on cyber attacks, we don't know when this would happen, how, or who would even be the perpetrator. Are they domestic? Are they foreign? Our opponents don't tell us.

Modern safety features make a meltdown exceedingly unlikely.

EPRI Advanced Nuclear Technology (), Nuclear Plant Safety, 2025,

<https://ant.epri.com/article/nuclear-power-plant-safety-doa-4-8-2025> (DNM)

Most notably, operating reactors are contained in a large, strong building of thick reinforced concrete, which is designed and certified to completely prevent the spread of radiation in case of a reactor accident. The containment building also protects and isolates the reactor from external events such as hurricanes, earthquakes, tornadoes, tsunamis, and even airplane impacts. This reinforced structure is the third and ultimate physical safety barrier around the nuclear reactor. Nuclear plants are contained on dedicated pieces of land. Environmental radioactivity-measuring devices are placed in and around the plant to monitor and ensure that no radioactivity is escaping from the reactor vessel or reactor building. The land is guarded to prevent clandestine intruders to the nuclear facility, and operates with a local network disconnected from the internet, eliminating the risk of cyberattacks. Operational Safety at Nuclear Power Plants No technology is perfect, but risks can be lowered to acceptable levels; for example, most people would consider airplanes safe even though a handful of crashes occur every year. For nuclear plants, different systems are in place to eliminate risks of potential failure as much as possible, and even in the exceedingly unlikely event of failure, additional standards reduce damage and radioactivity spread as much as possible. In addition to the three physical barriers already mentioned, here are some of the design standards that ensure that nuclear reactors operate as safely as possible. Negative Reactivity Coefficient First and foremost, a "runaway chain reaction" is not physically possible with today's reactor designs. Modern nuclear reactors have a negative reactivity coefficient, meaning if fuel temperature rises, the reaction slows down. A reactor with excess fissions will either return to critical equilibrium or shut itself down entirely, even without human intervention — an inherent safety measure in its design. Scram Mechanisms Complete shutdown of a nuclear reactor is always just a button away, and sometimes, it takes no human action at all. Nuclear facilities are equipped with hundreds of sensors which, if triggered, cause a complete reactor shutdown. In the event of a severe earthquake, for example, the control rods are inserted automatically and the reaction stops. Containment Ultimately, in a worst-case scenario, physical barriers prevent the spread of radioactivity. First, nuclear fuel and radioactive fission products are held inside the fuel cladding, which is designed to withstand temperatures of thousands of degrees Celsius. Next, the reactor core is contained inside the pressure vessel, which is similarly designed to withstand high temperatures and pressures. Last, the containment building is capable of withstanding extreme external events. For radioactivity to escape a nuclear plant, all three barriers would need to fail. In that worst-case scenario, every plant has a planned, tested, and rehearsed emergency preparedness plan that would minimize all risks to human health. While it is not impossible for containment failure to occur, it is extremely unlikely. If a hypothetical event occurred that was strong enough to compromise a nuclear reactor, the reactor failure would probably be of much less concern than the event itself. Who Oversees Nuclear Energy? The materials and designs used in nuclear power production are subject to strict oversight by multiple agencies, including the International Atomic Energy Agency (IAEA) and the regulatory bodies of the power plant's country, such as the U.S. Nuclear Regulatory Commission (NRC). The IAEA works in tandem with governments and regulatory agencies worldwide to ensure that reactors are

designed and operated safely and without risk of spreading nuclear material. They do this with frequent and thorough inspections. Ever since nuclear power's beginnings in the 1950s, regulators have always held safety to be paramount. Operational experience continues to

identify and inform safety measures that mitigate all possible risks to human health. Safety Comparison of Nuclear Energy Like all technologies, it is not possible to completely eliminate all risks of danger from nuclear energy. However, compared to other technologies, nuclear power is extremely safe based on its track record. Since fission power is carbon-neutral, nuclear power can help decarbonize and offset energy production from fossil fuels. Burning fossil fuels releases harmful chemicals such as sulfur oxides, particulate matter, and aerosols. These externalities of fossil fuel energy damage air quality and lead to an estimated 8 million premature deaths per year. Nuclear energy produced 2,653 terawatt-hours (TWh) of electricity in 2021 without releasing any carbon emissions or radiation to the public. Advanced Nuclear Reactors are Inherently Safe Nuclear reactors operate safely today to produce more than half of the carbon-free electricity in places like the U.S. and Europe. The reactors of the future will benefit from enhanced inherent safety fundamental to the physics of the fuels and designs. Advanced fuels like the TRISO fuel pebbles of the pebble bed or high-temperature gas reactors are made to be even more durable than existing fuels. They can withstand temperatures higher than their reactors can reach — even in accident scenarios. Some reactor technologies, like molten salt reactors or pebble bed reactors, use liquid and liquid-dispersed fuel, respectively, which can easily be drained using freeze plugs in the event of overheating or technical failure, making shutdown automatic. Nuclear power is already extremely safe, and advanced reactor technologies will only make it safer.

Government regulation means meltdowns are contained

U.S. Nuclear Regulatory Commission (), Backgrounder on Nuclear Reactor Risk, 11-7-2024, <https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/reactor-risk.html> doa-4-8-2025 (DNM)

Potential nuclear power plant accidents have a very small risk of releasing enough radioactivity to affect the public. The NRC further minimizes that risk in several ways. The agency requires U.S. nuclear power plants to have multiple, redundant barriers to contain radioactive material, as well as numerous safety systems, properly trained staff and ongoing testing and maintenance activities. NRC inspectors check on all these areas. Nuclear power plants are designed to operate safely and protect public health and safety and the environment. Any industrial activity, however, involves some risk. Nuclear reactors keep radioactive material isolated from the environment with several barriers. The first barrier is sealed metal tubes that encase the ceramic uranium fuel pellets. The second barrier is the heavy steel reactor vessel (nine inches to a foot thick) and the piping that carries cooling water to and from the reactor. The third barrier is the heavily reinforced concrete and steel containment building (up to several feet thick) that surrounds the reactor and would hold in radioactivity in the unlikely event a serious accident challenges the first two barriers. A nuclear power plant uses water to cool its fuel and prevent damage. Diverse and multiple systems at each plant, mostly running on electricity, provide this cooling water. Plants therefore use emergency diesel generators to provide backup electricity if their main power source is lost. In addition, plant operators must keep the plant within safe operating limits and under safe conditions as part of their license. These limits and conditions cover such things as operability of plant equipment, plant operating procedures, periodic equipment testing and maintenance. To top of page Policy, Regulations, and Regulatory Framework The Commission set nuclear power plant safety goals in a 1986 NRC policy statement, specifying expectations for an acceptably low level of risk to public health and safety. This includes how the risk of cancer fatalities to people near a normally operating nuclear power plant should not

exceed 0.1% of the total cancer fatality risks from all other causes. When the NRC issues a nuclear power plant license, the agency includes criteria and requirements that ensure risks to public health and safety are kept acceptably low. The agency bases its regulations on sound engineering concepts found acceptable for safe plant design and operation. The NRC supports its license application and review processes with detailed regulatory guides and a standard review plan, clarifying license requirements and describing practices that satisfy these requirements. In addition, the NRC issues various generic communications to all appropriate nuclear power plants to address potential safety concerns. **Risk is currently examined using probabilistic risk assessment, a structured look at the likelihood and consequences of system failures, fires and other serious events. A 1995**

Commission policy statement covers PRA use in nuclear regulatory activities. The policy consists of four basic elements: All regulatory processes should increase PRA use in a manner that complements the NRC's traditional defense-in-depth philosophy. PRA and associated analyses should reduce unnecessary conservatism associated with current regulatory requirements and guides, license commitments, and staff practices. Where appropriate, PRA should support the process for imposing additional regulatory requirements, called the backfit rule, 10 CFR 50.109. Appropriate procedures for including PRA in the process for changing regulatory requirements should be developed and followed. The existing rules and regulations shall be complied with unless subsequently revised. PRA evaluations supporting regulatory decisions should be as realistic as practicable, with a publicly available base of information available for review, as appropriate. PRA applications will account for uncertainties when using the Commission's safety goals and related objectives to propose and backfit new generic requirements on nuclear power plant licensees. The Commission's policy is intended to allow consistent and predictable implementation of PRA applications. This promotes regulatory stability, efficiency, and predictability of regulatory decisions, making the regulatory process risk-informed (focusing resources on those items most important to protecting public health and safety). These safety goals and policies set the basis for the NRC's regulatory framework for making risk-informed decisions. To top of page Risk-Informed Decision-making The NRC has used PRA to address complex safety issues and make risk-informed decisions, such as those involved in rules on events where a reactor fails to automatically stop the chain reaction, and events where the reactor vessel is suddenly cooled. PRA also contributed to formulating the backfit rule; prioritizing generic safety issues; and preparing generic letters and evaluating industry responses to them. The NRC has updated its standard review plan and associated regulatory guides to address risk-informed decision making, including: SRP Section RG • Determining technical adequacy 19.1 1.200 • Plant-specific changes to the licensing basis 19.2 1.174 • inservice testing 3.9.7 1.175 • inservice piping inspection 3.9.8 1.178 • technical specifications 16.1 1.177 Risk-informed decision-making also plays a role in the reactor oversight process, which includes inspection, enforcement, and assessment. Risk insights have been incorporated in many aspects of the inspection program and inspection tools. This better focuses inspection resources on the most safety-significant aspects of plant design and operations. It also ensures the NRC is making its regulatory decisions objectively, relying on sound data and operating experience. Risk-informed decision-making can also be used to support changes to regulatory requirements and regulations. When risk-informed decision-making approaches help modify basic reactor regulations, they focus on ensuring the regulatory burden of individual regulations matches the importance of that regulation to protecting public health and safety. One example allows licensees to risk-inform various requirements, focusing attention on more important equipment while still ensuring the plant meets its overall safety requirements. The process ensures plant systems can perform their functions with high quality and reliability consistent with their importance. October 2024

Nuclear plants are not connected to the web NEI 16

Cybersecurity And, 9-11-2001 (tagged wrong, go to article), "Cybersecurity for Nuclear Power Plants," Nuclear Energy Institute, <https://www.nei.org/resources/reports-briefs/cybersecurity-for-nuclear-power-plants>, accessed 4-12-2025 (ARD)

Critical safety and security systems at nuclear energy plants are isolated from the internet. They have no direct access to the web, nor do they have indirect access because they are not connected to the plants' internal networks. These systems use either air gaps, which do not require internal networking or internet connectivity, or robust hardware-based isolation devices that separate the control system from front-office computers. In addition to the protection afforded by isolation, nuclear power plant digital assets are further protected by cybersecurity and physical security plans required by the NRC.

