Contention 1 is Space

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

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

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

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

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

The nuclear fusion feat has broad implications, fueling hopes of clean, limitless energy. As for space exploration, one upshot from the landmark research is attaining the long-held dream of future rocketsthat are driven by fusion propulsion.

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

Investment secures fusion propulsion deployment by 2030.

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

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

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

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

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

Contention 2 is Climate

SMR development is being hampered by lack of investment.

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

In the vast chessboard of global energy, a new player is making its move—a promise wrapped in steel and uranium, heralded as the saviour of both the climate crisis and the nuclear industry itself. **Small Modular Reactors (SMRs) are being hailed as the future of clean energy, a technology that could redefine power generation as we know it**. **Compact, factory-built, and supposedly safer, faster, and cheaper,** SMRs have been cast as the solution to nuclear energy's greatest pitfalls. SMRs are marketed as a nuclear breakthrough—smaller, safer, and scalable—but their **high costs and lack of investment slow progress**. Yet, for all the fanfare, the revolution has yet to arrive. Over 80 different SMR projects have been proposed in recent decades, yet **only two have been designed and put into commercial operation .** The Western world, despite its enthusiasm, is struggling to make SMRs a reality. **Meanwhile, the East—led by Russia and China—is racing ahead, proving that when it comes to nuclear energy, state-backed ambition often trumps free-market hesitation**. Not too long ago , nuclear energy was the great hope of modern civilization. It was the power of the future, promising limitless energy without the environmental scars of coal and oil. But then came Chernobyl. Three Mile Island. Fukushima. One disaster after another shattered public confidence, turning nuclear into a relic of a more naive era. Now, as the world plummets toward climate catastrophe, **nuclear power is finding its way back into the mainstream energy discourse .** The International Energy Agency (IEA) has stated, unequivocally, that **nuclear capacity must double by 2050 if we are to meet global net-zero targets.** But here's the problem—**traditional nuclear plants are too expensive, too slow to build, and too politically fraught**(something that politicians dependant upon five year election cycles would consider too costly and politically less rewarding) **Enter SMRs, the golden compromise. They're small. They're scalable. They can be mass-produced in factories like airplanes instead of being built from scratch on-site. They take up a fraction of the space required by wind and solar farms**. In theory, they're a silver bullet. In practice? Not so much. **China and Russia lead the SMR race, using state-backed funding, streamlined regulation, and full-service nuclear deals to outpace the West**. The logic behind **SMRs is simple: make them smaller, make them safer, and make them modular. Instead of sprawling mega-facilities that take decades to construct, SMRs could be produced assembly-line style and shipped to wherever they're needed**. They could power remote towns, support industrial manufacturing, and even serve as a replacement for decommissioned coal plants. More importantly,**they are designed with passive safety features—instead of relying on external power and human intervention, many SMRs cool themselves naturally. No pumps, no backup generators—just physics doing its job**. The nuclear industry argues that this makes them inherently safer than their predecessors, ensuring that a **Fukushima-style meltdown would be nearly impossible.**

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

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

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

Fortunately, nuclear energy offers an effective solution.

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

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

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

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

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

Xtra cards

Space

US progress 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.

Investors are required for development of fusion. Windridge 23

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

Why **investors are key** Investors are in an interesting position. They **have the potential to** be a huge part of the solution to our climate/energy woes by making the **accelerate**d development of **fusion** possible. Legal & General Group, one of the UK's leading financial services groups and a major global investor, is up front about the power of investors to address climate change through investment, influence and operations. The Group's alternative asset platform, Legal & General Capital (LGC), plays a significant role in developing and deploying technologies that help to tackle climate change, such as electric charging infrastructure in the UK, super-efficient solar panels, offshore wind farms and also fusion energy, where they have been investing in Tokamak Energy for several years. John Bromley, Managing Director Clean Energy Strategy & Investments at Legal & General Capital, says: "Climate is not only the most urgent issue, but also the biggest investment opportunity of our lifetime. Investors who are focused on the challenges of decarbonising our economy, and can take a long term view, have a crucial role to play in the accelerated development of fusion energy." He continues: "As an energy transition investor, Legal & General Capital supports the growth of a new generation of clean energy technology and infrastructure providers, and innovative companies whose work will support the transition to net zero." Some consider that the **financing risk is**

the **biggest risk to fusion**, so investors are critical to success. Getting in on the action Investors also have the chance to win big on fusion, a market that Bloomberg has predicted could reach $40 trillion. Why is fusion so attractive? As John Bromley says, "Renewables will certainly be a large and important part of a decarbonised economy, but we will also require dispatchable zero carbon energy sources to end fossil fuel reliance. Fusion energy holds the potential to achieve and sustain a significant reduction in global emissions." There's no doubt that funding fusion is challenging,

involving high upfront costs, long timescales and high uncertainty. Yet investment in fusion has been increasing. Just last month, Breakthrough Energy Ventures (Bill Gates' investment firm seeking to finance, launch, and scale companies that will eliminate greenhouse gas emissions throughout the global economy—an investor in Commonwealth Fusion Systems and Zap Energy) invested in another fusion company, Type One Energy. Behind the scenes, more conventional investors, like pension funds, insurance companies and sovereign wealth funds, have quietly been investing in fusion. The mainstreaming of fusion among capital-providers has begun. What investors need Yet getting into fusion investment requires a steep learning curve. Fusion is a big and complex subject. Increasingly investors, investment banks or other financial players are enquiring wanting to learn about fusion, taking that first step into getting familiar with a new industry. Financing fusion is so critical to the mission that advocates of fusion should be asking how we can accelerate this mainstreaming of fusion and draw new capital to the table. Investors need access to opportunity, they need insight from industry insiders and existing investors, they need community and relationships. This is why events that bring all these things together can be so important. But **investors** also **need gov**ernment **support and certainty**. That's one reason why the U.K. is currently in a strong position for fusion energy development, because they have outlined their plans for a regulatory framework for fusion while other countries are still in discussion. It goes further than technology regulation, however. **Policy and incentives will be required** in the financial services industry **to drive** the effective **reallocation**

of capital. Michelle Scrimgeour, Chief Executive of Legal & General Investment Management, gave evidence to a 2022 U.K. parliamentary inquiry entitled 'The financial sector and the U.K.'s net zero transition'. Scrimgeour said: "A successful transition to a decarbonised economy, consistent with less than 1.5 degrees warming, will require a substantial change in capital allocation. Several trillion dollars a year of incremental capital will need to be invested into low carbon energy, energy infrastructure and energy efficiency. For this capital allocation to occur, a financial services industry that is aligned with net zero outcomes will be crucial. Equally, this requires global policy action at international governmental level, particularly on an effective regulatory structure to price carbon and other greenhouse gases." So while investors hold the key to the success of fusion and our clean energy future, it's not just down to investors–government policy will be **crucial in enabling investors** to drive the change.

Current funding is insufficient. Disregard doubt on fusion. Any risk that we prove federal investment is enough to make fusion possible AND faster means it's try or die. Risch 2/24

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

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

Thanks to decades of federal investment in basic research, American **scientists have** now **proven** that **fusion is possible**. Growing power demands,**recent tech**nological **breakthroughs**, and the shifting market dynamics of energy create a unique opportunity for fusion to finally see its time in the Sun. A big bet on fusion could **secure America's position** as a technological superpower for decades to come. The Global Fusion Race The U.S. Fusion Landscape America has led the world in fusion energy sciences since the days of the Manhattan Project.12 U.S. universities have consistently attracted the world's best talent, many of whom created today's leading fusion companies. Our National Labs beat the world in demonstrating fusion's scientific feasibility. **Yet** despite this legacy of scientific excellence, the **U**nited **S**tates finds itself **underprepared** for fusion's transition from experimental science to commercial reality.**Achieving fusion** energy on a competition-relevant timeline will**require** more than just tackling key scientific hurdles. It calls for an entirely different posture than the current U.S. approach, one that prioritizes commercialization and optimizes **U.S. spending on fusion.** Though progress has been made in strategy, infrastructure, and **investment**in recent years, it is not sufficient to compete and harness fusion energy's full potential. An assessment of the U.S. fusion landscape reveals: Strategy: Stemming from the 2022 Bold Decadal Vision,recent U.S. strategic initiatives have laudably sought to push fusion toward commercialization, but have **fallen short**in translating ambitious goals into urgent, concrete, actionable policies **and** programs.13 The Department of Energy's (DOE) 2024 Fusion Energy Strategy focuses on three pillars: bridging technological gaps for a pilot plant, enabling sustainable deployment, and forging external partnerships.14 The Milestone-Based Fusion Development Program, modeled after NASA's Commercial Orbital Transportation Services (COTS) program, seeks to reduce investment risk by setting discrete technical milestones that unlock government funds. Other programs include the Fusion Innovation Research Engine (FIRE) Collaboratives, which provide testing infrastructure that private firms can**not** develop on their own,15 the Innovation Network for Fusion Energy (INFUSE), which provides access to technical and financial support,16 and most recently the Private Facilities Research (PFR) program, which will enable public research at private fusion facilities.17However, 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**.

Climate

Clean energy transition is inevitable but must be faster.

Worland 21 [Justin Worland, Senior Correspondent @ Time & BA in History from Harvard University, 7-15-2021, The Energy Transition Is in Full Swing. It's Not Happening Fast Enough, TIME, https://time.com/6106341/green-energy-transition-iea/, Willie T.]

Even if you follow these things closely, it can be hard to understand where the world's fight against climate change stands. On the one hand, news abounds of the clean energy revolution, as wind farms and solar panels pop up in communities across the globe and automakers promise to go electric. On the other hand, scientists continue to warn that fossil fuels have placed the planet and everyone who lives on it on an unavoidable collision course with catastrophe.

A new report from the International Energy Agency (IEA) published Wednesday explains the dynamic in sharp detail: the world has begun a **momentous shift** in how we power the economy that will touch virtually every corner of human society, with investment in oil and gas slowing and spending on clean energy rising. But it's **not happening fast enough** to avoid dangerous levels of warming.

"A new global energy economy is emerging," IEA Executive Director Fatih Birol tells TIME. But when it comes to the necessary levels of investment in clean energy, there is "a **gross mismatch."**

The IEA's annual World Energy Outlook is designed to inform policymakers about the state of global energy markets as well as the emerging trends expected to define energy in the years to come. Its origins are undeniably wonky, but this year's report takes on new significance with climate change on the rise in public consciousness and on the international stage. The agency released the 2021 report a month early to help inform talks among the delegates who will gather in Glasgow, Scotland, in early November for the biggest United Nations climate summit in years.

Perhaps nothing is more urgent than the report's key message that countries need to dramatically accelerate their efforts to cut emissions for the world to have any hope of limiting temperature rise to 1.5°C, the level at which scientists say we might expect to see widespread catastrophic effects of climate change. Current pledges from countries to cut emissions only reduce carbon pollution by 20% of what's necessary to avoid reaching that marker, according to the report's analysis.

The report offers no shortage of solutions to make up the gap. Climate politics can often end up mired in debates about controversial topics like carbon capture and nuclear energy, but the report highlights four straightforward areas that would address the problem: electrification, energy efficiency, tackling methane emissions and advancing innovation. To make all of those happen, the world needs to grow annual investment in clean energy by close to $4 trillion by the end of the decade, according to the report. "Finance is the **missing ingredient** to accelerate," says Birol.

Looming energy crises

The analytical work that underpins the report began long before the energy crunch gripping Europe and China and threatens to spread across the globe. Nonetheless, the report warns that the energy crisis—which the IEA attributes to a rise in energy demand amid the economic recovery from the pandemic, among other things—may presage **future energy crises** that could occur if governments fail to plan carefully.

At the heart of the agency's concern is an underinvestment in clean energy. Investment in oil and gas has stalled in a way that is consistent with **limiting warming** to 1.5°C. At the same time, spending on clean energy infrastructure remains **far below** what it needs to be, creating the possibility of **volatility** and supply disruptions much like the world is facing today. "The longer this mismatch persists, the greater the risk for increased volatility," says Birol. "**What we need is very clear**: to increase investment in clean energy technologies."

Even as investment in oil and gas has slowed, the IEA warns that the economic recovery from the worst of the COVID-related downturn has failed to live up to the promises of a "green recovery" that was commonly touted as governments spent trillions to help prop up their economies in 2020. Just 2% of $16 trillion spent by countries around the world on COVID economic support was spent on clean energy, according to the report. As a result, the world is now experiencing the second largest uptick in carbon emissions in history, in large part as a result of growth of coal use to power the economic recovery. "We are now witnessing an unsustainable recovery," says Birol.

Transition Inevitable, Needs to be Faster

Weise 24 [Zia Weise, senior reporter covering climate policy @ POLITICO & B.A. in journalism from Kingston University, 11-6-2024, Climate world absorbs a reality they'd hoped to avoid: Trump is back, POLITICO, https://www.politico.eu/article/climate-world-diplomats-donald-trump-victory-clean-energy-fossil-fuels-greenhouse-emissions/, Willie T. + sumzom]

The morning of his victory, however, officials and climate campaigners talked down Trump's likely impact on plans to slow greenhouse gas emissions, hoping to calm nervous clean technology markets and present the transition as a **fait accompli**.

"Those investing in clean energy are already enjoying huge wins in terms of jobs and wealth, and cheaper, more secure energy. This is because the global energy transition is **inevitable** and gathering pace, making it among the **greatest economic opportunities** of our age," said United Nations climate chief Simon Stiell.

The challenge is that the world **isn't moving quickly enough** to prevent dangerous global warming, and any slowdown from the world's **second-largest emitter** — itself a major driver of the global shift to clean energy — is bound to throw a wrench into global climate efforts.

Trump hinted at what was coming in his victory speech early Wednesday morning, touting America's abundant supplies of "liquid gold." Addressing Robert F. Kennedy Jr., the environmental lawyer who appears likely to bring his unorthodox views on healthcare to the heart of a Trump administration, Trump said: "Bobby, leave the oil to me."

Transition now solves before the brink

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

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

Nuclear energy is key for climate goals.

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 CO_2-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 CO_2 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 CO_2 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 CO_2 emissions over the past 50 years, nearly equal to **2 years** of global energy-related CO_2 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.

As stated by Oxford '11–

University of Oxford, xx-xx-2011, No Publication, "Existential Risk Prevention as the Most Important Task for Humanity," https://pdfs.semanticscholar.org/53fb/690aed5705b283995b22962b2dacb1b6c908.pdf https://existential-risk.com/concept), DA 12-22-2023 // Recut SD

The scope of a risk can be personal (affecting only one person), local (affecting some geographical region or a distinct group), global (affecting the entire human population or a large part thereof), trans-generational (affecting humanity for numerous generations, or pan-**generational (affecting humanity overall, or almost all, future generations)**.The severity of a risk can be classified as imperceptible (barely noticeable), endurable (causing significant harm but not completely ruining quality of life), or crushing (causing death or a permanent and drastic reduction of quality of life). This is the category of risks that have (at least) crushing severity and (at least) pan-generational scope.6 As noted, **an existential risk is one that threatens to cause the extinction of Earth-originating intelligent life or the permanent and drastic failure of that life to realize its potential for desirable development.** In other words, **an existential risk jeopardizes the entire future of humankind.** In particular, **pan-generational risks** can **contain a** subclass of **risks so destructive that** their realization would not only affect or **pre-empt future human generations** but would also destroy the potential of the part of the universe that lies in our future light cone to produce intelligent or self-aware beings (cosmic scope).**Even if we use the most conservative** of these **estimates**, which entirely ignores the possibility of space colonization and software minds, we find that **the expected loss of an existential catastrophe is** greater than the value of **10^{18} human lives. This implies that the expected value of reducing existential risk by a mere one millionth of one percentage point is at least ten times the value of a billion human lives.** The more technologically comprehensive estimate of 10^{54} human-brain-emulation subjective life-years (or 10^{52} lives of ordinary length) makes the same point even more starkly. Even if we give this allegedly lower bound on the cumulative output potential of a technologically mature civilization a mere 1% chance of being correct, we find that the expected value of reducing existential risk by a mere one billionth of one billionth of one percentage point is worth a hundred billion times as much as a billion human lives. One might **consequently** argue that **even the tiniest reduction of existential risk has a**n expected **value greater than** that of the definite provision of **any "ordinary" good**, such as the direct benefit of saving 1 billion lives. And, further, that the absolute value of the indirect effect of saving 1 billion lives on the total cumulative amount of existential risk—positive or negative—is almost certainly larger than the positive value of the direct benefit of such an action. **Mitigation of existential risk is hampered by a lack of understanding, but also by a deficit of motivation. Existential risk mitigation is a global public good** (i.e., non-excludable and non- rivalrous), and economic theory suggests that such goods tend to be undersupplied by the market, since each producer of existential safety (even if the producer is a large nation) could capture only a small portion of the value.(51, 52) In fact, the situation is worse than is the case with many other global public goods in that **existential risk reduction is a strongly transgenerational (in fact, pan-generational) public good**: even a world state may capture only a small fraction of the benefits— those accruing to currently existing people. **The quadrillions of happy people who may come to exist in the future if we avoid existential catastrophe would be willing to pay the present generation astronomical sums in return for a slight increase in our efforts to preserve humanity's future**, but the mutually beneficial trade is unfortunately prevented by the obvious transaction difficulties.