## **Tech Aff --- Fusion, AI**

### **Contention 1 is Fusion**

#### **Nuclear fusion can unlock limitless, safe, clean energy. It’s possible and reaching commercial viability. Unlike current reactors which use fission, fusion reactors are inherently more powerful, safer, and waste free.**

**Davis ’22** [Nicola; December 12; the Guardian's science correspondent and presenter of the Science Weekly podcast. She has a MChem and DPhil in organic chemistry from the University of Oxford; The Guardian, “Breakthrough in nuclear fusion could mean ‘near-limitless energy’” https://www.theguardian.com/environment/2022/dec/12/breakthrough-in-nuclear-fusion-could-mean-near-limitless-energy]

**Researchers** have reportedly made a breakthrough in the quest to unlock a “near-**limitless**, **safe**, **clean**” source of energy: **they** have **got more** energy **out** of a nuclear fusion reaction than they **put in**.

Nuclear fusion involves smashing together light elements such as hydrogen to form heavier elements, releasing a huge burst of energy in the process. The approach, which gives rise to the heat and light of the sun and other stars, has been **hailed** as having **huge potential** as a **sustainable**, **low-carbon** energy source.

However, since nuclear fusion research began in the 1950s, researchers have been unable to a demonstrate a positive energy gain, a condition known as ignition.

That was, it seems, until now.

According to a report in the Financial Times, which has yet to be confirmed by the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory in California that is behind the work, researchers have managed to release 2.5 MJ of energy after using just 2.1 MJ to heat the fuel with lasers.

Dr Robbie Scott, of the Science and Technology Facilities Council’s (STFC) Central Laser Facility (CLF) Plasma Physics Group, who contributed to this research, described the results as a “momentous achievement”.

“Fusion has the potential to provide a near-limitless, safe, clean, source of carbon-free baseload energy,” he said. “This seminal result from the National Ignition Facility is the first laboratory demonstration of fusion ‘energy-gain’ – where more fusion energy is output than input by the laser beams. The scale of the breakthrough for laser fusion research cannot be overstated.

“The experiment **demonstrates unambiguously** that the **physics** of Laser Fusion **works**,” he added. “In order to transform NIF’s result into power production a lot of work remains, but this is a key step along the path.”

Prof Jeremy Chittenden, professor of plasma physics at Imperial College London, agreed. “If what has been reported is true and more energy has been released than was used to produce the plasma, that is a true breakthrough moment which is tremendously exciting,” he said.

“It proves that the long sought-after goal, the ‘**holy grail**’ of fusion, can indeed be **achieved**.”

#### **Investment in development jump starts fusion**

**Merrifield ’23** [Jeffrey S. and Sid Fowler; Former Comissioner of the Nuclear Regulatory Commission, JD in environmental law from Georgetown; Energy Attorney focused on advanced energy and energy transition technologies, former Attorney in the Nuclear Regulatory Commission's (NRC) Honor Law Graduate program; June 16; Journal of Fusion Energy, “Promoting Fusion Development Through Financial Policies: An Examination of How Clean Energy Investment Policies Can Better Incentivize Fusion Investment and Support Development and Deployment of Fusion Technology,” Vol. 42]

Over the past two decades, governments and private sector entities have established a diverse array of policies that have catalyzed massive investments in clean energy technologies. The way in which these policies work is as diverse as the policies themselves, but a common theme is that their effect is to create **financial incentives** that make certain **zero-carbon energy tech**nologies more **attractive** for companies, customers, and investors.Footnote1 These policies have shown **great success** and have encouraged the **significant build-out** of renewables while **helping lower** technology **costs**. Recent efforts by the U.S., Canada, and others to expand these incentives to other clean energy sources, including green hydrogen production and advanced nuclear reactors, is anticipated to **spur** even **greater** clean energy **investment**.

**Fusion** could potentially play a role in helping reach **global net zero** by 2050, and is expected by many to be a source of clean and renewable energy for humanity’s long-term future. The size of this role, though, and the **size of the market** for commercial fusion, have the potential to be **impacted** by **similar policies** to those described above. Energy infrastructure can last for decades, and nations may need to build or restructure their energy grids to accommodate certain energy choices,Footnote2 thus the energy choices made in the coming years could have meaningful long term consequences. All else being equal, **incentivized energy sources** may be better able to **attract capital** or **customers** and be **more widely adopted** than non-incentivized sources. Therefore, clean energy investment policies will likely (and in fact are often intended to) influence what portion of the long-term energy mix is made up of energy technologies favored by such policies and incentives.Given fusion’s potential as a clean, carbon free en

ergy source, it might be expected that **these policies** would similarly **incentivize investment** in **fusion**. However, clean energy investment policies, as **currently comprised**, are often **not structured** in a manner that provides similar **benefits to fusion**. Some of these policies may require further action to **add fusion** to the list of **specified eligible tech**nologies. Other policies may be technology neutral but have a limited time frame or require that the investment relate to a specific energy-producing facility, making these incentives ill-suited to fusion energy’s current stage of development. While an exhaustive review of clean energy investment policies is beyond the scope of this editorial, several recent prominent examples are described below.

Clean Energy Tax Credits

**Tax credits** are one **frequently deployed** method for **driving investment** in clean energy, and the **U.S**. has **long had** a variety of **tax credits** to **promote adoption** of renewable generation.Footnote3 Recently, these tax credits were expanded and extended by the U.S. Inflation Reduction Act (IRA).Footnote4 The IRA is a major U.S. law that provides approximately $369 billion for energy and climate change investments over a broad network of incentives, much in the form of monetizable tax credits.Footnote5 The U.S. Department of Energy has estimated that the IRA will boost clean energy investment and result in a reduction in U.S. economy-wide greenhouse emissions of 40% below 2005 levels by 2030.Footnote6

The IRA provides four clean energy tax credits of note here: a technology neutral production tax credit (PTC)Footnote7 and investment tax credit (ITC)Footnote8 for new clean energy generating facilities, and a technology specific ITCFootnote9 and PTCFootnote10 for advanced energy manufacturing.

Although fusion could potentially meet the eligibility requirements for the technology neutral clean electricity PTC and ITC, these **programs** are **scheduled to phase out** starting in **2032**. This means that only facilities which start construction during or prior to the **phase-out** date will be **eligible** for **credits**. While some fusion energy developers have suggested their desire to build and operate pilot fusion plants near this date,Footnote11 the **phase out** is likely to **occur too soon** to **meet** the **time horizon** of most commercial-scale fusion energy facilities. Further, both programs **require** that either production or investment relate to a **specific** generating **facility** which enters service, and so would not apply to investment in broader **R&D** or prototype machines.

The **IRA**’s advanced energy manufacturing **ITC** and **PTC** might be **more beneficial** to fusion developers, as such credits could apply to factories for building fusion facility components or to the components themselves. **However**, these credits are **tech**nology **specific** and do **not** currently include **fusion**. The U.S. **Sec**retary of **Treasury** may issue a **determination** allowing other technologies to **qualify** for the **ITC** but has not yet made such a **determination**.Footnote12

#### **Federal investment in fusion solves U.S. energy leadership and science diplomacy that addresses a range of existential threats *even without successful development***

**Fedoroff 8** (Dr. Nina, Science and Technology Adviser to the Secretary of State and the Administrator of USAID, “Making Science Diplomacy More Effective”, Testimony before the House Science Subcommittee on Research and Science Education, 4-2, http://2001-2009.state.gov/g/stas/2008/105286.htm)

Finally, some types of science a" particularly those that address the grand challenges in science and technology a" are **inherently international** in scope and **collaborative** by necessity. The ITER Project, an international **fusion** research and development collaboration, is a product of the thaw in superpower relations between Soviet President Mikhail Gorbachev and U.S. President Ronald Reagan. This reactor will harness the power of nuclear fusion as a possible new and viable energy source by bringing a star to earth. ITER serves as a **symbol** of international scientific cooperation among key scientific leaders in the developed and developing world a" Japan, Korea, China, E.U., India, Russia, and United States a" representing 70% of the world' current population.

The recent elimination of funding for FY08 U.S. contributions to the ITER project comes at an inopportune time as the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project had entered into force only on October 2007. The elimination of the promised U.S. contribution drew our allies to question our **commitment** and **credibility** in international cooperative ventures. More problematically, it jeopardizes a **platform for reaffirming U.S. relations with key states**. It should be noted that even at the height of the cold war, the United States used science diplomacy as a means to maintain communications and avoid misunderstanding between the world' two nuclear powers a" the Soviet Union and the United States. In a complex multi-polar world, relations are more challenging, the threats perhaps greater, and the need for engagement more paramount.

Using Science Diplomacy to Achieve National Security Objectives

The welfare and stability of countries and regions in many parts of the globe require a concerted effort by the developed world to address the causal factors that render countries fragile and cause states to fail. Countries that are unable to defend their people against starvation, or fail to provide economic opportunity, are susceptible to extremist ideologies, autocratic rule, and abuses of human rights. As well, the world faces common threats, among them **climate change**, **energy and water shortages**, **public health emergencies**, **environmental degradation**, **poverty**, **food insecurity**, and **religious extremism**. These threats can undermine the national security of the United States, both directly and indirectly. Many are blind to political boundaries, becoming regional or **global** threats.

The United States has no monopoly on knowledge in a globalizing world and the scientific challenges facing humankind are enormous. Addressing these common challenges demands common solutions and **necessitates scientific cooperation**, common standards, and common goals. We must increasingly harness the power of American ingenuity in science and technology through strong partnerships with the science community in both academia and the private sector, in the U.S. and abroad among our allies, to advance U.S. interests in foreign policy.

There are also important challenges to the ability of states to supply their populations with sufficient food. The still-growing human population, rising affluence in emerging economies, and other factors have combined to create unprecedented pressures on global prices of staples such as edible oils and grains. Encouraging and promoting the use of contemporary molecular techniques in crop improvement is an essential goal for US science diplomacy.

An essential part of the war on terrorism is a war of ideas. The creation of economic opportunity can do much more to combat the rise of fanaticism than can any weapon. The war of ideas is a war about rationalism as opposed to irrationalism. Science and technology put us firmly on the side of rationalism by providing ideas and opportunities that improve people' lives. We may use the recognition and the goodwill that science still generates for the **U**nited **S**tates to achieve our diplomatic and developmental goals. Additionally, the Department continues to use science as a means to reduce the proliferation of the **w**eaponsa of **m**ass **d**estruction and prevent what has been dubbed 'brain draina. Through cooperative threat reduction activities, former weapons scientists redirect their skills to participate in peaceful, collaborative international research in a large variety of scientific fields. In addition, new global efforts focus on improving biological, chemical, and nuclear security by promoting and implementing best scientific practices as a means to **enhance security**, **increase global partnerships**, and **create sustainability**.

#### **Fusion investment alone boosts the STEM workforce**

**Ludes 11** (Dr. Jim, Executive Director – American Security Project, “Fusion Energy: An Opportunity for American Leadership and Security”, American Security Project White Paper, 1-24, <https://life.llnl.gov/life_in_the_media/pdfs/fusion_2020_paper.pdf>)

With the political will and the **right investment**, the potential strategic gains for the U.S. in the aggressive development and deployment of fusion power plants are extraordinary. These would include:

• Clean, safe, sustainable, and affordable electricity generation in the U.S. and the world;

• Energy independence and associated freedom from foreign countries for our energy supplies;

• Transition to an electricity-generating economy to power our cars and trucks;

• Elimination of the actinides in spent nuclear-fuel by building fusion/fission hybrid plants (using the high neutron fields from fusion to transmute the actinides in spent fuel and thereby render the spent fuel non-toxic within 200 years – not tens of thousands of years);

• The two-fold boost to the U.S. economy of reducing our huge trade imbalance by eliminating the cost of importing oil and making the U.S. a world-leader in the energy market by providing fusion generating plants for the whole world;

• Creation of a large number of jobs in building and maintaining commercialized fusion power plants;

• **Demonstration** of how **U.S. leadership** in technology can be leveraged to drive leadership in energy; and

• **Increase interest** and high-paying jobs for young people going into **scientific** and **engineering** fields.

#### **Absent federal investment, STEM shortages threaten hegemony**

**STAC 24** “The U.S. Needs More STEM Workers ASAP. A National Science and Technology Strategy Can Help” The Science & Technology Action Committee (STAC) is a group of 25 non-profit, academic, foundation, and corporate leaders working to dramatically strengthen U.S. science and technology. The Committee is co-chaired by: Bill Novelli, Professor Emeritus and founder of Business for Impact at Georgetown University and former CEO of AARP, Sudip Parikh, CEO, American Association for the Advancement of Science (AAAS) and Executive Publisher of the Science Family of Journals, Mary Woolley, President & CEO of Research!America, and Keith Yamamoto, Vice Chancellor for Science Policy and Strategy at UCSF and Immediate Past President of the American Association for the Advancement of Science (AAAS). June 12, 2024, https://sciencetechaction.org/news-item/the-us-needs-more-stem-workers-asap-a-national-science-and-technology-strategy-can-help/ //STRONG

When it comes to driving the U.S. economy, fostering innovation, and securing global leadership, one of the greatest assets is a robust, diverse STEM workforce. Yet, with demand rapidly rising for skilled STEM professionals, **the U.S. risks not being able to fully meet this critical need**.

The STEM workforce today includes more than 36 million people and accounts for 24% of the total labor pool in the U.S. — and those numbers are growing rapidly. Unfortunately, the talent pipeline — including in the burgeoning AI industry — is not growing quickly enough to meet such high demand. For example, the semiconductor industry faces a significant workforce gap in the coming years. While the number of semiconductor jobs is projected to increase 33% by the end of the decade, 58% of these positions could go unfilled at current degree completion rates.

We can’t let that happen.

An all-encompassing national science and technology strategy that ramps up federal funding in science and technology can help solve the STEM talent crisis by building the diverse, domestic STEM workforce the nation needs to power innovation today — and in the future. Given the number of disciplines involved in STEM, comprehensive coordination among federal science and technology agencies, as well as strategic partnerships with the private sector, are also essential.

#### **U.S. hegemony prevents all conflict**

**Tertrais 22** – Deputy Director of Fondation Pour la Recherche Stratégique, a leading French think tank, former Senior Advisor to the French Ministry of Defense, PhD in Political Science from Sciences Po.

Bruno Tertrais, “Entangling Alliances?,” Atlantic Council, 06-xx-2022, <https://www.atlanticcouncil.org/wp-content/uploads/2022/06/Entangling_Alliances__Europe_the_United_States_Asia_and_the_Risk_of_1914_.pdf>

The United States **stands out as a security guarantor** due to the combination of its enjoyable location, its democratic nature, and its unparalleled power. US-led formal alliances **are unique** in that **they involve both interests and ideals**.78 Today, the US administration is expanding and consolidating these links seeking to “build a latticework of alliances and partnerships globally that are fit for purpose for the twenty-first century.”79 North Korean, Iranian and, to some extent, Turkish foreign policies have also contributed to various states seeking new defense partnerships for mutual protection.

Of course, this proliferation of defense accords **would not have happened** if security guarantors—Washington in particular—did not have direct interests at play. The protection of a weaker power remains a vehicle for political influence, commercial benefits (notably arms sales),80 military access (bases), capabilities, and legitimacy for common operations.81 Leaving aside the specific case of the Warsaw Pact, which was an instrument to control its members, these interests are never one-sided, and allies clearly see an upside to continued cooperation. Allies return the favor when they participate in operations led by their protector, for instance in the Middle East and Central Asia for the United States, or in the Sahel for France. They show goodwill by siding with their protectors on contested issues. This is what political scientist Glenn Snyder called the “halo effect” of alliances.82

Reassurance is also **instrumental in reducing the risk** of a renationalization of defense policies. This was an acute concern in 1945 (when NATO was also about “keeping the Germans down”) and immediately after the Cold War. It also helps reduce the risk of nuclear proliferation, a long-standing US and global concern: extended nuclear deterrence **is widely considered the best way to discourage** an ally from embarking on developing a nuclear weapons program of their own. **Alliances also have a pacifying effect**: they damp the risk of open conflict among members. This, in turn, facilitates economic cooperation and growth—the best examples being the recovery of Europe, Japan, and South Korea after 1945.

US attitudes have also **led to consolidation of military ties** between its own allies and friends, either to diversify security portfolios or to hedge against US retrenchment—“internal hedging,” given that all the actors belong to the same US-led alliance system. This is the case for Gulf countries, for instance, or for the aforementioned Greece-France security partnership.

Finally, the reinforcement of defense arrangements may reflect the post-1990 maturation of regional organizations, as was the case in Europe and to a lesser extent in Africa.

Is the Expansion Stabilizing or Destabilizing?

There are well-known objections to the multiplication of alliances, including free-riding (hence the classic burden-sharing debate within NATO, for instance) and overextension (the risk of an alliance being able to credibly uphold all its commitments). Two timelier questions stand out at this particular moment in world history: is this thickening web of alliances good or bad for global stability, and does it increase or decrease the risk of war? While definitive judgments are impossible to make, arguments claiming that alliances are good for stability are convincing

Deterrence is an improbable proposition, but it **does seem to work**. Russia and China have **never openly attacked** territories clearly covered by Western security guarantees. By contrast, **they have invaded** or encroached upon nonprotected countries and disputed territories.

Alliances also contribute to keeping the peace internally. The protector power can play **a mediating role between allies**, as the United States sometimes does **between Greece and Turkey**, or between **Japan and South Korea.**

The defensive nature of modern alliances **provides stability and predictability** in the international system.83 Such alliances provide stability and predictability in the international system. There is solid academic evidence that such **alliances do reduce the risk of war**. 84 They are also less likely in themselves to produce a pushback from other countries (the “security dilemma”), especially **when they adopt unilateral confidence-building measures** aimed at reassuring a potential adversary that they have no aggressive designs against it. Moreover, defensive alliances often operate by consensus.85 For example, it is not certain how NATO, with its thirty members, could obtain consensus to a policy of aggression.86 Almost all defense commitments have significant caveats that are stabilizing.87 Most of the time, they do not compel allies to use military force, and where applicable they mention national restrictions such as “the constitutional provisions and processes” (US-Japan) or “the specific character of the security and defense policy of certain member States” (Treaty on European Union, or TEU88).

#### **Extinction!**

**Clare '23** [Stephen Clare; Effective Altruism Writer; June 2023; "Great power war"; 80000 Hours; https://80000hours.org/problem-profiles/great-power-conflict/; accessed 12-05-2024] leon

**A modern great power war could see nuclear weapons, bioweapons, autonomous weapons, and other destructive new technologies** deployed on an unprecedented scale.

It would probably be the most destructive event in history, shattering our world. **It could even threaten us with extinction**.

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We’ve come perilously close to just this kind of catastrophe before.¶ On October 27, 1962 — near the peak of the Cuban Missile Crisis — an American U-2 reconnaissance plane set out on a routine mission to the Arctic to collect data on Soviet nuclear tests. But, while flying near the North Pole, with the stars obscured by the northern lights, the pilot made a navigation error and strayed into Soviet airspace.1¶ Soviet commanders sent fighter jets to intercept the American plane. The jets were picked up by American radar operators and nuclear-armed F-102 fighters took off to protect the U-2.¶ Fortunately, the reconnaissance pilot realised his error with enough time to correct course before the Soviet and American fighters met. But the intrusion enraged Soviet Premier Nikita Khrushchev, who was already on high alert amidst the crisis in Cuba.¶ “What is this, a provocation?” Khrushchev wrote to US President John F. Kennedy. “One of your planes violates our frontier during this anxious time when everything has been put into combat readiness.”¶ If the U-2’s path had strayed further west, or the Soviet fighters had been fast enough to intercept it, this incident could have played out quite differently. Both the United States and the USSR had thousands of nuclear missiles ready to fire. Instead of a nearly-forgotten anecdote, the U-2 incident could have been a trigger for war, like the assassination of Franz Ferdinand.

<<LINE BREAKS CONTINUE>>

**Competition among the world’s most powerful countries shapes our world today**. And whether it’s through future incidents like the lost U-2, or something else entirely, **it’s plausible that it could escalate and lead to a major, devastating war**.

Is there anything you can do to help avoid such a terrible outcome? It is, of course, difficult to imagine how any one individual can hope to influence such world-historical events. **Even the most powerful world leaders often fail to predict the global consequences of their decisions**.

But I think **the likelihood and severity of great power war makes this among the most pressing problems of our time** — **and that some solutions could be impactful enough** that working on them may be one of the highest-impact things to do with your career.

By taking action, I **think we can create a future where the threat of great power war is a distant memory rather than an ever-present danger**.

Summary

**Economic growth and technological progress have bolstered the arsenals of the world’s most powerful countries**. That means the next war between them could be far worse than World War II, the deadliest conflict humanity has yet experienced.

Could such a war actually occur? **We can’t rule out the possibility**. **Technical accidents or diplomatic misunderstandings could spark a conflict that quickly escalates**. **Or international tension could cause leaders to decide they’re better off fighting than negotiating**.

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It seems hard to make progress on this problem. It’s also less neglected than some of the problems that we think are most pressing. There are certain issues, like making nuclear weapons or military artificial intelligence systems safer, which seem promising — although it may be more impactful to work on reducing risks from AI, bioweapons or nuclear weapons directly. You might also be able to reduce the chances of misunderstandings and miscalculations by developing expertise in one of the most important bilateral relationships (such as that between the United States and China).¶ Finally, by making conflict less likely, reducing competitive pressures on the development of dangerous technology, and improving international cooperation, you might be helping to reduce other risks, like the chance of future pandemics.¶ Our overall view¶ Recommended¶ Working on this issue seems to be among the best ways of improving the long-term future we know of, but all else equal, we think it’s less pressing than our highest priority areas (primarily because it seems less neglected and harder to solve).¶ Scale ¶ There’s a significant chance that a new great power war occurs this century.¶ Although the world’s most powerful countries haven’t fought directly since World War II, war has been a constant throughout human history. There have been numerous close calls, and several issues could cause diplomatic disputes in the years to come.¶ These considerations, along with forecasts and statistical models, lead me to think there’s about a one-in-three chance that a new great power war breaks out in roughly the next 30 years.¶ Few wars cause more than a million casualties and the next great power war would probably be smaller than that. However, there’s some chance it could escalate massively. Today the great powers have much larger economies, more powerful weapons, and bigger military budgets than they did in the past. An all-out war could kill far more people than even World War II, the worst war we’ve yet experienced.¶ Could it become an existentially threatening war — one that could cause human extinction or significantly damage the prospects of the long-term future? It’s very difficult to say. But my best current guess is that the chance of an existential catastrophe due to war in the next century is somewhere between 0.05% and 2%.¶ Neglectedness ¶ War is a lot less neglected than some of our other top problems. There are thousands of people in governments, think tanks, and universities already working on this problem. But some solutions or approaches remain neglected. One particularly promising approach is to develop expertise at the intersection of international conflict and another of our top problems. Experts who understand both geopolitical dynamics and risks from advanced artificial intelligence, for example, are sorely needed.¶ Solvability ¶ Reducing the risk of great power war seems very difficult. But there are specific technical problems that can be solved to make weapons systems safer or less likely to trigger catastrophic outcomes. And in the best case, working on this problem can have a leverage effect, making the development of several dangerous technologies safer by improving international cooperation and making them less likely to be deployed in war.¶ At the end of this profile, I suggest five issues which I’d be particularly excited to see people work on. These are:¶ Developing expertise in the riskiest bilateral relationships¶ Learning how to manage international crises quickly and effectively and ensuring the systems to do so are properly maintained¶ Doing research to improve particularly important foreign policies, like strategies for sanctions and deterrence¶ Improving how nuclear weapons and other weapons of mass destruction are governed at the international level¶ Improving how such weapons are controlled at the national level¶ Profile depth¶ In-depth ¶ This is one of many profiles we've written to help people find the most pressing problems they can solve with their careers. Learn more about how we compare different problems, see how we try to score them numerically, and see how this problem compares to the others we've considered so far.¶ Why might preventing great power war be an especially pressing problem?¶ A modern great power war — an all-out conflict between the world’s most powerful countries — could be the worst thing to ever happen to humanity.¶ Historically, such wars have been exceptionally destructive. Sixty-six million people died in World War II, likely the deadliest catastrophe humanity has experienced so far.¶ Since World War II, the global population and world economy have continued to grow, nuclear weapons have proliferated, and military technology has continued to advance. This means the next world war could be even worse, just as World War II was much deadlier than World War I.¶ It’s not guaranteed that such a war will break out. And if it does, it may not escalate to such a terrible extent. But the chance can’t be ignored. In fact, there are reasons to think that the odds of World War III breaking out this century are worryingly high.¶ A modern great power war would be devastating for people alive today. But its effects could also persist long into the future. That’s because there is a substantial chance that this century proves to be particularly important. Technologies with the potential to cause a global catastrophe or radically reshape society are likely to be invented. How we choose to develop and deploy them could impact huge numbers of our descendants. And these choices would be affected by the outcomes of a major war.¶ To be more specific, there are three main ways great power conflict could affect the long-term future:¶ High international tension could increase other risks. Great power tensions could make the world more dangerous even if they don’t lead to war. During the Cold War, for example, the United States and the USSR never came into direct conflict but invested in bioweapons research and built up nuclear arsenals. This dynamic could return, with tension between great powers fueling races to develop and build new weapons, raising the risk of a disaster even before shots are fired.¶ War could cause an existential catastrophe. If war does break out, it could escalate dramatically, with modern weapons (nuclear weapons, bioweapons, autonomous weapons, or other future technologies) deployed at unprecedented scale. The resulting destruction could irreparably damage humanity’s prospects.¶ War could reshape international institutions and power balances. While such a catastrophic war is possible, it seems extremely unlikely. But even a less deadly war, such as another conflict on the scale of World War II, could have very long-lasting effects. For example, it could reshape international institutions and the global balance of power. In a pivotal century, different institutional arrangements and geopolitical balances could cause humanity to follow different long-term trajectories.¶ The rest of this profile explores exactly how pressing a problem great power conflict is. In summary:¶ Great power relations have become more tense. (More.)¶ Partly as a result, a war is more likely than you might think. It’s reasonable to put the probability of such a conflict in the coming decades somewhere between 10% and 50%. (More.)¶ If war breaks out, it would probably be hard to control escalation. The chance that it would become large enough to be an existential risk cannot be dismissed. (More.)¶ This makes great power war one of the biggest threats our species currently faces. (More.)¶ It seems hard to make progress on solving such a difficult problem (more) — but there are many things you can try if you want to help (more).¶ International tension has risen and makes other problems worse¶ Imagine we had a thermometer-like device which, instead of measuring temperature, measured the level of international tension.2 This ‘tension metre’ would max out during periods of all-out global war, like World War II. And it would be relatively low when the great powers3 were peaceful and cooperative. For much of the post-Napoleonic 1800s, for example, the powerful European nations instituted the Concert of Europe and mostly upheld a continental peace. The years following the fall of the USSR also seem like a time of relative calm, when the tension metre would have been quite low.4¶ How much more worried would you be about the coming decades if you knew the tension metre would be very high than if you knew it would be low? Probably quite a lot. In the worst case, of course, the great powers could come into direct conflict. But even if it doesn’t lead to war, a high level of tension between great powers could accelerate the development of new strategic technologies, make it harder to solve global problems like climate change, and undermine international institutions.¶ During the Cold War, for instance, the United States and USSR avoided coming into direct conflict. But the tension metre would still have been pretty high. This led to some dangerous events:¶ A nuclear arms race. The number of nuclear warheads in the world grew from just 300 in 1950 to over 64,000 in 1986.¶ The development of new bioweapons. Despite signing the Biological Weapons Convention in 1972, the search for military advantages motivated Soviet decision makers to continue investing in bioweapon development for decades. Although never used in combat, biological agents were accidentally released from research facilities, resulting in dozens of deaths and threatening to cause a pandemic.5¶ Nuclear close calls. Military accidents and false alarms happened regularly, and top decision makers were more likely to interpret these events hostilely when tensions were high. On several occasions it seems the decision about whether or not to start a nuclear war came down to individuals acting under stress and with limited time.¶ This makes international tension an existential risk factor. It’s connected to a number of other problems, which means reducing the level of international tension would lower the total amount of existential risk we face.¶ The level of tension today¶ Recently, international tension seems to have once again been rising. To highlight some of the most salient examples:¶ China-United States relations have deteriorated, leading to harsh diplomatic rhetoric and protectionist trade policies that aim to reduce the countries’ economic interdependence.¶ Russia’s invasion of Ukraine has killed about a hundred thousand people so far, raised the risk of nuclear war, and sent United States-Russia relations to their lowest point since the Cold War.¶ Chinese and Indian soldiers fought deadly skirmishes along their countries’ disputed border in 2020–21.¶ These dynamics raise an important question: how much more dangerous is the world given this higher tension than it would be in a world of low tension?¶ I think the answer is quite a bit more dangerous — for several reasons. First, international tension seems likely to make technological progress more dangerous. There’s a good chance that, in the coming decades, humanity will make some major technological breakthroughs. We’ve discussed, for example, why one might worry about the effects of advanced artificial intelligence systems or biotechnology. The level of tension could strongly affect how these technologies are developed and governed. Tense relations could, for example, cause countries to neglect safety concerns in order to develop technology faster.6¶ Second, great power relations will strongly influence how nations do, or do not, cooperate to solve other global collective action problems. For example, in 2022, China withdrew from bilateral negotiations with the United States over climate action in protest of what it perceived as American diplomatic aggression in Taiwan. That same year, efforts to strengthen the Biological Weapons Convention were reportedly hampered by the Russian delegation after their country’s invasion of Ukraine raised tensions with the United States and other western countries.¶ And third, if relations deteriorate severely, the great powers could fight a war.¶ How likely is a war?¶ Wars are destructive and risky for all countries involved. Modern weapons, especially nuclear warheads, make starting a great power war today seem like a suicidal undertaking.¶ But factors like the prevalence of war throughout history, the chance that leaders make mistakes, conflicting ideologies, and commitment problems, make me think that conflict could break out anyway.¶ On balance, I think such an event is somewhat unlikely but hardly unthinkable. To quantify this: I put the chance we experience some kind of war between great powers before 2050 at about one-in-three.7¶ War has occurred regularly in the past¶ One reason to think a war is quite likely is that such conflicts have been so common in the past. Over the past 500 years, about two great power wars have occurred per century.8¶ Naively, this would mean that every year there’s a 2% chance such a war occurs, implying the chance of experiencing at least one great power war over the next 80 years — roughly until the end of the century — is about 80%.9¶ This is a very simple model. In reality, the risk is not constant over time and independent across years. But it shows that if past trends simply continue, the outcome is likely to be very bad.¶ Has great power war become less likely?¶ One of the most important criticisms of this model is that it assumes the risk is constant over time. Some researchers have argued instead that, especially since the end of World War II, major conflicts have become much less likely due to:¶ Nuclear deterrence: Nuclear weapons are so powerful and destructive that it’s just too costly for nuclear-armed countries to start wars against each other.10¶ Democratisation: Democracies have almost never gone to war against each other, perhaps because democracies are more interconnected and their leaders are under more public pressure to peacefully resolve disputes with each other.11 The proportion of countries that are democratic has increased from under 10% in 1945 to about 50% today.¶ Strong economic growth and global trade: Global economic growth accelerated following World War II and the value of global exports grew by a factor of almost 30 between 1950 and 2014. Since war disrupts economies and international trade, strong growth raises the costs of fighting.12¶ The spread of international institutions: Multilateral bodies like the United Nations General Assembly and Security Council promote diplomatic dialogue and facilitate coordination to punish transgressors.13¶ It is true that we are living through an unusually long period of great power peace. It’s been about 80 years since World War II. We just saw that a simple model using the historical frequency of great power wars suggests there was only a 20% chance of going that long without at least one more war breaking out. This is some evidence in favour of the idea that wars have become significantly less common.¶ At the same time, we shouldn’t feel too optimistic.¶ The numerous close calls during the Cold War suggest we were somewhat lucky to avoid a major war in that time. And a 20% chance of observing 80 years of peace is not that low.14 Structural changes might have dramatically reduced the likelihood of war. Or perhaps we’ve just been lucky. It could even be that technological advances have made war less likely to break out, but more deadly when it occurs, leaving the overall effect on the level of risk ambiguous. It just hasn’t been long enough to support a decisive view.15¶ So while the recent historical trend is somewhat encouraging, we don’t have nearly enough data to be confident that great power war is a thing of the past. To better predict the likelihood of future conflict, we should also consider distinctive features of our modern world.16¶ One might think that a modern great power war would simply be so destructive that no state leader would ever choose to start one. And some researchers do think that the destruction such a war would wreak globally makes it less likely to occur. But it would be hard to find anyone who claims this dynamic has driven the risk to zero.¶ First, a war could be started by accident.¶ Second, sometimes even prudent leaders may struggle to avoid a slide towards war.¶ We could blunder into war¶ An accidental war can occur if one side mistakes some event as an aggressive action by an adversary.¶ This happened several times during the Cold War. The earlier example of the wayward American reconnaissance plane shows how routine military exercises carry some escalation risk. Similarly, throughout history, nervous pilots and captains have caused serious incidents by attacking civilian planes and ships.17 Nuclear weapons allow for massive retaliatory strikes to be launched quickly — potentially too quickly to allow for such situations to be explained and de-escalated.¶ It is perhaps more likely, though, that an accidental war could be triggered by a technological malfunction. Faulty computers and satellites have previously triggered nuclear close calls. As monitoring systems have become more reliable, the rate at which such accidents have occurred has been going down. But it would be overconfident to think that technological malfunctions have become impossible.¶ Future technological changes will likely raise new challenges for nuclear weapon control. There may be pressure to integrate artificial intelligence systems into nuclear command and control to allow for faster data processing and decision making. And AI systems are known to behave unexpectedly when deployed in new environments.18¶ New technologies will also create new accident risks of their own, even if they’re not connected to nuclear weapon systems. Although these risks are hard to predict, they seem significant. I’ll say more about how such technologies — including AI, nuclear, biological, and autonomous weapons — are likely to increase war risks later.¶ Leaders could choose war¶ All that said, most wars have not started by accident. If another great power war does break out in the coming decades, it is more likely to be an intentional decision made by a national leader.¶ Explaining why someone might make such a costly, destructive, unpredictable, and risky decision has been called “the central puzzle about war.” It has motivated researchers to search for “rationalist” explanations for war. In his 2022 book Why We Fight, for example, economist Chris Blattman proposes five basic explanations: unchecked interests, intangible incentives, uncertainty, commitment problems, and misperceptions.19¶ Blattman's Five (Rationalist) Explanations for War¶ This section discusses how great power tensions may escalate to war in the next few decades. It focuses on three potential conflicts in particular: war between the US and China, between the US and Russia, and between China and India. These are discussed because each of these countries are among the world’s largest economies and military spenders, and seem particularly likely to fight. At the end, I briefly touch on other potential large conflicts.¶ Projected real GDP of the US, China, India and Russia according to a 2022 Goldman Sachs analysis Source: Author’s figure using data from: Kevin Daly and Tadas Gedminas, “Global Economics Paper The Path to 2075 — Slower Global Growth, But Convergence Remains Intact,” Global Economics Paper (Goldman Sachs, December 6, 2022), https://www.goldmansachs.com/intelligence/pages/gs-research/the-path-to-2075-slower-global-growth-but-convergence-remains-intact/report.pdf.¶ United States-China¶ The most worrying possibility is war between the United States and China. They are easily the world’s largest economies. They spend by far the most on their militaries. Their diplomatic relations are tense and have recently worsened. And their relationship has several of the characteristics that Blattman identifies as causes of war.¶ At the core of the United States-China relationship is a commitment problem.¶ China’s economy is growing faster than the United States’. By some metrics, it is already larger.20 If its differential growth continues, the gap will continue to widen between it and the United States. While economic power is not the sole determinant of military power, it is a key factor.21¶ The United States and China may be able to strike a fair deal today. But as China continues to grow faster, that deal may come to seem unbalanced. Historically, such commitment problems seem to have made these kinds of transition periods particularly dangerous.22¶ In practice, the United States and China may find it hard to agree on rules to guide their interactions, such as how to run international institutions or govern areas of the world where their interests overlap.¶ The most obvious issue which could tip the United States-China relationship from tension into war is a conflict over Taiwan. Taiwan’s location and technology industries are valuable for both great powers.¶ This issue is further complicated by intangible incentives.¶ For the United States, it is also a conflict over democratic ideals and the United States’ reputation for defending its allies.¶ For China, it is also a conflict about territorial integrity and addressing what are seen as past injustices.¶ Still, forecasts suggest that while a conflict is certainly possible, it is far from inevitable. As of 8 June 2023, one aggregated forecast23 gives a 17% chance of a United States-China war breaking out before 2035.24¶ A related aggregated forecast of the chance that at least 100 deaths occur in conflict between China and Taiwan by 2050 gives it, as of 8 June 2023, a much higher 68% chance of occurring.25¶ United States-Russia¶ Russia is the United States’ other major geopolitical rival.¶ Unlike China, Russia is not a rival in economic terms: even after adjusting for purchasing power, its economy is only about one-fifth the size of the United States’.¶ However, Russia devotes a substantial fraction of its economy to its military. Crucially, it has the world’s largest nuclear arsenal. And Russian leadership has shown a willingness to project power beyond their country’s borders.¶ Country Military spending in 2021 (2020 USD, PPP adjusted)¶ United States 801 billion¶ China 293 billion¶ India 76.6 billion¶ United Kingdom 68.4 billion¶ Russia 65.9 billion¶ Top five countries by estimated military spending, 2021. Source: SIPRI¶ Russia’s 2022 invasion of Ukraine demonstrated the dangers of renewed rivalry between Russia and the United States-led West. The war has already been hugely destructive: the largest war in Europe since World War II, with hundreds of thousands of casualties already and no end to the conflict in sight. And it could get much worse. Most notably, Russian officials have repeatedly refused to rule out the use of nuclear weapons.¶ Unchecked interests and intangible incentives are again at play here. Vladimir Putin leads a highly-centralised government. He has spoken about how his desire to rebuild Russia’s reputation played in his decision to invade Ukraine.¶ Given their ideological differences and history of rivalry, it is reasonable to expect that the United States and Russia will continue to experience dangerous disagreements in the future. As of 8 June 2023, an aggregated forecast gives a 20% chance that the United States and Russia will fight a war involving at least 1,000 battle deaths before 2050.¶ China-India¶ India is already the world’s third-largest economy. If national growth rates remain roughly constant, the size of the Indian economy will surpass that of the United States’ sometime this century. India also has nuclear weapons and is already the world’s third-largest military spender (albeit at a much lower level than China or the United States).¶ One reason to worry that China and India could fight a war is that they already dispute territory along their border. Countries that share a border, especially when it is disputed, are more likely to go to war than countries that do not. By one count, 88% of the wars that occurred between 1816 and 1980 began as wars between neighbours.26¶ In fact, China and India already fought a brief but violent border war in 1962. Deadly skirmishes have continued since, resulting in deaths as recently as 2020.¶ Forecasters agree that a China-India conflict seems relatively (though not absolutely) likely. An aggregated forecast gives a 19% chance of war before 2035.¶ Other dangerous conflicts¶ These three conflicts — United States-China, United States-Russia, and China-India — are not the only possible great power wars that could occur. Other potential conflicts could also pose existential risk, either because they drive dangerous arms races or see widespread deployment of dangerous weapons.¶ We should keep in mind India-Pakistan as a particularly likely conflict between nuclear-armed states and China-Russia as a potential, though unlikely, conflict between great powers with a disputed border and history of war. Plus, new great powers may emerge or current great powers may fade in the years to come.¶ While I think we should prioritise the three potential conflicts I’ve highlighted above, the future is highly uncertain. We should monitor geopolitical changes and be open to changing our priorities in the future.¶ Overall predictions¶ Below is a table listing relevant predictions from the forecasting platform Metaculus, including the number of predictions made, as of 10 March 2023. Note the different timescales and resolution criteria for each question; they may not be intuitively comparable.¶ Prediction Resolution criteria Number of predictions Metaculus prediction¶ World war by 2151 Either:¶ A war killing >0.5% of global population, involving >50% of countries totalling >50% of global population from at least 4 continents.¶ Or:¶ A war killing at least >1% of global population, involving >10% of countries totalling >25% of global population¶ 561 52%¶ World War III before 2050 Involving countries >30% of world GDP OR >50% of world population¶ AND¶ >10M deaths¶ 1640 20%¶ Global thermonuclear war by 2070 EITHER:¶ 3 countries each detonate at least 10 nuclear warheads of at least 10 kt yield outside of their territory¶ OR¶ 2 countries each detonate at least 50 nuclear warheads of at least 10 kt outside of their territory¶ 337 11%¶ When will be the next great power war? Any two of the top 10 nations by military spending are at war¶ “At war” definition:¶ EITHER¶ Formal declaration¶ OR¶ Territory occupied AND at least 250 casualties¶ OR¶ Media sources describe them as “at war”¶ 25th percentile: 2031¶ Median: 2048¶ 75th percentile: 2088¶ Never (not before 2200): 8%¶ No non-test nuclear detonations before 2035 No nuclear detonation other than controlled test¶ [Note the negation in the question. It resolves negatively if a warhead is detonated]¶ 321 69%¶ At least 1 nuclear detonation in war by 2050 Resolves according to credible media reports 476 31%¶ I have previously independently estimated the likelihood of seeing a World War III-like conflict this century. My calculation first adjusts historical base rates to allow for the possibility that major wars have become somewhat less likely, and uses the adjusted base rate to calculate the probability of seeing a war between now and 2100.¶ This method gives a 45% chance of seeing a major great power war in the next 77 years. If the probability is constant over time then the cumulative probability between now and 2050 would be 22%. This is aligned with the Metaculus predictions above.¶ We can also ask experts what they think. Unfortunately, there are surprisingly few expert predictions about the likelihood of major conflict. One survey was conducted by the Project for the Study of the 21st Century. The numbers were relatively aligned with the Metaculus forecasts, though slightly more pessimistic. However, it seems a mistake to put too much stock in this survey (see footnote).27¶ We now have at least a rough sense of a great power war’s probability. But how bad could it get if it occurred?¶ A new great power war could be devastating¶ At the time, the mechanised slaughter of World War I was a shocking step-change in the potential severity of warfare. But its severity was surpassed just 20 years later by the outbreak of World War II, which killed more than twice as many people.¶ A modern great power war could be even worse.¶ How bad have wars been in the past?¶ The graph below shows how common wars of various sizes are, according to the Correlates of War’s Interstate War dataset.28¶ The x-axis here represents war size in terms of the logarithm of the number of battle deaths. The y-axis represents the logarithm of the proportion of wars in the dataset that are at least that large.¶ Using logarithms means that each step to the right in the graph represents a war not one unit larger, but 10 times larger. And each step up represents a war that is not one unit more likely, but 10 times more likely.¶ Cumulative frequency distribution of severity of interstate wars, 1816-2007 Source: Author’s figure. See the data here. Data source: Correlates of War Interwar dataset, v4.029¶ What the graph shows is that wars have a heavy tail. Most wars remain relatively small. But a few escalate greatly and become much worse than average.¶ Of the 95 wars in the latest version of the database, the median battle death count is 8,000. But the heavy tail means the average is 334,000 battle deaths. And the worst war, World War II, had almost 17 million battle deaths.30¶ The number of battle deaths is only one way to measure the badness of wars. We could also consider the proportion of the population of the countries involved who were killed in battle. By this measure, the worst war since 1816 was not World War II. Instead, it’s the Paraguayan War of 1864–70. In that war, 30 soldiers died for every 1,000 citizens of the countries involved. It’s even worse if we also consider civilian deaths; while estimates are very uncertain, it’s plausible that about half of the men in Paraguay, or around a quarter of the entire population, was killed.31¶ What if instead we compared wars by the proportion of the global population killed? World War II is again the worst conflict since 1816 on this measure, having killed about 3% of the global population. Going further back in time, though, we can find worse wars. Ghengis Khan’s conquests likely killed about 9.5% of people in the world at the time.¶ The heavy tail means that some wars will be shockingly large.32 The scale of World War I and World War II took people by surprise, including the leaders who initiated it.¶ It’s also hard to know exactly how big wars could get. We haven’t seen many really large wars. So while we know there’s a heavy tail of potential outcomes, we don’t know what that tail looks like.¶ That said, there are a few reasons to think that wars much worse than World War II are possible:¶ We’re statistically unlikely to have brushed up against the end of the tail, even if the tail has an upper bound.¶ Other wars have been deadlier on a per-capita basis. So unless wars involving countries with larger populations are systematically less intense, we should expect to see more intense wars involving as many people as World War II.¶ Economic growth and technological progress are continually increasing humanity’s war-making capacity. This means that, once a war has started, we’re at greater risk of extremely bad outcomes than we were in the past.¶ So how bad could it get?¶ How bad could a modern great power war be?¶ Over time, two related factors have greatly increased humanity’s capacity to make war. 33¶ First, scientific progress has led to the invention of more powerful weapons and improved military efficiency.¶ Second, economic growth has allowed states to build larger armies and arsenals.¶ Since World War II, the world economy has grown by a factor of more than 10 in real terms; the number of nuclear weapons in the world has grown from basically none to more than 9,000, and we’ve invented drones, missiles, satellites, and advanced planes, ships, and submarines.¶ Ghengis Khan’s conquests killed about 10% of the world, but this took place over the course of two decades. Today that proportion may be killed in a matter of hours.¶ First, nuclear weapons could be used.¶ Today there are around 10,000 nuclear warheads globally.34 At the peak of nuclear competition between the United States and the USSR, though, there were 64,000. If arms control agreements break down and competition resurges among two or even three great powers, nuclear arsenals could expand. In fact, China’s arsenal is very likely to grow — though by how much remains uncertain.¶ Many of the nuclear weapons in the arsenals of the great powers today are at least 10 times more powerful than the atomic bombs used in World War II.35 Should these weapons be used, the consequences would be catastrophic.¶ Graph showing that early nuclear weapons are 1,000s of times more explosive than previous conventional explosives Source: AI Impacts, Effect of nuclear weapons on historic trends in explosives

<<LINE BREAKS CONTINUE>>

By any measure, **such a war would be by far the most destructive, dangerous event in human history, with the potential to cause billions of deaths**.

**The probability that it would, on its own, lead to humanity’s extinction or unrecoverable collapse, is contested**. But there seems to be some possibility — **whether through a famine caused by nuclear winter, or by reducing humanity’s resilience enough that something else, like a catastrophic pandemic, would be far more likely to reach extinction-levels** (read more in our problem profile on nuclear war).

### **Contention 2 is AI**

#### **Computing power is central to US’s victory in the AI Race.**

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The **Trump administration is well positioned to take advantage of the AI policies put in place by the Biden administration to ensure that the United States and its democratic allies win the global AI competition. But doing so will require more than just doubling down on** the United States’ technological edge. It will also necessitate partnering with the private sector to up the country’s AI offering, both at the frontier and in “good enough” AI, to **outcompete China** around the world. The Trump administration can either choose to lead in shaping the rapidly emerging AI future—or watch as this brave new world is built by Beijing.

TIPPING THE SCALES

**Leading AI labs such as Anthropic, Google DeepMind, and OpenAI partner with U.S. hyperscalers Amazon Web Services (AWS), Google Cloud, and Microsoft Azure to provide the computational resources (or “compute”) needed to train and run frontier AI** models, while Meta and xAI combine proprietary data centers with external cloud services. These data centers rely heavily on advanced semiconductors, particularly graphics processing units, known as GPUs. U.S. companies Nvidia and AMD originally designed and developed GPUs to render video game graphics, but AI labs found that they excel in performing the massive number of simultaneous calculations needed to train deep learning models. Amazon and Google have designed their own specialized chips in an effort to make AI workloads even more efficient.

**Progress in frontier AI has relied heavily on scaling compute and data. U.S. companies are banking on this trend continuing. Last year, Elon Musk’s xAI constructed its Colossus data center**, with 100,000 Nvidia H100 GPUs to train the company’s Grok models, in Memphis, Tennessee, and has raised $5 billion to increase the center’s cluster of GPUs tenfold. Other leading U.S. AI labs and hyperscalers are planning similarly massive data centers.

Emerging frontier models have challenged the maxim, common among AI technologists, that inference—using trained models to respond to queries, make predictions, and generate outputs based on new, unseen data—is less compute-intensive than training. **Frontier AI models have come to rely on “test-time” compute, in which a model dedicates more resources during inference to engage in chain-of-thought “reasoning” and improve performance on complex tasks. The proliferation of models with larger context windows (the amount of text a model holds in its memory) and a rapidly growing user base are further driving escalating demands for compute.**

Because compute is central to frontier AI, Washington has focused on restricting China’s access to advanced AI chips and chipmaking equipment. The Trump administration devised this “denial” strategy in 2018 and 2019, when the United States successfully pressured the Netherlands to block China’s acquisition of extreme ultraviolet lithography equipment, exceedingly complex machines critical in the creation of advanced semiconductors, made by the Dutch company ASML. Starting in October 2022, the Department of Commerce’s Bureau of Industry and Security (BIS) intensified these controls, initially restricting the sale of top GPUs, such as Nvidia’s A100 and H100 chips, along with other AI accelerators, to China. To extend the territorial reach of U.S. controls, the Biden administration also imposed a foreign direct product rule covering foreign-made items derived from U.S. semiconductor technology. A year later, the administration expanded the measures to cover advanced GPUs that had been only slightly modified to satisfy previous restrictions and, in December 2024, it added high-bandwidth memory chips, older immersion deep ultraviolet (DUV) lithography machines, and other critical chipmaking software and tools. Implementing these controls has required significant and sometimes contentious negotiations with U.S. allies, especially the Netherlands; Japan, home to equipment makers Tokyo Electron and Nikon; South Korea, home to semiconductor producers Samsung and SK Hynix; and Taiwan, home to the world-leading chipmaker Taiwan Semiconductor Manufacturing Company (TSMC).

Progress in frontier AI has relied heavily on scaling compute and data.

These restrictions have undeniably slowed China’s access to advanced chips and hindered its ability to produce substitutes. SMIC, China’s most prominent chipmaker, has used existing DUV machines to manufacture some advanced chip nodes for smartphones. It also reportedly produced Huawei’s Ascend 910 AI chips, which Huawei asserts match the performance of Nvidia’s widely used A100s. But domestically manufacturing such chips with older DUV machines is expensive, reduces yield, and undermines reliability. Moreover, Huawei’s supposedly SMIC-produced Ascend 910B chip sets actually contained chips produced by TSMC, which TSMC had unknowingly sold to a Huawei front, casting doubt on SMIC’s true capabilities. In November, BIS directed TSMC to end all sales of its most advanced AI chips to China and has since blacklisted Sophgo, the Huawei cutout.

Meanwhile, U.S. chip designers are pulling further ahead. Nvidia’s leading, TSMC-manufactured H100s and H200s and new Blackwell chips are substantially faster than China’s best. Experts generally assess China to be at least five years behind leading-edge chip producers, with export controls slowing Beijing’s catch-up effort.

**Nevertheless, the computing power gap has not stopped Chinese tech giants such as Alibaba and Tencent, and startups such as 01.AI, DeepSeek, Moonshot AI, and Zhipu AI, from releasing high-performing generative AI** models. Chinese firms have capitalized on data centers equipped with Nvidia chips before the United States’ imposition of export controls, used downgraded chips not covered by U.S. controls, and optimized software to maximize less capable hardware. Crucially, many successful Chinese AI models rely on open-source models already released by U.S. labs or use outputs from U.S. models for training.

Despite these achievements, **U.S. AI labs likely remain one or two years ahead at the frontier, especially since many not-yet-released models are closed-source and therefore harder for Chinese companies to emulate. And as long as scaling state-of-the-art computing power remains** vital for frontier AI progress, U.S. companies will expand their lead. As DeepSeek’s CEO Liang Wenfeng has acknowledged, China’s difficulties competing with U.S. AI firms boil down to Washington’s “bans on shipments of advanced chips.”

#### **Investing in the AI-Nuclear nexus is the only way to stay ahead of China.**

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The **U.S. is lagging behind in the industrial race, losing ground to China** in batteries, EVs, solar, wind, and critical minerals processing. Yet in **a**rtificial **i**ntelligence—perhaps the most transformative technology of our time—**America still ranks number one globally. Maintaining this lead, however, hinges on a critical factor: powering the massive data centers that drive AI development**.

While Europeans have pretty much admitted defeat with respect to innovations, as evidenced by the Draghi report and manifested in a recent industry exodus from the E.U. powerhouse, Germany, there's still a lot of fight left on the other side of the Atlantic. **The alliance between tech entrepreneurs and the energy industry could secure both economic prosperity and environmental sustainability—if executed strategically.**

Maintaining the **U.S. leadership position in AI requires clean firm power. This is where nuclear energy comes to play**. In fact, 2024 marks a monumental shift for nuclear —the start of a long-awaited renaissance. Three developments stand out: the commitment of 14 major banks to finance nuclear projects, the tech sector's initiative to reopen retired nuclear power plants, and the signing of the ADVANCE Act, which modified the Nuclear Regulatory Commission's mission.

This renaissance comes at a critical time, as our electric grid faces unprecedented transformation with a sustained 3% growth through 2035. Beyond load growth, we are also decarbonizing and retiring old generating capacity. While data centers will drive the most dramatic expansion—growing from single digits to 22% of consumption—other sectors will also see significant increases, with transportation accounting for 46% of electricity use, buildings 16%, and industry 15%. Meeting this surging demand—particularly from energy-intensive data centers—requires power sources that can **deliver both scale and reliability.**

**Nuclear power plants and new supercomputers are a perfect match. Operating Nvidia's AI chips may demand as much as 1 GW of power – exactly what a typical AP1000 nuclear reactor provides. While data centers could theoretically run on solar and wind, intermittency poses a fundamental challenge**. Ensuring sufficient renewable electricity would require overbuilding grid infrastructure by at least a factor of 4, perhaps higher, paired with utility-scale battery storage. During electricity shortfalls, residential customers – not data centers – would face potential blackouts. With 80% of global internet traffic flowing through servers in Northern Virginia, even brief disruptions would create billions in economic damage.

The **obvious alternative—natural gas power plants—faces its own insurmountable barrier**. Many tech companies have committed to sustainability goals, promising to match their loads both temporally and geographically – meaning they must use clean power at the exact time it is consumed and from the same region as their data centers. Running datacenters on natural gas long-term is not feasible due to the tech sectors' climate commitments, since carbon capture and storage remains too costly.

**Nuclear power emerges as the only scalable solution to meet these demands. Currently, the United States leads in installed nuclear capacity with 94 working reactors and nearly 100 GW of capacity. This needs to triple by 2050 to meet growing demand – hence the Department of Energy's plan for 200 GW of new nuclear capacity. However, China is positioned to take the lead soon, as the U.S. has largely stopped building new plants**. After 1996, only three new reactors were commissioned: Watts Bar 2 in TN (2015), Units 3 and 4 in Plant Vogtle in GA (2023-2024).

How can the U.S. deliver on its plans to build multiple nuclear plants per year until 2050? The nuclear industry has a saying: France has two kinds of nuclear reactors and a hundred kinds of cheese, while the U.S. has two kinds of cheese but about a hundred kinds of reactors. Building a string of first-of-a-kind nuclear reactors has eroded industrial expertise and inflated costs. While Georgia's Vogtle plant unit 3 faced initial delays and cost overruns, the next reactor proved significantly more economical – demonstrating clear learning-by-doing benefits. But focusing just on construction costs misses the bigger picture. Recent research suggests that current **LCOE calculations may be biasing policy decisions against nuclear power, as they do not account for systems costs**, capacity factors, and reliability benefits. The real economic story becomes clear when examining fully depreciated nuclear plants, which can produce electricity at remarkably competitive rates around $31 per MWh.

#### **Specifically, nuclear is the only solution for growing power demand from data centers.**

**Skidmore ’24** [Zachary; He is a senior Reporter - Energy and Sustainability, DatacenterDynamics; “DOE: Nuclear energy needs to triple by 2050, AI and data centers drive demand”; Published 10/7/24; Accessed 2/22/25; https://www.datacenterdynamics.com/en/news/doe-report-highlights-need-to-triple-nuclear-capacity-by-2050-due-to-ai-and-data-center-load-growth/] mnn

The US needs three times its current nuclear energy capacity to meet AI's growing power needs, a new report has warned.

The US Department of Energy (DOE) has published an updated version of its Pathways to Commercial Liftoff Advanced Nuclear report, warning that AI and data center load growth will require tripling nuclear capacity by 2050; from 100GW to 300GW.

The report highlights a significant **rise in electricity demand over the past year, following decades of stagnation. This surge, primarily driven by AI and data centers, has intensified interest in nuclear energy** due to its ability to provide 24/7 carbon-free power within a compact footprint.

The report highlights the increasing value of clean firm resources by companies with clean energy targets and high-reliability requirements.

For example, **Google’s projections for meeting decarbonization targets for its global data centers found that clean firm technologies (including advanced nuclear) would reduce costs by 40 percent** compared to only wind and solar with lithium-ion storage.

Additionally, the report argues that rather than replacing renewables, nuclear energy can act as a complementary technology with more variable renewable assets, especially in sectors such as the data center sector, where much of the demand is disproportionate for 24/7 electricity. This is made more apparent by the fact that when nuclear capacity has been retired, it has not been fully replaced with wind and solar, it has largely been replaced with natural gas.

**The report emphasizes that securing 5-10 deployments of a single reactor design of at least 1,000MW is crucial for commercial success**. Building multiple reactors of the same design is expected to lower construction costs through repetition and learning. The DOE suggests that value and cost control improve when large reactors are built in "fleet mode."

The **major barrier to nuclear development is cost overrun, and the report highlights several measures to overcome this issue. These include sharing costs across multiple units under construction, public/private partnerships on funding**, and ensuring on-budget delivery through improved cost estimating and implementing best project management practices.

Small Modular Reactors (SMRs) are seen as key players in filling the load gap for certain applications. The report contends that SMRs could be the right fit for certain applications, such as replacing retiring coal plants or smaller-scale data centers. However, to justify investment in manufacturing facilities, microreactor designers may require a committed order book of 30-50 reactors.

The DOE recently said there are 190 coal and ex-nuclear sites that could be powered up for new nuclear capacity, potentially offering up to 269GW.

**Data center operators have increasingly begun to target nuclear power as a means to acquire clean consistent power for their operations.**

#### **It’s the linchpin of conclusively winning the AI race.**

**Kimball ’25** [Spencer; He is an energy reporter for CNBC; “Google says U.S. is facing a power capacity crisis in AI race against China”; Published 2/12/25; Accessed 2/23/25; <https://www.cnbc.com/2025/02/12/google-says-us-faces-power-capacity-crisis-in-ai-race-against-china.html>] mnn

The **U.S. is facing a power capacity crisis as the tech sector invests in data centers to support** artificial intelligence, said Caroline Golin, an energy executive at Alphabet’s Google unit.

Golin said Google turned to nuclear power after realizing utilities were investing in natural gas to back up renewables.

Google announced an agreement last October to purchase power from small nuclear reactors made by Kairos Power.

**The U.S. is facing a power capacity crisis as the tech sector races against China to achieve dominance in artificial intelligence, an executive leading the energy strategy of Alphabet’s Google unit said this week**.

The emergence of China’s DeepSeek artificial intelligence firm sent the shares of major power companies tumbling in late January on speculation that its AI model is cheaper and more efficient. But Caroline Golin, Google’s global head of energy market development, said more power is needed now to keep up with Beijing.

“We are in a capacity crisis in this country right now, and we are in an AI race against China right now,” Golin told a conference hosted by the Nuclear Energy Institute in New York City on Tuesday.

Alphabet’s Google unit embarked four years ago on an ambitious goal to power its operations around the clock with carbon-free renewable energy, but the company faced a major obstacle that forced a turn toward nuclear power.

Google ran into a “very stark reality that we didn’t have enough capacity on the system to power our data centers in the short term and then potentially in the long term,” Golin said.

Google realized the deployment of renewables was potentially causing grid instability, and utilities were investing in carbon-emitting natural gas to back up the system, the executive said. Wind and particularly solar power have grown rapidly in the U.S., but their output depends on weather conditions.

“We learned the importance of the developing clean firm technologies,” Golin said. **“We recognized that nuclear was going to be part of the portfolio.”**

#### **China AI lead causes a laundry list of existential risks.**

**Kroenig ’21** [Matthew; Winter; professor of government and foreign service at Georgetown University and the director of the Scowcroft Strategy Initiative at the Atlantic Council; Strategic Studies Quarterly, “Will Emerging Technology Cause Nuclear War?: Bringing Geopolitics Back In,” Vol. 15, Issue 4] recut manan

How will states use such a newfound advantage? Technology rarely fundamentally changes the nature or objectives of states. More often, states use technology to advance **preexisting geopolitical aims**. Moreover, enhanced power can result in greater ambition. Given the geopolitical landscape described, it is likely the United States and its Allies and partners at the core [end page 66] of the international system will behave differently with new military technologies than will revisionist powers, such as Russia and China.

The spread of new technology to the United States and its Allies and partners would likely serve, on balance, to **reinforce the existing sources of stability** in the prevailing international system. At the end of the Cold War, the United States and its Allies and partners achieved a technological- military advantage over its great power rivals, with the US using its unipolar position to deepen and expand a rules-based system. They also employed their military dominance to counter perceived threats from rogue states and terrorist networks. The United States, its Allies, and partners did not, however, engage in military aggression against great power, nuclear-armed rivals or their allies.

In the future, these status quo powers are apt to use military advantages to reinforce their position in the international system and to deter attacks against Allies and partners in Europe and the Indo-Pacific. These states might also employ military power to deal with threats posed by **terrorist networks** or by regional revisionist powers such as **Iran** and **North Korea**. But it is extremely difficult to imagine scenarios in which Washington or its Allies or partners would use newfound military advantages provided by emerging technology to conduct an armed attack against Russia or China.

Similarly, **Moscow** and **Beijing** would likely use any newfound military strength to advance their preexisting **geopolitical aims**. Given their very different positions in the international system, however, these states are likely to employ new military technologies in ways that are **destabilizing**. These states have made clear their dissatisfaction with the existing international system and their desire to revise it. Both countries have ongoing border disputes with multiple neighboring countries.

If Moscow **developed** new military technologies and operational concepts that shifted the **balance of power** in its favor, it would likely use this advantage to pursue **revisionist aims**. If Moscow acquired a **newfound ability** to more **easily invade** and **occupy territory** in Eastern Europe, for example (or if Putin believed Russia had such a capability), it is more likely Russia would be tempted to engage in **aggression**.

Likewise, if China acquired an **enhanced ability** through new technology to **invade** and **occupy Taiwan** or contested islands in the **E**ast or **S**outh **C**hina **S**eas, Beijing’s leaders might also find this opportunity **tempting**. If new technology enhances either power’s anti-access, area-denial network, then its leaders may be more confident in their ability to achieve a **fait accompli** attack against a **neighbor** and then **block** a **US-led liberation**.

These are **precisely** the types of **shifts in the balance of power that can lead to war**. As mentioned previously, the predominant **scholarly theory** on the causes of war—**the bargaining model**—maintains that imperfect information on the **balance of power** and the **balance of resolve** and credible commitment problems result in **international conflict**.52 New technology can exacerbate these causal mechanisms by increasing **uncertainty** about, or causing rapid **shifts** in, the balance of power. Indeed as noted above, new military technology and the **development** of new **operational concepts** have shifted the balance of power and resulted in **military conflict** throughout history.

Some may argue emerging military technology is more likely to result in a new tech arms race than in conflict. This is possible. But Moscow and Beijing may come to believe (**correctly or not**) that new technology provides them a **usable** military **advantage** over the **U**nited **S**tates and its **Allies** and partners. In so doing, they may underestimate Washington.

If **Moscow** or **Beijing** attacked a vulnerable **US Ally** or **partner** in their near abroad, therefore, there would be a risk of major war with the potential for **nuclear escalation**. The United States has formal treaty commitments with several frontline states as well as an ambiguous defense obligation to Taiwan. If Russia or China were to attack these states, it is likely, or at least possible, that the United States would come to the defense of the victims. While many question the wisdom or credibility of America’s global commitments, it would be difficult for the United States to **simply back down**. Abandoning a treaty ally could cause fears that America’s global commitments would unravel. Any US president, therefore, would feel great pressure to come to an Ally’s defense and expel Russian or Chinese forces.

Once the United States and **Russia** or **China** are at war, there would be a risk of **nuclear escalation**. As noted previously, experts assess the greatest risk of nuclear war today does not come from a bolt-out-of-the-blue strike but from nuclear escalation in a **regional**, **conventional** conflict.53 Russian leaders may believe it is in their interest to use nuclear weapons early in a conflict with the United States and NATO.54 Russia possesses a large and diverse arsenal, including thousands of nonstrategic nuclear weapons, to support this nuclear strategy.

In the 2018 Nuclear Posture Review, Washington indicates it could retaliate against any Russian nuclear “de-escalation” strikes with limited nuclear strikes of its own using low-yield nuclear weapons.55 The purpose of US strategy is to deter Russian strikes. If **deterrence fails**, however, there is a clear pathway to nuclear war between the United States and Russia. As Henry Kissinger pointed out decades ago, there is **no guarantee** that, once begun, a **limited** nuclear war **stays limited**.56

There are similar risks of nuclear escalation in the event of a **US-China conflict**. China has traditionally possessed a relaxed nuclear posture with a small “lean and effective” deterrent and a formal “no first use” policy. But China is relying more on its **strategic forces**. It is projected to double—if not triple or **quadruple**—the size of its **nuclear arsenal** in the coming decade.57

Chinese experts have acknowledged there is a narrow range of contingencies in which China might use nuclear weapons first.58 As in the case of Russia, the US Nuclear Posture Review recognizes the possibility of limited Chinese nuclear attacks and also holds out the potential of a limited US reprisal with low-yield nuclear weapons as a deterrent.59 If the nuclear threshold is breached in a conflict between the United States and China, **the risk of nuclear exchange is real**.

In short, if a coming revolution in military affairs provides a real or perceived battlefield advantage for Russia or China, such a development raises the likelihood of **armed aggression against US regional allies**, **major power war**, and **an increased risk of nuclear escalation**.

Implications

Future scholarship should incorporate geopolitical conditions and the related foreign policy goals of the states in question when theorizing the effects of technology on international politics. Often scholars attempt to conceptualize the effects of weapons systems in isolation from the political context in which they are embedded.

Studies treat technology as disembodied from geopolitics and as exerting independent effects on the international system. But technology does not float freely. Technology is a tool different actors can use in different ways. Bakers and arsonists employ fire in their crafts to strikingly different ends. In the current international environment, Russia and China would tend to employ technology toward advancing revisionist aims. Technological advances in these countries are therefore much more likely to **disrupt the prevailing international order** and **nuclear strategic stability**.

This approach also suggests the potential threat new technology poses to nuclear strategic stability is **more pervasive** than previously understood. To undermine strategic stability, new technology need **not** directly impact strategic capabilities. Rather, **any** technology that promises to shift the local balance of power in Eastern Europe or the Indo-Pacific has the potential to **threaten nuclear strategic stability**.

This understanding of this issue leads to different policy prescriptions. If the technology itself is the problem, then it must be controlled and should not be allowed to spread to any states. In contrast, the framework outlined here suggests a different recommendation: preserve the prevailing balance of power in Europe and Asia. Technological change that, on balance, **reinforces** the prevailing international system should **strengthen** stability.

Leading democracies, therefore, should **increase investments in emerging tech**nology **to maintain a tech**nological **edge** over their adversaries. Export control and nonproliferation measures should be designed to deny emerging military technology to Russia and China. Arms control should be negotiated with the primary objective of sustaining the current international distribution of power. Making progress in these areas will be difficult. But the consequences of failure could be **shifts in the international balance of power**, **conflict among great powers**, and **an increased risk of nuclear war**.

#### **China cares zero about AI risks – if they take the lead on development, it magnifies every single reason AI could be dangerous and they’ll smother any risky developments or accidents which means no checks**

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China, by contrast, ranks as the most optimistic country in the world when it comes to AI, with nearly four out of five Chinese nationals professing faith in its benefits over its risks. Whereas the United States government and Silicon Valley are many years into a backlash against a “move fast and break things” mentality, China’s tech companies and government still pride themselves on embracing that ethos. Chinese technology leaders are enthusiastic about their government’s **willingness to live with AI risks** that, in the words of veteran AI expert and Chinese technology executive Kai-Fu Lee, would “scare away risk-sensitive American politicians.”

DISASTER AMNESIA

The disparity between Chinese and American perceptions of the hazards of AI—and their respective tech sectors’ willingness to take risks—is no accident. It is a result of Chinese policies that systematically suppress citizens’ experience of disasters to protect the government from public criticism.

In the United States, disasters tend to prompt an elevated public consciousness and enhanced safety measures as their heart-rending consequences ripple through the media and society—in machinery-intensive industries such as oil drilling, everyday food and drug production, and the processing of dangerous chemicals. Even now, legislators in Ohio are making progress on new safety regulations in the wake of a fiery train derailment in February that shot a plume of toxic chemicals above the town of East Palestine.

But in China, these types of accidents rarely reverberate through the media as the state maintains a chokehold on information to promote a constant atmosphere of stability. The Chinese Communist Party smothers information when disaster responses are mismanaged and routinely falsifies death tolls. The government sometimes refuses to acknowledge, let alone report on, vast tragedies such as the mass radiation poisoning that resulted from at least 40 nuclear tests conducted between 1964 and 1996, which led to the premature deaths of nearly 200,000 citizens.

The result is a culture of disaster amnesia in which it is often impossible for the public to demand change or for the government to be forced to learn from costly accidents. Little accountability for mistakes means that business owners tend to play fast and loose with safety, as evidenced by China’s grisly history of industrial accidents. Even the rare instances in which mishaps are publicly exposed lack the staying power that might result in serious reform. For example, the public outcry about mass-produced toxic toothpaste in 2007, poisoned infant milk formula in 2008, and the collision of high-speed trains near Wenzhou in 2011 prompted well-publicized displays of scapegoating and loudly proclaimed government reform plans but had limited impacts on public safety. The Chinese government often projects a facade of responsiveness but then buries information about the events, quite literally in the case of the now-underground remains of the Wenzhou train wreckage. Given that China has a far more restrictive media ecosystem under Xi Jinping than it did when these incidents occurred, public exposure is even less likely today.

With the worst run-ins with emerging technologies routinely excised from public consciousness, Chinese society exhibits a seemingly boundless sense of techno-optimism, especially toward new technologies such as AI. Given that China’s historic ascent from poverty went hand in hand with high-speed technological advancement, accelerated scientific research is practically synonymous with national progress in the Chinese zeitgeist—viewed as having few, if any, downsides.

To see this full-steam-ahead approach in action, look no further than He Jiankui, the Chinese scientist who shocked the world in 2018 by genetically modifying human embryos in secret to produce the world's first gene-edited babies. The doctor expected, and initially received, high praise in China for his feat, but the government clumsily pulled an about-face in response to international outrage over his unilateral decision to push humanity into uncharted territory. Unsurprisingly, further examination showed that He irreversibly botched his experiment, in what one geneticist called "a graphic demonstration of attempted gene editing gone awry.” He not only likely failed to make the modified babies (and their potential offspring) HIV-resistant as intended, but also potentially increased their susceptibility to influenza, cancer, and other diseases. After a stint in prison, He was released and continues his research, alongside new Chinese legislation providing loopholes for similar ethically fraught and potentially lucrative genetic experimentation.

UNBRIDLED AMBITION

Not only are experimental technologies seen as largely risk-free in China, but the country has also committed itself to a feverish sprint to become “the world’s premier artificial intelligence innovation center” by 2030.

China’s efforts to overtake the United States in AI have been a priority for the Communist Party since at least 2015, when Xi announced his “Made in China 2025” strategy. This emphasis on AI has since been reiterated in various national documents and speeches. AI has become a linchpin of China’s **military modernization** strategy and is increasingly **integral to** the country’s system of state **surveillance,** **repression**, and **control.** With so much at stake, it is no surprise that China’s government has been investing tens of billions of dollars annually into its AI sector and leveraging its vast espionage network to try to steal foreign corporate technology secrets.