# NDCA - Tech Aff

### Contention 1– Russia

#### Russian dominance in nuclear energy---vis-à-vis state-backed corporation “Rosatom”---uses leverage and capacity to fuel Putin’s war machine

Doggett 23 [Lloyd Doggett, member of the U.S. House of Representatives, "Russia’s Rosatom Fuels Putin’s War Machine," Foreign Policy, 3-20-2023, https://foreignpolicy.com/2024/04/09/russia-rosatom-nuclear-uranium-sanctions-war-putin-ukraine/]

Western sanctions against Moscow have so far failed to effectively curb Russian President Vladimir Putin’s ability to wage his illegal war against Ukraine. Much of the weakness of the sanctions regime centers on energy. One still unsanctioned but critical target should be the network of companies associated with Rosatom, Russia’s state-owned nuclear corporation, which continues to expand its reach despite the ongoing war. U.S. operators of nuclear power plants purchase approximately $1 billion in nuclear fuel from Rosatom annually—or about 20 percent of U.S. demand for enriched uranium. That number would likely be even higher, were it not for a cap on U.S. uranium imports from Russia imposed in 2020. Many U.S. allies also rely at least partially on Russian fuel. Because of this continued dependence, Rosatom has so far been exempt from any attempts to sanction Russia. Moscow clearly believes that Rosatom will continue to get a free pass and is now using the company as a Trojan horse to circumvent Western sanctions. According to Rosatom Director-General Alexey Likhachev, the company’s military contracting has grown significantly. In January 2023, the Washington Post published information obtained by Ukrainian intelligence detailing Rosatom’s involvement in supplying the military industry with components, equipment, and raw materials, including aluminum oxide for rocket fuel, chemical compounds for aviation and rocketry, lithium-ion batteries for tanks and air defense systems, and 3D-printing technologies. Evidence strongly suggests that Rosatom is a full-fledged and growing partner of the Russian military machine. Rosatom is also expanding its reach into other sectors, which allows the Kremlin to tighten state control over companies that can help circumvent restrictions. For example, Rosatom recently acquired Fesco, one of Russia’s largest shipping companies, which accepts payments from customers in Chinese yuan in order to avoid sanctions affecting U.S. dollar and euro transactions. In November 2023, Putin signed a decree transferring state-owned shares of Fesco to Rosatom, granting the nuclear giant control over an extensive array of assets, including terminal complexes across the country—in Novosibirsk, Khabarovsk, Tomsk, and Vladivostok—as well as 37 ships, more than 170,000 shipping containers, and 11,000 platforms for container transportation. Rosatom’s expansion has become a hallmark of its activities in recent years, helping Moscow to reroute trade from sanctioned companies and goods. Renera, Rosatom’s energy storage subsidiary, has acquired the machinery to assemble high-quality lithium-ion batteries using cells and modules imported from a South Korean plant, despite a ban on the export of modules from South Korea. Under the umbrella of unsanctioned Rosatom entities, it is much easier for Russia to acquire the necessary technology to strengthen Rosatom’s dominance in the global market. The Ukrainian think tank DiXi Group has compiled open-source data on Rosatom’s new assets, including companies such as Security Code, one of Russia’s largest developers of hardware and software for certified information protection; Tomsk MPE Ilmenite, a major producer of titanium and zirconium; and Kirov-Energomash, a large Russian manufacturer of industrial equipment. As Rosatom and its subsidiaries continue to diversify into sectors beyond the nuclear industry, the company has become an unsanctioned funnel for high-tech products, not to mention for additional revenues, to strengthen Putin’s war machine. These activities are particularly intensive relating to the production of weapons, as they allow Russia to obtain, for example, microchips and other electronic components that go into missiles, aircraft, battlefield communications, and other things that it needs to keep fighting. Meanwhile, Rosatom’s core business continues to expand, with nearly 20 new agreements and memorandums of cooperation signed in 2023, primarily focusing on Asian and African countries interested in affordable nuclear technologies. All nuclear power plant construction projects initiated since the start of Russia’s full-scale invasion of Ukraine in February 2022 are progressing successfully. Last month, media reported that the Akkuyu plant in Turkey is on schedule with its first unit over 90 percent ready; the extension of the Paks plant in Hungary has entered a new stage; another batch of equipment for the Kudankulam plant in India has been manufactured and shipped; and Rosatom has signed a contract to supply nuclear fuel components for a research facility in Egypt. All these relationships serve Russian strategic interests by maintaining its political influence and building dependencies in various parts of the globe. The further Rosatom intertwines itself with developing countries, the more it increases Russia’s international support, the easier it is for Moscow to bypass restrictions, and the harder it becomes for the United States and its allies to enact tougher, more comprehensive sanctions. What’s more, Rosatom is also working to advance its interests in key members of the sanctions coalition, France and Germany. The French company Framatome Advanced Nuclear Fuels still intends to use a Rosatom subsidiary’s license to globally produce nuclear fuel assemblies at a plant in Lingen, Germany. Nor should Washington ignore Rosatom’s cooperation with China and Iran to help develop their nuclear energy programs, where the extent to which Russian technology powers these countries’ nuclear weapons programs is unclear. By keeping silent as Russia circumvents sanctions and globally sources what it needs for its military, the United States and its partners are helping Moscow even as they support Kyiv. In Washington, congressional momentum is building for a ban on Russian uranium imports, which the House passed unanimously last year. Although there is general support for such a ban, the bill has been stalled in the U.S. Senate over an unrelated matter. While the Biden administration has imposed some sanctions on the Russian nuclear industry, the list of sanctioned entities includes only about 20 of the nearly 460 companies that make up the Rosatom conglomerate. Restraining Russia’s capabilities requires much more comprehensive action, such as automatic sanctions against all Rosatom assets acquired after Feb. 24, 2022; sanctions against Rosatom-linked research organizations in order to restrict Russia’s access to modern technologies; and working with the EU and G-7 to ensure that sanctions have the highest possible impact. Without further intervention, Rosatom’s dominance in the global market for nuclear power plants—where the company already supplies more than 70 percent of worldwide exports—will continue to provide Russia with an edge in funding its war and advancing its interests. U.S. President Joe Biden and Congress can also do much more to eliminate U.S. dependence on Russia for nuclear fuel. In 2022, the Inflation Reduction Act included $500 million for the Energy Department to advance uranium production in the United States to fuel a new generation of nuclear reactors. Last month, another $2.7 billion was allocated to fund U.S.-based uranium processing and enrichment. Sanctions are effective only if the United States, along with the G-7+ coalition, demonstrates unity, strength, and resilience. Closer trans-Atlantic cooperation can create opportunities to reduce dependence on Russia and increase pressure on Moscow. If Russia’s nuclear industry remains sanctions-free, it will not only undermine clear U.S. foreign-policy goals but also risk failure in U.S. efforts to support Ukraine’s essential fight for freedom.

#### Rosatom’s reach is global and dangerous – they empirically disregard safety and weaponize facilities

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Russia’s nuclear industry has been expanding globally with little scrutiny since its full-scale invasion of Ukraine. While Western nations have focused on hobbling Russia’s oil and gas revenues, Rosatom, its state-owned nuclear energy company, has been left to work unhindered. Western allies, after deepening their reliance on Rosatom over recent decades, have taken great care not to disrupt the flow of Russian atomic materials and services, even though the company is accused of complicity in war crimes, poses serious safety risks worldwide, and is fueling the war in Ukraine. Rosatom describes itself as a pioneer and leader in civil nuclear technology, but its outreach is much wider and more nefarious, as shown in a report published in February by DiXi Group, a Ukrainian energy think tank. This documents the company’s increased involvement in the provision of equipment for military purposes using a high-density core made from depleted uranium. Many of its activities might have gone under the radar if Rosatom had not unleashed international outrage by joining the Russian military effort at Ukraine’s Zaporizhzhia nuclear power plant, which it has used as a weapon to threaten Europe. Since occupying the plant — Europe’s largest — Rosatom has breached security protocols by allowing unauthorized personnel to operate it and turned a blind eye to irresponsible military behavior, such as placing landmines in restricted areas. It has also aided and abetted war crimes against Ukrainians by facilitating the transformation of a part of the facility into a torture chamber. But concerns about Rosatom’s disregard for nuclear safety extend much wider than Ukraine and have a long history. In the early 2000s, the company supplied a nuclear reactor with multiple safety deficiencies to Iran, and it is currently completing Turkey’s first atomic power plant in an area of high seismic risk, prompting the European Parliament to raise the alarm over the safety of the Mediterranean region. Equipment-related risks are aggravated by the fact that many of the power plants Rosatom is developing are located in countries with questionable safety standards. It is building 28 reactors with an installed capacity of 30 gigawatts in Africa, Asia and Latin America, boasting that it has $200bn in foreign orders for the next decade. With the exception of Hungary, which has recently signed an agreement with Rosatom for the expansion of its Paks nuclear power plant, European countries have been seeking to diversify away from the company since the full-scale invasion of Ukraine. Nevertheless, breaking Rosatom’s dominance is complex. The company and its subsidiaries control about 30% of the global market for enriched uranium, which is required to power commercial nuclear reactors, and around 20% of the 450 nuclear power plants around the world are Russian-designed. In the US alone, more than a fifth of the fuel used by its 93 nuclear reactors is supplied via enrichment contracts with Russian contractors, mainly Rosatom, while the EU has 18 reactors which until recently relied on Russian fuel. The February 2022 invasion caught Western countries unprepared. Many had relied on cheap supplies from Rosatom after high domestic production costs and low demand in the wake of the Fukushima nuclear disaster, which forced them to reduce or wind down their own enrichment operations.

#### And, domestic nuclear production is key to reduce Russian influence

Lorenzini 3-7 [Marina, 3-7-25, “The US can reduce Russia’s nuclear energy—and geopolitical—influence”, Atlantic Council, https://www.atlanticcouncil.org/blogs/energysource/the-us-can-reduce-russias-nuclear-energy-and-geopolitical-influence/]

As the second Donald Trump administration settles in, at least one energy priority will remain consistent: bipartisan efforts to position the US nuclear energy industry for a greater share in the global marketplace. In early February, Secretary Chris Wright emphasized Trump’s priority for the United States: to “lead the commercialization of affordable and abundant nuclear energy” amid surging global energy demand. This opportunity will lead not only to economic growth and improved energy security in the United States, but also the chance to reduce Russian influence on nuclear energy markets in Europe—and the geopolitical leverage it affords. For the past two decades, Russia has wielded its nuclear energy technologies—through its state-owned conglomerate Rosatom—as a strategic export to exert geopolitical leverage. Rosatom has been a dependable, cost-effective, and technically competent partner for stakeholders around the world, enabling its dominant market position. Substantial up-front project finance and loans have contributed to Rosatom’s international success. Bangladesh, Belarus, Egypt, Hungary, and Turkey have benefitted from multibillion-dollar loans from Russia’s State Bank for Development and Foreign Economic Affairs (Vnesheconombank). State sponsorship allows Rosatom to offer favorable loan terms—such as a 3 percent interest rate—that competitors cannot match. Meanwhile, any analogous form of concessional loans for infrastructure projects has not been a part of the development strategy among Rosatom’s competitors. However, some countries that previously embraced the vision of energy integration with Russia continue to shift investments away from Russian partners. Countries tied to Rosatom for their nuclear supplies are keen to diversify—if not extract themselves entirely—from energy dependence on Russia. Additionally, Vnesheconombank‘s SWIFT ban and US sanctions designation increases risks for loan recipients. The United States—and allies with nuclear industries such as France and South Korea—could further convert the commercial interest for non-Russian products into strategic wins by focusing on countries with Soviet-era reactors. Countries and utilities often cite project finance as the primary barrier for building, but the new political momentum in the United States could galvanize both sufficient funds and new models across the public and private sectors. Bulgaria seeks two new reactors at Soviet-era site Bulgaria’s Kozloduy nuclear power plant operates two Soviet-era VVER-1000 reactors which supply one third of the country’s electricity. But in February 2024, Bulgaria signed an intergovernmental agreement with the United States to contribute to Bulgaria’s civil nuclear program, including the design, construction, and commissioning of two Westinghouse AP-1000 reactors at Kozloduy at a cost of $14 billion. Bulgaria’s energy minister said that the two reactors will be built entirely with public funds: either the Bulgarian treasury or the state plant owner will finance up to 30 percent of the project costs, and a loan will cover the remaining costs. In early February, the Bulgarian energy minister met with officials from the US Export-Import Bank (EXIM) to advance a $8.6 billion (more than 60 percent of the estimated cost) letter of interest for the two new reactors. For the remaining amount, the Bulgarian treasury or Kozloduy’s owner has several options. Bulgaria may also have access to debt or equity financing from the world’s largest multilateral development lender, the European Investment Bank. Additionally, as the World Bank considers how to incorporate nuclear power into their offerings, any steps toward engagement would encourage other lenders to do the same. If further capital is required, Bulgaria—with its relatively healthy domestic economy—could issue dollar-denominated bonds to raise funds, or the Kozloduy owner could issue green bonds similar to Canada’s Bruce Power. Bulgaria’s ability—and that of any potential lenders—to overcome financing hurdles will determine the success of such agreements. But if the agreement leads to new nuclear power generation, it bodes well for similar economies to undertake new reactor builds. Soviet reactor reaches end of life in Armenia Russia dominates Armenia’s energy system, but Armenian foreign policy has shifted dramatically away from Moscow in the past year, in part due to the lack of Russian military assistance to Armenia when Azerbaijan seized Nagorno-Karabakh. The policy change will not immediately impact Armenia’s Soviet-era VVER-440 nuclear reactor at Metsamor, which has received several upgrades and lifetime extensions—the latest, with Rosatom’s support, will sustain the remaining operational reactor until 2036. However, preparations must be made in the coming years to: extend the operational lifetime (a highly unlikely outcome due to the reactor’s age); build new light-water reactors (whether from China, Russia, South Korea, or the United States); or invest in small modular reactors (SMRs). Armenia may seek to build an SMR rather than a traditional reactor due to limited financing options and low power consumption. To build a new reactor, Armenia might want to follow Romania’s blended model for financing its SMR deal with NuScale. The EXIM and US International Development Finance Corporation offered Romania tentative financial support totaling $4 billion. Public and private partners then formed a coalition of stakeholders from Japan, South Korea, the United Arab Emirates, and the United States to finance the SMR project up to $275 million. If further capital is needed, private financial institutions have also recently announced their plans to support the nuclear industry. Whether and when construction begins for the reactor in Romania will demonstrate feasibility, but so far, the financial structure has shown promise. A great nuclear power balance In partnership with allies, the United States should advance financial and commercial solutions to help countries dependent on Russian nuclear energy diversify their domestic power programs. The United States is well positioned to do so. Trump, and Biden before him, have supported nuclear energy domestically, which, in turn, can result in the export of US technologies and expertise. Strong bipartisan appropriations from multiple administrations will reinforce Trump’s vision and the domestic nuclear energy industry. In 2019, during Trump’s first administration, the Nuclear Energy Innovation and Modernization Act became law, paving the way for a streamlined advanced reactor licensing process. Under the Biden administration, the multibillion-dollar appropriations from the Infrastructure Investment and Jobs Act and the Inflation Reduction Act bolstered the US nuclear energy industry. Further, the 2023 Nuclear Fuel Security Act and the 2024 ADVANCE Act enjoyed bipartisan support on Capitol Hill. Building on these domestic advances, Trump’s embrace of financial vehicles, such as the EXIM Bank or DFC, that bridge public and private sectors, will facilitate investments in multi-billion dollar infrastructure projects outside of the United States and bolster US energy-related exports, including from its domestic nuclear energy industry. These factors bode well for the United States to substantially weaken Russia’s share of global nuclear markets and its geopolitical influence.

#### And this domestic investment would be enough to undermine Russia’s efforts

Stricker & Ruggiero 23 [Andrea Stricker [Nonproliferation and Biodefense Program Deputy Director And Research Fellow] and Anthony Ruggiero [Nonproliferation And Biodefense Program Senior Adjunct Fellow], "Ending Global Reliance On Russia’S Nuclear Energy Sector," FDD, 2-3-2023, https://www.fdd.org/analysis/2023/02/03/ending-global-reliance-on-russias-nuclear-energy-sector]

Several countries could readily provide the mined and milled uranium that Russia supplies today: Australia, Canada, Kazakhstan, Namibia, Niger, Tanzania, Uzbekistan, and eventually the United States. For converted uranium, France, Canada, and Japan could begin to serve as suppliers and ramp up production over the course of a few years to replace Russian supplies. Eventually, the United States could as well. In addition, France, Urenco, Urenco USA, and soon other services in the United States could, over the course of several years, supply the enriched uranium fuel that Rosatom provides today. To meet more immediate HALEU needs, the United States is considering down-blending, or making available in a lower purity, its large stock of atomic weapons-grade uranium for HALEU production until enrichment services can meet this demand. Washington and Europe would need to assist the International Atomic Energy Agency’s international low-enriched uranium fuel bank in Kazakhstan, which relies in great part on Russian fuel, to mitigate shortages through supply from alternative sources. The imposition of sanctions on Rosatom will necessitate new sources for this fuel bank. The United States should also resist the urge to rely on Chinese supplies, as this would mean replacing one problem with another. To encourage new suppliers to enter the marketplace, Washington and its allies will have to make clear they seek a permanent decoupling from the Russian nuclear industry. A study by Columbia University’s Center on Global Energy Policy underscored the positive effect of market guidance for the nuclear fuel sector: “mining, conversion, and enrichment suppliers in the West will be looking to national governments to provide clear policies before they invest money in new facilities and capabilities. Their worry will be that in a year or two — perhaps less — Russian uranium products will be allowed back into national markets and will undercut them, causing them to lose out on their investments.”69

#### And, Rosatom is key to Russian power projection

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As a leading actor in the global nuclear sector, Russia’s state company Rosatom offers a highly relevant case study to analyse dependencies in civilian nuclear power and the evolving nature of the international nuclear sector. Rosatom is a vertically integrated corporation controlling either directly or via subsidiaries the full cycle of competences in the Russian nuclear industry, from uranium mining to the construction and operation of nuclear power plants, including processing and storage of spent fuel.2 Following its establishment in 2007, Rosatom has enjoyed a unique revival and expansion thanks to domestic political choices and economic support, a growing number of international clients and decreasing competition from the Western nuclear industry. Financial and diplomatic support from the Russian state, together with flexible and comprehensive business offers to customers, have enabled the company to acquire a large foreign portfolio (Szulecki and Overland 2023). The institutional set-up of Rosatom and the strong financial support it has received from the state thus far make it a textbook case of the realist understanding of energy politics. The Russian state retains control of the strategic nuclear sector and can potentially exploit its international ramifications to pursue foreign policy goals. Rosatom’s foreign activities receive full support by the Russian government, including during bilateral meetings between representatives of the partner country and the Russian president or senior members of government. Cooperation on the peaceful use of nuclear energy is included in the agenda of such meetings, mentioned in public speeches and sometimes codified in memoranda of understanding. When cooperation is at an advanced stage, the Russian president or senior Russian government members attend official ceremonies with their foreign counterparts and celebrate landmarks in the construction of new projects (Schepers 2019, 4–5). Moreover, Rosatom plays an important role for Russia’s international prestige and status, notably its claim to be a great power, beyond the domains of military force and fossil fuel geopolitics. Nuclear technology is one of the few high-tech sectors, where Russia is a world leader. Rosatom is investing in the development of new reactor technologies, most notably safe plants using fast neutron reactors, MOX (a blend of oxides of plutonium and uranium) and a closed fuel cycle, which would allow eliminating the production of radioactive waste from power generation. Currently, Russia is the main viable commercial supplier of high-assay, low-enriched uranium (with 5–20% concentration of the isotope U-235, instead of the 3–5% concentration that fuels the existing feet of light water reactors), which will be needed to power the new generation of advanced reactors (Lorenzini and Giovannini 2022). Besides Russia, only China has the infrastructure to produce HALEU at scale, whereas in the United States production started with a pilot project in November 2023 (US Department of Energy 2023). Hence, following a realist approach, Rosatom is an important element of Russia’s great power status and international influence. Considerations concerning financial profits seem to play a secondary role in its functioning, as highlighted by the fact that the company receives considerable state subsidies. Moreover, plans to increase electricity generation from nuclear massively—as specified in Russia’s Energy Strategy to 2035—are unlikely to be achieved without substantial government intervention (IAEA 2021; Mitrova and Yermakov 2019, 37).3 At the same time, keeping to a realist reading, the Russian nuclear sector has an important vulnerability: it needs to import . natural uranium from abroadRussia uses approximately 5,500 tons of natural uranium per year, but its domestic production has oscillated between 2870 and 3560 tons since 2004 (World Nuclear Association 2021). Moreover, domestic production is only a fifth of Rosatom’s needs if its requirements to fulfill export contracts of enriched uranium are considered (Meyer 2023, 5). While, Russia has substantial resources of natural uranium, extraction from remote locations make imports from abroad cheaper. Therefore, Rosatom has chosen to import part of its requirements from abroad, mostly from Kazakhstan, where its subsidiary Uranium One set up joint ventures with or acquired stakes from its Kazakh counterparts (Siddi and Silvan 2023). If Russia were to act fully in accordance with a realist script, it would prioritise domestic sourcing of natural uranium despite higher costs in order to avoid vulnerability to external supply shocks. Russian imports of Kazakh uranium show that Russia is in the position of leading global supplier only in two of the three identified main stages of the nuclear supply chain, namely uranium enrichment (and conversion) and the export of reactors and related services. We now turn to these two stages more in detail to assess whether and how Rosatom’s actorness reflects realist or liberal paradigms.

#### Russian expansionism ensures extinction from great power war, poverty, disease, and environmental destruction.

Harari 22 [Dr. Yuval Noah PhD from the University of Oxford, Professor in the Department of History in the Hebrew University of Jerusalem, “The End of the New Peace”, https://www.theatlantic.com/ideas/archive/2022/12/putin-russian-ukraine-war-global-peace/672385/]

If Putin’s gamble **succeeds**, the result will be the **final collapse of the global order** and of the New Peace. **Autocrats around the world** will learn that **wars of conquest** are again possible, and **democracies**, too, will be **forced to** **militarize** themselves for protection. We’ve already seen Russian aggression prompt countries such as Germany to sharply increase their defense budget overnight, and countries such as Sweden to reinstate conscription. The money that should go to teachers, nurses, and social workers will instead go to tanks, missiles, and cyberweapons. At 18, young people all over the world will do their mandatory military service. **The** **whole world will look like Russia**—a country with an oversize army and understaffed hospitals. A new era of **war**, **poverty**, and **disease** will result. **Alternatively**, if Putin is **stopped** **and punished**, the global order **won’t be broken** by what he did—it will be **strengthened**. Anyone who needed a **reminder** would rediscover that **you just cannot do these things.** Which of these two scenarios will materialize? Luckily for everyone, despite his military preparations, Putin was disastrously unprepared for one crucial thing: the courage of the Ukrainian people. The Ukrainians have pushed back the Russians in a series of stunning victories near Kyiv, Kharkiv, and Kherson. But Putin has so far refused to acknowledge his mistake, and he reacts to defeat with increased brutality. Seeing that his army cannot overcome the Ukrainian soldiers on the front line, Putin is now trying to freeze the Ukrainian civilians to death in their homes. Predicting how the war will end is impossible, as is the fate of the New Peace. History is never deterministic. After the end of the Cold War, many people thought that peace was inevitable, and that it would continue even if we neglected the global order. After Russia invaded Ukraine, some swung to the opposite view. They claimed that peace had always been just an illusion, that war was an ungovernable force of nature, and that the only choice humans had was whether they wanted to be prey or predator. Both positions are wrong. War and peace are decisions, not inevitabilities. Wars are made by people, not by a law of nature. And just as humans make wars, humans can also make peace. But to make peace is not a one-off decision. It’s a long-term effort to protect universal norms and values, and to build cooperative institutions. Rebuilding the global order doesn’t mean going back to the system that disintegrated in the 2010s. A new and better global order should give more important roles to non-Western powers that are willing to be part of it. It should also recognize the salience of national loyalties. The global order disintegrated above all because of the assault of populist forces, which argued that patriotic loyalties contradict global cooperation. Populist politicians preached that if you are a patriot, you must oppose global institutions and global cooperation. But there is no inherent contradiction between patriotism and globalism, because patriotism isn’t about hating foreigners. Patriotism is about loving your compatriots. And in the 21st century, **if you want to protect** **your compatriots** from **war**, **pandemic**, and **ecological collapse**, the best way to do that is by **cooperating** with foreigners.

### Contention 2– Grid

**US electricity is reliant on gas power plants---it’s bound to collapse due to extreme weather. Diversifying resources that power the grid is key to resilience and reliability.**

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While the scale of the five **storms** and their impacts **varied** widely, the energy system **failures** were **very similar** across them. A key commonality among all five was that gas plants accounted, by far, for the largest source of generating capacity knocked offline. The cumulative **gas** plant capacity that **failed** during each event was **more than twice** that of the **second**-most-impacted category of capacity (Figure 1). Each storm exposed vulnerabilities of both the gas plant fleet within affected regions and the gas infrastructure that delivered fuel to those plants. The US gas infrastructure system can be grouped into three primary components: production, transportation and storage, and end use, with power plants being the largest group of end users in terms of gas consumed (EIA 2023c). Extreme winter storms can affect all three components, potentially **compound**ing the strain on **gas plants** and forcing many of them to **fail** at the same time. The power and gas systems’ mutual dependence on each other has exacerbated these so-called correlated outages, but these plant failures can also be attributed to the sheer amount of area affected by the weather events in question. The **events** have exposed gas plants and gas infrastructure across large geographic areas to extremely **low temperatures**. Many facilities were unprepared and ill-designed for the low temperatures (Hilbert and Hallai 2021; FERC 2019). Even facilities that were prepared on paper often failed when an extreme storm hit (FERC 2021; FERC 2023). SEVERE WEATHER DIRECTLY IMPACTS GAS PLANTS A primary **cause** of gas plant **failures** is the direct impact of **extreme cold** weather on plant operations and equipment. Across all generator types, the top direct causes of plant outages in each of the major winter storm events related to equipment freezing, as well as to a second category labeled “mechanical/electrical” (FERC 2023). Equipment freezing is often caused by the freezing of particular components, including valves, water lines, inlet air systems, and sensing lines. Mechanical/electrical are non-freezing issues that occur when cold temperatures affect certain plant components. These issues include wiring failure, mechanical wear of valves, and embrittlement of flexible seal materials like rubber and silicone. A troubling pattern in the more **recent failures**, which were largely of gas plants, is that they generally took place when temperatures were **above** the plants’ minimum ambient **temperature** ratings.4 Across fuel types, 81 percent of the freeze-related outages during Winter Storm Uri in 2021 occurred when the temperature was above the generating unit’s minimum ambient temperature rating; that figure was more than 75 percent for Winter Storm Elliott in 2022 (FERC 2021; FERC 2023). SEVERE WEATHER JEOPARDIZES FUEL SUPPLIES Issues related to fuel supply are the second significant cause of lost gas capacity during extremely cold weather. Unlike other thermal power plant types, such as coal or nuclear plants, gas plants generally do **not store** their fuel **on site**. Instead, they **depend** on the real-time **delivery** of gas via pipeline, burning it upon delivery to produce electricity. This distinct characteristic leaves gas plants vulnerable to running out of fuel, since extreme cold weather can **interrupt** both the **production** and the **transportation** of gas. All five storm events involved gas-supply issues (FERC 2021; FERC 2023). The significant drops in gas production during the 2011, 2021, and 2022 storms arose largely due to such issues as “freeze-offs” as liquids in the gas wells, wellheads, and ancillary equipment froze up and blocked the flow of gas.5 During the 2022 event, gas production in the Marcellus and Utica shale formations in the Appalachian Basin dropped by 23 and 54 percent, respectively (FERC 2023). Production dropped even more during Winter Storm Uri in 2021: Texas experienced a 70 percent decrease and the lower 48 states saw an overall 28 percent decrease (FERC 2021). Gas supply issues can also arise even if production does not decrease. The 2014 and 2018 events did not cause significant drops in production even though fuel supply issues arose. In part, these occurred due to pressure drops and other physical issues affecting gas pipelines, but they also resulted from high coincident gas demand from non-power plant end users, such as homes and businesses trying to keep temperatures up. To save money, many gas plant owners choose to sign only “non-firm” or “interruptible” contracts for at least some of their fuel supply and transportation. The contracts of “firm” or “non-interruptible” customers, such as those in the residential sector, are fulfilled before non-firm customers, leaving less gas available to power plants during cold snaps as demand soars for residential heating. Even firm contracts to supply or transport fuel do not give a gas plant a guarantee that it can get fuel if a winter storm is severe enough. During Winter Storm Elliott in 2022, failed gas deliveries under firm fuel supply and/or transportation contracts led to 16.5 GW of cumulative losses of gas plant capacity. This was even more than the 14 GW of capacity lost due to failures to fulfill gas deliveries under non-firm transportation contracts (FERC 2023).6 The mutual **dependence** of the power and gas systems also presents a **vulnerability** with its potential to create a **feedback loop** of failures. Gas plants need fuel to produce electricity, and the gas system needs electricity to supply the fuel. Rolling blackouts can hit **gas production** and processing facilities, **constraining** the amount of fuel supplied to the country’s primary source of electricity, causing **more** rolling blackouts, and so on. FERC estimated that power losses caused 23.5 percent of the gas production drop during Winter Storm Uri (FERC 2021).7 Summer Also Threatens Gas Reliability Extreme summer weather can also pose significant threats to gas plants, even if these are typically less severe than those posed by extreme winter weather. **Heat** waves, droughts, hurricanes, and **floods** can all **affect gas** plants, with heat waves and droughts having the most significant impact. HEAT CAN FORCE POWER PLANT DERATES AND OUTAGES High temperatures can reduce both the efficiency and the maximum generating capacity of gas plants. High ambient air temperatures decrease the maximum generating capacity of gas plants by reducing the amount of fuel they can burn. In addition, gas plants require cooling; as the coolant (water or air) gets hotter, plants are less able to dissipate waste heat. As a result, they operate at lower power (Dumas, KC, and Cunliff 2019). Across all types of generation, extreme heat increases the likelihood of power plant output reductions (or “derates”) and forced outages (NERC 2023). In summer, high temperatures and prolonged operations often occur simultaneously as heatwaves lead to higher electricity demand; the combination can cause unexpected plant breakdowns. For example, many California gas plants were forced offline or significantly derated over the course of a 10-day heatwave in September 2022 (Regenerate California 2023). DROUGHT CAN HAMSTRING WATER-DEPENDENT POWER PLANTS Because many plants use water for cooling, a shortage of cooling water during extreme summer weather can also affect the gas fleet (EIA 2018). In fact, water shortages can force water-dependent plants to shut down entirely. For example, Texas experienced its second-worst drought in the state’s history between 2010 and 2015. As a result, one plant operator took three gas plant units, totaling 403 MW, offline for almost a year until rain replenished the reservoir from which they pulled cooling water (ERCOT 2016). Since then, Texas’s grid operator, ERCOT, has published drought risk analyses that have repeatedly classified more than 10,000 MW of gas plant capacity as at risk over the following 18 months (ERCOT 2023). As the impacts of climate change intensify and lead to more frequent and more severe weather events, the risks that drought poses to the gas fleet may increase significantly. For example, a recent analysis found that under a high-emissions climate scenario, the most severe drought could disrupt 20 percent of ERCOT’s thermal generation in Texas. The results were mixed when the same study looked at whether climate change could lead to an increase in thermal-generation disruptions in the state due to drought (Turner et al. 2021). A Reassessment of Gas Plants’ Contributions to Grid Reliability Is Overdue **Extreme weather** events, in both winter and summer, illustrate the **fragility** of **gas** plants. They also highlight the clear need to **reevaluate** the **assumed** contributions of these resources to **grid reliability**. For far too long, programs to ensure the ability of electricity supplies to meet customer demand (often referred to as “resource adequacy”) have overvalued the reliability contributions of gas plants. The methods used to evaluate resource adequacy can have multiple implications. First, the chosen method directly determines the contribution of existing resources, using the result to inform how much the owner of the resource gets compensated for that contribution. Second, when utilities and regulators make decisions about new resource investments, resource adequacy can be a major factor tipping the scales in favor of certain resource types. Finally, and most important, overestimating the contributions of certain resource types can ultimately lead to power outages. This has been the case especially for gas plants, which **failed** at an **unprecedented scale** during recent extreme winter storms.

#### And, commercial investment in nuclear energy increases opportunity to meet increasing demand

Ferrechio 4/2 [Susan, 4-2-25, Next-gen nuclear reactors poised for surge in U.S. power grid, https://www.washingtontimes.com/news/2025/apr/2/next-gen-nuclear-reactors-poised-surge-us-power-grid/]

A manufacturing plant in Texas plans to power its production with an advanced nuclear reactor instead of natural gas, advancing the Trump administration’s push to unleash commercial nuclear power in the U.S. When completed, the nation’s first grid-scale advanced nuclear reactor will power a 4,700-acre facility that produces plastics and other materials used in dozens of products. Dow Chemical and the nuclear energy engineering firm X-energy submitted a construction permit this week to the federal government for a small modular reactor, or SMR, at Dow’s Seadrift, Texas, manufacturing site. The reactor will replace an aging natural gas plant and eliminate nearly all greenhouse gas emissions. The permit is the first step in an anticipated resurgence in nuclear power. Mr. Trump initiated the nuclear power comeback during his first administration, and nuclear power is now set to skyrocket as the president seeks to rebuild the U.S. manufacturing base and establish the nation as a global leader in artificial intelligence. X-energy CEO J. Clay Sell said the Dow project “will demonstrate how the technology deployed at Seadrift, Texas, can be quickly and efficiently replicated to meet incredible power demand growth across America.” Enabling commercial nuclear power projects is a top priority of the Energy Department. Secretary Chris Wright announced in February that the department would “work diligently and creatively to enable the rapid deployment and export of next-generation nuclear technology.” He is following orders from Mr. Trump, who, just days into his second administration, said he would use an emergency declaration to expedite the building of plants needed to provide energy to artificial intelligence data centers. The president said the plants can use any source of power, including coal, but SMRs are poised to play a pivotal role. The technology has been in development for years but has never been deployed in the U.S. A handful of SMR plants are running in Russia and China. Under the Trump administration’s pro-nuclear energy policies, SMR plants are poised to advance rapidly. SMR plants are smaller than traditional water-cooled nuclear power plants and can be built quicker and cheaper. SMRs can use a variety of coolants, so they do not need to be positioned near large water sources. They produce about a third of the energy of a traditional nuclear reactor. The multiple modules SMRs allow the plants to conduct maintenance without shutting down entirely, as is required with large-scale nuclear power facilities. Mr. Trump has been promoting SMR technology since his first term and promised during his 2024 campaign to get SMR plants up and running. “These can be built ultra-safe. They are ultra-clean, and they’re very low-cost. But they are absolutely safe,” he told voters in York, Pennsylvania, in August. Big Tech companies have started investing significantly in the plants, hoping they will provide clean energy to power AI technology. In October, Google touted “the world’s first corporate agreement” with Kairos Power to deploy multiple SMRs in the U.S. beginning in 2030 to provide electricity to Google data centers. The tech giant said the deal accelerates the advancement of clean, round-the-clock energy needed for power-hungry AI. Days after Google’s announcement, Amazon said it would invest $500 million in three SMR projects that will power its data centers and provide electricity for homes and businesses. Amazon’s investments include support for a 320-megawatt X-energy project with the regional utility Energy Northwest in Washington state. Amazon’s agreement with X-energy pledges to bring 5 gigawatts into the power grid by 2039, which would become the largest commercial deployment of SMR technology. Other investors include Citadel CEO Kenneth C. Griffin. Construction of the Dow Seadrift project is expected to begin next year and be completed by the end of the decade. The energy-intensive plant manufactures plastic products such as food containers and drip irrigation tubing. It also manufactures glycols used in antifreeze, polyester fabrics and bottles. “What attracted them to X-energy was that our plant configuration is four modules that produce about 320 megawatts,” said Carol Lane, X-energy’s vice president of government affairs. “It gives very, very high reliability, which is something that the data centers and AI centers really care about.” Energy demand in the U.S. is forecast to increase by nearly 16% by 2029, according to GridStrategies, a clean-power consulting firm. “We are looking at the highest growth in electricity in maybe 30 or 40 years or longer,” Ms. Lane said. “We think these small reactors have a smaller footprint and have a much higher energy density you’ll be able to deploy many of them around the country.” The Seadrift project is set to become one of the nation’s first operational small modular reactors. The X-energy project planned for Dow’s Seadrift facility will use helium gas in the reactor core to cool billions of uranium-filled pebbles. The gas flows over the pebbles, heats up to nearly 1,000 degrees Fahrenheit and flows to a steam generator that will power the manufacturing plant. Kairos Power’s technology, which will provide electricity to Google data centers, will use a molten-salt cooling system to heat a steam turbine that generates power. The uptick in SMR projects follows the spectacular failure of Oregon-based NuScale Power’s six-reactor project at the Idaho National Laboratory. Mr. Trump’s first administration agreed to fund up to $1.4 billion for the project, which by 2029 was supposed to be generating enough electricity to power 300,000 homes. The Biden administration also funded the development of the plant. It was canceled in late 2023 because of cost overruns and too few subscriptions from area power providers who were wary of the untested SMR technology. Big Tech, with its need for reliable energy and desire to cut carbon emissions, is backing the technology. Mr. Trump plans to clear a regulatory path for its advancement. “If you can get the first ones built and demonstrated, we think the confidence level is just going to continue to increase in terms of where you could put these plants,” Ms. Lane said.

#### And it’s key to grid stability

Latief 23 [Yusuf, 11-13-23, Grid reliability: Is nuclear the stabiliser we’ve been looking for?, https://www.smart-energy.com/industry-sectors/energy-grid-management/grid-reliability-is-nuclear-the-stabiliser-weve-been-looking-for/]

Grid stability is consistently brought up as a key puzzle that needs to be solved to reach our net zero targets. One often overlooked piece, states Bernard Salha, group technical director and R&D director for French energy giant EDF, might be found in nuclear power. Although the volume of renewable energy sources coming online is an accolade worth touting, the issue behind intermittency persists. However, an answer might just be found in the role of nuclear and Salha, in an Energy Transitions Podcast episode, stated his confidence in this being the case: “Nuclear is clearly an asset to cope with the question of overall intermittency and, let me also say, the question of global stability of the grid. “The big question with renewables is that you have electricity (only) when you have wind or when you have sun…” The go-to answer for this intermittency conundrum is the use of storage systems, whether battery or long-duration, which can be co-located with renewable power plants to store energy when generated and discharge back to the grid during peak hours of demand. owever, states Salha, storage technology is not yet at a level where it can be fully relied on to keep our grid in check for the foreseeable future: “…the development of storage, at least of big (enough) volumes of storage, is not yet here, and is probably not going to be here for a very long time. “There are technical devices, which allow us to have stability on the grid – grid forming systems for example – but nuclear could help also in that respect by its natural inertia. And nuclear is flexible – that’s a key element I really want to stress; nuclear is flexible. “On our French fleet, we have reactors, which can increase (…) or decrease power very fast; the technical spec, with grey rods to which the reactors are equipped, is of 3% full power per minute. “Nuclear power plants can follow the load, and consequently, they can help to bring stability on the grid.” According to Salha, ensuring the stability of our grid systems needs to be recognised as a crucial element for the success of the energy transition as, with increasing shares of electricity and renewable energy coming online, its functioning will need to be maintained throughout. “As each share (of energy) is going to be larger and larger; we need a strong grid and a stable grid. “And in that respect, a nuclear power plant with the flexibility and capacity to follow the load is clearly an asset in this global, complex landscape.” According to Salha, a way in which the integration of nuclear, as a decentralised flexible load, can be efficiently coordinated is through the use of smart grid technologies. In fact, it is not a way, but rather the way: “The question of this very big increase in electricity means that we are going to have a lot of different demands – (from) EV charging stations, heat pumps, industrial customers – and we will have to manage the global stability, the global frequency, of the grid… “It means that all these global systems have to use digital tools. Digital tools in that respect are mandatory if we want the system to be able to operate. All the AI techniques, all the tools which may help the global operators in charge of the management of the grid to work are going to have a great effect and are completely necessary.

**Gas dependence itself underscores grid failure, amplifying energy inequality.**

Vivian Yang 24. Western states energy analyst for the Climate & Energy program at the Union of Concerned Scientists. Reliance on Gas Power Plants Fuels Inequity. The Equation, 10 January 2024. https://blog.ucsusa.org/vivian-yang/reliance-on-gas-power-plants-fuels-inequity/. Accessed 10 September 2024

An electric system that is over-reliant on **gas** can contribute to **higher** and more **volatile** electricity **bills**. Furthermore, thermal resources (gas, coal, and oil) are often overvalued for their contribution to maintaining grid reliability. Not only is this bad for keeping the lights on, but it means that gas power plant **owners** are being **overpaid** and those extra payments are coming from customers. During Winter Storm **Uri** in 2021, a devastating storm where power outages contributed to **hundreds of deaths**, Texans saw the extreme of price volatility from over-dependence on the gas system in a competitive power market. Wholesale electricity prices rose **7,400%**, in part because gas plants disproportionately **failed** in the **cold weather** causing electricity supply shortages. Higher and more volatile electricity bills are particularly difficult for households with a higher energy burden. Studies show that **low-income** households spend almost **9%** of their **income** on **energy**, on average, compared to 3% for non-low-income households. And compared to **white** households, **Black**, **Latinx**, and **Native** households spend between **20** and **45% more** of their income on electricity bills. Compounding effects on other vulnerable populations The disproportionate effects that all these harms have on communities of color and low-income communities is well documented, but it doesn’t end there. These harms **intersect** across social segments, particularly affecting other **vulnerable populations**. For example, older adults are more vulnerable to heat waves due to aging immune systems, higher likelihood of dehydration, and more limited mobility. In the 2022 summer heat wave in Europe, 90% of heat-related deaths were people aged 65 and older. Exposure to air pollutants emitted from gas production aggravates existing respiratory illnesses and has been linked to increased childhood asthma rates. Gas plants are more likely to be in communities with limited English proficiency, making it more difficult for these communities to advocate for stronger pollution standards or plant retirements. Farmers must deal with increasingly extreme weather events and land degradation from gas infrastructure that put their livelihoods at risk. Wells drilled for fracking near drinking water sources have been linked to higher incidences of pre-term births and low birth weight. This is a small snapshot of how the power grid’s **reliance** on **gas** harms **vulnerable populations**. When intersected with low-income communities and communities of color, these compounding burdens breed more extreme inequality. So, why is the grid still so reliant on a resource with such known inequitable harms? Steps towards a more equitable grid Gas is often touted by its champions as the key to grid reliability. It indeed accounts for 40% of the electricity currently generated for the grid. But studies show that at least 80 to 90% of the US grid could be reliably served with renewable energy and there is limited to zero need for new gas plants for reliability. On top of that, the gas-for-reliability **narrative** is increasingly **under scrutiny** as gas plants and the associated infrastructure disproportionately **fail** in extreme weather conditions. Gas doesn’t need to be the crux of a reliable electric grid. And based on the challenges gas faces in extreme summer weather in addition to its alarmingly poor track record in extreme winter weather, it shouldn’t be. As the country moves to phase out its reliance on gas and other fossil fuel resources, equity needs to be a much bigger part of the discussion. Grid planners should prioritize the retirement of gas plants and related infrastructure in low-income communities and communities of color. In parallel, there should be more concerted efforts to break down the barriers to the clean energy buildout. These reforms will be a much bigger boon to grid reliability and grid equity. Unfortunately, we can’t undo the long history of harm that the energy system has disproportionately placed on communities of color, low-income communities, and vulnerable populations. But we can plan to transition to an electric grid where equity is underscored in the design and decision-making processes. **Clean energy**, done right, **avoids** many of the very **harmful** impacts of **gas**-fueled power plants. The work we do now to create an equitable grid can have transformative benefits for communities and ultimately contribute to a fairer and healthier society and planet.

**Nation-wide grid collapse is likely and causes existential nuclear meltdowns.**

Mark Leyse 24. Former Nuclear Engineer, University of Wisconsin; Nuclear Safety Analyst and Consultant. Spent nuclear fuel mismanagement poses a major threat to the United States. Here's how. Bulletin of the Atomic Scientists, 4-2-2024. https://thebulletin.org/2024/04/spent-nuclear-fuel-mismanagement-poses-a-major-threat-to-the-united-states-heres-how/. Accessed 10-9-2024

The relatively **high probability** of a nationwide grid collapse, which would lead to multiple **nuclear disasters**, emphasizes the need to expedite the transfer of spent fuel to dry cask storage. According to Frank von Hippel, a professor of public and international affairs emeritus at Princeton University, the impact of a **single accident** at an overstocked spent fuel pool has the potential to be **two orders of magnitude** more devastating in terms of radiological releases than the three **Fukushima** Daiichi meltdowns combined. If the US grid collapses for a lengthy period of time, society would likely descend into **chaos**, as uncooled nuclear fuel burned at multiple sites and spewed **radioactive** plumes into the **environment**. The **value** of preventing the destruction of US society and untold human suffering is **incalculable**. So, on the issue of protecting people and the environment from spent fuel pool fires, it is surprising when one learns that promptly transferring the nationwide inventories of spent fuel assemblies that have been cooled for at least five years from US pools to dry cask storage would be “relatively inexpensive”—less than (in 2012 dollars) a total of $4 billion ($5.4 billion in today’s dollars). That is far, far less than the monetary toll of losing vast tracts of urban and rural land for generations to come because of radioactive contamination. One should also consider that plant owners are required, as part of the decommissioning process, to transfer spent fuel assemblies from storage pools to dry cask storage after nuclear plants are permanently shut down. So, in accordance with industry protocols, all spent fuel assemblies at plant sites are intended to eventually be placed in dry cask storage (before ultimately being transported to a long-term surface storage site or a permanent geologic repository). If the NRC continues to allow the industry’s **mismanagement** of spent fuel to pose an **existential threat** to the **U**nited **S**tates, Congress must be compelled to pass legislation requiring utilities to swiftly thin out spent fuel pools.

**Collapse destroys life-affirming infrastructure. It’s an existential threat.**

Benjamin Monarch 20, University of Kentucky College of Law, J.D. May 2015, LLM in Energy, Natural Resources, and Environmental Law and Policy from the University of Denver Sturm College of Law, Deputy District Attorney at Colorado Judicial Branch, and Term Member at the Council on Foreign Relations, “Black Start: The Risk of Grid Failure from a Cyber Attack and the Policies Needed to Prepare for It,” Journal of Energy & Natural Resources Law, vol. 38, no. 2, Routledge, 04/02/2020, pp. 131–160

In the industrial world, when a switch is flipped, we take for granted that it will produce light, boot a computer, illuminate a stadium or activate a power plant. We know, of course, that power losses can and do occur. Many of us have lit candles during a thunderstorm or brought out extra blankets when a blizzard takes down transmission lines. As of this writing, the most populated state in the United States, California, is experiencing rolling blackouts.1 Yet even in prolonged power outages, we expect that electricity will be restored and, consequently, life will return to normal. Perhaps we need ask, however, what if power **cannot** be restored in a timely manner? Concern is growing that in the not-too-distant future our electricity supply could be irreparably compromised by a cyber attack. The issue when considering a systemic grid failure of this nature is twofold: how did we reach a point where something so **critical** to **routine life** now presents an **existential threat**, and what can we do to **mitigate** the risk of a catastrophic grid attack? This article posits that the emergence of cyber attacks on industrial control systems, as a means of war or criminal menace, have reached a level of sophistication capable of crippling those systems. This article argues that a new grid security policy paradigm is required to thwart catastrophic grid failure – a paradigm that recognises the inextricable link between commercial power generation and national security. In section 5, seven policy recommendations are outlined that may, in part, mitigate a future where grid attacks pose **existential risk** to nations and their citizenry. Those recommendations are: first, develop a comprehensive insurance programme to minimise the financial risk of grid disruption; second, train more cybersecurity professionals with particular expertise in industrial control systems; third, institute a federally mandated information-sharing programme that is centralised under United States Cyber Command; fourth, subsidise and/or incentivise cybersecurity protections for small to mid-size utilities; fifth, provide university grants for grid security research; sixth, integrate new technologies with an eye towards securing the grid; and, lastly, formulate clear rules of engagement for a military response to grid disruption. The purpose of this article is to provide the reader with an introduction to this complex topic. It is the aim of the author to give orientation to this issue and its many branches in the hope that better understanding will animate further curiosity and, ultimately, positive action on the part of the reader. Although many skilled and earnest people work tirelessly to prevent a grid failure scenario, it is essential that more be added to their ranks each day. Advisors, engineers, regulators, private counsel to power generators, and many others who play roles in electric power production are crucial to this subject. So, while this article provides entrée to the topic of grid security, its long-term objective is to spur action by the entire energy-related community. In the end, no one is immune to consequences of grid failure and, therefore, everyone is responsible, in part, for promoting grid integrity.2 In this regard, lawyers who represent various actors in the energy sector are going to be faced with questions and potential legal risks of a magnitude that they have never experienced before. 1.2. Turning the power back on in a powerless world ‘Black start’, not to be confused with the term ‘blackout’, is the name given to the process of restoring an electric grid to operation without relying on the external electric power transmission network to recover from a total or partial shutdown.3 At first glance, this description is unremarkable, but it implies a disturbing catch-22 – how might one restore power if the entire external transmission network is compromised? If an electric disruption occurs at a household level, some homes may be equipped with a modest gasoline generator to temporarily restore power. If a hospital loses power, it will almost invariably be resupplied by automatic, industrial-scale generators. These **micro** considerations hardly give **anyone pause**; they are hiccups on a stormy night or a snowy day. In other words, their ‘black start’ is a quick and effective process for restoring power. But what happens, at a macro level, when an electric **grid** supplying power to **large portions** of the **U**nited **S**tates goes black, or worse, what happens if **all** of the United States’ electric grids go down **simultaneously?**4 In that scenario, how might enough non-grid power be harnessed and transmitted to turn the United States’ lights back on? Moreover, how might such a catastrophe occur in the first place? Perhaps the more **ominous question** is **not how**, but **whether or not we can survive** such circumstances if they persist in the long term. The United States electric grid (‘the grid’) is the ‘largest interconnected machine’ in the world.5 It consists of more than 7000 power plants, 55,000 substations, 160,000 miles of high-voltage transmission lines and millions of low-voltage distribution lines.6 The scale and complexity of the grid in the context of the modern digital world are beyond comprehension because within it are innumerable industrial control systems; incalculable connections to digital networks; millions, if not billions, of analogue or digital sensors; many thousands of human actors; and trillions of lines of programming code.7 Further complexifying the grid is that it is comprised of generations of technologies, stitched together in ways that are not inherently secure in a world of cyber threats.8 The vastness of the grid makes security of it challenging. Likewise, the **vastness** of the grid makes the opportunities for intrusion **seemingly infinite**. By **any measure**, grid **failure** will unleash a **parade of horrors**. **Stores** would **close**, **food** scarcity would follow, **communication** would cease, **garbage** would **pile up**, planes would be grounded, clean **water** would become a **luxury**, service stations would yield **no fuel**, **hospitals** would eventually **go dark**, financial **transactions** would stop, and this is only the **tip of the iceberg** – in a prolonged grid failure **social chaos** would reign, once-eradicated **diseases** would **re-emerge** and, increasingly, hope of returning to a normal life would fade.9 The notion of complete grid failure, once relegated to science fiction comics or James Bond movies, is now not only possible but also one of the most pressing national security threats today.10