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## 1NC – Grid Meldown DA

#### Abolishing subsidies kills oil and coal.

David Roberts 7-26-18, "Friendly policies keep US oil and coal afloat far more than we thought," Vox, <https://www.vox.com/energy-and-environment/2017/10/6/16428458/us-energy-coal-oil-subsidies> LHSLA LH

In an analysis published in Nature in October 2017, researchers from the Stockholm Environment Institute (SEI) attempt to clear this up, quantifying, to the extent possible, just how much a difference production subsidies make. They do this by focusing in on a specific economic decision on the part of producers: whether or not to develop a new oil field they’ve discovered.∂ After tallying up their own long list of production subsidies and attempting to calculate how those subsidies shift the economic returns of new production, they came to some pretty startling conclusions, emphasis mine:∂ We find that, at recent US oil prices of US$50 per barrel, tax preferences and other subsidies push nearly half of new, yet-to-be-developed oil into profitability. This potentially increases US oil production by almost 17 billion barrels over the next few decades, equivalent to 6 billion tonnes (Gt) of CO2.∂ Almost half of the new oil fields getting drilled would have been left alone if not for subsidies. That is no small effect!∂ The researchers acknowledge that the impact of subsidies on these decisions is extremely sensitive to oil prices. If oil prices rise back up to, say, $75bbl, as some forecasters project, the impact of subsidies will appear far smaller.∂ Photo of oil rigs sit just outside of Theodore Roosevelt National Park near Watford City, North Dakota.∂ Almost half of these from the least few years are thanks to your taxpayer dollars. Thanks? (Ken Cedeno/Corbis via Getty Images)∂ But at current low oil prices, subsidies are making a huge, huge difference.∂ Coal is propped up by government policy too∂ As the charts from OCI show, direct federal tax expenditures on behalf of coal production are dwarfed by oil and gas subsidies. The main federal tax subsidy is cheap leases to mine coal on public land.∂ But as a report from Carbon Tracker details, coal is still very much propped up by public policy.∂ It’s no big revelation that new coal plants are uneconomic. There hasn’t been a new coal plant built in the US in years and there will probably never be another one, for reasons of raw economics. Here are net capacity additions and subtractions from the US power fleet, from 2011 to 2016:∂ capacity additions∂ (Carbon Tracker)∂ As you can see, crappy old coal plants are coming offline and nobody’s building new plants to replace them.∂ Problem is, new coal plants have to be “clean,” which is to say, they have to have the filters and scrubbers to meet modern pollution standards. And as I’ve been saying for years, coal can either be cheap or clean, not both; making a new coal plant clean makes it uneconomic (to say nothing of what happens when you force it to bury its carbon).∂ What’s more striking is how imperiled existing, fully paid-off coal plants are. Even many of those can’t compete against natural gas or renewables.∂ Many existing coal plants are balanced on a fine edge. To the extent they can escape requirements to upgrade to modern pollution equipment — and believe it or not, decades after the Clean Air Act was passed, they still can — they can stay profitable for longer.∂ “When current costs are considered, 72% of operating coal units are unprofitable compared to the operating cost of an equivalent [natural gas plant],” Carbon Tracker writes, “and 98% when the anticipated costs [of environmental upgrades] are included.”∂ In other words, once the entire coal fleet upgrades to modern pollution standards ... basically none of it will be economically competitive. Cheap or clean; never both.∂ The A.E.P. (American Electric Power) coal burning plant in Conesville, Ohio. ∂ Not v. competitive. (Michael Williamson/Washington Post/Getty Images)∂ That’s a narrow path to remaining profitable, and coal plants are only on that path at all because of all the other ways they are propped up by regulatory policy:∂ Capacity markets favor already-built coal over new natural gas or renewables: Unlike electricity markets, which pay for power, capacity markets pay for the ability to spin up, just in case. They are a way of maintaining reserve capacity in case other power plants unexpectedly go offline. For various reasons (see the report), such markets favor plants that are already amortized and have readily available fuel, i.e., generally coal plants. So yeah, even coal plants that rarely produce power still get paid to sit around and ... not be closed.∂ In regulated energy markets, utilities get paid to keep investing in unneeded, expensive coal plants: In competitive energy markets, plants close if they can’t make enough profit from their power to cover their ongoing costs. But in fully regulated markets (which contain 67 percent of US coal capacity), a utility’s return on investment in a plant is guaranteed by regulators, whether or not closing that plant would be better for ratepayers (as it very often would). Ironically, that’s why more coal plants in regulated markets have pollution-control equipment. In competitive markets, that would render them uneconomic (better just to shut them down). But in regulated markets, hell, why not? Every bit of investment means more guaranteed profits.∂ pollution equipment∂ (Carbon Tracker)∂ Utilities shuffle coal plants from their deregulated side to their regulated side, to shield them from competition: This one is so devious. Utility holding companies — which own utilities in both regulated and deregulated markets — move coal plants from the books of the latter to the books of the former, to shield them from competition and keep them alive via regulation. “This accounting practice typically shifts the economic burden from the shareholder to the consumer,” Carbon Tracker writes, “with the former often benefiting to the detriment of the latter.∂ Utilities hedge against changing natural gas costs: Some forecasters expect natural gas prices to rise in coming years (though, honestly, everyone is guessing). To hedge against that, utilities often keep uneconomic coal plants open, just in case rising NG prices retroactively render them economic.∂ This is just a partial accounting. The broader point is that the edifice of regulation governing the US electricity sector favors coal incumbents in myriad ways.∂ If all coal plants had to adopt their full costs and face full market competition tomorrow, the US coal fleet would quickly shrink to negligible size. It only survives because, through taxes and regulations, the US has protected it.

#### Shortages of gas mean increased importance of coal and oil—collapse of these industries ensures grid collapse in winter.

Terry Jarrett, 12-5-2018, "The lights could go out this winter if we close more coal and nuclear power plants," MarketWatch, <https://www.marketwatch.com/story/the-lights-could-go-out-this-winter-if-we-close-all-the-coal-and-nuclear-power-plants-2018-12-04> LHSLA LH

It’s been an early start to winter this year across much of the Central and Eastern United States. And plunging temperatures have highlighted a surprising fact: Not only are natural-gas prices soaring, but fuel stockpiles have dipped to unusually low levels.∂ It’s a somewhat unexpected turn of events — since the United States has been the world’s top producer of natural gas since 2009. But a number of factors are combining to significantly alter the landscape for utilities in the United States that rely on natural-gas-fired power generation.∂ For starters, last winter was a whopper. A deep freeze hit the United States in January, taxing much of the nation’s power grid to the limit. Not only were natural-gas pipelines spread thin in delivering fuel to power plants, but available gas was prioritized for home heating.∂ PJM Interconnection, which oversees electricity supplies for 13 states and

the District of Columbia, published a subsequent review of the January 2018 deep freeze. And what PJM reported, particularly for demand centered around a very cold Jan. 7, raises questions about the nation’s current natural-gas capacity.∂ At peak winter demand, 5,913 megawatts of natural-gas capacity was simply unavailable due to “supply outages.” And more than 8,000 megawatts of gas-plant capacity was forced to shut down. Overall, more than 23,000 megawatts was unavailable—12.1% of PJM’s total capacity.∂ Thankfully, according to the Department of Energy (DOE), the nation’s coal plants came to the rescue. Coal-fired power plants ramped up to provide 55% of daily incremental power at the time. The DOE says that, without the sturdy baseload power generation produced by coal, “the Eastern United States would have suffered severe electricity shortages, likely leading to widespread blackouts.”∂ The 2018 winter left other troubles in its wake, too. The late arrival of spring meant gas producers had less time to refill the nation’s storage capacity. And even as utilities have been playing catch-up on refills, the recent record Thanksgiving cold snap further siphoned stockpiles.∂ As a result, U.S. natural gas storage currently remains at unusually low levels. An analysis in Forbes is now warning of “historically low gas storage” — and cautioning that the U.S. “cannot meet winter gas demand without storage.”∂ The potential for a real natural gas shortage isn’t simply a hypothetical. The Energy Information Administration (EIA) says that storage of natural gas is running roughly 16% lower than its five-year average. And a MarketWatch analysis similarly reported that the U.S. is experiencing a “15-year low in stockpiles.”∂ Natural gas spiked to a four-year high last month.∂ Ironically, even as natural-gas supplies are tightening in the U.S., producers are focused on shipping more gas overseas. Natural-gas exports are expected to triple by the end of 2019. And all of this will undoubtedly hit U.S. consumers in the wallet, since natural-gas prices are now rising steadily. Last month, the price of natural gas rose US:NGF19 to the highest level in more than four years.∂ It would be comforting to say that, if any unexpected problems crop up, coal and nuclear power plants will simply jump in to save the day. But many coal and nuclear units have been retired over the past decade, and more are on the chopping block.∂ The North American Electric Reliability Corp. (NERC) notes that more than 46.5 gigawatts of coal-fired generation has been shut down since 2011, and another 19 gigawatts of coal capacity is slated to close in the next decade.∂ As for nuclear-power plants, six units have been retired since 2012, with 14 more set to close by 2025.∂ All of this suggests a worst-case scenario wherein the United States experiences a cold snap, and sufficient power generation simply isn’t available to meet demand. The rapid dismantlement of coal over the past decade, plus an inability to add new natural-gas pipeline capacity portends real problems — and at a time when Americans need reliable electricity.∂ The obvious answer is to maintain sufficient baseload power from all sources — including coal, nuclear, natural gas, and renewables. It would be wise, then, not to hastily eliminate the coal and nuclear plants that — as the 2018 winter demonstrated — continue to carry America’s peak power needs on their backs.

#### Blackouts cause nuclear meltdowns.

AP 11 [03/29/11, Associated Press, "Nuclear power plants in U.S. vulnerable to power outages, study shows", [www.pennlive.com/midstate/index.ssf/2011/03/nuclear\_power\_plants\_in\_us\_vul.html](http://www.pennlive.com/midstate/index.ssf/2011/03/nuclear_power_plants_in_us_vul.html)]

Nuclear power plants in U.S. vulnerable to power outages, study shows

WASHINGTON — It's a nightmarish scenario: a days long blackout at a nuclear power plant leading to a radioactive leak. Though the odds of that happening are extremely remote, an Associated Press investigation has found that some U.S. plants are more vulnerable than others. Long before the nuclear emergency in Japan, U.S. regulators knew that a power failure lasting for days at an American nuclear plant, whatever the cause, could lead to a radioactive leak. Even so, they have required the nation's 104 nuclear reactors only to develop plans for dealing with much shorter blackouts on the assumption that power would be restored quickly. In one simulation presented by the Nuclear Regulatory Commission in 2009, it would take less than a day for radiation to escape from a reactor at a Pennsylvania nuclear power plant after an earthquake, flood or fire knocked out all electrical power and there was no way to keep the reactors cool after backup battery power ran out. That plant, the Peach Bottom Atomic Power Station outside Lancaster, has reactors of the same older make and model as those releasing radiation at Japan's Fukushima Dai-ichi plant, which is using other means to try to cool the reactors. And like Fukushima Dai-ichi, the Peach Bottom plant has enough battery power on site to power emergency cooling systems for eight hours. In Japan, that wasn't enough time for power to be restored. The risk of a blackout leading to core damage, while extremely remote, exists at all U.S. nuclear power plants, and some are more susceptible than others, according to an Associated Press investigation. While regulators say they have confidence that measures adopted in the U.S. will prevent or significantly delay a core from melting and threatening a radioactive release, the events in Japan raise questions about whether U.S. power plants are as prepared as they could and should be. As part of a review requested by President Barack Obama in the wake of the Japan crisis, a top Nuclear Regulatory Commission official said Tuesday that the agency will investigate whether the nation's nuclear reactors are capable of coping with station blackouts and whether regulatory requirements need to be strengthened. Bill Borchardt, the agency's executive director for operations, said an obvious question is whether nuclear plants need enhanced battery supplies, or ones that can last longer. "There is a robust capability that exists already, but given what happened in Japan there's obviously a question that presents itself: Do we need to make it even more robust," he said at a hearing before the Senate Energy and Natural Resources Committee. "We didn't address a tsunami and an earthquake, but clearly we have known for some time that one of the weak links that makes accidents a little more likely is losing power," said Alan Kolaczkowski, a retired nuclear engineer who worked on a federal risk analysis of Peach Bottom released in 1990 and is familiar with the updated risk analysis. Risk analyses conducted by the plants in 1991-94 and published by the commission in 2003 show that the chances of such an event striking a U.S. power plant are remote, even at the plant where the risk is the highest, the Beaver Valley Power Station near Pittsburgh, Pa. These long odds are among the reasons why the United States since the late 1980s has required nuclear power plants to cope with blackouts only for four or eight hours. That's about how much time batteries would last. After that, it is assumed that power would be restored. And so far, that's been the case. Equipment put in place after the Sept. 11, 2001, terrorist attacks could buy more time. Otherwise, the reactor's radioactive core could begin to melt unless alternative cooling methods were employed. In Japan, the utility has tried using portable generators and dumping tons of seawater, among other things, on the reactors in an attempt to keep them cool. A 2003 federal analysis looking at how to estimate the risk of containment failure said that should power be knocked out by an earthquake or tornado it "would be unlikely that power will be recovered in the time frame to prevent core meltdown." In Japan, it was a one-two punch: first the earthquake, then the tsunami. Tokyo Electric Power Co., the operator of the crippled plant, found other ways to cool the reactor core and, so far, avert a full-scale meltdown without electricity. "Clearly the coping duration is an issue on the table now," said Biff Bradley, director of risk assessment for the Nuclear Energy Institute. "The industry and the Nuclear Regulatory Commission will have to go back in light of what we just observed and rethink station blackout duration." David Lochbaum, a former plant engineer and nuclear safety director at the advocacy group Union of Concerned Scientists, put it another way: "Japan shows what happens when you play beat-the-clock and lose." At Tuesday's Senate committee hearing, he said the government and the nuclear power industry have to do more to cope with prolonged blackouts, such as having temporary generators on site — or at nearby military bases — that can recharge batteries. A complete loss of electrical power, generally speaking, poses a major problem for a nuclear power plant because the reactor core must be kept cool, and back-up cooling systems — mostly pumps that replenish the core with water— require massive amounts of power to work. Without the electrical grid, or diesel generators, batteries can be used for a time, but they will not last long with the power demands. And when the batteries die, the systems that control and monitor the plant can also go dark, making it difficult to ascertain water levels and the condition of the core. Eleven U.S. reactors are designed to cope with a station blackout lasting eight hours, while 93 are designed for four-hour blackouts. Exelon Corp., the operator of the Peach Bottom plant, referred all detailed questions about its preparedness and the risk analysis back to the NRC. In a news release issued earlier this month, the company, which operates 10 nuclear power plants, said "all Exelon nuclear plants are able to safely shut down and keep the fuel cooled even without electricity from the grid." Others, looking at the crisis unfolding in Japan, aren't so sure. In the worst-case scenario, the NRC's 1990 risk assessment predicted that a core melt at Peach Bottom could begin in one hour if electrical power on- and off-site were lost, the diesel generators — the main backup source of power for the pumps that keep the core cool with water — failed to work and other mitigating steps weren't taken. "It is not a question that those things are definitely effective in this kind of scenario," said Richard Denning, a professor of nuclear engineering at Ohio State University, referring to the steps NRC has taken to prevent incidents. Denning had done work as a contractor on severe accident analyses for the NRC since 1975. He retired from Battelle Memorial Institute in 1995. "They certainly could have made all the difference in this particular case," he said, referring to Japan. "That's assuming you have stored these things in a place that would not have been swept away by tsunami."

## 1NC – Military Grid DA

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This potentially increases US oil production by almost 17 billion barrels over the next few decades, equivalent to 6 billion tonnes (Gt) of CO2.∂ Almost half of the new oil fields getting drilled would have been left alone if not for subsidies. That is no small effect!∂ The researchers acknowledge that the impact of subsidies on these decisions is extremely sensitive to oil prices. If oil prices rise back up to, say, $75bbl, as some forecasters project, the impact of subsidies will appear far smaller.∂ Photo of oil rigs sit just outside of Theodore Roosevelt National Park near Watford City, North Dakota.∂ Almost half of these from the least few years are thanks to your taxpayer dollars. Thanks? (Ken Cedeno/Corbis via Getty Images)∂ But at current low oil prices, subsidies are making a huge, huge difference.∂ Coal is propped up by government policy too∂ As the charts from OCI show, direct federal tax expenditures on behalf of coal production are dwarfed by oil and gas subsidies. 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(Michael Williamson/Washington Post/Getty Images)∂ That’s a narrow path to remaining profitable, and coal plants are only on that path at all because of all the other ways they are propped up by regulatory policy:∂ Capacity markets favor already-built coal over new natural gas or renewables: Unlike electricity markets, which pay for power, capacity markets pay for the ability to spin up, just in case. They are a way of maintaining reserve capacity in case other power plants unexpectedly go offline. For various reasons (see the report), such markets favor plants that are already amortized and have readily available fuel, i.e., generally coal plants. So yeah, even coal plants that rarely produce power still get paid to sit around and ... not be closed.∂ In regulated energy markets, utilities get paid to keep investing in unneeded, expensive coal plants: In competitive energy markets, plants close if they can’t make enough profit from their power to cover their ongoing costs. 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#### Nuclear war

Andres & Breetz 11. Richard Andres and Hanna Breetz. Professor of National Security Strategy at the National War College and a Senior Fellow and Energy and Environmental Security and Policy Chair in the Center for Strategic Research, Institute for National Strategic Studies, at the National Defense University, doctoral candidate in the Department of Political Science at The Massachusetts Institute of Technology, “Small Nuclear Reactors for Military Installations: Capabilities, Costs, and Technological Implications”, [www.ndu.edu/press/lib/pdf/StrForum/SF-262.pdf](http://www.ndu.edu/press/lib/pdf/StrForum/SF-262.pdf)

Grid Vulnerability. DOD is unable to provide its bases with electricity when the civilian electrical grid is offline for an extended period of time. Currently, domestic military installations receive 99 percent of their electricity from the civilian power grid. As explained in a recent study from the Defense Science Board: DOD’s key problem with electricity is that critical missions, such as national strategic awareness and national command authorities, are almost entirely dependent on the national transmission grid . . . [which] is fragile, vulnerable, near its capacity limit, and outside of DOD control. In most cases, neither the grid nor on-base backup power provides sufficient reliability to ensure continuity of critical national priority functions and oversight of strategic missions in the face of a long term (several months) outage.7 The grid’s fragility was demonstrated during the 2003 Northeast blackout in which 50 million people in the United States and Canada lost power, some for up to a week, when one Ohio utility failed to properly trim trees. The blackout created cascading disruptions in sewage systems, gas station pumping, cellular communications, border check systems, and so forth, and demonstrated the interdependence of modern infrastructural systems.8 More recently, awareness has been growing that the grid is also vulnerable to purposive attacks. A report sponsored by the Department of Homeland Security suggests that a coordinated cyberattack on the grid could result in a third of the country losing power for a period of weeks or months.9 Cyberattacks on critical infrastructure are not well understood. It is not clear, for instance, whether existing terrorist groups might be able to develop the capability to conduct this type of attack. It is likely, however, that some nation-states either have or are working on developing the ability to take down the U.S. grid. In the event of a war with one of these states, it is possible, if not likely, that parts of the civilian grid would cease to function, taking with them military bases located in affected regions. Government and private organizations are currently working to secure the grid against attacks; however, it is not clear that they will be successful. Most military bases currently have backup power that allows them to function for a period of hours or, at most, a few days on their own. If power were not restored after this amount of time, the results could be disastrous. First, military assets taken offline by the crisis would not be available to help with disaster relief. Second, during an extended blackout, global military operations could be seriously compromised; this disruption would be particularly serious if the blackout was induced during major combat operations. During the Cold War, this type of event was far less likely because the United States and Soviet Union shared the common understanding that blinding an opponent with a grid blackout could escalate to nuclear war. America’s current opponents, however, may not share this fear or be deterred by this possibility. In 2008, the Defense Science Board stressed that DOD should mitigate the electrical grid’s vulnerabilities by turning military installations into “islands” of energy self-sufficiency.10 The department has made efforts to do so by promoting efficiency programs that lower power consumption on bases and by constructing renewable power generation facilities on selected bases. Unfortunately, these programs will not come close to reaching the goal of islanding the vast majority of bases. Even with massive investment in efficiency and renewables, most bases would not be able to function for more than a few days after the civilian grid went offline.

## 1NC – Renewables Grid DA

#### Grid reliability depends on dispatchable generation from nonrenewable energy—minor shifts in the supply-demand balance cascade into blackouts

Fisher, 15—IER Economist (Travis, “ASSESSING EMERGING POLICY THREATS TO THE U.S. POWER GRID,” <http://instituteforenergyresearch.org/wp-content/uploads/2015/02/Threats-to-U.S.-Power-Grid.compressed.pdf>, dml)

Electric reliability in the U.S. is excellent overall, which is a testament to the men and women working in power plants and control rooms across the country. Aside from two major blackouts (1965 and 2003), electricity consumers in the U.S. have not been subjected to persistent, region-wide blackouts —unlike less developed nations 8 with less reliable electric systems. 9

Given the positive track record of America’s power grid, it is no surprise that some experts characterize the grid as “underrated.” According to a 2014 report 10 by the North American Electric Reliability Corporation (NERC)—which is the U.S.’s federally designated electric reliability organization—the grid remains stable:

The availability of the bulk transmission system remained high from 2008 to 2013. The [alternating current] transmission circuit availability remained above 97 percent, and transmission transformer availability was above 98 percent for the 2010 to 2013 period (unavailability includes both forced and planned outages). High transmission availability demonstrates that the [bulk power system] is able to perform reliably over a variety of operating conditions.11

This report focuses on the power plants and high-voltage transmission lines that make up the bulk power grid. Even with a top- 12 notch bulk power grid covering the U.S., consumers will experience outages on local distribution lines from time to time. This is 13 due largely to the fact that many of our neighborhood power lines are on overhead poles and thus vulnerable to damage from storms, ice, falling trees, etc. The alternative —burying distribution lines underground—is impractical and would be incredibly expensive. For the purposes of this report, 14 statements about grid reliability refer to the bulk power grid.

The U.S. power grid actually consists of three region-wide interconnections: the Eastern Interconnection, the Western Interconnection, and the Texas Interconnection. When we refer to the American power grid, we refer to these interconnections collectively, with a special focus on their generation and transmission infrastructure.

To keep these interconnections up and running (and to keep the lights on), electricity generators must meet the total demand on the system at all times and do so within tight margins of error. Electricity is a unique good in that it must be produced at the moment it is consumed, and grid supply must match demand during every second of every day. As people demand higher or lower amounts of power throughout the day (shown below), reliable generators adjust their output accordingly. “Baseload” plants run consistently at nearly all hours, whereas other plants come online to satisfy higher levels of demand or “load.” Having a reliable grid means matching supply to demand in real time, all the time.

The technology that makes large electricity grids possible in the first place—the alternating current (AC) system—presents some operating challenges. For example, in an AC system, all generators and devices running on the grid are synchronized to the same frequency (in the U.S., grid current alternates at 60 cycles per second or 60 hertz). If demand outstrips supply (or vice versa), the whole system experiences a dangerous drag (or boost) in frequency that can cause blackouts across a large area. Diverging from 60 hertz is dangerous for some of the equipment on the grid, including generators, so power plants will shut themselves off when the frequency changes too much.

For example, in the 2003 blackout that spread across the Eastern U.S., grid operators were slow to realize that a generator had failed and transmission lines had tripped offline, causing other transmission lines to overload, which, in turn, caused other generators to trip offline, further losing power and exacerbating the frequency collapse.

The cascading effect continued until much of the Eastern U.S. and Canada suffered a major blackout. The 2003 blackout 15 demonstrated that, even in good conditions, the power grid is susceptible to system-wide disruptions.

To understand how fragile the balance of the grid truly is—and how well operators manage the grid—look no further than the second-by-second frequency fluctuations across the three interconnections.

Below is a screen capture of the real-time, color-coded frequency map maintained by the Power Information Technology Laboratory at the University of Tennessee.16 Blue areas are experiencing lower grid frequency (less than 60 hertz), indicating that overall electricity supply is lagging demand in that moment, and red areas are the opposite. Green areas indicate that the system is balanced at 60 hertz.

These conditions change in real time, cycling second-by-second through the rainbow of colors. As total demand on the system changes (as lights, electric motors, air conditioners, computers, etc. turn on and off), hundreds of generators respond by increasing or decreasing their power output at a moment’s notice. The blues and reds reflect the fact that generators require some reaction time to respond to changing power demand. Minor deviations in frequency are normal—extreme deviations or “frequency excursions” can cause serious reliability problems.17

Grid planners and operators go to great lengths to make sure the grid’s delicate supply/demand balance is stable, not just minute to minute, but also five and ten years into the future. In those long-range plans, having enough reliable supply to meet demand in many different situations is key. Planners pay special attention to peak demand forecasts, ensuring there will always be enough reliable generation to match demand at its highest. The buffer or cushion above peak demand provided by reliable sources of electricity is called the “reserve margin,” and it is absolutely crucial in grid planning. Planners also take into account the potential loss of equipment such as transmission lines, substations, generators, and so on. That is why this report stresses the importance of having enough reliable generators up and running.

The U.S. Energy Information Administration (EIA) is careful to distinguish between “dispatchable” generation—power plants that can be controlled, i.e., turned on and off, ramped up and down—and nondispatchable generation. In the U.S., 18 power plants fueled by coal, natural gas, and nuclear power are the largest sources of dispatchable generation. Nondispatchable sources include wind, solar, and hydroelectric power. This distinction is 19 important because dispatchable generation is absolutely essential to grid reliability.

According to the most recent data from the EIA, the U.S. is home to an amazing 875 gigawatts (GW) of dispatchable generation from coal, natural gas, petroleum, and nuclear power. That is more installed 20 capacity than all of Central and South America, Eurasia, and the Middle East combined.21

#### Nuclear war

Andres & Breetz 11. Richard Andres and Hanna Breetz. Professor of National Security Strategy at the National War College and a Senior Fellow and Energy and Environmental Security and Policy Chair in the Center for Strategic Research, Institute for National Strategic Studies, at the National Defense University, doctoral candidate in the Department of Political Science at The Massachusetts Institute of Technology, “Small Nuclear Reactors for Military Installations: Capabilities, Costs, and Technological Implications”, [www.ndu.edu/press/lib/pdf/StrForum/SF-262.pdf](http://www.ndu.edu/press/lib/pdf/StrForum/SF-262.pdf)

Grid Vulnerability. DOD is unable to provide its bases with electricity when the civilian electrical grid is offline for an extended period of time. Currently, domestic military installations receive 99 percent of their electricity from the civilian power grid. As explained in a recent study from the Defense Science Board: DOD’s key problem with electricity is that critical missions, such as national strategic awareness and national command authorities, are almost entirely dependent on the national transmission grid . . . [which] is fragile, vulnerable, near its capacity limit, and outside of DOD control. In most cases, neither the grid nor on-base backup power provides sufficient reliability to ensure continuity of critical national priority functions and oversight of strategic missions in the face of a long term (several months) outage.7 The grid’s fragility was demonstrated during the 2003 Northeast blackout in which 50 million people in the United States and Canada lost power, some for up to a week, when one Ohio utility failed to properly trim trees. The blackout created cascading disruptions in sewage systems, gas station pumping, cellular communications, border check systems, and so forth, and demonstrated the interdependence of modern infrastructural systems.8 More recently, awareness has been growing that the grid is also vulnerable to purposive attacks. A report sponsored by the Department of Homeland Security suggests that a coordinated cyberattack on the grid could result in a third of the country losing power for a period of weeks or months.9 Cyberattacks on critical infrastructure are not well understood. It is not clear, for instance, whether existing terrorist groups might be able to develop the capability to conduct this type of attack. It is likely, however, that some nation-states either have or are working on developing the ability to take down the U.S. grid. In the event of a war with one of these states, it is possible, if not likely, that parts of the civilian grid would cease to function, taking with them military bases located in affected regions. Government and private organizations are currently working to secure the grid against attacks; however, it is not clear that they will be successful. Most military bases currently have backup power that allows them to function for a period of hours or, at most, a few days on their own. If power were not restored after this amount of time, the results could be disastrous. First, military assets taken offline by the crisis would not be available to help with disaster relief. Second, during an extended blackout, global military operations could be seriously compromised; this disruption would be particularly serious if the blackout was induced during major combat operations. During the Cold War, this type of event was far less likely because the United States and Soviet Union shared the common understanding that blinding an opponent with a grid blackout could escalate to nuclear war. America’s current opponents, however, may not share this fear or be deterred by this possibility. In 2008, the Defense Science Board stressed that DOD should mitigate the electrical grid’s vulnerabilities by turning military installations into “islands” of energy self-sufficiency.10 The department has made efforts to do so by promoting efficiency programs that lower power consumption on bases and by constructing renewable power generation facilities on selected bases. Unfortunately, these programs will not come close to reaching the goal of islanding the vast majority of bases. Even with massive investment in efficiency and renewables, most bases would not be able to function for more than a few days after the civilian grid went offline.

# Extra Cards

## Grid Uniqueness

### Good

### Bad

#### [Bad evidence] Grid on the brink of collapse because of renewable tech promoted by Russians—collapses all of society.

Droz 18 (John Droz Jr., John Droz, Jr. is the founder of Alliance for Wise Energy Decisions. “Looming Catastrophe: Power Grid Collapse Now In Sight in New York.” *What’s Up With That?* 5-7-18. <https://wattsupwiththat.com/2018/05/07/looming-catastrophe-power-grid-collapse-now-in-sight-in-new-york/>) LHSLA LH

As an overview, there are several startling acknowledgments, essentially saying:

Wind energy is an unrelentingly unpredictable and uncontrollable energy source,

Increasing wind energy on the grid is causing serious reliability issues,

Wind energy has very little Capacity Value, and that has not been adequately addressed,

Due to the inherent nature of wind energy it must be permanently paired with gas,

Adding more wind energy to the grid will require substantially more gas to be added to the grid,

The costs to deal with wind energy on the grid are rapidly increasing,

None of the costs incurred by wind energy are directly attributed to wind energy,

There are similarly major issues with solar, also not quite as severe,

None of the politicians or NGOs promoting wind or solar are acknowledging any of these issues,

“Stakeholders” are currently discussing a carbon tax, to make this situation even worse.

What else do you need to know to confirm that we are headed for a catastrophe? Well, there’s more…

Note that there is a very strong parallel here with the US mortgage meltdown of several years ago — which led to a world-wide major economic downturn. After the fact, when insiders were interviewed about what happened, they acknowledged that everyone-in-the-know knew that the lending, etc. policies put in place (by lobbyists) were guaranteed to fail.

Unless major changes are made quickly, several years from now there will be experts commenting on how the US energy grid failure (which will lead to a collapse of our economy, and our national security, and our society), was entirely predictable based on the self-serving unscientific energy policies put in place by lobbyists.

If you think this is an exaggeration, simply shut off the electricity in a major city, and see quickly it is before chaos and lawlessness ensues.

Now do the same for an entire region. Etc.

Once you’ve grasped the magnitude of that, you’ll understand why the Russians have put so much effort into promoting US energy policies that are completely nonsensical — to anyone but them. (See Subverting US Energy Policies for more details.)

## Grid Dependent on FF

### Supply Side Flex

#### Renewable grid still requires natural gas.

Nader Sobhani, 9-23-2019, "Renewables Do Not Rely On “Magical Thinking” — They Are Winning On Price," Niskanen Center, <https://www.niskanencenter.org/renewables-do-not-rely-on-magical-thinking-they-are-winning-on-price/> LHSLA LH

In reality, a renewables-dominated power grid will not depend solely on battery storage to meet cyclical surges in demand. Instead it should include a broad portfolio of supply- and demand-side flexibility measures: Improving demand-side interruptible loads, increasing energy efficiency, transmitting greater amounts of power over long distances, and using natural gas power plants for on-demand generation will all lessen the burden on battery technology. A 2012 National Renewable Energy Laboratory study envisioned a more flexible approach to a high-renewable electricity future in the U.S. by 2050. The authors found that renewable generation sources could adequately supply 80 percent of total U.S. electricity generation in 2050 while meeting electricity demand at the hourly level. 50 percent of renewable energy capacity would come from variable wind and solar photovoltaic sources. Storage capacity would have to increase to roughly 100 to 152 GW in 2050, which does not seem unlikely. Bloomberg’s latest “Long-Term Energy Storage Outlook” expects the cumulative global energy storage business to grow to 942 GW by 2040, with the U.S. being one of the leading markets. The report estimates that by 2040, the U.S. will have over 100 GW of cumulative storage capacity deployed.

Mills is justified in his concern that a transition to a grid dominated by renewable energy will entail complex material and infrastructural challenges, but the 100 percent renewables vision he is outlining is not what experts say is necessary. The goal is to decarbonize our electricity systems, which will require a wide variety of energy generation technologies including biomass, advanced nuclear, and even fossil fuels equipped with carbon capture technology, as well as renewables. Additionally, we should not dismiss the role of energy efficiency measures in achieving this goal. In fact, half of the carbon dioxide emission reductions in the electric power sector since 2005 have come from slowing growth in demand for electricity. While the 2008 recession played its role in reducing electricity demand, since 1990, energy efficiency has become the third largest electricity resource in the United States.

#### Especially true during winter.

OFE 18 (Office of Fossil Energy. “Fossil Fuels Power the Winter Season.” DECEMBER 19, 2018. <https://www.energy.gov/fe/articles/fossil-fuels-power-winter-season>) LHSLA LH

Although winter is barely underway, many Americans have already been feeling the freeze brought on by recent winter storms. Since Thanksgiving, the Northeast, Midwest, Mid Atlantic, South, Rocky Mountains, and Great Plains have all experienced significant winter storms bringing cold temperatures and energy disruptions.

Not only does December bring winter storms, it also brings the holiday season, resulting in Americans using more energy. Heating our homes, decorating with holiday lights, cooking large meals—all of these can cause spikes in residential energy usage.

This increased demand requires a steady and reliable energy supply, and fossil fuels play an important role in meeting that demand. In fact, nearly half of all U.S. households use natural gas to heat their homes, and another 5 percent of households use home heating oil, while 5 percent of homes use propane.

Electricity accounts for another 40 percent of home heating, and fossil fuels are the primary fuel source for generating electricity. For instance, in 2017, fossil fuels were among the most-used sources for electricity generation in 35 states. In 18 of those states, coal provided the greatest share of fuel for generating electricity.

This need for more heating and electricity can put a strain on the electric grid—especially during extreme weather events. But, fossil fuels provide a stable source of power generation to keep the grid up and running. And should severe storms disrupt the delivery of home heating fuels, the Energy Department has programs in place to help.

For example, the Office of Fossil Energy’s Office of Petroleum Reserves is home to the Northeast Home Heating Oil Reserve (NEHHOR). The NEHHOR is a 1 million barrel supply of diesel that serves as an extra supply of heating oil for homes and businesses in northeastern United States in the event of a supply disruption. Since most homes that use heating oil are located in the northeastern United States, the NEHHOR provides those residents with a reserve supply of heating oil that can be released under certain conditions.

### General

#### Current approaches to integrate renewables fail: grid integration, poor planning.

D. Jacobs, B.K. Sovacool, in Comprehensive Renewable Energy, 2012 “Photovoltaic Solar Energy,” <https://www.sciencedirect.com/topics/engineering/energy-subsidies> LHSLA LH

Third, the rules of today’s electricity markets are tailored like a well-fitting tuxedo to the needs of conventional power generators. Some minor modifications have already been made in progressive countries, for instance, related to the cost-sharing methodology for grid connection. The so-called deep connection charging approach, which leaves the producer of renewable electricity with all costs, both for grid connection and for grid reinforcement, has been replace by the shallow connection charging approach in many European countries. Historically, the deep connection approach was employed for large-scale conventional power plants. In light of the high investment costs for these power plants, the additional expenditures for grid connection under the deep approach were negligible. This is different for renewable energy projects, which tend to have much lower overall costs per project than mammoth nuclear and coal-fired units. Furthermore, the deep approach provides an incentive to produce electricity in areas with a well-developed electricity grid. This makes sense in the case of coal- or gas-fired power plants but not in the case of renewable energy projects. Wind power plants, for instance, should be built in the windiest locations and not just in regions with available grid capacity. Under the shallow connection charging approach, the renewable energy producer only has to pay for the new electricity line to the next grid connection point, while the grid operator has to cover all costs for potential reinforcement of existing grid infrastructure. The costs covered by the grid operator will be passed on to the final consumer in terms of system charges. Under this approach, the renewable electricity producer will choose the location for the power plant depending on the resource availability (e.g., wind speed) and not infrastructure availability. Recently, a super shallow connection charging approach was implemented in some European countries to promote the deployment of offshore wind power plants, particularly in Denmark and Germany. Connection lines from offshore wind fields to the nearest onshore connection point are rather expensive because of the long distances involved. To free the offshore wind power developers from this financial burden, legislators decided that even the costs for the new connection line from the offshore wind park to the next onshore connection point have to be paid by the grid operator.

Moreover, Spain has established new gate closures for renewable electricity producers wanting to sell their power on the national spot market. For fluctuating technologies, such as wind power and solar PV, a high number of intraday gates are crucial in order to make short-term adjustment with respect to the amount of electricity that can be delivered to the system [127]. The Spanish regulation even allows wind power producers to make hourly adjustments to the power production forecasts.

However, further measures need to be taken in the future. As described above, ‘grid parity’ and ‘generation parity’ will be reached eventually, depending on the costs for conventional power generation and the solar resource conditions in a given country. Therefore, the future necessity for support for solar PV will largely depend on how these two factors vary from country to country. Consequently, time-of-use electricity retail prices could make investment into solar PV more attractive. This is already the case in California, where the electricity price for final consumers ranges from 10 US¢ kWh−1 in off-peak periods in winter time to 50 US¢ kWh−1 for peak periods in summer time (see Figure 13).

#### Coal most used fuel in 18 states.

EIA 18 (“Coal is the most-used electricity generation source in 18 states; natural gas in 16” 9 – 10 – 18. <https://www.eia.gov/todayinenergy/detail.php?id=37034>. LHSLA LH

Electricity generators that use fossil fuels continue to be the most common sources of electricity generation in most states. In all but 15 states, coal, natural gas, or petroleum liquids were the most-used electricity generation fuel in 2017. Since 2007, the number of states where coal was the most prevalent electricity generation fuel has fallen as natural gas, nuclear, and hydroelectricity have gained market share.

In 2017, coal provided the largest generation share in 18 states, down from 28 states in 2007. Natural gas had the largest share in 16 states, up from 11 in 2007. Petroleum remained the largest generation share in only one state—Hawaii—providing 62% of the state’s electricity generation in 2017. For the United States as a whole, natural gas provided 32% of total electricity generation in 2017, slightly higher than coal's 30% share.

Beyond fossil fuels, nuclear power plants provided the largest electricity share in nine states, up from six in 2007. Hydroelectricity is the most prevalent electricity generation source in six states, up from four in 2007. Hydro is the only renewable energy source with the largest share in any state, but that may soon change with the continued addition of wind turbines in states such as Kansas and Iowa.

#### Shortages of gas mean increased importance of coal and oil—collapse of these industries ensures mass blackouts in winter.

Terry Jarrett, 12-5-2018, "The lights could go out this winter if we close more coal and nuclear power plants," MarketWatch, <https://www.marketwatch.com/story/the-lights-could-go-out-this-winter-if-we-close-all-the-coal-and-nuclear-power-plants-2018-12-04> LHSLA LH

It’s been an early start to winter this year across much of the Central and Eastern United States. And plunging temperatures have highlighted a surprising fact: Not only are natural-gas prices soaring, but fuel stockpiles have dipped to unusually low levels.

It’s a somewhat unexpected turn of events — since the United States has been the world’s top producer of natural gas since 2009. But a number of factors are combining to significantly alter the landscape for utilities in the United States that rely on natural-gas-fired power generation.

For starters, last winter was a whopper. A deep freeze hit the United States in January, taxing much of the nation’s power grid to the limit. Not only were natural-gas pipelines spread thin in delivering fuel to power plants, but available gas was prioritized for home heating.

PJM Interconnection, which oversees electricity supplies for 13 states and the District of Columbia, published a subsequent review of the January 2018 deep freeze. And what PJM reported, particularly for demand centered around a very cold Jan. 7, raises questions about the nation’s current natural-gas capacity.

At peak winter demand, 5,913 megawatts of natural-gas capacity was simply unavailable due to “supply outages.” And more than 8,000 megawatts of gas-plant capacity was forced to shut down. Overall, more than 23,000 megawatts was unavailable—12.1% of PJM’s total capacity.

Thankfully, according to the Department of Energy (DOE), the nation’s coal plants came to the rescue. Coal-fired power plants ramped up to provide 55% of daily incremental power at the time. The DOE says that, without the sturdy baseload power generation produced by coal, “the Eastern United States would have suffered severe electricity shortages, likely leading to widespread blackouts.”

The 2018 winter left other troubles in its wake, too. The late arrival of spring meant gas producers had less time to refill the nation’s storage capacity. And even as utilities have been playing catch-up on refills, the recent record Thanksgiving cold snap further siphoned stockpiles.

As a result, U.S. natural gas storage currently remains at unusually low levels. An analysis in Forbes is now warning of “historically low gas storage” — and cautioning that the U.S. “cannot meet winter gas demand without storage.”

The potential for a real natural gas shortage isn’t simply a hypothetical. The Energy Information Administration (EIA) says that storage of natural gas is running roughly 16% lower than its five-year average. And a MarketWatch analysis similarly reported that the U.S. is experiencing a “15-year low in stockpiles.”

Natural gas spiked to a four-year high last month.

Ironically, even as natural-gas supplies are tightening in the U.S., producers are focused on shipping more gas overseas. Natural-gas exports are expected to triple by the end of 2019. And all of this will undoubtedly hit U.S. consumers in the wallet, since natural-gas prices are now rising steadily. Last month, the price of natural gas rose US:NGF19 to the highest level in more than four years.

It would be comforting to say that, if any unexpected problems crop up, coal and nuclear power plants will simply jump in to save the day. But many coal and nuclear units have been retired over the past decade, and more are on the chopping block.

The North American Electric Reliability Corp. (NERC) notes that more than 46.5 gigawatts of coal-fired generation has been shut down since 2011, and another 19 gigawatts of coal capacity is slated to close in the next decade.

As for nuclear-power plants, six units have been retired since 2012, with 14 more set to close by 2025.

All of this suggests a worst-case scenario wherein the United States experiences a cold snap, and sufficient power generation simply isn’t available to meet demand. The rapid dismantlement of coal over the past decade, plus an inability to add new natural-gas pipeline capacity portends real problems — and at a time when Americans need reliable electricity.

The obvious answer is to maintain sufficient baseload power from all sources — including coal, nuclear, natural gas, and renewables. It would be wise, then, not to hastily eliminate the coal and nuclear plants that — as the 2018 winter demonstrated — continue to carry America’s peak power needs on their backs.

#### [Stolen from Kentucky BT—to recut] The alternative to air-polluting fossil fuels is renewables – those collapse the grid

Curry 16 (Judith, Professor and former Chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology, “Renewables and grid reliability”, \*note – it’s unclear whether Judith herself wrote the post or someone writing under the name Planning Engineer – but PE is a professional engineer who’s an expert on FERC and electricity generation\*, https://judithcurry.com/2016/01/06/renewables-and-grid-reliability/)

The costs of major grid outages are staggering and recovery from such outages is challenging; therefore the North American grids are planned and operated to ensure high levels of reliability. Despite changing conditions and various threats, it is widely expected that that current levels of reliability will be maintained or improved upon. The grid is impacted by multiple electro-mechanical effects that planners have learned to model and plan for over time and through experience. The rapid deployment of any new technology will present both modelling and operational challenges to maintaining high levels of grid reliability. With the increased focus on reducing fossil fuel generation the question frequently comes up as to, “How much solar and wind can be integrated with the grid without unduly impacting system reliability?” The increase in renewables relative to conventional generation is often referred to as “penetration”. The US grids have sufficient robustness such that small penetration levels do not pose excessive risk, however high levels of penetration raise serious reliability concerns. This post will argue that there is not a single answer and that the answers are not easy, therefore estimates will involve considerable uncertainty. Casual readers may want to read the “Key Points” and then skip to the “Conclusions” or specific topics of interest. Those seeking a more optimistic assessment may want to read Volume 4 of the National Renewable Energy Laboratory’s Renewables Electricity Futures Report. Key Points There has been a high value placed on having an extremely reliable bulk grid as the costs and consequences of bulk grid outages are severe The bulk grid supports and is supported by conventional rotating generators (Coal, natural gas, hydro, nuclear, biomass) which provide “Essential Reliability Services” (ERSs) Wind and solar provide increased reliability risks because they are new changing technologies, they are intermittent and they do not as readily provide ERSs Current high levels of reliability depend upon experience gained over time through the gradual adoption of new technologies Wind and solar can be made to provide approximations of ERSs, but that requires significant increased costs and reduced generation output Because of the complexity of impacting factors and the high level of reliability maintained for the US grids, systemic degradation of the reliability of the grid is hard to detect and measure The amount of renewable penetration that can be accommodated will vary from area to area and power system to power system – There is not a single answer Because conventional resources produce an abundance of ERSs, accommodation of low levels of renewables may be accomplished with negligible risks Because current renewables do not provide adequate ERSs high penetration levels provide significant risks Between the above two levels there is a gap of (wicked?) uncertainty. For assessing grid reliability, the maximum penetration of wind and solar during times of stress is the key number not the “average” contribution of wind and solar Increased penetration of such asynchronous resources, all else equal, will likely adversely impact bulk grid reliability As the penetration level of asynchronous generation increases this will either increase cost, limit operational flexibility, degrade reliability or most likely result in a combination of all three factors The above statements have the following important caveats In some situations renewable resources may have some practical benefits and better support reliability in some limited applications For example: Air quality standards often prohibit the location of new generation resources in congested areas. If renewable resources are allowed to be located close to load centers –the system may see benefits Electronic emulation of ERSs in some cases will not be as good as actual synchronous machines, but with proper controls it may also be better in some cases Given time the reliability risk associated with new technology can be reduced as more experience is gained so that penetration levels can be increased What is Meant by Bulk Grid Reliability and Why is it So Hard to Measure? Bulk Grid Reliability applies to the high voltage backbone system that supports bulk generation and the load serving distribution systems. Bulk reliability is concerned with preventing voltage collapse, instability, cascading outages and uncontrolled separation. Events of this sort make national and international news when they occur on modern grids and are called blackouts. They are widespread unplanned, unintentional loss of load. There is a fundamental difference between these events and brownouts. The term brownouts sometimes refer to periods of low voltage and these can damage equipment and disrupt service. When load is deliberately shed (outages occurs by design in a controlled manner) this is also sometimes referred to as a brownout, blackout or as rotating blackouts. This situation can result from poor reliability, but is actually employed as a reliability measure to protect the bulk grid from a major outage. Avoiding needed load curtailments (in order to avoid adverse public relations and the economic burdens imposed by such curtailments) is a reliability risk itself. The impacts of uncontrolled outages are far more severe than controlled or contained area loss of load. The Northeast Blackout of 2003 is an example of a bulk system blackout. It impacted 55 Million people in the US and Canada, causing an estimated $6 billion in damage, shutting down major cities, interrupting industrial processes, leaving many businesses, residences and industries without power for days, some for nearly a week and contributing to at least 11 deaths. Grid Reliability is very different from distribution reliability, which is more concerned with individual consumer outages (or even city wide blackouts in some cases) that occur due to localized distribution networks. Distribution outage data is not directly related to grid reliability and cannot serve as a measure of grid reliability, although it is not uncommon to see articles touting the strength of the German grid based on measures of distribution reliability. Assessing grid strength based on measures of distribution performance is as inappropriate as would be assessing the foundational strength of a bridge based upon the crash performance of its guardrails. Major power outages (blackouts) are costly infrequent events and are hopefully are becoming rarer and more infrequent on modern grids. Unless caused by major natural disasters they are typically associated with multiple things going wrong. In a complex, 24 hours a day system over the course of time it is inevitable however that at times multiple things might go wrong, however power systems should be sufficiently robust that such confluences of events do not lead to major disturbances. There is not a clear easy answer as to what is “robust enough”. As noted major grid outages are rare. If the reliability of the system is significantly reduced, we may not see additional major outages for years anyway. Moderate sized utilities may spend tens of millions of dollars to reduce risks related to major outages that might have less than a 50/50 chance of occurring in a 50 year time span. The results of such valuations of reliability are not readily observed in any available performance measures. The industry is struggling to develop such measures. The best thing we have going for us beyond our models is the experience with current technologies. If the current level of reliability were to be greatly reduced it could be a while before the impacts become obvious. But over time consequences will emerge. If bulk system reliability is allowed to degrade it will be challenging to turn it around and return to today’s high levels. Planners have confidence that at low levels of penetration the existing conventional synchronous rotating machines will likely provide sufficient robustness in most cases. At very high levels of penetration from intermittent renewables the system will disproportionately lack contributions from synchronous machines which support the grids stable and reliable operation. The “uncertainty range” is large. Generally the more synchronous rotating machines with inertial mass the better. Planners desire a large amount of margin (as it can be eaten up by unusual and unanticipated events). Conventional Rotating Generators Support the Grid in Ways That Solar and Wind Do Not Conventional generation has characteristics that support the stability and operation of the grid. They have inertial mass and spin in synchronism with the wave forms powering the system while readily providing voltage and frequency support. The grid was built upon and depends on the characteristics associated with large rotating machines. For additional, more detailed information on this topic see the following posts: “Transmission Planning: wind and solar”, “More renewables? Watch out for the Duck Curve”, and “All megawatts are not equal”. The North American Electric Reliability Corporation (NERC) recently issued an announcement stating that “New generation resources must provide adequate levels of frequency support, ramping capability and voltage control to maintain the reliability of the bulk power system during its ongoing transformation”. This NERC Report provides more detail as do these basic introductory videos on load ramping, voltage and frequency. They describe the collective desirable characteristics of generation known as essential reliability services (ERSs). Modern wind resources do not economically spin in synchronism with the grid so they are electrically decoupled from the system. Solar generation does not involve rotating machinery. Solar and wind do not inherently provide ERSs. In addition wind and solar are intermittent resources. This dramatically increases the number of potential operating scenarios to be studies and increases the chances that unanticipated scenarios might cause problems. An additional emerging area of concern centers on protecting the system from faults. When faults occur on the system it is essential that that the impacted parts of the system be quickly disconnected and isolated from the grid. Extended faults can cause significant damage and lead to system collapse. When a fault occurs, conventional generators contribute an inrush of “fault current” (short circuit current). The protective devices (relays) sense parameters associated with fault current and know how and when to operate to properly isolate the fault. Closer relays respond more quickly and more distant relays operate more slowly in order to serve as backup in case of failure. This approach minimizes outraged elements while providing redundancy for relay failures. When inverter-based generation (wind and solar) replaces traditional synchronous generation the fault current contribution is approximately cut in half. Fault currents will vary significantly depending on whether there is low or high renewable penetration at any given time. With higher than expected fault currents, distant relays may trip too soon. With lower than expected fault current all relays may not operate quickly enough. Accommodating higher and varying penetration levels will require comprehensive studies, system-wide relay coordination efforts, large capital improvement projects and labor intensive testing and engineering in order to implement the new relay schemes.

#### Renewable transition requires substantial changes to the grid that they don’t fiat.

Grace Hood, 7-8-2019, "Experts Say U.S. Power Grid Needs To Change Before Shifting To All Renewable Energy," NPR.org, https://www.npr.org/2019/07/08/739643772/experts-say-u-s-power-grid-needs-to-change-before-shifting-to-all-renewable-ener

HOOD: The job is harder when you have renewables in the mix. The sun doesn't always shine, and the wind doesn't always blow. Xcel Energy uses weather forecasts. It even has meteorologists on staff. It ramps up natural gas and coal plants when needed. But to become 100% carbon-free, they may need to get more clean power from other states and develop new technologies.

BARTLETT: As we move towards a carbon-free grid, we have ideas of how we're going to get there, but there are other parts of it that we don't know.

HOOD: Including how they'd move renewable energy across long distances. Rich Sedano heads up the Regulatory Assistance Project, a nonprofit focused on the clean energy transition.

RICH SEDANO: We're going to need to have a lot of changes in the system to make a very high-penetration renewable system work.

HOOD: Sedano says one idea is to send renewable power from where it's plentiful to where it's most needed, from sunny California to the East, for example. But the nation's grid is fragmented. It would take a system of efficient high-voltage transmission lines for this to work, and that doesn't exist. Sedano says Congress would have to make that a higher priority.

SEDANO: Generally, we don't get the kind of direction that will motivate these kinds of big-picture developments.

HOOD: Building those transmission lines could also cost billions, meaning cutting down lots of trees, and pose a major headache getting the right of way from landowners. The lack of political will and federal dollars means, right now, grid improvements are all local.

In Colorado, Xcel is spending hundreds of millions of dollars to update its grid so it can better manage intermittent power sources, like rooftop solar on homes. Drake Bartlett says in the future, it could also let customers hook up smart appliances that would run when electricity is cheaper.

BARTLETT: So the advanced grid allows that to happen. It's an enabler, even though a lot of those technologies don't exist yet.

#### Grid collapse in one area spills over to the whole grid.

Tollefson 13 (Jeff Tollefson. “US electrical grid on the edge of failure,” *International weekly journal of science*. 25 Aug. 2013, <https://www.nature.com/news/us-electrical-grid-on-the-edge-of-failure-1.13598>.) LHSLA LH

Facebook can lose a few users and remain a perfectly stable network, but where the national grid is concerned simple geography dictates that it is always just a few transmission lines from collapse.

That is according to a mathematical study of spatial networks by physicists in Israel and the United States. Study co-author Shlomo Havlin of Bar-Ilan University in Ramat-Gan, Israel, says that the research builds on earlier work by incorporating a more explicit analysis of how the spatial nature of physical networks affects their fundamental stability. The upshot, published today in Nature Physics, is that spatial networks are necessarily dependent on any number of critical nodes whose failure can lead to abrupt — and unpredictable — collapse1.

The electric grid, which operates as a series of networks that are defined by geography, is a prime example, says Havlin. “Whenever you have such dependencies in the system, failure in one place leads to failure in another place, which cascades into collapse.”

#### Grid collapse cascades

Patrick J. Kiger, 10-25-2013, "’American Blackout’: Four Major Real-Life Threats to the Electric Grid," National Geographic, https://www.nationalgeographic.com/environment/great-energy-challenge/2013/american-blackout-four-major-real-life-threats-to-the-electric-grid/ LHSLA LH

A catastrophic, prolonged failure of the electrical grid—the sort of event whose effects are depicted in National Geographic Channel’s upcoming American Blackout, which premieres Sunday—may seem like just apocalyptic science fiction to some viewers. Unfortunately, though, the possibility of such a breakdown is all too real. (See related interactive: “Survive the Blackout.”)

Government and utility industry officials are so concerned, in fact, that in November, they will stage a massive emergency drill, called GridEx II, that will involve thousands of utility workers, business executives, National Guard officers, FBI antiterrorism experts and government officials from the U.S., Canada and Mexico. They’ll practice responding to a simulated failure of large parts of the electrical system across North America. (See related quiz: “What You Don’t Know About Electricity.”)

The scenario envisioned by GridEx II is a particularly scary one, in which terrorists or an enemy country stages a combination of cyber attacks and physical attacks that destroy or render inoperable crucial power facilities and take down large sections of the grid. As a May 2013 Congressional report noted, sophisticated cyber saboteurs may already be probing our vulnerability to a massive blackout. U.S. utility companies already come under frequent attack from Internet hackers who continually try to infect utilities’ computer networks with malware and search for security flaws. One company alone told congressional investigators that it was hit with an astonishing 10,000 attacks in a typical month.

If hackers managed to penetrate utility companies’ electronic defenses, they might be able to give instructions to key pieces of equipment that would cause them to fail. In a 2006 study, researchers at the Department of Energy’s Idaho National Laboratory demonstrated that an attacker could instruct an electrical generator’s turbine to spin wildly out of control until smoke began pouring out, as this video illustrates. Since then, we’ve seen a real-life example of how such vandalism easily could be ratcheted up to a massive scale. In 2010, a piece of malware called Stuxnet destroyed as many as 1,000 centrifuges in an Iranian nuclear fuel-processing plant, in an attack that some suspect was launched by U.S. and/or Israeli clandestine agencies.

No wonder that former federal counterterrorism advisor Richard Clarke has warned that such an “electronic Pearl Harbor” could cause devastating damage and thousands of deaths across the nation. A 2012 National Academy of Sciences report concurred, envisioning that attackers using a combination of hacking and physical sabotage could cripple the U.S. power grid and cause cascading failures of equipment that could take months to fix.

“We are woefully unprepared for any large-scale geographic outage that might take place over an extended period of time,” explained Joel Gordes, research director for the U.S. Cyber Consequences Unit, an independent group that assesses the danger of such attacks and what it would take to thwart them. He said that while some generators and transmission lines probably would survive such an attack, they might not be able to muster enough juice to reboot the grid, which experts call a “black start.” And if critical equipment is damaged beyond repair, it might be necessary to transport replacement units long distances—an undertaking that would be difficult, if communications systems were also seriously damaged by the attack.

U.S. Secretary of Energy Ernest Moniz said the Energy Department had recently created a new internal cyber council, spanning four offices. “We believe this is an area of increasing focus,” he said at a Center for Strategic and International Studies on Thursday. “Our energy infrastructures are coming under increasing and more sophisticated cyber attacks, and we have to stay ahead of that.”

Besides a cyber attack, experts have envisioned other scenarios for a grid collapse.

EMP (electromagnetic pulse) attack: In this scenario, terrorists or an enemy nation would detonate a nuclear weapon at a high altitude above the U.S., releasinga burst of radiation that would interact with the Earth’s magnetic field and atmosphere—including the ionosphere, the thin upper layer filled with free electrons, which facilitates radio communications. As a result, a powerful electrical current would radiate down to the Earth and create additional currents that would course through manmade electrical circuits as well. Electrical infrastructure and electronic devices would receive severe shocks, causing severe, widespread damage. A 2004 Congressional commission warned that such an attack could cause “unprecedented cascading failures.” But even a localized EMP attack could cause a lot of damage. A 2008 Congressional Research Service report predicted that an attack on the Washington DC-Baltimore region that only damaged 10 percent of communications systems and the electrical grid and 20 percent of electronic devices would still require a month of recovery time and inflict as much as $34 billion in economic losses.

Solar flare: Not all of the threats to the grid are from human enemies. A solar storm, which would spew a surge of radiation across the 93million-mile distance between the Sun and our Earth, causing an electromagnetic pulse similar to the one that a high-altitude nuclear blast would trigger–except that it might be even bigger, and have even more devastating effects. While we’ve known the destructive effects of solar weather on Earth’s electrical infrastructure since the 19th century, the first really clear-cut warning came in 1989, when a moderate-intensity solar storm caused northeastern Canada’s Hydro-Quebec power grid to fail, leaving millions of people without electricity for nine hours. Yousef Butt, a scientist at Center for Astrophysics at Harvard University, argued in a 2010 article in the online journal Space Review that the likelihood of a devastating EMP from a solar storm is greater than that from an intentional EMP attack. (See related story: “As Sun Storms Ramp Up, Electric Grid Braces for Impact.”)

Grid failure: There’s also the possibility that the grid simply could break down on its own. (See related photos: “The World’s Worst Power Outages.”) That’s because of a crucial design flaw: when one part of the grid breaks down, it can cause a phenomenon called “cascading failure,” in which the whole grid progressively collapses like a stack of dominoes. “What happens is, a failure occurs somewhere and weakens the system a bit,” Iowa State University engineering professor Ian Dobson explained in a 2012 article. “On a bad day, something else happens. Usually it doesn’t, but on that day, let’s say, it does. If it’s a really bad day, then a third thing happens and the system becomes degraded. You’re in a situation where it’s more likely that the next failure is going to happen because the last failure already happened. That’s the idea of cascading failure…Everything in the power system is protected so it doesn’t fry when something goes wrong. Things can disconnect to protect the equipment, but if you disconnect enough things, you get a blackout.” (See related blog post: “Preparing for the Zombie Apocalypse: Are Microgrids Our Only Chance?”)

#### Renewables collapse the grid.

Robert Blohm, 10-5-2019, "The Green New Deal’s Impossible Grid," WSJ, <https://www.wsj.com/articles/the-green-new-deals-impossible-electric-grid-11550705997> LHSLA LH

The Democrats’ Green New Deal calls for a fully renewable electric power grid. Regardless of the economic or political challenges of bringing this about, it is likely technologically impossible.

An electric power grid involves second-by-second balancing between generated supply and consumer demand. In the case of a sudden imbalance—such as from the loss of a generator’s output—all the remaining generators on the grid instantaneously pool together. Each one pitches in a small part of the required power to make up for the lost generator fast enough to keep supply and demand balanced.

This doesn’t work for wind and solar because you can’t spontaneously increase wind or sunshine. Hydro power is limited and unevenly distributed around the country. And for safety reasons, nuclear power—even if the Green New Dealers accepted it—can’t be cranked up to neutralize imbalances. Nor can consumer demand be suddenly reduced enough.

Fossil-fuel turbines, by contrast, very naturally compensate for sudden supply outages. The inertia of the spinning mass of rotors provides the extra energy needed to compensate for the loss for the first few seconds. (Wind-rotor inertia is too short-lived.) Meanwhile the generators’ on-line reserve capacity kicks in, giving a rapid boost in power output to prevent the turbines from slowing down. That substitute power, called “governor response,” lasts as long as 15 minutes. During that time a single replacement generator ramps up to compensate entirely for the loss. All the turbines on the grid are thereby restored to their original speed, and the governor response is rearmed for the next disturbance.

An all-renewables grid would require prohibitively expensive battery storage to compensate for sudden power losses. Even with batteries, the lost power would have to be fed through “inverters”—a technology that converts variable-wind-speed alternating current, solar-power direct current, and battery-power direct-current into alternating current—to allow for synthetic inertia and governor response in the case of a disruption.

But according to a 2017 report from the Institute of Electrical and Electronics Engineers, if a large enough share of the power grid flows through inverters, the grid itself may collapse. Existing inverter technologies have faced serious software problems and prompted outages where they have been deployed. The IEEE is trying to create a global standard for inverter design—though heavy input by Chinese suppliers bent on commandeering the technology may pose a national-security risk if the U.S. were to incorporate the standard.

How could the market price in the cost of providing rapid replacement energy that renewable sources can’t provide reliably? The entity that caused the outage should need to pay. Yet the power industry—to say nothing of the Green New Dealers—hasn’t given this much thought. An all-renewables power grid is destined to collapse.

### AT Microgrids Solve

#### Microgrids need subsidies to work—you don’t fiat that.

Xu and Long 6-5 (Deng Xu and Yong Long, School of Economics and Business Administration, Chongqing University, Chongqing 400030, China. “The Impact of Government Subsidy on Renewable Microgrid Investment Considering Double Externalities,” MDPI. 6-5-19. [file:///C:/Users/lucas/Downloads/sustainability-11-03168-v2.pdf](file:///C%3A/Users/lucas/Downloads/sustainability-11-03168-v2.pdf)) LHSLA LH

Although some researchers have determined that the deployment of renewable microgrids can boost employment, ensure energy security, adjust the energy supply structure, share investment risks, and so forth, these are insufficient reasons to implement government subsidies from the perspective of the free market economy. In this paper, we argue that the economic rationales for government subsidies for renewable microgrids derive from market failures along with double externalities. One rationale for such subsidies is the learning spillover effect. Key microgrid technologies, such as distributed energy storage, controls and supervisory systems, and protection and automation, still require an immense amount of research. The R&D of an individual company is beneficial for the whole microgrid industry through the spillover effect and significantly contributes to microgrid cost reduction. Therefore, it is necessary to offer subsidies for microgrids due to the weak protection of intellectual property rights since China is still in a transition stage. Another rationale is the environmental externality of renewable energy. While microgrids can reduce carbon emissions by substituting for electricity generated by fossil fuels, the societal benefits cannot be included in the profit function of an individual microgrid. Consequently, the market price fails to signal the real cost of a microgrid when competing with conventional power. Simply put, we maintain that the economic rationales of renewable microgrid subsidies derive from their public interest benefits, in terms of both technology and the environment, and government intervention helps to internalize the double externalities.

#### Removing subsidies moves to the Grand Central grid model—fails and leads to collapse because of overcomplexity.

Notes: very complex card, please read the article. TSO = transmission system operator. DSO = distribution system operator. DER = distributed energy resources. ICT = Information communication technology. VPP = virtual power plants.

David Roberts 11-30-2018, "Clean energy technologies threaten to overwhelm the grid. Here’s how it can adapt.," Vox, <https://www.vox.com/energy-and-environment/2018/11/30/17868620/renewable-energy-power-grid-architecture> LHSLA LH \*Brackets in text

The electricity sector is changing rapidly and the grid is changing with it. That will continue no matter what. The question is whether to reinforce and enhance the current grid architecture or to conceive and build something new.

That choice is laid out in “A Tale of Two Visions: Designing a Decentralized Transactive Electric System,” published in 2016 in IEEE Power and Energy Magazine by Kristov, Paul De Martini of the California Institute of Technology, and Jeffrey Taft of the Pacific Northwest National Laboratory.

Kristov, De Martini, and Taft sketch two ways that the profusion of DERs can be managed, involving different roles for TSOs and DSOs. They purposefully describe two opposing poles, two contrasting extremes, acknowledging that in the real world many systems will be some mix, or may change incrementally and slowly from one to another.

The first vision is the logical extension of the current wholesale market system — just with a lot more DERs involved. The study’s authors call this the “Grand Central Optimization” model, because all optimization, all balancing of supply and demand, would be done in one place, the TSO. It is a “total TSO” model.

Under the Grand Central model, TSOs would continue to manage and dispatch DERs (or aggregations of DERs) for any transactions affecting wholesale markets. Wholesale markets would become much more complex, involving many more diverse participants.

This would be a “minimal DSO” model, in that the DSO, typically a distribution utility, would remain uninvolved in such transactions and continue merely to maintain operations and reliability at the distribution level.

Here’s how Grand Central might look, with lots and lots of DERs feeding energy and services directly into wholesale markets from down at the grid edge:



This is more or less where the system is heading by default, unless something big changes. But the evolution seems less intentional than a matter of path dependence and lack of holistic planning.

Kristov, De Martini, and Taft worry that Grand Central is not the right model — that it will ultimately increase the cost and complexity of integrating more renewable energy and DERs.

The details get can get technical, but there are two basic problems with Grand Central.

The first is that DERs more and more often serve two masters. They have a relationship with the TSO that bypasses the DSO, in the form of wholesale-market commitments. They also have a relationship with the DSO; it must manage them in the name of distribution-grid stability and reliability.

As DERs and their aggregations grow more numerous and larger, the risk arises that large chunks of the system will receive dueling instructions. The paper’s authors call this “tier bypassing, which occurs when two or more system components have multiple structural relationships with conflicting control objectives.”

The second problem is simply complexity. DERs are still at a fairly nascent level of development, but they are set to explode in coming years, as rooftop panels, electric vehicles, home batteries, and smart meters become more common. Soon there will be all kinds of combinations and aggregations, at all levels, across every one of hundreds of LDAs.

Wholesale markets could go from having dozens of participants to having hundreds, or thousands, or hundreds of thousands.

That’s going to be a lot for a TSO to track — a thicket of new rules, new enforcement mechanisms, and sheer computational bulk. “Under this model,” Kristov, De Martini, and Taft write, “the TSO needs detailed information and visibility into all levels of the system, from the balancing authority area [i.e., the TSO level] down through the distribution system to the meters on end-use customers and distribution-connected devices.”

TSOs would have to track and manage all this information while working alongside, and attempting to coordinate with, dozens of DSOs maintaining local reliability.

Already some TSOs are complaining to FERC that state energy policies are distorting their wholesale markets. Imagine when those federally run markets involve thousands of DER participants, all of which are also subject to a variety of state energy policies and all of which are also constrained by DSO reliability requirements.

These are the kinds of thoughts that give FERC commissioners migraines. Balancing the interests of TSOs against the interests of dozens of DSOs will be an unending hassle.

Some economists like to think that if each energy source and service were priced properly, based on its real-time, location-specific value, the market would allocate electricity with perfect efficiency. Just get the right pricing algorithms in place and let ’er rip.

But there are reasons to doubt that distribution systems, filled with quirky and unpredictable human behaviors, can be adequately guided by the invisible hand alone. They need a more personal touch.

Kristov, De Martini, and Taft take no stand in the paper on whether the Grand Central model is possible, but when I asked De Martini directly, he was frank. “I don’t think the grand centralization model will work at scale,” he said, “as there are too many dynamic, random variables [in distribution systems] involving both machines and humans.”

“As I think about a TSO trying to have full awareness of what’s going on in a distribution system, bringing that together in a simultaneous optimization with the transmission grid, it just doesn’t make sense,” Kristov told me. “It seems needlessly complex. But if you don’t have that, then you need the DSO to step up to some higher-level responsibilities.”

## Renewables I/L

#### Renewables causes grid collapse

Popik 17 (“TESTIMONY OF THE FOUNDATION FOR RESILIENT SOCIETIES”, [https://www.ferc.gov/CalendarFiles/20170717080647-Popik,%20Resilient%20Societies.pdf](https://www.ferc.gov/CalendarFiles/20170717080647-Popik%2C%20Resilient%20Societies.pdf),)

Many people are hoping for wind and solar PV to transform grid electricity in a favorable way. Is this really possible? Is it really feasible for intermittent renewables to generate a large share of grid electricity? The answer increasingly looks as if it is, “No, the costs are too great, and the return on investment would be way too low.” We are already encountering major grid problems, even with low penetrations of intermittent renewable electricity: US, 5.4 percent of 2015 electricity consumption; China, 3.9 percent; Germany, 19.5 percent; Australia, 6.6 percent. In fact, I have come to the rather astounding conclusion that even if wind turbines and solar PV could be built at zero cost, it would not make sense to continue to add them to the electric grid in the absence of very much better and cheaper electricity storage than we have today. There are too many costs outside building the devices themselves. It is these secondary costs that are problematic. Also, the presence of intermittent electricity disrupts competitive prices, leading to electricity prices that are far too low for other electricity providers, including those providing electricity using nuclear or natural gas. The tiny contribution of wind and solar to grid electricity cannot make up for the loss of more traditional electricity sources due to low prices. Leaders around the world have demanded that their countries switch to renewable energy, without ever taking a very close look at what the costs and benefits were likely to be. A few simple calculations were made, such as “Life Cycle Assessment” and “Energy Returned on Energy Invested.” These calculations miss the fact that the intermittent energy being returned is of very much lower quality than is needed to operate the electric grid. They also miss the point that timing and the cost of capital are very important, as is the impact on the pricing of other energy products. This is basically another example of a problem I wrote about earlier, Overly Simple Energy-Economy Models Give Misleading Answers. Let’s look at some of the issues that we are encountering, as we attempt to add intermittent renewable energy to the electric grid. Issue 1. Grid issues become a problem at low levels of intermittent electricity penetration. In 2015, wind and solar PV amounted to only 12.2 percent of total electricity consumed in Hawaii, based on EIA data. Even at this low level, Hawaii is encountering sufficiently serious grid problems that it has needed to stop net metering (giving homeowners credit for the retail cost of electricity, when electricity is sold to the grid) and phase out subsidies. Figure 1. Hawaii Electricity Production, based on EIA data. Other Disp. electricity is the sum of various other non-intermittent electricity sources, including geothermal and biomass burned as fuel. Hawaii consists of a chain of islands, so it cannot import electricity from elsewhere. This is what I mean by “Generation = Consumption.” There is, of course, some transmission line loss with all electrical generation, so generation and consumption are, in fact, slightly different. The situation is not too different in California. The main difference is that California can import non-intermittent (also called “dispatchable”) electricity from elsewhere. It is really the ratio of intermittent electricity to total electricity that is important, when it comes to balancing. California is running into grid issues at a similar level of intermittent electricity penetration (wind + solar PV) as Hawaii–about 12.3 percent of electricity consumed in 2015, compared to 12.2 percent for Hawaii. Figure 2. California electricity consumption, based on EIA data. Other Disp. is the sum of other non-intermittent sources, including geothermal and biomass burned for electricity generation. Even with growing wind and solar production, California is increasingly dependent on non-intermittent electricity imported from other states. Issue 2. The apparent “lid” on intermittent electricity at 10 percent to 15 percent of total electricity consumption is caused by limits on operating reserves. Electric grids are set up with “operating reserves” that allow the electric grid to maintain stability, even if a large unit, such as a nuclear power plant, goes offline. These operating reserves typically handle fluctuations of 10 percent to 15 percent in the electricity supply. If additional adjustment is needed, it is possible to take some commercial facilities offline, based on agreements offering lower rates for interruptible supply. It is also possible for certain kinds of power plants, particularly hydroelectric and natural gas “peaker plants,” to ramp production up or down quickly. Combined cycle natural gas plants also provide reasonably fast response. In theory, changes can be made to the system to allow the system to be more flexible. One such change is adding more long distance transmission, so that the variable electricity can be distributed over a wider area. This way the 10 percent to 15 percent operational reserve “cap” applies more broadly. Another approach is adding energy storage, so that excess electricity can be stored until needed later. A third approach is using a “smart grid” to make changes, such as turning off all air conditioners and hot water heaters when electricity supply is inadequate. All of these changes tend to be slow to implement and high in cost, relative to the amount of intermittent electricity that can be added because of their implementation. Issue 3. When there is no other workaround for excess intermittent electricity, it must be curtailed–that is, dumped rather than added to the grid. Overproduction without grid capacity was a significant problem in Texas in 2009, causing about 17 percent of wind energy to be curtailed in 2009. At that time, wind energy amounted to about 5.0 percent of Texas’s total electricity consumption. The problem has mostly been fixed, thanks to a series of grid upgrades allowing wind energy to flow better from western Texas to eastern Texas. Figure 3. Texas electricity net generation based on EIA data. The Texas grid is separate, so there is no imported or exported electricity. In 2015, total intermittent electricity from wind and solar amounted to only 10.1 percent of Texas electricity. Solar has never been large enough to be visible on the chart–only 0.1 percent of consumption in 2015. The total amount of intermittent electricity consumed in Texas is only now beginning to reach the likely 10 percent to 15 percent limit of operational reserves. Thus, it is “behind” Hawaii and California in reaching intermittent electricity limits. Based on the modeling of the company that oversees the California electric grid, electricity curtailment in California is expected to be significant by 2024, if the 40 percent California Renewable Portfolio Standard (RPS) is followed, and changes are not made to fix the problem. Issue 4. When all costs are included, including grid costs and indirect costs, such as the need for additional storage, the cost of intermittent renewables tends to be very high. In Europe, there is at least a reasonable attempt to charge electricity costs back to consumers. In the United States, renewable energy costs are mostly hidden, rather than charged back to consumers. This is easy to do, because their usage is still low. Euan Mearns finds that in Europe, the greater the proportion of wind and solar electricity included in total generation, the higher electricity prices are for consumers. Figure 5. Figure by Euan Mearns showing relationship between installed wind + solar capacity and European electricity rates. Source Energy Matters. The five countries shown in red have all had financial difficulties. High electricity prices may have contributed to their problems. The United States is not shown on this chart, since it is not part of Europe. If it were, it would be a bit below, and to the right of, Czech Republic and Romania. Issue 5. The amount that electrical utilities are willing to pay for intermittent electricity is very low. The big question is, “How much value does adding intermittent electricity add to the electrical grid?” Clearly, adding intermittent electricity allows a utility to reduce the amount of fossil fuel energy that it might otherwise purchase. In some cases, the addition of solar electricity slightly reduces the amount of new generation needed. This reduction occurs because of the tendency of solar to offer supply when the usage of air conditioners is high on summer afternoons. Of course, in advanced countries, the general tendency of electricity usage is down, thanks to more efficient light bulbs and less usage by computer screens and TV monitors. At the same time, the addition of intermittent electricity adds a series of other costs: - Many more hook-ups to generation devices are needed. Homes now need two-way connections, instead of one-way connections. Someone needs to service these connections and check for problems. - Besides intermittency problems, the mix of active and reactive power may be wrong. The generation sources may cause frequency deviations larger than permitted by regulations. - More long-distance electricity transmission lines are needed, so that the new electricity can be distributed over a wide enough area that it doesn’t cause oversupply problems when little electricity is needed (such as weekends in the spring and fall). - As electricity is transported over longer distances, there is more loss in transport. - To mitigate some of these problems, there is a need for electricity storage. This adds two kinds of costs: (1) Cost for the storage device, and (2) Loss of electricity in the process. - As I will discuss later, intermittent energy tends to lead to very low wholesale electricity prices. Other electricity providers need to be compensated for the effects these low prices cause; otherwise they will leave the market. To sum up, when intermittent electricity is added to the electric grid, the primary savings are fuel savings. At the same time, significant costs of many different types are added, acting to offset these savings. In fact, it is not even clear that when a comparison is made, the benefits of adding intermittent electricity are greater than the costs involved. According to the EIA’s 2015 Wind Technologies Market Report, the major way intermittent electricity is sold to electric utilities is as part of long term Power Purchase Agreements (PPAs), typically lasting for 20 years. Utilities buy PPAs as a way of hedging against the possibility that natural gas prices will rise in the future. The report indicates that the recent selling price for PPAs is about $25 to $28 per MWh (Figure 6). This is equivalent to 2.5 to 2.8 cents per kWh, which is very inexpensive. (Click to enlarge) Figure 6. EIA exhibit showing the median and mean cost of wind PPAs compared to EIA’s forecast price of natural gas, from 2015 Wind Technologies Market Report. In effect, what utilities are trying to do is hedge against rising fuel prices of whatever kind they choose to purchase. They may even be able to afford to make other costly changes, such as more transmission lines and energy storage, so that more intermittent electricity can be accommodated. Issue 6. When intermittent electricity is sold in competitive electricity markets (as it is in California, Texas, and Europe), it frequently leads to negative wholesale electricity prices. It also shaves the peaks off high prices at times of high demand. In states and countries that use competitive pricing (rather than utility pricing, used in some states), the wholesale price of electricity price varies from minute to minute, depending on the balance between supply and demand. When there is an excess of intermittent electricity, wholesale prices often become negative. Figure 7 shows a chart by a representative of the company that oversees the California electric grid. (Click to enlarge) Figure 7. Exhibit showing problem of negative electricity prices in California, from a presentation at the 2016 EIA Annual Conference. Clearly, the number of negative price spikes increases, as the proportion of intermittent electricity increases. A similar problem with negative prices has been reported in Texas and in Europe. When solar energy is included in the mix of intermittent fuels, it also tends to reduce peak afternoon prices. Of course, these minute-by-minute prices don’t really flow back to the ultimate consumers, so it doesn’t affect their demand. Instead, these low prices simply lead to lower funds available to other electricity producers, most of whom cannot quickly modify electricity generation. Related: Is Elon Musk Taking Advantage Of Solar City Investors? To illustrate the problem that arises, Figure 8, prepared by consultant Paul-Frederik Bach, shows a comparison of Germany’s average wholesale electricity prices (dotted line) with residential electricity prices for a number of European countries. Clearly, wholesale electricity prices have been trending downward, while residential electricity prices have been rising. In fact, if prices for nuclear, natural gas, and coal-fired electricity had been fair prices for these other providers, residential electricity prices would have trended upward even more quickly than shown in the graph! Figure 8. Residential Electricity Prices in Europe, together with Germany spot wholesale price Note that the recent average wholesale electricity price is about 30 euros per MWh, which is equivalent to 3.0 cents per kWh. In US dollars this would equate to $36 per MWh, or 3.6 cents per kWh. These prices are higher than prices paid by PPAs for intermittent electricity ($25 to $28 per MWh), but not a whole lot higher. The problem we encounter is that prices in the $36 MWh range are too low for almost every kind of energy generation. Figure 9 from Bloomberg is from 2013, so is not entirely up to date, but gives an idea of the basic problem. (Click to enlarge) Figure 9. Global leveled cost of energy production by Bloomberg. A price of $36 per MWh is way down at the bottom of the chart, between 0 and 50. Pretty much no energy source can be profitable at such a level. Too much investment is required, relative to the amount of energy produced. We reach a situation where nearly every kind of electricity provider needs subsidies. If they cannot receive subsidies, many of them will close, leaving the market with only a small amount of unreliable intermittent electricity, and little back-up capability. This same problem with falling wholesale prices, and a need for subsidies for other energy producers, has been noted in California and Texas. The Wall Street Journal ran an article earlier this week about low electricity prices in Texas, without realizing that this was a problem caused by wind energy, not a desirable result! Issue 7. Other parts of the world are also having problems with intermittent electricity. Germany is known as a world leader in intermittent electricity generation. Its intermittent generation hit 12.2 percent of total generation in 2012. As you will recall, this is the level where California and Hawaii started to reach grid problems. By 2015, its intermittent electricity amounted to 19.5 percent of total electricity generated. Figure 10. German electricity generated, based on BP Statistical Review of World Energy 2016. Needless to say, such high intermittent electricity generation leads to frequent spikes in generation. Germany chose to solve this problem by dumping its excess electricity supply on the European Union electric grid. Poland, Czech Republic, and Netherlands complained to the European Union. As a result, the European Union mandated that from 2017 onward, all European Union countries (not just Germany) can no longer use feed-in tariffs. Doing so provides too much of an advantage to intermittent electricity providers. Instead, EU members must use market-responsive auctioning, known as “feed-in premiums.” Germany legislated changes that went even beyond the minimum changes required by the European Union. Dörte Fouquet, Director of the European Renewable Energy Federation, says that the German adjustments will “decimate the industry.” In Australia, one recent headline was Australia Considers Banning Wind Power Because It’s Causing Blackouts. The problem seems to be in South Australia, where the last coal-fired power plants are closing because subsidized wind is leading to low wholesale electricity prices. Australia, as a whole, does not have a high intermittent electricity penetration ratio (6.6 percent of 2015 electricity consumption), but grid limitations mean that South Australia is disproportionately affected. Related: Slashing Dividends: The Only Option Left For Big Oil? China has halted the approval of new wind turbine installations in North China because it does not have grid capacity to transport intermittent electricity to more populated areas. Also, most of China’s electricity production is from coal, and it is difficult to use coal to balance with wind and solar because coal-fired plants can only be ramped up slowly. China’s total use of wind and solar is not very high (3.9 percent of consumption in 2015), but it is already encountering major difficulties in grid integration. Issue 8. The amount of subsidies provided to intermittent electricity is very high. The renewable energy program in the United States consists of overlapping local, state, and federal programs. It includes mandates, feed-in tariffs, exemption from taxes, production tax credits, and other devices. This combination of approaches makes it virtually impossible to figure out the amount of the subsidy by adding up the pieces. We are pretty certain, however, that the amount is high. According to the National Wind Watch Organization: At the federal level, the production or investment tax credit and double-declining accelerated depreciation can pay for two-thirds of a wind power project. Additional state incentives, such as guaranteed markets and exemption from property taxes, can pay for another 10 percent. If we believe this statement, the developer only pays about 23 percent of the cost of a wind energy project. The US Energy Information Administration prepared an estimate of certain types of subsidies (those provided by the federal government and targeted particularly at energy) for the year 2013. These amounted to a total of $11.3 billion for wind and solar combined. About 183.3 terawatts of wind and solar energy was sold during 2013, at a wholesale price of about 2.8 cents per kWh, leading to a total selling price of $5.1 billion dollars. If we add the wholesale price of $5.1 billion to the subsidy of $11.3 billion, we get a total of $16.4 billion paid to developers or used in special grid expansion programs. This subsidy amounts to 69 percent of the estimated total cost. Any subsidy from states, or from other government programs, would be in addition to the amount from this calculation. Paul-Frederik Bach shows a calculation of wind energy subsidies in Denmark, comparing the prices paid under the Public Service Obligation (PSO) system to the market price for wind. His calculations show that both the percentage and dollar amount of subsidies have been rising. In 2015, subsidies amounted to 66 percent of the total PSO cost. Figure 11. Amount of subsidy for wind energy in Netherlands, as calculated by comparing paid for wind under PSO with market value of wind energy. In a sense, these calculations do not show the full amount of subsidy. If renewables are to replace fossil fuels, they must pay taxes to governments, just as fossil fuel providers do now. Energy providers are supposed to provide “net energy” to the system. The way that they share this net energy with governments is by paying taxes of various kinds–income taxes, property taxes, and special taxes associated with extraction. If intermittent renewables are to replace fossil fuels, they need to provide tax revenue as well. Current subsidy calculations don’t consider the high taxes paid by fossil fuel providers, and the need to replace these taxes, if governments are to have adequate revenue. Also, the amount and percentage of required subsidy for intermittent renewables can be expected to rise over time, as more areas exceed the limits of their operating reserves, and need to build long distance transmission to spread intermittent electricity over a larger area. This seems to be happening in Europe now. In 2015, the revenue generated by the wholesale price of intermittent electricity amounted to about 13.1 billion euros, according to my calculations. In order to expand further, policy advisor Daniel Genz with Vattenfall indicates that grids across Europe will need to be upgraded, at a cost of between 100 and 400 billion euros. In other words, grid expenditures will be needed of that amount to between 7.6 and 30.5 times wholesale revenues received from intermittent electricity in 2015. Most of this will likely need to come from additional subsidies, because there is no possibility that the return on this investment can be very high. There is also the problem of the low profit levels for all of the other electricity providers, when intermittent renewables are allowed to sell their electricity whenever it becomes available. One potential solution is huge subsidies for other providers. Another is buying a lot of energy storage, so that energy from peaks can be saved and used when supply is low. A third solution is requiring that renewable energy providers curtail their production when it is not needed. Any of these solutions is likely to require subsidies. Conclusion We already seem to be reaching limits with respect to intermittent electricity supply. The US Energy Information Administration may be reaching the same conclusion. It chose Steve Kean from Kinder Morgan (a pipeline company) as its keynote speaker at its July 2016 Annual Conference. He made the following statements about renewable energy. (Click to enlarge) Figure 12. Excerpt from Keynote Address slide at US Energy Administration Conference by Steve Kean of Kinder Morgan. This view is very similar to mine. Few people have stopped to realize that intermittent electricity isn’t worth very much. It may even have negative value, when the cost of all of the adjustments needed to make it useful are considered. Energy products are very different in “quality.” Intermittent electricity is of exceptionally low quality. The costs that intermittent electricity impose on the system need to be paid by someone else. This is a huge problem, especially as penetration levels start exceeding the 10 percent to 15 percent level that can be handled by operating reserves, and much more costly adjustments must be made to accommodate this energy. Even if wind turbines and solar panels could be produced for $0, it seems likely that the costs of working around the problems caused by intermittent electricity would be greater than the compensation that can be obtained to fix those problems. The situation is a little like adding a large number of drunk drivers, or of self-driving cars that don’t really work as planned, to a highway system. In theory, other drivers can learn to accommodate them, if enough extra lanes are added, and the concentration of the poorly operating vehicles is kept low enough. But a person needs to understand exactly what the situation is, and understand the cost of all of the adjustments that need to be made, before agreeing to allow the highway system to add more poorly behaving vehicles. In An Updated Version of the Peak Oil Story, I talked about the fact that instead of oil “running out,” it is becoming too expensive for our economy to accommodate. The economy does not perform well when the cost of energy products is very high. The situation with new electricity generation is similar. We need electricity products to be well-behaved (not act like drunk drivers) and low in cost, if they are to be successful in growing the economy. If we continue to add large amounts of intermittent electricity to the electric grid without paying attention to these problems, we run the risk of bringing the whole system down.

## Renewables Price Surges

#### Transition to renewables causes massive price surges- subsidies are the only check

Baker 19 (“Sometimes, a Greener Grid Means a 40,000% Spike in Power Prices”, <https://www.bloomberg.com/news/articles/2019-08-26/sometimes-a-greener-grid-means-a-40-000-spike-in-power-prices>)

The road to a world powered by renewable energy is littered with unintended consequences. Like a 40,000% surge in electricity prices. Texas power prices jumped from less than $15 to as much as $9,000 a megawatt-hour this month as coal plant retirements and weak winds left the region on the brink of blackouts during a heat wave. It’s a phenomenon playing out worldwide. Germany averted three blackouts of its own in June and has seen prices both spike and plunge below zero within days as it swaps out coal and nuclear energy for wind and solar. In the U.K., more than a million homes lost power on Aug. 9, in part because a wind farm tripped offline. The recent stumbles serve as a warning shot to the rest of the world as governments work to displace aging nuclear reactors and coal-fired power plants with cheaper and cleaner renewable energy. Grid operators, policy makers and power providers are learning the hard way that losing massive, around-the-clock generators can be a challenge, if not carefully planned. “We have to have systems in place to make sure we still have enough generation on the grid -- or else, in the best case, we have a blackout, and in the worst case, we have some kind of grid collapse,” said Severin Borenstein, an energy economist at the University of California at Berkeley, where state officials have a goal of getting all power from clean energy resources by 2045. Texas spot power prices surged during this month's heatwave There is no easy solution. In Germany, grid operators were forced to tap emergency reserves to avoid outages in the heat of June as some blamed bad wind generation forecasts. Power prices there surged at times on the prospect of shortages and plunged below zero at other times when solar generation flooded the system. A group representing the nation’s biggest power suppliers warned that the grid may become increasingly unstable as the government orders coal and nuclear plants to shut. “By 2023 at the latest, we will be running with eyes wide open into a shortfall in secure capacity,” said Stefan Kapferer, a managing director for the group BDEW. Governors of Germany’s coal regions have called on German Chancellor Angela Merkel to coordinate a carefully planned exit from the fossil fuel without sending power prices soaring and risking blackouts. The country is meanwhile expected to grow increasingly dependent on imports from neighbors, some of which are dealing with their own energy revolutions. In the U.K., where coal once provided nearly all electricity, inquiries into the August blackout found that a lightning strike on a transmission line north of London caused a natural gas plant and a giant offshore wind farm to drop off the grid. While officials are still probing the exact cause, National Grid Plc said in a preliminary report to regulators that it’s looking into better ways to incorporate renewables. “Wind generation, solar and interconnectors are different to the conventional electricity generation sources,” National Grid said in the report. In Australia, regulators this month took four wind farm operators to court, alleging that their facilities contributed to a massive 2016 blackout. The incident has sparked a debate over whether a nation so rich in coal and natural gas resources should even allow the grid to become so dependent on renewable power. Life Beyond Fossil Fuels Coal and gas will all but disappear from the U.K. energy mix by 2050 Source: BloombergNEF Note: Generation data estimated from 2019 Some grids have taken on large volumes of solar and wind without widespread blackouts. California, for example, often gets more than 40% of its power from renewable energy resources in the early afternoon and regularly sees its power prices drop below zero. Texas, which has more wind power than anywhere in America, is home to some of the cheapest wholesale electricity in the country. Renewable energy is now the most affordable source of new power generation in two-thirds of the world. Clean energy advocates point to batteries as a solution to renewables’ intermittent nature. Companies including Tesla Inc. and Germany’s Sonnen GmbH have developed massive energy-storage systems that can stockpile electricity when demand is low and dispatch it when it’s needed. Utilities have also pressed for stronger transmission networks. The Trump administration has argued the only way to keep a grid resilient is to keep money-losing coal and nuclear plants online with bailouts. Those efforts have gained little traction, but states are carving out subsidies to save reactors from early retirement, sparking a review by federal regulators that has already delayed the largest annual power auction in the U.S. by months. Meanwhile, in Texas, the grid is becoming increasingly exposed to the swings of wind generation. The run-up in electricity prices earlier this month was in part because generation from farms sank to the lowest level in months. Unlike Texas, some regions use capacity markets to ensure there’s enough power to keep the lights on. In these, plants get paid to guarantee power during a certain time period, even if it turns out the market doesn’t need their electricity. There are ways, said Daniel Shawhan, a research fellow with the Resources for the Future think tank, to make the switch to cleaner energy “such that the probability of a blackout does not go up.” (Michael R. Bloomberg, the founder and majority stakeholder of Bloomberg LP, the parent company of Bloomberg News, has committed $500 million to launch Beyond Carbon, a campaign aimed at closing the remaining coal-powered plants in the U.S. by 2030 and slowing the construction of new gas plants.)

## Subsidy Elimination Link

#### GOP ensures subsidies are here to stay—removing them decks the fossil fuel industry.

Dana Nuccitelli, 7-30-2018, "America spends over $20bn per year on fossil fuel subsidies. Abolish them," Guardian, <https://www.theguardian.com/environment/climate-consensus-97-per-cent/2018/jul/30/america-spends-over-20bn-per-year-on-fossil-fuel-subsidies-abolish-them> LHSLA LH

Imagine that instead of taxing cigarettes, America subsidized the tobacco industry in order to make each pack of smokes cheaper.

A report from Oil Change International (OCI) investigated American energy industry subsidies and found that in 2015–2016, the federal government provided $14.7bn per year to the oil, gas, and coal industries, on top of $5.8bn of state-level incentives (globally, the figure is around $500bn). And the report only accounted for production subsidies, excluding consumption subsidies (support to consumers to lower the cost of fossil fuel use – another $14.5bn annually) as well as the costs of carbon and other fossil fuel pollutants.

At a time when we need to transition away from fossil fuels as quickly as possible, the federal and state governments are giving the industry tens of billions of dollars to make the production of their dirty, dangerous products more profitable.

We already have to leave tapped fossil fuels in the ground

Crucially, the OCI report noted that if we want to meet the Paris target of limiting global warming to less than 2°C (and we do!), not only does the fossil fuel industry have to stop developing new reserves, but “some already-tapped reserves must be retired early.”

 Developed fossil fuel reserves vs. remaining carbon budget to meet 2°C and 1.5°C Paris climate targets. Illustration: Oil Change International

This reality is incompatible with continued US government subsidization of fossil fuel industry production, including $2.5bn per year for the exploration of new fossil fuel resources ­– new resources that simply cannot be developed if we’re to meet the Paris climate target.

To achieve that goal, we instead need to replace fossil fuels with clean energy as quickly as possible. And yet, OCI notes that permanent tax breaks to the US fossil fuel industry are more than seven times larger than those for renewable energy. Some of those fossil fuel subsidies have been around for over a century. And they’re making it profitable for the oil industry to extract resources that would otherwise be left in the ground:

at current prices, the production of nearly half of all U.S. oil is not economically viable, except with federal and state subsidies.

And as David Roberts notes, federal policy is also propping up the coal industry. Were they forced to meet modern pollution standards, 98% of currently operating coal power plants would be unprofitable compared to an equivalent natural gas plant. Coal power plants only stay open through regulations allowing pollution exemptions, and by forcing taxpayers to pick up the climate change bill.

Add another trillion dollars in climate subsidies

Without a price on carbon pollution, Americans are effectively subsidizing the fossil fuel industry for the costs incurred through its products’ climate change damages. For example, think about the added costs to taxpayers for worse wildfires, droughts, hurricanes, and flooding, all amplified by human-caused climate change. In the absence of a price on carbon pollution, the fossil fuel industry doesn’t pay a cent of those costs. Taxpayers pick up the whole tab.

These costs can be estimated via the ‘social cost of carbon.’ It’s a difficult number to pin down, but even at the extremely conservative US federal estimate of $37 per ton of carbon dioxide pollution (some recent research pegs the value at more than five times higher), that’s about $200bn per year for America and $1.3tn globally. While direct government subsidies to the fossil fuel industry are expensive, they’re dwarfed by the costs incurred by failing to tax carbon pollution.

The fossil fuel industry owns the GOP

The OCI report noted that the Obama administration actually proposed to eliminate 60% of federal fossil fuel industry subsidies, but that proposal went nowhere for one obvious reason:

In the 2015-2016 election cycle oil, gas, and coal companies spent $354 million in campaign contributions and lobbying and received $29.4 billion in federal subsidies in total over those same years - an 8,200% return on investment.

Of those fossil fuel industry contributions to political campaigns, 88% went to Republican politicians. As a result, 97% of House Republicans oppose taxing carbon pollution, and the Trump administration is looking into every possible scheme to further prop up the dying coal industry. The GOP might as well rebrand itself as the Grand Oil Party.

Americans needs to rethink what subsidies are for

Subsidies are a way for the government to assist an industry, hypothetically for good reason. For example, wind and solar power help meet our energy needs without producing harmful pollution in the process. Because of the associated societal benefits, it’s possible to justify subsidizing clean energy. Alternatively, we could eliminate all energy subsidies and instead tax carbon and other forms of pollution. If rising energy prices are a concern, we could offset those costs by returning the pollution tax revenue to taxpayers.

#### Abolishing subsidies kills oil and coal.

David Roberts 7-26-18, "Friendly policies keep US oil and coal afloat far more than we thought," Vox, <https://www.vox.com/energy-and-environment/2017/10/6/16428458/us-energy-coal-oil-subsidies> LHSLA LH

In an analysis published in Nature in October 2017, researchers from the Stockholm Environment Institute (SEI) attempt to clear this up, quantifying, to the extent possible, just how much a difference production subsidies make. They do this by focusing in on a specific economic decision on the part of producers: whether or not to develop a new oil field they’ve discovered.

After tallying up their own long list of production subsidies and attempting to calculate how those subsidies shift the economic returns of new production, they came to some pretty startling conclusions, emphasis mine:

We find that, at recent US oil prices of US$50 per barrel, tax preferences and other subsidies push nearly half of new, yet-to-be-developed oil into profitability. This potentially increases US oil production by almost 17 billion barrels over the next few decades, equivalent to 6 billion tonnes (Gt) of CO2.

Almost half of the new oil fields getting drilled would have been left alone if not for subsidies. That is no small effect!

The researchers acknowledge that the impact of subsidies on these decisions is extremely sensitive to oil prices. If oil prices rise back up to, say, $75bbl, as some forecasters project, the impact of subsidies will appear far smaller.

Photo of oil rigs sit just outside of Theodore Roosevelt National Park near Watford City, North Dakota.

Almost half of these from the least few years are thanks to your taxpayer dollars. Thanks? (Ken Cedeno/Corbis via Getty Images)

But at current low oil prices, subsidies are making a huge, huge difference.

Coal is propped up by government policy too

As the charts from OCI show, direct federal tax expenditures on behalf of coal production are dwarfed by oil and gas subsidies. The main federal tax subsidy is cheap leases to mine coal on public land.

But as a report from Carbon Tracker details, coal is still very much propped up by public policy.

It’s no big revelation that new coal plants are uneconomic. There hasn’t been a new coal plant built in the US in years and there will probably never be another one, for reasons of raw economics. Here are net capacity additions and subtractions from the US power fleet, from 2011 to 2016:

capacity additions

(Carbon Tracker)

As you can see, crappy old coal plants are coming offline and nobody’s building new plants to replace them.

Problem is, new coal plants have to be “clean,” which is to say, they have to have the filters and scrubbers to meet modern pollution standards. And as I’ve been saying for years, coal can either be cheap or clean, not both; making a new coal plant clean makes it uneconomic (to say nothing of what happens when you force it to bury its carbon).

What’s more striking is how imperiled existing, fully paid-off coal plants are. Even many of those can’t compete against natural gas or renewables.

Many existing coal plants are balanced on a fine edge. To the extent they can escape requirements to upgrade to modern pollution equipment — and believe it or not, decades after the Clean Air Act was passed, they still can — they can stay profitable for longer.

“When current costs are considered, 72% of operating coal units are unprofitable compared to the operating cost of an equivalent [natural gas plant],” Carbon Tracker writes, “and 98% when the anticipated costs [of environmental upgrades] are included.”

In other words, once the entire coal fleet upgrades to modern pollution standards ... basically none of it will be economically competitive. Cheap or clean; never both.

The A.E.P. (American Electric Power) coal burning plant in Conesville, Ohio.

Not v. competitive. (Michael Williamson/Washington Post/Getty Images)

That’s a narrow path to remaining profitable, and coal plants are only on that path at all because of all the other ways they are propped up by regulatory policy:

Capacity markets favor already-built coal over new natural gas or renewables: Unlike electricity markets, which pay for power, capacity markets pay for the ability to spin up, just in case. They are a way of maintaining reserve capacity in case other power plants unexpectedly go offline. For various reasons (see the report), such markets favor plants that are already amortized and have readily available fuel, i.e., generally coal plants. So yeah, even coal plants that rarely produce power still get paid to sit around and ... not be closed.

In regulated energy markets, utilities get paid to keep investing in unneeded, expensive coal plants: In competitive energy markets, plants close if they can’t make enough profit from their power to cover their ongoing costs. But in fully regulated markets (which contain 67 percent of US coal capacity), a utility’s return on investment in a plant is guaranteed by regulators, whether or not closing that plant would be better for ratepayers (as it very often would). Ironically, that’s why more coal plants in regulated markets have pollution-control equipment. In competitive markets, that would render them uneconomic (better just to shut them down). But in regulated markets, hell, why not? Every bit of investment means more guaranteed profits.

pollution equipment

(Carbon Tracker)

Utilities shuffle coal plants from their deregulated side to their regulated side, to shield them from competition: This one is so devious. Utility holding companies — which own utilities in both regulated and deregulated markets — move coal plants from the books of the latter to the books of the former, to shield them from competition and keep them alive via regulation. “This accounting practice typically shifts the economic burden from the shareholder to the consumer,” Carbon Tracker writes, “with the former often benefiting to the detriment of the latter.

Utilities hedge against changing natural gas costs: Some forecasters expect natural gas prices to rise in coming years (though, honestly, everyone is guessing). To hedge against that, utilities often keep uneconomic coal plants open, just in case rising NG prices retroactively render them economic.

This is just a partial accounting. The broader point is that the edifice of regulation governing the US electricity sector favors coal incumbents in myriad ways.

If all coal plants had to adopt their full costs and face full market competition tomorrow, the US coal fleet would quickly shrink to negligible size. It only survives because, through taxes and regulations, the US has protected it.

## CPs

#### The US federal government should

#### Subsidize natural gas companies only for the creation of emergency gas pipelines.

Mark Harrington, 10-2-2019, "Senators urge 'conditional' state approval of gas pipeline," Newsday, <https://www.newsday.com/long-island/politics/national-grid-williams-pipeline-nese-1.37091201> LHSLA LH

Six Long Island Democratic state senators on Wednesday urged the state’s top environmental official to approve a contested natural gas pipeline “on an emergency basis” if certain conditions are met, just days after Gov. Andrew M. Cuomo publicly expressed his opposition to it.

The lawmakers, led by Sen. Todd Kaminisky (D-Long Beach), who chairs the Senate’s environmental conservation committee, argued in a letter to the state Department of Environmental Conservation that a moratorium enacted by the pipeline’s chief backer, National Grid, has “already impacted thousands of our constituents.”

Kaminsky declined to comment beyond the senators’ letter, which was also signed by Long Island State Sens. John Brooks, James Gaughran, Anna Kaplan, Monica Martinez and Kevin Thomas.

The request to DEC Commissioner Basil Seggos asks for “conditional” approval of the pipeline, which the DEC has twice rejected on environmental grounds.

The senators said the pipeline should be approved only after an independent body — “not National Grid” — finds that the additional gas supply is truly needed to meet the state’s energy safety and reliability needs. They also asked that the amount of gas allowed from the pipeline be “scaled back” to align with “the increased availability of cleaner, renewable alternatives over time,” and that proceeds from the pipeline’s use be used for renewable investments to more quickly meet the state’s green-energy goals.

National Grid spokeswoman Karen Young, in a statement, said the company believes the pipeline “is vital and necessary to provide consumers with access to natural gas supplies,” which it called the “most cost-effective and environmentally sound heating option available to heat homes and run businesses.”

Young also said the company continues to work with the Public Service Commission in its investigation on “customer connection issues and the need for the additional gas supply to serve the needs of new and existing customers.”

National Grid has argued it needs the $1 billion pipeline to head off a looming natural gas shortage but opponents, chiefly in the environmental community, say the crisis has been largely made up so the company can guarantee a long-term fossil fuel future.

Cuomo, speaking on the Brian Lehrer radio program last month, took a stand against the pipeline, and has ordered a stepped-up investigation into National Grid’s claims of a shortage and its denial of service to certain customers.

“We have taken a position: We’re against the pipeline,” Cuomo told the radio host. “That’s our position. DEC has considered it, and they are resubmitting additional information. But there’s no negotiation. If they’re extorting people, and wrongfully turning off gas service to homes to create political pressure, I’m not negotiating over that. That’s extortion. That’s a crime.”

A spokesperson for Cuomo, in a statement released after the senators’ letter was circulated, noted that a decision on the pipeline’s state permit is “pending with DEC, which has made clear through its previous denial that it will not compromise on our water quality standards."

Further, Cuomo's spokesperson said, "National Grid is going to be held accountable by the PSC if it finds they inappropriately denied service to their existing customers.”

State Senate Republican leader John Flanagan was quick to pounce on his Democratic rivals’ plan. “Today, months after their leadership was sorely needed on the Williams pipeline project, these Long Island Democrats finally say it should be approved on an ‘emergency basis,’ whatever that means,” Flanagan said in a statement.

He accused the Democrats of remaining “silent during the entire application process, threatening billions of dollars of investment,” and concluded their policies “are only going to make things worse.”

A spokesperson for the DEC didn’t immediately comment.

Kim Fraczek, director of the Sane Energy Project, an activist group that opposes the pipeline, criticized the senators’ stance, and expressed shock that Kaminsky signed the letter.

“This is not aligned with how Kaminsky presents himself as a climate champion,” Fraczek said. “I don’t think rolling over for a corporation so they can get their way is the way to show that we are ready to move to a renewable economy that’s rooted in justice and getting his constituents better jobs.”

The senators aren’t the only local Democrats calling for the pipeline. Their letter follows by several days a joint opinion piece by Suffolk County Executive Steve Bellone and Nassau County Executive Laura Curran expressing support for the pipeline. “The two of us believe strongly that without access to natural gas, there will be significant disruption for both the economy and the environment,” they wrote in support of the pipeline in a opinion piece in the Daily News. “The Williams pipeline will help us ensure that the historic progress we are making is not halted.”

Even while asking for approval of the pipeline on an emergency basis, the senators' letter pointed to the legislature’s recent approval of legislation that requires all electric generation in the state to be carbon-free by 2040. The law “sets hard caps on greenhouse gas emissions, effectively eliminating the long-term reliance on fossil fuels, including natural gas.”

But, they noted, their constituents in the near term “continue to need natural gas as a cleaner transition energy source.” Many have “had their lives disrupted.”

One of them is Sean Pryor, who recently bought a home in Amityville, only to discover the natural gas was turned off. National Grid, after initially indicating it would restore service, ultimately declined, citing the moratorium, Pryor said. He faces a winter without gas heat and finding an expensive alternative such as propane or electric.

“I have a bunch of bad options,” for heat this winter and “I don’t know if I’m ever going to get gas,” Pryor said, adding that he’s filed a complaint against National Grid with the state Department of Public Service. “We’re just a bunch of pawns.”

### UQ

The utility of this CP is against affs that defend the removal of all subsidies in order to strengthen the uniqueness of the grid DA.

#### [aff actor] should substantially increase natural gas subsidies.

#### Boosts gas production and stabilizes the grid.

### Grid

#### The United States federal government should restructure its energy grid into a decentralized, layered-decomposition optimization structure.

#### Solves grid complexity from warming and microgrids.

Notes: very complex card, please read the article. TSO = transmission system operator. DSO = distribution system operator. DER = distributed energy resources. ICT = Information communication technology. VPP = virtual power plants.

David Roberts 11-30-2018, "Clean energy technologies threaten to overwhelm the grid. Here’s how it can adapt.," Vox, <https://www.vox.com/energy-and-environment/2018/11/30/17868620/renewable-energy-power-grid-architecture> LHSLA LH \*Brackets in text

The alternative grid architecture that the study’s authors propose solves these problems in an elegant way. It is called ... hang on to your hats ... a “decentralized, layered-decomposition optimization structure.” Whee!

Let’s translate that into English. (Side note: Layered or “laminar” structure is a familiar concept in telecoms and software architecture. It is somewhat newer to power systems.)

In the Grand Central model, the TSO optimizes everything in one place, not only power plants at the transmission level, but thousands of DERs and aggregations at the distribution level, in service of wholesale markets and transmission system reliability, while having sufficient real-time visibility into the distribution system to avoid conflicts with local reliability needs.

In Kristov, De Martini, and Taft’s proposed model — which I’m going to call LDO, for layered decentralized optimization, because I don’t want to type all those words again — each layer, the transmission layer and the distribution layer, would be responsible for its own optimization and its own reliability.

Remember tier bypassing? The LDO model would prevent that by effectively sealing the layers off from one another, except at their electrical interface points. The only point of communication and coordination between the transmission layer and the distribution layer beneath it would be at the TD interface (the substations). Everything below the TD interface would be managed and optimized by the DSO.

Responsibility “decomposes” to the layer beneath — that’s what “layered-decomposition” refers to.

The DSO would balance supply and demand within a local distribution area (LDA) using, to the extent possible, local DERs. It would then aggregate all remaining supply or demand into a single bid to wholesale markets (either a purchase or a power offer).

This would radically simplify things for a TSO.

It would not need to keep track of, manage, and dispatch tens of thousands of DERs, DER aggregations, and microgrids across the LDAs in its region. The DSOs would handle all that.

Each DSO would present to the TSO as a single unit at each TD interface. All the TSO would need to do is accept one aggregate wholesale market bid from each TD interface, of which there would be dozens or hundreds (rather than tens of thousands). That would maintain the simplicity and manageability of wholesale markets.

Just as responsibility for optimization would decompose downward, so too would responsibility for reliability.

The TSO would be responsible only for the reliability of the transmission system, up to the point of TD interface. Beyond that, each DSO would be responsible for reliability within its own LDA.

Every grid architecture must have a “coordination framework” that assigns basic roles and responsibilities to various components of the system. The LDO architecture is a “maximum DSO” or “total DSO” model, in that it assigns substantial new roles and responsibilities to DSOs, well beyond those assigned to them by the current system. (We’ll talk more about that in a moment.)

An architecture that scales all the way down

There are many advantages to the LDO architecture, which we’ll get into below, but one worth highlighting is scalability. LDO serves as a way of managing complexity up (or down) to any scale.

The electricity system need not have only two layers; it can have many.

Recall that in the LDO model, the transmission layer interacts with the distribution layer only at a limited number of TD interfaces. The only interaction a distribution system has with the transmission system above it is at that single point.

But there could be another layer beneath that first distribution layer. And it could communicate with that first distribution layer the same way the first distribution layer communicates with the transmission layer, i.e., through a single interface. Responsibilities would decompose downward again — the second layer would be responsible for its own optimization and reliability.

And there could be a third layer below that, and a fourth, ad infinitum.

For instance, imagine a local microgrid that links together dozens of buildings, solar panels, combined heat-and-power (CHP) units, batteries, EV charging stations, and perhaps even a few smaller microgrids into a single network (a university campus, say). That network can island off from the larger grid and run on its own, at least for a limited time, if there is a blackout.

That microgrid is another layer. Rather than managing dozens of DERs, the DSO now manages the microgrid as a single aggregated asset. As for the microgrid, its only interaction with the larger distribution layer above it is through a single interface. It is responsible for its own optimization and reliability and can island if necessary.

Now, imagine the big microgrid contains several smaller microgrids within it. Each of them connects, say, three buildings, some solar panels, and some batteries.

Same deal: There’s a single point of contact between the big microgrid and each small microgrid (thus simplifying things for the big microgrid). Beneath those points, responsibility decomposes again, to the small-microgrid level.

Now imagine one of the small microgrids contains a building (say, a hospital) that is itself a microgrid — it has solar panels on the roof, diesel generators in the basement, some batteries, and a smart inverter that allows it to island off from the small microgrid in emergencies.

Same deal: One point of contact with the microgrid above it; responsibility decomposes down.

Now, imagine the hospital has an emergency wing that is itself a microgrid (nanogrid? teeny-weenygrid?), with a smart inverter and one diesel generator, just enough to power a couple of respirators and monitors.

Same deal: single point of contact; responsibility decomposes.

Because responsibility devolves downward, no single entity gets stuck tracking and dispatching an unwieldy number of DERs. And there is no tier bypassing. Each layer is responsible for itself and interacts with the level above it through a single point of contact.

This helps tame the problem of rapidly increasing complexity in the electricity sector. Whereas in the Grand Central model, the TSO will have to single-handedly keep track of all the blooming and buzzing DERs beneath it — which, let’s be serious, will eventually overwhelm it — in the LDO model, each layer is its own, tractable domain.

# Aff

## Renewable Grid Good

### AT Mills

#### Mills is wrong—overemphasizes the role of and cost of batteries.

Nader Sobhani, 9-23-2019, "Renewables Do Not Rely On “Magical Thinking” — They Are Winning On Price," Niskanen Center, <https://www.niskanencenter.org/renewables-do-not-rely-on-magical-thinking-they-are-winning-on-price/> LHSLA LH

Mills argues that modern battery technology is too inefficient and expensive to backstop a renewables-based energy grid. And that may be true, but Mills’ analysis overemphasizes the role that batteries will have to play in order for a renewables-dominated grid to meet U.S. electricity demand. He stipulates that it would take Tesla’s Gigafactory 1,000 years of production to store two days’ worth of U.S. electricity demand. The basic arithmetic is correct, but the figures he is using are arbitrarily selected and go far beyond what experts say is necessary for renewables to meet U.S. electricity demand and decarbonization goals.

A 2018 study published in the journal Energy & Environmental Science analyzed 36 years of hourly U.S. weather data to understand the geophysical constraints to supplying electricity with only wind and solar power, and found that 80 percent of the U.S. grid could be powered by the combination of the two. This level of renewable energy penetration must be accompanied by either a network of high-voltage transmission lines or by the construction of enough storage capacity to meet 12 hours of U.S. energy demand. The U.S. currently uses 4,200 terawatt-hours (TWh) of electricity per year, and back of the envelope calculations suggest that a 12-hour chunk of that would be roughly 5.8 TWh. At a battery-pack price of $176 per kilowatt hour, that would cost roughly $1 trillion — a substantial, but not inconceivable investment, especially since battery prices are still experiencing significant cost reductions.

#### Mills’ concerns are outdated—renewables will be cheaper than gas soon.

Nader Sobhani, 9-23-2019, "Renewables Do Not Rely On “Magical Thinking” — They Are Winning On Price," Niskanen Center, <https://www.niskanencenter.org/renewables-do-not-rely-on-magical-thinking-they-are-winning-on-price/> LHSLA LH

The transition to a new energy economy does not rely on “magical thinking,” as Mills would argue, but instead relies on attractive economics. Fortunately, significant cost reductions are driving unprecedented growth in the renewable energy industry. Levelized Cost of Energy analysis from Lazard finds unsubsidized wind and solar to be cheaper on the margin than coal, and even cheaper than natural gas in some cases.

However, Mills attacks the credibility of such LCOE analysis for making renewables-biased assumptions about natural gas prices and about capacity factors — the amount of power a plant actually produces in a given period compared to its maximum capacity. He argues that natural gas prices have decreased over the past decade and that assumed capacity factors are higher than actual capacity factors for renewables.

According to data from the Energy Information Administration, natural gas prices have in fact been increasing since 2016, and although they will remain relatively low, they are estimated to continue rising into the future. Lazard’s 2018 LCOE analysis used a natural gas price of $3.45, and at the time of its publication in November the Henry Hub spot price for natural gas was at $4.68. This spike in the price of natural gas was driven by forecasts for extremely cold weather across the U.S. and indicates how volatile natural gas prices can be. Given these trends, natural gas prices used in LCOEs do not always bias calculations away from gas.

Capacity factors used in LCOE analysis are arbitrarily assumed and are usually inflated, as Mills points out, but that is true for all generation technologies, not just renewables. Lazard’s LCOE uses capacity factors that are based on upper limits, most likely coming from newer plants. The analysis uses capacity factors for wind and solar of 55 percent and 34 percent respectively, and 93 percent and 80 percent for coal and gas combined-cycle plants respectively. Capacity factors recorded in 2018 by EIA found wind and solar to operate at 37 percent and 26 percent respectively. Capacity factors for coal and natural gas were found to be 54 percent and 58 percent respectively. Thus, comparing assumed capacity factors in Lazard’s LCOE analysis with EIA data, the capacity factors for fossil fuel plants are more inflated than those for renewable energy generation technologies.

There is certainly room for improvement in LCOE analysis, but these studies do provide a relatively accurate picture of the cost trends in the power sector. In fact, recent data on purchase power agreements (PPAs) are consistent with Lazard’s estimates. In June 2018, NV Energy asked regulators to approve six solar PPAs, all of which netted contracts under $30 per MWh, which is right on par with Lazard’s cost estimates for subsidized solar power. The utility even set a new low-cost record when it entered into a 300 MW PPA at $23.76 per MWh for 25 years. A Department of Energy report published last year found that the average PPA price for wind projects in 2017 fell to $20 per MWh, also in line with Lazard’s estimates of subsidized wind prices of $14 to $47 per MWh. PPA prices do vary by location, and a majority of these projects were found in wind belts in the U.S. But the overall trends are in line with estimates coming from LCOE analysis, and are further evidence that wind and solar energy technologies are experiencing dramatic cost reductions that are making them competitive and cost-effective sources of electricity.

Mills’ main concern with LCOE analysis is that these studies consider the costs of producing electricity on each source’s own terms while ignoring the real-world imperative of supplying 24/7 power, a concern Mills shares with many. While renewable energy plants have zero fuel costs, they rely on sources that are inherently variable.

As noted above, at high levels of renewable energy penetration, this variability will require systemwide improvements in storage and transmission infrastructure. Mills and many others are concerned that increased levels of renewable energy penetration into the grid will thus result in higher electricity prices for consumers. As evidence, Mills claims that declining fuel costs for coal and natural gas over the last 15 years should have resulted in declining retail electricity prices, but that instead, average U.S. residential electric costs have risen by 20 percent over the same period. However, this is a misleading depiction: The figures that Mills uses as evidence of price increases are nominal values, meaning they have not been adjusted for inflation. Federal data shows that the inflation-adjusted price of electricity has actually fallen over the last decade.

The overall price decline was driven by a fall in generation prices, which was largely due to the nation’s burgeoning supply of natural gas. But over the same decade electricity generation from renewables grew significantly, and further growth could lead to generation costs falling even more. A study from the Lawrence Berkeley National Laboratory found that in a power grid where solar and wind make up 40-50 percent of generation, wholesale energy prices could drop by as much as $16 per MWh.

However, wholesale electricity prices are only half the picture — the prices consumers pay for electricity account for transmission and distribution costs, as well as the reliability costs associated with maintaining a stable energy grid.

Careful analysis that includes all those factors suggests that the higher systemwide costs associated with renewables generation will be manageable. The 2014 Deep Decarbonization report found that the cost of a high-renewables future, where wind and solar provide more than 50 percent of the energy supply, is roughly $.04 per KWh higher than the baseline. The result is a total electricity cost of $.20 per KWh (the average cost right now is $.13 per KWh). Well over half of the baseline costs are a result of the fixed costs of renewable generation, which are primarily made up of the capital costs of this technology.

Close to a third of the estimated $.20/KWh price comes from storage, transmission, and distribution to handle the intermittency of renewables — at a cost 25 percent higher than in the baseline case. But there is reason to believe the 25 percent increase in the Deep Decarbonization report is high. The report took a conservative approach and assumed technology costs would remain relatively flat for many technologies till 2050. This has certainly not been the case so far, as wind, solar, and battery technology costs have dropped significantly and are predicted to keep falling, which will in turn reduce the system costs of a high-renewables future.

Mills, however, points to Europe as a prime example of greater renewables penetration resulting in higher electricity prices. This is not surprising, considering that these countries were subsidizing expensive, early-stage technology. The European experience with renewable energy and its impacts on electricity prices is markedly different than the U.S. experience. The design of these programs in Europe, and Germany in particular, was such that customers were paying a renewable energy surcharge, whereas in the U.S., part of our renewable-energy subsidies go through the tax system (by lowering investors’ tax liabilities) and bypass consumer electricity prices.

Ultimately, greater levels of renewables will require a new way of operating the power system, and there are very real costs to handling the intermittency of renewables. But painting the relationship between increased renewable energy generation and higher electricity prices as causal is overly simplistic. If the capital costs for renewables keep falling, as expected, then the increased systemwide costs of a high-renewables future could be greatly reduced. Continuing to deploy these technologies will lead to further cost reduction and will make a high-renewables future much more affordable.

That being said, all industries are subject to the law of diminishing marginal returns, where every incremental gain yields less progress than in the past, and as Mills points out, the renewable energy industry is no exception. He argues that the gains in the renewable energy industry “are now all measured in single-digit percentage gains,” and that we should not expect any revolutionary improvements that could make a new energy economy possible. But he goes astray once more when he argues the reason we should not expect any more massive gains in these technologies is that we are reaching their physically-imposed energy limits.

Although the renewable energy industry will certainly experience diminishing marginal returns, the potential cost reductions for both solar and wind technology could go well beyond single-digit percentages. A 2016 report from the International Renewable Energy Agency concluded that wind and solar costs could fall by as much as 35 percent and 59 percent, respectively, between 2015 and 2025. However, these cost reductions are heavily dependent on ensuring that a virtuous cycle of policy support driving increased deployment, technological improvements, and cost reductions remains in place.

Focusing on the conversion of photons to electrons to demonstrate that cost reductions in the renewable energy industry will be limited is smoke and mirrors. Based on EIA data, coal, natural gas, and petroleum power plants have an efficiency of 33, 44, and 31 percent respectively. As Mills points out, the efficiency of solar PV panels currently sits around 26 percent, while the efficiency of wind turbines is roughly 45 percent. Clearly, it is difficult to convert energy into electricity for all sources. The main point, however, is that the efficiency rates of wind and solar technologies do not need to improve by much (or in the case of wind, at all) to make them as efficient as fossil fuel sources.

In fact, the incremental cost reductions in the renewable energy and battery storage industries have brought them to a point where they are already cheaper than coal and could soon be competitive with natural gas. Just last year, a utility company in Colorado decided to retire two coal plants and replace them with 1,800 MW of solar, wind, and battery storage technology, a move that could save ratepayers $213 million to $375 million. The decision is due to the fact that the utility company has solicited record-low clean energy prices, with wind pricing at $11 to $18 per MWh and solar-plus-storage coming in at $30 to $32 per MWh. This shift is being mirrored by utilities across the country. PacifiCorp utility recently proposed a plan to retire four coal units in Wyoming and replace them with a portfolio of wind, solar, and storage technologies, a move it says will save customers $248 million over the next 20 years.

Although natural gas plants made up most of the power sector’s 2018 capacity additions, utility-scale renewables had made up the majority of capacity additions since 2014, and now proposals to build new natural gas plants are drawing increasing scrutiny from state regulators. In April, Indiana regulators rejected a proposal by Vectren, an electric and gas utility, to replace a baseload coal plant with a new, 850 MW natural gas plant because of concerns about stranding a $900 million energy asset in the face of declining renewable prices. The regulators argued that the utility company had overestimated the costs of renewable energy and screened out multiple less expensive alternatives. California utility Southern California Edison recently selected a portfolio of energy storage projects totaling 195 MW instead of a 262 MW natural gas peaker plant to supply local capacity needs, while Arizona recently extended its moratorium on new gas plants over 150 MW to allow the state more time to consider renewable alternatives.

Of course, part of the explanation for this increased skepticism of new natural gas plants is that states have adopted policies that support the build-out of renewable energy, such as Renewable Portfolio Standards and clean energy mandates. However, the economics of renewables has also been a significant factor behind this trend.

The figure above, from the Department of Energy report mentioned earlier, demonstrates that the price of wind PPAs in the U.S. Interior region, but also in some other regions, has become competitive with the projected fuel costs of gas-fired combined-cycle generators over time. These PPAs do benefit from the tax credits that the wind industry receives, and cost reductions will likely slow when the credit expires. However, McKinsey’s Global Energy Perspective finds that by 2030, new-build renewables will outcompete both coal and gas in most regions of the world, conclusions that are also echoed in Bloomberg’s New Energy Outlook for 2019.

Focusing on the conversion limits of renewables is a distraction from the current economics of renewable energy technologies. The economic trends of different generation sources, and the significant gains still to come, demonstrate that revolutionary and massive improvements in the costs of renewable energy technologies are no longer necessary to make them cost-competitive. We are entering a period where utilities are forgoing running costly coal plants and are skeptical of building natural gas plants and are instead opting to build new, clean energy portfolios.

#### Renewables are cheaper—higher capital but lower fuel costs.

Nader Sobhani, 9-23-2019, "Renewables Do Not Rely On “Magical Thinking” — They Are Winning On Price," Niskanen Center, <https://www.niskanencenter.org/renewables-do-not-rely-on-magical-thinking-they-are-winning-on-price/> LHSLA LH

The concerns that Mills raises in his piece should be taken seriously. There are very complex physical and economic challenges associated with the transition to a renewables-heavy power system, but they are not as insurmountable as Mills claims. There is a reason why solar and wind will account for 64 percent of utility-scale additions in 2019, and why renewables will be the fastest growing source of electricity generation in the U.S. for the next two years, while fossil fuel capacity will only increase about 1 percent by 2022. It is because the transition to a decarbonized energy grid is worth it, especially when you consider the very real and substantial social costs of using fossil fuels.

To illustrate this point, one can compare the total 30-year electricity production from $1 million in hardware among a natural gas combined-cycle plant, wind turbines, and solar arrays. Mills uses a similar comparison to argue that hydrocarbons produce more energy per dollar of capital invested than both wind and solar. He claims,

“With today’s technology, $1 million worth of utility-scale solar panels will produce 40 millon kilowatt-hours (KWh) over a 30-year operating period. A similar metric is true for wind: $1 million worth of modern wind turbine produces 55 million KWh over the same 30 years. Meanwhile, $1 million worth of hardware for a shale rig will produce enough natural gas over 30 years to generate over 300 million KWh.”

If only the upfront capital cost of energy sources dictated the decisions of investors, then we would expect fossil fuels to dominate new capacity builds and investment flows to new generation technologies, but as has been demonstrated above, this is simply not the case.

Using only the energy density and the capital cost per kilowatt of capacity to compare energy sources gives an incomplete comparison of different generation methods. All forms of power generation require capital investments that will convert the energy source into electricity, but there are a host of other costs that must be considered. For example, using hydrocarbons to produce electricity entails fuel costs. From a utility or consumer perspective, the final electricity prices of hydrocarbons are inherently volatile because they are tethered to prices of the fuel. Additionally, natural gas needs to be processed, transported, and then regasified, all of which entail further costs. Moreover, Mills’ footnotes admit that his calculations do not include the $1,000/KW of capital cost of a turbine generator for natural gas, which further skews his numbers. By contrast, renewable energy technologies have fuel costs of zero. The price of renewable energy ultimately depends on technology costs, which are only coming down. So although renewable energy technologies tend to have higher capital costs, their minimal operation and maintenance costs and zero fuel costs can easily make them cost-competitive with hydrocarbons.

Just as the real-world systemwide costs of intermittent renewable energy should be taken seriously, so too should the real-world, hidden costs of fossil fuel generation. Energy generation using hydrocarbons produces externalities in the form of greenhouse gas emissions that contribute to global warming and thus lead to environmental damage and related social costs. Although there are various difficulties in determining the exact value for the social costs of carbon, taking them into account illuminates the real costs of using hydrocarbons.

Accounting for the emissions over the entire life cycle of a power plant, 300 million KWh of electricity produced from a $1 million investment in a natural gas combined cycle plant would produce nearly $3.5 million in damages at a very modest $25-per-metric-ton carbon price. Comparatively, wind and utility-scale solar plants would produce $44,000 and $96,000 in damages, respectively. Although wind and solar plants currently produce less electricity output per dollar of capital invested, they also produce significantly less damage from greenhouse gas emissions, and these benefits can manifest themselves in reduced ecosystem, infrastructure, and even health costs. These are real economywide costs that must be considered when comparing conventional generation sources to alternative sources such as renewables. These costs can either be internalized via a carbon price, or we can continue to pay these costs in damage to our ecosystems and infrastructure.

The declining costs of renewable energy technologies, coupled with the consideration of the environmental damage caused by hydrocarbons, have swayed investors and utility companies to believe that the transition to a new energy economy is worth it, and the American public seems to be in agreement. This transition will undoubtedly be challenging, but we should not allow overblown concerns to paralyze the significant progress being made in the energy space. We must seize and sustain this momentum to ensure that near-term transition to a new energy economy remains within reach.

## AT Random

### At Grid Collapse Spillover

#### Their models are based on idealized math—real world models and electrical engineering disprove, 2003 thumps impact uniqueness.

Tollefson 13 (Jeff Tollefson. “US electrical grid on the edge of failure,” *International weekly journal of science*. 25 Aug. 2013, <https://www.nature.com/news/us-electrical-grid-on-the-edge-of-failure-1.13598>.) LHSLA LH

The warning comes ten years after a blackout that crippled parts of the midwest and northeastern United States and parts of Canada. In that case, a series of errors resulted in the loss of three transmission lines in Ohio over the course of about an hour. Once the third line went down, the outage cascaded towards the coast, cutting power to some 50 million people. Havlin says that this outage is an example of the inherent instability his study describes, but others question whether the team’s conclusions can really be extrapolated to the real world.

“I suppose I should be open-minded to new research, but I'm not convinced,” says Jeff Dagle, an electrical engineer at the Pacific Northwest National Laboratory in Richland, Washington, who served on the government task force that investigated the 2003 outage. “The problem is that this doesn’t reflect the physics of how the power grid operates.”

Critical order

Havlin and his colleagues focused on idealized scenarios. They found that randomly structured networks — such as social networks — degrade slowly as nodes are removed, which in the real world might mean there is time to diagnose and address a problem before a system collapses. By contrast, the connections of orderly lattice structures have more critical nodes, which increase the instability. The problem is that such orderly networks are always operating near an indefinable edge, Havlin says. To reduce that risk, he recommends adding a small number of longer transmission lines that provide short cuts to different parts of the grid.

Benjamin Carreras, a physicist at Oak Ridge National Laboratory in Tennessee who has conducted similar work2, says that network theory can be useful for providing insight into electric grids but must be complemented with more complex models that attempt to represent both the physical realities and the responsiveness of the modern electric grid. Although in some cases adding long lines can benefit the overall stability of an electric system, Carreras’ work suggests that in certain circumstances such an approach allows problems to propagate even farther.

“More connections may stabilize some processes, by, for instance, increasing the number of paths to generators, but also may destabilize others,” Carreras says. “One cannot make generic statements on this topic.”

Although local outages caused by falling trees knocking down distribution lines are common, large-scale failures within the core transmission lines rarely occur on a modern electric grid. Before 2003, the last major blackout in the United States had been on the west coast in 1996, and more recently an outage has struck in the San Diego area.

Dagle says that the 2003 blackout stemmed from a combination of bad vegetation management — the first three lines tripped after sagging into trees but were all within their load rating — and a series of monitoring and communications breakdowns. Vegetation requirements have since been standardized, and a new generation of sensors is providing grid operators with more information about what is happening across the grid at any given moment.

“Many more utilities have much more data,” Dagle says. “The next phase of our voyage is to make better use of that data.”

# Impacts

#### Grid collapse causes nuclear meltdown- current checks fail

CBS 11 (“Long blackouts pose risk to U.S. nuke reactors”, <https://www.cbsnews.com/news/long-blackouts-pose-risk-to-us-nuke-reactors/>)

WASHINGTON - Long before the nuclear emergency in Japan, U.S. regulators knew that a power failure lasting for days at an American nuclear plant, whatever the cause, could lead to a radioactive leak. Even so, they have only required the nation's 104 nuclear reactors to develop plans for dealing with much shorter blackouts on the assumption that power would be restored quickly. In one nightmare simulation presented by the Nuclear Regulatory Commission in 2009, it would take less than a day for radiation to escape from a reactor at a Pennsylvania nuclear power plant after an earthquake, flood or fire knocked out all electrical power and there was no way to keep the reactors cool after backup battery power ran out. That plant, the Peach Bottom Atomic Power Station, has reactors of the same older make and model as those releasing radiation at Japan's Fukushima Dai-ichi plant, which is using other means to try to cool the reactors. Complete coverage: Disaster in Japan Crisis of confidence for Japan's government Video: New concerns over Japan nuke plant Trending News Full text: What the top U.S. diplomat in Ukraine told Congress Trump lawyer argues he's immune from prosecution — even if he shot someone Impeachment updates: Republicans storm secure hearing room Kamille "Cupcake" McKinney's remains found in dumpster And like Fukushima Dai-ichi, the Peach Bottom plant has enough battery power on site to power emergency cooling systems for eight hours. In Japan, that was not enough time for power to be restored. According to the International Atomic Energy Agency and the Nuclear Energy Institute trade association, three of the six reactors at the plant still can't get power to operate the emergency cooling systems. Two were shut down at the time. In the sixth, the fuel was removed completely and put in the spent fuel pool when it was shut down for maintenance at the time of the disaster. A week after the March 11 earthquake, diesel generators started supplying power to two other two reactors, Units 5 and 6, the groups said. The risk of a blackout leading to core damage, while extremely remote, exists at all U.S. nuclear power plants, and some are more susceptible than others, according to an Associated Press investigation. While regulators say they have confidence that measures adopted in the U.S. will prevent or significantly delay a core from melting and threatening a radioactive release, the events in Japan raise questions about whether U.S. power plants are as prepared as they could and should be. A top Nuclear Regulatory Commission official said Tuesday that the agency will review station blackouts and whether the nation's 104 nuclear reactors are capable of coping with them. As part of a review requested by President Barack Obama in the wake of the Japan crisis, the NRC will examine "what conditions and capabilities exist at all 104 reactors to see if we need to strengthen the regulatory requirement," said Bill Borchardt, the agency's executive director for operations. Borchardt said an obvious question that should be answered is whether nuclear plants need enhanced battery supplies, or ones that can last longer. "There is a robust capability that exists already, but given what happened in Japan there's obviously a question that presents itself: Do we need to make it even more robust," he said at a hearing before the Senate Energy and Natural Resources Committee. "We didn't address a tsunami and an earthquake, but clearly we have known for some time that one of the weak links that makes accidents a little more likely is losing power," said Alan Kolaczkowski, a retired nuclear engineer who worked on a federal risk analysis of Peach Bottom released in 1990 and is familiar with the updated risk analysis. A report released this month by the Union of Concerned Scientists says the Nuclear Regulatory Commission investigated 14 "near misses" at US nuclear plants in 2010 that the report describes as "troubling events, safety equipment problems, and security shortcomings." 14 "near misses" cited at US nuke plants in 2010 Risk analyses conducted by the plants in 1991-94 and published by the commission in 2003 show that the chances of such an event striking a U.S. power plant are remote, even at the plant where the risk is the highest, the Beaver Valley Power Station in Pennsylvania. These long odds are among the reasons why the United States since the late 1980s has only required nuclear power plants to cope with blackouts for four or eight hours. That is about how much time batteries would last. After that, it is assumed that power would be restored. And so far, that has been the case. Equipment put in place after the Sept. 11, 2001, terrorist attacks could buy more time. Otherwise, the reactor's radioactive core could begin to melt unless alternative cooling methods were employed. In Japan, the utility has tried using portable generators and dumped tons of seawater, among other things, on the reactors in an attempt to keep them cool. A 2003 federal analysis looking at how to estimate the risk of containment failure said that should power be knocked out by an earthquake or tornado it "would be unlikely that power will be recovered in the time frame to prevent core meltdown." In Japan, it was a one-two punch: first the earthquake, then the tsunami. Tokyo Electric Power Co., the operator of the crippled plant, found other ways to cool the reactor core and so far avert a full-scale meltdown without electricity. "Clearly the coping duration is an issue on the table now," said Biff Bradley, director of risk assessment for the Nuclear Energy Institute. "The industry and the Nuclear Regulatory Commission will have to go back in light of what we just observed and rethink station blackout duration." David Lochbaum, a former plant engineer and nuclear safety director at the advocacy group Union of Concerned Scientists, put it another way: "Japan shows what happens when you play beat-the-clock and lose." At Tuesday's Senate committee hearing, he said the government and the nuclear power industry have to do more to cope with prolonged blackouts, such as having temporary generators on site that can recharge batteries. A complete loss of electrical power, generally speaking, poses a major problem for a nuclear power plant because the reactor core must be kept cool, and back-up cooling systems — mostly pumps that replenish the core with water require massive amounts of power to work. Without the electrical grid, or diesel generators, batteries can be used for a time, but they will not last long with the power demands. And when the batteries die, the systems that control and monitor the plant can also go dark, making it difficult to ascertain water levels and the condition of the core. One variable not considered in the NRC risk assessments of severe blackouts was cooling water in spent fuel pools, where rods once used in the reactor are placed. With limited resources, the commission decided to focus its analysis on the reactor fuel, which has the potential to release more radiation. An analysis of individual plant risks released in 2003 by the NRC shows that for 39 of the 104 nuclear reactors, the risk of core damage from a blackout was greater than 1 in 100,000. At 45 other plants the risk is greater than 1 in 1 million, the threshold NRC is using to determine which severe accidents should be evaluated in its latest analysis. The Beaver Valley Power Station, Unit 1, in Pennsylvania had the greatest risk of core melt — 6.5 in 100,000, according to the analysis. But that risk may have been reduced in subsequent years as NRC regulations required plants to do more to cope with blackouts. Todd Schneider, a spokesman for FirstEnergy Nuclear Operating Co., which runs Beaver Creek, told the AP that batteries on site would last less than a week. In 1988, eight years after labeling blackouts "an unresolved safety issue," the NRC required nuclear power plants to improve the reliability of their diesel generators, have more backup generators on site, and better train personnel to restore power. These steps would allow them to keep the core cool for four to eight hours if they lost all electrical power. By contrast, the newest generation of nuclear power plant, which is still awaiting approval, can last 72 hours without taking any action, and a minimum of seven days if water is supplied by other means to cooling pools. Despite the added safety measures, a 1997 report found that blackouts — the loss of on-site and off-site electrical power — remained "a dominant contributor to the risk of core melt at some plants." The events of Sept. 11, 2001, further solidified that nuclear reactors might have to keep the core cool for a longer period without power. After 9/11, the commission issued regulations requiring that plants have portable power supplies for relief valves and be able to manually operate an emergency reactor cooling system when batteries go out. The NRC says these steps, and others, have reduced the risk of core melt from station blackouts from the current fleet of nuclear plants.

### Grid---1NC

#### Nuclear war

Andres & Breetz 11. Richard Andres and Hanna Breetz. Professor of National Security Strategy at the National War College and a Senior Fellow and Energy and Environmental Security and Policy Chair in the Center for Strategic Research, Institute for National Strategic Studies, at the National Defense University, doctoral candidate in the Department of Political Science at The Massachusetts Institute of Technology, “Small Nuclear Reactors for Military Installations: Capabilities, Costs, and Technological Implications”, [www.ndu.edu/press/lib/pdf/StrForum/SF-262.pdf](http://www.ndu.edu/press/lib/pdf/StrForum/SF-262.pdf)

Grid Vulnerability. DOD is unable to provide its bases with electricity when the civilian electrical grid is offline for an extended period of time. Currently, domestic military installations receive 99 percent of their electricity from the civilian power grid. As explained in a recent study from the Defense Science Board: DOD’s key problem with electricity is that critical missions, such as national strategic awareness and national command authorities, are almost entirely dependent on the national transmission grid . . . [which] is fragile, vulnerable, near its capacity limit, and outside of DOD control. In most cases, neither the grid nor on-base backup power provides sufficient reliability to ensure continuity of critical national priority functions and oversight of strategic missions in the face of a long term (several months) outage.7 The grid’s fragility was demonstrated during the 2003 Northeast blackout in which 50 million people in the United States and Canada lost power, some for up to a week, when one Ohio utility failed to properly trim trees. The blackout created cascading disruptions in sewage systems, gas station pumping, cellular communications, border check systems, and so forth, and demonstrated the interdependence of modern infrastructural systems.8 More recently, awareness has been growing that the grid is also vulnerable to purposive attacks. A report sponsored by the Department of Homeland Security suggests that a coordinated cyberattack on the grid could result in a third of the country losing power for a period of weeks or months.9 Cyberattacks on critical infrastructure are not well understood. It is not clear, for instance, whether existing terrorist groups might be able to develop the capability to conduct this type of attack. It is likely, however, that some nation-states either have or are working on developing the ability to take down the U.S. grid. In the event of a war with one of these states, it is possible, if not likely, that parts of the civilian grid would cease to function, taking with them military bases located in affected regions. Government and private organizations are currently working to secure the grid against attacks; however, it is not clear that they will be successful. Most military bases currently have backup power that allows them to function for a period of hours or, at most, a few days on their own. If power were not restored after this amount of time, the results could be disastrous. First, military assets taken offline by the crisis would not be available to help with disaster relief. Second, during an extended blackout, global military operations could be seriously compromised; this disruption would be particularly serious if the blackout was induced during major combat operations. During the Cold War, this type of event was far less likely because the United States and Soviet Union shared the common understanding that blinding an opponent with a grid blackout could escalate to nuclear war. America’s current opponents, however, may not share this fear or be deterred by this possibility. In 2008, the Defense Science Board stressed that DOD should mitigate the electrical grid’s vulnerabilities by turning military installations into “islands” of energy self-sufficiency.10 The department has made efforts to do so by promoting efficiency programs that lower power consumption on bases and by constructing renewable power generation facilities on selected bases. Unfortunately, these programs will not come close to reaching the goal of islanding the vast majority of bases. Even with massive investment in efficiency and renewables, most bases would not be able to function for more than a few days after the civilian grid went offline.

### Grid Impact---2NC

#### It’s a conflict multiplier --- causes war in every hotspot

Kagan and O’Hanlon 7 Frederick, resident scholar at AEI and Michael, senior fellow in foreign policy at Brookings, “The Case for Larger Ground Forces”, April 2007, <http://www.aei.org/files/2007/04/24/20070424_Kagan20070424.pdf>

We live at a time when wars not only rage in nearly every region but threaten to erupt in many places where the current relative calm is tenuous. To view this as a strategic military challenge for the United States is not to espouse a specific theory of America’s role in the world or a certain political philosophy. Such an assessment flows directly from the basic bipartisan view of American foreign policy makers since World War II that overseas threats must be countered before they can directly threaten this country’s shores, that the basic stability of the international system is essential to American peace and prosperity, and that no country besides the United States is in a position to lead the way in countering major challenges to the global order. Let us highlight the threats and their consequences with a few concrete examples, emphasizing those that involve key strategic regions of the world such as the Persian Gulf and East Asia, or key potential threats to American security, such as the spread of nuclear weapons and the strengthening of the global Al Qaeda/jihadist movement. The Iranian government has rejected a series of international demands to halt its efforts at enriching uranium and submit to international inspections. What will happen if the US—or Israeli—government becomes convinced that Tehran is on the verge of fielding a nuclear weapon? North Korea, of course, has already done so, and the ripple effects are beginning to spread. Japan’s recent election to supreme power of a leader who has promised to rewrite that country’s constitution to support increased armed forces—and, possibly, even nuclear weapons— may well alter the delicate balance of fear in Northeast Asia fundamentally and rapidly. Also, in the background, at least for now, Sino Taiwanese tensions continue to flare, as do tensions between India and Pakistan, Pakistan and Afghanistan, Venezuela and the United States, and so on. Meanwhile, the world’s nonintervention in Darfur troubles consciences from Europe to America’s Bible Belt to its bastions of liberalism, yet with no serious international forces on offer, the bloodletting will probably, tragically, continue unabated. And as bad as things are in Iraq today, they could get worse. What would happen if the key Shiite figure, Ali al Sistani, were to die? If another major attack on the scale of the Golden Mosque bombing hit either side (or, perhaps, both sides at the same time)? Such deterioration might convince many Americans that the war there truly was lost—but the costs of reaching such a conclusion would be enormous. Afghanistan is somewhat more stable for the moment, although a major Taliban offensive appears to be in the offing. Sound US grand strategy must proceed from the recognition that, over the next few years and decades, the world is going to be a very unsettled and quite dangerous place, with Al Qaeda and its associated groups as a subset of a much larger set of worries. The only serious response to this international environment is to develop armed forces capable of protecting America’s vital interests throughout this dangerous time**. Doing so requires a military capable of a wide range of missions**—including not only deterrence of great power conflict in dealing with potential hotspots in Korea, the Taiwan Strait, and the Persian Gulf but also associated with a variety of Special Forces activities and stabilization operations. For today’s US military, which already excels at high technology and is increasingly focused on re-learning the lost art of counterinsurgency, this is first and foremost a question of finding the resources to field a large-enough standing Army and Marine Corps to handle personnel intensive missions such as the ones now under way in Iraq and Afghanistan. Let us hope there will be no such large-scale missions for a while. But preparing for the possibility, while doing whatever we can at this late hour to relieve the pressure on our soldiers and Marines in ongoing operations, is prudent. At worst, the only potential downside to a major program to strengthen the military is the possibility of spending a bit too much money. **Recent history shows no link between having a larger military and its overuse**; indeed, Ronald Reagan’s time in office was characterized by higher defense budgets and yet much less use of the military, an outcome for which we can hope in the coming years, but hardly guarantee. While the authors disagree between ourselves about proper increases in the size and cost of the military (with O’Hanlon preferring to hold defense to roughly 4 percent of GDP and seeing ground forces increase by a total of perhaps 100,000, and Kagan willing to devote at least 5 percent of GDP to defense as in the Reagan years and increase the Army by at least 250,000), we agree on the need to start expanding ground force capabilities by at least 25,000 a year immediately. Such a measure is not only prudent, it is also badly overdue.

### Chemical Release---2NC

#### Causes chemical explosions --- functional nuke war.

Yulia Latynina 3. Journalist for Novaya Gazeta. World Press Review. Vol. 50, No. 11

The scariest thing about the cascading power outages was not spoiled groceries in the fridge, or elevators getting stuck, or even, however cynical it may sound, sick patients left to their own devices without electricity-powered medical equipment. The scariest thing of all was chemical plants and refineries with 24-hour operations, which, if interrupted, can result in consequences even more disastrous and on a larger scale than those of an atomic bomb explosion. So it is safe to say that Americans got lucky this time. Several hours after the disaster, no one could know for certain whether the power outage was caused by an accident or someone’s evil design. In fact, the disaster on the East Coast illustrates just one thing: A modern city is in itself a bomb, regardless of whether someone sets off the detonator intentionally or by accident. As I recall, when I was writing my book Industrial Zone, in which business deals were bound to lead to a massive industrial catastrophe, at some point in time I was considering making a cascading power outage the cause of a catastrophe. Back then, I was amazed and shocked at the swiftness of the process. Shutting down at least one electric power plant is enough to cause a drop in power output throughout the entire power grid. This is followed by an automatic shutdown of nuclear power plants, a further catastrophic drop in power, and finally a cascading outage of the entire grid system. To start with, the electric power plant may burn out because of just about anything. In Ekibastuz [Kazakhstan] under the Soviet regime, a large hydroelectric power station was burned to the ground because of the negligence of one extremely smart worker, who used a wrench to unscrew the cap from a pressurized oil vessel. A stream of oil shot up to the ceiling; the worker got scared and dropped the wrench, which hit against the steel floor and created a spark that set the stream of oil on fire. Then the lights went off. Which brings us back to our main thesis. In order to destroy a modern city, one does not need to have nuclear weapons, because the modern city is in itself a weapon. The city infrastructure is an infrastructure with dual purpose. Why should terrorists need chemical weapons if their enemies already have chemical plants? Why should terrorists need nuclear weapons if their enemies already have skyscrapers and airplanes with tanks full of fuel, which can be hijacked with the help of a penknife? Why would they need sophisticated military technologies and stolen explosives if the KamAZ truck that blew up the hospital in Mozdok was carrying a load of, let us say, fertilizer? So-called dictatorship regimes and terrorists themselves have long since figured that out. That is exactly why there were no nuclear or bacteriological weapons in Iraq. Why not? A bomb planted on an airplane would kill dozens fewer people than a failure of the air traffic control system of a large airport. Sept. 11 taught the world that the infrastructure of the modern civilization could be as lethal as the weapons themselves.

### Meltdowns---2NC

#### Causes meltdowns

Dina Cappiello, 3/29/2011. Reporter for the AP. “AP IMPACT: Long Blackouts Pose Risk to US Reactors” The Post and Courier <http://www.postandcourier.com/news/2011/mar/29/ap-impact-long-blackouts-pose-risk-us-reactors/?print>

Long before the nuclear emergency in Japan, U.S. regulators knew that a power failure lasting for days at an American nuclear plant, whatever the cause, could lead to a radioactive leak. Even so, they have only required the nation’s 104 nuclear reactors to develop plans for dealing with much shorter blackouts on the assumption that power would be restored quickly. In one nightmare simulation presented by the Nuclear Regulatory Commission in 2009, it would take less than a day for radiation to escape from a reactor at a Pennsylvania nuclear power plant after an earthquake, flood or fire knocked out all electrical power and there was no way to keep the reactors cool after backup battery power ran out. That plant, the Peach Bottom Atomic Power Station outside Lancaster, has reactors of the same older make and model as those releasing radiation at Japan’s Fukushima Dai-ichi plant, which is using other means to try to cool the reactors. And like Fukushima Dai-ichi, the Peach Bottom plant has enough battery power on site to power emergency cooling systems for eight hours. In Japan, that wasn’t enough time for power to be restored. According to the International Atomic Energy Agency and the Nuclear Energy Institute trade association, three of the six reactors at the plant still can’t get power to operate the emergency cooling systems. Two were shut down at the time. In the sixth, the fuel was removed completely and put in the spent fuel pool when it was shut down for maintenance at the time of the disaster. A week after the March 11 earthquake, diesel generators started supplying power to two other two reactors, Units 5 and 6, the groups said. The risk of a blackout leading to core damage, while extremely remote, exists at all U.S. nuclear power plants, and some are more susceptible than others, according to an Associated Press investigation. While regulators say they have confidence that measures adopted in the U.S. will prevent or significantly delay a core from melting and threatening a radioactive release, the events in Japan raise questions about whether U.S. power plants are as prepared as they could and should be. A top Nuclear Regulatory Commission official said Tuesday that the agency will review station blackouts and whether the nation’s 104 nuclear reactors are capable of coping with them. As part of a review requested by President Barack Obama in the wake of the Japan crisis, the NRC will examine “what conditions and capabilities exist at all 104 reactors to see if we need to strengthen the regulatory requirement,” said Bill Borchardt, the agency’s executive director for operations. Borchardt said an obvious question that should be answered is whether nuclear plants need enhanced battery supplies, or ones that can last longer. “There is a robust capability that exists already, but given what happened in Japan there’s obviously a question that presents itself: Do we need to make it even more robust?” He said the NRC would do a site-by-site review of the nation’s nuclear reactors to assess the blackout risk. “We didn’t address a tsunami and an earthquake, but clearly we have known for some time that one of the weak links that makes accidents a little more likely is losing power,” said Alan Kolaczkowski, a retired nuclear engineer who worked on a federal risk analysis of Peach Bottom released in 1990 and is familiar with the updated risk analysis. Risk analyses conducted by the plants in 1991-94 and published by the commission in 2003 show that the chances of such an event striking a U.S. power plant are remote, even at the plant where the risk is the highest, the Beaver Valley Power Station in Pennsylvania. These long odds are among the reasons why the United States since the late 1980s has only required nuclear power plants to cope with blackouts for four or eight hours. That’s about how much time batteries would last. After that, it is assumed that power would be restored. And so far, that’s been the case. Equipment put in place after the Sept. 11, 2001, terrorist attacks could buy more time. Otherwise, the reactor’s radioactive core could begin to melt unless alternative cooling methods were employed. In Japan, the utility has tried using portable generators and dumped tons of seawater, among other things, on the reactors in an attempt to keep them cool. A 2003 federal analysis looking at how to estimate the risk of containment failure said that should power be knocked out by an earthquake or tornado it “would be unlikely that power will be recovered in the time frame to prevent core meltdown.” In Japan, it was a one-two punch: first the earthquake, then the tsunami.

#### Leads to global fallout --- that outweighs

Sidney D. Drell, 2009. Professor emeritus of theoretical physics at the SLAC National Accelerator Laboratory at Stanford University, senior fellow at the Hoover Institution, and a member of the President's Foreign Intelligence Advisory Board and Science Advisory Committee. The Nuclear Enterprise, High-Consequence Accidents: How to Enhance Safety and Minimize Risks in Nuclear Weapons and Reactors, pg. 1-3

We live in dangerous times for many reasons. Prominent among them is the existence of a global nuclear enterprise made up of weapons that can cause damage of unimaginable proportions and power plants at which accidents can have severe, essentially unpredictable consequences for human life. For all of its utility and promise, the nuclear enterprise is unique in the enormity of the vast quantities of destructive energy that can be released through blast, heat, and radioactivity. We addressed just this subject in a conference in October 2011 at Stanford University's Hoover Institution. The complete set of papers prepared for the conference is reproduced in this book. The conference included experts on weapons, on power plants, on regulatory experience, and on the development of public perceptions and the ways in which these perceptions influence policy7. The reassuring outcome of the conference was a general sense that the U.S. nuclear enterprise currently meets very high standards in its commitment to safety and security. That has not always been the case in all aspects of the nuclear enterprise. And the unsettling outcome of the conference was that it will not be the case globally unless governments, international organizations, industry7, and media recognize and address the nuclear challenges and mounting risks posed by a rapidly changing world. The acceptance of the nuclear enterprise is now being challenged by concerns about the questionable safety and security of programs primarily in countries relatively new to the nuclear enterprise, and the potential loss of control to terrorist or criminal gangs of fissile material that exists in such abundance around the world. In a number of countries, confidence in nuclear energy production was severely shaken in the spring of 2011 by the Fukushima nuclear reactor plant disaster. And in the military sphere, the doctrine of deterrence that remains primarily dependent on nuclear weapons is seen in decline due to the importance of non-state actors such as al Qaeda and terrorist affiliates that seek destruction for destruction's sake. We have two nuclear tigers by the tail. When risks and consequences are unknown, undervalued, or ignored, our nation and the world are dangerously vulnerable. Nowhere is this risk-consequence equation more relevant than with respect to the nucleus of the atom. The nuclear enterprise was introduced to the world by the shock of the devastation produced by two atomic bombs hitting Hiroshima and Nagasaki. Modern nuclear weapons are far more powerful than those early bombs, which presented their own hazards. Early research depended on a program of atmospheric testing of nuclear weapons. In the early years following World War II, the impact and the amount of radioactive fallout in the atmosphere generated by above-ground nuclear explosions was notfully appreciated. During those years, the United States and also the Soviet Union conducted several hundred tests in the atmosphere that created fallout. The recent Stanford conference focused on a regulatory weak point from that time that exists in many places today, as the Fukushima disaster clearly indicates. The U.S. Atomic Energy Commission (AEC) was initially assigned conflicting responsibilities: to create an arsenal of nuclear weapons for the United States to confront a growing nuclear-armed Soviet threat; and, at the same time, to ensure public safety from the effects of radioactive fallout. The AEC was faced with the same conundrum with regard to civilian nuclear power generation. It was charged with promoting civilian nuclear power and simultaneously protecting the public. Progress came in 1963 with the negotiation and signing of the Limited Test Ban Treaty (LTBT) banning all nuclear explosive testing in the atmosphere (initially by the United States, the Soviet Union, and the United Kingdom). With the successful safety7 record of the U.S. nuclear weapons program, domestic anxiety about nuclear weapons receded somewhat. Meanwhile, public attitudes toward nuclear weapons reflected recognition of their key role in establishing a more stable nuclear deterrent posture in the confrontation with the Soviet Union. The positive record on safety of the nuclear weapons enterprise in the United States—there have been accidents involving nuclear weapons, but none that led to the release of nuclear energy—was the result of a strong effort and continuing commitment to include safety as a primary criterion in new weapons designs, as well as careful production, handling, and deployment procedures. The key to the health of today's nuclear weapons enterprise is confidence in the safety7 of its operations and in the protection of special nuclear materials against theft. One can imagine how different the situation would be today if there had been a recognized theft of material sufficient for a bomb, or if one of the two four-megaton bombs dropped from a disabled B-52 Strategic Air Command bomber overflying Goldsboro, North Carolina, in 1961 had detonated. In that event, just one switch in the arming sequence of one of the bombs, by remaining in its "off position" while the aircraft was disintegrating, was all that prevented a full-yield nuclear explosion. A close call indeed! In the twenty-six years since Chernobyl, the nuclear power industry has strengthened its safety practices. Over the past decade, growing concerns about global warming and energy independence have actually strengthened support for nuclear energy in the United States and many nations around the world. Yet despite these trends, the civil nuclear enterprise remains fragile. Following Fukushima, opinion polls gave stark evidence of the public's deep fears of the invisible force of nuclear radiation, shown by public opposition to the construction of new nuclear power plants in close proximity. It is not simply a matter of getting better information to the public but of actually educating the public about the true nature of nuclear radiation and its risks. Of course, the immediate task of the nuclear power component of the enterprise is to strive for the best possible safety record with one overriding objective: no more Fukushimas. Another issue that must be resolved involves the continued effectiveness of a policy of deterrence that remains primarily dependent upon nuclear weapons, and the hazards these weapons pose due to the spread of nuclear technology and material. There is growing apprehension about the determination of terrorists to get their hands on weapons or, for that matter, on the special nuclear material—plutonium and highly enriched uranium—that fuels them in the most challenging step toward developing a weapon. The global effects of a regional war between nuclear-armed adversaries such as India and Pakistan would also wield an enormous impact, potentially involving radioactive fallout at large distances caused by a limited number of nuclear explosions. This is true as well for nuclear radiation from a reactor explosion—fallout at large distances would have a serious societal impact on the nuclear enterprise. There is little understanding of the reality and potential danger of consequences if such an event were to occur halfway around the world. An effort should be made to prepare the public by providing information on how to respond to such an event.

### Turns Cred---2NC

#### Large and visible blackouts crush cred

Stephen Walt 2/4/2013. Professor of IR at Harvard, Foreign Policy. ”The eclipse of American (electrical) power", <http://walt.foreignpolicy.com/posts/2013/02/04/the_eclipse_of_american_electrical_power>

I've made this point before -- here and here -- and I suspect I'll have to make it again. But whatever you think of the outcome of yesterday's Super Bowl, the unexpected second half power outage was a small blow against U.S. power and influence. Why? Because one of the reasons states are willing to follow the U.S. lead is their belief that we are competent: that we know what we are doing, have good judgment, and aren't going to screw up. When the power goes out in such a visible and embarrassing fashion, and in a country that still regards itself as technologically sophisticated, the rest of the world is entitled to nod and say: "Hmmm ... maybe those Americans aren't so skillful after all." Or maybe we've just spent too much money building airbases in far-flung corners of the world, and not enough on infrastructure -- like power grids -- here at home.

### Turns Everything---2NC

#### Extinction

Friedemann 16 Alice, transportation expert, founder of EnergySkeptic.com, citing Dr Peter Vincent Pry, executive director of the Task Force on National and Homeland Security, a Congressional advisory board dedicated to achieving protection of the United States from electromagnetic pulse and other threats, (1/24/16, “Electromagnetic pulse threat to infrastructure (U.S. House hearings)” <http://energyskeptic.com/2016/the-scariest-u-s-house-session-ever-electromagnetic-pulse-and-the-fall-of-civilization/>

Modern civilization cannot exist for a protracted period without electricity. Within days of a blackout across the U.S., a blackout that could encompass the entire planet, emergency generators would run out of fuel, telecommunications would cease as would transportation due to gridlock, and eventually no fuel. Cities would have no running water and soon, within a few days, exhaust their food supplies. Police, Fire, Emergency Services and hospitals cannot long operate in a blackout.Government and Industry also need electricity in order to operate. The EMP Commission warns that a natural or nuclear EMP event, given current unpreparedness, would likely result in societal collapse.

### Turns Econ---2NC

#### Grid collapse wrecks the economy.

Maynard & Beecroft 15 Trevor Maynard is the Head of Exposure Management and Reinsurance at Lloyd's and a PhD in Statistics from the London School of Economics; Nick Beecroft is the Emerging Risks and Research Manager at Lloyds and a MSc in International Relations and Affairs from the University of London “SOCIETY & SECURITY: Business Blackout,” Emerging Risk Report, Cambridge University’s Centre for Risk Studies, <http://activu.com/uploads/business-blackout20150708.pdf>]

Modern economic activity depends on the availability of electricity, and any significant interruption to electricity supply has severe economic consequences. Growing demand means the USA is becoming ever more dependent on power for economic growth, placing an increasing strain on ageing electricity networks. These trends are driven by the growth in electricity intensive industries such as energy and manufacturing and a new demand for consumer electronics and ICT. The rapid pace of change and the increasing interdependency between different sectors of the economy means that it is difficult to fully predict how different technical, social and economic systems will react to large power system failure; further detail on the methodology used to generate the estimates of economic loss is given in the accompanying Appendix 2 (available online). Evidence from historical outages and indicative modelling suggests that power interruptions already cost the US economy roughly $96bn8 annually.9 However, uncertainty and sensitivity analysis suggest this figure may range from $36bn to $156bn. Currently over 95% of outage costs are borne by the commercial and industrial sectors due to the high dependence on electricity as an input factor of production.10 The majority of these costs (67%) are from short interruptions lasting five minutes or less.11 This estimate only provides the expected annual economic loss in an average year, and does not give an indication for the losses that might occur due to a single extreme event. Categories of economic loss The economic losses from electricity failure can be broken down as follows: Direct damage to assets and infrastructure: the costs associated with replacing damaged assets, when this is the cause of electricity failure. Direct loss in sales revenue to electricity supply companies: the revenue that would have been generated if the power failure had not occurred. Estimating revenue losses is achieved by multiplying the expected price of electricity by the amount of electricity that would have been supplied in the event of no failure. Lost revenue would impact generator companies, electricity supply companies and network operators. Direct loss in sales revenue to business: the revenue that a business would have received if the supply of electricity had not failed. This is the integrated difference between the projected ‘no disaster’ trajectory and the trajectory defined by the scenario where electricity fails. This value varies greatly by sector and from one business to the next, largely depending on their reliance on an electricity supply under normal operating conditions and the availability of backup electricity supply systems. The estimates for revenue at risk for electricity supply companies and the wider business sector are detailed in Table 2 below. [TABLE 2 OMITTED] Indirect losses through value chains: the losses upstream and downstream caused by direct interruption to production activities. The lack of supply of electricity prevents goods and services being produced and leads to losses both up and downstream in the supply chain. Long term economic effects: changes in the behaviour of market participants as a result of perceived longterm changes in supply security, including the choice of business location, potential increase in prices due to an increased need for backup facilities and customer churn from unreliable delivery deadlines. Different classes of customer will experience different losses within these categories. At a broad level, these can be broken down into residential, commercial and industrial customers. The residential sector In the electricity regions targeted in this scenario (the NPCC and RFC regions, as described at Annex C), the residential sector consumes 36% of all electricity but across all sectors incurs the smallest cost per unit of unsupplied electricity. This is because the electricity delivered to households is considered as final consumption, ie it is not used to produce goods for use as inputs elsewhere in the economy. Households are not considered to use electricity to generate income, so losses are the direct costs incurred by undelivered electricity. Losses can be grouped into material and immaterial losses. Material costs include out-of-pocket expenses such as candles, prepared food and food spoilage. Immaterial losses include stress, inconvenience, fear and anxiety, etc. Immaterial losses are particularly difficult to evaluate but can be captured using contingent valuation techniques where people are asked how much they would be willing to pay to avoid an electricity outage or, alternatively, how much they would be willing to accept as payment to experience an outage. The industrial sector incurs the highest direct and indirect losses for unsupplied electricity. In 2014, the industrial sector accounted for 25% of total electricity consumption within NPCC and RFC. Electricity is required as an input factor of production to produce goods that are used elsewhere in the economy, meaning that the impacts compound along the supply chain. This is particularly important for supply chains that operate using ‘just-in-time’ philosophy and therefore have little inventory to draw on. In an outage event with a long duration, even industries with large stocks of inventory may experience supply chain disruption. Several studies have estimated the value of lost load to industrial customers as being in the range of US$10 and US$50 for each kWh of electricity unserved12. The commercial sector consumes 39% of total electricity and as a sector is willing to pay twice as much as the industrial sector on average to avoid a power outage13. This is most likely explained by the commercial sector’s high dependence on electricity for making sales and a loss of patronage and reputation in the event of electricity failure. Unlike the industrial sector, the commercial sector sells most of its goods directly to end consumers, thus downstream indirect losses are capped. However, as the commercial sector purchases its goods from elsewhere in the economy, upstream indirect losses will be significant. Impact by economic sector Table 3 below provides the estimated losses for each sector of the economy under the scenario variants. The estimates were generated using a methodology developed by Reichl et al (2013) for estimating the direct dollar value of lost electricity load across different sectors of the economy. [TABLE 3 OMITTED] Impact to the US economy The economy suffers both supply and demand side shocks. On the demand side, consumption is impacted because people are unable to complete economic transactions, are not able to travel to buy goods and cannot use online sources to make purchases. Exports and imports are also impacted, as ports are not able to load and unload goods that come from international markets. On the supply side, labour is negatively impacted because people are either unable to get to work or their productivity is critically dependent on electrically powered technology. All of these factors have serious negative consequences on market confidence. For the areas affected by electricity failure, it is assumed that there is a 100 [percent] % shock to exports and a 50 [percent] % drop in labour productivity and consumption for the duration of the outage in each variant of the scenario. For example, in S1 the regions affected represent 29.5% of the US population for 3.78 outage days. Over one quarter this represents a shock to the US economy of 0.61%. This process was repeated for each of the variants and each of the variables being shocked. These values are given in Table 4. [TABLE 4 OMITTED] By applying these shocks to the Oxford Economics Model we are able to derive estimates for the total USA ‘GDP@Risk’ under each scenario variant. The GDP@Risk for the USA is shown in Figure 3. [FIGURE 3 OMITTED] These results suggest that although the initial shock on the economy is severe, it reverts to pre-shock equilibrium levels before the end of the third year. In the standard variant scenario, when the crisis lasts two weeks to 90% power restoration, the total expected GDP@Risk is $243bn. At the other extreme, in the X1 scenario the outage lasts four weeks and the losses to the economy exceed $1trn [one trillion dollars]. Note that the economic impacts are non-linear with respect to the size and duration of the outage. Even though the marginal cost of electricity failure decreases for direct losses, the reverse is true for indirect losses. The marginal cost of indirect losses grows as the severity of the outage increases and the duration is extended across scenario variants. The economy is slow to rebound to pre-disaster levels once power is returned. For extended outages like in X1, businesses may relocate to other regions, market confidence will wane for several quarters, international competitiveness will drop, and investments from overseas will be diverted elsewhere. The relationship between direct and indirect impacts concurs with the existing literature, which suggests indirect impacts are of much larger magnitude than direct impacts.

### Turns Food---2NC

#### Destroys the food chain

Laurence Hecht, 6/17/2011. Editor in Chief @ 21st Century Magazine. Solar Storm Threatening Power Grids – Yet no Action Taken to Implement Defences, <http://oilprice.com/Energy/Energy-General/Solar-Storm-Threatening-Power-Grids-%E2%80%93-Yet-no-Action-Taken-to-Implement-Defences.html>

\*Language Modified

A prolonged lack of electricity in any of these areas would reduce the population to Dark Age-like conditions. Drinking water supply would break down for lack of pumping, and sewage service would cease shortly thereafter. For lack of refrigeration, the food chain would collapse, and medical supplies would be lost. Fuel could not be pumped, and thus transportation would break down. Heating and air conditioning systems would cease functioning. Communication would be [undermined] crippled by the lack of electricity as well as from the direct damage to satellites and sensitive electronics which a solar storm produces—perhaps no Internet and no cell phones. Modern life would come to an end, and a population and economic infrastructure unprepared for a return to pre-electricity conditions could descend into chaos.

### AT: Backup Generators

#### Generators fail and cannot adapt to mission needs.

Marqusee et al. 17—Jeffrey Marqusee is the Chief Scientist at Noblis, former Executive Director of the DoD’s Strategic Environmental R&D Program, and a PhD from MIT in Physical Chemistry; Craig Schultz is a Principal at ICF specializing in the energy industry and a MBA from the University of Chicago; Dorothy Robyn has a MPP and PhD in public policy from Berkeley [“Power Begins at Home: Assured Energy for U.S. Military Bases,” *Noblis* (nonprofit science, technology, and strategy organization), 12 Jan, <http://www.pewtrusts.org/~/media/assets/2017/01/ce_power_begins_at_home_assured_energy_for_us_military_bases.pdf>]

Maintainability: Maintenance and testing of standalone generators on military bases is often inadequate, although that is less of an issue on bases that have a private utility operator who maintains and test the generators. Proper maintenance requires monthly testing of each unit and semi-annual or annual testing if the monthly tests do not meet the appropriate benchmarks.23 Only about 60 percent of military installations perform the required testing, according to OSD.24

Beyond the military’s testing protocols, there are many other components of a well-designed maintenance program that are important for good long-term asset performance. These additional maintenance activities for larger generators include comprehensive inspection, replacement of cooling system fluid, engine inspection and adjustment, and battery replacement.25 According to military base staff and energy contractors we interviewed, such comprehensive planned maintenance programs are often not followed.

The lack of adequate maintenance and testing is a direct result of the current, decentralized approach to facility energy security. Installations do not invest in staff training and high-quality maintenance. (As one senior Service official in charge of energy told us, “Maintenance of generators is underfunded and no one checks.”) The diversity of generators—with up to dozens of different types of equipment on a base—compounds the problem because it makes it impossible to implement standardized and efficient maintenance approaches.

Reliability: The reliability of an energy security system is a function of the reliability of both the first line of defense and any secondary independent backup systems. In this case, a single standalone generator is the first line of defense, and an independent backup system would consist of a second redundant standalone generator.

The lack of adequate maintenance and testing—attributable to the factors described above—results in a higher than expected failure rate for the first line of defense. An even bigger reliability deficit stems from the lack of an independent power source to provide backup if the original backup generator fails.26 In reliability parlance, there is no N + X reliability, where “X” refers to the number of independent backups that exist to cover a failure.27 Moreover, because standalone generators are disconnected from one another, N+1 reliability would require that every backup generator on an installation have its own dedicated backup unit.

Flexibility: An energy security strategy needs the flexibility to serve an installation’s power needs over time. Electric power needs can change even over the course of a multi-day outage; they will almost certainly change over time, as the missions carried out on a facility expand, contract, and evolve.

Standalone generators can meet changing needs only insofar as the initial oversizing can accommodate an increase in the peak critical load. Because generators are hardwired to the buildings they support, the process of moving one to a new location is costly and time-consuming, requiring de-commissioning, transport, and re-commissioning.28

Coverage: Coverage is a variant of flexibility that refers to the ability to cover a range of power needs at a given point in time. The reliance on standalone generators—a 20-year asset purchased on the basis of its (fixed) capacity—forces operators to make an “all or nothing” decision about whether a load is critical or non-critical: critical loads get 24/7 backup with high reliability, and non-critical loads get no (assured) backup power. However, the military’s energy security needs do not fit neatly into those binary categories. Certain “intermediate” loads, while not mission-critical, could nevertheless advance the mission during an emergency if they had backup power. Moreover, some critical loads could get by with a lower level of backup protection. For example, short outages (say, an hour) are not a threat to “critical” refrigeration and HVAC systems in essential buildings because of the time it takes for the relevant conditions (refrigerator and room temperatures) to deteriorate.

### AT: Grids Stable

#### Grids are interdependent --- that causes total collapse.

Geiger 16—Researcher and editor studying the electricity industry and citing Jon Wellinghoff the chairperson of the Federal Energy Regulatory Commission [Julianne, “What Will You Do When The Lights Go Out? The Inevitable Failure Of The US Grid,” Oil Price, 12 Aug 2016, <http://oilprice.com/Energy/Energy-General/What-Will-You-Do-when-the-Lights-Go-Out-The-Inevitable-Failure-of-the-US-Grid.html>, accessed 26 Aug 2016]

When you look at the layout of the grid above, it’s easy to see that a single grid going offline would disrupt a huge segment of North America.

Wait—make that all of North America.

To give it to you straight, our national electrical grid works as an interdependent network. This means that the failure of any one part would trigger the borrowing of energy from other areas. Whichever grid attempts to carry the extra load would likely be overtaxed, as the grid is already taxed to near max levels during peak hot or cold seasons.

The aftermath of a single grid going down could leave millions of residents without power for days, weeks or longer depending on the scope of the failure.

So although on the surface it looks like the U.S. has wisely put its eggs into three separate baskets for safer keeping, the U.S. has in essence, lined up our baskets so that if one were to drop, or if the bottom were to fall out, the eggs from basket #1 would fall into basket #2. Which would break from the load, falling into basket #3—eventually scrambling all the eggs. Sorry, Texas.

When multiple parts of the grid fail at the same time, it’s not necessarily more catastrophic—the catastrophe just happens more quickly.

### AT: Islanding

#### No islanding --- bases rely on the civilian grid.

Marqusee et al. 17—Jeffrey Marqusee is the Chief Scientist at Noblis, former Executive Director of the DoD’s Strategic Environmental R&D Program, and a PhD from MIT in Physical Chemistry; Craig Schultz is a Principal at ICF specializing in the energy industry and a MBA from the University of Chicago; Dorothy Robyn has a MPP and PhD in public policy from Berkeley [“Power Begins at Home: Assured Energy for U.S. Military Bases,” *Noblis* (nonprofit science, technology, and strategy organization), 12 Jan, <http://www.pewtrusts.org/~/media/assets/2017/01/ce_power_begins_at_home_assured_energy_for_us_military_bases.pdf>]

II.1 Vulnerability of Defense Installations

Defense installations carry out a wide range of functions, almost all of which require reliable electric power. Tactical unmanned aircraft systems in theater are piloted from U.S. bases, and many bases have enhanced intelligence, surveillance, and communications capabilities that support critical missions. Military bases are home to laboratories that perform high-value research and development (R&D), test and training ranges used to demonstrate multibillion-dollar weapon systems, and industrial facilities (such as aircraft maintenance depots and specialized ammunition plants) that directly support mission readiness. Hospitals, fire stations, and emergency management centers on military bases typically operate 24/7, and bases increasingly provide support to civil authorities during national emergencies here at home.

Military bases rely almost entirely on the commercial grid for their electric power, and a base is often the largest customer served by its local utility. No two bases are the same; as facility experts often say, “When you’ve seen one base, you’ve seen one base.” However, a typical large military base has a peak electricity demand of about 50 megawatts (MW), of which about 20 MW (40 percent) represents “critical loads”. Critical loads are those functions that must have emergency backup power under OSD’s power resilience requirements. Although the Services define the term somewhat differently, critical loads generally include activities related to life safety and health (e.g., hospitals), public safety (e.g., policing and firefighting), communications, environmental systems, and critical mission support.

Despite the presence of backup generators, power outages are a serious problem for military bases. Outages that last just a few hours are not the major concern, although even they can be costly. For example, at one facility, the Navy had to postpone a long-planned test of a weapon system because of a short-term loss of power; Navy officials estimated that the schedule interruption cost more than $1 million.

The real concern is power outages that last days or even weeks, which can cost DoD tens of millions of dollars and jeopardize the mission of the facility and/or the health and safety of its personnel. For example:

• In April 2011, a tornado swept through northern Alabama leaving the Army’s Redstone Arsenal base in Huntsville, which is home to the U.S. Army Material Command and NASA’s Marshall Space Flight Center, without power for eight days.14 The base, which employs 35,000 people, was closed to all but a few essential activities, such as a Marshall Space Flight Center unit that supports the space shuttle liftoff and one that communicates with the Space Station. The NASA units relied on several large backup generators that they maintained for just such an emergency; but by the time that power was restored, the generators were, in the words of one base official, “running on fumes.”

• Following the failed coup in July 2016, the government of Turkey cut off commercial electric power to the U.S. Air Force’s Incirlik Air Base in that country for nearly a week. Incirlik Air Base is key to the U.S. military’s operations against ISIS: the 2,700 DoD personnel who are stationed there operate both manned and unmanned sorties from the base. Although the Air Base made use of standby generators, the Air Force was forced to reduce the number of sorties flown; had the power outage continued, it would have had to stop flying altogether.

Just how vulnerable are military bases to these kinds of outages? As a starting point, consider the reliability of those utilities that serve the 30 largest military bases in the United States, as measured by their energy consumption—a sample that is typical of U.S. utilities nationwide. The two most common indicators of utility reliability are the System Average Interruption Frequency Index (SAIFI), which measures the average number of sustained interruptions in power (more than 5 minutes) that a customer would experience, and the System Average Interruption Duration Index (SAIDI), which measures the average length of those interruptions. (SAIFI and SAIDI are based on utility-reported data.)

As shown in Figure 2, in 2013 and 2014, for customers served by these 30 utilities, the average number of power interruptions a year (SAIFI) ranged from 1-3 (on the y-axis), and the average duration of those interruptions (SAIDI) ranged from 1-7 hours (on the x-axis). These reliability measures illustrate two points. First, there is significant variability in the (average) reliability of U.S. utilities. Second, outages are a genuine problem. To illustrate, if the average duration of outages for a given utility is seven hours, the distribution of outage durations will likely include multi-day outages.

While SAIFI and SAIDI measures are a useful reference, they understate the threat of outages to military bases in three ways. First and most important, military bases experience more frequent power outages and longer-duration outages than other customers served by a given utility. Many military bases are located in remote areas, and that fact, combined with their size, means that bases are often situated at the end of utility distribution feeders. That leaves them particularly vulnerable to service disruptions from downed power lines and other natural hazards.

#### DoD depends on civilian grids.

Yachanin 16—Naval Officer and a MS in Civil and Environmental Engineering from Stanford [Alex, “Small Nuclear Reactors for Military Bases,” 12 Mar, <http://large.stanford.edu/courses/2016/ph241/yachanin2/>, accessed 11 Jan 2017]

In the U.S., military installations are almost always dependent on the civilian electrical grid for their power. [3] This patchwork grid, built over decades across the country, is aging, near its capacity limit, and outside of DOD control. In addition, it is increasingly susceptible to kinetic or cyber attack. One report sponsored by the Department of Homeland Security claims that a coordinated cyber attack on the grid could result in a weeks-long blackout across one third of the country. [3] In the event of such an attack, many military bases could lose critical intelligence, communications, and logistics capabilities. One method to mitigate this risk is to construct microgrids on military installations that would island them from the civilian electric grid. Because most bases have relatively light power demands, a small nuclear reactor located on base could provide all of its required power. [3]

### AT: Not kt Heg

#### Grid failure wrecks US critical mission operations

Stockton 11 Paul, assistant secretary of defense for Homeland Defense and Americas’ Security Affairs, “Ten Years After 9/11: Challenges for the Decade to Come”, <http://www.hsaj.org/?fullarticle=7.2.11>. Modified for ableist language.

The cyber threat to the DIB is only part of a much larger challenge to DoD. Potential adversaries are seeking asymmetric means to [eliminate] cripple our force projection, warfighting, and sustainment capabilities, by targeting the critical civilian and defense supporting assets (within the United States and abroad) on which our forces depend. This challenge is not limited to man-made threats; DoD must also execute its mission-essential functions in the face of disruptions caused by naturally occurring hazards.20 Threats and hazards to DoD mission execution include incidents such as earthquakes, naturally occurring pandemics, solar weather events, and industrial accidents, as well as kinetic or virtual attacks by state or non-state actors. Threats can also emanate from insiders with ties to foreign counterintelligence organizations, homegrown terrorists, or individuals with a malicious agenda. From a DoD perspective, this global convergence of unprecedented threats and hazards, and vulnerabilities and consequences, is a particularly problematic reality of the post-Cold War world. Successfully deploying and sustaining our military forces are increasingly a function of interdependent supply chains and privately owned infrastructure within the United States and abroad, including transportation networks, cyber systems, commercial corridors, communications pathways, and energy grids. This infrastructure largely falls outside DoD direct control. Adversary actions to destroy, disrupt, or manipulate this highly vulnerable homeland- and foreign-based infrastructure may be relatively easy to achieve and extremely tough to counter. Attacking such “soft,” diffuse infrastructure systems could significantly affect our military forces globally – potentially blinding them, neutering their command and control, degrading their mobility, and isolating them from their principal sources of logistics support. The Defense Critical Infrastructure Program (DCIP) under Mission Assurance seeks to improve execution of DoD assigned missions to make them more resilient. This is accomplished through the assessment of the supporting commercial infrastructure relied upon by key nodes during execution. By building resilience into the system and ensuring this support is well maintained, DoD aims to ensure it can "take a punch as well as deliver one."21 It also provides the department the means to prioritize investments across all DoD components and assigned missions to the most critical issues faced by the department through the use of risk decision packages (RDP).22 The commercial power supply on which DoD depends exemplifies both the novel challenges we face and the great progress we are making with other federal agencies and the private sector. Today’s commercial electric power grid has a great deal of resilience against the sort of disruptive events that have traditionally been factored into the grid’s design. Yet, the grid will increasingly confront threats beyond that traditional design basis. This complex risk environment includes: disruptive or deliberate attacks, either physical or cyber in nature; severe natural hazards such as geomagnetic storms and natural disasters with cascading regional and national impacts (as in NLE 11); long supply chain lead times for key replacement electric power equipment; transition to automated control systems and other smart grid technologies without robust security; and more frequent interruptions in fuel supplies to electricity-generating plants. These risks are magnified by globalization, urbanization, and the highly interconnected nature of people, economies, information, and infrastructure systems. The department is highly dependent on commercial power grids and energy sources. As the largest consumer of energy in the United States, DoD is dependent on commercial electricity sources outside its ownership and control for secure, uninterrupted power to support critical missions. In fact, approximately 99 percent of the electricity consumed by DoD facilities originates offsite, while approximately 85 percent of critical electricity infrastructure itself is commercially owned. This situation only underscores the importance of our partnership with DHS and its work to protect the nation’s critical infrastructure – a mission that serves not only the national defense but also the larger national purpose of sustaining our economic health and competitiveness. DoD has traditionally assumed that the commercial grid will be subject only to infrequent, weather-related, and short-term disruptions, and that available backup power is sufficient to meet critical mission needs. As noted in the February 2008 Report of the Defense Science Board Task Force on DoD Energy Strategy, “In most cases, neither the grid nor on-base backup power provides sufficient reliability to ensure continuity of critical national priority functions and oversight of strategic missions in the face of a long term (several months) outage.”23 Similarly, a 2009 GAO Report on Actions Needed to Improve the Identification and Management of Electrical Power Risks and Vulnerabilities to DoD Critical Assets stated that DoD mission-critical assets rely primarily on commercial electric power and are vulnerable to disruptions in electric power supplies.24 Moreover, these vulnerabilities may cascade into other critical infrastructure that uses the grid – communications, water, transportation, and pipelines – that, in turn, is needed for the normal operation of the grid, as well as its quick recovery in emergency situations. To remedy this situation, the Defense Science Board (DSB) Task Force recommended that DoD take a broad-based approach, including a focused analysis of critical functions and supporting assets, a more realistic assessment of electricity outage cause and duration, and an integrated approach to risk management that includes greater efficiency, renewable resources, distributed generation, and increased reliability. DoD Mission Assurance is designed to carry forward the DSB recommendations. Yet, for a variety of reasons – technical, financial, regulatory, and legal – DoD has limited ability to manage electrical power demand and supply on its installations. As noted above, DHS is the lead agency for critical infrastructure protection by law and pursuant to Homeland Security Presidential Directive 7. The Department of Energy (DOE) is the lead agency on energy matters. And within DoD, energy and energy security roles and responsibilities are distributed and shared, with different entities managing security against physical, nuclear, and cyber threats; cost and regulatory compliance; and the response to natural disasters. And of course, production and delivery of electric power to most DoD installations are controlled by commercial entities that are regulated by state and local utility commissions. The resulting paradox: DoD is dependent on a commercial power system over which it does not – and never will – exercise control.

### AT: Meltdowns Defense

#### Accidents are likely and devastate the environment.

Kopytko & Perkins, ’11 [Natalie, PhD Researcher in the Environment Department, University of York, John, former chief economist at a major international consulting firm, advised the World Bank, United Nations, IMF, U.S. Treasury Department, Fortune 500 corporations, and countries in Africa, Asia, Latin America, and the Middle East, his books on economics and geo-politics have sold more than 1 million copies, spent many months on the New York Times and other bestseller lists, and are published in over 30 languages, “Climate Change, Nuclear Power, and the Adaptation-Mitigation Dilemma,” Energy Policy, [Volume 39, Issue 1](http://www.sciencedirect.com/science/journal/03014215/39/1), January 2011, Pages 318–333, Science Direct]

5.5. Other environmental problems Nuclear power has the potential for catastrophic accidents and consequently widespread environmental damage, unlike any other form of energy. The potential costs of not adapting nuclear operations to climate change are exceptionally high. Safe operation during extreme climate events remains a challenge. For one, the uncertainty in predicting climate change poses a problem for safety. Historical flood levels can no longer serve as an adequate predictor of future floods. As seen in France, recent floods have exceeded design basis levels. Regardless of design parameters, storms at coastal locations continue to be a problem because they often lead to the failure of multiple systems, and despite previous experience, failures in alarm and communication systems continue to occur. In certain cases, licensees have shown a low awareness of potential problems caused by external events. Moisture build-up leads to equipment failure; nonetheless, a licensee at one site did not recognize the problem as something requiring preventative and corrective measures. In addition, after a hurricane had passed a site in Florida, the missile shield doors that protected safety related equipment were found open and according to the licensee these doors could have been open for several years. These examples indicate that licensees do not always take proper action in dealing with external events; moreover, they are not prepared for the issues that will arise due to climate change.

### AT: Readiness Not Key

#### Readiness is key to prevent nuclear great power war

Dowd 15 (Alan, Senior fellow at the Sagamore Institute for Policy Research and a contributing editor for the American Legion magazine “Shield & Sword: The Case for Military Deterrence”, 12/31/15, <https://providencemag.com/2015/12/shield-sword-the-case-for-military-deterrence/>, Providence Magazine)

Surely, the same principle applies in the realm of nations. Our world teems with violent regimes and vicious [humans]. And something precious—our notion of peace, sovereignty, liberty, civilization itself—sits exposed to all that danger. In a world where might makes right, the only thing that keeps the peace, defends our sovereignty and liberty, and upholds civilization is the willingness to use our resources to keep the dangers at bay. Yet too many policymakers disregard the wisdom of military deterrence, and too many people of faith forget that the aim of deterrence is, by definition, to prevent wars, not start them. Some people of faith oppose the threat of military force, let alone the use of military force, because of Christ’s message of peace. This is understandable in the abstract, but we must keep in mind two truths. First, governments are held to a different standard than individuals, and hence are expected to do certain things individuals aren’t expected to do—and arguably shouldn’t do certain things individuals should do. For example, a government that turned the other cheek when attacked would be conquered by its foes, leaving countless innocents defenseless. A government that put away the sword—that neglected its defenses—would invite aggression, thus jeopardizing its people. Second, all uses of force are not the same. The sheriff who uses force to apprehend a murderer is decidedly different from the criminal who uses force to commit a murder. The policemen posted outside a sporting event to deter violence are decidedly different from those who plot violence. Moral relativism is anything but a virtue. Some lament the fact that we live in such a violent world, but that’s precisely the point. Because we live in a violent world, governments must take steps to deter those who can be deterred—and neutralize those who cannot. In this regard, it pays to recall that Jesus had sterner words for scholars and scribes than He did for soldiers. In fact, when a centurion asked Jesus for help, He didn’t admonish the military commander to put down his sword. Instead, He commended him for his faith.[i] “Even in the Gospels,” soldier-scholar Ralph Peters reminds us, “it is assumed that soldiers are, however regrettably, necessary.”[ii] They are necessary not only for waging war but, preferably, for maintaining peace. It’s a paradoxical truth that military readiness can keep the peace. The Romans had a phrase for it: Si vis pacem, para bellum. “If you wish for peace, prepare for war.” President George Washington put it more genteelly: “There is nothing so likely to produce peace as to be well prepared to meet an enemy.” Or, in the same way, “We infinitely desire peace,” President Theodore Roosevelt declared. “And the surest way of obtaining it is to show that we are not afraid of war.” After the West gambled civilization’s very existence in the 1920s and 1930s on hopes that war could somehow be outlawed, the men who crafted the blueprint for waging the Cold War returned to peace through strength. Winston Churchill proposed “defense through deterrents.” President Harry Truman called NATO “an integrated international force whose object is to maintain peace through strength…we devoutly pray that our present course of action will succeed and maintain peace without war.”[iii] President Dwight Eisenhower explained, “Our arms must be mighty, ready for instant action, so that no potential aggressor may be tempted to risk its own destruction.” President John Kennedy vowed to “strengthen our military power to the point where no aggressor will dare attack.” And President Ronald Reagan steered the Cold War to a peaceful end by noting, “None of the four wars in my lifetime came about because we were too strong.” Reagan also argued, “Our military strength is a prerequisite for peace.”[iv] Even so, arms alone aren’t enough to deter war. After all, the great powers were armed to the teeth in 1914. But since they weren’t clear about their intentions and treaty commitments, a small crisis on the fringes of Europe mushroomed into a global war. Neither is clarity alone enough to deter war. After all, President Woodrow Wilson’s admonitions to the Kaiser were clear, but America lacked the military strength at the onset of war to make those words matter and thus deter German aggression. In other words, America was unable to deter. “The purpose of a deterrence force is to create a set of conditions that would cause an adversary to conclude that the cost of any particular act against the United States of America or her allies is far higher than the potential benefit of that act,” explains Gen. Kevin Chilton, former commander of U.S. Strategic Command. It is a “cost-benefit calculus.”[v] So, given the anemic state of America’s military before 1917, the Kaiser calculated that the benefits of attacking U.S. ships and trying to lure Mexico into an alliance outweighed the costs. That proved to be a grave miscalculation. In order for the adversary not to miscalculate, a few factors must hold. First, consequences must be clear, which was not the case on the eve of World War I. Critics of deterrence often cite World War I to argue that arms races trigger wars. But if it were that simple, then a) there wouldn’t have been a World War II, since the Allies allowed their arsenals to atrophy after 1918, and b) there would have been a World War III, since Washington and Moscow engaged in an unprecedented arms race. The reality is that miscalculation lit the fuse of World War I. The antidote, as alluded to above, is strength plus clarity. A second important factor to avoid miscalculation: The adversary must be rational, which means it can grasp and fear consequences. Fear is an essential ingredient of deterrence. It pays to recall that deterrence comes from the Latin dēterreō: “to frighten off.”[vi] Of course, as Churchill conceded, “The deterrent does not cover the case of lunatics.”[vii] Mass-murderers masquerading as holy men and death-wish dictators may be immune from deterrence. (The secondary benefit of the peace-through-strength model is that it equips those who embrace it with the capacity to defeat these sorts of enemies rapidly and return to the status quo ante.) Third, the consequences of military confrontation must be credible and tangible, which was the case during most of the Cold War. Not only did Washington and Moscow construct vast military arsenals to deter one another; they were clear about their treaty commitments and about the consequences of any threat to those commitments. Recall how Eisenhower answered Soviet Premier Nikita Khrushchev’s boast about the Red Army’s overwhelming conventional advantage in Germany: “If you attack us in Germany,” the steely American commander-in-chief fired back, “there will be nothing conventional about our response.”[viii] Eisenhower’s words were unambiguously clear, and unlike Wilson, he wielded the military strength to give them credibility. Discussing military deterrence in the context of Christianity may seem incongruent to some readers. But for a pair of reasons it is not. First, deterrence is not just a matter of GDPs and geopolitics. In fact, scripture often uses the language of deterrence and preparedness. For example, in the first chapter of Numbers the Lord directs Moses and Aaron to count “all the men in Israel who are twenty years old or more and able to serve in the army.” This ancient selective-service system is a form of military readiness. Similarly, I Chronicles 27 provides detail about the Israelites’ massive standing army: twelve divisions of 24,000 men each. II Chronicles 17 explains the military preparations made by King Jehoshaphat of Judah, a king highly revered for his piety, who built forts, maintained armories in strategically located cities “with large supplies” and fielded an army of more than a million men “armed for battle.” Not surprisingly, “the fear of the Lord fell on all the kingdoms of the lands surrounding Judah, so that they did not go to war against Jehoshaphat.” In the New Testament, Paul writes in Romans 13 that “Rulers hold no terror for those who do right, but for those who do wrong…Rulers do not bear the sword for no reason.” Again, this is the language of deterrence. Those who follow the law within a country and who respect codes of conduct between countries have nothing to fear. Those who don’t have much to fear. Likewise, to explain the importance of calculating the costs of following Him, Jesus asks in Luke 14, “What king would go to war against another king without first sitting down to consider whether his 10,000 soldiers could go up against the 20,000 coming against him? And if he didn’t think he could win, he would send a representative to discuss terms of peace while his enemy was still a long way off.” In a sense, both kings are wise—one because he recognizes that he’s outnumbered; the other because he makes sure that he’s not. Put another way, both kings subscribe to peace through strength. Again, as with the Centurion earlier, Jesus could have rebuked the martial character of these kings, but he did not. This is not just description but commendation. We ignore their example at our peril. Secondly, it is not incongruent if we understand military deterrence as a means to prevent great-power war—the kind that kills by the millions, the kind humanity has not endured for seven decades. We know we will not experience the biblical notion of peace—of shalom, peace with harmony and justice—until Christ returns to make all things new. In the interim, in a broken world, the alternatives to peace through strength leave much to be desired: peace through hope, peace through violence, or peace through submission. But these options are inadequate. The sheer destructiveness and totality of great-power war testify that crossing our fingers and hoping for peace is not a Christian option. Wishful thinking, romanticizing reality, is the surest way to invite what Churchill called “temptations to a trial of strength.” Moreover, the likelihood that the next great-power war would involve multiple nuclear-weapons states means that it could end civilization. Therefore, a posture that leaves peer adversaries doubting the West’s capabilities and resolve—thus inviting miscalculation—is not only unsound, but immoral and inhumane—unchristian. “Deterrence of war is more humanitarian than anything,” Gen. Park Yong Ok, a longtime South Korean military official, argues. “If we fail to deter war, a tremendous number of civilians will be killed.”[ix] Peace through violence has been tried throughout history. Pharaoh, Caesar and Genghis Khan, Lenin, Hitler, Stalin and Mao, all attained a kind of peace by employing brutal forms of violence. However, this is not the kind of “peace” under which God’s crowning creation can flourish; neither would the world long tolerate such a scorched-earth “peace.” This option, too, the Christian rejects. Finally, the civilized world could bring about peace simply by not resisting the enemies of civilization—by not blunting the Islamic State’s blitzkrieg of Iraq; by not defending the 38th Parallel; by not standing up to Beijing’s land-grab in the South China Sea or Moscow’s bullying of the Baltics or al-Qaeda’s death creed; by not having armies or, for that matter, police. As Reagan said, “There’s only one guaranteed way you can have peace—and you can have it in the next second—surrender.”[x] The world has tried these alternatives to peace through strength, and the outcomes have been disastrous. After World War I, Western powers disarmed and convinced themselves they had waged the war to end all wars. By 1938, as Churchill concluded after Munich, the Allies had been “reduced…from a position of security so overwhelming and so unchallengeable that we never cared to think about it.”[xi] Like predators in the wilderness, the Axis powers sensed weakness and attacked. In October 1945—not three months after the Missouri steamed into Tokyo Bay—Gen. George Marshall decried the “disintegration not only of the Armed Forces, but apparently…all conception of world responsibility,” warily asking, “Are we already, at this early date, inviting that same international disrespect that prevailed before this war?”[xii] Stalin answered Marshall’s question by gobbling up half of Europe, blockading Berlin, and arming Kim Il-Sung in patient preparation for the invasion of South Korea.[xiii] The U.S. military had taken up positions in Korea in 1945, but withdrew all combat forces in 1949.[xiv] Then, in 1950, Secretary of State Dean Acheson announced that Japan, Alaska and the Philippines fell within America’s “defensive perimeter.”[xv] Korea didn’t. Stalin noticed. Without a U.S. deterrent in place, Stalin gave Kim a green light to invade. Washington then reversed course and rushed American forces back into Korea, and the Korean peninsula plunged into one of the most ferocious wars in history. The cost of miscalculation in Washington and Moscow: 38,000 Americans, 103,250 South Korean troops, 316,000 North Korean troops, 422,000 Chinese troops and 2 million civilian casualties.[xvi] The North Korean tyranny— now under command of Kim’s grandson—still dreams of conquering South Korea. The difference between 2015 and 1950 is that tens of thousands of battle-ready U.S. and ROK troops are stationed on the border. They’ve been there every day since 1953. The lesson of history is that waging war is far more costly than maintaining a military capable of deterring war. As Washington observed, “Timely disbursements to prepare for danger frequently prevent much greater disbursements to repel it.” Just compare military allocations, as a percentage of GDP, during times of war and times of peace: In the eight years before entering World War I, the United States devoted an average of 0.7 percent of GDP to defense; during the war, U.S. defense spending spiked to 16.1 percent of GDP. In the decade before entering World War II, the United States spent an average of 1.1 percent of GDP on defense; during the war, the U.S. diverted an average of 27 percent of GDP to the military annually. During the Cold War, Washington spent an average of 7 percent of GDP on defense to deter Moscow; it worked. Yet it seems we have forgotten those hard-learned lessons. In his book The World America Made, Robert Kagan explains how “America’s most important role has been to dampen and deter the normal tendencies of other great powers to compete and jostle with one another in ways that historically have led to war.” This role has depended on America’s military might. “There is no better recipe for great-power peace,” Kagan concludes, “than certainty about who holds the upper hand.”[xvii]

### XT – No Islanding

#### Islanding is a far-off dream --- the military makes project decisions based on cost.

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Although the Services cite energy security as a rationale for their 1 GW initiatives, other goals—largely the desire to reduce their utility costs—have been the major driver for project decisions. For example, when a Service contracts to procure off-site renewable energy, it counts toward the 1 GW goal and may lower the Service’s utility costs; however, it does not enhance the energy security of the base(s) to which the power will be wheeled via the commercial grid. Moreover, even those projects that are located on-base are often not sited, sized, or designed based on security considerations. In many cases, the generation assets are connected directly to the grid, leaving the base with no ability to access the renewable energy during a power outage.

Importantly, the Services now routinely include a contractual provision that specifies that the military gets “first dibs” on power generated on base in the event of a grid outage. However, the Services are not making even the initial investments needed to enable islanding, starting with upgrades to the base’s electrical distribution system and culminating in a microgrid. The Army’s claim that it is making its projects “microgrid-ready” can be limited to the use of smart inverters, which have become standard on new solar arrays. In other respects, the Army is negotiating its projects with a primary focus on getting the best possible deal on the cost of power.