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The Grid Pandemic

Will Make COVID-19 Look Like a Side Show

The White House Awakens to a Looming Vulnerability

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WARNING: Contents may be disturbing

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A year after I arrived in the U.S. as a young and ambitious Scottish immigrant, James Brown released the song Living in America. The power of that song and its ability to evoke a feeling of invincibility in America and the American Dream struck me in 1985

and it still strikes me today. "You may not be looking for the promised land, but you may find it anyway" – I certainly did.

Three and a half decades later the United States can seem more invincible than ever – the richest and most powerful nation in the history of humanity. The Second World War and the Cold War that followed, were won by America's industrial and military might and, perhaps, (I like to think so anyway) because America was in the right in both instances. The mighty Atlantic and Pacific Oceans protect us to our east and west and we have generally friendly and relatively benign neighbors to the north and south. All has been well Living in America.

And yet, from time to time something comes along that shakes our unflinching faith in our invincibility. An event, or series of events that makes us ask ourselves if perhaps our great strength and isolation might, one day, not be enough. 9/11 was one such moment and COVID 19 has very nearly managed to do what the Nazis, the Soviets, Al Qaeda and ISIS all failed to do – bring the world's mightiest economy to its knees. 9/11 required, and received, a military response. It's too early to say what the complete response to COVID-19 will be but it does, at least today, seem that the solutions will be within our reach. We have the economic tools to sustain and rebuild the economy and I have faith that science and technology will deliver a vaccine and the other tools we will need to relegate COVID to the history books where it can join its peers, polio, small pox, Spanish Flu and all the others.

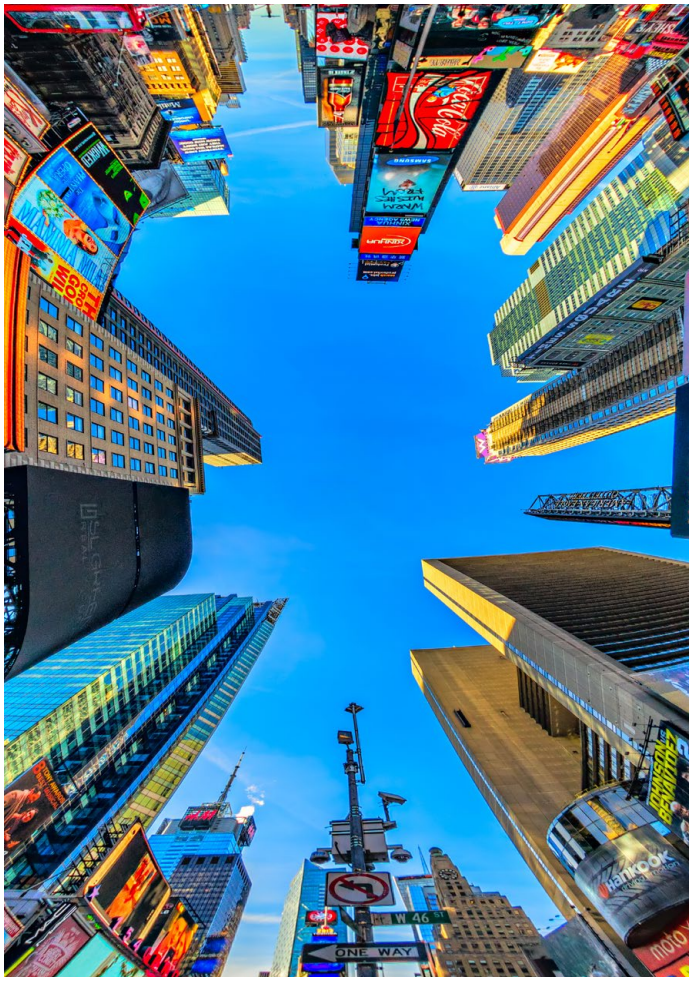
But are there other threats to our peace and wellbeing?

> **"History shows us that all great powers come to an end**

Threats that might actually have a fundamentally and even devastating impact on this American life?

AN EMPIRE WITHOUT END?

The best way to see the future is to look at the past. History shows us that all great powers come to an end. Great Britain, my native land, controlled history's largest empire. At the outbreak of the First World War Britain had a policy of maintaining a navy that was at least as large as any other two nation's navies together. 25% of



the worlds land surface, essentially all of the oceans and more than a quarter of its population were controlled from London. Less than three decades, and two World Wars, later Britain was Great in name only; a struggling island reeling from history's greatest decline. Rome is still today a magnificent city but one without global clout. Yet it once controlled most of Europe and the states bordering the Mediterranean. Most people have heard of Genghis Khan and know that he controlled a massive empire. But few could point to Mongolia, from where he hailed on a map today. Empires and great states come and go. History has allowed no exception. Does American exceptionalism extend to its being the first empire without end? The U.S.'s hitherto (mostly and relatively) benign application of its great power might make it the best candidate for such a title, but it feels naïve to assume that the current stasis can last forever even if only because stasis of any sort never does. Entropy is a universal and unassailable inevitability.

So, what event or process might lead to the decline? The answers to that question and the opinions that inform them could fill several volumes and far exceed any clairvoyance I might claim. But there is a subject about which I have more than a casual level of understanding which might just cover the most significant and potential vulnerability facing the United States today.

> **"The air we breathe, the water we drink, our shelter, our means of earning a living and our actual physical wellbeing are all fundamentally important to the nation state**

When endeavoring to identify a vulnerability that can have national implications one must first consider the elements upon which society is most reliant. The air we breathe, the water we drink, our shelter, our means of earning a living and our actual physical wellbeing are all fundamentally important to the nation state. They are all also, and this is one of Americas great strengths, generally highly distributed in this country and as such very hard to target with a knockout punch. There is too much air to poison as part of an act of aggression, and the same goes for water, at least at the national level. The structures we rely on for shelter and commerce are dispersed. We have learned in the past that even massive, prolonged and wholesale bombing of dense urban areas has a surprisingly small impact on a nation's ability to continue to provide, at least minimally, for its citizens.

Certainly, nuclear weapons are capable of delivering a knockout blow but the nation states that have meaningful stockpiles are unlikely to use them at scale because they understand the impossibility of having a favorable outcome from such a move. Rogue states could do a great deal of damage at a local or even regional level but doing such a thing would mean their ceasing to exist and as such seems unlikely in all but an accidental case. At any rate it would not be the knockout punch.

There are, of course, many other diabolical potentialities – dirty bombs, biological and chemical weapons and cyber attacks, to name but a few – which would deliver tragic and ugly consequences but none of them are likely to be more than local or limited in some other way, and, arguably, all of them would be very hard to pull off at great scale.

It's tempting therefore to think that none of the essentials to the maintenance of our homeland are at risk in any definite and final sense and that therefore, our invincibility will not be challenged by a nefarious actor, domestic or foreign – at least not in the foreseeable future.

Tempting perhaps, but is it valid to think this way?

OUR VERY REAL ACHILLES HEEL

It is my view that there is one essential upon which all the others depend in this 20th year of the third millennium. Electricity. We have become so reliant on electricity that we can no longer function as a society without a reliable source of it. You might argue that water is more important to our survival than electricity and I certainly would not argue that point. But I place electricity at the top of my vital resource pyramid because without it we will not have access to water. All the water we consume is pumped to us and away from us using electric pumps. Similarly, all of our communications systems rely on electricity. All of our transportation systems, no matter how they are fueled, rely on electricity for their

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operation. All of our commerce and banking rely on electricity. Our military relies on electricity and the food production and distribution system cannot function in the 20th century without it. The Healthcare industry cannot perform its vital tasks without electrons coursing down copper to maintain even the most basic of services. In short, everything we do or consume is enabled by, and reliant upon, electricity. That reliance on electricity, and the centralized infrastructure that delivers it, is such a severe and strategic vulnerability that, according to the findings of a U.S. Congressional Joint Hearing before the Subcommittees on National Security and the Interior, "a prolonged collapse of this nation's electrical grid—through starvation, disease, and societal collapse — could result in the death of up to 90% of the American population.

It turns out that one need not bomb the United States into submission – all one needs to do is turn the power off for a few months to deprive most of us of our lives, and doing that, as will be seen, is not a daunting task, practically or technically.

The U.S. grid is an engineering marvel. It is the largest machine ever built and it has been delivering electricity to the nation for more than a century. In many ways it serves as a useful analogy for the broader U.S. – it is massive and powerful and seemingly invincible but it is a Goliath that can be toppled by the tiniest of stones from a slingshot controlled by a small number of unknown individuals or, equally, by the concerted and ongoing efforts of a powerful nation state that need never set foot on American soil.

To understand how these vulnerabilities can exist we must first understand how the grid operates. It is a massive chain, or set of chains, and as we all know a chain is only as strong as its weakest link. Identify the weak links in the grid and you have the means to topple the giant.

THE GRID - A CHAIN OF CHAINS

The first vital link is at the point of generation – the power plant. Large centralized power stations have been the linchpins of the grid since its inception. Whether powered by coal, natural gas, nuclear power or even renewables like solar and wind, these generating facilities are centralized and distanced from the load – your home or factory or hospital. To deliver the electricity to the load several other links in the chain become involved. First, transmission lines transport high voltage electricity across long distances, closing the gap between generation and load. We've all seen these power lines slung from pylons, marching in Orwellian lockstep across the countryside. The voltages in these lines are much higher than can be realistically used to power the appliances that make our lives easy. A series of transformers in substations take these high voltages and turn them into lower voltages which are then sent across distribution networks and finally, through more transformers, into the wiring which enters your home or place of business. Those wires terminate at the outlet that you plug into before blending the perfect margarita. This single action which you take for granted, and probably never give a second thought, is actually enabled by a fantastically complex chain of components stretching across vast distances. Break any link in that complex chain and it ceases to function. It is important to understand that one need not disable any of the large and hardened links in the chain – any link will do, and that's where the very real and practical vulnerability exists.

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It's almost impossible that anyone reading this has not, at one time or another, experienced a break in the chain. The wind blows and a tree limb falls on a power line. Hurricane Sandy knocks out poll top transformers (the flashes you see in the news reports) and New York is without power for four days. A drunk driver piles their pickup truck into a neighborhood transformer. Sometimes our own actions cause the black outs. Just as plugging too many Christmas lights into the same outlet

can trip your breakers, so too, can lots of people turning on air conditioners, during a balmy August evening, cause large sections of the grid to trip and shut down. This happens either automatically or because the utility deliberately throws switches to protect their infrastructure from the overload. Vehicle accidents are a common cause of grid interruptions. Crashing into a power pole or worse, a substation, can shut down any area served by those assets. Crashing several vehicles into several assets at the same time could have very significant results, but more on that later.

There have even been instances in which deliberate acts have shut down sections of the grid. Cyber and physical infrastructure attacks have occurred. The grid is, today, not only reliant on the sorts of physical assets described above but also increasingly upon computer networks for its command and control. Hacking those networks can create opportunities to control the flow of power - or turn it off.

So far none of these grid interruptions have been calamitous or on a national scale. None have delivered the sort of knockout punch that could result in the horrific conclusions of the Sub Committee on National Security. A grid failure that results in 9 out of 10 Americans perishing would have to be both nationwide and prolonged. Weather events and the other situations cited above are likely to result in local, or at worst, regional outages. So what options are available to the bad actor that wants to take down the U.S. and how expensive, complicated and challenging would they be to pull off?

THE BIG THREATS ARE REAL

There are several options available to large well-funded state-level players and natural phenomena which science has already identified could also succeed. I will list the top candidates in the following paragraphs, but I am going to spend the most time describing the low-tech simple approaches because while all the eventualities are possible and catastrophic the least complicated approaches are most worrying to me. This is simply because they are so attainable and the pool of those qualified to carry them out so broad that I feel (and it is just a feeling) that these scenarios are the most likely to occur and therefore constitute our greatest vulnerability.

From nature, we could receive a large and dramatic geomagnetic storm caused by a coronal mass ejection (CME) from the sun. I'll spare you the astrophysics, but such an event could subject the U.S. grid to an intense magnetic field which could destroy enough infrastructure to cause a complete and prolonged black-out. While this scenario is probably unlikely it is far from impossible. There is nothing we can do to prevent the

sun behaving in this way. It has happened in pre-electric history and there have been regional blackouts caused by smaller events in the post-electric era. Will the big one come? We won't know until it does. It is possible to harden the grid to make it resistant to such events but it's not cheap and like many theoretical threats that are not cheap it is not a budget priority for anyone.

Large state actors could, in every practical sense, mimic the coronal mass ejection. The physics are slightly different, but the results would be more or less the same. Detonating nuclear weapons in the upper atmosphere would create a high-altitude electromagnetic pulse (HEMP) which would destroy grid assets in the same way that a CME would (again, more or less). How many nuclear devices and how big they would have to be is a subject for some debate amongst the experts but even the highest estimates are well within the capabilities of the larger nuclear states. The benefit to the aggressor is that there is no collateral damage on the ground. No blast impact and no radiation so theoretically one could achieve the aims of war and actually gain assets that were worth having post victory. This contrasts materially with the spoils of a terrestrial nuclear exchange – though HEMP would take a bit longer and carry other risks, like the potential for short term retaliation for example. Mainstream state actors, rogue states, terrorist organizations and even individuals might be able to deliver on the next potential vulnerability on the list. As noted earlier, electrical grids, like all vital modern infrastructure, are increasingly commanded and controlled by computer or automation networks of varying degrees of modernity, sophistication and integration. The utility industry has been relatively slow, when compared to other industries, to automate and provide for remote command and control of its infrastructure. While this has undoubtedly led to an increase in time and resources required to solve certain traditional power interruptions over what might otherwise be possible, the grid's lack of sophistication has also provided a level of defense against high-tech intrusions. It's hard to remotely hack an analogue system. This has lead utilities and some in government to minimize their assessment of the potential threat, citing

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a lack of historical damage caused by cyberattacks. This is reminiscent of the French in 1940 not fortifying the Ardennes because no-one had ever driven a mechanized army through them. Just because something hasn't happened does not mean that the threat does not exist and, of course, we now know that the Russians and others have hacked into our utility networks on several occasions. Most worryingly, they didn't seem to do much while they were there. What they might be planning, what they left behind or whether they were just probing to see what they could do in the future, can only be

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known by them at this stage. What seems certain is that it was not for our benefit.

Beyond nation state intervention, the increased reliance on computer networks without a commensurate policy of securing that infrastructure creates vulnerabilities that could be exploited by far more numerous and harder to trace groups and even individuals. In the 1983 movie Wargames, a young early adopter hacks into

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a U.S. military supercomputer and almost starts World War Three. It was a fiction and a bit of fun but there have been more than enough subsequent events in reality to demonstrate that truth is very often stranger than fiction. It is not terribly farfetched to suppose that a hacker with sufficient skill to successfully break in to sites such as Ebay, Linkedin, Equifax, FaceBook and, best of all in

my opinion, AdultFriendFinder, could probably also breach whatever security our utility companies consider state of the art.

All of the above scenarios are possible and might even be likely, but they do not cause the hair on the back of my neck to stand up in the same way as a kinetic attack does. A ***kinetic attack***, as the name suggests, involves physically hitting a vital piece of infrastructure with something, anything, which is capable of damaging it. The reason that I consider this sort of attack to be the greatest vulnerability to our electric grid, and therefore the greatest vulnerability facing this nation, is because it is so easy to carry out. There are already examples of such attacks having taken place on grid infrastructure and on September 11th, 2001, the most famous kinetic attack (outside of war) in our history took place when nineteen, mostly Saudi Arabian, hijackers crashed two commercial aircraft into the World Trade Center, one into the Pentagon and would have crashed a fourth into the Capitol Building in Washington DC had it not been brought down in a field in Pennsylvania by the incredibly courageous passengers.

The terrorist attacks of 9/11 were the culmination of a great deal of planning, training and physical and material preparation. As repulsed as one might be by the motivation and the results of those attacks one cannot help but be impressed, in the most disturbing sense, by the immense destruction caused by the actions of such a small group, without any assets but those of the targeted victims. Delivering a knockout punch to the electrical grid is far less challenging and yet can be executed in astrikingly similar, though much less demanding manner by an even smaller team.

A GRIM POSSIBILITY

The Federal Energy Regulatory Commission (FERC) in 2012, found that the destruction of 9 critical sub stations and one transformer manufacturer would cause a total collapse of the U.S. electrical grid resulting in a blackout

that would last for about 18 months; quite a bit longer than the Congressional Subcommittee estimated would be required for a loss of 90% of American's lives.

There are about 55,000 substations in the United States but because of what is commonly referred to as cascading effects, destroying the nine identified by FERC would cause a domino effect of failures that would wreak havoc as it rippled across the 100-year-old grid. The reason that it's important to destroy the transformer manufacturer as well, is that it takes about three years from time of placing an order to time of receiving a high voltage transformer. Most of them come from overseas and because they are large and expensive and because there is a lot of demand in emerging economies like China, there are none in inventory – anywhere. Taking out the factory would eliminate the last of the U.S. manufacturing capability and thus ensure that no quick fix was available. Hence the 18-month black out and the inconceivable loss of life.

Destroying the transformers in a substation is not a technically challenging project. It certainly requires far less skill than is necessary to fly a commercial airliner into a tall building. There is essentially no barrier to entry for an aspirant.

WE'VE SEEN THIS MOVIE BEFORE

On the morning of April 16th, 2013, unidentified gunmen opened fire on the Metcalf Transmission Substation near San Jose in California, severely damaging 17 transformers. While the attack had a sophisticated and professional air it was not complicated, and the weapons and ammunition used are available at most U.S. sporting goods stores. The disruption to electrical service was in this case local and limited because PG&E (the utility) was able to route power from other substations to take up the slack caused by the damage. Because the attack was limited to one element of the infrastructure, the cascading or domino effect did not take place. But how hard would it have been to carry out similar attacks simultaneously at eight other substations? The shots were fired from a nearby hillside. Entry to the substation was not required. The identities of perpetrators and their motives remain a mystery but the potential in their actions is crystal clear.

I have no special or privileged information about the U.S. grid. I know nothing that any other enquiring mind could not easily learn from publicly available information. And yet I do not think that I would have difficulty putting together a simple plan to deliver the terrible-knockout punch. All I lack is the sort of deranged, fundamental hatred for this country and its people that would be necessary to contemplate such an egregious act. Sadly, we know that there is no shortage of people both foreign and domestic who have the necessary qualities and who have shown that they are willing to go to extraordinary lengths, including sacrificing their own lives, to make a reality of their twisted plans. If one can find 19 individuals who are willing to hijack and crash plane loads of civilians into buildings, how hard would it be to find ten similarly minded operators to drive 18 wheelers into 9 substations and a transformer factory. That's all it would take, 10 operators, 10 cell phones, and 10 trucks.

HIGHLY DISTRIBUTED ENERGY INFRASTRUCTURE - A MUST HAVE

The sub heading of this article states that the Whitehouse has awakened to the grid vulnerability threat. That may be the case but the threats they have identified, at least publicly, and the mitigation, seem to miss the real vulnerabilities that we face. Buying American grid infrastructure components sounds like a good idea.

I run an American energy infrastructure product company and I believe strongly in creating good jobs in this country. We, whenever possible, source American components for our products because we believe that we can make and supply a superior product with a reduced supply chain risk and a reduced carbon footprint if we do so. But we also know that sourcing American components cannot defend us from the sorts of risks identified above, particularly the low-tech kinetic attacks. An American built transformer is just as susceptible to bullets or a well-aimed semi-truck as a Chinese one is. That's why our entire philosophy is geared toward creating highly distributed energy infrastructure which generates and stores all its energy locally and is, as a result, immune to the sort of centralized vulnerability that our aging grid provides.

According to the Department of Energy, grid interruptions already cost U.S. businesses around $200 billion a year in lost productivity and related costs. Now, we are heading towards an electrified transportation sector. Within the next few decades the majority of our terrestrial transportation will be powered by electricity. That's a very good thing because it will reduce our reliance on foreign oil and the volatility that oil markets force on Americans. It's also good because we have the technology to generate all the electricity we will ever need right here in the United States. Never again will we have to negotiate with, or go to war with, anyone to ensure that we have the fuel we need to transport the goods and services and people which deliver us the highest standard of living in the world. We'll save trillions of dollars and we'll say goodbye to smog and all the costs, both financial and human, associated with transportation related pollution.

But how much more attractive a target will the grid become when not only our current electricity dependent industries are affected but when our entire transportation sector can be grounded by even a relatively short-term shutdown of the grid? The 2033 version of the Movie Wargames might be called Grid Pandemic. The bad guys will shut down the grid and hold us to ransom for its return to operations – or perhaps even, do something far worse.

The solution to all of this is not to set up tariffs and other anti-market mechanisms to force U.S. businesses to buy American components for the grid. That's anti-competitive and un-American in itself but worse, it doesn't

solve the problem. The true weakness in the grid is its susceptibility to centralized failure. I hire veterans, some of whom have come from the Special Operations community. Ask a Navy Seal if he'd rather take on a large target with centralized critical vulnerabilities which can cripple the enemy, or lots and lots of small decentralized assets each of which require his full attention and none of which can deliver a knockout punch. I have asked that question of many ex SOF community operatives and I've only ever received one answer – the obvious one.

THE QUANTUM GRID

It is essential that we remove the centralized dependencies of our most vital infrastructure. Instead of relying on large generating facilities which deliver power, hub and spoke style, across vast transmission networks, we must deploy a fleet of far smaller distributed facilities which are much closer to the load they serve. Those facilitiesshould be renewably energized so that they are not reliant on supply chains to deliver the fuel they convert to electricity. They must generate and store all of their own electricity so as to overcome any intermittency issues inherent in renewable sources. They must operate autonomously even as they are monitored remotely. They must be small enough to be mass produced and rapidly deployed at scale. Not utility grids, not micro grids or even nano grids – we might call them quantum grids.

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The loss of one or more of them must have no impact on the others ability to continue to deliver the power we need. All these qualities exist in tried and tested products which exist today. The U.S. is actually leading the development of technologies that make them possible and there are U.S. workers producing and selling them.

As infrastructure stimulus spending by the Federal Government is rolled out to reverse the catastrophic economic impacts of the current pandemic it should target the prevention of future, potentially more devastating crises. There is no more vital and vulnerable infrastruc-

ture than our electric grid. There is no more shovel-ready and impactful infrastructure upgrade than the deployment of vast amounts of American made quantum grids. The jobs created are high quality and long lasting in nature. A highly robust, essentially free supply of energy will ensure that America remains competitive as our peers and competitors race towards the same goals. As the 21st century continues, real competitive power will be measured in clean and reliable kilowatt hours, not weapons and warheads.

CALL TO ACTION

America needs an electricity infrastructure that is as invincible as its military, its commerce and its peoples' spirit of ingenuity. America needs electricity. Without it we will stop moving, stop working, stop healing and stop eating. Without it we will stop altogether. This magnificent nation cannot be brought to a stop. The great social experiment has its best years yet ahead of it. It must have a reliable source of electrical power to continue to shine.

When James Brown sang "I Love Living In America," he meant the America with lights.

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