ON PROTECTING THE ELECTRIC POWER GRID

Testimony of Ambassador Henry F. Cooper

To

The U.S. Senate Committee on Energy and Natural Resources:

May 4, 2017 Hearing to examine the threat posed by electromagnetic pulse (EMP) and policy options to protect energy infrastructure and to improve capabilities for adequate system restoration.

Madam Chairman, thank you for this opportunity to share my views on the need to address the fragilities of the electric power grid and the means to do so. I view that the related current status and plans known to me leave the grid vulnerable to existential threats. And I believe we have the technical means to rectify these vulnerabilities—but are regrettably blocked from doing so, primarily because of political conditions that this Committee can, and hopefully will, address[1].

I consider that we are living in the most dangerous period of my lifetime for a number of reasons, but the vulnerability of our national electric power grid is among the most important ones. Moreover, I believe we have had clear warning of the nature of this threat for years, and are collectively continuing to ignore and/or take ineffective countermeasures to deal with it. Frankly, I have become so concerned about the dysfunctionality of the federal government in dealing with the threat that I am now spending whatever remaining time the Good Lord gives me to work with local and state authorities and private citizens to address the key issues from the "bottom up"—and I will address one of these important initiatives. If enough of our citizens gain an understanding of the issues and how they can—actually must—be addressed at the local level, then I believe Washington will eventually do its part in addressing this urgent problem.

The following sections briefly review some important lessons from recent events and their implications for understanding the various threats to the electric grid, including from natural and manmade EMP; the nature of this so far poorly addressed existential EMP threat; the maturing related threat posed by hostile adversaries and our thus far inept response; and recommended initiatives to counter that threat and protect the grid.

IMPORTANT LESSONS FROM RECENT EVENTS

To set the stage for discussing EMP issues, please consider the fragility/vulnerability of the electric grid illustrated by the events of Friday just three weeks ago (April 21st) when nearly concurrent grid outages occurred in New York City, in Los Angeles and particularly in San Francisco where, for hours, there was consequent jammed traffic, people stranded in elevators, hospitals on backup generators and other disruptions that continued for several hours before emergency management operations restored electric power[2].

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[1] Please permit me to tell you why I believe you should consider my views on this important—and I believe—urgent matter. I am a PhD engineer, with very pertinent experience—from working on developing military and civilian systems at Bell Telephone Laboratories in the early 1960s, to over 20 years conducting research and developing simulators to test our strategic systems against nuclear weapons effects, to overseeing the Research, Development and Acquisition of U.S. Air Force Strategic and Space Systems under Presidents Carter and Reagan, to backstopping our bilateral negotiations with the Soviet Union while developing our national space arms control policy and serving as Chief U.S. Defense and Space Negotiator with the Soviet Union under President Reagan, as Strategic Defense Initiative (SDI) Director and Acquisition Executive for all our missile defense programs under President George H.W. Bush, and for 15 years as Chairman of the Board of Directors of a successful R&D company. In short, I've been around and solving technical and political problems of concern for essentially my entire professional career.

[2] See a Reuters review of these events at http://www.reuters.com/article/us-usa-sanfrancisco-power-idUSKBN17N27T

Joseph Weiss, an international authority on cybersecurity, control systems and system security regularly gives his views at http://www.controlglobal.com/blogs/unfettered/ . On April 24, he noted San Francisco's 7-hour outage was due to cascading effects triggered by a single breaker in one allegedly low-impact substation, the Larkin Street Substation. Weiss noted problems at this Larkin substation were identified years ago, but authorities have not taken remedial action. On April 28, he noted some root causes, like "thermally overloaded transmission lines" were well known years in advance and that this "home town" event should raise red flags at the Department of Energy (DOE), the Federal Energy Regulatory Commission (FERC) and the North American Electric Reliability Corporation (NERC) and the need for substantial improvements[3].

Indeed! This regulatory system is failing to protect the nation's electric grid from many threats, including EMP.

IMPORTANT IMPLICATIONS FOR THREATS TO THE GRID

From my perspective, Weiss' most important observation is that the major San Francisco grid failures cascaded from a single relatively "minor" event: A lowly breaker failure in a single substation, however caused[4]. This observation brings to mind conclusions by former FERC Chairman Jon Wellinghoff following the April 16, 2013 San Jose's Metcalf Substation attack that similar cascading failures from only nine identifiable substations could bring down the entire electric grid for an extended period[5]. But the Larkin Substation was enclosed in a structure that would have shown evidence of Metcalf kind of terrorist attack with rifle fire—not evidenced in San Francisco three weeks ago. Maybe terrorists with radio-frequency (RF) weapons could have triggered such a failure, but as Weiss pointedly wrote: "Given the walled enclosure, a physical attack such as the rifle attack against the PG&E Metcalf substation would not be possible."

Moreover, while simultaneous terrorist and cyberattacks could have been planned to occur across the nation[6], the concurrent events in cities on both the East and West Coasts more likely reflect the April 21 (updated on April 22) warning by *The Sun* (a United Kingdom News Company) that "a mega hole in the Sun could cause blackout mayhem" due to its "belching" of radioactive particles toward the Earth[7]. Thus, such "space weather" effects are understood and were anticipated.

NATURAL AND MANMADE EMP

Such "Solar Hole" events are longer lasting but much less damaging than would be a Coronal Mass Ejection (CME) like in the 1859 Carrington event that interacted with the earth's geomagnetic field

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[3] For more information, see http://www.controlglobal.com/blogs/unfettered/additional-information-concerning-the-april-21st-san-francisco-outage/ for Weise's April 28 message which includes a link to his April 24 message.

[4] Notably, Weiss told me this breaker failure brought to mind the 2007Aurora cyberattack demonstration conducted by Idaho National Laboratories that caused catastrophic damage to a generator associated with a nuclear plant, by commanding breakers out of phase with the grid's operating frequency. I do not believe this vulnerability has been rectified at all our nuclear plants—a very significant possibility if true, given their importance as discussed later.

[5] See the *Wall Street Journal* reports on this important matter at https://www.wsj.com/articles/assault-on-california-power-station-raises-alarm-on-potential-for-terrorism-1391570879?tesla=y and https://www.wsj.com/articles/u-s-risks-national-blackout-from-small-scale-attack-1394664965?tesla=y .

[6] See http://www.acq.osd.mil/dsb/reports/2010s/DSB-CyberDeterrenceReport_02-28-17_Final.pdf for a pertinent February 2017 Defense Science Board report, prefaced by the Chairman's conclusion: "The cyber threat to U.S. critical infrastructure is outpacing efforts to reduce pervasive vulnerabilities, so that for the next decade at least the United States must lean significantly on deterrence to address the cyber threat posed by the most capable U.S. adversaries."

[7] See https://www.thesun.co.uk/tech/3379806/solar-flare-spewing-from-mega-hole-in-the-sun-could-cause-blackout-mayhem-next-week/.

to produce a Geomagnetic Disturbance (GMD) that destroyed telegraph lines, with little impact on that low-tech agrarian society. Today, a Carrington-class CME/GMD would cause catastrophic damage to critical electronic infrastructure, particularly our unprotected electric power grid. We missed such an event by a week in 2012, as explained by NASA and other scientists[8] who study "Space Weather," or "natural" EMP. They project a 12-percent-per-decade likelihood for a Carrington CME/GMD.

While current efforts (however meritorious—see below) seek to protect the grid against such natural EMP events, little to nothing is being done to protect the grid against much more stressful "manmade" EMP, caused by nuclear weapons detonated high in or above the Earth's atmosphere.

Notably, if the grid is protected from manmade EMP attack, it will be protected from Natural EMP events—but the converse is not true, because of fundamental differences in the EMP pulses. Missing in the Natural EMP pulse are the high frequency components that threaten solid state electronics, like the supervisory control and data acquisition (SCADA) systems that control much of our critical infrastructure, including our electric grids and natural gas and petroleum pipelines.

OUR ENEMIES PLAN EMP ATTACKS—A RAPIDLY MATURING THREAT

Such manmade EMP attacks are known to be included in the doctrine and planning of Russia, China, North Korea and Iran. One particularly important report on Iranian doctrine and strategy was referenced by Rep. Trent Franks at the July 21, 2015 International Electric Infrastructure Security (EIS) Summit in Washington, DC[9]. He stated that the conclusion of this doctrine is that nuclear EMP is "an advanced and useful weapon in modern warfare."

These nations also have information on how to build low-yield "Super" EMP weapons. (It is a myth that high yield nuclear weapons are required to produce extensive and intensive EMP effects.) In 2004, the EMP Commission was advised by very senior Russian Generals, experts on nuclear EMP weapons, that this "Super" EMP knowledge had been transferred to North Korea, which would probably develop these weapons in a few years[10]. We should also assume that Iran knows whatever North Korea knows and has whatever the Mullahs wish to buy.

Thus, North Korea and Iran may now or in the foreseeable future actually have such low yield super EMP weapons—indeed, that possibility could explain North Korea's underground low-yield nuclear tests—and we should assume Iran also has that information. David Albright, an often quoted expert on these matters, estimates that North Korea already has 13-30 nuclear weapons and is capable of building 3-5 each year[11].

Both nations could deliver an EMP attack on the United States by simply detonating a nuclear weapon carried by one of their satellites as it passes over the United States—no hardened reentry vehicle or accurate guidance system is needed as would be the case for a conventional intercontinental ballistic missile (ICBM) targeted on a city or other surface target. Both nations

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[8] See https://science.nasa.gov/science-news/science-at-nasa/2014/23jul_superstorm for a detailed discussion.

[9] Rep. Franks reported: "The National Intelligence University translated an Iranian military doctrine called *Passive Defense from 2010*, which emphasizes the importance of targeting critical infrastructure in warfare and references 22 times the use of EMP as a weapon to damage or disable the civilian electric grids of potential opponents. The Iranian doctrine states that nuclear and non-nuclear EMP weapons operate differently, but morally are the same.

[10] Personal Communication with Dr. William R. Graham, EMP Commission Chairman.

[11] See David Albright, "North Korea's Nuclear Capabilities: A Fresh Look," *Institute for Science and International Security*, April 28, 2017 at http://isis-online.org/isis-reports/detail/north-koreas-nuclear-capabilities-a-fresh-look

have launched such satellites—Iran successfully placed satellites in orbit in 2009, 2011, 2012 and 2015 but had a failure in 2016 and plans more attempts[12]; and North Korea, after several failed attempts, in 2012 and 2016[13].

These satellites were launched over the South Polar regions to approach the United States, from our mostly undefended South. The test launches generally are reported to be of concern because they could be a stepping stone to developing ICBMs—as is certainly the case. However, they also could be intended to develop a means to carry out an EMP attack on their first passage from the South over the United States[14]. And that is why that possibility should not continue to be ignored, especially since we have little if any defense against that possibility[15].

Moreover, the 2008 EMP Commission report[16] noted that Iran had in the late 1990s launched a ballistic missile from a barge in the Caspian Sea, and sent electronic signals that suggested it "triggered" a simulated a nuclear weapon detonation at altitudes up to 400 kilometers, to produce a potentially devastating EMP. To date, the United States has not deployed a ballistic missile defense (BMD) system to counter this identified threat that could originate on a vessel off our coasts—including from the Gulf of Mexico. We are essentially defenseless against this plausible threat[17].

MISSILE DEFENSE ROLE

Our Aegis BMD ships have demonstrated an ability to shoot down such threat missile/satellite attacks—if they operate with appropriately trained crews in response to the identified threat, especially when they are near our coasts.

Aegis BMD ships do not operate in the Gulf of Mexico, but the Aegis Ashore BMD system, now operational in Romania and slated to be operational in Poland by the end of this year, could be deployed on our military bases around the Gulf to protect us from such an attack[18].

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[12] See https://spaceflightnow.com/2015/02/02/iranian-satellite-successfully-placed-in-orbit/ and http://presstv.ir/Detail/2016/10/04/487619/Iran-Space-Agency-Mohsen-Bahrami-Sharif-Sat-Amirkabir-Nahid-I-satellite

[13] The most recent satellite http://www.space.com/31860-north-korea-satellite-launch.html was successfully placed in orbit but was subsequently reported to be "tumbling" and not transmitting signals.

[14] In February 2016, I joined Former CIA Director R. James Woolsey, Former Reagan Science Advisor (and EMP Commission Chairman) Dr. William R. Graham, Former Chairman of the National Intelligence Council Fritz Ermarth and EMP Commission Staff Director Dr. Peter Vincent Pry) to challenge underestimates of North Korea's and Iran's threat. See http://www.nationalreview.com/article/431206/iran-north-korea-nuclear-threats-are-very-real.

[15] U.S. Commander of Pacific Command Admiral Harry Harris testified last week that all nations should take the North Korean threat seriously because "North Korea's missiles point in all directions." Furthermore, Secretary of State Rex Tillerson also referred to this same fact in his Fox News interview with Bret Bair last Thursday. It would be reassuring if U.S. authorities also recognized that such missiles headed south can also deliver a devastating EMP strike by carrying a nuclear weapon payload and detonating it over us in its first orbit, rather than reentering the atmosphere to attack a American city. North Korea could plausibly accomplish this potentially existential threat attack today.

[16] The 2004 and 2008 reports of the Congressional Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack, or the EMP Commission, can be found its webpage at http://www.empcommission.org/.

[17] Note that in 2013, a North Korean vessel was caught smuggling from Cuba two SA-2 rocket launchers and nuclear capable rockets (without warheads) under tons of sugar. See http://www.nbcnews.com/news/other/north-korean-ship-carrying-hidden-missile-equipment-detained-after-leaving-f6C10647045 .

[18] The Aegis BMD system, which I am proud to have originated as SDI Director, is in my opinion our most cost-effective BMD system with a very impressive test record, now deployed on 35 ships around the world and soon to be at several sites in a land based mode, including in Hawaii. It should be built on military bases around the Gulf of Mexico, beginning on Tyndall AFB in Panama City, Florida—home of 1st Air Force which has the lead mission for air defense of the continental United States, the Dominican Republic and Puerto Rico. No additional R&D is needed to protect Americans at home, just build the same Aegis Ashore system now deployed to protect our allies and overseas troops.

Congress and the President also should give our Aegis BMD ships a homeland defense mission when they are near or in our coastal waters—including while in port, e.g., at Norfolk, Virginia[19].

These BMD capabilities are technically available in the near term. I also urge that we return to the development of the most cost-effective BMD systems of the Strategic Defense Initiative (SDI) era (March 1983-January 1993)—those based in space that can intercept threat ballistic missiles beginning in their boost phase, while their rockets are still burning. We referred to this most cost-effective BMD concept as "Brilliant Pebbles." That program was cancelled abruptly in 1993 by the Clinton administration and as yet has not been revived. With the needed funding and management skills, I believe such a cost-effective system could be deployed within five or so years, now even more capable and for less money because of more advanced technology developed since 1993[20].

HARDEN THE GRID

But no defense is perfect—so we should "harden" our critical civil infrastructure, especially the electric power grid, against the full complement of threats. And it should be understood that if any adversary mounts an EMP attack against us, he will employ a preemptive combination of cyber, physical, radiofrequency and other weapon attacks to confuse and devalue our response.

As already acknowledged by the Obama administration, the grid must be hardened to protect against a GMD event that will surely one day occur, only its timing is uncertain. But as noted above, even if this hardening effort is successful (currently an unlikely prospect, based on my understanding of progress toward that end), it will not protect the grid from the manmade nuclear EMP threat—or from other threats that might be posed by terrorists or rogue regimes. Rather, we should be addressing the manmade nuclear EMP threat, together with protection against natural geomagnetic disturbances, with competently executed, integrated efforts that work the problem from the bottom up—beginning at the local level. Such efforts should also include protection against physical, cyber and radiofrequency weapon attacks.

As a prelude to my recommendations on how best to deal with this threat—which focus on protecting the grid from the bottom-up (beginning at the local level in conjunction with cooperative electric power companies (CoOps)), consider the Chairman of the EMP Commission Dr. William R. Graham's observations in his April 20 letter to Secretary of Energy Rick Perry[21]:

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[19] A few years ago, there were usually 4-6 Aegis ships near our East Coast or in port there. If coupled with one of our relatively inexpensive TPY-2 radars appropriately placed in New England, they could supplement our Ground Based Interceptors in Alaska—especially against ICBMs from Iran, long before an additional East Coast site can be built.

[20] See http://www.nationalreview.com/article/442532/ for a *National Review* article, "How Trump can Fulfill Reagan's Defense Vision" explaining the basis for a cost-effective "rapid startup" strategy, co-authored with Retired US Army Lt General Mal O'Neill, my Deputy SDI Director (and subsequently the BMD Acquisition Executive of the Clinton administration and Assistant Army Secretary for Acquisition, Logistics and Technology); Dr. Robert L. Pfaltzgraff Jr. president of the Institute for Foreign Policy Analysis (IFPA), Inc., and Shelby Cullom Davis Professor of International Security Studies at The Fletcher School, Tufts University, and chairman of the Independent Working Group on Missile Defense, and Retired USAF Colonel Rhip Worrell who was the SDI Brilliant Pebbles Program Manager.

[21] In introducing the following list, Dr. Graham indicated the context for these observations was to explore with the Secretary of Energy how the Energy Department was going to support to the Critical Infrastructure Protection Act (FY 2017 National Defense Authorization Act, Section 1913, "EMP and GMD Planning, Research and Development, and Protection and Preparedness" p. 1762), which directed the Department of Homeland Security: to develop plans to protect the electric grid and other critical infrastructures from EMP; to educate and train federal, state and local emergency planners and first responders on the EMP threat; and to conduct research and development to mitigate EMP.

1. Nuclear EMP is the ultimate cyber weapon in the military doctrines and plans of Russia, China, North Korea and Iran for Combined Arms Cyber Warfare that they see as a decisive new Revolution in Military Affairs.
2. Protecting the grid from the worst threat—nuclear EMP attack—can also mitigate lesser threats, including from natural EMP from solar storms, non-nuclear EMP from radiofrequency weapons, cyber-attacks, physical sabotage and severe weather.
3. State electric grids can be "islanded" by installation of surge arrestors, blocking devices, Faraday cages, and other devices to protect individual states, even though they may be part of a larger regional electric grid, from a prolonged catastrophic blackout. For example, Texas State Senator Bob Hall has introduced legislation to harden the Texas Electric Grid.
4. The Commission is profoundly concerned that the 2014 Obama administration intelligence community assessment of nuclear EMP is profoundly erroneous, and perhaps the worst ever produced on EMP, and that has been used to thwart efforts to protect the nation against nuclear EMP by dismissing the threat, despite overwhelming evidence to the contrary.
5. The Commission is very concerned over misleading and erroneous studies by the NERC and others that grossly underestimate the natural EMP threat from solar storms, and dangerously, have become the basis for grossly inadequate standards for EMP/GMD protection approved by the Obama administrations' FERC.
6. The Commission is also concerned over misleading and erroneous studies recently completed by industry's Electric Power Research Institute (EPRI), in cooperation with Obama administration holdovers in the Department of Energy, that grossly underestimate the nuclear EMP threat.

Dr. Graham's observations provide a sound basis for assessing and responding to the current vulnerabilities in the management and execution of efforts to provide a viable electric power grid. The EMP Commission is the most competent and technically credible source of such advice.

Below, I will elaborate on how I am actively seeking in South and North Carolina a stepping stone to achieve his third observation, by taking Texas State Senator Bob Hall's "islanding" approach to a more fundamental level.

It is interesting that when Dr. Graham and I were junior USAF officers at the Air Force Weapons Laboratory (AFWL) at Kirtland AFB, NM conducting research on nuclear weapons effects and developing simulators to test the nation's strategic systems and their essential command, control and communications (C3) systems to assure their viability under nuclear attack, Senator Hall was also a USAF junior officer at the Space and Missile Systems Organization (SAMSO) at Norton AFB, CA—helping to harden the Minuteman ICBM system, specifically to EMP effects. Our efforts were highly classified because all our systems were vulnerable to EMP—as then recently discovered on atmospheric nuclear tests. Our EMP knowledge base remained highly classified until most were downgraded and published in the 2008 EMP Commission report—see Footnote 16.

Now we have the opportunity again to cooperate on hardening the electric power grid (and other related critical infrastructure)—and to exploit the urgency of effecting change that I believe we all feel. This includes overcoming political challenges, which are in fact more daunting than the costs of making needed improvements or technical challenges, which were solved a half century ago by the Department of Defense (DoD) and its contractors expert in protecting military systems from the effects of nuclear weapons.

POLITICAL/BUREAUCRATIC CHALLENGES

Not the least of the political challenges is associated with ineptness in the responsible DoD agencies that have blocked progress—e.g., by stalling the initial startup of the Congressionally re-established EMP Commission by almost a year and, as I understand it, continuing to inhibit its effective operation. Moreover, DoD is withholding information it learned many years ago in establishing threat EMP environmental information standards to protect our strategic systems that our nation's power companies now need to develop, deploy and maintain effective hardening designs.

So, DOE laboratories and other agencies are conducting studies to learn again, under the best of conditions, lessons mastered by DoD nearly a half century ago. Under less desirable conditions on several fronts—and without the knowledge that comes from a half century of practical experience, the current efforts can easily—perhaps predictably—run amok.

In the decades when nuclear testing was conducted, the DOE had so little interest in EMP and other nuclear weapon effects that the DoD had to pay the DOE to calculate the necessary weapon gamma ray and other outputs to allow accurate EMP analyses to be performed by the DoD. Now that the DOE and its national laboratories are searching for relevant missions, both government and private monies are going to replicate what the DoD accomplished years ago at considerable taxpayer expense. See Dr. Graham's Items 5 and 6, above.

Moreover, political/bureaucratic problems come from mission conflicts between DoD and other government departments and agencies—particularly the Department of Homeland Security (DHS). Evidence of these difficulties was graphically illustrated a couple of years ago when then Commander of Northern Command (NORTHCOM) Admiral William Gortney made clear he understood the significance of the EMP threat (See Dr. Graham's Items 1 and 4.) by supporting a major program to improve the viability of his mission to provide warning to our strategic forces and the President (costing almost a billion dollars) to harden and move key equipment from Peterson AFB to his Cheyenne Mountain command center to assure viability of that mission against EMP.

At the same time, little has been done to assure the NORTHCOM's Homeland Defense mission is viable in the face of the same EMP attack—not NORTHCOM's job to protect the nation's critical civil infrastructure except in commanding our BMD systems. Admiral Gortney indicated his was a supporting role to DHS and the Justice Department. I again call your attention to Footnote 9 and note that to my knowledge DHS has not even listed EMP among the strategic disaster scenarios against which all emergency managers (federal, state and local) are supposed to prepare[22]. See Footnote 21 that explains Dr. Graham's purpose in his letter to Secretary Perry. Unlike the previous DHS Secretary, Secretary Kelley has stated his support for addressing such EMP and related issues.

Senator Hall certainly understands many of these political challenges, since this is his second try at getting the full Texas Senate to pass needed legislation to harden the Texas Grid—and the Texas legislature meets only every other year. Other states have tried and are trying to pass legislation in various formats to protect their citizens. But so far, most of their efforts have been blocked by a lethargic regulatory, self-supervising regime and lack of leadership at the federal level—in both the legislature and executive branches. And I would add, a lack of knowledge of what needs to be done.

[22] I'd also note that NORTHCOM has refused at least two attempts known to me by the SC Adjutant General's office to permit the National Guard to include EMP in its annual Vigilant Guard exercises. So the National Guard upon which we all depend in major emergencies is unprepared to deal with EMP threats.

In 2013, the first state legislation was initiated by State Representative Andrea Boland and passed in Maine, and I understand the subsequent response has been helpful but limited—inhibited by pushback from the private sector and a lethargic response by Maine's Public Utility Commission. That public record is pertinent for others to exploit. A successful legislative example is Virginia's, which I understand is being effectively supported by Dominion Power—perhaps because Virginia's major military presence has a collective background that appreciates the EMP threat. A number of other states are also considering initiatives, and there are combined positive efforts, such as are being pursued by Ohio's American Electric Power, involving 11 states.

WHAT TO DO?

Given these political/bureaucratic difficulties (and others), I concluded several years ago that I would never see major progress in dealing with the EMP existential threat in my lifetime, especially if the current conditions remain. And I could see no prospect for meaningful improvement. So, I decided to try a different approach and work the problem from the "bottom up" . . . literally.

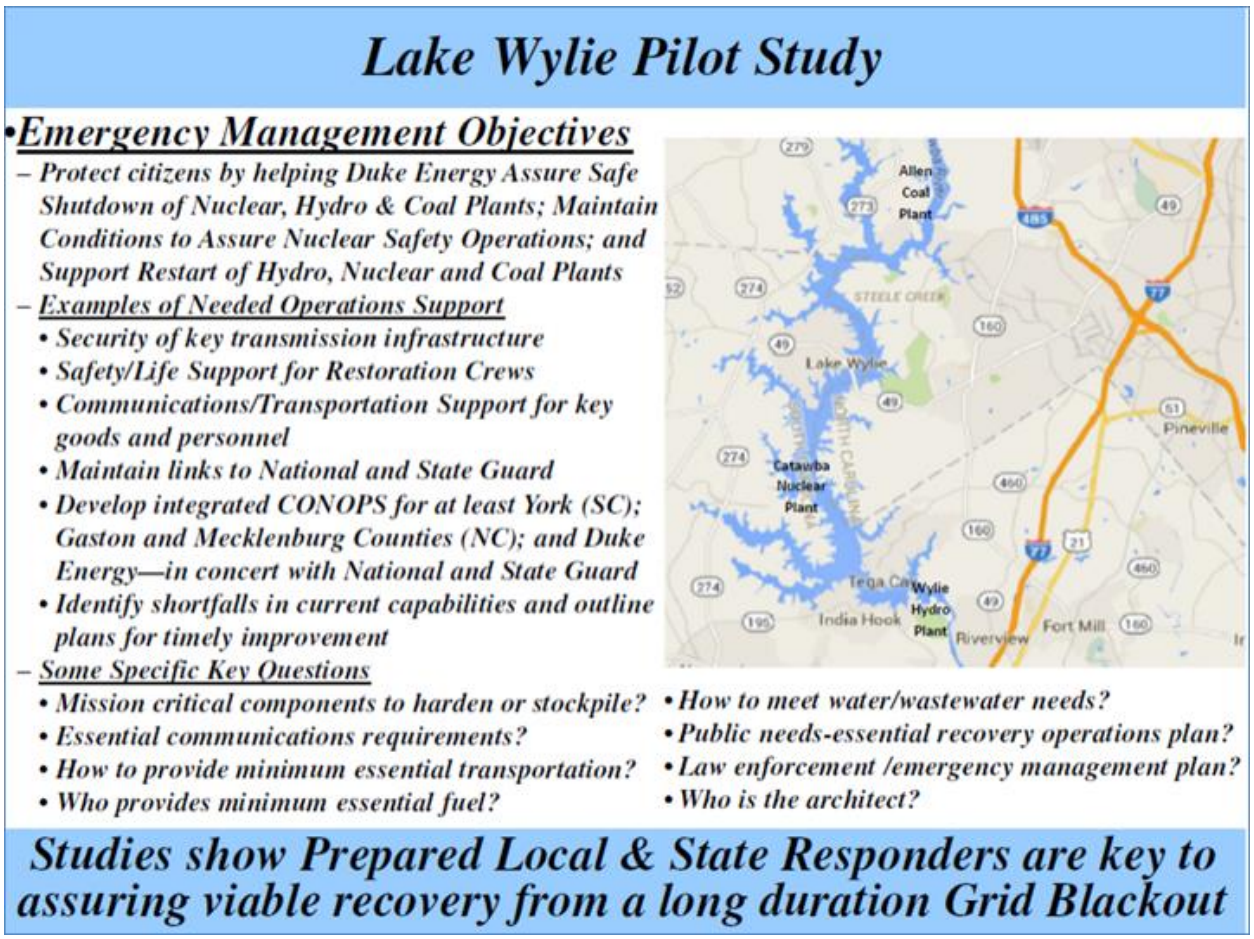
I entered this phase with several biases, based on a lifetime of pertinent experiences, which have survived to this day and which guide my assessments and recommendations.

- I have no confidence that we will ever harden the entire grid, so I believe we have to establish priorities—I give top priority to assuring the safety and viability of our ~100 nuclear power plants that produce about 20-percent of the nation's electricity, and half the electricity of my home state South Carolina. Thus, I believe our top priority is to build protected "islands" around our nuclear power plants[23].
- To assure the viability of the nuclear power plants, we must first assure their cooling water systems are viable in an indefinite grid shutdown to avoid Fukushima-like disasters.
- We must assure that sufficient generating and loading conditions provided by the surrounding "island" in the grid—and linked with other critically important elements of the grid—are available to restart the nuclear power plants—and other power plants, which will shut down to protect themselves if the grid goes down.
- I don't believe anything that isn't regularly tested and subjected to independent critical review—effective design and deployment is not enough; truly effective testing and maintenance are major challenges.
- Accomplishing these objectives requires considerable emergency management cooperation at the local level—without which there is little hope for most citizens who today depend on electricity for life-line services in our "just-in-time" economy.

I approached the Electrical Engineering Department Chairman at my alma mater, Clemson University, and requested information on faculty who might be interested in my concerns and graduates who were employed by Duke Energy—one of the nation's largest companies, if not its largest, with whom I could begin working to address the EMP threat to the grid. I want to make clear I was not selling anything to or for Duke and would not take money from them if they offered it. I just want to cut through the morass described above, and provide hope that my grandkids can survive if we experience an EMP attack. I know that all our citizens want this objective met.

[23] This "Islanding" approach to prioritizing what to harden first is similar to the approach adopted by the DoD in giving top priority to protecting our strategic systems and their supporting command, control and communications systems. This objective was central to our "deterrent" policies of the Cold War. And we hardened little military infrastructure and essentially no critical civil infrastructure beyond assuring that we could meet that objective.

To make a long story short, I developed an excellent relationship with a key professor and several Duke engineers who also are concerned about this threat—and we agreed on how we could proceed with a meaningful "bottoms-up" program to assure the viability of three Duke Energy power plants on Lake Wylie, on the Catawba River that runs between North and South Carolina—and of course key transmission infrastructure that interconnects those power plants and others to their customers. We refer to this project as the "Lake Wylie Pilot Study," briefly summarized in the following chart.



I have now been working for nearly two years with Duke Energy engineers to address how best to assure we can restart the grid after a major blackout—while giving top priority to assuring the safety and viability of our Nuclear Power Plants[24]. Duke Energy's senior management has agreed to share broadly the lessons learned from the Lake Wylie Pilot Study.

In particular, we are working with local and state authorities and citizens to help Duke engineers exploit the most resilient electric power source, the Wylie Hydroelectric Power Plant, to assure availability of electricity to the cooling water pumps at the Catawba Nuclear Power Plant, if its diesel generator fuel is exhausted and can't be replaced. (See the list of "Needed Operations

[24] Along the way, I discovered that Duke Energy was funding related research at several universities and in cooperation with other energy companies. While that research is primarily focused on the cyber threat, EMP concerns will no doubt also receive attention. Recently I learned that Duke plans to invest significant funds to modernize and protect their power systems over the next 10 years, $13 billion in North Carolina (http://www.utilitydive.com/news/duke-energy-to-harden-north-carolinas-power-system-with-13b-initiative/440524/) and $25 billion in the several states in which they have infrastructure http://www.charlotteobserver.com/news/business/article133059044.html .

Support" and "Key Questions" in the above chart.) The Allen Coal Plant in Gaston County, NC also should be available relatively quickly and has a major supply of coal to support operations.

So, at a top level, the key operations of the Duke infrastructure are being considered and with no question Duke Energy intends to assure its power plants are functional after an EMP attack. From my perspective, there would likely be problems with SCADAs, especially those that control natural gas and petroleum pipeline operations, so that is a remaining concern—at least to me.

We are working to assure that electricity gets restored to subscribers around the Lake Wylie "Island" in the grid, especially high priority subscribers like the water-wastewater operations that are not served directly by Duke Energy infrastructure[25]. That service is provided by other utility companies and Electric Cooperatives (CoOps) that maintain important grid infrastructure between Duke Energy, from whom they purchase electricity, and their subscribers. Moreover, Duke Energy engineers need information from these utility companies and CoOps if they are to exploit that set of loading conditions to enable rapid restart of their power plant operations serving the general public throughout York County and beyond.

We are progressing well toward this end—engaging with city, county and state officials to assure (at least in York County, SC and Gaston and Mecklenburg Counties, NC) that the utility companies and CoOps who buy electricity from Duke and distribute it through their own grid infrastructure to their customers/subscribers are prepared to deal with a major grid outage. We seek to assure that Duke Energy's nuclear, hydroelectric and coal power plants serve the local interests—and that the lessons learned are exploited throughout South and North Carolina—and beyond. Our effort should serve as a pattern that can be followed in integrating the activities of the several thousand electric utilities and CoOps that are key to delivering electricity to their subscribers throughout the nation.

We plan to engage with others as we progress—as previously noted, I intend to join forces with Texas Senator Bob Hall and other friends in Texas as they progress with their legislative initiative and related efforts to harden the Texas Grid and especially related to nuclear power plants and associated islands in the overall grid. I also intend to engage other states, particularly Pennsylvania and Illinois. Like South and North Carolina, they rely heavily on electricity from nuclear plants.

I also intend to work closely with the National Guard and the Adjutants General of the United States because of their key roles in disaster emergency management activities[26].

Before we began our Lake Wylie Pilot Study in earnest, my Duke Energy partner engineers got approval from their front office that the lessons learned would not be treated as "Duke Proprietary"—but could be shared with others in the electric power and related sectors. We are working with local and county officials and associated utility companies and other CoOps to

[25] Water-wastewater operations are perhaps the top priority, especially for urban operations. The June 2016 report by the National Infrastructure Advisory Council (NIAC) http://highfrontier.org/wp-content/uploads/2016/08/NIAC-Water-Sector-Resilience-Final-Report-Recommendations-July-2016.pdf indicates how key services are rapidly lost without water-wastewater services. For example, casualties in hospitals are expected within hours following a loss of water-wastewater support.

[26] While our SC Adjutant General—a Georgia Tech electrical engineering graduate—is on board with our Lake Wylie project, we have not yet engaged our state legislators to seek a supportive legislative initiative. However, SC State Senators and Legislators have indicated to me during the past two years that they would help sponsor such legislation when we are ready. The Duke engineers with whom I am working have cleared our project with their front office and lessons learned will be shared with all when we are ready. I understand from my Duke partners that they are fully engaged in a related NC initiative by their Lt. Governor.

understand how best to assure infrastructure connectivity to enable a Black Start following a major grid shutdown, beginning with the Lake Wylie "Island" in the grid.

South Carolina is one of the few states (joined only by Wisconsin when last I checked) focusing a statewide effort associated with NERC's November GRIDEX-IV national exercise on responding to cyber and physical attack threats. I believe the lessons learned will be helpful in extending, again from the bottom up, our Lake Wylie efforts. Therefore, we are also engaging with several other counties in this national exercise to build the relationships to share our lessons learned.

Note, there are several thousand utility companies and CoOps in the United States—so solving this important problem for that integrated "crazy quilt" distribution system is very complicated.

I have serious doubts that I will see a solution result in my lifetime from a "top-down" federal or state initiative. This is not to argue against such initiatives—which are important at least for consciousness-raising purposes. But I do worry that at best they have been proven to be very inefficient in producing serious progress in actually dealing with a truly existential threat.

I'm excited about our progress in working the problem from the bottom-up thus far—with a particular focus on assuring viable water-wastewater services to local citizens, and will be sharing more information in the future, especially with the lessons learned on how best to deal with the political issues that have for more than a decade confounded our collective progress.

My final comment is a lesson I have learned from my entire career: Effectively designing, deploying and operating any complex system requires a competent "Red Team" with access to all design, deployment and operations information, and which can challenge at the top level all efforts and report findings to the top management[27].

In my opinion, the EMP Commission should be chartered to play that role—indefinitely, and it should report directly to the President through an appropriate White House office hosting secretariat services.

Thank you for your interest and attention.

[27] During my watch as SDI Director (1990-93), I voluntarily sent several hundred million dollars from my five year budget to the Defense Special Weapons Agency (now the Defense Threat Reduction Agency) with no strings attached, except that the funds be spent to develop an independent competent assessment capability that could provide needed independent "Red Team" inputs to me (and my boss, the Secretary of Defense) on our BMD acquisition efforts. My distinct impression is that DTRA's capability and interest is a pale shadow of the DSWA's in that era a quarter century ago. I have no idea whether the key BMD systems developed under acquisition programs that I began (our ground-based interceptors in Alaska and California, our Aegis BMD system, our Patriot System or the THAAD system now being deployed in South Korea—and their associated command, control and communications systems) are confidently hardened against EMP, but without question, they certainly should be.