Prepared Statement of Thomas S. Popik
Foundation for Resilient Societies
Testimony on SB 83 Relating to Protection of Energy Critical Infrastructure
April 11, 2017

Thank you for the opportunity to testify in regard to SB 83. I am Thomas Popik, chairman and president of the Foundation for Resilient Societies, a public interest non-profit. We perform research on electric grid reliability and security and provide our findings to the Federal Energy Regulatory Commission (FERC), state governments, and other authorities responsible for critical infrastructures. We also educate the public on electric grid threats. For an overview of our work, visit www.resilientsocieties.org.

We are the only public interest group that regularly participates in FERC rulemaking for electric grid reliability standards to protect against cyberattack, physical attack, and solar storms—and we have urged FERC to protect against nuclear electromagnetic pulse (EMP) as well.

My personal background is that of both an engineer and a businessman—I have an engineering degree from MIT and an MBA from Harvard Business School. I have previously testified before FERC, various state legislatures, and the Canadian Parliament.[1]

Cost Recovery Impediments to Electric Grid Protection

Today you have heard about catastrophic threats to the Texas electric grid—threats that could result in the deaths of the vast majority of Texans. In our experience, most utility executives want to protect the electric grid in order to save their companies, their communities, and the nation from harm, but tangible progress has bogged down on two fundamental issues:

1. Lack of transparent and defensible cost estimates for grid security protections.
2. Lack of mechanisms for utilities to recover protection costs for compliance with grid standards or, alternatively, costs for prudent adoption of "best practices."

For high-impact events that have not yet occurred, protection costs are understandably uncertain. However, in most cases, cost estimates have not yet even been attempted by legislative bodies, federal regulators, state regulators, and the utilities themselves.

SB 83 contains provisions for the Public Utility Commission to both determine reasonable protection costs and for these costs to be recovered by utilities. In this regard, SB 83 would be ground-breaking legislation, both for the State of Texas and for the nation.

Experience at the Federal Level with Grid Reliability and Security Standards

For the federally-regulated bulk power system, grid reliability and security standards are almost always "unfunded mandates" for certain classes of utilities. For example, there is no good regulatory mechanism for Independent Power Producers to recover costs for grid security protections. In Texas, which is federally-regulated for electric reliability, this unfunded mandate is especially detrimental because Independent Power Producers generate 60 percent of your electric power.

[1] In accord with our policies, the Foundation for Resilient Societies does not testify for or against specific legislation.

Prepared Statement of Thomas S. Popik
Foundation for Resilient Societies
Testimony on SB 83 Relating to Protection of Energy Critical Infrastructure
April 11, 2017

When utilities confront unfunded mandates for compliance with electric reliability standards—and potentially suffer cost disadvantages—what are they to do?

Under the federally legislated "Section 215" system for setting electric reliability standards, utilities can have significant influence on standards' requirements, because standard-setting has been delegated to an industry-dominated body, the North American Electric Reliability Corporation (NERC). Adversely affected utilities can serve on key committees and also volunteer for standard drafting teams. In fact, this is what Resilient Societies has observed over the five years that we have participated in NERC standard-setting. For example, with heavy influence by potentially affected utilities, the NERC physical security standard finally approved by FERC in April 2015 exempted generation plants of all sizes and technologies from protection requirements. Employees of major Independent Power Producers served in key positions on the standard-drafting team.

Operating within this federal system of unfunded mandates, NERC has set inadequate standards for grid security threats and FERC has approved these standards. As just mentioned, the NERC standard for physical security does not mandate protections for any generation facilities, even when loss of a single facility can cause a cascading outage, and when loss of several can black out large regions. NERC standards allow communications between grid control rooms and substations to remain completely unencrypted and therefore susceptible to cyberattack. In January 2017, FERC gave final approval to a NERC standard for solar storms based on a model discredited by Los Alamos National Laboratory and others; this standard has so many technical loopholes that not a single transformer in North America need be outfitted with protection hardware.

For critical functions, such capital and operating costs for system restoration, known as *blackstart*, FERC allows cost recovery for capital, operating, and "crank path" investments to enable bulk power system recovery after an extended grid blackout. Sections 205 and 206 of the Federal Power Act do authorize cost recovery, but generator owners rarely qualify, and the burden of proof is upon an applicant to qualify for cost-recovery.

In summary, under the federal system of unfunded mandates, inadequate provisions for cost recovery are powerful motivators for the electric power industry to delay or weaken mandatory protection. Industry resistance to grid security improvements persists despite physical attacks on critical substations, compromise of grid control systems by foreign cyber-attackers, transformer damage during minor solar storms, and North Korea's ongoing development of an EMP attack capability.

Ironically, some utilities' good-faith efforts to achieve protection above the minimal level prescribed by NERC standards — so-called "best practices" — may not be eligible for cost recovery. Lacking ability to recover grid security costs, utility executives who are patriotic and

motivated to protect their companies, their communities, and the nation from catastrophic blackout have been placed in agonizingly difficult positions.

Industry Excuses to Do Nothing

Because cost recovery for grid security improvements is difficult or impossible, the electric utility industry has become skilled at developing elaborate technical justifications to do nothing, or do nothing of significance. An excellent example is NERC's reliability standard for solar storm protection. This discredited standard allows utilities to perform paper studies to escape the necessity of installing real hardware protection for their transformers. This point is so important, it bears repeating: under the NERC solar storm protection standard, not a single transformer in North America need be protected!

The latest industry attempt to use defective science to baffle legislators and others is the February 2017 Electric Power Research Institute (EPRI) electromagnetic pulse study, "Magnetohydrodynamic Electromagnetic Pulse Assessment of the Continental U.S. Electric Grid." In an appendix to this testimony, I've outlined major defects of this EPRI study, but for brevity I give you this one highlight: there are thousands of transformers in the North American electric grid with hundreds of designs, but EPRI used tests on just two transformers to conclude that less than one-tenth of one percent of transformers might be damaged in an EMP attack. Would you feel safe riding in your car if you knew that crash tests had been performed on only two models of cars, a 2017 Cadillac and a 1995 Subaru?

In regard to today's testimony by EPRI employees on EMP, I quote a 1981 California appeals court ruling, "The correct rule on the necessity of expert testimony has been summarized by Bob Dylan: 'You don't need a weatherman to know which way the wind blows.' " And you don't need to be an expert on power systems to know the EPRI study is bogus.

A Bad Ending Can Be Prevented

Increasingly, the American public is recognizing that inadequate electric grid security is a threat to their livelihoods and lives. But policymakers and politicians have been slow to act, especially at the federal level. Action at the state level—especially Texas—could break this logjam.

Based on my personal knowledge and Resilient Societies' research on grid vulnerabilities and policy shortfalls, I am gravely concerned that a major region of the U.S. will experience a long-term blackout within the next decade or two.

Under a long-term blackout scenario, power restoration will not be accomplished within hours or a few days, but instead will require weeks, months, or even years. Utilities have regional mutual assistance groups to support the North American grid. Nevertheless, if the blackout affects sufficiently large regions and takes down critical grid equipment that may not be replaced for months or years, both outside assistance and large-scale evacuation will be infeasible. According to 2008 congressional testimony of Dr. William R. Graham, former science

advisor to the President, casualties in the aftermath of a nationwide infrastructure outage could be as high as 90% in the first twelve months.[2] Certain areas are more prone to blackout than others, including California, New York, and Florida. I would also point out that Texas has already had serious outages in April 2006 and February 2011, and had a close call in January 2014.

Texas can act now to prevent a long-term, wide area blackout. Utility cost recovery for protection against electromagnetic, geomagnetic, physical, and cyber-attack threats must be established. Yes, this will be an expensive undertaking, but already Texas has demonstrated the willingness to pay for infrastructure improvements, such as the $7 billion spent on Competitive Renewable Energy Zone (CREZ) transmission upgrades for wind power.

It is helpful to remember that when the grid is not protected, the entire $1.6 trillion Texas economy is at elevated risk. Healthcare spending by the State of Texas was $42.9 billion in 2015, but for Texas children of today, their greatest health risk may be premature death from long-term electric grid blackout. Fortunately, technology exists to protect the electric grid from electromagnetic pulse, cyberattack, physical attack, and solar storms.

I urge you to act now to improve grid security and prevent a long-term outage of the Texas electric grid.

I look forward to any questions.

[2] U.S. House Committee on Armed Services, "Threat Posed by Electromagnetic Pulse Attack (EMP) Attack." Hearing held July 10, 2008. 110th Cong., 2d sess., 2008. pp. 8-9. https://fas.org/irp/congress/2008_hr/emp.pdf .

Appendix: Major Defects in EPRI Electromagnetic Pulse Study

The EPRI EMP study, "Magnetohydrodynamic Electromagnetic Pulse Assessment of the Continental U.S. Electric Grid" concluded that "for the worst-case target location, only 14 of the tens of thousands of transformers that were included in the model were found to be at potential risk of thermal damage."[3] The EPRI study is riddled with major technical defects. Here are a few:

- The "E3" threat level of 24 volts/kilometer has been low-balled and is only 60% of the 40 volts/kilometer threat in the International Electrotechnical Commission EMP standard.
- According to EPRI's optimistic scenario, "Only a single, high-altitude burst over a given target location was considered." However, in the real-world, an attacker could detonate multiple nuclear weapons in quick succession.
- Only thermal effects on high voltage transformers were considered; despite real-world evidence of vibration-related failure of transformers, vibration was ignored.
- Data on transformer failures during the last half century's solar storms, which inject DC currents into transformers similar to EMP effects, have not been collected or used. If these data were examined, it would likely show that EPRI's models of thermal stress on transformers are incorrect.
- Data on impacts to grid equipment other than transformers, such as hard-to-replace generators, has been ignored, even when this data exists. Generators may suffer damage along with Generator Step Up transformers during conditions of DC current injection to connected transformers.
- Harmonic effects on grid controls, such as tripping of analog relays, have been ignored.
- Out of hundreds of transformer designs, only two designs were tested and these two tests were conducted under unrealistic and unloaded conditions—a "factory acceptance test" and a "field test."
- For one of the transformer tests, only 5 amps of DC current was injected. In contrast, the EPRI report discloses that hundreds of transformers will be subjected to DC currents exceeding 75 amps per phase during an EMP event. For the other transformer test, the maximum injected DC current was 200 amps in the neutral, or only 67 amps per phase. DC currents during an EMP attack could be 1,000 amps or more.
- According to EPRI, "Transformers experiencing effective GIC levels less than 75 amps/phase were assumed to be immune to thermal damage." This *assumption* is based on a NERC standard for which FERC has ordered a remedial research work plan.
- Neither of two tests stressed transformers to the point of failure, so it not possible to know the true immunity or resilience of these transformers to EMP.

[3] Horton, R., et. al. *Magnetohydrodynamic Electromagnetic Pulse Assessment of the Continental U.S. Electric Grid*. Palo Alto, CA: Electric Power Research Institute. February 2017. p. 3-9. Accessed April 9, 2017. https://www.epri.com/#/pages/product/3002009001/