FACT SHEET

ON PRELIMINARY COSTING MODEL OF THE FOUNDATION FOR RESILIENT SOCIETIES TO PROTECT THE U.S. ELECTRIC GRID FROM MAN-MADE ELECTROMAGNETIC PULSE (EMP) HAZARDS AND SOLAR GEOMAGNETIC DISTURBANCES (GMD)

Foundation for Resilient Societies—May 13, 2015

The Foundation for Resilient Societies has developed an Electromagnetic Pulse (EMP) and Geomagnetic Disturbance (GMD) Protection Cost Model to assist public policymakers in prioritized protection of critical infrastructure in the United States. Infrastructure protection should start with the electric grid, the keystone infrastructure upon which all other infrastructures depend. While an "all hazards" grid protection approach must take into account physical security, cyber protection, solar geomagnetic storms, and man-made electromagnetic pulse hazards, our model starts by estimating the cost to mitigate risks from man-made electromagnetic pulse and solar geomagnetic storms.

Both man-made EMP and naturally-occurring GMD induce currents in long transmission lines and cause transformers at the end of these lines to overheat and prematurely fail. The "long pulses" from these two hazards, often known as E3 power surges, are generally mitigated using the same protective equipment. Man-made EMP also causes a "fast pulse," commonly known as E1, which impacts microelectronic components and systems. Unless equipment is installed to protect against E3 hazards, there is little benefit to solely protect against E1 because grid collapse would de-power all equipment. Much of electric grid equipment is already protected from a mid-range threat known as E2, by use of lightning arresters now widely deployed.

What is the probability of a solar geomagnetic storm that could cause the North American electric grid to separate with cascading collapse over one or more major grid interconnections? Multiple estimates for a super storm approximating the May 1921 Railroad Storm or the August-September 1859 Carrington Event place the probability at about 12 percent per decade. Therefore, without equipment redesign or protection, over the next fifty years the risk of cataclysmic grid outage is about 50 percent.

The projected costs of a regional or nationwide electric grid outage lasting months or years vary widely, but range from $1 trillion to over $10 trillion—plus potential widespread loss of life for the substantial majority of the 320 million people living in this nation. The costs of recovery without pre-disaster protection far exceed the costs of prevention, mitigation, and resiliency enhancements.

What is the probability of a man-made electromagnetic pulse attack, consisting of one or more EMP weapons detonated at high altitude? We do not know the answer. Both the governments of North Korea and Iran, among others, have articulated interest in EMP weapons as vehicles of *asymmetric warfare.* Because the U.S. government has developed and deployed EMP protection systems for the Department of Defense and for other nationally critical facilities over many decades, one may hope that EMP threats or actual use of EMP weapons are deterred. We can expect that protecting even a fraction of our electrical grid and associated critical infrastructures will enhance deterrence.

Resilient Societies' Electromagnetic Pulse & Geomagnetic Disturbance Protection Cost Model does not address net expected benefits, because of uncertainties relative to combined probabilities of the events occurring and the investment required for anticipatory protection versus societal costs of protection failures. Nonetheless, given the extreme consequences, the benefits of protecting against man-made EMP and naturally-occurring GMD should be obvious to even the casual observer.

Our preliminary cost model, released as Version 0.18 in Microsoft Excel format, provides a *range* of protective options, and hence a *range of projected costs*. Our projected costs, over the five year period 2016-2020 range from a low end of about $10 billion dollars to a high end of about $30 billion dollars. Some of the cost components are "best buys" under all conditions. For example, initiatives to protect the control systems, batteries, and communications for key grid "blackstart" facilities are less than one percent (1%) of total costs for both the low-end and high-end estimates.

Some protection costs are expensive for both scenarios—for example, the cost to protect large electric generation plants. Electric generation plants are complex and expensive machines, with multiple control systems and long cable runs exposed to E1. There are many different plant designs, even within general categories such as coal-fired, natural gas, petroleum, and hydroelectric. Modifications to control systems, such as implementing fiber optic communications, would need to be extensively tested for operational effectiveness and safety. When originally built, large electric generation plants cost hundreds of millions or billions of dollars and any retrofits would also be costly. As a result, we estimate that EMP protection of electric generation plants would cost in the millions of dollars per plant and we have reflected this in our cost model. Other specific assumptions and references are provided in the cost model itself.

No doubt some will disagree with details of our cost estimates. Nonetheless, we believe our methodology is robust. We take a systems approach, recognizing that to protect the electric grid, it is also necessary to protect supporting infrastructures such as telecommunications, natural gas pipelines, and rail transport. We estimate costs from the bottom up, listing the components to be protected and their approximate units, and then multiplying by per-unit costs. We do not always assume 100% protection. Cost drivers are clearly delineated. For those who wish to run alternative scenarios, our model enables users to substitute assumptions about the protection components that are essential, or not, the percentages of equipment types to be protected, and variants in per-unit protection costs.

The congressional EMP Commission took a systems approach to EMP protection, as we do with our cost model. However, the Report of the Commission to Assess the Threat from Electromagnetic Pulse (EMP) Attack; Critical National Infrastructures (April 2008) contains a different methodology and different costs than our model.[1] (An analysis of the estimated EMP protection costs from the Critical National Infrastructures report is included as a worksheet tab in our cost model.) Additional information is now available on costs to mitigate solar storms and costs to harden control centers since the year 2008 EMP Commission Report. Moreover, our cost model includes significant cost elements that the EMP Commission only qualitatively addressed; we include separate cost elements for telecommunications, natural gas pipelines and storage, and rail transport for resupply of fuel to coal-fired plants.[2]

A benchmark program of the U.S. Department of Energy for Smart Grid modernization provides a sense of comparability. Over a five year period in 2010-2015, the Smart Grid program provided up to 50% federal matching funds, with federal expenditures of $5.023 billion through March 31, 2015. When the program ends in coming months, the federal component will be about $5.2 billion with matching funds from electric utilities of around $7 billion dollars. This Smart Grid program could enable managed “load shedding” during emergencies and other benefits. But in terms of system reliability and system recovery, an EMP & GMD Protection Program could provide far more robust benefits at comparable program costs. A low-cost EMP & GMD Protection Program, if providing 50% federal grant eligibility, would cost taxpayers about as much as the Smart Grid Program while protecting the U.S. electric grid from both severe solar storms and man-made EMP attack.

For further information on the Foundation for Resilient Societies, Inc., see our website at: www.resilientsocieties.org.

For further information on the Resilient Societies EMP & GMD Protection Cost Model, please contact: Thomas S. Popik at: 1-855-OUTAGE-0. (1-855-688-2430).

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[1] See Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures, April 2008, at pp. 60-61.

[2] Rail transport is vital for operation of most coal-fired plants. See Ibid., p 107: “Coal dominates all other categories of freight, accounting for 44 percent of Class I railroad tonnage in 2003. More than 90 percent of this coal, some 700 million tons, is delivered annually to coal-fired power plants. Power plants that depend on railroad-delivered coal account for more than one-third of our electricity production.”