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This month's *The CIP Report* focuses on Critical Infrastructure Security and Resilience issues associated with the **Energy Sector**. All Critical Infrastructure sectors are dynamic and in a constant state of change, yet the Energy Sector has been exceptionally dynamic in recent years. The revolution in extractive technologies has opened new fossil fuel sources, which has had the cascade effect of bringing change to the transportation networks that serve the energy supply chain. The development of renewable resources has likewise opened up new energy sources in new locations and forced change on existing generation and distribution systems. The linkage of legacy industrial control systems to the internet has brought efficiency, but opened new cyber vulnerabilities. The list of dynamic forces on this "lifeline sector" is long, so this is a rich subject for inquiry and dialogue

Contributors Lindsey Hale and Monta Elkins of FoxGuard Solutions offer valuable cyber insights to the energy sector, examining the use of patches in industrial control systems and the incentives and potential remedies available for energy sector cybersecurity. Next, Julia Phillips, Frédéric Petit, Doug Bessette, and Celia Porod, colleagues from Argonne National Laboratory, examine a developing U.S. Department of Energy approach for capturing system resilience to extreme weather hazards with a particular focus on bulk power generation and distribution systems.

The Honorable Bill Ritter, former Colorado Governor and now Director of Colorado State's Center for the New Energy Economy, offers an article that suggests that the United States is undergoing an energy revolution and lays out a path forward to empower the transition to a clean energy economy and result in a more resilient energy infrastructure. Next, Zara Saydjari highlights the interdependence between the energy and transportation infrastructure sectors in an article that identifies needed improvements to the critical infrastructure protection of coal transportation, with implications across all energy-transportation relationships.

Finally, Kayla Matola with the Homeland Defense & Security Information Analysis Center discusses the U.S. Military's growing effort to implement sustainable energy policies and employ alternative energy sources to reduce costs, improve energy security, and reduce risk to DoD mission assurance.

As I outlined in last month's CIP Report, this will be our last PDF-based issue before we convert to an e-mail format. We expect to have full conversion to this improved format by early August, when we will continue to provide our readers with innovative thought and rich dialogue. We would like to take this opportunity to thank this month's contributors. We hope you enjoy this issue of *The CIP Report* and find it useful and informative. Thank you as always for your support and feedback as we look to the future!

Warm Regards,

Mark Troutman, PhD
Director, Center for Infrastructure Protection and Homeland Security

Simplifying the Patch Management Process

by Lindsey Hale and Monta Elkins, FoxGuard Solutions

What does "Patch" mean? "A patch is a software update comprised of code inserted (or patched) into the code of an executable program. Typically a patch is installed into an existing software program. Patches are often temporary fixes between full releases of a software package."[1] Software, hardware, and firmware updates are a necessary evil; we don't necessarily want to do them but have to for multiple reasons. For some, it's the nagging fear of what will happen if they don't. For others, it is more serious as many entities face regulations (NERC CIP[2]) which require electric utilities to identify and patch their devices on a regular basis. More items than ever need patching and the size of the task may not be apparent at first glance. This effort, both bulk and ongoing, can consume a great deal of time for utilities. As we all know, time is money.

What did utilities do in the past? Historically, the energy sector has avoided patching and updating its industrial control system equipment for fear of impeding critical energy delivery operations. Control systems were once considered secure because they were not connected to external networks ("air-gapped"). However, this is no longer the case and the approach of not patching Industrial Control System (ICS) equipment is no longer a viable option given the current threat to the critical infrastructure landscape. More often than not, when we hear about a security vulnerability or breach in the news, the target of the attack is a financial institution or, most recently, the government. Yet, Critical Infrastructure (including energy) is also a potential target for similar attacks with repercussions that could stress our society in new ways.

With the NERC CIP Version 5 deadline looming, there seems to be pent-up demand from the energy sector for a solution that will help address software, hardware, and firmware patching and updating across various ICS vendors. Existing energy sector solutions target, at best, the equipment of a single vendor. This proves to be one of the primary roadblocks to implementing a patch and update program for utilities—the asset owner's plant is most commonly a heterogeneous equipment environment. That heterogeneous utilities environment complicates both the security and compliance aspects of patching but FoxGuard Solutions is working on a project to help. In 2013, FoxGuard submitted a proposal in response to the U.S. Department of Energy's funding opportunity: "Innovation for Increasing Cybersecurity for Energy Delivery Systems"[3] and was awarded a $4.3 million shared funding Cooperative Agreement for a project entitled the "Patch and Update Management Program."[4] Building upon our current patching, validation, and security expertise in the Operations Technology environment, we are excited to tackle this research and development effort in an effort to simplify the process of patching and updating ICS devices <u>for both end users and equipment vendors</u>. Reducing the burden of patching/updating ICS equipment will help utilities more easily adhere to NERC CIP compliance regulations around patch management and will ultimately lead to a safer, more secure grid.

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[1] "Definition – What does Patch mean?", Technopedia, accessed June 24, 2015, http://www.techopedia.com/definition/24537/patch.
[2] Version 5 Critical Infrastructure Protection Reliability Standards, 78 Fed. Reg. 24107 (Apr. 24, 2013).
[3] "DOE Issues Funding Opportunity for Innovations for Increasing Cybersecurity for Energy Delivery Systems," Office of Electricty Delivery and Energy Reliability, February 11, 2013, http://energy.gov/oe/articles/doe-issues-funding-opportunity-innovations-increase-cybersecurity-energy-delivery.
[4] "Patch and Update Management Program," FoxGuard Solutions, May 2015, http://www.foxguardsolutions.com/images/uploads/PUMP2015.05.01.pdf.

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Project Overview

The Patch and Update Management Program research project will develop and demonstrate technology and techniques needed to identify, verify the integrity of, and facilitate deployment of patches and updates for energy delivery control system software, hardware, and firmware. The project has several components; this article focuses upon the first deliverable.

First in Queue:
The *Patch and Update Data Aggregator Service* will give users the ability to research and gather information available about patches and updates for ICS devices in a centralized location. All too often, end users must visit countless websites for equipment vendors and other 3rd party software provider's to determine patch availability. Our centralized web portal will aggregate data in one location, facilitate collaboration and information sharing, and host organized patch information with vendor patch locations at a per device level.

For more information on the Patch and Update Management Program (PUMP), please visit www.icsupdate.com.

If you would like updates on the progress of the program or would like to discuss your unique patch needs, please contact Lindsey Hale, Program Manager, at lhale@foxguardsolutions.com or 540-382-4234 Ext. 108. We would love to hear from you.

Electric Distribution System Resilience

by Julia Phillips, Frédéric Petit, Doug Bessette, and Celia Porod
Risk and Infrastructure Science Center
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Introduction

A strong case can be made for enhancing resilience at various levels—asset, community, regional, national—in terms of the social benefits that would accrue from such actions. However, enhancing resilience can be costly in terms of both time and resources. At the community and regional levels, governmental budgets are severely strained in the current economic environment. Thus, local and regional governments must understand the benefits of investing in assessment and enhancement of the regional resilience of their critical infrastructure.

Recognizing that more than 85 percent[1] of critical infrastructure is privately owned and operated, it is important to be able to convince owners and operators that investment in both the assessment and, where necessary, the enhancement of critical infrastructure resilience is in their best interest. There is growing awareness in the business community that enhanced resilience is part of a well-designed strategy to improve a business's ability to withstand various shocks (i.e., natural and man-made disasters, supplier outages, industrial accidents, or economic disruptions) and thus increase the business's competitive position. The recent Quadrennial Energy Review, published in April 2015, reinforces the need to increase the resilience, reliability, safety, and security of energy infrastructures, and to improve assessment tools and frameworks for measuring the effects of best practices for response and recovery.[2] This paper describes an approach being developed for the U.S. Department of Energy (DOE) to measure electric distribution system resilience to extreme weather events to improve owners' and operators' understanding of where their systems are in terms of resilient infrastructure and where improvements should be considered.

System Resilience

The electric grid has strong interconnections with other lifeline utilities such as water, natural gas, and telecommunications. A resilient grid can help reduce the likelihood of cascading or escalating impacts as the interruption of electric power propagates throughout a community or region. Previous efforts to facilitate the collection of critical infrastructure information resulted in the development of a survey tool designed to collect protection and resilience information from facilities in all 16 critical infrastructure sectors in an all hazards environment.[3] This survey is general in nature as it must be flexible enough to capture information that is both critical infrastructure and hazard agnostic.

To capture system resilience, it is necessary to identify each of the components within the system to provide a holistic picture; such identification allows for a more comprehensive understanding of how the components are interconnected to achieve successful delivery of the product to the end user (e.g., electric power to the customer). Defining the characteristics of the

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[1] Government Accountability Office, *The Department of Homeland Security's* (DHS) *Critical Infrastructure Protection Cost-Benefit Report*, GAO-09-654 (Washington, D.C.: United States Government Accountability Office, 2009), 12, available at http://www.gao.gov/new.items/d09654r.pdf.

[2] Department of Energy (DOE), *The Quadrennial Energy Review,* Office of Energy Policy and Systems Analysis, accessed June 2, 2015, http://energy.gov/epsa/quadrennial-energy-review-qer.

[3] Frédéric Petit, G.W. Bassett, R. Black, W.A. Buehring, M.J. Collins, D.C. Dickinson, R.E. Fisher, R.A. Haffenden, A.A. Huttenga, M.S. Klett, J.A. Phillips, M. Thomas, S.N. Veselka, K.E. Wallace, R.G. Whitfield, and J.P. Peerenboom, *Resilience Measurement Index: An Indicator of Critical Infrastructure Resilience*, No. ANL/DIS-13-01 (Argonne, IL: Argonne National Laboratory (ANL), 2013), 70.

(Continued from Page 4)

system allows system-specific information to be captured and analyzed. For example, the quantification of resilience in electric power distribution systems includes many physical factors that characterize overall distribution system reliability. "Among the commonly considered factors are system voltage, feeder length, exposure to natural elements ([i.e.,] overhead or underground conductor routing), sectionalizing capability, redundancy, conductor type/age and number of customers on each feeder."[4]

Electric Distribution Resilience

Traditionally, there have been standard, accepted metrics for electric reliability (i.e., SAIFI, CAIDI, and SAIDI). In this approach, reliability and resilience are not synonymous. There are many factors in addition to reliability that must be considered to indicate the resilience of the electric grid. Additional resilience data that should be captured include planning, training and exercising of plans focused on responding to disruptions to normal operations; relationships with local emergency responders; and the ability of the facilities that are dependent on the electricity distribution system to perform their core mission. Further, the information that allows characterization of electric distribution system resilience may vary depending of the types of hazard or threat considered. In particular, the assessment must consider that electric distribution systems extend over large geographic areas with variable characteristics. The challenge, therefore, is to capture enough information to identify the common resilience characteristics of these systems and take into account their specificities to allow comparison among systems that operate in similar environments.

Conceptualization of an Assessment Approach

Resilience represents a complex set of capabilities that enable an entity—e.g., asset, system, organization, community, or region—to anticipate, resist, absorb, respond to, adapt to, or recover from a disturbance whether from natural or manmade causes.[5] The components of this definition can be aggregated into four major domains: preparedness, mitigation, response, and recovery.[6]

High quality data are required to calculate an index that captures the performance of a system in terms of resilience. It is important to define a process to ensure the consistency of the data collected. With the appropriate training, private entity owners and operators can populate a questionnaire. The information can be displayed under the four domains in an interactive display to provide the owners and operators with relevant information about their infrastructure-specific resilience. To ensure the uniformity and reproducibility of the data collected, the survey tool must be combined with specific explanation for each question and a quality assurance process.

Decision analysis can be used to determine the relative importance of each component to the overall resilience by aggregating the information gathered and calculating a system resilience performance indicator.[7] The value of the indicator will range from 0 (low resilience) to 100 (high resilience). A high value does not mean that a specific event will not affect the system or have severe consequences. Conversely, a low index does not mean that a disruptive event will automatically lead to a failure of the critical infrastructure system and to serious consequences. However, the index can be used to compare the system level of resilience against the resilience level of other similar systems and guide prioritization for improving resilience.

While important in terms of the data it represents, without a frame of reference, the value of the

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[4] American Public Power Association (APPA), *Evaluation of Data Submitted in APPA's 2011 Distribution System Reliability & Operations Survey* (Washington, D.C.: APPA, 2012), available at http://www.publicpower.org/files/PDFs/2011DSReliabilityAndOperations_Report_Final.pdf.

[5] L. Carlson, G. Basset, W. Buehring, M. Collins, S. Folga, B. Haffenden, F. Petit, J. Phillips, D. Verner, and R. Whitfield, *Resilience Theory and Applications*, Argonne National Laboratory, Decision and Information Sciences Division, ANL/DIS-12-1 (Argonne, IL: ANL, 2012).

[6] Petit, *Resilience Measurement Index.*

[7] J. Phillips, F. Petit, and D. Bessette, "Using Decision Analysis to Construct Risk Performance Indicators", *The CIP Report 13*, no. 3 (2014): 12-15, available at http://cip.gmu.edu/wp-content/uploads/2015/01/CIPHS_TheCIPReport_October2014_Cybersecurity.pdf

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index alone does not convey its full meaning. Indeed, this value is strongly related to the characteristics of the system and to the context of its operating environment. Using Xcelsius 2008, a Microsoft Windows application that combines Microsoft Excel and Adobe Flash Player, allows for a visual presentation of the data gathered and the index calculated.[8]This interactive tool will allows users to see the system characteristics as they were at the time of the assessment (when the data were collected), as well as how they would appear in different mitigation scenarios (e.g., deploying backup generators to delay operational impacts from an electric power outage). The visualization tool will also allow comparison of like systems (e.g., electric power distribution systems in suburban areas within similar environment) by providing managers a report on both the strengths and weaknesses of their protective posture and the resilience of their system in relation to other like systems.

Conclusion

Resilience of the electric grid has gained an increasing amount of attention over the past seven years since the Energy Independence and Security Act of 2007.[9] The Obama administration expanded on these efforts through the American Recovery and Reinvestment Act (ARRA) of 2009. The ARRA allocated $4.5 billion to DOE to be used for investment in electric delivery and energy reliability in support of grid modernization.[10] In June 2011, the Office of the President, National Science and Technology Council, released a policy framework focused on cost effective investments, encouraging innovation and in turn educating and enabling consumers to make smart decisions to secure the grid from attacks.[11]

Assessing the resilience of electric distribution system operations is complex and requires analysts to consider the specificities of the distribution system and its operational environment. Decision analysis concepts can be used to calculate a resilience performance indicator that will support decision making. Developing and applying this system resilience assessment tool will result in a clearer, more meaningful picture of electric distribution system resilience to aid in critical decision making and investment strategies moving forward.

Acknowledgment

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[8] Business Objects, *Xcelsius 2008 User Guide*, available at http://help.sap.com/businessobject/product_guides/xcelsius2008/en/xcelsius2008_user_guide_en.pdf.

[9] Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1494, available at https://www.congress.gov/110/plaws/publ140/PLAW-110publ140.pdf.

[10] National Science and Technology Council, *A Policy Framework for the 21st Century Grid: Enabling our Secure Energy Future* (Washington, D.C.: Executive Office of the President of the United States, 2011), 108, http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.

[11] Ibid.

Infrastructure for the New Energy Economy

By Bill Ritter, Jr., 41st Governor of Colorado
Center for the New Energy Economy

When the U.S. Department of Energy (DOE) issued the nation's first Quadrennial Energy Review (QER) earlier this year, it boasted, "The United States has one of the most advanced energy systems in the world."[1] The 7,300 power plants that move electrons over 640,000 miles of high-voltage lines has been called the greatest engineering achievement of the last century,[2] no small praise in an era that saw the invention of the automobile, air flight, television, spacecraft and the Internet.

Whether our energy system remains one of the most advanced in the world depends, however, on how intelligently we invest in pipelines, power lines and energy transport systems in a world much more complicated than it was when most of the existing infrastructure was built. As DOE emphasized in the QER, "the focus of energy-policy discussions has shifted from worries about rising oil and natural gas imports to debates about how much and what kinds of U.S. energy should be exported, concerns about safety and resilience, integrating renewable sources of energy, and the overriding question of what change in patterns of U.S. energy supply and demand will be needed—and how they can be achieved—for the United States to do its part in meeting the global climate-change challenge."[3]

To put it more succinctly, the United States is undergoing an energy revolution. We are on the cusp of the carbon economy of the 20th century and the carbon-constrained economy of the 21st. The energy system is changing, or is under pressure to change, because of factors that include the need to reduce carbon emissions, the increasing competitiveness of renewable energy technologies, the rising popularity of distributed energy generation, and the importance of protecting the system against extreme weather events and cyber attacks. The criteria for what constitutes an advanced energy system are changing, and our choices are complicated by uncertainties, risks and threats.

The good news is that this is an ideal time for modernization. Our existing energy infrastructure needs major investments at the same time the demands on the system are changing. To quote DOE again, we have reached a "strategic inflection point—a time of significant change for a system that has had relatively stable rules of the road for nearly a century."[4] Our opportunity and obligation now is to rebuild the system to respond to those new demands. The result must be infrastructure that not only accommodates but empowers our transition to a clean energy economy. States, utilities and investors need the same stable rules of the road, the same market certainty, that they were afforded over the last century when the public policy objective was to build large central power plants and transmission lines with the primary goal of electrifying America at the least internal cost.

The QER details many of the factors that have brought us to this inflection point. Here are a few points that are implied but not explicit in its review:

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[1] United States Department of Energy (DOE), Q*uadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure*, (Washington, D.C.: DOE, 2015), 5-2, available at http://energy.gov/sites/prod/files/2015/05/f22/QER%20Full%20Report_0.pdf.
[2] "Greatest Engineering Achievements of the 20th Century," National Academy of Engineering, 2015, http://www.greatachievements.org/.
[3] DOE, *Quadrennial Energy Review*.
[4] Ibid., 5-14.
[5] Jim Kennerly & Autumn Proudlove, "Going Solar America: Ranking Solar's Value to America's Largest Cities," NC Clean Energy Technology Center, accessed June 19, 2015, http://nccleantech.ncsu.edu/wp-content/uploads/Going-Solar-in-America-Ranking-Solars-Value-to-Customers_FINAL.pdf.

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The Solar Revolution

In 42 of the nation's 50 biggest cities today, rooftop solar systems are providing less expensive power than customers can obtain from their utilities.[5] The number of homes equipped with rooftop solar collectors has grown from 30,000 in 2006 to 400,000 in 2013. Projections are that by 2020, the number could approach 4 million.[6]

While on-site, or consumer-sited, generation seems to get the most public attention (primarily due to the debate over net metering), central-station wind and solar farms built by utilities are the major reason that solar power has grown 20-fold in the United States since 2008. Wind power has more than tripled. The Energy Information Administration, which historically has been very conservative in projecting the growth of electric generation with renewable resources, estimates that wind and solar energy will account for nearly 40 percent of new generation capacity between 2013 and 2040.[7] Other analysts, including those at DOE's National Renewable Energy Laboratory (NREL), project that renewable resources could provide 80 percent of America's electricity by mid-century if we make the right infrastructure investments.[8]

Some of that energy will be generated and distributed not by traditional utilities, but through micro-grids. With major weather-related power interruptions still a fresh memory this spring, the state of New York offered a $40 million competition for its communities to develop these standalone systems so customers have electricity when the utility grid goes down.[9]

In addition, batteries in households will allow consumers to draw on stored solar energy during peak times when some utilities charge higher rates. Shortly after Elon Musk unveiled Tesla's new wall-mounted battery pack at the end of April, he quickly received 38,000 pre-orders from around the world.[10]

These obviously are disruptive developments for the power system. There are unresolved questions about what distributed energy management can mean for the conventional grid. Utilities are faced with the challenge of developing new revenue models including rate structures that allow solar customers to buy less electricity while still paying an equitable share of the power company's fixed costs. They must find the right balance between central station and distributed power to create the best electric system. Utility executives with whom I have met say they want to be part of the solution. But as they put it, new technologies typically are 10 years ahead of utilities, and utilities are 10 years ahead of their regulators.

It may be too early to tell exactly how these disruptive challenges will shape the public service objective of our utilities. What is clear is that generating power with diverse resources at diverse locations and diverse scales will make electric power less vulnerable to cyber attacks and large-scale outages.

The Changing Climate

Weather already is the principal cause of the major power outages that cost the economy between $18 billion and $33 billion each year between 2003 and 2013.[11] Extreme weather events range from heat waves, floods and fires to droughts that threaten the water supplies necessary for fossil energy production and power plant cooling. These events are expected to become more frequent.[12]

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[6] "Installing Rooftop Solar Panels Has Never Been More Affordable," *Union of Concerned Scientists*, accessed June 11, 2015, http://www.ucsusa.org/our-work/clean-energy/increase-renewable-energy/affordable-rooftop-solar-united-states#.VVJZ59NVhBc.
[7] John J. Conti, Paul D. Holtberg, James T. Turnure & Lynn D. Westfall, "Annual Energy Outlook 2015 with projections to 2040," U.S. Energy Information Administration, April 2015, http://www.eia.gov/forecasts/aeo/section_elecgeneration.cfm.
[8] M.M Hand, S. Baldwin, E. DeMeo, J.M. Reilly, T. Mai, D. Arent, G. Porro, M. Meshek & D. Sandor, "Renewable Electricity Futures Study," National Renewable Energy Laboratory, 2012, last modified September 9, 2014, http://www.nrel.gov/analysis/re_futures/.
[9] David Robinson, "New York Offering $40 Million to Encourage Micrgrids," Emergency Management, February 13, 2015, http://www.emergencymgmt.com/disaster/New-York-Offering-40-Million-Encourage-Microgrids.html.
[10] Katie Lobosco, "Elon Musk: Tesla Home Battery Orders are Off the Hook," CNNMoney, May 6, 2015, http://money.cnn.com/2015/05/06/investing/tesla-earnings-energy/.
[11] Susan Combs, Texas Power Challenge: Getting the Most from Your Energy Dollars (Austin: Texas Office of the Comptroller, 2014), available at http://comptroller.texas.gov/specialrpt/electricity/96-1767.pdf.
[12] DOE, *Quadrennial Energy Review,* 5-10.

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While the precise regional and local impacts of climate change are difficult to predict, a more immediate uncertainty is the impact of public policies in the months and years ahead. Will Congress, states or the international community put a price on carbon? If so, what will that mean for fossil energy demand and by extension for investments in new pipelines, refineries and storage facilities? What impact will the rising efficiency of vehicles and the use of electric vehicles have on the oil industry's infrastructure planning? What about the volatility of oil and gas prices? The current disruption in U.S. oil and gas production due to decisions by OPEC proves that domestic production does not protect us from vicissitudes in the global petroleum market.

And what impacts will utility-scale solar and wind power have on more traditional generation fuels such as coal and natural gas? Once the systems are built, the marginal cost of wind and solar energy approaches zero due to no fuel cost.[13] If utilities continue to dispatch least-cost power first, will coal or natural gas have to wait until all the available renewables capacity is online?

Perhaps the blackest of the black swans for the oil, gas and coal industries is the so-called carbon bubble. The International Energy Agency (IEA) among others has accepted the calculation that to keep global warming below the ceiling set by the international community, 60-80 pecent of the world's proved reserves of fossil fuels must remain unburned.[14] These reserves represent trillions of dollars of assets for the fossil energy sector. Experts as distinguished as former Treasury Secretary Henry Paulson have warned that because of the carbon bubble, underground assets already are overvalued.[15] The possibility of carbon pricing, regulatory limits on carbon emissions, or obligations in international agreements must be factored into planning if companies are to avoid substantial stranded investments in infrastructure.

Managing Risks

Energy companies have a responsibility to their customers and shareholders to manage uncertainties like these. Policy makers along with shareholders, investors and regulators should be talking about how to build an energy infrastructure that avoids, mitigates or manages the substantial risks and uncertainties in today's energy sector. The QER contributes to that conversation. So will DOE's new Partnership for Energy Sector Climate Resilience, a group of investor-owned, municipal and cooperative utilities that will discuss infrastructure in the context of climate change.[16]

In whatever venue it occurs, the conversation should include several topics not mentioned in the Administration's QER announcement:

• A few Republicans and conservative organizations have publicly supported the creation of a carbon surcharge.[17] Most propose that all or part of the revenues be used to reduce the federal corporate tax rate. The revenues would have greater public benefit if some of them were

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[13] Public estimates of marginal costs of wind and solar are not widely available. Some analysts assume it is zero because there is no fuel cost. Some portion of operations and maintenance and ancillary services, however, should be attributed to the marginal costs of renewable energy. Even with these costs, it is assumed that the marginal cost of RE is far below fossil generation.

[14] "Redrawing the Energy-Climate Map", International Energy Agency, (June 2013), 98; Frank McDonald, "Two-thirds of Energy Sector Will Have To Be Let Undeveloped, Bonn Conference Told," *The Irish Times*, June 12, 2013, http://www.irishtimes.com/news/world/europe/two-thirds-of-energy-sector-will-have-to-be-left-undeveloped-bonn-conference-told-1.1425009.

[15] Henry M. Paulson, "The Coming Climate Crash: Lessons for Climate Change in the 2008 Recession," *New York Times*, June 21, 2014, http://www.nytimes.com/2014/06/22/opinion/sunday/lessons-for-climate-change-in-the-2008-recession.html?_r=0.

[16] The Partnership is one of several proposals and executive actions the White House announced in conjunction with the QER's release. "Fact Sheet: Administration Announces New Agenda to Modernize Energy Infrastructure," The White House: Office of the Press Secretary, April 21, 2015, https://www.whitehouse.gov/the-press-office/2015/04/21/fact-sheet-administration-announces-new-agenda-modernize-energy-infrastr.

[17] The Carbon Tax Center lists prominent Republicans who support a carbon tax, including former U.S. Rep. Bob Inglis and former Secretary of State George Schultz. Former Treasury Secretary Hank Paulson also publicly supports a carbon tax. "Conservatives," Carbon Tax Center, last modified June 10, 2015, http://www.carbontax.org/services/supporters/conservatives; Paulson, "The Coming Climate Crash," *New York Times*.

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used to help modernize our energy infrastructure. For starters, the Administration has proposed that Congress allocate about $15 billion over the next decade for a variety of programs to increase energy infrastructure resilience.[18]

- Congress should examine the use of fiscal incentives in the energy world, and consider leveling the playing field by eliminating all subsidies, other than those necessary for the most nascent technologies to prove their investment-worthiness.

- DOE should study and report on the impacts of distributed generation, battery storage, micro-grids and other emerging technologies on electric system reliability, taking into account that energy flows will change from one-way to a two-way/multi-way flow pattern.[19] The national laboratories should provide technical assistance to utilities, regulators and infrastructure planners to help them integrate renewable energy technologies, flexibility and climate risks into infrastructure plans.

To sum up, we are living in an incredibly dynamic moment in the evolution of the nation's energy systems. We should anticipate more black swans ahead, more consumer demand for distributed generation, more technical advances, more political debate and more energy market volatility. With their limited roles in developing and managing energy infrastructure, the federal and state governments can help. But as the QER notes, most energy infrastructure is owned by private entities. What they decide to do in this period of rapid change will have a critical affect not only the national economy and the environment, but also on the lives of every American.

The energy infrastructure we build today will serve our children and their children if we design it to meet the challenges of resilience, reliability and sustainability. One of the legacies from our generation should be power systems that do not pollute, electricity that does not go out, pipelines that do not leak, and energy supplies whose prices and supplies are more stable because unlike the primary fuels of the carbon era, sunlight and wind are ubiquitous and free.
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[18] Jennifer A. Dlouhy, "Analysis Calls for $15 Billion in Work to Update U.S. Energy Infrastructure," *Emergency Management*, April 29, 2015, http://www.emergencymgmt.com/safety/Analysis-15-Billion-in-Work-Update-US-Energy-Infrastructure.html.

[19] These recommendations are among dozens listed in *Powering Forward*, a report on federal energy policy that the Center for the New Energy Economy presented to the White House in 2014 after consultations with more than 100 thought leaders from industry, environmental organizations and academia. Bill Becker, Jeff Lyng, & Tom Plant, *Powering Forward*: *Presidential and Executive Agency Actions to Drive Clean*

Securing Coal Transportation from the Powder River Basin

by Zara Saydjari

Challenge to Critical Infrastructure

Coal is an important source of energy in the United States; however, the combustion of coal adds a significant amount of carbon dioxide to the atmosphere, which experts believe may be a contributing factor to global warming.[1] Despite these concerns, reliance on this fossil fuel for electricity generation remains consistent in this country, which means that the relationship between the energy and transportation sector is more critical than ever.[2]

The Powder River Basin (PRB), located in northeastern Wyoming, is responsible for producing forty percent of the nation's coal. Two main railroad lines, Burlington Northern Santa Fe (BNSF) and Union Pacific (UP), transport approximately 305 million tons of coal annually to generation plants in more than twelve states.[3] Moving the same volume of coal by truck—currently the only alternative to rail—is expensive, complicated, and inefficient.[4] For that reason, critical infrastructure protection must focus on securing railroad infrastructure components, specifically rail-only bridges, in order to ensure that coal is transported in a timely and efficient manner to power generation facilities. The closest railway hub to the PRB is located in Gillette, Wyoming (see Figure 1). From Gillette, the majority of

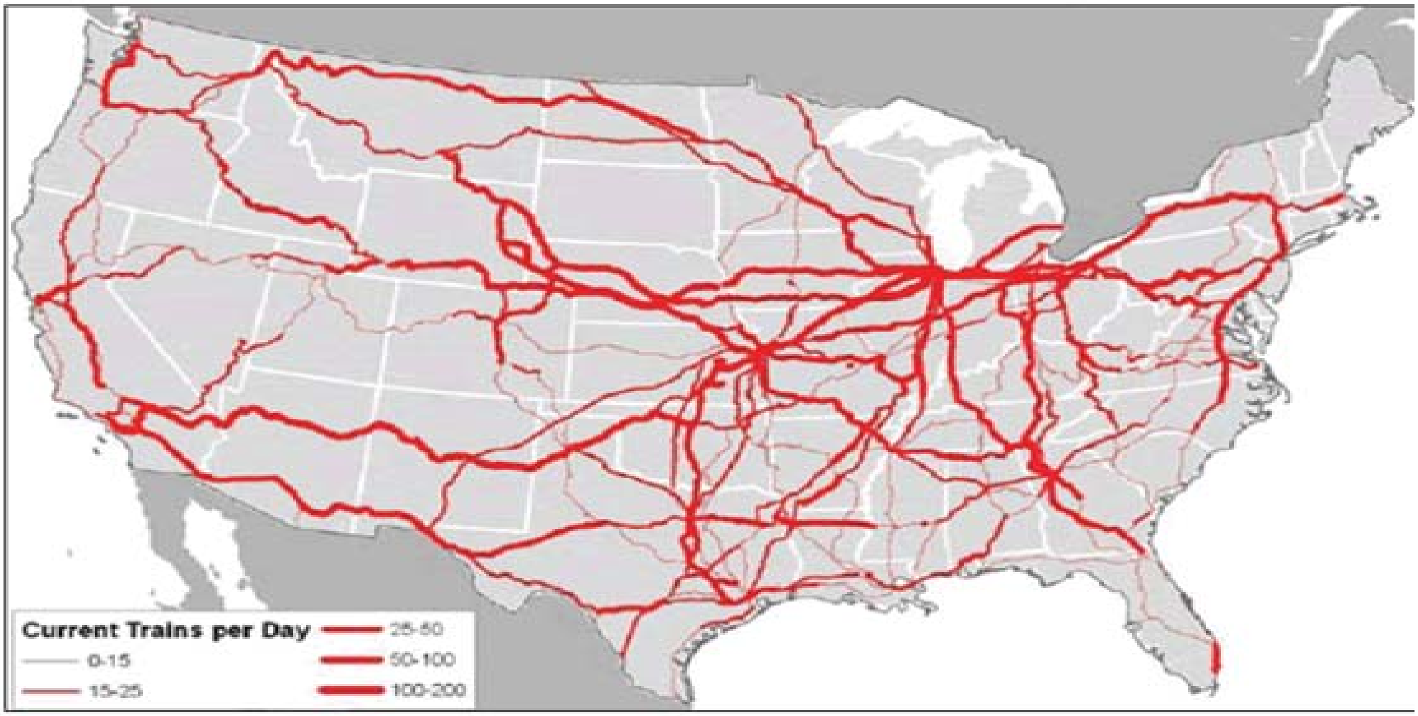

Figure 1: Railroad Corridor Volumes [5]

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[1] B.D. Hong & E. Slatick, *Carbon Dioxide Emission Factors for Coal: Quarterly Coal Report*, DOE/EIA-0121(94/Q1) (Washington, D.C.: U.S. Energy Information Administration 1994), 8.

[2] *Energy Information Administration, Monthly Energy Review: May 2015*, DOE/EIA-0035(2015/05) (Washington, D.C.: U.S. Energy Information Administration, 2015), 224, available at http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.

[3] Ted G. Lewis, *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation* (New Jersey: John Wiley & Sons, 2006), 271.

[4] Ibid.

[5] Cambridge Systematics, Inc., *National Rail Freight Infrastructure Capacity and Investment Study (*Cambridge, MA: Cambridge Systematics, 2007), available at http://www.camsys.com/pubs/AAR_Nat_%20Rail_Cap_Study.pdf.

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the coal is moved east on one of two lines. The destruction of an important bridge, like the Triple Bridge over Antelope Creek, would stop coal transport on one of two primary lines servicing the PRB.[6]

Therefore, critical infrastructure protection must focus on securing railroad infrastructure components, specifically rail-only bridges, in order to ensure that coal is transported in a timely and efficient manner to power generation facilities. In the event of a service interruption, severe economic and public health issues would arise. Economically, coal from the PRB is valued at $10.9 million per day, therefore an inaccessible bridge on one of the two main lines would cut production in half resulting in an economic loss of approximately $5.5 million per day.[7] In terms of public health, most power generation plants keep 60 days worth of coal in their stockpiles, meaning that power generation plants would likely have to decrease their coal consumption until service was fully restored, possibly forcing the consumer to minimize electricity use.[8] This paper will perform a threat, vulnerability, and risk assessment, describe these three steps in detail and conclude with a few recommendations to better protect this unique critical infrastructure challenge.

Threat Assessment

There are three common threats to railroad bridges: environmental, foundational, and the threat of a terrorist attack.[9] This paper will focus specifically on the environmental threat and the terrorist threat as they pertain to the PRB.

Environmental. There are several environmental factors that threaten the accessibility of railroad bridges servicing the region. These environmental threats include fire, flood, earthquake, high winds, and hurricanes.[10] Based on climate

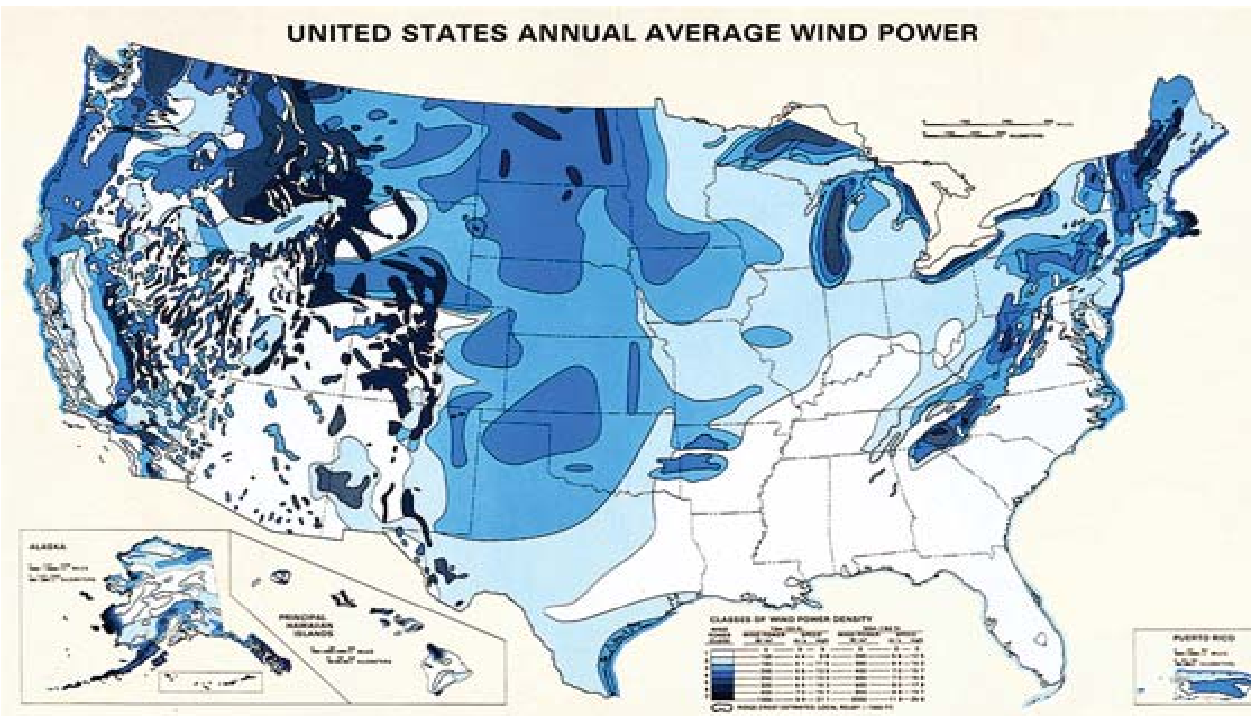

Figure 2: United States Annual Average Wind Power

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[6] Ibid.

[7] "Historic Coal Prices by Region: 2010-2015," U.S. Energy Information Administration, accessed June 19, 2015, http://www.eia.gov/coal/news_markets/archive/.

[8] "Coal Stockpiles at Electric Power Plants Were Above Average through 2012," U.S. Energy Information Administration, January 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=9711.

[9] United States Department of Homeland Security (DHS), *Characteristics and Common Vulnerabilities Infrastructure Category: Railroad Bridges*, (Washington, D.C.: DHS, 2003), 19.

[10] Eric Christopher Lazo, "Risk and Vulnerability Analysis of Civil Infrastructure: A Florida Bridges Case Study," Electronic Theses, Treatises and Dissertations, no. 3216 (2008), http://diginole.lib.fsu.edu/etd/3216/

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trends and observation, the most likely environmental threats to railroad bridges in the PRB include earthquakes and high winds. Due to active faults beneath Yellowstone National Park, the United States Geological Survey (USGS) warns that earthquakes are common in Wyoming and capable of reaching a 6.5-7.5 magnitude in the near future.[11] While Gillette, Wyoming does not rest on an active fault, it is close to Yellowstone National Park, making the threat of seismic activity (and subsequent bridge destruction) a possibility worth considering.[12]

Figure 3: BNSF System Map[17]

High winds in Wyoming are common (see Figure 2) and pose a threat to the structural integrity of the state's railroad bridges.[13] When periods of strong winds occur bridges may experience excessive vibration, which can cause fatigue to the bridge members and cause other general safety issues.[14] While high winds are not likely to cause complete destruction of a railroad bridge, high winds could create weaknesses to a bridge's infrastructure. These weaknesses, exacerbated by high volumes of frequent heavy coal train traffic, could contribute to a failing infrastructure.

Terrorist Attack. The majority of railroad security today focuses on the possibility of a railroad cargo container holding a nuclear device; however, emergency planners are aware that failure of a railroad bridge due to a terrorist attack resulting in bridge failure could lead to substantial loss of life and a cascading effect on the federal, state, and local economies.[15] The Department of Homeland Security predicts that an extended interruption of service to railroad bridges in the PRB could realize the following impacts: the coal mining industry would be halted in approximately two weeks and the ability of power generation plants to generate electricity would be severely comprised almost immediately due to small stockpiles.[16] The following section

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11 James C. Case & Annette Green, *Earthquakes in Wyoming* (Laramie, WY: Wyoming State Geological Survey, 2000), available at http://waterplan.state.wy.us/BAG/snake/briefbook/eq_brochure.pdf.
12 Ibid. 2.
13 "United States Annual Average Wind Power," accessed June 9, 2015, http://rredc.nrel.gov/wind/pubs/atlas/maps/chap2/2-01m.html.
14 Lazo, "Risk and Vulnerability Analysis of Civil Infrastructure."
15 Ibid, 19.
16 DHS, *Characteristics and Common Vulnerabilities*
17 BNSF Railway Company, FY12 Form 10-K for the Period Ending December 31, 2012, accessed December 11, 2014, http://www.sec.gov/Archives/edgar/data/15511/000001551113000005/bnsfrailway-12312012x10k.htm.

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will provide vulnerability analyses for each of the aforementioned threats likely to impact railroad infrastructure near the Gillette, Wyoming hub.

Vulnerability Analysis. Vulnerability is defined as the probability of a successful attack on a component.[18] Looking at BNSF's system map (see Figure 3), there are several network nodes that are absolutely vital to the railroad transportation system.

Although the Gillette hub is not the highest-degree node in the network, it is the only hub that services the PRB and distributes this region's valued coal to power generation plants scattered throughout the country.

Environmental. High winds will not likely lead to an acute bridge failure. The threat they present is not quantifiable and is only presented to properly inform the audience about regional threats to railroad infrastructure. On the other hand, earthquakes are capable of causing a complete bridge failure, and because this environmental threat occurs on a much more infrequent basis, it seems more appropriate to assess this threat in the form of a ground motion hazard map since a scientific method of determining actual probabilities of an earthquake is lacking. According to a 2014 survey by USGS (see Figure 4) there is 2 percent probability that an earthquake occurring in the next 50 years in Gillette, Wyoming will exceed a specific Richter scale magnitude. In the map below peak acceleration as a fraction of standard gravity is used instead of the Richter scale. The highest magnitude of an earthquake in a specific vicinity is an educated guess based on tectonic plate theory.[19] While this results in less than a 1 percent chance of an earthquake per

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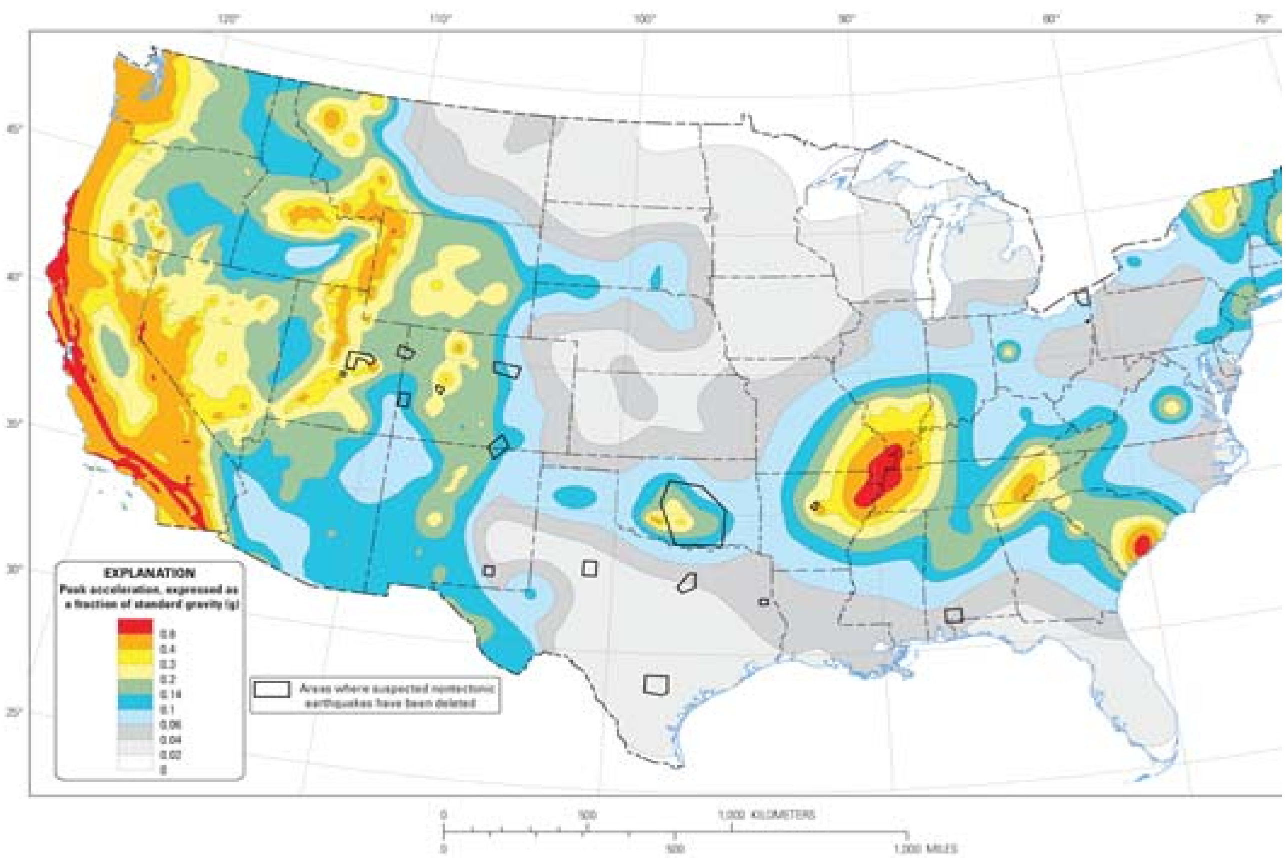

Two-percent probability of exceedance in 50 years map of peak ground acceleration

Figure 4: 2014 National Seismic

[18] Lewis, Critical Infrastructure in Homeland Security.
[19] "2014 National Seismic Hazard Map," U.S. Geological Survey, last modified April 28, 2015, http://earthquake.usgs.gov/hazards/products/conterminous/

(Continued from Page 14)

year, Gillette is close to Yellowstone National Park, which is known for its frequent seismic activity.

Terrorist Attack. Probability calculations and historical analyses are inappropriate to assess the risk of terrorism on the nation's infrastructure. Terrorists change their motivations and thoughts as they learn from previous events and other experiences, making terrorist attacks difficult to predict. Therefore a terrorism vulnerability analysis must deviate from traditional vulnerability analyses processes. The CARVER plus Shock method is an offensive targeting prioritization tool that can be used to assess a system or infrastructure's vulnerability to an attack. CARVER is an acronym for the following six attributes: Criticality, Accessibility, Recuperability, Vulnerability, Effect, and Recognizability. In addition, there is a seventh attribute called SHOCK, which evaluates the combined health, economic, and psychological impacts of an attack. The attractiveness of a target is ranked on a scale from 1-10 (1 being lower vulnerability and 10 being higher vulnerability) based on scales that have been developed for each of the seven attributes. The table below assigns a score for each attribute based on thorough research of potential threats that jeopardize railroad bridges servicing the Gillette, Wyoming node.

An average of the seven scores is 5.14, which means that the threat of a terrorist attack against railroad bridges on the two main lines servicing the Gillette, Wyoming node is moderate. Anything higher than a moderate vulnerability is unfitting because one of the main goals of a terrorist organization is mass mortality, and due to the remote location of the Gillette hub, mass mortality would not be achievable.[20]

Considering the environmental threat and the threat of a terrorist attack together, the threat of a bridge failure affecting the rail transportation from the Gillette hub is moderate.

Risk Analysis

There are several ways to calculate risk, but the general equation is risk = vulnerability x damage (R = V x D).[21] Here risk will be conceptualized as financial risk, which is defined as expected loss of productivity measured in dollars for the Gillette node. Additionally, the cost of replacing the railroad bridge should be incorporated; in other words:

D = expected loss of productivity + cost of bridge replacement

Because a finite number cannot be assigned for the vulnerability variable as it applies to the environmental threat, there is no way to calculate the exact financial risk for these two threats. That being said, a basic equation can be set up to serve as a basis for financial risk evaluation of this threat category.

R = V x D (expected loss of productivity + cost of bridge replacement)

R = Unknown x ($5.5 million/day + $3-6 million)[22]

With this information, an equation for risk can be set up using a range.

R = Unknown x ($5.5 million/day + $3 million) -> minimum financial risk

R = Unknown x ($5.5 million/day + $6 million) -> maximum financial risk

Therefore, if an analyst had a vulnerability figure for the environmental threat, knew how long it would take to restore service (construct a complete bridge), and could approximate the cost of a new railroad bridge, a financial risk value could be assigned to this threat. The same equation could be applied to the threat of a terrorist attack.

R = Unknown x ($5.5 million/day + $3 million) -> minimum financial risk

R = Unknown x ($5.5 million/day + $6 million) -> maximum financial risk

While the threat of a terrorist attack

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[20] Lewis, Critical Infrastructure Protection in Homeland Security, 107-108.
[21] Ibid, 177.
[22] Ibid, 112; Cost Estimating Methodology for High-Speed Rail on Shared Right-of-Way," Quandel Consultants, LLC, April 18, 2011, http://www.dot.state.mn.us/passengerrail/mwrri/files/Appendix%20E-Cost%20Estimating%20Methodology.pdf.

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was given a moderate vulnerability score, it is a difficult variable to conceptualize because its units are unknown.

Conclusion

Wyoming's Class I railroad lines, the UP and BNSF, face unique threats to their railroad infrastructure. Coal will continue to play a major role in nationwide energy production, which means that rail will experience increased traffic and railroad infrastructure will wear faster than normal. Vulnerability and risk analysts must recognize that increased rail traffic, combined with environmental threats, represent an increased threat level to railroad bridges servicing the PRB. In the short term, the UP and BNSF should consider implementing detection systems (if they have not done so already) and promote awareness of current terrorism threat levels. In the long term, Wyoming's Class I railroads need to work toward developing a feasible alternative method of transporting coal from the PRB. Whether this means implementing a large slurry pipeline network, or a smaller network that transports coal to a less vulnerable railroad node (developing redundancy in the transportation system), BNSF and the UP must continue to work together and with the Department of Transportation to establish alternative transportation options in the event of a bridge failure in the PRB. Gillette may be in a remote area, but it is a critical node in the coal transportation network that is moderately vulnerable to a variety of threats, any of which would have far-reaching economic and public health implications if they caused a bridge-related service interruption at this critical location.

Attribute	Impact	Score
Criticality	-Loss of between \$1-10 billion -Company level: Loss of between 31-60% of total economic value	5
Accessibility	-Easily accessible: Target is outside, no perimeter fence, limited physical or human barriers -Relatively unlimited access to target	1
Recuperability	> 1 year	10
Vulnerability	-Target characteristics almost always allow for easy introduction of sufficient agents to achieve aim. -Aside from BNSF/UP police, attack is relatively easy to accomplish	8
Effect	-25-50% of the node's production impacted	8
Recognizability	-The target is clearly recognizable and requires little or no training for recognition	10
SHOCK	-Target has little historical, cultural, religious, or other symbolic importance -Small impact on sensitive subpopulations -National economic impact between \$100 million and \$1 billion	3

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Military's Shift Toward Renewable Energy

By Kayla Matola, Homeland Defense and Security Information Analysis Center

Overview of Military's Energy Consumption

To achieve military operational success, the Department of Defense (DoD) relies on one mission-essential resource: energy. DoD is the largest government consumer of energy in the United States, with petroleum-based liquid fuels making up approximately two-thirds of DoD's consumption.

In 2012, DoD energy use was 75 percent operational and 25 percent installation. Operational energy includes energy required for training, moving and sustaining military forces and weapons platforms for military operations. Installation energy is energy consumed at permanent DoD facilities, which costs approximately $4 billion annually.[1]

ARMY	NAVY	AIR FORCE
➢ Derive 25% of total energy consumed from renewable energy sources by 2025 ➢ Deploy 1 GW of renewable energy on Army installations by 2025 ➢ Reach net-zero energy consumption by 2030 ➢ Launch a "Green Warrior Convoy" of vehicles in 2013 ➢ Reduce use of fossil fuel by 30% by FY 2015 from FY 2003 baseline	➢ Derive 50% of total energy consumption from alternative energy sources by 2020 ➢ Produce at least 50% ashore-based energy requirements from alternative sources; goal of 50% of Navy installations to be net zero by FY2020 ➢ Deploy 1 GW of renewable energy on Navy installations by 2020 ➢ Demonstrate a "Green Strike Group" in local operations by 2012 and deploy a "Great Green Fleet" in 2016 ➢ Reduce non-tactical commercial fleet petroleum use by 50% by 2015	➢ Increase facility consumption of renewable or alternative energy to 25% of total electricity use by 2025 ➢ Construct on-base renewable energy production to achieve 1% of Air Force facility consumption by 2013 and develop 1 GW of on-site capacity by 2016 ➢ Ensure all new buildings are designed to achieve zero-net-energy by 2030, beginning in 2020 ➢ Increase use of cost-competitive drop-in alternative aviation fuel blends for non-contingency operations to 50% of total consumption by 2025 ➢ Increase alternative fuel use in ground vehicles by 10% compounded annually, through 2015 (2008 baseline)

Figure 1: Goals, Priorities and Requirements for Renewable Energy in the Army, Navy and Air Force[5]

DoD is the largest single consumer of energy and oil on the planet. A rise in the price of a barrel of oil by $1 equates to approximately $130 million per year. The cost of oil creates vulnerability and energy insecurity. The greater cost of fuel resupply is the endangerment of warfighters' lives.[2] Implementing sustainable energy policies would mitigate costs, decrease energy insecurities, and eliminate risk. Utilizing alternative energy sources would allow soldiers in combat to go farther, longer, and efficiently.

DoD Mandated Energy Innovation

DoD has requisitioned deploying 3 gigawatts (GW) of renewable energy to power military facilities by 2025.[3] This goal is designed to meet a larger DoD mandate, Title 10 USC § 2911, which directs at least 25 percent of any DoD

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[1] American Council on Renewable Energy (ACORE), *Renewable Energy for Military Installations: 2014 Industry Review* (Washington, D.C.: ACORE, 2014), available at http://www.acore.org/files/pdfs/Renewable-Energy-for-Military-Installations.pdf.
[2] Ryan Koronowski, "Why The U.S. Military Is Pursuing Energy Efficiency, Renewables And Net-Zero Energy Initiatives," Climate Progress, April 4, 2013, http://thinkprogress.org/climate/2013/04/04/1749741/why-the-us-military-is-pursuing-energy-efficiency-renewables-and-net-zero-energy-initiatives/.
[3] ACORE, *Renewable Energy for Military Installations: 2014 Industry Review*.
[4] Solar Energy Industries Association (SEIA), *Enlisting the Sun: Powering the U.S. Military with Solar Energy* (Washington, D.C.: SEIA, 2013), available at http://www.seia.org/sites/default/files/Enlisting%20the%20Sun-Final-5.14.13-R6.pdf.
[5] ACORE, *Renewable Energy for Military Installations: 2014 Industry Review*.

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facility energy consumption come from renewable energy sources. The implementation of alternatives has evolved from increasing energy distribution costs, foreign oil dependency, the threat of energy supply disruptions, and the need for more secure and clean energy generation and distribution. Figure 1 highlights the military goals and requirements regarding renewable energy.

Army Initiatives

The Army, the most populous branch of the military, consumes less energy than the Navy or Air Force because of the Army's reliance on the Air Force and the Military Sealift Command for transportation. The Army's energy consumption is concentrated in its installations, which consume an average of 21 million barrels of petroleum per year. The DoD's shift toward energy security has encouraged Army energy initiatives, including the Army Energy Security Implementation Strategy, which requires at least five installations that meet "net-zero" energy goals by 2020 and deploys 1 GW of renewable energy on their installations by 2025.[6]

Energy initiatives have begun at several bases since the inception of the energy strategy. Fort Carson, the Army's flagship base for the net-zero energy initiative, was awarded the Federal Energy Management Program (FEMP) Director's Award in 2013 for its energy intensity reduction and water conservation efforts. Through the EITF, the Army also has multiple projects regarding solar, wind and biomass energy. Fort Stewart, predicted to be one of the largest renewable solar energy producers in the state of Georgia, is constructing a solar farm capable of generating around 30 megawatts (MW) of electricity, which is expected to be the largest project on any DoD installation.[7] Fort Drum, in New York, was recognized for the provisioning, production, and delivery of 100 percent of the installation's on-site electricity requirements from a biomass generation renewable energy facility.[8] Additionally, Fort Hood is implementing a wind and solar project at the installation in Texas that will provide 230 GWh of renewable energy. The Army's implementation of these multiple alternative energy projects would strengthen economic vitality and research in this domain, as well as help the Army's objective to produce 1 GW of renewable energy by 2025.

Figure 2: Aerial view of the 2 megawatt photovoltaic system at U.S. Army Fort Carson. U.S. Army Photo

Navy Initiatives

The Secretary of the Navy's (SECNAV) objectives include increasing energy security and enhancing warfighter capabilities through the implementation of renewable energy. In FY 2013, relative to its 2003 baseline, the Navy and the Marine Corps had reduced its energy intensity by 19.3 percent.[10] The Navy has a comprehensive goal of producing 1 GW of renewable energy by 2020—five years earlier than the Army. The Navy's energy goals include: energy efficient acquisition, reduction of petroleum use, production of 50 percent clean

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[6] "DoD's Energy Efficiency and Renewable Energy Initiatives," Environmental and Energy Study Institute, July 1, 2011, http://www.eesi.org/files/dod_eere_factsheet_072711.pdf.

[7] Richard Wrigley, "Fort Stewart Leads DOD in Green Initiative," U.S. Army, May 19, 2015, http://www.army.mil/article/148844/Fort_Stewart_leads_DOD_in_green_initiative/.

[8] "Fort Drum: Large-Scale Renewable Energy Project," *ASAIE*, September 1, 2014, http://www.asaie.army.mil/Public/ES/oei/docs/Fort-Drum_FactSheet_25SEP2014.pdf.

[9] "Fort Hood: Large-Scale Renewable Energy Wind & Solar Project," *ASAIE*, October 1, 2014.,http://www.asaie.army.mil/Public/ES/oei/docs/FortHood_FactSheet_15OCT2014.pdf.

[10] Office of the Deputy Under Secretary of Defense (Installations and Environment), *Department of Defense: Annual Energy Management Report Fiscal Year 2013* (Washington, D.C.: United States Department of Defense, 2014), available at http://www.acq.osd.mil/ie/energy/energymgmt_report/FY%202013%20AEMR.pdf.

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Figure 3: USS Princeton alongside the USNS Henry J. Kaiser to refuel with biofuel at sea during the Great Green Fleet demonstration at the RIMPAC 2012 exercise. U.S. Navy Photo

energy installations on shore, and the sailing of the Great Green Fleet.

The development and deployment of the Great Green Fleet will include more energy efficient ships and aircraft in addition to utilizing alternative energy, predominantly nuclear power. In 2012, the Navy successfully completed one interim goal by demonstrating the capabilities of the Great Green Fleet during the world's largest international maritime exercise, the Rim of the Pacific Exercise (RIMPAC).[11]

Naval energy initiatives ashore, including the installation of solar systems in more than 12 states and the District of Columbia.[12] These systems are capable of producing more than 58 MW, triumphing over the Army and Air Force capacities, which produce 38 MW and 36 MW at their installations, respectively. Prior to 2013, the Navy completed its largest solar project to date, a 14 MW photovoltaic power system at the Naval Air Weapons Station China Lake in California. This installation is expected to save the Navy more than $13 million over the next 20 years and will generate enough clean energy to supply a third of the facility's annual electricity demand.[13] Another large naval initiative is the reconstruction of Naval Support Facility Indian Head in Maryland. This $62 million project will transform the facility into a decentralized steam and cogeneration facility, in turn demolishing the last naval operated coal-fired power plant. Implementation of the facility will result in a 50 percent reduction in energy use in addition to saving $7.5 million each year.[14]

Air Force Initiatives

The Air Force is responsible for utilizing more than 2.4 billion gallons of jet fuel annually, making it the largest DoD energy consumer.[15] Implementation of the Air Force Energy Strategic Plan includes four priorities: improve resiliency, reduce demand, assure supply and foster and energy awareness culture. Like the Army and Navy, the Air Force has a goal of producing 1 GW of renewable energy, but wants this goal to support on-site capacity by 2016. The Air Force also is pushing toward ensuring all new buildings are designed to achieve net-zero-energy by 2030, beginning in 2020.

The Air Force continues to work with industry to implement Energy Savings Performance Contracts (ESPCs) and Utility Energy Service Contracts (UESCs) which fund energy conservation projects. These contracts not only encourage development and use of alternative energy operations but also fund infrastructure and equipment costs while minimizing the risk and the capital investment required of the Air Force.[16]

In FY 2013, the Air Force had approximately 261 renewable energy

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[11] Chika Onyekanne, "Great Green Fleet," Department of the Navy Energy Security, September 10, 2014, http://greenfleet.dodlive.mil/files/2014/07/20140910_Great-Green-Fleet-Factsheet.pdf.
[12] SEIA, *Enlisting the Sun*.
[13] "13.78-Megawatt SunPower Solar Power Plant at NAWS China Lake Begins Operations, Expected To Reduce Costs by $13 Million," *PRN Newswire.*, October 1, 2012, http://www.prnewswire.com/news-releases/1378-megawatt-sunpower-solar-power-plant-at-naws-china-lake-begins-operations-expected-to-reduce-costs-by-13-million-175028291.html.
[14] Gary Wagner, "Construction Project to Demolish Navy's Last Coal-Fired Power Plant and Build Energy-Efficient System," Department of the Navy, July 9, 2013, http://www.navy.mil/submit/display.asp?story_id=75287.
[15] "Military Green: U.S. Air Force Flies on Biofuel," *Scientific American*, accessed June 24, 2015, http://www.scientificamerican.com/gallery/military-green-us-air-force-flies-on-biofuel/.
[16] "Energy Savings Performance Contracts," Air Force Civil Engineer Center, accessed June 16, 2015, http://www.afcec.af.mil/energy/projectdevelopment/espc/.

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projects, including solar, waste-to-energy using landfill gas, and wind energy.[17] Davis-Monthan Air Force Base in Arizona is an example of a large-scale Air Force renewable energy installation of a 16.4 MW solar plant. The system is expected to generate 35 percent of the base's energy needs and save an estimated $500,000 per year. In Texas, Dyess Air Force Base is developing a waste-to-energy plant, using biomass or municipal solid waste, which will generate approximately 50 percent of the base's energy requirements.[18] Cape Cod Air Force Station is the first Air Force net-zero installation, using wind power turbines on site. These turbines generate approximately 8,000 MW of electricity, saving Cape Cod an estimated $1 million per year.[19] These projects are a few examples of how the Air Force plans to continue operations by making the shift to alternative energy usage.

Summary

The military's shift toward renewable energy is not just a political ploy but also an operational imperative. Improvements toward energy alternatives can increase warfighter efficiency, enhance energy security and cut installation and operational energy costs.[20] Between 2010 and 2012, DoD renewable energy projects increased 43 percent and are anticipated to exponentially increase over the next 20 years.[21] DoD's implementation of alternative energy and supporting infrastructure is one area where DoD is utilizing industry to promote research thus fortifying energy security across the nation.

Figure 4: Wind turbine at Cape Cod Air Force Station. U.S. Air Force Photo

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[17] "Rewable Energy," Air Force Civil Engineer Center, accessed June 16, 2015, http://www.afcec.af.mil/energy/ratesandrenewables/index.asp.
[18] "Air Force Renewable Energy Projects in Development," Air Force Civil Engineer Center, November 1, 2012, http://www.afcec.af.mil/energy/renewableenergy/upcomingprojects/index.asp.
[19] Rose Forbes, Brad Johnson, and John Miller, "Achieving Net Zero Energy on Cape Cod." *The Military Engineer*, June 1, 2013, http://themilitaryengineer.com/index.php/item/226-innovation-in-air-compressor-controls.
[20] ACORE, *Renewable Energy for Military Installations*.
[21] Sandra Erwin, "Renewable Energy Boom Underway at U.S. Military Bases" *National Defense Magazine*, January 16, 2014, http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=1380.

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