DAY ONE PROJECT

Accelerating Deployment of Innovations to Modernize the U.S. Electric Grid

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Summary

Grid modernization should be a major part of a national infrastructure-investment initiative. Effectively and efficiently modernizing the U.S. electric grid requires rapid deployment of innovative grid technologies. The next administration should establish a Grid Resilience Innovation Demonstration (GRID) Network, run in partnership between the Department of Energy (DOE) and the Department of Defense (DoD), to test and accelerate deployment of such technologies. The GRID Network would integrate and build on existing microgrids on federal installations and other relevant facilities, resulting in a group of geographically distributed test beds that can be managed and operated as a national user facility. The distributed nature of the network would allow test beds to ensure that solutions are compatible with a variety of grid technologies and operational structures and would also insulate the network from security threats, and other risks. Prioritizing establishment of the GRID Network early in the next administration will enable our nation to quickly realize the benefits of a modern electric grid, including enhanced resilience to natural disasters, entrepreneurship opportunities, and job growth. Failure to act will leave our national grid vulnerable to hostile actors, rob the country of needed shovel-ready construction projects and manufacturing jobs, and undermine U.S. leadership in electric sector innovation and the resulting impacts to our economy.

Challenge and Opportunity

The U.S. electric grid is a critical backbone of our nation's economy, national security, health, and social interactions. Yet the current grid is ill-suited to modern demands. Our nation's grid contains many critical components that were originally constructed in the early 20th century. The grid as a whole is based on an outdated structure that was not designed for today's varying power demand requirements, such as for the internet data centers, or for the widescale integration of intermittent sources of electricity such as wind turbines and solar panels. The grid is also poorly equipped to withstand the many cyber, physical, and electromagnetic threats that exist today.

These problems can cause extensive and expensive blackouts, such as the widespread outages across the Northeast in 2003 that cost $6 billion in damages.[1] The possibility of foreign interference presents a threat multiplier. In 2015, a Russian assault on the Ukrainian grid cut power for six hours in the dead of winter. A similar attack on the U.S. grid is possible. In fact, the same malware the triggered the Ukraine attack has been found in US-based critical infrastructure facilities.

There is a clear need to make the U.S. electric grid much more secure to thwart attacks, robust to withstand physical threats, resilient to ensure rapid and full recovery from adverse impacts,

[1] Electricity Markets & Policy (2004). Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations. https://emp.lbl.gov/publications/final-report-august-14-2003-blackout.

stronger to accommodate greater demands, and flexible to enable a broader deployment of clean-energy technologies.

Yet grid modernization is easier said than done. The U.S. electric grid is a massive, complex system that comprises various technologies for electricity generation, transmission, and distribution as well as multiple operators, regulators, and markets to ensure the continual flow of electricity. Few incentives or financially-attractive opportunities exist for grid stakeholders to demonstrate and deploy innovative models and technologies. And finally, the national-security benefits of a secure, robust, and resilient grid do not deliver direct, sufficient financial gains, creating a market failure that leaves the grid vulnerable to interference.

Plan of Action

The next administration should establish the Grid Resilience Innovation Demonstration (GRID) Network, a national-scale test facility designed to propel the nation toward a more secure, robust, and resilient grid that can strengthen economic and national security while enabling a clean-energy future. The GRID Network should comprise multiple, geographically distributed test beds that are widely accessible to institutions and researchers seeking to demonstrate technologies in prototypical environments. These test beds would be user facilities similar to those owned by the National Science Foundation (NSF) and the Department of Energy (DOE).[4,5]

The overall goal of the GRID Network would be to support development, demonstration, and deployment of innovations in grid operation and technology, which are needed to address the evolving energy needs and expanding risks. The types of innovations could run from small to large scale, and from technical to operations, for example, components for high-voltage transmission or distribution, smart meters and associated cyber controls, direct current connects and disconnects, and microgrid operations with a variety of sources, loads and sizes.

The GRID Network would focus on innovations at mid- to high technology-readiness levels, i.e., innovations that have already been demonstrated successful at a limited level and seem like promising candidates for scale-up and commercialization. GRID Network test beds would provide the capacity to test at all scales from individual components in situ up to full end-to-end tests from the electricity generator to the final use. As modernization of the grid continues to occur, the anticipated outcomes will continue to evolve, and this facility will enable more innovations to be developed rapidly and tested such that the decision and risk of implementation can be reduced, which in turn should facilitate deployment. After all, utilities and investors want proven technologies, not science projects. As a result, we will see a more resilient grid that is both more secure and more robust (i.e., less blackouts, more value, savings and/or avoided costs).

[4] Department of Energy (2020). User Facilities at a Glance. https://science.osti.gov/User-Facilities/User-Facilities-at-a-Glance.
[5]National Science Foundation (2019). Major Multi-User Research Facilities. https://www.nsf.gov/about/budget/fy2019/pdf/40_fy2019.pdf.

GRID Network test beds could serve as official sites for the government to validate and certify any concept or technology intended for use in national-security applications. Through partnerships with community colleges, test beds could also offer workforce-development opportunities and vocational training to prepare technicians to install and operate next-generation grid technologies.

Implicit in the proposed action is that there are innovative technologies and strategies for operation that could be tested and rapidly deployed. While this has not been demonstrated through a survey or collection of data, it is a reasonable assumption based on our knowledge of the research and development (R&D) that is being done in this area as well as some general issues that impact the rapid, successful advancement from R&D to demonstration and deployment (i.e., crossing the so-called "Valley of Death"). Having a user facility aimed at helping bridge that gap that is available to companies and researchers widely would encourage innovators and innovations to surface, as has been demonstrated to work well in the past in the DoD and DOE. A minimally viable prototype will be needed for testing, which focuses the role of the facility between "development" and "deployment." The costs for testing would be covered by the government, and like the existing user facilities, access to apply for time on GRID would be open to all ideas through a merit-review process. As a result, innovators should be motivated to develop their ideas to a product or operations model that can be tested given the low or zero cost of testing because the value of a having a government-tested and demonstrated device or operating model will be very high.

As is typical for federally-funded user facilities, the GRID Network would be run by a private entity (e.g., an objective management organization) through a public-private partnership with government agencies: in this case, likely DoD and DOE. The partnership could be managed by either agency or by an external entity, such as the National Resilient Grid Authority (NRGA) conceptualized in a 2020 report from the National Commission on Grid Resilience.[6] Existing microgrids and other assets at DoD and DOE sites could provide the foundation for the GRID Network. The GRID Network will also build on and enhance the grid-resilience and modernization efforts[7] that were established and have been pursued at both agencies.

Establishing and managing the GRID Network would cost the Federal Government an estimated $25–50 million per year at the low end to $200–300 million per year at the high end. This funding range is consistent with the funding levels for similar research and development facilities that DOE and DoD have supported over the last 15 years. Funding at the high end would support more sophisticated, comprehensive testing equipment, would permit users to take more time to test ideas, and would permit testing of more high-risk, high-reward ideas. Funding at the high end would also support efforts beyond just testing, such as development of national standards

[6] National Commission on Grid Resilience (2020). Grid Resilience: Priorities for the Next Administration. Available at https://gridresilience.org/wp-content/uploads/2020/09/NCGR-Report-2020-Full-v2.pdf.
[7] Department of Energy (2020). Grid Modernization Initiative. https://www.energy.gov/grid-modernization-initiative

and protocols for grid operations, pursuit of collaborative technologies that would benefit niche applications, such as defense resilience pilot projects,[8] and technology certifications.

The U.S. electric grid must be modernized to enable more use of renewable energy, deploy storage, and assure we improve the resilience. A test facility, such as the GRID facility described above, could help with modernization and entice investments toward deployment of new technologies. As a result, federal investment in the GRID Network would pay off directly or indirectly in four key ways:

1. Modernizing the U.S. electric grid will create shovel-ready construction jobs across the country. Since the GRID facility would be oriented toward rapid development and deployment of innovations, the facility could help enable aggressive and comprehensive modernization of the electric grid, which would involve construction jobs.
2. Grid components that are critical to U.S. infrastructure and national security—ranging from sensors to transformers—must be made through a trusted U.S. supply chain. Investments in the GRID Network hence represent investments in American manufacturing.
3. The GRID Network will support user generation of intellectual property and associated small business start-ups because some of the innovations that are tested and deployed will be manufactured, distributed and installed by start-ups, which will strengthen the US supply chain. This new wave of business activity will propel the U.S. economy for years to come.
4. Grid modernization is a huge effort that will cost at least $500 billion and likely $1–2 trillion.[9] Investing in technologies that could facilitate modernization will retire risks for grid modernization as the decisions by the various grid operators will be based on testing at an applicable scale. As a result, the GRID facility should help ensure the costs for grid modernization are in the middle of the range rather than at the higher end or above.

Conclusion

The U.S. electric grid is a crucial piece of the nation's infrastructure. If it fails, critical sectors such as finance, healthcare, transportation, defense, agriculture, and manufacturing are at risk of failure as well. Yet the grid remains unacceptably vulnerable to threats large and small. There is a real danger of attacks on the grid by adversarial nations, and natural disasters can wipe out large sections of the grid for hours, days, or longer. Even factors as seemingly trivial as mylar balloons, small arms fire, and broken tree branches can cause costly damage when they interfere with critical grid components. It is past time to create a more robust and resilient system. Creating a testing ground for innovative solutions in grid operations and technology is an important step: one that will not only shore up a glaring weakness in our national security, but

[8] Office of the Assistant Secretary of Defense for Sustainment (2020). Energy Resilience Program. https://www.acq.osd.mil/eie/IE/FEP_Energy_Resilience.html

9 Department of Energy (2016). Grid Modernization Multi-Year Program Plan. https://www.energy.gov/sites/prod/files/2016/01/f28/Grid%20Modernization%20Multi-Year%20Program%20Plan.pdf

will also boost our economy through shovel-ready construction projects, creation of new and good-paying jobs, and development of intellectual property.

Frequently Asked Questions

What pieces of this proposal are already in place?

The proposed GRID Network would leverage microgrids and other assets already distributed at DOE and DoD sites across the country. By linking these assets through a national-scale user facility, the GRID Network will ensure that these assets are put to their fullest use. The GRID Network would also build on and enhance the grid resilience and modernization efforts that both DOE and DoD have funded over the last 15 years.

How much does the federal government spend on the electric grid? What would additional spending achieve?

The amount the Federal Government spends on grid R&D and modernization varies but has been as high as $750 million and as low as about $50 million. The investment is supplemented by matching funds from private industry, as the grid is largely operated by private companies. There is not currently a federally-funded facility to support testing and scale-up of innovative grid operating models and technologies. Investing in such a facility would accelerate grid modernization and could perhaps cut grid-maintenance costs in the long term.

Why should the federal government take action on grid modernization instead of state or local government? What about the private sector?

Few systems are more complicated than the U.S. electric grid. The U.S. electric grid is managed by more than 3,000 public and private institutions (including generators, operators, and markets). Energy is often transmitted across state lines, which requires cooperation and coordination at multiple levels of government. As such, the private sector as well as state and local government will necessarily be involved in grid modernization. But in light of the importance of the grid to U.S. economic and national security, there are clear and specific roles for the Federal Government. For instance, the Federal Government can assure that new grid technologies and ideas have been tested and certified in order to mitigate risk of implementing those new technologies and ideas. The federal government can also help scale promising innovations quickly. A federally-funded GRID Network would be a key piece—but still only a piece—of a larger national grid-modernization effort.

Is the issue of grid modernization specific to the United States?

The technologies utilized in the U.S. electric grid is typical of electric grids in many other countries, particularly those that developed electricity distribution contemporaneously with the United States. However, the size and geographic diversity of our nation means that the U.S. electric grid is especially large and complex. To an extent, this complexity offers protection since no single attack or incident could impact the entirety of the national grid. However, our grid's

size and complexity also mean that coordinating grid modernization efforts in the United States is far more difficult than in other nations.

The GRID Network could help turn this bug into a feature. The United States has always excelled at out-innovating other countries, particularly for things at large scale. The GRID Network would allow U.S. innovators to field-test technologies and strategies in many different scenarios and conditions, and would help innovators commercialize promising solutions at a pace that other countries simply do not have the capacity to match. The GRID Network could hence address vulnerabilities in the U.S. grid while simultaneously enhancing the international competitiveness of our nation with respect to grid modernization.

What is the first step needed to get the GRID Network off the ground?

The first step is to develop a written plan that can form the basis for the funding requests and appropriations and the follow-on steps needed to establish the GRID Network. The plan would (1) identify the specific activities of the GRID Network, (2) inventory existing facilities and capabilities that could be integrated into the GRID Network, (3) identify new facilities and capabilities that would be needed to achieve GRID Network goals, (4) identify necessary approvals and propose an operating model for the facility, and (5) lay out a detailed roadmap for launching the facility, including conceptual cost, scope and schedule. Development of the plan should be carried out by a contractor and overseen by an interagency group.

What would a less ambitious version of this proposal look like?

The GRID Network could be operated at various scales: for instance, it could be piloted in a small collection of states before being expanded nationwide. The roles and capabilities of component test beds could be tailored based on available funding, and the path toward the full facility could be established in the plan discussed above.

About the Authors

Adam Cohen is the CEO and President of AUI, which manages and operates large R&D facilities for the U.S. government, including the NSF's National Radio Astronomy Observatory. He served as the Deputy Under Secretary for Science and Energy at the U.S. Department of Energy (DOE) under the Obama administration, where he oversaw basic science, applied energy research, technology development, and deployment efforts, including the stewardship of 13 of the 17 DOE National Laboratories and several large international projects. Previously, he served for 25 years in various positions at the National Labs, primarily Argonne and Princeton. Dr. Cohen started his career serving as a submarine officer in the U.S. Navy. In addition to his role at AUI, Dr. Cohen serves as a Senior Associate with the Center for Strategic and International Studies Energy and National Security Program.

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