



Economic and Social Impacts of Compromised Power System Devices

Blake Davidson, William Fralia, Yessica Bello-Luna, Ben McCornack



INTRODUCTION

A paradigm shift

Traditionally, power systems have been owned and operated by utility companies. However, with the advent of renewable energy in the form of distributed energy resources (DERs) such as solar panels and dispatchable home energy such as Tesla Powerwall, home-owners and private companies can participate in the open electricity markets. While this has been advantageous for the DER owners, as the percentage of these non-utility owned power sources grows, the utility has less ability to keep their grid "secure". These DERs are IOT enabled devices, allowing for their owners to log in and check the status of their asset.

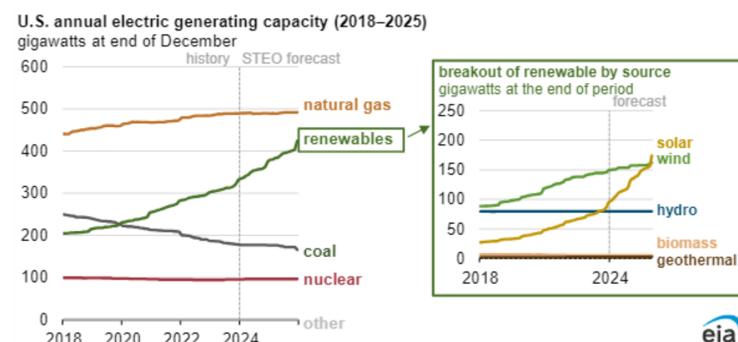
Implications

Anytime a device is put on the web it becomes a potential attack vector. While utilities may have a large incentive to invest into good cyber security practices. These new participants in the electricity market may not understand their role in the security of their nations grid.

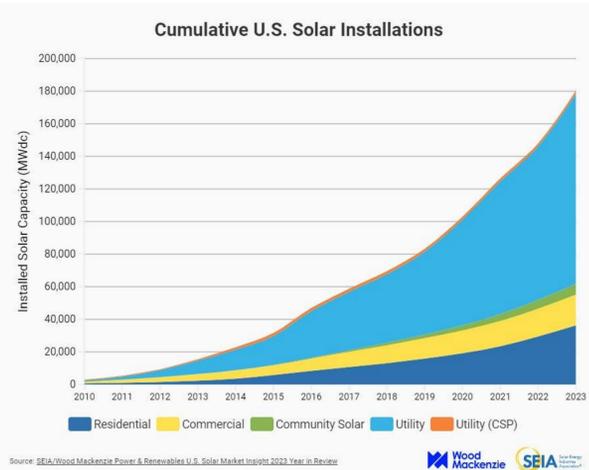
JUSTIFICATION

The Rise of Solar Power and its Risks

Solar power in the US power grid is on the rise and is only expected to increase in the future, making up for much of the predicted increase in renewables as shown in the graph below.



As distributed energy resources grow, the ability for the utility to manage a "secure" grid is lessened as new vectors for attack are created. Additionally, residential solar power has also grown to contribute to 1/6 of solar power output. The rate of rooftop PV growth is shown in Cumulative U.S. Solar Installations graph. Residential installations are prime targets for vectors of attack, as many would likely not maintain the same safety standards of utilities but are still connected to the nation's power grid.



Previous Precedent

Large scale cyber attacks on national power grids are not just a theoretical threat. In 2015, an attack on the Ukraine power grid by a Russian affiliated hacker group led to a partial shutdown which left over 200,000 temporarily without power. [8] When questioned by Congress on the security of the US power grid in 2014, NSA director Admiral Michael Rogers testified that China and 1 or 2 other adversarial nations probably had the capability to shut down the US power grid. [9]

ECONOMIC IMPACT OF POWER OUTAGES

Business and Industry

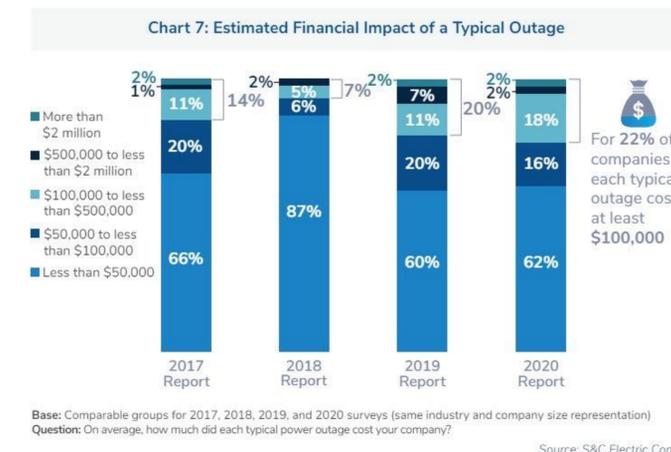
Power outages can have a significant impact on both businesses and households. For businesses in particular, power outages can lead to a direct financial loss due to halts in operations, manufacturing, and other supply chain delays. In fact, according to a S&C Electric Company study, in a survey of 253 U.S. based commercial and industrial companies, in 2020 as much as 44% of companies reported losing power at least monthly [1]. This can be detrimental to a company's financial state and the economy as a whole. For American businesses, the U.S. Department of Energy estimates that power outages cost businesses around \$150 billion per year [2]. Of that 150, according to Bloom Energy, "for large manufacturing enterprises, a single hour of downtime tops the \$5 million mark" [3].

Household

Power outages can have a similar significant economic impact on households. An example of this is the 2021 Winter Storm Uri. The storm caused blackouts across Texas, as its power grid was unable to keep up because of an increase in demand coupled with a decreased energy supply due to equipment failures from cold temperatures. Additionally, the Electric Reliability Council of Texas (ERCOT) grid, which serves 90% of people living in Texas, is substantially isolated from the national grid, which limited electricity imports [4]. The outages directly caused 210 deaths, however that number may increase up to 700 when considering indirect deaths, according to Texas's Department of Health [4]. On top of the death toll, the Federal Reserve Bank of Dallas estimates that the storm-related financial impact ranged from \$80-\$130 billion [5]. The financial impact significantly affected households due to the extremely expensive electrical bills. Residents, specifically ones that opted for variable-rate power plans, were hit the hardest with increased bills [6]. Normally, the average price for electricity in the winter in Texas is 12 cents per kWh. However, that price was increased to \$9 per kWh [6]. According to the New York Times, one man received a bill of \$16,752 [7].

So what?

A lack of power caused these prices to rise. The lack of power came from broken infrastructure, failure of equipment, and unpreparedness. What if the lack of power came from DERs being shut off that were forecasted to provide much of the systems power at a given time. But the problem could be turned off and on at the flick of a switch.



DANGER / THREATS

Exposure

Traditionally, utility installed solar inverters had low cyber security risks due to their lack of internet connectivity. However, the rise of smart home systems has led to most solar inverters being connected to the internet for monitoring and control, significantly increasing their vulnerability to cyberattack such as hacking, malware, and disruption. As more homes adopt solar systems, the associated cyber risks to the power grid grow.

3rd party security test

TÜV Rheinland's testing revealed significant vulnerabilities in PV inverters and batter storage systems that could be exploited by hackers. These vulnerabilities could allow unauthorized access to the system software, letting hackers alter critical settings. Potential dangers include causing batteries to corrode, falsely indicating charge levels, and disrupting power flow to the grid. This could lead to safety hazards such as batteries overheating or even exploding, and grid instability that could cause blackouts. [10]

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ACKNOWLEDGEMENTS

This work is supported by funding for the VICEROY Northwest Institute for Cybersecurity Education and Research (CySER) provided by The Office of the Undersecretary of Defense for Research and Engineering, in collaboration with the Air Force Research Laboratory and Griffiss Institute.



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