US ENERGY GRID

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"The power of the city lights". Image showing what the United States of America looks like at night, made by satellites orbiting the planet. (Image courtesy of NASA).

SUMMARY

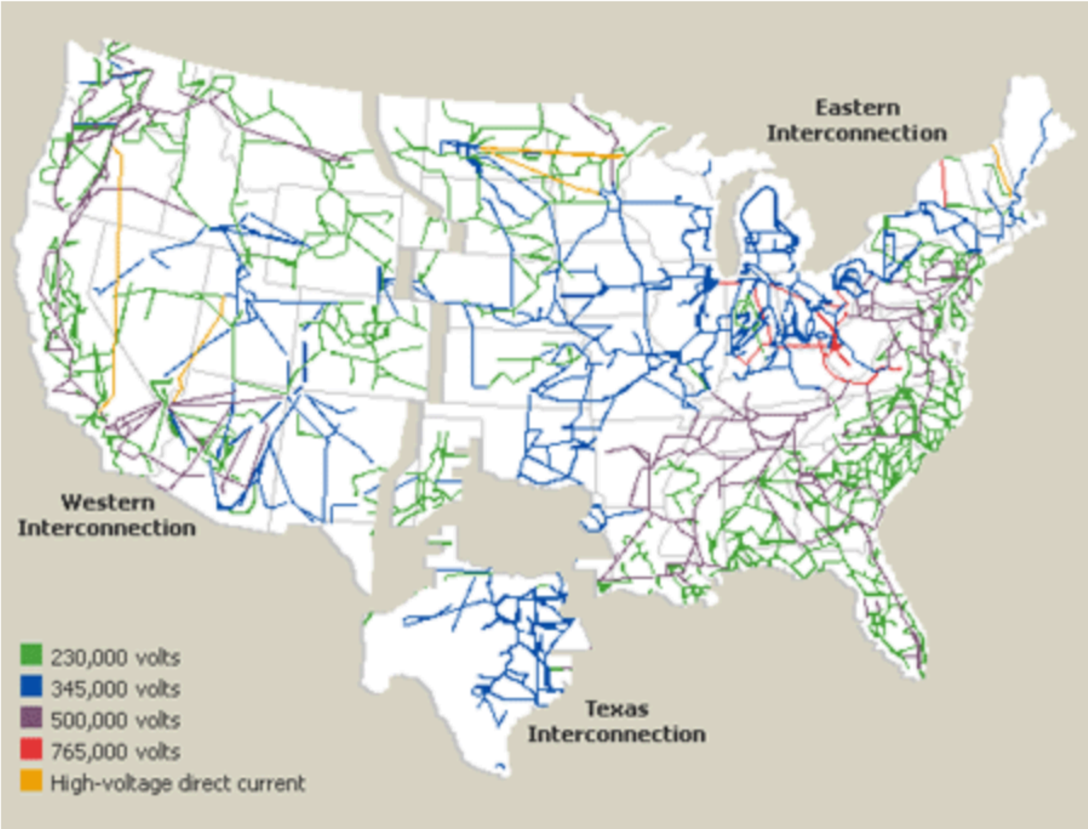
The challenges facing the energy sector in a rapidly changing ecosystem have made it essential to rethink different aspects including distribution, transportation, and alternative sources. The American energy grid is built on an antiquated structure that despite its old glory needs to be upgraded. Important new perspectives to consider moving forward revolve around making the grid more secure, reliable and efficient. Additionally, the grid must be able to accommodate new generation sources from renewable energy. Resiliency and efficiency will therefore heavily depend upon the ability to upgrade existing energy infrastructure in order to reach the goals envisioned with a "Smart Grid".

REPORT

The U.S. electric grid dates back to 1882 with Thomas Edison's Pearl Street Station project. Its basic structure remained unchanged from those days and what began as a neighborhood project has been replicated throughout the country. While modest changes have been made, the distribution of electric power from generation to end user remains something Edison would still recognize.

Modern systems are based on a high voltage (HV) transmission of electricity over long distances. This shift brought three main advantages: efficiency in transmission, fewer installations to cover a large portion of territory, and consequently less environmental impact. Despite national connectivity however, weaknesses and inefficiencies of the current U.S. power grid have caused brownouts, blackouts, and other service disruptions.

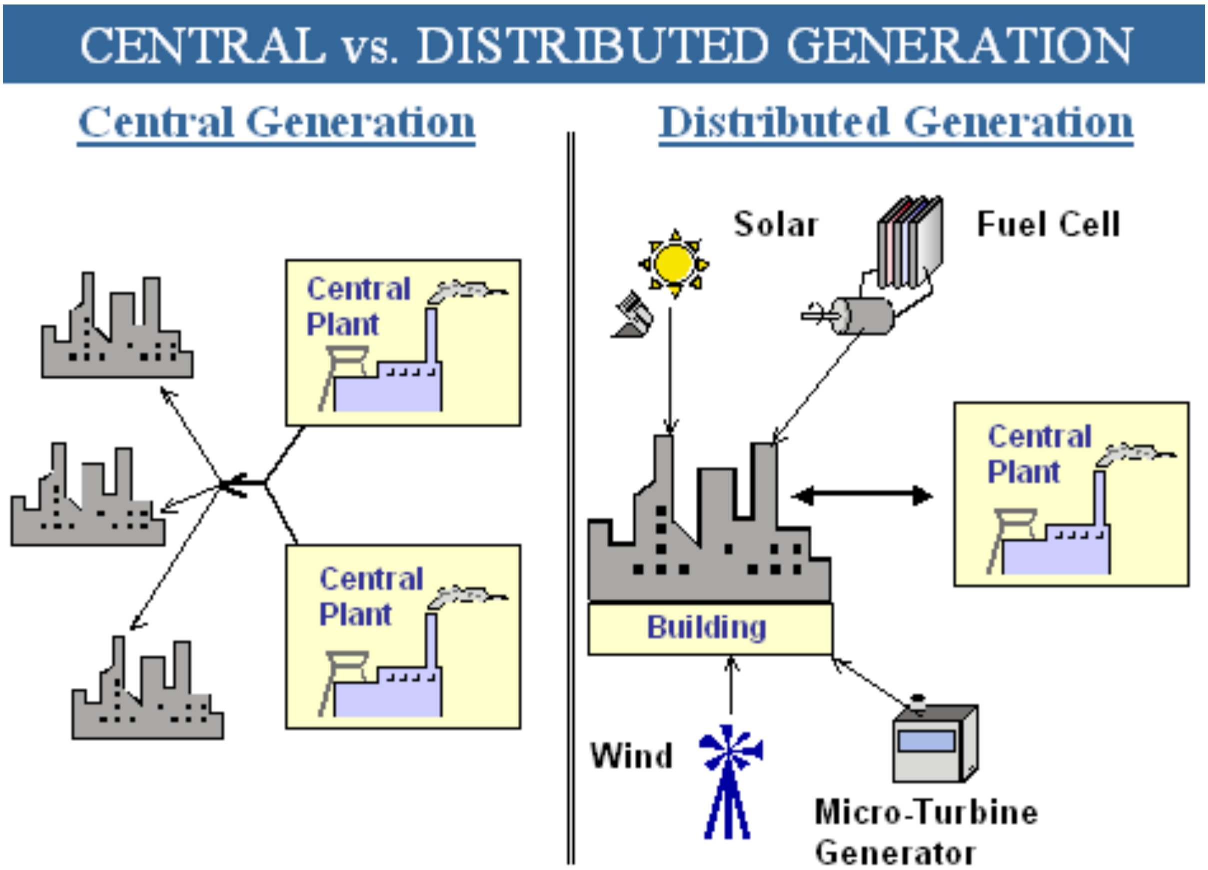
The national grid consists of approximately 5,800 power generation facilities (power plants) administered by 3,200 separate utilities spanning over 2.7 million miles of power lines. The grid itself is actually not a single interconnected system, but rather three distinct geographical systems which are known simply as the Eastern, Western, and Texas interconnections. This complex network is independently owned by energy utilities and is administered by, and prices set, through State regulators. New York blackouts (1965 and something like 2008), California brownouts (2000-2001), as well as natural and manmade threats has placed a spotlight on the national grid. This has in turn originated a debate that involves technicians, politicians, and environmentalists.



The national power grid. (Image courtesy of EIA.gov).

Smart Grid

Smart grids are intelligent networks designated to produce major changes in the way electric current is handled. These concepts introduce a new revolution affecting production, transportation, and distribution of electricity. The modern electrical grid uses information and communication technology to gather data on the behavior of suppliers and consumers that in turn improves efficiency, reliability, and lowers expenses. As the name suggests, the smart grid collects, measures, and then makes recommendations in order to continuously fine-tune the grid to match available generation (load) with commercial and residential demand. The technology deployed in a smart grid also helps facilitate the integration of renewable sources closer to where it is actually used. This concept is commonly referred to as Distributed Generation (DG) which despite the controversy, has the ability to provide electricity at the local level on smaller grids commonly referred to as micro grids. Yet even with micro grids, renewables have not yet achieved the reliability and consistency required to replace the traditional systems. Moreover, the influx of power from millions of spots along the grid means that power demands are more variable than ever, further necessitating the deployment of smart grids to adequately integrate renewable projects.



(Image courtesy of The Berkeley Energy & Resources Collaborative (BERC).

Issues

This current scenario, when coupled with the current state of existing grid structure, highlights the need for action of paramount importance. One of the largest challenges facing the U.S. grid is the ability to maintain efficient, safe, reliable, and secure transmission of electrical power throughout the country. In order to bring the grid current, significant investment is needed to modernize the system. Simply put, today's grid is vulnerable, and places the industry in a difficult and untenable position absent radical innovation.

Information collected and distributed by a smart grid also means that the system must be hardened against unauthorized access. Failure to do so means that any grid is subject to information probes which could later be used to damage or even bring down the grid. While such scenarios may appear unlikely to many, the threats of our interconnected world cannot be underestimated. Given the importance therefore of this system, thoughtful redundancies are needed to identify, isolate, reroute, and regenerate the grid from any external threats. Such an upgrade would also offer significant survivability enhancements over our current system, which is based on limited and one-way communication.

While most agree it is time to bring the grid into the modern era, differences remain over whether a grid is even necessary, and if it is, who should bear the costs of necessary upgrades? This correlation might seem simplistic but it creates what is commonly referred to as "utility death spiral". For example, with the expectation of future increases, it is likely that more families will shift to solar panels with a result of fewer grid consumers and an even higher price increase that will consequently bring more users off the grid. Given this scenario, is the grid going to be obsolete?

While technicians and experts will agree that a 100% renewable grid is theoretically possible in terms of science, engineering, and technology (Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Center), it is not realistic for the foreseeable future because renewable electricity cannot be stored in any significant quantities which is the Achilles Heel of renewables. As previously mentioned in this paper, the integration of renewables doesn't eliminate a grid at all, it makes it even more crucial. Moreover, many believe renewables are better deployed at a macro (large scale deployment) versus being utilized on a per-user basis because economies of scale are far more favorable.

On the political perspective, President Barack Obama's Energy Policy was oriented to reach a green, sustainable, and independent future. The Obama presidency has undoubtedly started a radical change based on an "all of the above" approach to energy generation. The development of shale gas and shale oil, and the amendments made to the legislation that regulates international trade in fossil fuels, have helped spur a modern "energy renaissance" in America as domestic production surged and imports reached their lowest levels in decades. Natural gas also began to replace coal as the primary energy source for electric power generation. That said, the large increase of renewable sources, especially wind and solar energy, contributed to the U.S. energy independence.

CONCLUSION

The need to invest, and invest heavily in modernizing the electric grid has not waned with the accelerated deployment of renewable energy. Rather the pressing need to do so is even more acute now more than ever. When coupled with the real threats from third party actors, we can ill afford to stand idly by while the grid that Edison built continues to age, lest we do so at our own peril. Although President-elect Trump has already stressed the importance of investments in modern infrastructures and smart grids, the future of the U.S. grid remains as uncertain as who would ultimately pay for the needed upgrades. These costs can however be significantly reduced through public-private partnerships, reinventing the tax code, and efficiency offsets that will be realized by more efficiently managing the grid.