

Grid-Enhancing Technologies

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With the increasing number of renewable energy projects, data centers driven by the demand for AI, and extreme weather conditions caused by our changing climate, the U.S. electricity grid isn't ready to handle all of that change. Unfortunately, there is a "congestion" problem with the U.S. grid, where insufficient transmission capacity prevents the efficient delivery of low-cost energy to consumers, leading to market congestion costs of approximately \$20.8 billion nationwide and delays in bringing new projects online.ⁱ Renewable energy projects encouraged by CO² emission reductions targets and the Inflation Reduction Act have been surging, yet there are about 11,600 projects currently waiting to be connected to the grid, with 95% of them being solar, storage, or wind projects.ⁱⁱ These projects are needing to wait an average of 5 years from the time they request interconnection to when they begin commercial operation. Simultaneously, data centers are expected to consume 8% of power in the U.S. by 2030 versus only 3% in 2022.ⁱⁱⁱ

Investing in improving the U.S. grid's efficiency could solve congestion problems and have significant economic and environmental benefits. Economically, it would save grid operators from monetary losses caused by congestion and low operational efficiency. Additionally, it would incentivize further innovation of electrical equipment and the nascent Grid-Enhancing Technology (GET) markets, as more efficient technology and grid management techniques evolve. From an environmental perspective, expanding and enhancing electricity transmission capabilities can cut greenhouse gas emissions by about one billion tons per year in 2030.^{iv} Currently there are thousands of renewable energy projects waiting in the queue to connect to the grid, as many wind and solar projects are far from cities. Poor electricity transmission capabilities make it easier to connect non-renewable energy power plants to the grid because they can be located relatively closer to cities,



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Grid Enhancing Technologies (GETs) At a Glance ^{xiv}

Dynamic Line Ratings

Adjusting the carrying capacity of transmission lines based on real-time measurement of ambient conditions

Transit analogy: real-time adjusted speed limits



Advanced Power Flow Controls

Hardware solutions that push power away from lines with capacity constraints and pull power to lines with spare capacity

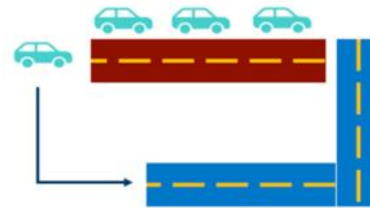
Transit analogy: railroad switching stations that direct trains to free tracks



Topology Optimization

Software solutions that automatically route power flows around congested areas

Transit analogy: re-routing drivers around traffic



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even though many of them are more expensive and environmentally worse.^{vii}

Economic Benefits of Grid Efficiency Investments

While building new transmission lines is a necessary long-term goal to keep pace with rapidly increasing electricity demand, it is a time-consuming process that won't address the immediate high demand for transmission capacity caused by renewable energy sources (and data centers). An effective and cheaper alternative exists to accommodate the grid's short- and long-term goals: Grid-enhancing Technologies (GETs). Both software and hardware GETs can be installed on high-voltage transmission lines to enhance their operational efficiency and reduce congestion. GETs primarily include hardware solutions that adjust transmission line capacity in real-time based on environmental conditions to optimize performance, hardware that balances the load across the grid by redirecting power

from congested areas to those with spare capacity, and software that automatically reconfigures the grid to divert electricity around overloaded areas, ensuring efficient power distribution.^{vii}

A case study on the Southwest Power Pool (SPP), focusing on Kansas and Oklahoma, demonstrated that an investment of \$90 million to implement GETs could result in annual production cost savings of over \$175 million, with the additional renewables integrated with GETs able to save the energy generation cost of \$20/MWh compared to new natural gas-fueled combined cycle plants or coal plants. This means the payback period for the investment could be as little as six months. Besides the cost savings, such an investment would enable more than twice the amount of additional renewable energy to be integrated. For example, the base case would allow about 2,580 MW of renewables to be integrated into the SPP grid, while the GETs case would allow about 5,250



MW, reducing carbon emissions by 3 million tons per year. Expanding these results to a nationwide scale suggests that an initial investment of \$2.7 billion in GETs could result in approximately \$5.3 billion in annual production cost savings, with annual costs around \$300 million.^{viii}

GETs, alongside switchgears, distribution transformers, and other electrical hardware and software equipment, are considered part of the transmission and distribution (T&D) equipment market. Investments in new transmission lines or enhancements to the existing grid could increase demand for products in the T&D market, leading to significant growth for players in that market. Many industry leaders have recognized this opportunity and are actively investing in research and development to innovate new T&D technologies and enhance existing ones. Some companies are already experiencing rising demand for their products as utilities prioritize the modernization of aging grid infrastructure. One of the companies that saw an increased demand for their electrical products was Siemens. Their Smart Infrastructure segment saw a 38% profit increase from 2022, which was mainly driven by their electrical products and electrification businesses.^{ix} Landis+Gyr, a leader in integrated energy management solutions, has highlighted how investments in grid modernization, supported by regulatory and government initiatives, have allowed them to provide utilities with new digital solutions that help optimize grid operations and integrate distributed energy resources at scale.^x Similarly, Schneider Electric has reported strong growth in its Energy Management segment, with systems sales growing by 17% organically in Q4 of FY 2023, driven in part by infrastructure projects, due to their significant exposure to the electric utilities segment.^{xi} Additionally, in their 2024 outlook, Schneider Electric projected that grid

infrastructure investment will be one of the main drivers of demand for their Systems business.^{xii}

Challenges that Face GETs

Grid-enhancing technologies (GETs) are arguably the cheapest method of enhancing operational efficiency of the electricity grid, but they are not widely implemented by transmission owners. One reason transmission owners aren't implementing GETs is simply caution. GETs are relatively new to transmission owners, and their lack of experience with these technologies makes them concerned about the risk of grid failures or blackouts that could occur if implemented incorrectly.^{xiii} Additionally, regulated utilities are more incentivized to invest in high-cost infrastructure rather than cost-saving technologies like GETs. Since their profits are linked to the amount they spend on capital expenditures, this setup rewards them for making larger investments in new or upgraded systems, rather than focusing on cost-saving operational improvements.^{xiv}

Initiatives like the Advancing Grid-Enhancing Technologies (GETs) Act, introduced by U.S. congress, aims to boost adoption of and investments in GETs.^x The bill suggests shared savings incentives to encourage the implementation of GETs, with the cost savings from these installations being divided between the installers and the rate-payers.^{xv} As GETs gain more awareness, similar actions and policies could further incentivize their adoption, encouraging transmission owners to invest in these cost-saving technologies.

Environmental Impact of Grid Modernization

Investing in grid modernization is not only a beneficial financial decision but also a significant environmental one. Many of our future environmental hopes rely on improving the current electricity grid by either building new transmission lines or enhancing the already



ADDITIONAL RENEWABLES INTEGRATED									
State	Base Case			With GETs Case			Delta (GETs - Base)		
	Wind	Solar	Total	Wind	Solar	Total	Wind	Solar	Total
Kansas	1,710	0	1,710	1,910	0	1,910	200	0	200
Oklahoma	770	100	870	3,200	140	3,340	2,430	40	2,470
Total	2,480	100	2,580	5,110	140	5,250	2,630	40	2,670



existing ones. For instance, the Inflation Reduction Act (IRA) could potentially decrease greenhouse gas emissions by about one billion tons annually in the U.S. by 2030 and could reduce greenhouse gas emissions from 2023 to 2032 by 6.3 billion tons.^{iv} However, results expected from the IRA depend on how fast electricity transmission capacity expands. To achieve the maximum amount of emissions reduction possible, transmission should be expanding at a pace of 2.3% per year. Unfortunately, the historical rate of transmission expansion has been around 1% per year. If transmission expansion is constrained at 1% per year, about 80% of the potential emissions reduction could be lost.^{iv} Investments from utilities and transmission system operators, supported by government incentives, could increase that number to reach the needed 2.3%. Similarly, implementing GETs into the existing grid system could have a potential

nationwide carbon emission reduction of 90 million tons annually.^{viii} That is the equivalent of offsetting all the new automobiles sold in the U.S. each year. The good news is that hundreds of clean and renewable energy projects are already in queue awaiting connection to the existing grid. Modernizing the electricity grid would enable these clean projects to replace current fossil fuel sources of electricity much more quickly.

Conclusion

Investing in grid efficiency is crucial for overcoming current congestion challenges and preparing for future energy demands. By using Grid Enhancing Technologies and modernizing transmission infrastructure, significant economic savings and environmental benefits can be achieved. These strategic investments can enhance operational efficiency of the grid helping accelerate the integration of renewable energy projects and contribute to a more sustainable future.



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