THIRD WAY

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Unlocking our Power Grid's Potential

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Takeaways

- The US has the existing and planned capacity needed to supply our projected demand surge—the issue lies in ensuring that capacity can get to where it's most needed. Luckily, we possess a suite of ready-to-go technologies that can meet near term electric demand projections, sidestepping the timing challenges associated with new generation and transmission infrastructure.
- Innovative solutions such as grid enhancing technologies (GETs), advanced conductors, and virtual power plants (VPPs) can individually unlock 20-100 GW of capacity on our existing electric infrastructure. Deployed together, these technologies offer compounding benefits.
- High performance computing (HPC) and artificial intelligence (AI) can maximize those benefits, optimizing grid processes, streamlining complex calculations, and improving the efficiency of existing technologies.

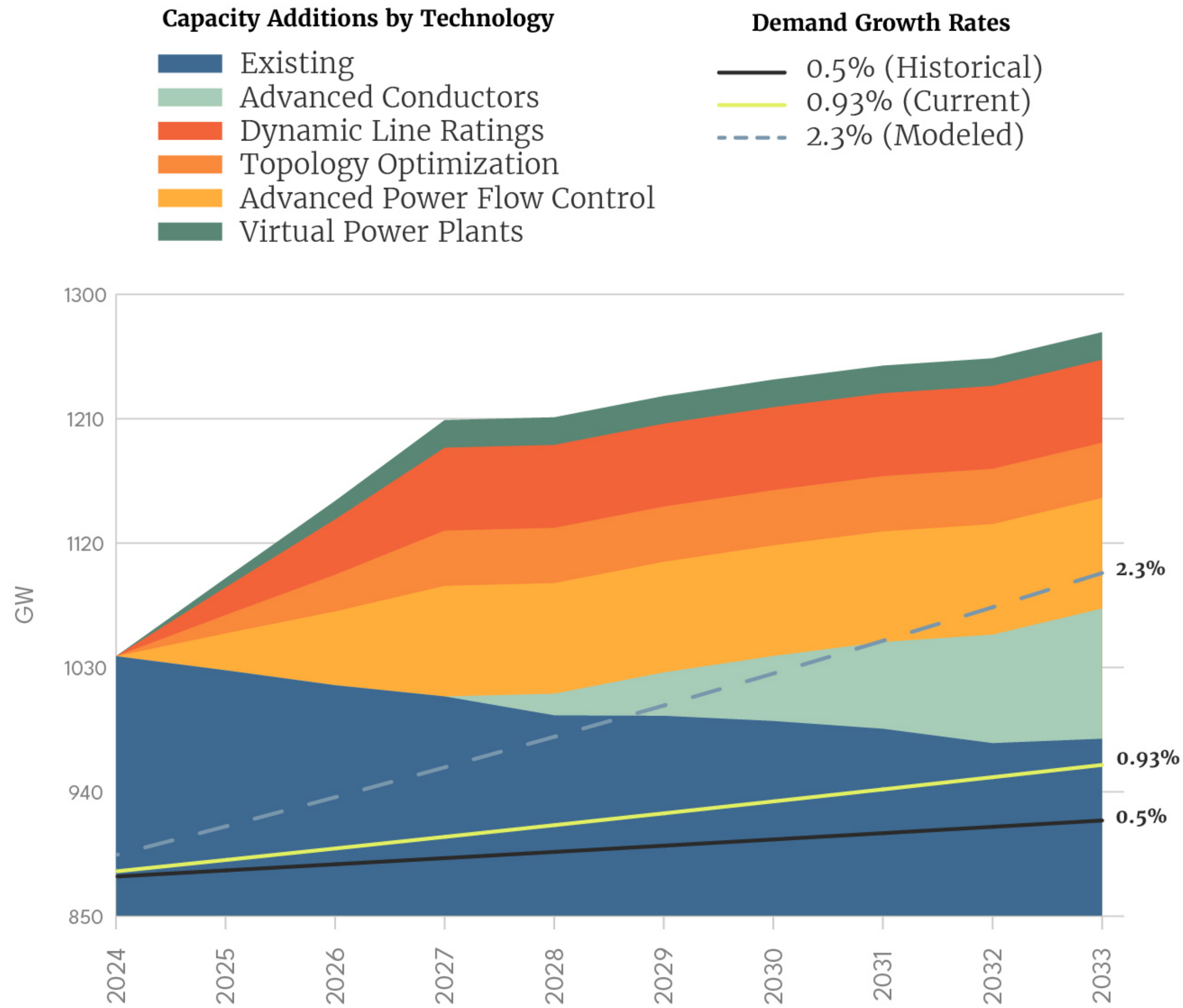
Introduction

Rising electric demand projections from the nation's grid regulator recently threw policymakers, utilities, and industry experts into a panic, leading to a prominent doomsday narrative in the media and a rise in planned natural gas power plant construction across the Southeast. While it's true that electric demand is rapidly increasing due a surge in electrification, manufacturing facilities, and new data center developments, the US possesses the tools necessary to meet this moment. As our last memo showed, the US has the existing and planned capacity needed to supply our projected demand surge—the issue lies in ensuring that capacity can get to where it's most needed. Unfortunately, with new generation, transmission, and distribution infrastructure taking longer than ever to be sited, permitted, and constructed, this is no simple feat.

Luckily, we have commercially viable, quick-to-install, innovative, and affordable technologies waiting to be deployed. Tools such as grid enhancing technologies (GETs), advanced conductors, virtual power plants (VPPs), high-performance computing (HPC), and artificial intelligence (AI) have the potential to transform our grid, unlocking the capacity of *existing* infrastructure and circumventing the need for new generation and transmission in the near term.

In fact, the immediate commercialization and deployment of only one of these readily available, innovative grid solutions could support 20-100 GW of incremental peak demand. [1] A value that compounds when multiple technologies are jointly deployed. As the graph below shows, the unlocked system capacity from the robust deployment of only a few innovative grid technologies more than covers the US' forecasted peak demand surge over the next decade (~91 GW increase in winter peak demand), without the addition of new generation sources. [2]

System Capacity Increase from Deployment of Innovative Grid Technologies



Note: Innovative grid technologies offer a compounding benefit to the grid, unlocking capacity on our existing infrastructure. DOE's Innovative Grid Deployment Liftoff Report provides a range of system increase potentials (GW) for advanced conductors, grid enhancing technologies (dynamic line ratings, topology optimization, and advanced power flow controls), and virtual power plants. This chart assumes that an equal proportion of each technology is installed over its deployment timeline while ramping up to its full capacity potential. With the system capacity increases from advanced grid technologies, the US should be able to reach not only its current demand growth rate, but also modeled increased demand growth rates.

Source: White, Louise, et.al. Pathways to Commercial Liftoff: Innovative Grid Deployment. Department of Energy (DOE), April 2024. https://liftoff.energy.gov/wp-content/uploads/2024/04/Liftoff_Innovative-Grid-Deployment_Final_4.15.pdf

Londagin, Shane. "Tackling America's Electricity Challenges." Third Way, April 2024. https://www.thirdway.org/memo/tackling-americas-electricity-challenges

While more long-term solutions to our new power crunch (i.e., permitting reform, interconnection queue reform, clean-firm generation, and transmission infrastructure buildout) will be needed to secure our clean energy transition and meet our net zero goals, innovative grid solutions represent a clear and feasible path forward to achieving our reliability targets over the next three to five years while modernizing our grid for the 21st century.

Below, we unpack each of these technological solutions in brief, highlighting how they work, and their potential impact.

GET-ing the Most out of our Existing Infrastructure

Inefficiencies in power flow management lead to lost electrons—an issue exacerbated by surging load growth. Grid enhancing technologies (GETs) represent a readily available group of technological innovations that improve the efficiency, increase the capacity, and expand the flexibility of existing transmission and distribution (T&D) infrastructure. These cheap and quick-to-install tools are already widely used in Europe and Australia but have historically lacked high penetration rates in the US. [3] While the term 'GETs' can apply to dozens of solutions to improve grid structure and operations, three are most applicable in the US context: dynamic line ratings, advanced power flow control, and topology optimization.

Dynamic line ratings (DLR) represent one the most well-known GET options. Traditionally, transmission lines receive static ratings that determine the amount of power fed through them. However, statically rated lines often experience power flow curtailment, reducing overall efficiency of the bulk power system (BPS). To combat this, grid operators can deploy sensors and analytic technology that provide a steady stream of data for dynamic line ratings which rate power lines on a continuous basis, adjusting for real-time weather and temperature scenarios, allowing for more efficient power flow.

Advanced power flow control (PFC) technology uses hardware to reroute power on the grid to prevent transmission lines from becoming overloaded. Instead, power is pushed from congested lines onto underutilized lines to reduce electrical bottlenecks and increase overall capacity of the BPS.

Topology optimization (TO) accomplishes the same outcome as advanced power flow control, rerouting power flow around congested lines. However, TO uses software rather than hardware to achieve this result, garnering it the nickname as the 'GPS of the BPS.'

In a grid plagued with rising inefficiencies, GETs create an accessible, affordable, and quick-to-install avenue to squeeze additional capacity out of our existing power system. Deployed together, DLR, TO, and advanced PFCs increase system utilization, unlocking an average of 10% to 50% of additional carrying capacity in existing infrastructure. [4] Not only do GETs increase reliability, but they save ratepayers money as well. Studies show that in the PJM region alone, the deployment of GETs enable grid operators to save around $500 million in infrastructure upgrades and save ratepayers $1 billion of annual production costs due to reduced congestion and increased system efficiencies. [5]

Advancing Current Capacity Levels

Growth in interregional transmission is necessary to meet increased demand projections in the long-term. In a high clean energy, high load growth future (one that we are currently facing), the US is expected to require a *quintupling* of current interregional transfer capacity by 2035. Even a moderate load growth scenario would require a *doubling* of current interregional capacity. [6]

While new high-voltage direct-current lines are indeed a pivotal part of our clean energy future, the current siting, permitting, cost allocation, and construction process for new transmission lines (specifically interregional lines) can take upwards of a decade. Reforming this process will require bipartisan support from Congress paired with targeted rulemaking from the Federal Energy Regulatory Commission (FERC). FERC has started to address these issues, most recently releasing Order No. 1920 which reforms the regional transmission planning and cost allocation process. Notably, this rule also supports the implementation of several innovative grid technologies including GETs and advanced conductors.

Advanced conductors (transmission lines carrying high-voltage power) are composed of advanced aluminum alloys, steel, and composite materials that have lower losses, higher carrying capacity, lower weight, and lower sag than the most common conductor used today. [7] Reconducting an existing transmission line with an advanced conductor can *double* the capacity of the line within an existing right-of-way (ROW) while avoiding the timely permitting and construction process for establishing new infrastructure. In fact, large-scale reconductoring using advanced composite-core conductors can unlock over 80% of the interzonal transmission needed to reach 90% clean electricity by 2035. [8] DOE predicts that, if deployed to scale overnight, advanced conductors could support upwards of 110 GW of capacity on our existing system. [9] These benefits make advanced conductors a critical part of the path towards grid modernization for the 21st century.

Putting the Pieces Together

In addition to wires-based technologies, non-wires investments present an incredible opportunity to expand capacity on the grid and increase reliability. Virtual power plants (VPPs) bring together a diverse set of multi-use technologies to provide power generation, demand balancing, and energy storage services to the grid. These tools, known as distributed energy resources (DERs), are typically installed near end-use sites to support local reliability needs on the distribution grid. DERs include a vast number of technologies that are familiar to most consumers such as smart thermostats, rooftop solar PV, electric vehicle (EV) chargers, behind-the-meter batteries, smart water heaters, and more.

Demand DERs shift their active operating time to hours of low demand to help balance the grid during on-peak hours when electricity consumption is high. Storage DERs paired with generation DERs store and supply backup power to the grid during stress events, balance the grid during on-peak hours, and provide ancillary services such as frequency regulation and ramping.

A VPP aggregates and manages DERs to provide scaled benefits to the grid. These combined services allow our power system to operate more efficiently, flexibly, and reliably at a lower cost with reduced emissions and increased consumer engagement. [10] The expansion of VPPs helps entire operating regions overcome the challenges presented by our changing climate. [11]

Currently, the US only deploys 30-60 GW of VPP capacity. DOE estimates that deploying 80-160 GW of VPPs by 2030—a *tripling* of current levels—is needed to manage 10-20% of peak demand and support the country's goal of reaching 100% clean electricity. Beyond these massive decarbonization and grid reliability benefits, this level of VPP commercialization is projected to save American consumers up to $10 billion in annual grid costs across VPP operating areas. [12]

The level of cost savings, reliability benefits, flexibility, and consumer choice provided by VPPs makes them a critical tool in enabling the grid of the future, overcoming infrastructure constraints, and giving consumers back some power over their energy future.

The Technology of Tomorrow, Today

GETS, advanced conductors and VPPs directly unlock T&D capacity on our existing electric infrastructure. Optimizing the efficiency of these innovative technologies, rapidly conducting complex calculations, and speeding up the permitting process requires a different form of technology. High performance computing (HPC) and artificial intelligence (AI) can fill that gap. HPC systems combine the workflows of hundreds of individual servers (known as nodes) to function as a single supercomputer housed in a data center. AI models are trained on HPC systems for a host of applications across the energy sector and beyond.

While a young technology, HPC has successfully streamlined projects across the energy industry. For example, the Pacific Northwest National Laboratory (PNNL) developed a tool (HIPPO) to calculate the complex algorithms used in wholesale day-ahead electricity markets. Trials demonstrated that HIPPO ran these calculations 35x faster than the incumbent technology. [13]

Early projects are exploring AI's use in streamlining the siting and permitting process for energy infrastructure. DOE is currently running a three-year pilot demonstration project to identify and test the efficiency of AI across different permitting and review processes. [14] AI's use in this space is emerging not only from the public sector but also from the private sector. UK-based Continuum Industries developed an evolutionary AI tool that automates the identification and assessment of siting options for large linear infrastructure projects (transmission lines and pipelines). The tool has successfully accelerated the development and permitting timelines of these infrastructure projects, completing, in some cases, twelve weeks of work within three. [15]

Additional uses for HPC and AI in the energy sector are currently being researched. Stakeholders in the federal government and beyond are looking into AI's applicability in areas from grid planning to operations to bolster resilience in the face of climate change. [16] If implemented responsibly, AI and HPC can build upon and enhance the potential of innovative grid solutions such as GETs, advanced conductors, and VPPs. [17]

Where Do We Go from Here?

While each of these technologies come with a cascade of benefits, they too face their fair share of challenges. Upfront costs, few utility incentives, a lack of technical knowledge, and the lack of standardized operational evaluation tools plague the deployment of innovative grid technologies. DOE, FERC, national laboratories, and industry associations will play a critical role in ensuring the wide-scale adoption of these solutions.

Policy Recommendations

Policy Recommendation #1: Incentivize utility investment in GETs, VPPs, and advanced conductors

The upfront costs of advanced grid solutions remain a critical barrier towards their implementation, despite their overall benefits. For instance, while advanced conductors cost less than half the price of a new build, they can cost twice the amount of conventional conductors. [18]

Utilities typically collect profits on their capital expenditures which incentivizes them to pour funds into large, capital-intensive projects (such as new natural gas plants) while disincentivizing smaller projects that save ratepayers money or increase system efficiency. GETS, VPPs, and reconductoring projects all experience this dichotomy in deployment. Creating alternative cost recovery mechanisms that realign investment strategy models is key to overcoming this issue. FERC and state regulators should consider creating incentives supporting performance-based regulation, a process rewarding utilities on the operational ability of their assets rather than just on capital expenditure.

Work has already begun on this front. The *Advancing Grid Enhancing Technologies Act* that was recently introduced in Congress would require FERC to establish a shared savings incentive for GETs. This would allow developers to recoup some of their project costs while splitting cost saving with ratepayers. [19] In response to stakeholder interest, FERC should implement its strongest possible mechanisms to incentivize investment in innovative grid technologies.

Policy Recommendation 2: Build technical knowledge and operational evaluation tools for advanced grid solutions

GETs, VPPs, and advanced conductors frequently face delayed deployment due to a lack of publicly available technical data and consistent operational evaluation tools. DOE, national laboratories, and industry associations (e.g., NARUC, NASEO) should work together to implement technology briefs or convenings to institute an information sharing community in the innovative grid solutions space. Furthermore, these groups should establish industry-wide frameworks to comprehensively assess the performance of these technologies such as through a new cost-benefit metric.

Policy Recommendation 3: Invest in R&D for HPC and AI Applications for the Grid

As Third Way's Mike Sexton wrote recently, HPC and AI applications are inherently energy intensive, with data centers partially accounting for the rapid uptick in electricity demand projections over the next decade. In response to President Biden's October 2023 Executive Order on the Secure Development of AI, DOE published its new report, *AI for Energy,* diving into both current and potential applications for AI in the energy sector. [20] However, additional research and funding opportunities at both national laboratories and universities are needed to quantify the benefits of these technologies and better understand their energy usage to create avenues for increasing efficiency.

As our traditionally mechanical electric grid continues to become more digitized, enhanced data privacy and cybersecurity measures must also be deployed. DOE's Office of Cybersecurity, Energy Security, and Emergency Response (CESER) has begun evaluating AI through a security lens—researching the potential of cyber-attacks against our existing infrastructure and developing ways to mitigate this risk. Continued research and support on this front from DOE and private tech companies is critical as HPC and AI technologies mature and advance.

Conclusion

The challenges facing our grid are immense, but so too are the opportunities. Innovative grid solutions represent a key tool towards modernization, with the ability to service surging demand in the near term while paving the runway for more long-term expansion solutions. Not only do these tools expand transmission and distribution capacity, but they also support grid resilience, affordability, and decarbonization—lighting the path for a more reliable, secure, and clean grid of the future.

TOPICS

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ENDNOTES

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