Building the Future Electricity Grid

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On a hot September afternoon in 2023, Odaro Omusi (MBA 2023) watched a FedEx truck drive away from his downtown Houston office building. He breathed a sigh of relief knowing that the truck contained a package of CD-ROMs holding the 200-page bid documents he had been compiling. These documents outlined Grid United's bid–his employer–to build a transmission project for the California Independent System Operator (CAISO) called North Gila-Imperial Valley #2 (NGIV2). Omusi had joined Grid United as a Project Manager earlier that summer after graduating with an MBA from Harvard Business School. He was thrust right into the action with bidding on this consequential project.

CAISO operated California's competitive wholesale electricity market and managed the reliability of its transmission grid.[1] It asked for bids for the NGIV2 project to be submitted by CD-ROM (yes, CD-ROMs). This led to a hectic last-minute scramble for Omusi and the Grid United team who, moments before the bid submission deadline, discovered a typo in their bid documents and had to frantically re-burn and package the updated CD-ROMs to be carried away on that FedEx truck. Who said there was no room for drama in the world of electric power transmission?

Grid United was founded just two years earlier in 2021 to revolutionize the U.S. power grid. The Houston-based startup brought together seasoned energy executives and fresh talent to reimagine the future of energy infrastructure. From their website, "Grid United's mission is to develop next generation energy infrastructure to power our future. We believe that the grid of the future should reliably deliver the energy that people want, exactly when and where they need it. This means that the grid must be efficient, resilient, and secure."[2]

NGIV2 was named as such because it would be the second transmission line to connect the North Gila substation in southern Arizona to the Imperial Valley substation in southern California. The first NGIV line was also known as the Southwest Power Link (SWPL).[3] While new the planned line was only about 90 miles long, it spanned the California-Arizona border and thereby connected CAISO to its neighboring regional transmission organization, the Southwest Power Pool (SWPP). The line connected meaningful power demand centers in Southern

[1] https://www.ferc.gov/industries-data/electric/electric-power-markets/caiso
[2] https://www.gridunited.com/about/
[3] https://www.caiso.com/documents/caiso-2022-2023-transmission-plan-approved.pdf

California and the Phoenix metro area, and meaningful power supply centers including solar farms in the region.

Omusi knew that Grid United was one of multiple transmission developers bidding for this project. His 200-page bid document covered Grid United's organizational structure and qualifications, project management plans and timelines, project financing plans, and more. It proposed the project as a cost capped annual revenue requirement (ARR) transmission solution with a few exceptions to the cost cap. In such a model, Grid United and CAISO would agree to maximum dollar amounts that CAISO would pay Grid United for operation of the transmission line, barring any unforeseen additional costs in the agreed upon exceptions to the cost cap. Since the basic economics of the project for Grid United depended on these revenues versus the upfront investment to build the transmission line, these ARR caps were a critical component of the bid document that combined all of the considerations of delivering the project. Setting the ARR caps too low could render the project unprofitable for Grid United, but setting them too high risked losing the bid to another developer who could deliver the project at a lower cost to CAISO.

Grid United's bid included multiple options and provisions that would allow it to prove its innovative approach to transmission development. Notable among these was its emphasis on partnerships with landowners and local stakeholders. NGIV2 differed from Grid United's typical development projects. Most of its projects utilized high-voltage direct current (DC) technology on lines that spanned the seams between North America's three major interconnections. DC was the preferred technology for moving large amounts of power long distances. But NGIV2 was a high-voltage alternating current (AC) line.[4] Nonetheless, it fit Grid United's mission and offered the young company an opportunity to earn more credibility as a project developer.

These factors circled Omusi's head as he watched the FedEx truck drive away with the CD-ROMs. Had Grid United set the ARR caps high enough to ensure profitability, but low enough to be competitive with other bidders? Would the non-economic provisions of their bid be attractive to CAISO? And was this the right project for Grid United to be bidding on at this time?

The Company

Michael Skelly (MBA 1991) co-founded Grid United in 2021 with energy investment billionaire John Arnold. Based in Houston, Texas, the startup aimed to modernize the U.S. grid through large-scale transmission projects. By 2023 the company still had fewer than 50 employees, but many of them were industry experts with deep experience.

Skelly's background was diverse. After graduating with his MBA from Harvard Business School in 1991, he moved to Costa Rica for four years to develop an aerial tram to promote ecotourism.

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[4] AC (alternating current) is commonly used for regional transmission due to its ease of voltage transformation. DC (direct current) is more efficient for long-distance transmission with lower losses but requires complex and costly conversion equipment.

He then developed wind energy projects internationally and in the U.S., most notably with Horizon Wind Energy which was the third largest U.S. wind developer before it was sold to the Portuguese company EDP Renovaveis. He also ran for U.S. Congress in 2008. Skelly took his first major step into transmission development in 2009 by founding Clean Line Energy Partners, a company that focused on building high-voltage direct current (HVDC) transmission lines to connect renewable energy resources like wind and solar to demand centers like major cities. Clean Line shut down in 2018 but multiple of its projects were sold to other developers who carried them forward.

Skelly applied lessons learned from Clean Line when shaping Grid United's approach. Perhaps chief among these was its landowner-first approach that prioritized engaging the local communities who would be impacted by their projects early and often. Community engagement included sponsoring local events like county fairs and meeting directly with individual landowners. A major part of Grid United's approach here is through community investment programs, where they would fund grants to community organizations which then in turn setup grant applications and select awardees. Skelly's experience at Clean Line had proven the challenges of developing horizontal infrastructure projects that necessitated this landowner and community first approach.

Horizontal infrastructure–here transmission lines–is useless if it does not connect point A all the way to point B, and a single landowner can have multiple levers to stop a project in its tracks if desired. Opposition often manifests through legal challenges and public campaigns. For example, landowners can file lawsuits arguing that compensation is inadequate or that the project infringes on property rights[5]. Landowners may also band together to form opposition groups, organizing community resistance that can lead to prolonged negotiations, increased costs, and even project cancellation. In some cases, landowners have refused to grant easements entirely, forcing developers to reroute projects or, in the worst cases, abandon them altogether[6]. Law firms have specialized practices in assisting landowners.[7] A range of landowner compensatory models have been explored, as detailed in **Exhibit 1**.

Grid United also adopted an energy-source-agnostic approach, even quoting on its website that "Transmission lines are open to all sources of electrical power generation."[8] This approach helped to unify stakeholders and avoid any debates about the energy transition. In 2023, terms like "green energy" or "clean energy" were received differently across groups. Grid United also sought to avoid projects involving three or more states. Experience at Clean Line had proven that three or more states added stakeholder complexity that could slow or kill a project, especially if it was not clear how each state along the line would benefit from the project.

As of 2023, Grid United was actively developing five projects. See **Exhibit 2** for a map and description of these projects. These projects were 100-420 miles in length, all high voltage but

[5] https://scholarsbank.uoregon.edu/server/api/core/bitstreams/37fa65f8-9ccc-43df-ac87-dbc2a93881b5/content
[6] https://ceepr.mit.edu/wp-content/uploads/2024/06/Crossed-Wires_Full-Report.pdf
[7] https://yourlandlawyer.com/Eminent-Domain-Information/Utilities-Electric-Transmission-Line-Issues.html
[8] https://www.gridunited.com/solutions/

sometimes AC and sometimes DC, and geographically positioned to connect the three major interconnections in North America. Each of these projects was in pre-construction development stages.

Omusi's path to joining Grid United followed an arc that began in his childhood in Nigeria. At the age of nine, his family home burned down due to an electrical issue, sparking an interest in electrical systems and their impact on communities and individuals. This interest led to an undergraduate degree in electrical engineering from Notre Dame, followed by graduate studies focused on electrical grids and micro-grids. Omusi then joined the auto manufacturer Cummins Inc. in Indiana as an engineer for seven years, spending the latter half of that time focused on electric vehicles. In 2021, Omusi enrolled at Harvard Business School with a goal to become a leader in the energy transition.

Omusi's initial list of exciting companies to join included cutting-edge technologies like long-duration energy storage and advanced geothermal energy. By comparison, transmission seemed to lack the innovation and excitement of those alternatives. But a visit to Grid United's Houston office during Omusi's second year at Harvard Business School changed that perspective. Skelly convinced Omusi that transmission played a critical role in the energy transition. Omusi agreed to join as a Project Manager upon completion of his MBA, realizing a unique opportunity to tie together his lifelong interests and educational and professional experience.

"The Grid" in the United States

The electric power transmission grid ("the grid") is one of the contiguous United States' most robust and complex infrastructure systems. It delivers electricity to the vast majority of U.S. households and most industrial, commercial, and manufacturing facilities. Its impact spans multiple dimensions:

- **Technical:** physical infrastructure to support the generation, transmission, and distribution of electricity
- **Economic:** electricity markets with individual and institutional participants to balance supply and demand of electricity
- **Political:** local, state, and federal organizations to govern and regulate these systems
- **Social:** consumers and communities that rely on the grid for daily energy needs

The U.S. grid has been referred to as the largest machine in the world.[9] It connects thousands of power plants to hundreds of millions of electricity customers via millions of miles of power lines.[10] Because of the physics of electricity, the grid must balance supply and demand, meaning that the quantity of power generated at any moment matches the quantity of power used by all electricity customers on the grid. This requires extensive coordination across multiple entities. The contiguous U.S. is divided into three main interconnections: Eastern, Western, and Texas

[9] https://www.cfr.org/backgrounder/how-does-us-power-grid-work
[10] https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php

(see **Exhibit 2** for a map of these interconnections). These interconnections operate largely independently from each other, though they have some transfer capacity between them.

Within each interconnection are various balancing authorities that operate the system to ensure supply matches demand. Parts of the U.S. have vertically integrated regulated monopoly utilities that own all the infrastructure from the power plant to the delivery of electricity. In these regions, the regulated utilities are the balancing authorities. In other regions, independent system operators (ISO) or regional transmission organizations (RTO) have formed as the balancing authorities (see **Exhibit 4** for a map of these organizations). In general, these are nonprofits that do not own any equipment and simply oversee the market mechanisms that connect power supply with power demand within their jurisdiction. These balancing authorities drive the long-term planning that results in the development of new infrastructure projects. The electric power industry must comply with the North American Electric Reliability Corporation's (NERC) grid reliability standards, which are regulated by the Federal Energy Regulatory Commission (FERC).

The grid follows multiple linked steps to deliver power to customers. First, electricity is generated at some form of power plant. Most regions of the U.S. rely on a mix of power generation sources. In 2023, U.S. utility-scale generation came from the following sources: natural gas 43%, coal 16%, other fossil fuels 1%, nuclear 19%, wind 10%, hydropower 6%, solar 4%, other renewable 1%.[11] Second, transmission lines carry electricity long distances from power plants to demand centers, usually at high voltages so as to minimize energy loss. Finally, distribution lines and associated transformers deliver power to individual customers by "stepping down" the voltage and connecting directly to each customer via wires. See **Exhibit 5** for a visual overview of electricity generation, transmission, and distribution.

Developing Transmission Infrastructure

Building a new transmission line in the U.S. in 2023 was no easy feat (see **Exhibit 6** for a schematic of the steps involved). It was not uncommon for a project to take over a decade between origination and completion, and plenty were stopped in their tracks and abandoned altogether. Transmission developers often pointed to the "Three P's" as the main components of a project that must be addressed: planning, permitting, and paying.

Planning starts with the process of identifying transmission needs based on future electricity demand and the goals of providing low-cost and reliable power in line with the planning body's policy goals (e.g., low emissions). Most transmission planning is led by the balancing authority in a given region, which is typically either a utility or an ISO or RTO. Interregional transmission projects face the additional requirement of coordination between neighboring regional balancing authorities, who for the most part have conducted their planning processes independently of one another.

[11] https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

Planning includes more “on the ground” challenges, too. Chief among these is securing the right of way for the line’s route. Developers are tasked with securing easements, often through a mix of private, public, and tribal land. While there are some eminent domain mechanisms to force an unwilling landowner to give right of way, these can lead to other forms of opposition that can stifle a project. Because of these factors, successful developers go to great lengths to garner community and individual support from the people impacted by construction of their projects. Planning also includes the necessary engineering, design, and procurement work to prepare for construction – each a large and costly undertaking in its own right.

Permitting can be an extensive and long process for a new transmission line. Developers must secure a series of federal, state, and local permits. Depending on the details of the project, this can involve entities like the Bureau of Land Management (for public land easements), the Army Corps of Engineers (for any water crossings), FERC (if the project crosses state borders), the Environmental Protection Agency (for compliance with the National Environmental Policy Act regarding impact on wildlife, vegetation, cultural resources, and local communities), the state public utilities commissions (for alignment with their energy and environmental policies), and county and municipal bodies (for zoning regulations, land use plans, and local approvals). In a transmission project with multiple developers bidding for the project, sometimes each developer must apply for the same permits which increases inefficiencies and total cost. Developers are also challenged with navigating permitting processes in parallel with project planning and pulling together a business plan.

Paying refers to the commercial model of a transmission project that determines how the development, construction, and operational costs of the project will be paid for, with a sufficient return to the developer to encourage them to take the risk of developing the project. The general goal in any project is to match who is paying for the project with who is benefitting from the project. With intra-regional projects, costs are often socialized across the region’s customers through a “rate base” process under the presumption that the aggregation of all infrastructure investments supports the region’s customers equally. With inter-regional projects, cost allocation can be much more challenging and is often the issue that stifles coordination between regions due to differences in regulatory frameworks, variations in regional energy demands, and disparities in electricity pricing. Each region may benefit from the project to different extents, making it difficult to determine a fair distribution of costs. For instance, a transmission line connecting a wind-rich region in the Midwest to a high-demand urban center in the Northeast may primarily benefit consumers in the Northeast, but the infrastructure and land costs occur largely in the Midwest. Some transmission projects have adopted merchant commercial models rather than rate base models to address this. Merchant models establish offtake agreements with customers and provide more exposure to regional differences in power prices. While this can provide a wider band of return outcomes for developers given arbitrage opportunities, it also introduces much more to risk to the developer than a rate base model.

Paying for transmission projects is also complicated by existing cost-benefit frameworks that consider a narrow scope of benefits and broad scope of costs. For example, these projects can create system-wide reliability and emissions benefits. But these can be hard to quantify and which makes it difficulty for the project developer to capture.

The State of the Grid in 2023

Amidst these challenges across the "Three P's," the U.S. grid had seen relatively few transmission lines added each year in the decade leading up to 2023 (see **Exhibit 7**). In interregional lines specifically, the U.S. developed 3 GW of transmission capacity between 2014-2021, compared to 44 GW in Europe and 260 GW in China (see **Exhibit 8**). Transmission capacity between U.S. regions was limited, often on the order of 10% of the peak electric load in the larger of the bordering regions (see **Exhibit 9** for a map with estimates of interregional transmission capacity). This led to persistent differences in the price of power between regions, such as a $25/MWh average difference between hubs in west Texas and neighboring New Mexico and Arizona from 2012-2020 (see **Exhibit 10** for estimates of these price differences across regions).

By 2023, plenty of industry participants were raising caution about aging grid infrastructure in the U.S. From the U.S. Department of Energy, "Much of the U.S. electric grid was built in the 1960s and 1970s. While the system has been improved with automation and some emerging technologies, our aging infrastructure is struggling to meet our modern electricity needs, such as renewable energy resources and growing building and transportation electrification. For example, 70 percent of transmission lines are over 25 years old and approaching the end of their typical 50–80-year lifecycle. This has major consequences on our communities: power outages, susceptibility to cyber-attacks, or community emergencies caused by faulty grid infrastructure."[12] Outage counts across the U.S. suggested a notable increase from the early 2000s into the early 2020s. While weather events and natural disasters were to blame for a plurality of these outages, it was by no means the only cause (see **Exhibit 11**).

The energy transition also had implications for the U.S. grid on both supply and demand. On supply, power generation was expected to continue shifting toward renewable sources, particularly solar and wind. Solar energy had more potential in the Southwest U.S. because of higher solar irradiance, while onshore wind energy had more potential in a North-to-South strip through the center of the U.S. from North Dakota to Texas because of higher wind speeds (see **Exhibit 12**). Thus, even if the U.S. developed enough solar and wind resources to meet total U.S. electricity demand, it would still need a massive interregional transmission build-out to bring that energy to market (e.g., to large cities in the Northeast U.S.).

On the demand side, multiple factors had industry participants expecting a return to growth in aggregate U.S. electricity demand. Demand had flatlined from the late 2000s to the early 2020s as efficiency gains and economic growth mostly offset each other, but by 2023 the NERC forecast for electricity demand showed a return to demand growth into the 2030s (see **Exhibit 13**). Growth drivers like electrification (e.g., adoption of electric vehicles and electric heating and

[12] https://www.energy.gov/gdo/articles/what-does-it-take-modernize-us-electric-grid

cooling systems) and data center build-outs were commonly cited as the primary factors for the change in expectations.

The U.S. Department of Energy's 2023 National Transmission Needs Study called for significant increases in transmission capacity by 2035. Their most conservative model scenario of moderate load growth and moderate clean energy growth called for 20% more intra-regional transmission capacity by 2035 and 25% more interregional capacity. In the high load growth and high clean energy growth scenario, these figures jumped to 128% and 412%, respectively, which would constitute a more than doubling of intra-regional capacity on the grid and even more interregional capacity (see **Exhibit 14**).[13]

Fixing the Grid

Regulators have proposed many solutions to reform the U.S. grid, particularly for projects that cross regional boundaries. In 2011, FERC Order No. 1000 was issued to improve transmission planning and cost allocation processes. It required public utility transmission providers to participate in regional transmission planning, consider transmission needs driven by public policy requirements, and coordinate with neighboring regions to identify more efficient or cost-effective solutions.[14] It also mandated the development of regional and interregional cost allocation methods for new transmission facilities. However, despite these reforms, the pace of interregional transmission development remained slow, with an average of only 72 circuit-miles of new lines energized per year from 2011-2020.[15]

In 2023, a group within the U.S. Congress proposed the Building Integrated Grids with Inter-Regional Energy Supply (BIG WIRES) Act.[16] It aimed to accelerate the construction of interregional transmission projects by setting minimum transfer requirements between regions and mandating that utilities collaborate to meet these targets. The bill would require FERC to establish minimum interregional electricity transfer capabilities within 18 months of the bill's passage, with regions having two years to submit joint plans for building the necessary infrastructure. It also addresses issues such as cost allocation and the designation of entities responsible for building the new transmission lines.[17]

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[13] https://www.energy.gov/sites/default/files/2023-12/43451_DOE_GDO_Needs_Study_Fact_Sheets_United_States_v6_RELEASE_508_Compliant.pdf

[14] https://www.ferc.gov/electric-transmission/order-no-1000-transmission-planning-and-cost-allocation

[15] https://www.energypolicy.columbia.edu/estimating-interregional-transmission-expansion-under-the-big-wires-act/

[16] https://www.hickenlooper.senate.gov/wp-content/uploads/2023/09/BIG-WIRES-One-Pager-Sep.-20231.pdf

[17] https://www.energypolicy.columbia.edu/estimating-interregional-transmission-expansion-under-the-big-wires-act/

Around the same time, the U.S. Department of Energy released a final rule to improve federal environmental reviews and permitting processes for qualifying onshore electric transmission facilities. The rule established the Coordinated Interagency Transmission Authorizations and Permits Program (CITAP), with a goal to coordinate federal permitting processes and set a two-year deadline for completing federal authorizations and permits for transmission projects. The program requires a comprehensive public participation plan that encourages early engagement with communities and Tribes and allows potential applicants and agencies to coordinate via an online portal.[18]

Many other versions of reform had been attempted and proposed by 2023. Among others, these included a transmission investment tax credit system, direct government intervention in global supply chains for critical transmission equipment, and new eminent domain regulations.

NGIV2: A Bid Battle

Shortly after Omusi started as a Project Manager at Grid United, Skelly asked him to get involved in an ongoing bid process for the CAISO NGIV2 project. The primary questions for Omusi were "how should we bid and how much should we bid?" While these may seem like straightforward questions, they required Omusi to grasp a multitude of factors from project finance to permitting processes.

CAISO had a reputation for being one of the most forward-looking and sophisticated grid balancing authorities in the U.S. They were known for requiring detailed project proposals from bidding developers. CAISO categorized their projects by their primary objective: reliability, economic (focused on lower energy costs for consumers), and policy (mostly related to clean energy standards). NGIV2 was categorized as a policy-driven project.

NGIV2, LLC, a joint venture between ITC Grid Development and Southwest Transmission Partners (STP),[19] submitted the NGIV2 project to CAISO during its 2022 interregional transmission coordination submission window.[20] NGIV2, LLC had been developing the project for years prior to this submission.[21] CAISO found that the project fit its policy-driven requirements to meet the renewable generation requirements in the California Public Utilities Commission's renewable generation portfolios by delivering wind and solar resources from New Mexico and western Arizona to the San Diego and Los Angeles basin areas of southern California. NGIV2 was one of 21 such policy-driven projects identified in CAISO's 2022-2023

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18 https://www.energy.gov/gdo/coordinated-interagency-transmission-authorizations-and-permits-program#:~:text=The%20Coordinated%20Interagency%20Authorizations%20and%20Permits%20(CITAP)%20Program%20implements%20Section,necessary%20to%20site%20transmission%20lines.

19 https://www.caiso.com/documents/ngiv2comments-2018-2019transmissionplanningprocess-nov162018.pdf

20 https://www.caiso.com/documents/caiso-2022-2023-transmission-plan-approved.pdf

21 https://www.caiso.com/documents/ng-iv2itpsummary.pdf

Transmission Plan.[22] CAISO determined that NGIV2 was eligible for its competitive transmission procurement solicitation process, and estimated the project would cost $340 million.[23] CAISO's solicitation process would include a comparative analysis of the bids submitted by each project sponsor and ultimately select a sponsor to finance, construct, own, operate, and maintain the transmission line.[24] The bid submission window would open on June 26, 2023, and close on September 29, 2023. The project was formally defined as "a new 500 kV circuit between North Gila and Imperial Valley substations, estimated at 85 miles."[25] See **Exhibit 15** for a map of these two substations relative to southern California and Arizona.

Grid United took the opportunity to submit a bid for NGIV2 in a consortium that included STP, the firm that had been developing the NGIV2 project for over a decade and originally submitted the project to CAISO in 2022. NGIV2 was shorter in length than Grid United's other projects, and it used AC technology rather than DC. But Grid United saw value in developing an interregional line with a quick timeline to construction, offering the young company a chance to build its reputation.

Grid United's Proposal

Grid United assembled a consortium of strategic partners in its bid for the NGIV2 project:

- Southwest Transmission Partners (STP), who had been involved in developing the project for over a decade and would provide development support services
- Imperial Irrigation District (IID), whose participation would lower CAISO's costs for the project because Grid United would allocate some of the project costs to IID and the remainder to CAISO. IID would also share its permitting and land acquisition experience in the NGIV2 project region and serve as the California Environmental Quality Act lead for the project, accelerating the project timeline
- Citizens Energy, who would invest in the project and dedicate half of its profits to supporting low-income ratepayers in the NGIV2 project region, in line with its nonprofit mission
- Multiple engineering, construction, maintenance, environmental, and land acquisition firms who were likely contractors should Grid United win the project bid

The bid committed to an accelerated project timeline that delivered the project as early as December 2029, well ahead of CAISO's requirement of June 2032. STP's extensive experience with the project enabled this accelerated timeline. They provided detailed routing studies, environmental assessments, and interconnection studies with Arizona Public Service (APS) and San Diego Gas & Electric (SDG&E).

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[22] https://www.caiso.com/documents/caiso-2022-2023-transmission-plan-approved.pdf
[23] https://www.caiso.com/documents/caiso-2022-2023-transmission-plan-approved.pdf
[24] https://www.caiso.com/documents/2022-2023-tpp-approved-project-sponsor-for-the-north-gila-imperial-valley-2-500kv-transmission-line-project.html
[25] https://www.caiso.com/documents/2022-2023-tpp-approved-project-sponsor-for-the-north-gila-imperial-valley-2-500kv-transmission-line-project.html

The proposed route for NGIV2 avoided going through tribal land near the eastern portion of the route, instead opting to route the line through a combination of public and private land (see **Exhibit 16** for map of proposed route). The development team had already worked with the Bureau of Land Management for right of way through public lands. STP shared Grid United's emphasis on direct engagement with private landowners and had established relationships with impacted landowners that it had developed for years, which the consortium now continued. The proposal to CASIO emphasized past and ongoing landowner and stakeholder engagement efforts.

Because of the extensive development work that STP led before Grid United's involvement, the bid included 60% complete engineering designs (the consortium estimated that other parties would only have 30% complete engineering designs in their bids). This engineering work had studied the unique soil in the project area and adjusted tower foundation designs to account for the soil. While this added some costs to the engineering estimates, it de-risked the project overall by identifying it before the bid was submitted. Omusi hoped this would be an advantage for the project.

Setting the Price

Grid United proposed the project as a cost capped annual revenue requirement (ARR) transmission solution with a few exceptions to the cost cap. In such a model, Grid United would recover its costs (plus a reasonable return for its investors) from CAISO, but only up to a predetermined cost cap. If the actual project costs for the transmission line exceeded the cost cap, then Grid United would not be able to recover them from CAISO's rate base, barring predetermined exceptions to the cost cap like routing changes required by permitting or siting authorities.

Grid United included two options for the ARR cap and allowed CAISO to choose its preference: a declining ARR cap and a levelized ARR cap (i.e., same cap each year for the project's 43-year operating life). These options were equivalent on a net present value basis when discounted at an 8.2% rate. The cap in each option persisted for the full life of the project, which was a choice by Grid United (i.e., they could have removed the ARR cap after 15 years).

The bid's ARR cap values were based on a projected capital expenditure that was higher than Grid United's original projection due to siting and engineering findings from STP's extensive experience with the project (e.g., the unique soil conditions). However, the bid's projected capital expenditure was still lower than the $340M that CAISO originally estimated for the project. Grid United realized that these higher costs could make their bid less competitive, but they determined that including their best estimates and full rationale for higher capital costs was the most transparent and de-risked approach.

Submitting the Bid

As Omusi watched the bid documents carried away via CD-ROMs on a FedEx truck, he wondered what the future of NGIV2 would hold. Had they bid at too high an ARR cap to be competitive? The Grid United team had analyzed it extensively and determined it was their most accurate estimate of project costs. Omusi also recalled the news of just two months prior when CAISO made headlines for asking FERC to reject another transmission developer's request to blow past its transmission cost cap.[26] Stories like that reminded Omusi that perhaps the bigger risk was bidding at too low an ARR cap and running into cost overruns.

Omusi wondered how CAISO would appraise the other components of Grid United's bid, too. He saw real de-risking value in their partnerships, thoughtful route, advance engineering and permitting work, and extensive community engagement. But would those matter to CAISO? Tick-tock…

[26] https://www.utilitydive.com/news/caiso-ferc-starwood-dcr-delaney-ls-power-transmission-cost/688733/

Exhibits

Exhibit 1

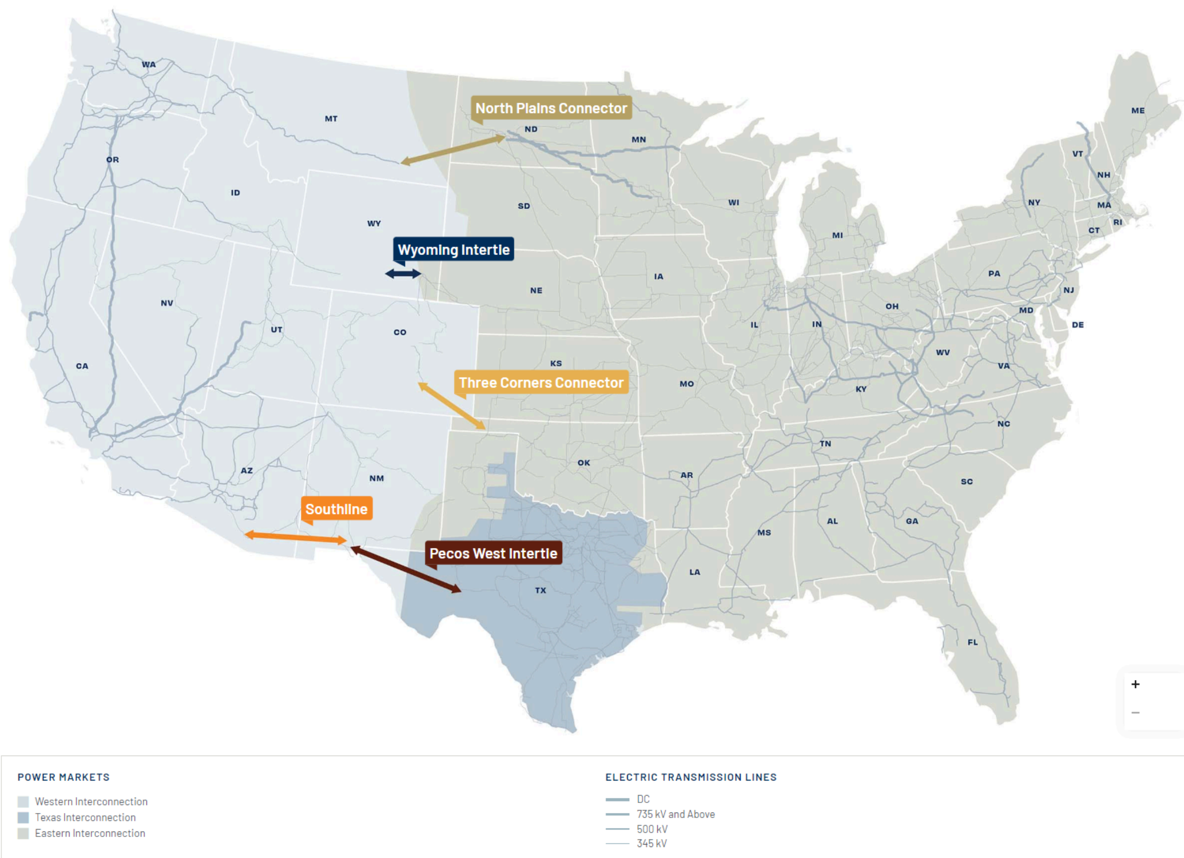
Compensation Model	Description	Example	Reference
Damage Payments	Payments made to individual landowners on the basis of damages (to business or assets)	Montana-Alberta Tie Line; landowners affected by the transmission line were offered compensation for lost crop production (they were also paid annual pole payments ~$200/pole, see row below).	Berry, 2013
Annual Per-Pole Payments	Utilities pay a fee for each pole they use to string electric lines or communications cables on the land of individual landowners	For landowners affected by the Rock Island Clean Line, landowners were given the choice between one-time payments or annual-payments, both on the basis of pole usage.	Berry, 2013
Landowner Association	Groups of landowners are represented by a single association, who collectively bargain for association preferred compensation	Rocky Mountain Farmers Union (RMFU) represents family farmers and ranchers in Wyoming, Colorado, and New Mexico and negotiates directly with utilities.	Berry, 2013
Rapid Response Team for Transmission	The RRTT was a 2011 initiative by the Obama administration to fast-track federal permitting across agencies for seven transmission projects.	Since 2011, two of the seven projects have been built; one of the seven projects has been under construction; three of the sevens projects have been cleared for construction only in the fall of 2023, including SunZia and TransWest; one of the projects was canceled entirely.	Berry, 2013; Storrow, 2022
Buy the Farm	Landowners can select to have the utility purchase the entire property over which a transmission line will pass.	Minnesota is the only state with a "buy the farm" statute–Xcel Energy has utilized this statute in previous rights-of-way matters.	Berry, 2013
Royalty Payments	Landowners are paid royalty compensation for right-of-ways. Costs come out to .00099 cents / kw.	Cornerstone TansCo LLC uses this approach and has never had to use eminent domain to secure land.	Berry, 2013
Special Purpose Development Corporation	Landowners are given the choice to trade their land for an equally valuable number of shares in what's known as a Special Purpose Development Corporation. This entity is created solely to assemble and sell land parcels to the developer. This policy theoretically gives the landowners more collective leverage to negotiate for more desirable deals.	The policy has been proposed by the Center for Rural Affairs and has not yet been enacted.	Winn, 2014
Land Assembly	Especially useful for fragmented parcels.		Gerstle, 2014

District	Landowners assemble into a common organization that negotiates with developers. The united organization can use eminent domain to override minority voices of its members.		
Land Readjustment	Landowners collectively agree to redevelop their land. In the framework described by Gerstle it takes 25% of landowners to begin proceedings, under which a public body holds hearings. If no significant objections arise, the developing campaign seeks the consent of a majority of landowners. After several back and forth elections between an established board, public body, and landowners, a development plan is established, and landowners receive shares or other payment	This approach has been used in urbanization processes across the world.	Gerstle, 2014 Hong and Needham, 2007
Equity Model Limited Liability Corporation	This method is very similar to the SPDC. Landowners receive shares in an LLC created by the developer. They can later sell their shares, or simply enjoy the flow of money from their shares.	Proposed in 2010 by developer Ralph Basile.	Gerstle, 2014
Transmission Corridor District	First the planning agency plans several routes, divided into specific segments. Then it must seek the support of 25% of those landowners of a segment, or else that segment is disqualified from the development process. Then at least 10% of landowners vote to elect a board, which negotiates with the developer. Then the developer needs at least 50% of the landowners' support. Then the developer wins easement rights as part of a special purpose vehicle entity. The landowners receive tradable shares in that entity as compensation, and dissenting landowners receive FMV payments. Representatives from the route segment boards continue to represent the landowners.	This policy has been proposed by Gerstle but is not yet in practice.	Gerstle, 2014

Source: Moudgalya, P., Ornstein, J., & Tingley, D. "Interregional Transmission, Economic Development and Workforce Opportunities.", 2024

These compensation models show the complexity of addressing landowner opposition to transmission projects, ranging from direct payments to collective bargaining and equity-based approaches. These varied strategies highlight efforts to manage resistance, with many innovative models still in the proposal phase.

Exhibit 2



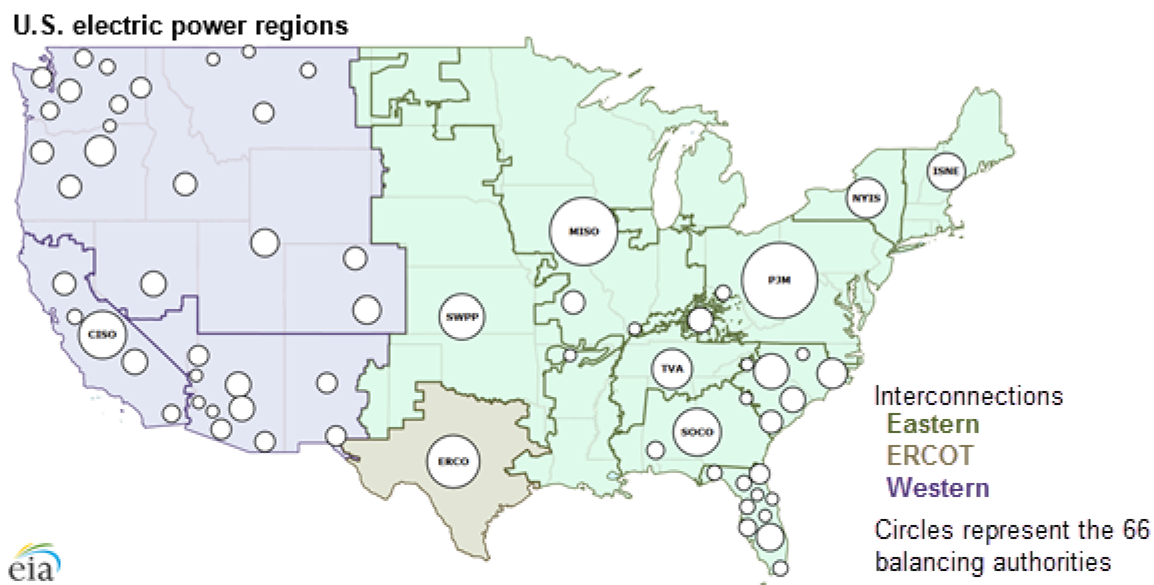
Project	Description
North Plains Connector	The North Plains Connector is an approximately 420-mile and up to 525 kilovolt high voltage direct current (HVDC) transmission line connecting the U.S. Eastern and Western electric grids in Montana and North Dakota.
Pecos West Intertie	Pecos West is an approximately 280-mile, 525 kilovolt HVDC intertie line stretching from Bakersfield in Pecos County, Texas to El Paso, providing a valuable link between ERCOT and the Western Interconnection.
Southline	Grid United and Black Forest Partners are co-developing the Southline Transmission Project (“Southline” or “the Project”), a 278-mile, double-circuit, high voltage transmission line and associated substation facilities.
Three Corners Connector	Three Corners Connector is an up to 300-mile, 525 kilovolt HVDC transmission line connecting the existing electric systems near Pueblo, Colorado, and the Oklahoma Panhandle, providing

	a valuable link between the Eastern and Western Interconnections.
Wyoming Intertie	Wyoming Intertie is an approximately 150-mile, high voltage transmission line that will connect the Eastern and Western Interconnections by linking infrastructure in Carbon County, Wyoming to that in Platte County, Wyoming.

Five active projects being developed by Grid United (2023)
Source: Grid United, "Projects," Accessed: September 2024

Grid United focuses on developing multiple large-scale transmission projects across the U.S., highlighting its strategic focus on interconnecting the grid and its experience in handling complex, regionally significant infrastructure

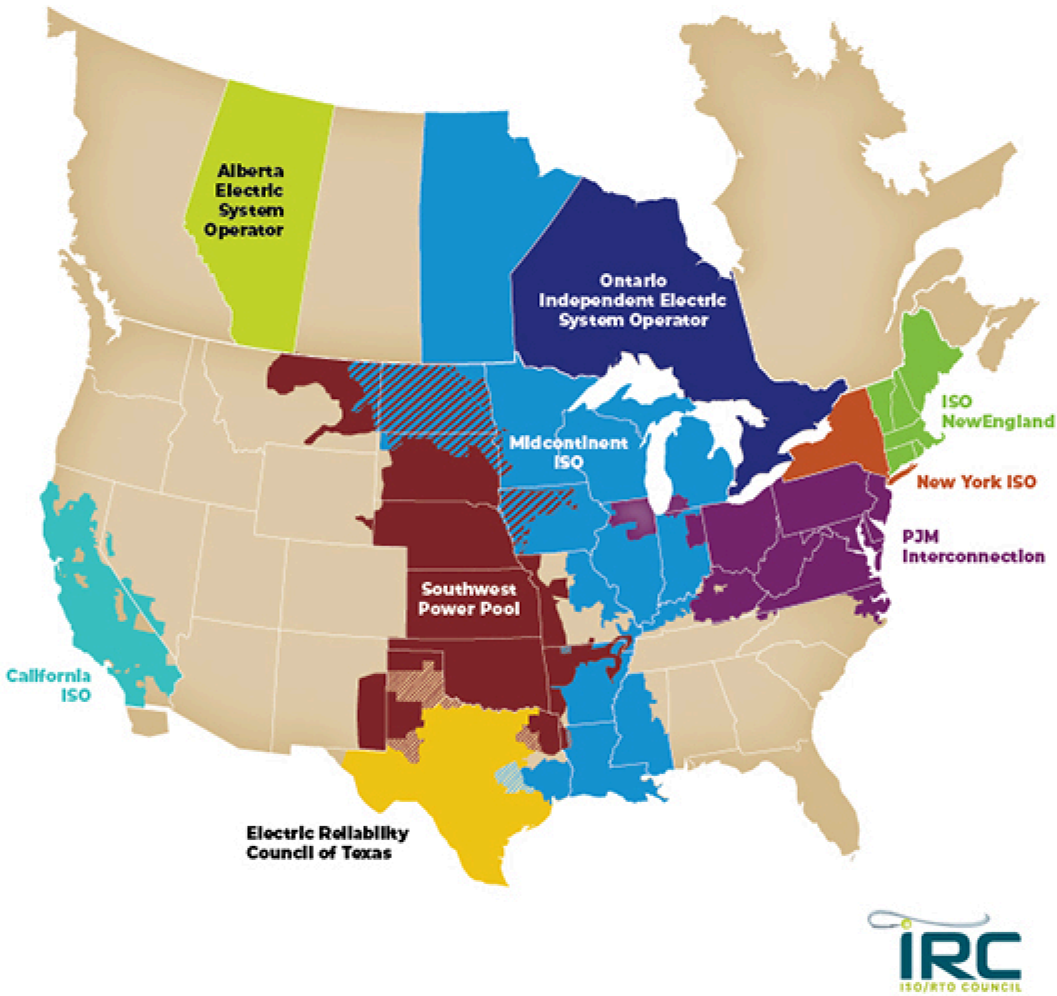
Exhibit 3



The contiguous US is divided in the Eastern, Western, and Texas interconnections.
Source: U.S. Energy Information Administration, "U.S. electric system is made up of interconnections and balancing authorities," July 20th, 2016

The US power grid's three major interconnections—Eastern, Western, and ERCOT (Texas)—along with the 66 balancing authorities highlight the complexity and fragmentation of the grid, emphasizing the need for projects like Grid United's to improve interregional connectivity and grid reliability.

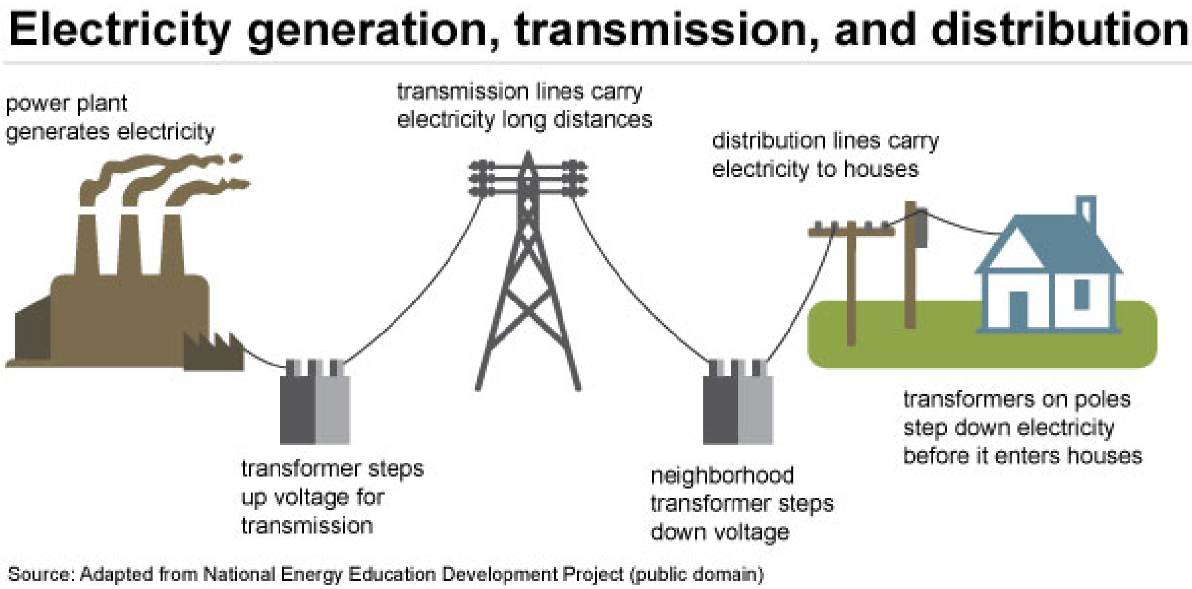
Exhibit 4



ISO operators and RTOs oversee market mechanisms to connect supply with power demand.
Source: [IRC ISO/RTC Council](), Accessed: September, 2024

The presence of Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) across North America illustrate the fragmented nature of electricity markets.

Exhibit 5



Electricity generation, transmission, and distribution
Source: U.S. Energy Information Administration, "Electricity explained," April 16th, 2024

The process of generating and delivering energy from power plants to homes and businesses is complex, involving various public and private infrastructure elements. Safety, economic, and environmental concerns are all important considerations for those who develop or maintain such infrastructure.

Exhibit 6

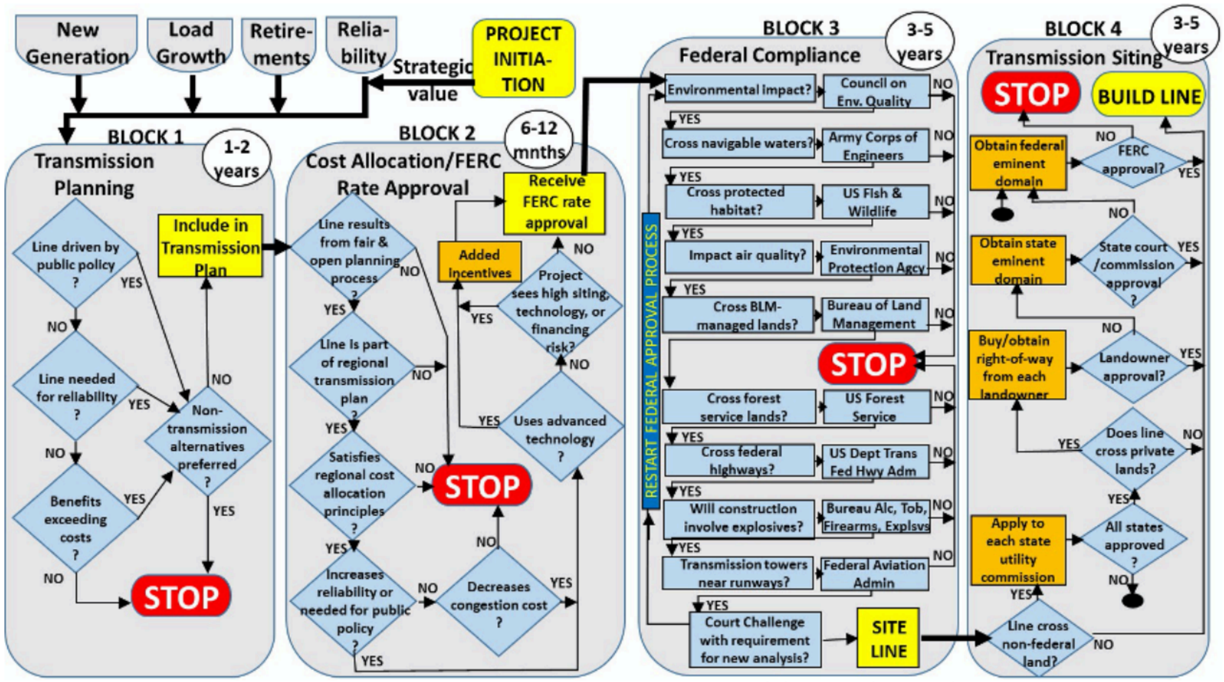
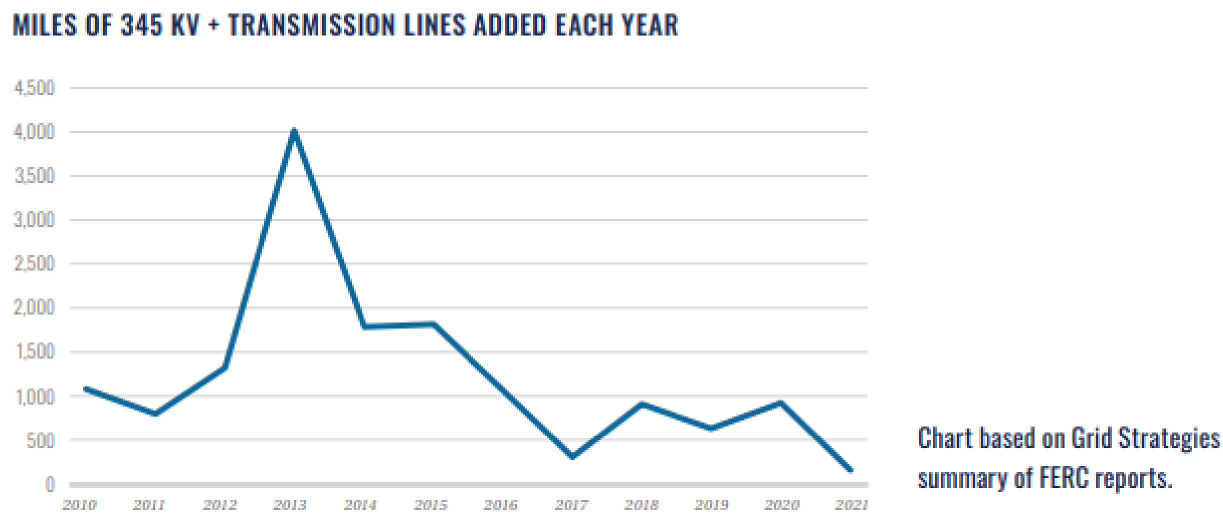


Figure 6: Transmission planning, cost allocation, approval, siting process in the US (adapted from [52])

Steps involved with building new transmission infrastructure in the US
Source: McCalley, J., & Zhang, Q, "[Macro Grids in the Mainstream: An International Survey of Plans and Progress](#)," Americans for a Clean Energy Grid, November 2020

The process of planning, approving, and siting new transmission lines in the U.S is complex and lengthy, involving multiple stages like transmission planning, cost allocation, federal compliance, and transmission siting. The exhibit highlights the numerous regulatory hurdles and approvals needed, underscoring why transmission projects, such as those pursued by Grid United, often face extended development timelines and challenges. involving multiple stages like transmission planning, cost allocation, federal compliance, and transmission siting.

Exhibit 7



Miles of 345 KV transmission lines added each year, 2010-2021
Source: Caspary, J., Goggin, M., Gramlich, R., & Selker, J. "Fewer New Miles: The US Transmission Grid in the 2010s," Grid Strategies LLC, May 2024

This chart shows a significant decline in the addition of new 345 kV+ transmission lines in the U.S. since 2013, highlighting a slowdown in grid expansion and the growing need for accelerated infrastructure development to meet future energy demands.

Source: Data from MAPSearch Transmission Database (2023).

Note: The scale of circuit-miles shown on the y-axis changes with each row of charts, as indicated by the circle, obscuring the scale of projects relative to other regions. All interregional projects are grouped together and shown separately from regional projects.

Figure ES-2. Regional circuit-miles of new or upgraded transmission lines (≥100 kV) energized in each year by project driver.

Regional variation in U.S. transmission line expansion and drivers
Source: United States Department of Energy, "National Transmission Needs Study," 2023

There has been tremendous regional variability in new or upgraded transmission lines (≥100 kV) across the U.S. from 2012 to 2020, with factors such as reliability, high-capacity needs, and interconnection driving development. These trends underscore the uneven pace of grid expansion, with certain regions like Texas and the Midwest seeing significant growth, while others experience minimal upgrades.

Exhibit 8

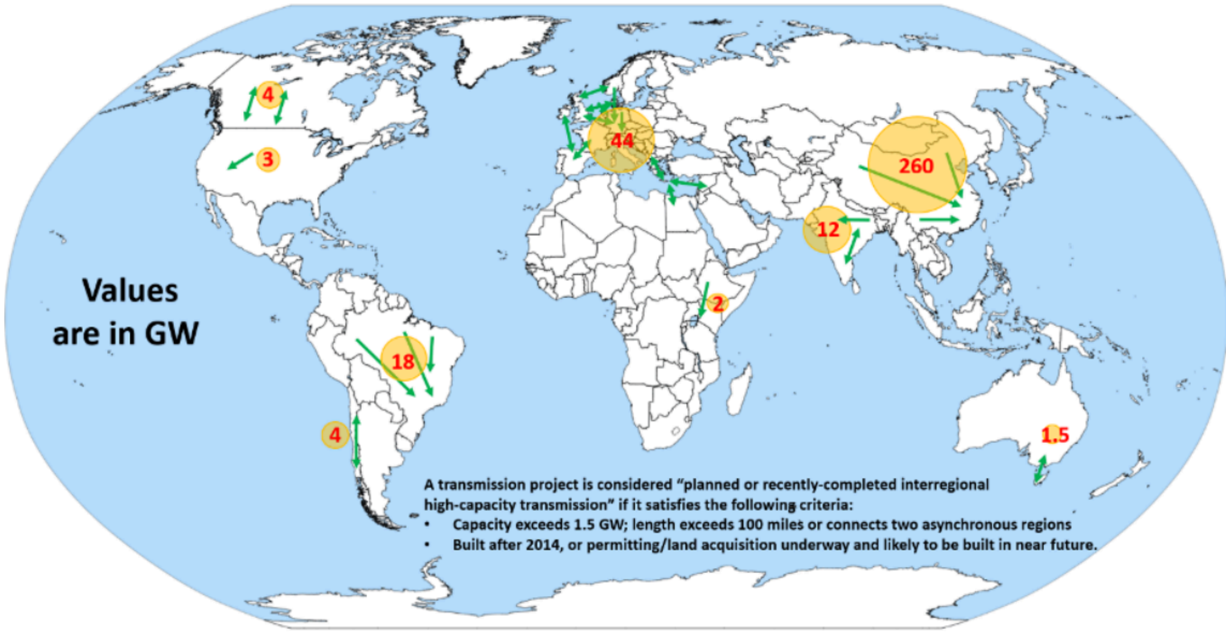
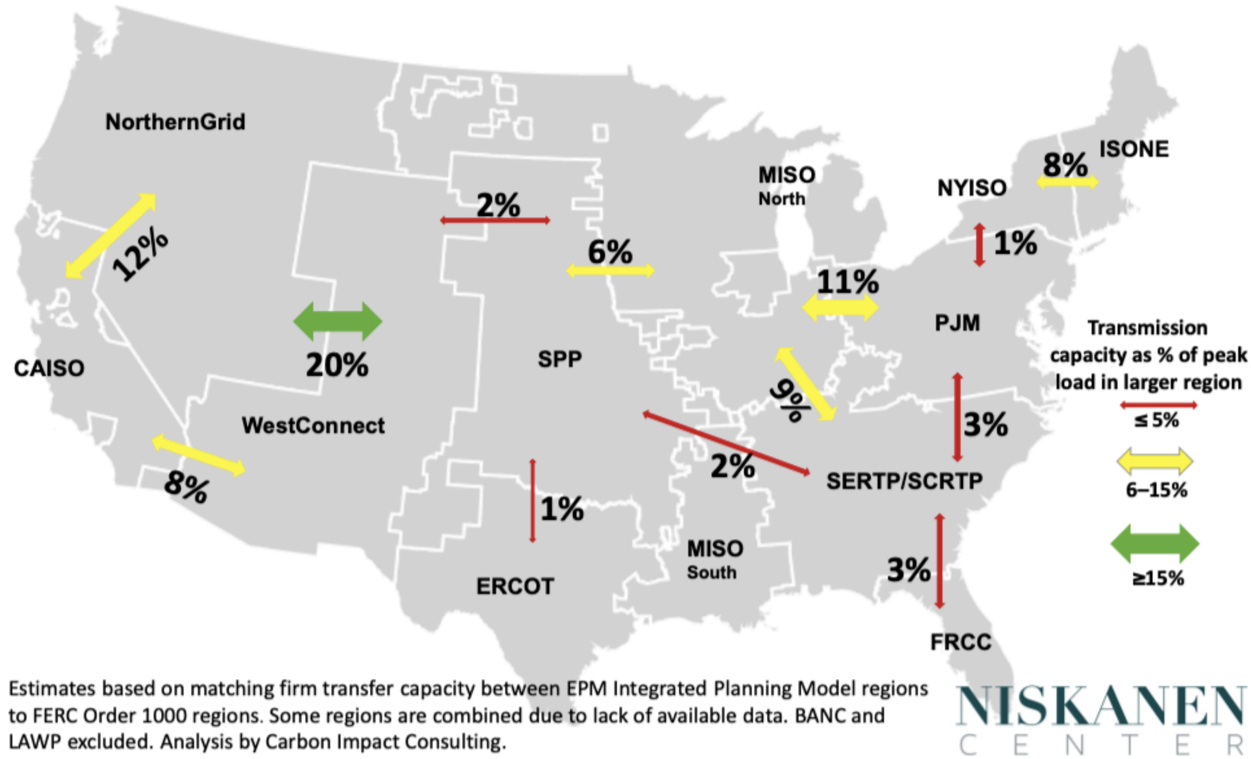


Figure 1: Total capacity of planned or recently-completed interregional transmission projects

Global interregional transmission capacity overview
Source: McCalley, J., & Zhang, Q, "Macro Grids in the Mainstream: An International Survey of Plans and Progress," Americans for a Clean Energy Grid, November 2020

There is a significant global disparity in planned or recently completed high-capacity interregional transmission projects, with Asia (China especially) and Europe leading in capacity, indicating a significant push toward grid expansion and energy integration in those regions compared to others.

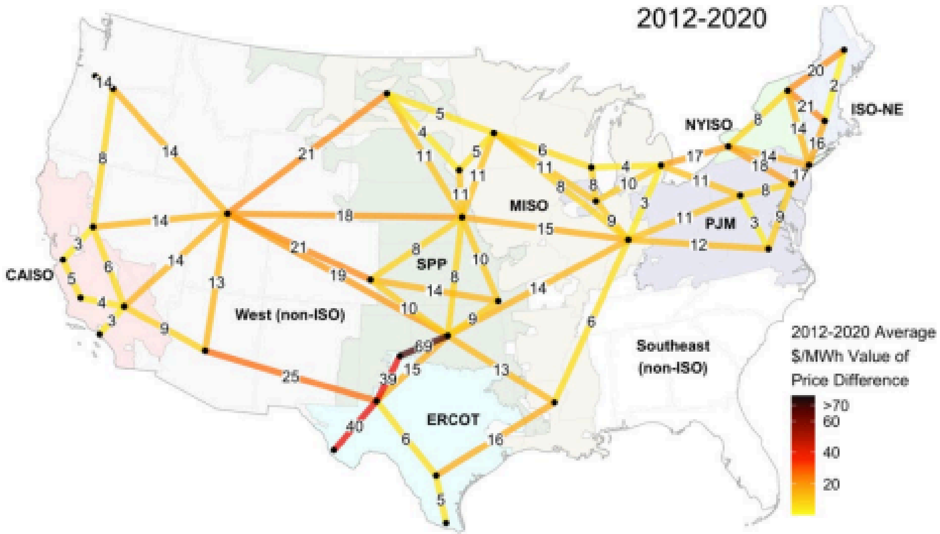
Exhibit 9



Interregional transmission capacity as a percentage of peak load
Source: Reed, L., & Xu, Andrew, "FERC is coalescing around the idea of minimum transfer capacity but needs data and definitions," Niskanen Center, September 8th, 2022

There exists limited transmission capacity between U.S. regions, often less than 15% of peak load, indicating significant constraints on power transfer across regions. This fact underscores the need for expanded interregional transmission infrastructure to enhance grid reliability and energy distribution.

Exhibit 10

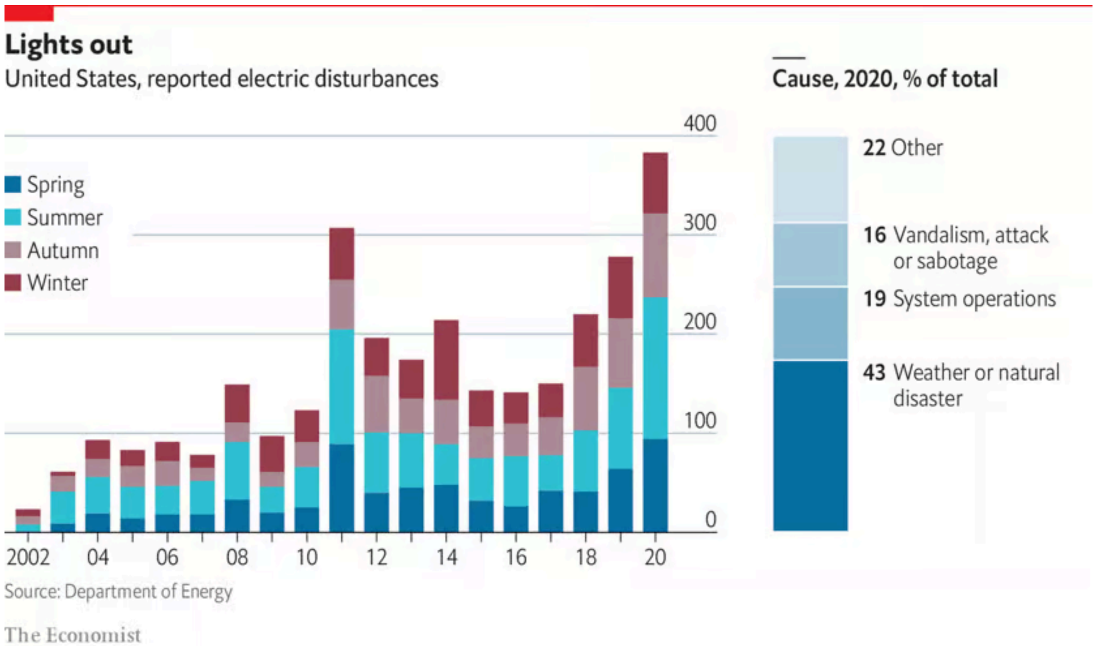


Source: Lawrence Berkeley National Laboratory (Millstein et al. 2022b).

Average price differences across U.S. power regions (2012–2020)
Source: United States Department of Energy, "[National Transmission Needs Study](#)," 2023

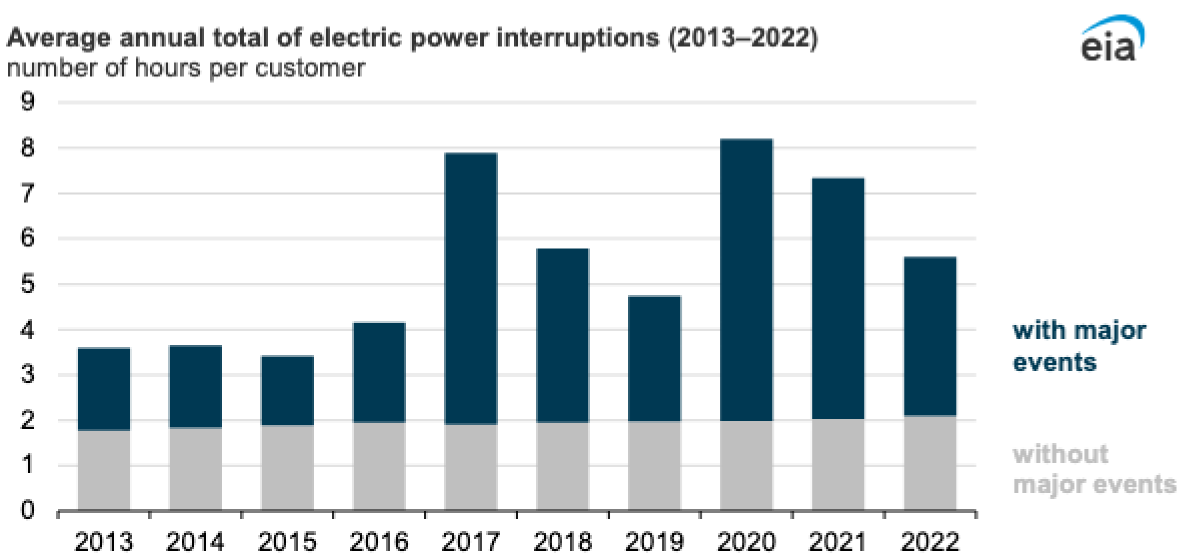
There exists significant variation in electricity prices across U.S. regions from 2012 to 2020, with larger price disparities, particularly between regions like ERCOT (Texas) and its neighbors.

Exhibit 11



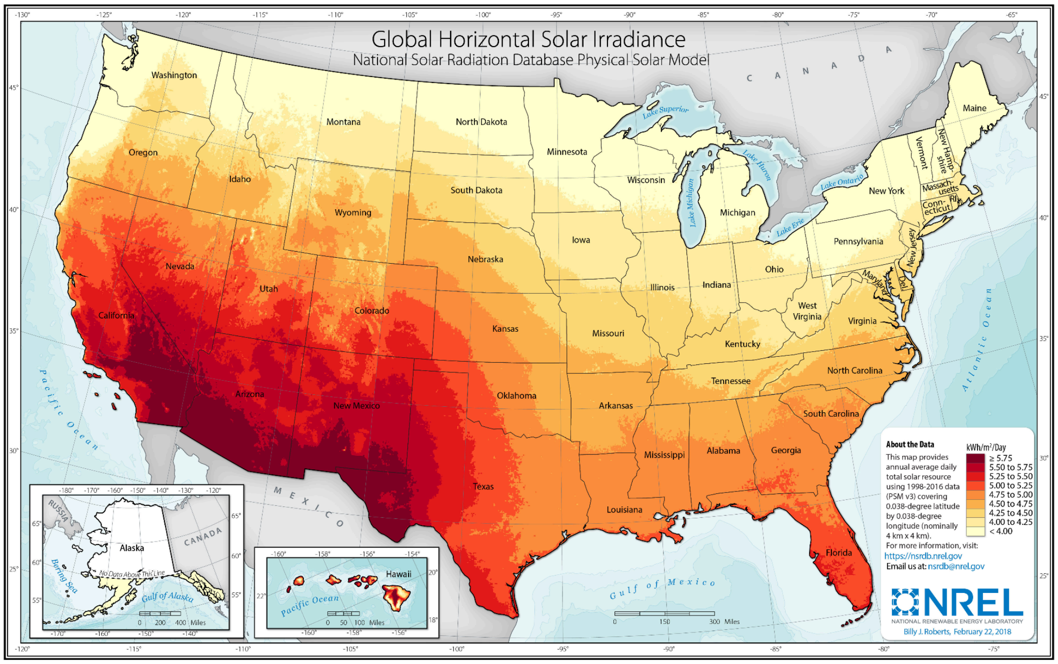
U.S. electric disturbances by season and cause (2002–2020)
Source: The Economist, "Power outages like the one in Texas are becoming more common in America," March 1st, 2021

This chart points to a marked increase in reported electric disturbances in the U.S. from 2002 to 2020, with weather and natural disasters accounting for the largest share in 2020. Seasonal variations indicate that outages are more frequent in winter and summer, underscoring the growing need for grid resilience amidst changing climate patterns and extreme weather events.



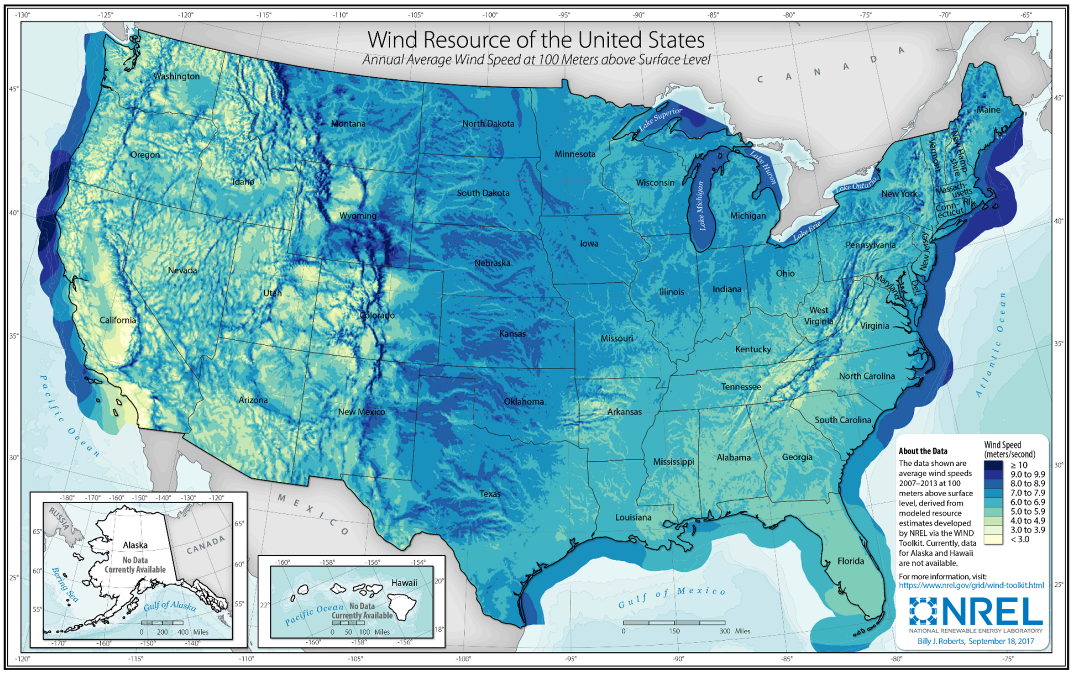
Average annual total of electric power interruptions (2013-2022)
Source: US Energy Information Administration, "In-brief analysis January 25, 2024 U.S. electricity customers averaged five and one-half hours of power interruptions in 2022," January 25th, 2024
This chart highlights the substantial spike in power interruptions after 2020, many. of which were caused by winter storm Uri, severe heat domes, and other extreme weather events.

Exhibit 12



Global horizontal solar irradiance across the United States
Source: Source: Roberts, B. "Global Horizontal Irradiance," National Renewable Energy Laboratory, February 22nd, 2018

The southwestern region of the United States receives the nation's highest levels of solar energy, underscoring the importance of the region's transmission infrastructure to distribute this renewable energy to other parts of the country.

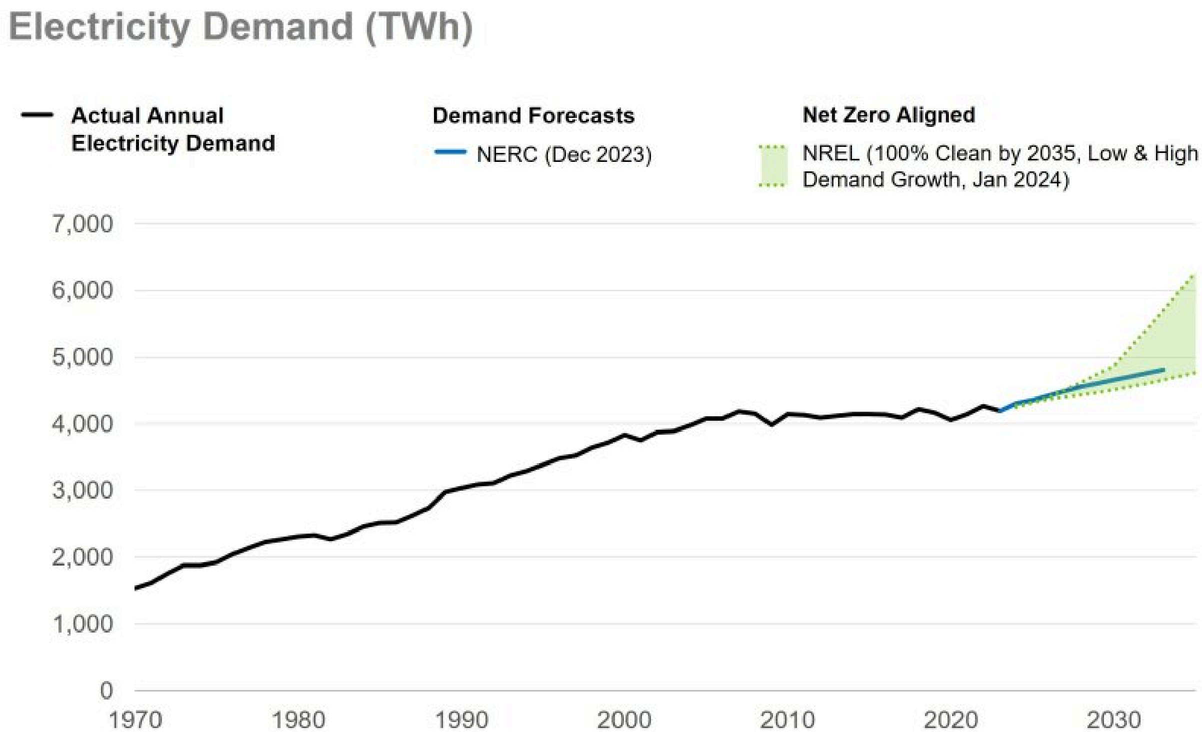


Wind resource distribution across the United States
Source: Source: Roberts, B. "[Wind Resource of the United States](https://www.nrel.gov/grid/wind-toolkit.html)," National Renewable Energy Laboratory, September 18th, 2017

The nation's highest wind speeds are concentrated in a north-to-south strip through the central states as well as the western and eastern seaboards.

Exhibit 13

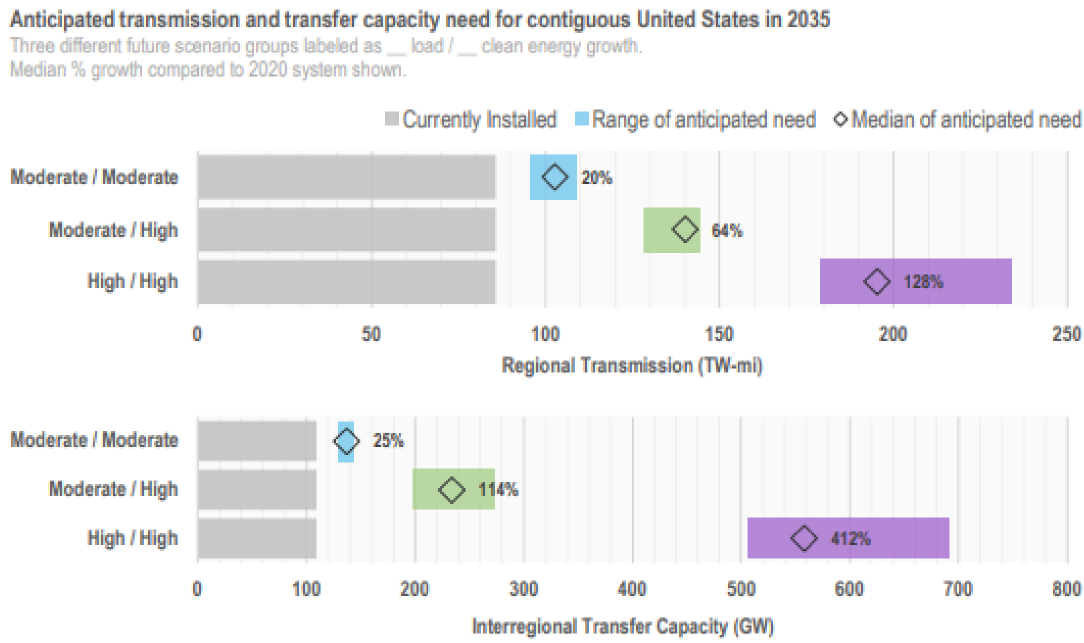
Figure 1: U.S. Electricity Demand (1970-2035)



Projected electricity demand growth and net-zero alignment (1970–2035)
Source: US Department of Energy, "[Clean Energy Resources to Meet Data Center Electricity Demand](#)," August 12th, 2024

There has been a steady rise in U.S. electricity demand from 1970 to 2020, with projections indicating a significant increase by 2035, especially under net-zero alignment scenarios.

Exhibit 14

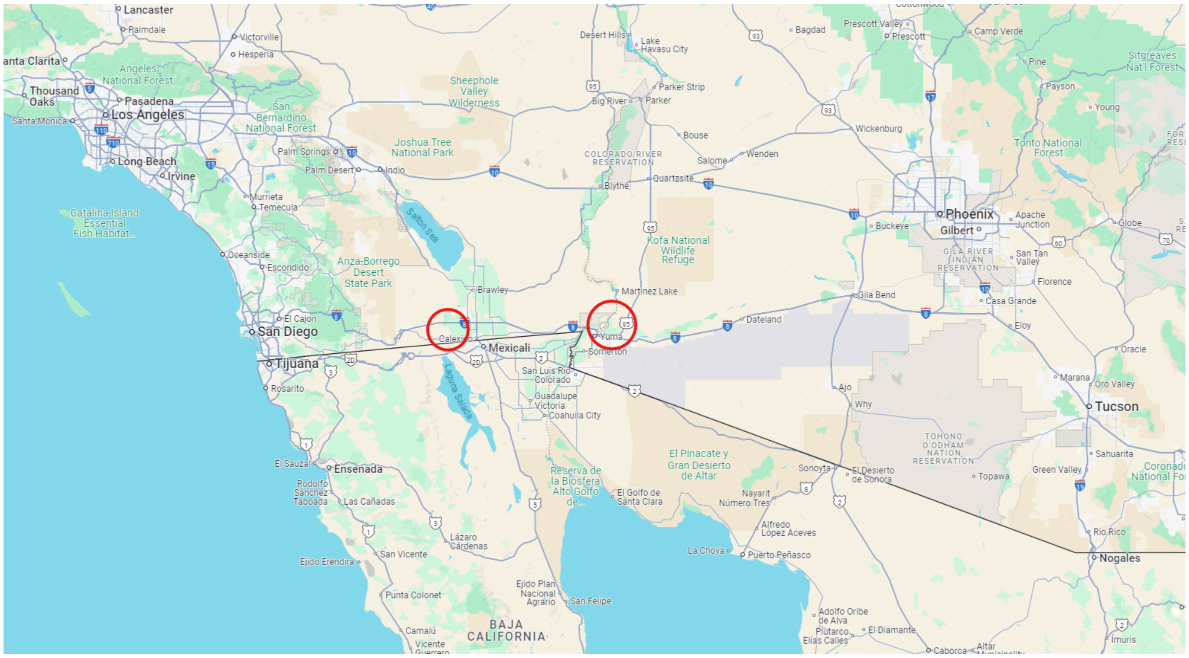


Note: Median and interquartile range of within-region transmission and interregional transfer results for six different recent capacity expansion models shown. Currently installed transmission and transfer capacity as pictured from Denholm et al. (2022a). Considered scenarios are categorized into groups by their future load and clean energy growth, respectively (e.g., ***High*** *load/****High*** *clean energy growth).*

Projected transmission capacity needs for the U.S. by 2035
Source: United States Department of Energy, "National Transmission Needs Study," 2023

The chart projects a significant increase in both regional and interregional transmission capacity needs by 2035, with up to 128% growth for regional transmission and 412% for interregional transfer in high-demand, high-clean energy scenarios. Such needs emphasizes the critical importance for substantial grid expansion to support the future clean energy transition and rising electricity demand.

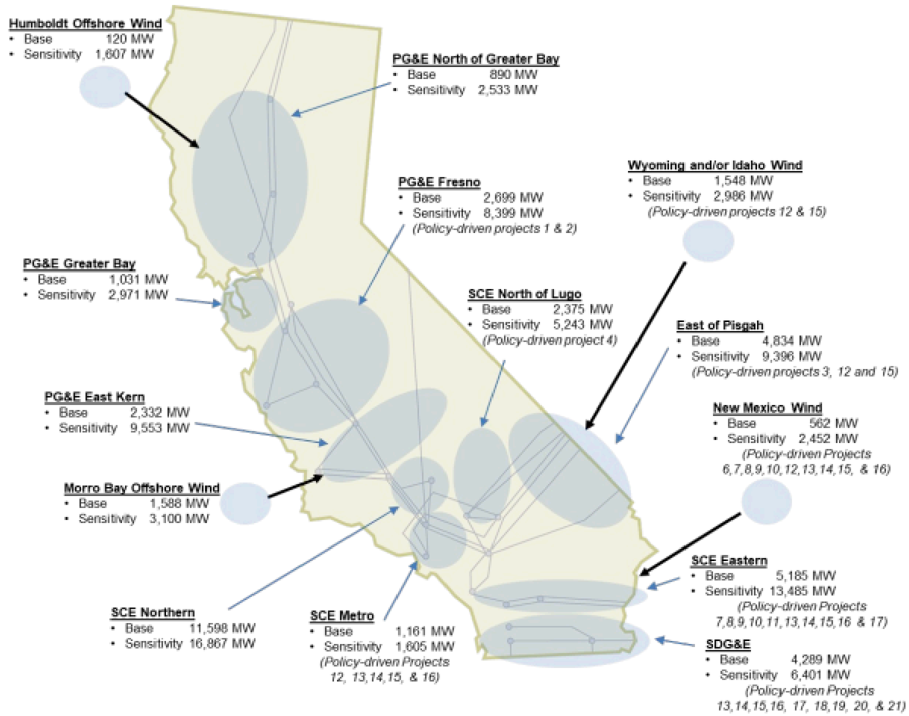
Exhibit 15



Proposed NGIV2 transmission line route between North Gila and Imperial Valley
Source: Adapted from the Grid United NGIV2 Application to the California ISO

This map illustrates the strategic placement of the proposed NGIV2 transmission line, designed to connect the renewable-rich areas of Arizona and New Mexico with the high-demand regions of Southern California.

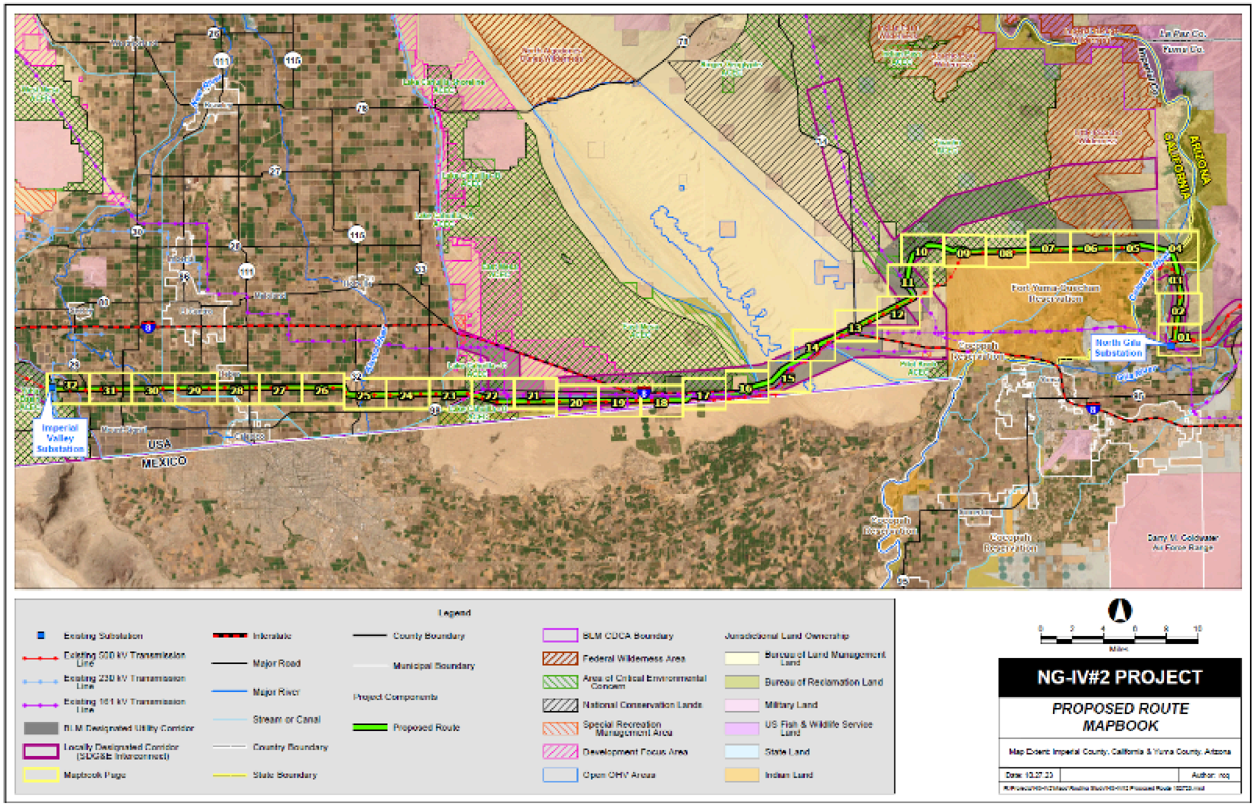
Figure ES-1: Transmission Planning Zones and Capacity



California transmission planning zones and capacity projections
Source: Adapted from the Grid United NGIV2 Application to the California ISO

This map identifies key transmission planning zones across California and the surrounding regions, highlighting both current base and potential sensitivity capacities, particularly in areas with high renewable energy potential like offshore wind and solar. It underscores the strategic focus on connecting diverse renewable sources, such as offshore wind and solar in areas like Humboldt, Morro Bay, and the Greater Bay, with high-demand centers

Exhibit 16



Proposed NGIV2 transmission line route through California and Arizona
Source: Adapted from the Grid United NGIV2 Application to the California ISO

This exhibit shows the proposed route for the NGIV2 transmission line, highlighting its path through various land types, including federal, state, and tribal lands, as well as areas of critical environmental concern. The route's careful design reflects the complexity of balancing infrastructure development with environmental, legal, and land-use considerations