June 2024

CROSSED WIRES

A Salata Institute-Roosevelt Project Study of The Development of High-Voltage Transmission Lines in the United States

CLIMATE ACTION ACCELERATOR
Salata Institute for Climate and Sustainability
Harvard University

Crossed Wires:

A Salata Institute-Roosevelt Project Study of The Development of High-Voltage Transmission Lines in the United States

June 2024

Principal Authors

Stephen Ansolabehere
Jason Beckfield
Hannah Dobie
Major Eason
Pranav Moudgalya
Jeremy Ornstein
Ari Peskoe
Elizabeth Thom
Dustin Tingley

Additional Contributors:
Parrish Bergquist, Daniel Alain Evrard, Quinn Lewis, Ana Martinez

Introduction

The electricity grid in the United States stands as one of the great success stories of the nation's industrial development in the 20th century. Over the course of the past 100 years, the grid developed from uncoordinated networks of wires in just a few cities into a highly reliable system that delivers electricity to nearly every household in America, as well as supporting commercial, manufacturing, and industrial sectors of the economy. At the beginning of the 21st century, the electricity infrastructure of the U.S. must be renovated and expanded substantially to meet growing demand and maintain reliability and low prices.[i]

More important still is the need to reduce greenhouse gas emissions dramatically and quickly over the next 25 years, and that requires an even greater expansion and reconfiguration of the U.S. electricity grid. The need to lower greenhouse gas (GHG) emissions demands that we both decarbonize electricity generation and increase use of electricity in transportation, industrials, and other sectors. Reducing greenhouse gas emissions will require even more fundamental changes in the electric grid because the areas of the continent with the highest capacity to generate electricity using wind, solar, dams, and other low-GHG sources of electricity are far from the industrial and urban centers of the U.S. The Plains States have the highest potential for on-shore wind. The Southwest has the highest potential for solar. Canada has the highest potential for hydroelectric generation. Much of the coastal United States has high off-shore wind potential. Connecting these areas to industrial and urban centers requires greatly increasing the extent and capacity of the nations' electricity transmission system.[ii]

Such changes in the scale, location, and type of electricity generation technologies will bring social and political conflict. The choice of wind or solar power located far from existing industry or cities means that the U.S. will favor the firms that operate those distant generators over local power plants, which in most cases operate using natural gas or coal. Approximately 200,000 people work at electric power plants fueled by coal or natural gas, and most of these are relatively high-paying, unionized jobs.[iii] Of course, there will be new transmission, wind, and solar jobs created, but not in the same locations. Moving away from local fossil-fuel generation to more distant wind and solar electricity generation will likely create opposition from the companies that operate existing power plants and the people who work at those power plants. Building a new network of long-distance transmission lines that connect areas with high potential wind and solar generation requires traversing thousands of miles of land—farmland, tribal land, rural communities, and ecosystems. Even groups that would be naturally sympathetic to the decarbonization effort find the scale and extent of these long-distance transmission lines difficult to accept.[iv]

This study examines the legal and political institutions and the social context within which transmission lines are built in the U.S., and the challenges that an aggressive expansion of the grid face. We focus on one aspect of the grid: long-distance transmission lines. There are many other important pieces to the overall system, including generation, storage, and local area distribution. Several recent studies—specifically, the Department of Energy's National Transmission Assessment of 2023, the National Renewable Energy Lab's 2023 Transmission Study, and Princeton's Net-Zero America study in 2020—offer a technological road map for different ways that the U.S. can develop its long-distance electricity transmission system to help the nation meet net zero goals by 2050. These studies are the starting point for this inquiry by laying out a picture of *what* the future electricity transmission system might be. Our analysis is not tied to a net zero goal, but rather analyzes the social, legal, and political challenges of a significant increase in long-distance transmission lines. Substantial increases in electricity demand and transmission might be required in even shorter time frames, such as the next two to five years, in some parts of the U.S. to meet spiking demand for electricity driven by rapid growth in data centers.[v] It is unclear whether that demand will be met by increasing fossil fuel infrastructure or, alternatively, with renewables.[vi] Either way, the U.S. needs to expand its long-distance transmission capacity significantly—and quickly.

The scale of development called for in the DOE, the National Renewable Energy Laboratory (NREL), and Princeton assessments is ambitious, but not impossible. NREL's 2023 report, for instance, suggests that the U.S. will have to double the number of gigawatt miles of electric power lines over the next 25 years. That would be akin to building power lines at the rate they were constructed in the 1960s and early 1970s, when the U.S. built approximately 8,000 miles of transmission lines annually. Currently, the nation is building about 3,000 miles per year. The challenge in building long-distance transmission over the coming quarter century is not simply a matter of how much gets built and how fast, but where those lines are constructed.

This study examines *how* we get there: the process for developing, scrutinizing, and approving long-distance transmission lines. We examine, side-by-side, the regulatory, economic, and social challenges that arise with the development of long-distance transmission lines. These different layers and aspects of long-distance transmission lines speak to one another, though they are often analyzed in isolation. For example, as discussed in the regulatory analysis, public utility commissions often focus on the benefits and costs of transmission lines as they are reflected in energy prices. However, as discussed in our economic analysis, many of the economic benefits and labor force demands of grid development are outside the scope of the cost-benefit analyses relied on by state public utility commissions, as are the effects of electricity infrastructure on local employment. Electricity development has substantial implications for local energy jobs, local tax bases, and other economic and social considerations. Bringing these into the picture will require changing the way public utility commissions and other entities make decisions.

Much of the conflict over transmission lines that results in long delays of projects stems not from the economic consequences or from the regulatory process per se. Rather, substantial delays arise from the lack of public acceptance of transmission line projects. The conflict between developers' plans and communities needs and interests spawns political opposition to projects. Such opposition leads to conflict over granting easements at the local level; it can lead to interventions and investigations by state legislatures; it results in lawsuits that can wind their way through the court system over the course of many years; and it can even generate referenda to re-route or stop the development of power lines. Most of these problems are avoidable, but they require a shift in the way firms relate to communities and the broader public.

It is evident to us that the process for developing long-distance transmission lines is broken. Transmission projects around the country today have taken at least 15 years to get from the design stage to the final project approvals to begin construction. That is simply an unreasonably long lead time.

Reform of the process should follow a simple goal: figure out how to shorten development times from 15 years to 10 years, or perhaps 7 years, without sacrificing equity or environmental standards.

This study describes the processes for development of transmission lines, from goal setting to permitting to public approvals. The first chapter of this study lays out the institutional context of grid development and, in broad terms, the technical architecture envisioned by the Department of Energy and the NREL. The second chapter lays out the existing regulatory landscape that will govern the planning, siting, and permitting of such an infrastructure development. The third chapter explores the role the public may have in the creation of a 21st century electricity system in the U.S. Here we draw out an essential lesson of this study: Local communities and the public broadly should be treated as a partner in the development of new electric transmission infrastructure. The fourth chapter examines the economic benefits of developing a grid that meets net zero goals and considers possible workforce and supply constraints.

In tandem with this study, we have explored transmission line developments in four different areas of the country. These states and locales are currently grappling with the challenges presented by developing long-distance, high-capacity transmission lines. Three of these cases are specific transmission lines: (i) the New England Clean Energy Connect (NECEC) power line in Maine, (ii) the Grain Belt Express power line extending from Kansas to Indiana, and (iii) the Gateway West power line connecting Wyoming to eastern Oregon. And one case study examines an alternative process: the Texas Competitive Renewable Electricity Zone (CREZ). All four cases also involve different developers and different strategies taken by those developers to build long-distance transmission.

We draw lessons from these cases, especially in developing recommendations for how to improve public engagement in the process. One of the biggest lessons from these cases is that the existing development process is ill-suited to meet the nation's growing demand for electricity and the need to reduce our greenhouse gas emissions.

The NECEC, Grain Belt Express, and Gateway West projects are all distinct in design and scope. Different sorts of developers pursued different strategies in each of these contexts. Two of the lines went largely through private property; one went through federal lands. Grain Belt was developed by a merchant firm operating independently of any state; NECEC was the product of a state's request for proposals to develop a transmission line; Gateway West was led by two utilities (Idaho Power and PacifiCorp). Regardless of what sort of entity developed the project and whether it went through private or federal lands, all have taken about the same length of time to get to the point at which they are actually being built: 15 years. That pace is surely too slow if the U.S. is to meet its renewable energy goals.

Our assessment is that the nation is at an important moment in the development of its electricity infrastructure. There are substantial opportunities to improve the way we build infrastructure and, in doing so, further our national climate goals. Here we highlight important conclusions and their implications. Each chapter of this study also provides more specific takeaways and recommendations.

Five common themes emerge from our analysis of institutional and social context in which long-distance transmission lines are built in the United States.

(1) Lack of a guiding vision makes it hard to justify specific projects, and it makes it difficult for people to accept them. There is no grand design, as there was with the federal Interstate project, that shows generally where long-distance transmission is needed and that lays out the economic, environmental, and social justifications for development in these areas.

Recommendation 1: The national government needs to articulate a common vision for transmission infrastructure development.

(2) Development in a federal system is risky and difficult. Interstate and inter-regional lines are needed, but permitting, siting, and planning are usually done within states. Economic

benefits from a transmission line in another state are not valued in the cost-benefit assessment that informs the deliberations of a public utility commission or state legislature. When lines run through multiple states, the risks of failures and delays are only multiplied. The federal system presents barriers to planning and development of transmission lines. There are promising developments of regional planning, such as the recent long-term planning initiatives of the Mid-Continent Independent System Operator (MISO). Such efforts will need to be expanded considerably.

Recommendation 2: The Federal Energy Regulatory Commission (FERC) should require utilities to participate in long-term transmission planning processes modeled after MISO's model.

(3) Public engagement often comes too late in the process. Common refrains in our interviews were that people did not feel listened to and that companies and state and local governments began to engage with them late in the process, when designs were already solidified. Even marginal changes in the lines were not possible, leading to an "all or nothing" conflict over permitting. Involving communities and local people early in the design and development process is something that companies and governments can do. That might increase the amount of time needed early in the design of a transmission line, but it will likely save more time later in the process, because many public concerns will have already been addressed.

Recommendation 3a: Companies should put in place processes in which there is continuous engagement with communities throughout the design and development process. Engage communities and local land holders as early as possible in projects, possibly even in the design stage of projects, and maintain that engagement throughout. Engage communities as partners in developments, rather than as obstacles.

Recommendation 3b: State governments should engage the public in setting goals for transmission development. State governments should establish public evaluation and assessment processes that include a broad set of stakeholders. This process should consider not one project at a time but an entire portfolio of projects. That would allow the state to make more equitable siting, such that some communities do not bear the disproportionate burden of infrastructure development without appropriate compensation.

(4) There is a lack of trusted information and trust in communications about projects. Trust in developers and local governments is vitally important to people. When that is lost, it becomes doubly difficult to gain public support in the quest for approval from legislatures, public utility commissions, and other government bodies. In many instances, lack of transparency, poor firm reputations, and other communication problems created public distrust and heightened public opposition to projects. That, in turn, created delays that allowed other opponents, such as incumbent firms and environmental groups, to mobilize or strengthen their opposition. A critical problem in public discourse about these projects is the lack of objective information about power line projects. There was no state or federal office that provides reliable, trusted information about proposed projects. Instead, citizens depend on either the developer or the opponents of projects for information. This can lead to conflict over and distortions of basic information about proposed projects.

Recommendation 4: State governments need to provide a clearinghouse of information about proposed projects in their states. Citizens must be able to readily find basic facts about the location of proposed power lines, the surrounding environment and communities, economic and environmental costs and benefits, and other proposed lines and locations of the project.

(5) To meet net zero goals by 2050, the U.S. needs to speed up development of long-distance transmission lines, but speed often comes at a social cost, especially to marginalized communities. Rapid development of transmission lines requires expediting the normal permitting and siting processes. Numerous stakeholders (including supporters of projects) said that speeding up the permitting review process may lead to approval and development of many inferior projects. Moreover, shortening the time for permitting and siting may increase the political leverage of those who are already most influential. When time for review is short, only firms and organizations that are ready to oppose a project or are already engaged will be prepared. This can be a recipe for worsening environmental justice concerns as the groups that have excluded from the process in the past are even less likely to engage in a system in which permit times are simply shortened.

Recommendation 5: The DOE needs to perform an assessment of the entire development cycle of transmission lines (from early-stage planning to construction), interstate transmission lines and off-shore wind lines. That assessment should determine what points in the process account for the longest lead times in project development and identify where faster development processes might generate adverse consequences. The goal of this assessment should be to set a reasonable target for final approval of projects and to work for reforms that get the process closer to that goal, without backing off from existing environmental standards.

The chapters that follow provide the foundations for these observations and present more specific recommendations related to each of the themes raised in this introduction.

Chapter One: Institutional Context and Architectures of a Future Grid

The U.S. electricity grid is a complicated technical, economic, and political system. Technically, the grid consists of transmission lines, substations, transformers, and storge that link power plants generating electricity to end-use consumers. Economically, the electricity grid is managed by companies that buy and sell electricity for delivery to consumers. Consumers in many states are served by competitive wholesale markets for electricity in which load operators (usually a local utility) buy power from generators and merchant operators; some states are served by a monopoly firm that owns generation and transmission. Politically, the electricity grid is the product of and is constrained by thousands of different organizations[vii] that make decisions regarding its development and operation, including public utility commissions (PUCs), state legislatures and agencies, regional transmission organizations (RTOs), and the Federal Energy Regulatory Commission. All of this is nearly invisible to the over 140 million households and millions of companies who get their electricity at the flick of a switch.

For all its complexity, Americans are generally happy with the existing electricity system in the United States. In a survey conducted by YouGov for this report, 80% of the public rated the electric grid as "Excellent" or "Good." It is the highest-rated infrastructure system in the nation, more highly regarded than our highways, airports, water, and sewer systems, and even the Internet. Americans' satisfaction with the existing electricity grid reflects the remarkable success of the system to deliver electricity reliably, nearly everywhere across the continent, at reasonable prices.

The success of the American electricity grid reflects the value of long-run planning and development and reforms that have improved the efficiency of the system. Simply put, we are reaping the benefits today of the overdevelopment of power lines in the 1950s to the 1970s and in institutional and market reforms in the 1990s and early 2000s.[viii] The United States, however, finds itself at an important juncture in the development of its electricity system generally and in long-distance transmission in particular. The reasons are two-fold. First, we are approaching the limits of existing transmission capacity, and new capacity has developed very slowly over the past three decades. To meet growing demand for electricity, we will need to build more transmission capacity.[ix] Second, we now face new challenges that will require the U.S. to think differently about how it develops its electricity grid.

The planning, development, and operation of the U.S. electric grid optimizes and improves on many different objectives. The primary objective, though, that the electricity system optimizes is, above all others, <u>reliability</u>. The electricity grid requires that power lines maintain a steady frequency of 60 Hz. To maintain this steady frequency, transmission managers must balance supply and demand at all times. Deviations from that, caused when events such as storms disrupt the system or when generators cannot deliver enough power, lead to brownouts and blackouts. Once common, large-scale power outages are now relatively rare in the U.S. [x]

Of course, there are other factors that governments, companies, and other organizations involved in planning the grid consider when siting, permitting, and building electricity lines, power plants, and other components of the grid. These objectives include:

- maintaining low retail prices of electricity
- economic development
- equity
- environmental protection
- national security

Elected state entities, or those accountable to governors and state legislators, are particularly concerned with the prices that consumers pay for electricity. State legislatures and governors often emphasize the broader employment and economic development implications of having a robust electricity system. Federal agencies tasked with regulating pollution, protecting habitats and species, and stewarding federal lands courts focus on protecting endangered species and enforcement of pollution regulations. While all of these are valued in the planning of the electricity system, reliability remains the main objective of the current system. As the Department of Energy surmised, "[t]he reliability of the electric system underpins virtually every sector of the modern U.S. economy." [xi]

Today we face the additional challenge of substantially reducing greenhouse gas emissions in the U.S. economy and achieving a net zero economy by 2050. Doing so requires decarbonizing electricity generation itself *and* expanding the network of long-distance transmission lines to use electricity to decarbonize transportation, industrials, and other sectors. Decarbonizing electricity will affect technical features of the architecture of the grid, such as the location of long-distance transmission lines and the capacity of those lines. The enormity and pace of the transformation of the U.S. electric grid will also present new challenges for the economic institutions that manage the delivery of electricity and the political institutions that must decide how and where power lines are placed.

The need to maintain a reliable electricity system and achieve other goals requires that the United States expand and modernize the grid. In 2021, before the passage of the Inflation Reduction Act, the National Renewable Energy Laboratory projected that the U.S. would need to increase its electricity generating capacity by 2050. Much of that, the NREL concluded, could be met with additional solar and natural gas-powered electricity generation and with a 25% increase in the number of miles of new long-distance transmission.[xii] In its 2023 report, the NREL projected an even steeper growth in long-distance transmission lines by 2050 to meet net zero GHG emissions.[xiii]

Building a new electricity grid on a national scale requires a clear mission. Such a vision would lay out where we need to develop long-distance transmission lines, akin to earlier initiatives to develop cross-continental railroads and interstate highways. It would also lay out the economic, social, and national security reasons for such development. Our interviews across the cases in the second part of this study echo this theme. Companies, state officials, and people in communities and environmental organizations all say that there is a need for a comprehensive vision of where we are headed and how we are going to get there.

The need for a clear vision of where we are headed is acute. That vision has the potential to guide people by framing current decisions as part of a larger goal. Humans are storytellers, and so a national narrative matters. We all want to know why we should care about grid development, and where we fit into the bigger story. Without such a vision to articulate a frame and a narrative, it is hard to justify why anyone would bear the burdens, displacement, and environmental damages associated with any given project that benefits some other community. Without such a vision the answer from communities and environmental groups might always be: "Put it somewhere else," or, "Don't build this at all." But a clear, compelling statement of the collective economic, health, and social implications of a new electric grid will help people understand what is being asked of them and see the long-term implications for their communities, their states, and for their country. A vision sets a frame that tells people what a grid development project is really about and articulates a narrative that tells people how our stories fit together.

This chapter presents two key aspects of the "architecture" of the grid. The first is the Institutional Architecture: the political organization and industrial organization of the electricity grid. The second is the Technical Architecture: the magnitude, location, and sort of long-distance transmission lines needed to meet a national net zero goal by 2050.

I. Institutional Architecture

The electricity transmission system of the United States is nested within economic and political institutions that determine who can build what, where, and why.

A. Industrial Organization

Historically, the U.S. electricity system consisted of local and regional utilities that provided all the power to a given area. Usually, these monopolies were vertically integrated, owning generation, transmission, and local distribution. In order to provide reliable service, these local monopolies often had to overdevelop infrastructure, leading to large amount of excess capacity, which still might not be enough to meet peak demand. Up until the 1980s, nearly all electricity was provided through such monopolies. [xiv]

Restructuring of state and federal electricity markets, especially the creation of regional electricity markets, radically altered the economic and political institutions through which electricity is distributed. Starting in the 1990s, the Federal Energy Regulatory Commission (FERC) issued a series of orders that opened utility-owned transmission lines to competing power plant developers and allowed for the creation of interstate power markets. New regional transmission organizations formed by utilities administer these markets and plan transmission expansion across their territories. [xv]

Over time, six regional markets have been formed under FERC's rules and subject to FERC regulation. These are the California Independent System Operator (CAISO), the Independent System Operator of New England (ISONE), the Midcontinent Independent System Operator (MISO), the New York Independent System Operator (NYISO), PJM Interconnection, and the Southwest Power Pool (SPP). In addition, the Electric Reliability Council of Texas (ERCOT) operates most transmission in Texas and is regulated by the state of Texas.

Not all utilities joined the RTOs. Outside of the six RTOs and ERCOT, there is no entity responsible for the markets and there is not a centralized market either. These other markets are the Southeast, the Northwest (Idaho, Montana, northern Nevada, Oregon, and Washington), and Southwest (Arizona, southern Nevada, New Mexico, and Utah). In general, each region is served by vertically integrated utilities. The Southeast Market is dominated by Southern Company and the Northwest by PacifiCorp. The federal government is also a major energy provider. The Bureau of Reclamation and Bonneville Power Authority are two of the main energy providers in the Northwest; the Southeast includes the Tennessee Valley Authority; and the Southwest includes has Western Area Power Authority. All of these are operated by the federal government. Today, in two-thirds of the country regional markets and transmission are administered by an RTO. [xvi]

The non-RTO areas are further divided into Balancing Authorities. In each Balancing Authority, a utility is responsible for dispatching generation (turning the power plants on), buying electricity, operating the grid, monitoring reliability, and ensuring that there are adequate reserves in the event of excesses in demand or equipment failure. One advantage of the RTOs is that they consolidate and eliminate multiple balancing authorities.[xvii]

The RTOs manage three essential wholesale markets. First, the Day-Ahead Market accounts for nearly all the electricity bought and sold to meet demand on a given day. Second, the Real-Time Market is typically run every five minutes to account for fluctuations in supply and demand. Third, some RTOs run an annual or monthly Capacity Market that aims to ensure the region has sufficient resources to meet peak demand. In addition, the RTOs engage in transmission planning that can shape the electricity markets in the future.

While FERC created the opportunity for RTOs to form and manage electricity markets, the RTOs themselves are voluntary organizations in which utilities, merchant generators, and other market participants can be members. In some RTOs, only market participants are voting members. The advantage of joining an RTO derives from its scale. In a midsize state, there may be a few dozen large generators available to provide power. Weather events, such as hurricanes or heat waves, may similarly affect all generators and threaten the system's ability to provide enough power. In a regional market managed by an RTO, there may be 1,000 different generators across a broad geographic range, and thus not susceptible to the same weather events that can disable power plants. In addition, the large number of providers willing to offer energy into the market helps to lower prices. In a big, connected market it is easier to find a generator to sell power, thus keeping costs low and supplies reliable.

One of the largest issues for the next phase of grid development is how to handle inter-regional connections. We have not one grid, but several regional grids. Each region engages in its own planning process and manages its own market. The interconnections are both power lines that run power from one of the regional markets to another, and interconnections are contracts to deliver power on a wholesale market. Both the technical and institutional boundaries of the grid limit the efficiency of the grid to operate as a truly national electricity system and market. The implications are limitations on the efficiency of the U.S. electricity system and higher prices for consumers, especially when there are severe weather events that increase consumer demand and disrupt the supply of power. The lack of interconnections is a potentially massive restriction on our ability to develop a new electricity grid.

Building sufficient transmission capacity and improving interconnections across the regional boundaries are essential for improving the stability, capacity, and competitiveness of the regional markets. Efforts at interregional transmission expansion are underway, but these initiatives will need to be scaled up to meet projected demand increases and net zero goals. And many of the largest interregional transmission developments underway are being done by merchant developers, not RTO planners. In the cases we cover in our companion report, utilities are developing Gateway West, and Grain Belt Express and NECEC-Hydro-Quebec are merchant projects.

B. Politics of the Development Process

While much of the decision making about transmission lines is made by firms, especially utilities, planning and development of electric transmission lines occurs in the states, the RTOs, and at the federal level, FERC. State PUCs and state legislatures are key venues for permitting, siting, and assertion of eminent domain. The RTOs themselves have no independent political authority, but they have emerged as important forums for planning. RTOs have evolved into the institutions in which the many stakeholders in the electricity grid in a region can engage with each other and plan future transmission development.

Each RTO has its own decision-making and planning processes, and distinctive cultures. By all accounts, the utilities remain the central players to the process. Our interviews have suggested that the utilities try to protect their market share in the RTO arena. The utilities often make it hard for new entrants, and, when a change in the market is coming, they use their position with the RTOs to insulate themselves. For example, a merchant firm that owns an inter-regional line may have to pay for upgrades to utility-owned assets that are needed to accommodate the merchant project. For utility projects, upgrade costs are shared across the region. That distinction affects how the merchant is treated in determining who pays what (cost allocations), which in turn affects whether lines get built in the first place. Efforts to build new long-distance lines creates discomfort for utilities and conflict within the RTOs as the new lines can reduce the profits of the incumbent utilities and generators.

States' Renewable Portfolio Standards (RPS) also create other fault lines within the regional markets. Differing state policy objectives can lead to disagreements about the goals of regional transmission planning. If some states in an RTO have more aggressive renewable standards than other states, then the states with the more aggressive RPS may favor planning for more renewable transmission.

These tensions between states are evident in public meetings about transmission siting, in RTO public meetings, and in state legislatures and PUC meetings. The policies of one state can become a source of resentment in the other. A case in point is the NECEC line in Maine. This line would connect hydro power from Hydro-Quebec to a connection in Lewiston, Maine. The state of Massachusetts put out an RFP to build the line in order to access hydro power to meet it greenhouse gas goals. Opposition to the line before the Maine Legislature and the Maine PUC, as well as discussion of the project within ISO NE, highlighted the out-of-state initiative driving the line and concerns that Maine absorbed the economic, social and environmental cost of a project that helps Massachusetts meet its greenhouse gas emission limits.[xviii] These tensions among state interests within the regional markets are already present in planning discussions.

The conflicts examined in the case studies presented in our companion report are a small taste of the future political conflicts that the development of a net zero grid will necessarily create. We anticipate that the scale and pace of transmission development required to meet a net zero goal by 2050 will create tensions within RTOs and between them. Interregional and interstate lines are bound to cross through large swaths of territory to deliver renewable energy from where it can be cheaply produced to larger markets. A pass-through state may not value that form of generation, and the line may not have a drop that would improve electricity service in the communities through which it passes. The planning process within the RTOs and within the states will need to navigate the objections to proposed transmission lines that benefit people and industries located hundreds, even thousands, of miles away.

As discussed in the next section, the most prominent and respected studies of the Future Grid envision a Technical Architecture for a net zero grid that may be highly constrained and in conflict with the existing Institutional Architecture of the Grid. The proposed power corridors cut across the country, mostly running horizontally, west to east. The Western and Eastern Interconnection runs vertically, north to south. The MISO and SPP RTOs are also oriented up-down. They carve out long-swaths of the middle of the nation, running north to south. The power lines the nation will need to build run smack into the boundaries of the market and political institutions that are charged with managing our electricity system today.

At a very high level (state and region), there is a mismatch between the political process and the projected electricity development over the coming decades. Energy and industrial developments necessarily create conflicting interests, and Americans work out their differences in the state legislatures, the state Public Utility Commissions, and the RTOs. However imperfect those processes are, the simple fact is that the boundaries of those institutions do not line up with the sort of development that is required to decarbonize the grid. The misalignment between the institutions and the projected development will make the process for planning, permitting, and developing long-distance electric transmission lines a complicated, expensive process.

The fact that a power line will have to go through so many different institutions whose constituencies do not align with the power line, and likely do not benefit from it directly, will create openings and opportunities for opponents to power lines. In particular, the incumbent utilities and generators have a strong incentive to oppose any new entrants into their market. A new power line linking another generator will only lower the market opportunities for the existing firms. In the Grain Belt Express and NECEC-Hydro-Quebec cases, the incumbent firms fought hard to oppose and delay the proposed lines. This should come as no surprise; nor should we be upset or find this to be unethical behavior. These companies are doing what they can to survive economically and to serve their own constituencies, the investors and shareholders who own their companies. In fact, they have a fiducial responsibility to maximize their profits.

Our federal system, however, stacks the deck against what we as a nation want to achieve in this instance: a more efficient, economical, reliable, and environmentally sustainable electricity grid.

The complex, multi-institution permitting and market system opens wide the opportunities to oppose and delay transmission line development. A key question, examined in

Chapter 3, is what process of engagement and consideration of transmission projects is most appropriate, and what level of scrutiny of a project may be excessive.

There are two key pressure points in the political system that govern the development of the grid: (1) permitting, and (2) public engagement. The three interstate, interregional power line projects examined closely in this report all took roughly 15 years to get the point of final approvals. Legal and regulatory delays in permitting were a critical source of delay. In some instances, lack of state government capacity (sufficient numbers of people in the relevant offices to examine permits in a timely manner) was itself a source of delay. Fueling many of these legal and regulatory fights, though, was public discontent over the planning and development process to begin with.

Perhaps the most difficult nut to crack in this respect is the very first step in the process. The earliest stages of development of a project are usually heavily focused on the engineering design and finance of a project. These early phases often do not include effective public engagement and comment on projects, as we discuss in Chapter 3. As a result, new projects often come out of the design and selection process blind to potential objections from communities—and bereft of the kinds of relationships that can help in solving the inevitable problems projects face in the real world. We turn now to some of the technical aspects of grid development and where transmission projects often get stalled.

II. Technical Aspects of Grid Architecture

The grid consists of both long-distance and local electricity systems. The long-distance systems are high-voltage power lines that move electricity from generators to urban areas and commercial and industrial facilities. The local portions of the system consist of substations, transformers, local lines, and other technology that deliver lower voltage energy to consumers.

This study focuses on long-distance power lines. The technical, economic, and political issues around power sources and generators are thoroughly studied, [xix] though there are important grid architecture questions raised by the assumptions regarding the nature and location of generation. There are also substantial opportunities to improve the efficiency, reliability, and cost of the local systems, such as smart grid technologies, and in doing so reduce greenhouse gases.

We take as given the assumptions of the most important studies of grid development, including the National Renewable Electricity Lab's (NREL) 2023 study *Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035,*[xx] the Department of Energy's *National Transmission Needs Study*, [xxi] and Princeton University's 2020 study *Net-Zero America: Potential Pathways, Infrastructure, and Impact.*[xxii] These studies foresee the need for substantial build-out of utility-scale wind onshore in the Plains and offshore along the East and West coasts and of utility-scale solar in the Southwest. The Princeton *Net-Zero America* study further envisions substantial connections internationally between the U.S. and Canada in order to access wind and hydropower. New wind, solar, and hydroelectric generating capacity would have to be connected to the largest urban areas and industrial centers of the United States using long-distance high voltage power lines that cross state and even regional boundaries.

There are profound questions about the environmental implications, equity concerns, and cost of the development of power generation under these projections. We set those aside the issues associated with generation and instead focus on the constellation of issues arising from the projected expansion in long-distance power lines.

There are three dimensions to the technical architecture of the grid: (i) Scope, (ii) Scale, and (iii) Efficiency. Scope refers to the mix of generating technologies available. This report focuses on long-distance power lines rather than generation. That said, generation using wind and solar will require different locations of power lines than will generation using natural gas and coal. Scale refers to the amount of power line development: how many miles? How much land? Efficiency refers to how well the electricity system can use its resources. What sort of power lines are built where will affect how well the entire electricity system can function. For example, converting existing, older transmission lines to higher capacity, two-way transmission lines may achieve substantial improvements in efficiency without increasing the number of miles or amount of land used. Improvements in existing power lines can help the U.S. meet its climate goals, but changes in the scope (location) and scale of transmission lines is necessary.

(i) Scope.

The scope of the electricity system is the mix of technologies deployed on the grid. Perhaps the most important scope factor is the mix of generation deployed. Much of the current electricity system in the United States was developed for fossil fuel and nuclear power generation. The location of generation technologies has enormous implications for the transmission system. The existing configuration of transmission lines reflects the existing generation portfolio. Specifically, existing transmission infrastructure was developed to connect fossil fuel and nuclear generation to communities and industry.

Decarbonizing the U.S. electric grid requires a very different mix of generating technologies. The highest potential for wind generation is in the Great Plains and offshore. The highest potential for solar generation is in the southwestern United States. And there is enormous hydropower potential in Canada. These generation resources likely hold the key to decarbonization of the U.S. electricity system and industries. Accessing the regions of the nation with the highest potential to generate electricity using wind, solar, or hydro require building high-voltage long-distance transmission lines connecting these areas to urban and industrial areas.

We are agnostic about the optimal location of transmission lines over the coming decades. Reports from NREL, DOE, Princeton, and other modeling exercises show a similar overall picture. We will need to develop a large number of transmission lines that integrate the electricity grid, that cross state lines and regional boundaries, especially those running east-west, and that are much higher capacity than existing power lines.

Consider NREL's 2023 report, which presents six scenarios for long-distance power-line development in the United States over the next 15 years, from 2020 and 2035. The first scenario, shown in the first map in Figure 1, reflects the capacity of existing long-distance power lines as of 2020. The thickness and color of the lines denotes the capacity of the lines and type of line (AC or DC). Most of the lines are thin, indicating relatively low capacity to move energy.

The Reference ADE case (the second map) is a projection of likely grid development given current rates of growth and projected adoption of new generation technology without accelerated investment in grid development and related changes in policies. Notably, the Reference case is quite similar to the 2020 map. In other words, little change will occur without concentrated effort.

Not all investment in transmission will have the same effect on the ability of the grid to expand the contribution of low-GHG generation to our electricity grid. The Constrained scenario, shown in the third map in Figure 1, displays this insight well. Substantial investment in grid infrastructure would increase capacity of lines, but these new lines would be relatively short distance and largely intrastate developments, rather than the long inter-regional lines projected under an aggressive decarbonization.

What drives the Constrained Scenario are the political and market boundaries. To capture the potential of wind and solar power fully, the United States needs to develop high-capacity power lines that largely run horizontally: from the Plains eastward, connecting wind power to eastern cities or from the Mountain West region westward, connecting solar and wind to cities on the Pacific Coast. The problem is that doing so requires crossing many RTOs and ISOs and state boundaries. In this politically Constrained Scenario, the development of power lines horizontally across the U.S. will be frustrated by the vertical market and state boundaries.

Crossing multiple political boundaries results in constraints on land use and delays in permitting. These increase substantially the costs of development in ways that, under the Constrained Scenario, preclude development of interregional connections and make transmission five times more costly. The result is less development of wind generation, more storage, and higher costs.[xxiii]

The Fourth, Fifth, and Sixth Scenarios in the NREL 2023 report show what is possible if the United States can navigate those institutional constraints. The fourth scenario considers a future in which the U.S. develops wind, solar, nuclear, and fossil energy sources, and uses carbon capture technologies to deploy all possible ways of decarbonizing electricity. Under this scenario there would be a large deployment of long-distance power lines, primarily running in an east-west direction across the continent.

A system without carbon capture and sequestration, as shown in the fifth map, requires even more high-capacity long-distance transmission lines. Pushing natural gas and coal out of generation would create even more demand for wind and solar. Because gas and coal-fired power plants are in much closer proximity to urban areas in the eastern United States and along the Pacific Coast, eliminating fossil fuels will require still more power line development in order to meet decarbonization needs. This eventuality would require more land use and more conflict over equity and environmental concerns with the location of these lines.

The fifth scenario envisions advances in transmission technology and deployment of high-voltage direct current lines in an integrated macro-grid. This Infrastructure Renaissance would mirror the All Options scenario, albeit with much higher capacity per mile of transmission line. It would have implications for other aspects of the grid, especially the magnitude of utility-scale solar development.

These three scenarios—All Options, No Carbon Capture, and Infrastructure Renaissance—have remarkably similar architecture: a large number of interstate and interregional power lines will be required to connect wind and solar generated electricity to consumers. Similar simulations and projections developed by Princeton show the same general pattern of power line development.

A final aspect of the scope of technology is the nature of the lines themselves. What is the optimal capacity of lines? Should power lines be above ground or buried? Can they be collocated with other technologies and infrastructure, such as pipelines and highways? Where is storage (such as batteries) more efficient than placement of new power lines? What is the location of lines that would have the largest impact on the price of electricity, the reliability, and the rate of uptake in low-GHG energy sources?

These more specific features of grid architecture have important implications for the feasibility of power line development. Collocation of power lines and burial of power lines may be especially important to gain public acceptance and to minimize land-use and environmental impact. Satisfying public demand may increase construction costs, but it may speed up the permitting and approval process so much that burial or collocation becomes cost-effective. Some studies have investigated aspects of these questions. There has not yet been a thorough-going exploration of these issues in the context of a broader system architecture, such as the NREL and Princeton net zero studies. The next generation of these system-wide simulations should consider the implications of variations in technologies in minimizing delays or environmental impacts of transmission.

Burial and collocation of power lines is worthy of further systematic study. They are attractive architectural choices for power lines for aesthetic reasons. Burial and collocation work in tandem. Buried power lines near highways, railways, and pipeline reduces risks of accidents or damage from downed power lines, concerns that have led some states forbid above-ground power lines near highways and railway lines. Burial of power lines increases costs of installation substantially. One study indicates that burial of power lines can be up to 10 times more expensive than above-ground installations, and others put the cost closer to 3 to 6 times more than above-ground power lines. The primary reason for the higher cost is the need for insulation. High voltage power lines can be quite hot. When installed on towers above ground, air insulates and cools them. When buried, they must be encased in oils and other chemicals to prevent the lines from heating the ground. The insulation itself can be toxic and raises further environmental concerns.[xxiv] The SOO Green HVDC Link is an important test case for the viability of burial and collocations. SOO would connect Mason City, Iowa, to Chicago, Illinois, following railways and installed underground. The developers seek to accomplish this at 1.5 times the cost of above-ground wires. [xxv] One area for technological development, then, is improving the cost and insulation of below-ground HVDC lines.

One important near-term recommendation is that DOE and NREL embark on a series of national-scale studies of the economic, environmental (including land use and pollution), and social implications of different grid technology choices. Key factors in such a study include collocation with existing infrastructure, above-ground versus buried installations, line capacity, optimization technologies, and interconnections. More continuous study of these dimensions of grid development will better inform local and state governments, RTOs, companies, and citizens about the nature of the choices we face.

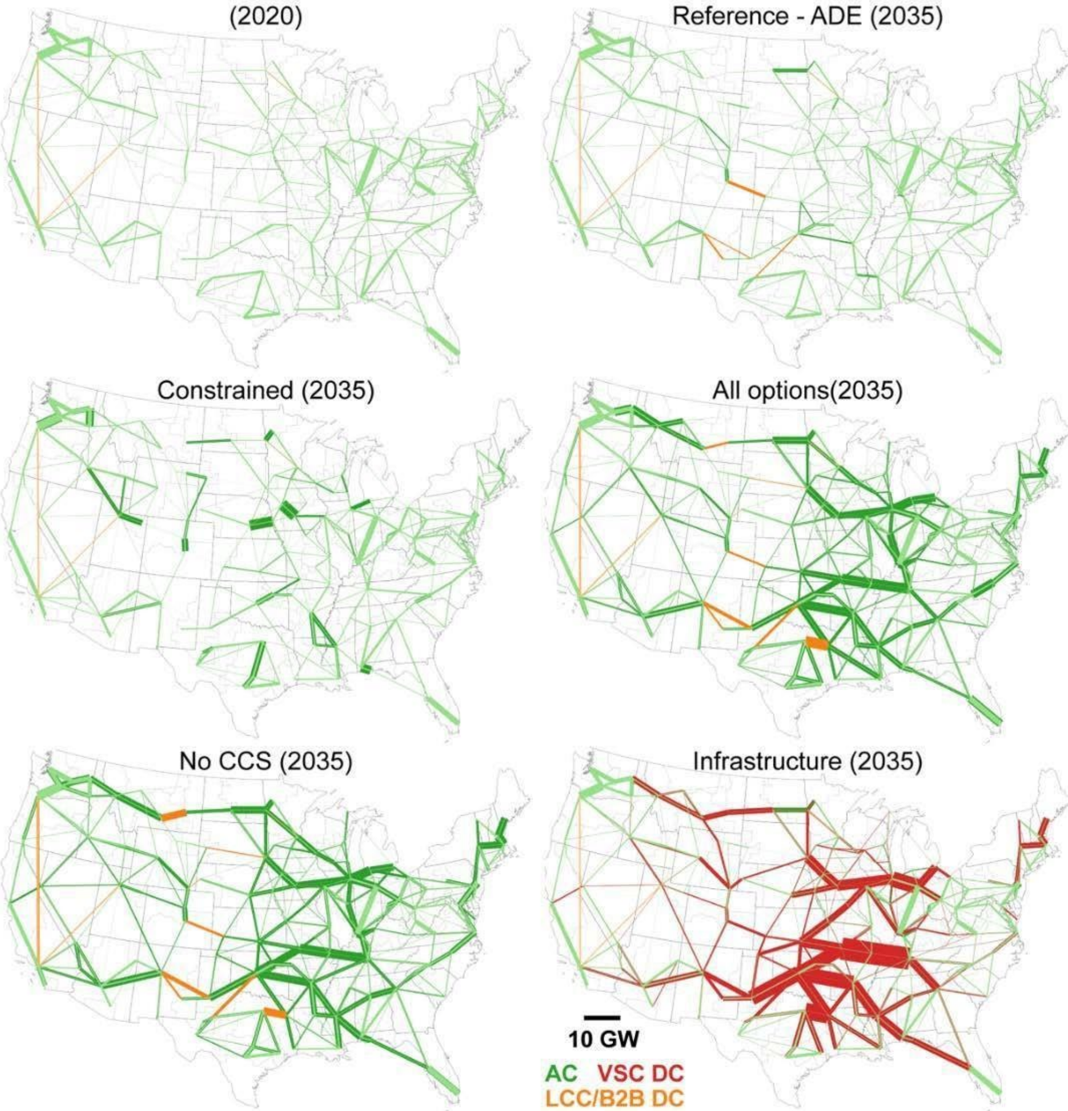

Figure 1. NREL 2023 Electricity Grid Scenarios

(ii) Scale.

Scale is the magnitude of projected transmission development. While scope has implications for where power lines are built, scale is simply a matter of how much. Scale can be measured in terms the miles of transmission line and the capacity of those lines. Scale is also reflected in land use, which is ultimately the heart of many political battles over transmission development. Every mile of line also encompasses a right of way, and, with that right of way, a swath of land devoted to that power line, an area comparable to the footprint of a large interstate.

According to the U.S. Energy Information Agency, the current electricity system consists of 7,300 power generators connected through more than 160,000 miles of high-voltage transmission lines that ultimately provide power to 145 million customers.[xxvi] Additionally, there are millions of miles of low-voltage power lines inside cities and other power generation sources, such as small-scale solar.

How big is the task of building an electricity grid that taps the enormous wind and solar energy potential of the country? The NREL 2023 and Princeton net zero studies arrive at nearly the same answer, though with different parameters in their simulations.

The United States will need to double or triple the size of its electricity grid. The NREL 2023 report, for instance, projects that building a 100% clean electricity system will require 330 to 420 terawatt miles of interregional transmission capacity (depending on the scenario) compared to 161 terawatt miles today.[xxvii] Ultimately, the calculation of how many miles of transmission lines are needed will depend on the capacity of those lines, the directionality of the lines (one-way or two-way), the need for redundancy, and other engineering, design, and political factors.

The reason for such a large-scale development is that a change in the scope of the grid (i.e., what generation is used) is required, and that change in scope increases the scale of transmission line development. If the U.S. were to build more nuclear power generators or deploy carbon capture along with natural gas and coal, then nation may not need to build as many long-distance power lines because those power plants could be located closer to cities, co-located with existing power generation, or on existing transmission lines.[xxviii] The choice of what power generation we want to use will drive where and how much transmission we must build. Likewise, if the United States wishes to open the electricity market to more wind, solar, and hydro power, the nation must build the transmission to support it. Most estimates, though, are that complete decarbonization of our economy requires something on the order of a doubling of transmission by 2050.

That's a lot of miles of power lines. But it is not impossibly large. For example, from 1965 to 1975, the United States built approximately 8,000 miles of transmission lines a year. Were the United States to build transmission at that rate for the coming two decades it would easily reach the projected transmission capacity of the NREL 2023 and *Net-Zero America* reports. Furthermore, over the past 11 years, the number of miles of new or upgraded transmission lines have grown to roughly 3,300 miles per year, compared to roughly 1,500 from 1985 to 2012.[xxix]

Another way to understand the scale of the proposed grid development is land use. The amount of land used by development is related to its potential impact on other industries (such as agriculture) and on the environment. The scale of grid development envisioned in the NREL, *Net-Zero America* and other projections will require a massive commitment of land. An assessment by the Samantha Gross of the Brookings Institution summarized existing studies and existing land utilization and concluded that renewable energy uses far more land than fossil fuels for every BTU of energy produced, and additional transmission built for wind and solar development would affect far more people and communities than does the location of existing fossil fuel generation.[xxx] The right of way for transmission lines, according to the NREL study, is between 20,000 and 30,000 square kilometers (7,500 to 12,000 square miles). That is roughly the same footprint as currently disturbed coal beds. It is only a fraction of the land used for livestock grazing and feed, which covers 41% of the land of the U.S.[xxxi]

Land availability has substantial implications for the configuration, cost, and speed of development of electric power lines. NREL's Constrained Scenario imposes constraints on land use (as well as other restrictions) and results in much less long-distance transmission than in other scenarios. These constraints also result in much higher consumer prices and much higher costs of achieving 100% decarbonization.[xxxii]

The scale of land required for transmission and generation in a 100% renewable grid may create conflict with other activities that use the same land, especially agriculture. Currently, proposed long-distance power lines are creating conflict between transmission developers and cattlemen and farming corporations in the Midwest, and these conflicts mobilize agricultural interests against power line development, as arose with the Grain Belt Express line.[xxxiii]

In addition, land use raises important equity concerns. Power lines run through rural areas, but they may not connect to or serve those communities directly. The fact that the transmission lines may use rural land to serve urban consumers often engenders resentment among rural voters and communities. Urban and out-of-state interests are easily villainized in political debates over development, as is evident in the NECEC, Grain Belt Express, and

Gateway West cases. The challenge for developers is to find some local benefit for rural communities from proposed power lines, as we discuss in Chapter 3.

Rural electrification and broadband internet access, which remain acute problems in rural communities, offer an opportunity to overcome these challenges and to solve long-standing inequities. Over the course of the debate over the Grain Belt Express line in Missouri, the planned delivery of electricity from the project to rural areas was increased substantially. In both the NECEC and Grain Belt Express cases, there were proposals to run broadband internet alongside the electricity towers to improve rural internet access, and to increase support for the developments in rural areas. Rural communities, then, bear a disproportionate burden for long-distance electric power line development. Transmission development represents an opportunity to improve rural electric service and other services, such as telecommunications.

Nowhere is this more evident than in Native American communities. Power line siting, especially in the western states, often runs near or through Native lands. Yet these communities tend to have limited access to electricity and other infrastructure such as fiber-optic cable and broadband. These issues are explored in greater depth in the Gateway West case study in the companion report and in Chapter 3 of this report.

(iii) Efficiency

A third technical aspect of the grid is its efficiency. How well does the architecture use and distribute the resources used for power generation? Efficiency itself might be taken as an objective of the system, and it is certainly shaped by the scope and scale of the system. Yet even with a system of a given size and a specified mix of energy sources, there are important decisions to be made about the configuration of the system to optimize its efficiency.

Efficiency itself is a resource that enters into decisions about the configuration of the grid. More efficient design of the architecture means fewer power lines and less land use. New technologies, such as storage or improved systems for load management, can reduce the total amount of generation needed to a meet a given level of electricity demand (or load). In addition, technologies and planning that can reduce the energy-intensity for industry, government, and households reduces total energy demand, thereby requiring less energy generation and transmission. Power industry efforts to reduce energy use are, on the whole, not prioritized over efforts to build new infrastructure. In general, utilities and other developers profit by deploying capital, not by encouraging efficient consumption. In many states, load reduction is supposed to be part of the integrated resource planning process. That efficiency is in practice often overlooked is a regulatory failure. Setting that aside, generation and transmission development are premised on load forecasts. To the extent that the utility or RTO forecasts lower load due to efficiency or economic activity, it is considered in development processes. An important question for planners and developers is how efficiency enters their decisions about the grid. For example, what improvements count in the assessment of costs and benefit?

The architecture itself can improve efficiency. The Midcontinent region is a good example of scale affecting efficiency. Before the 1980s, interstate trading among utilities was weak, which led utilities to build excess local generation capacity in order to meet local peak demands. The Midcontinent region creates a massive market for power that allows people to buy and sell power across multiple states throughout the Midwest. The development of an integrated regional market in the late 1990s allowed the industry to capture efficiencies of scale. By facilitating interstate trading, the new centrally administered market reduced the amount of excess capacity needed by each individual utility. Enhanced trading reduced power costs and improved reliability.

How does efficiency show up in planning? How do utilities, PUCs, and RTOs make tradeoffs among investments shape efficiency, some of which may lie outside of the conventional scope of grid managers?

Perhaps the most obvious high-level efficiency problem is the organization of our electricity grid into three broad regions: the Eastern Interconnection, the Western Interconnection, and the Electricity Reliability Council of Texas (ERCOT). These regions divide the country vertically roughly at the boundary between Montana (West) and the Dakotas (East). Kansas, Nebraska, and Oklahoma end up in the Eastern Region; Wyoming, Colorado, and New Mexico end up in the Western Interconnection. Most of Texas operates on its own. Very few power lines cross these regional boundaries. This creates reliability vulnerabilities. The challenges created by the regional interconnection system were exposed in the recent power outages in Texas. An unusually cold winter storm taxed Texas' electricity and gas systems resulting in outages and extraordinarily high wholesale prices. Texans' plight would have been lessened had ERCOT been better integrated into the surrounding electricity systems.[xxxiv]

Nearly all of the simulation studies, including the NREL and Princeton net zero analyses, show long-distance, high-capacity power lines that cross the boundaries of the Eastern, Western, and ERCOT interconnections. To make such visions a reality requires building transmission across the interconnections. Standing in the way, though, are the states and the institutions of the market – the regional transmission organizations and the utilities. They are the primary organizations that plan the electricity grid. Their boundaries and organizational scope typically do not cross the interconnection boundaries, creating little incentive to break through the seams that divides the eastern and western and Texas interconnections. MISO and SPP have begun a series of projects to plan and build lines across the boundaries of those RTOs. The Joint Targeted Interconnection Queue Study projects would enable connection of 30 gigawatts of clean energy from Kansas up to North Dakota.[xxxv] The JTIQ is a promising step and a model of the sort of analysis needed to bridge state, RTO, and regional boundaries.

Conclusions

The institutional and technical architecture of the electricity system reveals three big pressure points for an expansive development of transmission lines in the U.S.

First, interstate and interregional connections are weak. Decarbonizing the grid will require building an extensive network of national, interconnected long-distance lines. The markets, the political organizations, and the lines themselves are not aligned to allow such development to proceed smoothly, if at all. DOE's National Transmission Needs Study highlights the need for substantial increases in interregional connections.[xxxvi] No institution exists to implement such lines into electricity planning and markets. Utilities have little financial incentive to facilitate seamless flows of power across markets and regions. This creates an uneven and disjointed pathway for transmission development.

Second, an uneven pathway is hard to balance. Conflicting state policies, such as renewable portfolio standards in one state but not others, make it difficult to satisfy all at once. This problem becomes abundantly clear when a line runs through one state to serve the communities in another state. Interstate rivalries arise and the state through which the line runs does not necessarily value any of the benefits that happen in the receiving state. We have no way currently of balancing the interests in two different states.

Third, public engagement is happening far too late in the planning and development process. That is fueling dissatisfaction, distrust, and opposition to developments. The next two chapters consider these matters in greater depth.

Chapter Two: Regulation and Permitting

I. Introduction

Transmission development is driven primarily by investor-owned utilities (IOUs or utilities). Utilities typically expand the grid on a project-by-project basis based on a patchwork of industry-driven project evaluation methods and state permitting regimes. The regulated project review process pushes utilities to pursue smaller projects that require less industry collaboration and fewer permits from government officials. Because Congress has never set transmission development objectives, such as expanding the system to meet clean energy targets, most development focuses on meeting short-term needs rather than achieving any long-term vision of our energy future.

That said, rules governing industry-run project selection and state permitting processes tend to be flexible enough to allow for more ambitious development. In a few instances, regional transmission organizations (RTOs) charged with planning transmission expansion have successfully developed projects aligned with decarbonization goals. Meanwhile, several states are permitting construction of privately developed and funded projects that will ship wind and solar power across multiple states. These “merchant” projects do not require utility industry approval. In addition, a few states have passed laws supporting projects that move clean energy. But without a new national law or strong federal regulatory action, alignment between energy policy goals and transmission development may be limited.

II. Benefits and Costs of Large-Scale Transmission

To navigate successfully the heavily regulated transmission development process, a large-scale project must pass several benefit-cost tests. Industry-run transmission planning processes tend to focus on quantifiable benefits and costs that accrue to electricity consumers. These “in-system” benefits and costs are typically reflected in the prices paid by consumers. For instance, consumers reimburse utilities for project construction costs, plus a profit margin set by regulators, but those costs may be offset by lower power prices if the new transmission project enables delivery of cheap electricity. Transmission can provide other in-system benefits, including improved reliability and operational efficiency.

Many costs and benefits are not explicitly accounted for by industry because they are difficult to quantify or do not directly affect electricity system costs. For instance, new transmission can generate construction jobs (as we discuss in Chapter 4) and revenue for local governments, but it can also harm wildlife and affect local landowners. If these broader effects on society are considered at all, they may be accounted for by state regulators reviewing a permit application or environmental agencies tasked with preparing impact studies.

Table 2.1 outlines some of the in-system and societal benefits and costs of transmission. It distinguishes between diffuse benefits and costs that are distributed broadly to ratepayers or to the general public and those benefits and costs that are concentrated on a handful of private entities or individuals. Chapter 4 provides greater detail on the benefits of large-scale transmission development, particularly for industry.

Table 2.1: Transmission Benefits and Costs

		Public	Private
In-System	*Benefits*	· Enhances power system reliability and resilience by providing redundancy and enabling resource sharing. · Reduces regional needs for backup generation. · Improves the efficiency of power delivery. · Increases competition in power markets. · Interconnects low-cost generation. · Reduces consumer bills by improving the efficiency of the transmission network and connecting cheaper power sources. · Meets clean energy policy goals.	· Profits for the transmission developer and generation owners that will connect to the network due to the new project.
	Costs	· Increases consumer bills that include costs of transmission construction.	· Harms profitability of existing generators. · Intrudes on local utility's transmission monopoly if the developer is not the local utility.
Societal	*Benefits*	· Creates construction and maintenance jobs. · Facilitates industrial or other load growth. · Reduces greenhouse gas emissions and other pollutants.	· Generates revenue for local landowners who host infrastructure and communities that sign benefits agreements with developers or increase their tax base.
	Costs	· Impacts local environment. · Causes regulators and other government officials to spend time evaluating the project.	· Harms landowners that do not want infrastructure on their property. · Affects local communities that host construction and the new line. · Could lead to local job losses if generators retire due to the new line.

As we detail in the following sections, a transmission project can be subjected to numerous and inconsistent benefit-cost tests by industry and government officials. Projects that traverse multiple states must typically pass a benefit-cost test in the industry-led planning phase and then separate benefit-cost analyses in each state that permits construction of the project. In addition, the industry allocates project development costs in proportion to the benefits each utility in the region is expected to receive from the project. That calculation may be premised on other benefit metrics. By contrast, a small transmission project contained within a single utility's footprint within one state may be built without any government approvals or industry-run benefit-cost analyses. The stark difference in the level of scrutiny applied by industry and regulators to large-scale, multistate projects as compared to low-voltage, single-utility projects pushes the industry to over-invest in small-scale projects.

III. Transmission Development Regulatory Framework

The legal architecture that governs nearly all transmission development was designed for IOUs, privately owned companies that have state-granted monopolies over electricity distribution to consumers. Historically, an electric utility built, owned, and operated all electric power infrastructure within its state-granted territory. Because reliable and affordable electric service is essential for modern society, states enacted laws in the early 20th century that aimed to foster the industry's expansion while also protecting consumers from exploitation by utilities that enjoy the exclusive right to deliver power to local consumers. To varying degrees, states' utility laws have evolved over the past century, but the twin aims of promoting the power sector's development while also protecting consumers remain at the heart of the regulatory framework.

As applied to transmission development, public utility law allows a utility or other developer to recover the costs of a new project through consumers' rates, as long as regulators find that the project is needed to provide reliable and affordable service. This foundational principle animates the transmission development regulatory framework that is split across state and federal jurisdictions and segmented into three interrelated processes: planning, financing, and permitting.

The overarching goal of each process is to advance projects that provide net benefits. A large-scale project is assessed at multiple project development processes regulated by state and federal regulators. Each process considers different benefits and beneficiaries. For instance, utilities plan local projects within their territories primarily to meet deliverability requirements for in-state consumers. Regional planning conducted by alliances of utilities and industry stakeholders generally ignores these metrics and instead considers benefits tied to interstate reliability, economic efficiency, and energy policy goals. When a project advances to the permitting stage, state officials are likely to prioritize in-state interests over regional beneficiaries. Disagreements about the benefits and beneficiaries of large-scale projects spill over into fights about who pays for the project. Utilities and other parties who want to reduce their share of regional project costs often argue that the benefits calculations compel particular cost allocations (and naturally reduce their share of the costs). These cost allocation disputes can be fatal to regional development.

Despite vast differences in benefit-cost analyses, each process tends to value in-system benefits over societal impacts. Effects on landowners and communities are background conditions in planning processes, if considered at all. Industry is likely to account for national parks, sensitive ecosystems, and other protected lands in the planning process and consider avoiding these areas due to permitting risks and delays, which can increase costs. But when industry advances a project based on a benefit-cost test, it does not quantify or otherwise explicitly account for environmental harms. Similarly, industry might profit from a project's economic development benefits, as growth in consumer demand enabled by the project may boost power sales and justify new and profitable local infrastructure. The industry's planning analysis likely considers only the in-system effects of this development and ignores the broader economic effects of transmission development.

State utility regulators that review permit applications are also likely to focus on in-system benefits and costs, such as reliability and consumer bill impacts, and may under-value societal impacts, such as economic development, environmental effects, economic equity, and environmental justice.[xxxvii] Projects that receive federal funding or traverse federally owned land, tribal land, navigable waters, historic sites, or other spaces regulated by Congress must clear additional hurdles. These reviews are not tied to utility regulation and are applied to any infrastructure development in these areas. They consider societal and environmental impacts and can require lengthy consultation and approval processes.

This development framework demands that large-scale projects spend years navigating bureaucratic processes regulated by different agencies. The complexity and extent of the process pushes industry to single-state projects that do not require any regional coordination and few environmental permits. Such local investments earn low-risk returns that can exceed profits on harder-to-execute regional projects.[xxxviii]

However, a small but growing amount of transmission is being developed outside of the regulated planning and financing processes. Merchant transmission developers plan their own projects and finance them through negotiated rates with generators, utilities, and other industry players. Merchant projects are generally designed to move power from low-cost to high-cost regions. For instance, Grain Belt Express, discussed in the companion report *Four Case Studies of Long-Distance Transmission Development*, is a merchant project that will ship cheap wind energy from Kansas to Missouri and Illinois, where there is demand for renewable energy and where market prices tend to be higher. Merchant transmission projects are subject to the same permitting processes and environmental reviews as utility industry projects. They must obtain utility permission to connect to the existing transmission system.

The public has a narrow role in transmission development. The project developer is often required to inform landowners along or near the proposed project route about the application. Once a utility or other developer applies for a construction permit, anyone can submit a comment to a state or federal agency reviewing the application. Public opposition can sway decision makers, although officials generally must justify their decisions based on the project's technical characteristics, such as whether it improves electric service or imposes excessive environmental damage.

In the following sections, we provide an overview of the regulated financing, planning, and permitting processes and discuss merchant transmission development. Because these processes subject high-voltage interstate projects to far more scrutiny than smaller investments, the existing development framework may limit the ability of the United States to expand long-distance transmission capacity over the coming decades.

A. Utility Incentives Drive Transmission Development

Approximately 40 IOUs, with a collective market capitalization of about a trillion dollars, own most of the nation's high-voltage transmission.[xxxix] These utilities share a common business model that is designed to sustain their profitable monopolies over local power delivery. Regulated rates "balance" consumers' and utility investors' interests by funding the IOUs' operations, rewarding them for spending on infrastructure, and setting profit margins.[xl] This rate-making formula funds the IOU to keep the lights on and incentivizes it to build power plants and delivery infrastructure.

To promote their publicly traded stocks to investors, IOUs release capital spending plans that signal earnings growth potential. These pronouncements are precursors to the regulated processes that plan, finance, and permit infrastructure investments. As they translate their corporate spending targets to investable plans, IOUs consider ramifications for shareholders. Government-set rates provide utilities with a fixed profit margin, or return on equity (ROE), on each dollar of invested capital. Nearly all IOU investment decisions are informed by two different ROEs. The relevant state utility commission and the Federal Energy Regulatory Commission (FERC) separately apply its own ROE to IOU investments within its jurisdiction. FERC now sets ROEs for most local transmission and nearly all large-scale projects.

The incentive to deploy capital does not necessarily persuade IOUs to pursue large-scale transmission projects. Dollar for dollar, small investments are less risky than regional spending and can be more profitable because the heavily regulated development process is uncertain and can prevent a utility from hitting its financial targets. In many regions, large-scale projects are reviewed by third parties with authority to cancel the project, potentially jeopardizing utility profits and even creating a loss. Some regional projects must be planned through competitive solicitations that can block utility investment entirely and dilute the long-term value of the utility's longstanding transmission monopoly. Local projects controlled by the utility are the path of least resistance for achieving financial goals.

Beyond the financial risks, regional projects may also have strategic downsides. In two-thirds of states, utilities build power plants, as well as local and regional delivery infrastructure. To protect past investments and future opportunities, utilities may disfavor transmission projects that could benefit their generation competitors. Large-scale projects designed to enable new entry may be intentionally undervalued in industry-run planning processes, despite plausible consumer benefits.

Large-scale project development may also cause utilities to spend money without receiving any profits. As we discuss below, every utility participates in a regional planning process, and costs of regional projects are paid for by the participating utilities. This regional and cost allocation framework can force a utility to pay for its share of a project that is being developed by another utility or other developer. While the developer profits from the project, utilities paying for the project only incur costs, which they typically recover through rates charged to consumers. Nonetheless, because paying for another developer's project is not profitable, utilities may oppose regionally beneficial projects.

The potential strategic and financial downsides of regionally planned projects explain why some utilities are building large-scale projects through local planning processes. Gateway West, discussed in *Four Case Studies of Long-Distance Transmission Line Development*, is one such example. PacifiCorp, a multistate utility company, is developing the project, will earn a return on its investment, and will charge all costs to its local ratepayers. As we describe below, PacifiCorp designed the project to benefit its own power plants.

Most self-planned utility projects are much smaller in scope and evade regulatory scrutiny. IOUs can recover costs without a traditional rate case that would require the utility to demonstrate to regulators that its spending benefits ratepayers. In addition, many small-scale local projects, particularly investments that refurbish or reconstruct existing infrastructure, are exempt from state permitting requirements.

B. Industry-run Planning Processes Select Projects With Little Regulatory Oversight or Stakeholder Participation

Utilities plan and operate electric transmission systems to provide reliable electric service to the consumers. Industry practice and regulatory requirements demand that IOUs work with neighboring utilities and other market participants to achieve that goal more efficiently than they could acting alone. Utilities coordinate with each other and other market participants by buying and selling energy through markets and contracts and partnering on transmission projects that can reduce system costs or improve industry performance.

State-regulated planning tends to focus on energy generation, while federally regulated processes culminate in local, regional, or interregional transmission development plans. Regulated planning processes typically require utilities to publicly disclose potential investments and allow industry stakeholders to comment on utility proposals. However, in practice, public influence is limited by the highly technical nature of electric system planning and the utility's informational advantages. Government oversight also varies widely. Utility discretion ultimately controls.

1. State Planning Focuses on Power Plants

About 30 states require IOUs to periodically file plans for meeting forecasted consumer demand for electricity.[xli] Planning laws and regulations require IOUs to propose a portfolio of resources that can include new generation capacity, long-term contracts with third-party owned power plants, and conservation and efficiency programs that can reduce consumer demand.[xlii] These exercises are primarily driven by the IOUs' proposed generation retirements and additions. Transmission investments typically follow generation decisions, although a few states include transmission in the planning process.

Because they focus on a portfolio of resources, these planning processes do not approve specific IOU investments and consider only a rough approximation of in-system benefits and costs of the portfolio. Planning processes are nonetheless important because a project's inclusion in a plan can be persuasive evidence in future permitting or financing proceedings to demonstrate that the project is needed to provide affordable and reliable service.[xliii] State-regulated planning can thus be a critical first step in infrastructure development.

State planning processes typically allow public participation, but meaningful feedback on an IOU's proposed plan requires technical expertise. An IOU plan is the product of a computer modeling exercise performed with expensive software and supported with reports written by IOU staff and economic and engineering consultants retained by the IOU. Ratepayer advocates, clean energy groups, and other organized groups may attempt to undermine the IOU's assumptions and results by cross-examining IOU personnel or filing competing analyses. Landowners and communities that bear private costs of projects in the IOU's plan rarely participate, either because they are unaware that the planning process may ultimately affect them, or they do not have the resources to meaningfully affect the outcome. Even sophisticated and well-resourced interests face an uphill battle in challenging the IOU. The IOU's assumptions, forecasts, models, and financial goals inform the plan it files, which set the terms of debate (if any) before the PUC.

State laws create different roles for utility regulators in these planning processes. In many states, regulators review utility plans to determine whether they meet relevant standards and metrics specified in law or regulation. For instance, South Carolina law requires regulators to determine whether the plan "represents the most reasonable and prudent means of meeting" consumers' needs and lists several factors that regulators may consider at their discretion. South Carolina regulators have ordered utilities to modify their plans.[xliv] In other states, utilities must file a plan, but regulators do not conduct a formal public review.[xlv]

The development of Gateway West, discussed in *Four Case Studies of Long-Distance Transmission Line Development*, demonstrates how IOU generation decisions expressed through state-regulated resource plans can drive transmission expansion decisions. PacifiCorp, an IOU with service territory in six Western states, proposed Gateway West in 2008 to connect its coal-fired power plants in Wyoming to its consumers in other states.[xlvi] By 2017, PacifiCorp had invested considerable time and effort in permitting processes but found that it would have to retire certain coal plants that would have connected to Gateway West in order to meet federal Clean Air Act requirements.[xlvii]

To replace its retiring coal assets and salvage its proposed transmission project, PacifiCorp proposed to repurpose Gateway West. In a last-minute move in the midst of an ongoing proceeding, PacifiCorp modified its proposed portfolio and added 2,000 megawatts (MW) of wind turbines.[xlviii] The Oregon Public Utility Commission expressed strong reservations about PacifiCorp's "abrupt" and "radical" proposal and attached several caveats to its approval of the plan. With that limited endorsement PacifiCorp then conducted a solicitation for the wind projects and chose itself as the main developer. An independent auditor and regulatory staff found that the "dispositive" factors in project selection were undisclosed transmission interconnection criteria imposed by PacifiCorp.[xlix] Because of this "extreme constraint," regulators concluded that the solicitation was flawed and declined to acknowledge the results. Notwithstanding these concerns, PacifiCorp developed these wind projects and regulators ultimately approved rates that reimbursed PacifiCorp for its development costs and provided a state-set ROE.

The case study highlights that a transmission project can formally appear first in a utility's state resource plan. In this case, the line was closely related to the utility's power plant investments that were also disclosed through the state planning process.

2. Federal Transmission Planning Demands Industry Coordination to Advance Regional Projects

FERC requires IOUs to conduct local transmission planning and participate in regional and interregional planning processes. Each utility has complete control over the contents of its own local plan for development within its retail footprint. Regional and interregional planning are conducted by 11 FERC-approved regional planners that are either alliances of neighboring utilities or RTOs, nonprofit entities that are responsible for ensuring reliable operations and planning transmission expansion.[l] Each regional planner uses different benefit-cost frameworks for advancing potential regional and interregional projects and sharing the costs of those projects among participating utilities. Projects in a transmission plan are financed through regulated rates.

Unlike state regulators that scrutinize utility resource plans, FERC does not review transmission plans. Instead, FERC sets high-level planning principles, requires each utility and RTO to file planning process rules consistent with those principles, and reviews those filings to ensure they comply with FERC's principles. For instance, FERC demands that planning meetings be open to industry stakeholders, that utilities accept feedback about their plans, and publish their final plans. At the regional level, planners must consider whether new projects can improve the efficiency and reliability of the network and whether development can support states' energy policy goals.

But FERC has not dictated how each utility or each region should assess potential projects. At the local level, each utility sets its own criteria for defining local transmission needs, which generally aim at delivering power to the utility's ratepayers. FERC does not evaluate each utility's local planning criteria or determine whether local investments benefit consumers. At the regional level, FERC reviews the benefit-cost methodologies that planners use to select projects, but it has not standardized the benefits or beneficiaries and does not review analyses of specific projects.

Across the country, the volume of regional development has declined since the industry implemented FERC's 2011 rule that mandated regional planning.[li] The failure of regional planning to advance projects is attributable in part to FERC's rule that certain projects be developed through competitive processes open to non-utility developers. Prior to FERC's rule, utilities enjoyed exclusive access to regulated transmission rates and were typically the only entities building transmission within their local territories. Because FERC's rule had the potential to disrupt their local dominance, expose them to competition for the first time, and dilute the value of their delivery monopolies, utilities have sought to limit competition by expanding the scope of their own local development and carving out exemptions from competitive development.[lii]

That said, a few regions are advancing major projects. The California and New York RTOs are developing projects designed to facilitate achievement of their states' clean energy goals.[liii] These are the only single-state RTOs regulated by FERC, and that tight geographic scope enables coordination between RTO transmission planning and state policy goals. MISO, whose territory spans all or part of 15 states in the middle of the country, finalized a $10 billion portfolio of regional projects in 2022 designed in part to increase deployment of wind and solar. The planning process included meetings with state regulators, utilities, and other market participants to define a long-term vision for the region's generation resource mix.[liv] About 90% of the portfolio will be developed without competition due to state laws that bypass FERC's mandate and MISO rules that define some projects as upgrades to existing infrastructure and therefore exempt from FERC's rule.[lv]

Texas's Competitive Renewable Energy Zones is another rare case of a regional planning process to support clean energy deployment. In 2005, the Texas Legislature set a renewable energy development target and directed the Public Utility Commission of Texas (PUCT) to designate areas suitable for renewable projects and create a plan to build transmission that connect those areas to the existing transmission system.[lvi] The law also streamlined the permitting process and cost recovery processes for selected projects.[lvii] Because the Texas RTO is regulated by Texas, and not FERC, the state controls all three transmission development steps and can guide them toward its renewable policy goal. Texas's process resulted in 3,600 circuit miles of new transmission, amounting to 23% of all new high-voltage transmission lines developed in the United States between 2008 and 2020.[lviii]

Interregional transmission planning is more of a theory than a practice, as few interregional projects have advanced through regulated planning processes in the past decade. One obstacle is the so-called "triple hurdle" that demands potential projects pass three different benefit-cost tests. For instance, a committee of MISO and SPP staff periodically recommends projects connecting the two regions based on models and studies created by the committee. Once a project advances past that initial screen, a project must be approved separately by both the MISO and SPP regional planning processes. After clearing those three hurdles, the two RTOs must then agree on how to split the project costs between the two regions.[lix]

Despite vast differences in planning approaches across regions, all regional and interregional planning processes begin at the same starting point. IOU-planned local projects are taken as given and rolled into the higher-level processes. This bottom-up structure preferences each IOU's self-identified projects that it plans based on its own unregulated criteria. By starting the transmission planning process with a baseline of unreviewable IOU preferences, FERC-regulated planning allows local investment to obviate the need for a more efficient large-scale solution.[lx]

By contrast, regional and interregional planning processes are multiparty endeavors. Advancing a project requires garnering support from utilities that may disagree over a project's benefits, may oppose paying for another developer's project, and may prioritize protecting their own assets over claiming a share of a project's diffuse ratepayer savings. As a result, some utilities and other market participants may prefer that there be no regional or interregional development at all. Utilities that oppose potential projects may seek to stymie their development by protesting how project costs are spread among the region's utilities.[lxi] Transmission opponents can object in multiple forums. Cost allocation methodologies are proposed by utilities or RTOs, reviewed by FERC, and can be litigated in federal court.

Moreover, unlike their own local projects, regional and interregional project development can be scrutinized by RTOs or other parties that have an interest in ensuring projects are completed on time and on budget. RTO-planned regional projects have been cancelled because they are no.[lxii] For the developer, cancellation can lead to unrecoverable development costs, lost profit opportunities, and wasted resources.

The New England Clean Energy Connect project (NECEC) in Maine illustrates how states that are dissatisfied with the results of industry-led regional planning can circumvent that process and develop projects on their own. In response to FERC's 2011 regional planning rule, the New England RTO proposed that state officials, rather than the RTO itself, select regional transmission projects needed to meet the state's policy goals. But FERC rejected that proposal and instead demanded that the RTO choose these regional projects.[lxiii] With states formally cut out of the regional planning process, the Massachusetts Legislature ordered utilities to circumvent the RTO and procure their own transmission. A 2016 law instructed the state's utilities to solicit long-term contracts for clean energy and included criteria for potential projects that favored transmission lines that would import Canadian hydropower.[lxiv] After New Hampshire officials rejected the permitting application of the Massachusetts' utilities first choice, the utilities selected the NECEC and ultimately signed contracts with Hydro-Quebec for power and NECEC for transmission service.[lxv] Massachusetts and other New England states, as well as New Jersey, are pursuing similar end-arounds to RTO regional planning in order to meet state clean-energy policies.[lxvi] Such transmission procurements are uncommon.

C. Merchant Project Developers Avoid Regulated Planning Processes

Unlike utilities, merchant transmission developers do not provide power directly to consumers or rely on government-set rates. Rather than funding projects through regulated rates, merchant developers negotiate transmission prices with energy buyers and sellers, such as power plants and utilities.[lxvii] This business model is premised on exploiting inefficiencies of interstate markets structured around IOU monopolies and regulated transmission planning processes. Some recent merchant projects connect regions, filling gaps left by ineffective interregional planning processes.

While a handful of merchant projects that move clean energy are under construction and several more are in development, there are no such projects yet in operation. Although they can bypass industry-run planning and financing processes, merchant developers must receive state siting permission, pass other environmental permitting hurdles, and navigate the technical process for connecting to the transmission network.

Connecting to the transmission system is usually a multiyear process.[lxviii] Today, the typical interconnection customer is a wind or solar power plant developer.[lxix] The interconnection process evaluates whether the existing transmission network needs upgrades to accommodate the generator. To receive interconnection permission, the new generator must pay for the costs of those upgrades. There is no standardized approach to studying interconnection requests, and each RTO or utility administers its own process.

Transmission projects vetted by utilities through a regulated planning process do not need any separate interconnection study process. The planning process itself considers whether the existing network can accommodate a proposed project. Upgrade costs are folded into the costs of new projects and allocated to utilities that participate in the regional planning process based on the expected benefits of the projects. For a merchant developer, project benefits are not valued by a utility industry planning process. Like a generation developer, a merchant transmission developer must pay for the privilege of injecting energy into the transmission network. Merchant projects also have to wait in the same interconnection queues as generation developers, often waiting years for RTO or IOU studies to determine how much they must pay for transmission upgrades.

The NECEC interconnection process illustrates how a market participant whose financial and strategic interests are harmed by the project can cause delays, add costs, and even doom the project. NECEC sought to connect to transmission infrastructure owned by NextEra, a power plant and transmission developer that owns a nuclear plant in New Hampshire. NextEra feared that energy imported through NECEC into New England would reduce regional power prices and cut into NextEra's profit. The interconnection study conducted by the New England RTO concluded that upgrades to equipment owned by NextEra were needed to accommodate NECEC. But NextEra declined to do the work. NECEC then filed a complaint with FERC, alleging that NextEra was attempting "block, delay or add unreasonable costs to the interconnection of the NECEC Project." [lxx] Nearly three years later, FERC ordered NextEra to upgrade its equipment, at NECEC's expense.[lxxi] NextEra has filed an appeal in federal court.[lxxii]

D. State and Federal Construction Permits

By the time a developer applies for construction permits, the project has accumulated significant momentum. It has advanced through the developer's own internal and perhaps multiple regulated planning processes and may have secured financing. The project's fate may now depend on whether it can receive construction permits and pass environmental reviews. Most projects require state-issued construction permits from utility regulators, an environmental protection agency, or an infrastructure siting board. In addition, projects that cross wetlands, navigable bodies of water, federally owned land, or other areas regulated by Congress or that receive federal funding may need federal permission. Various laws, including the National Environmental Policy Act (NEPA), the Endangered Species Act, and the Clean Water Act, outline the scope of review and may set the parameters for approval.

Unsurprisingly, large-scale projects typically require more reviews and approvals than single-state projects located within a single utility's footprint. Projects that traverse multiple states need a permit from each state. Each regulatory body reviewing a project may consider a different set of benefits and costs. State regulators tend to focus on a project's in-state effects and may not value regional benefits or out-of-state costs.

1. State Permitting Bodies Prioritize In-State, In-System Benefits

In most states, transmission proposals are reviewed by utility regulators who typically assess whether the project is consistent with the "public convenience and necessity," a legal term of art that dates back to the 19th century.[lxxiii] Determinations tends to focus on in-system benefits and costs, although state laws may specify relevant factors, including broader societal considerations. [lxxiv] In about a dozen states, other agencies provide state construction permits. These bodies may similarly consider whether the line is needed to provide reliable service and may also consider environmental protection and other societal impacts.[lxxv] State permitting processes are open to public participation. Opponents can protest a permit application and appeal an issued permit in state court.

Permitting decisions by utility regulators often hinge on whether a majority of regulatory commissioners find the project is "needed." The paradigmatic example of "need" is the utility's expectation that consumer demand will grow, and that existing infrastructure is insufficient to meet that growth. During the post-World War II baby-boom era, national demand for electricity grew nearly 10% per year, and transmission expansion plausibly met this traditional test.[lxxvi] For the last 20 years, however, electricity consumption has been flat. States have nonetheless found that new lines are needed to meet other objectives, such as reducing energy prices, improving reliability, and meeting clean energy goals.

State permitting regimes tend to emphasize in-state benefits and costs and may overlook regional considerations. For example, even though the project was designed to move energy across Missouri, Grain Belt Express needed to demonstrate in-state benefits to receive permission from Missouri utility regulators. In 2015, Missouri regulators denied Grain Belt's application in part because no Missouri utilities committed to purchasing energy from the project.[lxxvii] Four years later, Missouri regulators approved the project after Grain Belt had contracted with cities and other entities in Missouri. Regulators then concluded that the in-state demand reflected by these contracts empowered them to conclude that Grain Belt was "needed" under the state's permitting law. In 2023, Missouri regulators approved Grain Belt's application to increase the amount of energy being delivered into the state.[lxxviii]

The series of Grain Belt decisions highlight how regulators have discretion to weigh benefits and costs differently in each proceeding. When they initially denied the project's application in 2015, regulators were skeptical of any regional benefits and concluded that "actual benefits to the general public from the Project are outweighed by the burdens on affected landowners." In a complete reversal, regulators in 2023 found that the project's "broad economic and environmental benefits," as well as regional reliability benefits and other positive impacts, "outweigh the interests of the individual landowners." The change of heart was likely due in part to new evidence provided by the developer. Regulators must make decisions based on information filed by the developer and other parties. Grain Belt's developer attempted to remedy the deficiencies in its initial application by filing analyses showing the project would lower regional energy prices, reduce air pollution, and even improve national security due to various technical features that protect against outages and support Department of Defense clean energy goals.

The siting process for the NECEC illustrates how state laws can take different approaches to local impacts. Maine law states that "in determining public need" for a proposed transmission project, utility regulators must, "at a minimum, take into account" numerous factors, including "economics, reliability, public health and safety, scenic, historic and recreational values, [and] state renewable energy generation goals." [lxxix] In reviewing the NECEC's permit application, utility regulators concluded that they should value quantitative in-system benefits over qualitative "scenic, historic and recreational factors." Their unanimous decision notes that other state agencies "will conduct expert reviews of the scenic impacts" and may "mitigate these effects through their own proceedings." [lxxx] When project opponents appealed the Maine regulators' decision to a state court, the court concluded that regulators properly considered adverse societal impacts and dismissed all challenges to the permit. [lxxxi] The court noted that state law does not impose any obligation on regulators to mitigate adverse societal impacts of the line.

In neighboring New Hampshire, a committee of utility regulators, various state agency heads, and two members of the public appointed by the governor is empowered to review transmission line permit applications [lxxxii] To issue a construction permit, the committee must find that the project "will not unduly interfere with the orderly development of the region," and "will not have an unreasonable adverse effect" on various environmental factors.[lxxxiii] In 2018, the committee rejected Northern Pass, a project that would have imported hydro energy from Quebec to Massachusetts because it found that the applicant had failed to demonstrate that the project would not "unduly interfere" with regional development.[lxxxiv] The state's supreme court upheld the denial.[lxxxv]

In some states, multiple agencies review permit applications. For instance, both the Oregon Public Utilities Commission (PUC) and the Energy Facility Siting Council (EFSC) must provide construction permits. Oregon law requires that the PUC determine the "necessity, safety, practicability and justification in the public interest for the proposed transmission line." [lxxxvi] The EFSC's task is to the determine whether "the overall public benefits of the facility outweigh any adverse effects on a resource or interest" that is among the 15 specified in the law or that the council considers at its discretion.[lxxxvii] In 2022, the council approved the segment of PacifiCorp's Gateway project that is in Oregon.[lxxxviii] In 2023, the Oregon PUC provided a certificate of public convenience and necessity of the same segment.[lxxxix] A third Oregon agency has the authority to review the project's plan related to historic preservation.[xc] The Oregon Supreme Court upheld the council's permit, while the PUC's decision has yet to be appealed. The complexity of permitting in each state is only compounded when lines run through multiple states.

States tend to exempt smaller projects from permitting requirements or provide expedited proceedings for projects below a certain threshold. For instance, Massachusetts does not require permits for transmission lines under 69 kV.[xci] In Pennsylvania, utilities can build new projects smaller than 100 kV without regulatory approvals.[xcii] Developers in Michigan are not required to obtain a permit to build projects less than 345 kV.[xciii] These exemptions encourage development of smaller projects.

Regulatory approval generally confers the developer's right to use eminent domain to acquire needed land. Some states require additional regulatory approval before the developer can exercise eminent domain to acquire land. [xciv] State laws or regulations may require a developer applying for a construction permit to notify property owners within a certain distance of a proposed line.[xcv] Developers will negotiate with landowners before exercising eminent domain authority. For state or federally owned land, developers must navigate additional permitting processes, which are discussed in the next section.

In an eminent domain proceeding, a state court or other state body determines the "fair market value" of the property that the developer intends to take.[xcvi] Landowners can challenge the premise of the taking by, for instance, arguing that the transmission line is not a "public use" that can trigger eminent domain authority under constitutional law.[xcvii] For instance, a few courts had historically been skeptical that transmission moving energy out of state would meet the public use standard.[xcviii] However, such litigation is likely to be expensive and unsuccessful. Landowners may have better odds of challenging the amount of compensation.

State legislatures can limit eminent domain authority.[xcix] Iowa, for instance, prevents merchant transmission developers from exercising eminent domain authority on agricultural land.[c] In Missouri, where the Grain Belt project stirred controversy in parts of the state, legislators introduced a bill in 2021 that would similarly prevent merchant developers from exercising eminent domain authority.[ci] In 2022, the state passed a law that requires a court to find that the developer engaged in "good faith negotiations" prior to exercising eminent domain authority and sets the minimum compensation for landowners at no less than 150% above the appraised value.[cii]

2. State Land Use Permitting Considers Environmental and Other Public Costs

Developers may need additional permits from state agencies to cross state-owned land or due to a project's specific impacts. Each of these regulatory processes opens an opportunity for public involvement and can lead to litigation or political pushback.

Opponents of the NECEC challenged various state permits and agreements, including a lease from the Bureau of Parks and Land to cross a 0.9-mile stretch of state-owned land and approvals issued by the Department of Environmental Protection under various state environmental laws.[ciii] These permits were suspended after opposition groups garnered majority support for a ballot initiative that would have effectively invalidated the NECEC's certificate issued by the PUC and its lease of state-owned lands.[civ] However, the Maine Supreme Court held that the ballot initiative was unconstitutional (a subsequent ballot initiative was approved by voters but then later nullified by the state's supreme court).[cv] Following the decision, the state permits were reinstated and construction proceeded.[cvi] The NECEC stated that the permitting and construction delays have increased the project budget by $500 million (50%). The Massachusetts Legislature is considering legislation that would allow these cost overruns to be borne by ratepayers.[cvii]

Finally, a handful of states carve out roles for municipalities or counties in the permitting process. For instance, in Utah and Colorado, in addition to receiving a permit from a state agency, transmission developers must also obtain land use permits issued by municipalities or counties.[cviii] Many states require public hearings in counties or localities that would host new transmission infrastructure.[cix]

3. Federal Environmental Reviews Protect Worthy Interests but Also Extend Development Timelines

Transmission projects that impact land or resources regulated by Congress may need permission from federal environmental and land-use agencies. Federal reviews are more common for projects located in the western United States where nearly half of all land is owned by the federal government.[cx] Transmission projects crossing federal land can require approvals from numerous agencies under multiple statutes that specify different approval standards.[77] For instance, the Boardman to Hemingway segment of PacifiCorp's Gateway project was reviewed or authorized by six federal agencies.[cxi] The NECEC in Maine required approval from the U.S. Department of Energy (DOE) to cross an international border and from the Army Corps of Engineers due to construction impacts on bodies of water.[cxii] Each of these reviews includes public engagement and risks of legal challenges.

Federal reviews can trigger consultation processes across federal agencies and National Environmental Policy Act (NEPA) reviews. NEPA requires agencies to prepare an environmental impact statement (EIS) for any "major federal action significantly affecting the quality of the human environment," including projects that receive certain federal funding. Between 2010 and 2021, 46 transmission projects required an EIS. About one-third of those EISs were challenged in federal court.[cxiii] Project opponents can also contest an agency decision not to conduct an EIS. For instance, the NECEC's opponents challenged the Army Corps' decision that filling certain wetlands and constructing a tunnel under a river did not require an EIS.[cxiv] A federal appeals court denied a preliminary injunction and the case is ongoing in federal court in Maine.

NEPA requires coordination across agencies.[cxv] Under a recently proposed rule, the DOE will lead federal agencies' reviews of transmission projects.[cxvi] In this role, the DOE will coordinate with agencies who have responsibilities under various federal laws to review project impacts. For instance, the Clean Water Act tasks the Army Corps of Engineers or the Environmental Protection Agency with reviewing projects that cross certain bodies of water or can affect water quality. Under the Endangered Species Act, projects may need permission from the U.S. Fish and Wildlife Service. Each of these agencies would provide input into the DOE-led NEPA review. In addition, each agency must independently determine whether the project meets rules under the law it administers. For example, the Army Corps of Engineers might both contribute to the DOE-led NEPA environmental review and separately review a permit application under the Clean Water Act.

NEPA requires that agencies consider alternatives to the proposed project.[cxvii] For instance, PacifiCorp altered the route of the Boardman to Hemingway segment of its Gateway project following consultation with tribes. As part of the consultative process required by the National Historic Preservation Act, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) asserted that a 1955 treaty grants them rights to "fish at usual and accustomed stations as well as hunt, gather and graze on unclaimed lands." They claimed that the proposed project route would impair these rights.[cxviii] After engagement with the tribes, the Bureau of Land Management (BLM) and other stakeholders, PacifiCorp changed the route to avoid sensitive areas.[cxix]

For another segment of the Gateway project that passes through Idaho, BLM spent a decade developing a Final Supplemental EIS that considered the least impactful route to protected bird species under species protection laws, including the Endangered Species Act and Migratory Birds Treaty Act. On the final day of the Obama Administration, BLM approved a route that mostly avoided the Morely Nelson Snake River Birds of Prey National Conservation Area. But Idaho's governor, local officials, and private property owners objected to this route, arguing that by avoiding the bird sanctuary the project would cross more private property and disturb more sage grouse habitat than necessary. A few months later, the BLM volunteered to reconsider alternative routes.[cxx] In May 2017, then-President Donald Trump signed a law championed by Idaho Rep. Mike Simpson that rerouted the transmission line through the conservation area.[cxxi]

Recently, there has been an effort to reform NEPA permitting to make the process more efficient, effective, and inclusive of impacted stakeholders. In 2023, the Biden administration issued guidance directing agencies to consider environmental justice-related concerns earlier and more comprehensively in their NEPA analysis.[cxxii] In addition, Congress passed the Fiscal Responsibility Act of 2023 (FRA), which includes a two-year deadline for EISs and other NEPA amendments.[cxxiii]

IV. Conclusions

The regulatory framework for transmission development biases IOUs to consider each transmission project in isolation. While large-scale projects spend years navigating bureaucratic processes regulated by different agencies, smaller projects within the utility's local footprint often glide through abbreviated planning and permitting process with little scrutiny.

Chapter 3: Public Engagement

Long-distance transmission lines face intense public scrutiny. State and local governments usually solicit public input about the approval, location, and configuration of long-distance transmission lines during the permitting and siting processes. Governments often must approve land sales and, on occasion, condemn private land for the sake of the transmission line development. Landowners, residents of local communities, power industry competitors, and environmental advocacy groups can challenge developments in regulatory hearings, legislative committees and municipal councils, and courts of law. Long-distance transmission lines are frequently subject to extensive press coverage in local news outlets, to debate in city councils and state legislatures, and have even been subject to statewide referenda seeking to block their development.[cxxiv] Opposition to long-distance transmission lines sometimes moves out of the formal political process and escalates into public protests and even civil disobedience.[cxxv]

From the perspective of many developers, public engagement is a nuisance. It slows down construction; those delays add costs. The developers must support debt on the project and, on top of that, they must pay costs associated with regulatory proceedings, legislative inquiries, and court cases. The potential for such delays and regulatory costs may, in turn, dissuade developers from even attempting to construct long-distance projects. For national policymakers seeking to meet energy and climate goals, delays in power line construction act as a brake on the nation's ability to expand its electricity capacity and to decarbonize the economy. Prioritizing the construction of long-distance transmission lines to support growing electricity demand or to expand wind, solar, and hydroelectric power generation has led some to support limits on public engagement, on the time to permit, and on legal challenges.

The extent and intensity of public scrutiny of transmission line developments, however, reflects the profound effects that power lines can have on individuals and communities. Power lines go through private property, tribal lands, and federal lands, and they can split ecosystems. Lines can alter the ability of farmers, ranchers, and others who depend on the land as it currently exists to make a livelihood. They require clearing land and developing easements, such as access roads, that become permanent features of the landscape. They pose fire dangers from arcing in forested areas and hazards for other facilities nearby from downed lines. Some people also fear the effects of electromagnetic fields. Larger transmission towers alter local aesthetics, which can change the meaning and value of not just one parcel of land, but an entire valley, prairie, mountain ridge, riverway, or coastline.[cxxvi]

The interests of developers often conflict with the interests of people in the path of transmission lines. The points at which developers and the public engage in the political processes are moments when our society tries to deal with these conflicts. The public vetting process allows elected officials and agencies to learn whether the public benefit of a project is worth the potential political cost (not just the economic cost). It can also be a time when developers learn from communities about how to improve their projects. For example, public scrutiny has changed the locations of towers to avoid hazards that people in the community know and understand, but that are not evident to engineers in the design of a transmission line. In this way, people who live where developers want to build lines can help to solve the inevitable unanticipated problems that arise as any project is underway. While many developers use public engagement as a learning process, many others do not, viewing it instead as a “hurdle to clear” or an “obstacle.”

The challenge is to improve the siting and permitting process to support less adversarial, more collaborative forms of social interaction. Ideally, relating to communities as learners would help to establish more productive social relationships among developers, regulators, and the public. In approaching communities with an attitude of learning, developers may learn how to align their projects better with the values of local residents and communities throughout a region. Developers may also learn about unanticipated problems and their solutions at a much earlier and thus more economical stage. Shifting efforts from the back end to the front end of a project can help speed up permitting and siting. As the work of Professor Elinor Ostrom, winner of the Nobel Prize in Economics in 1990, reveals, processes that allow wisdom from people and communities to emerge can lead to better and often faster development of infrastructure.[cxxvii]

Public and community engagement is complex and multifaceted. It is difficult to capture the richness and entirety of this subject in any single chapter. To develop a fuller picture of the ways in which public engagement shapes transmission projects, researchers affiliated with Harvard's Salata Institute, in collaboration with the Roosevelt Project at MIT, conducted four case studies in different parts of the nation. These inquiries are presented in a companion study, titled *Four Case Studies of Long-Distance Transmission Development*. The cases are (i) the New England Clean Energy Connect (NECEC) power line, which would draw hydropower from Quebec through Maine to serve customers in Massachusetts, (ii) the Grain Belt Express power line, which would extend from Kansas to Indiana, (iii) the Gateway West power line, which would connect wind generation in Wyoming to Oregon, and (iv) the Texas Competitive Renewable Electricity Zone (CREZ), which connects wind in West Texas to the state's urban centers. Throughout this chapter we reference these case studies as examples and as the source from which we derive various lessons and recommendations.

This chapter is organized into three parts. First, what problems arise for people, communities, and firms in the existing permitting and siting processes? Second, what are best practices for when and how people are engaged? Third, what are prescriptive lessons from our interviews with stakeholders in different transmission development projects?

1. Problems

Megaprojects, such as transmission lines and powerplants, almost always face intense public scrutiny. Any proposal that affects large numbers of people or large swaths of land deserves careful attention to ensure that the development fits with public values and has minimal negative impacts on other people or the environment and generates benefits that are fairly distributed. The conflicts over energy infrastructure, however, often seem to spiral out of control leaving developers, regulators, and the public frustrated with the outcomes.

From the developers' perspective, the primary problem with the current permitting and siting process is delay. In the Gateway West (Idaho-Oregon-Wyoming), Grain Belt Express (Illinois-Indiana-Kansas-Missouri), and the NECEC (Maine-Massachusetts-Quebec) cases, the projects have met public opposition in every phase of the permitting process. All three of the projects have taken roughly 15 years to get the relevant approvals and through the legal process. All three left trails of public distrust in their wakes. Research by other scholars provides extensive evidence that public opposition creates delay in all manner of large infrastructure development.[cxxviii]

That observation leads some to advocate for time limits for permitting and reductions in opportunities for public comment. Several recent studies, however, raise doubts about such reforms. Studies of India, the U.K., and the U.S., for instance, have found that quantitative measures of time delay are not correlated with the political circumstances or regulatory regimes but with the contracting and financing of projects.[cxxix] Also, the U.K. recently undertook significant reform in the permitting and siting process but experienced no significant decrease in time to completion of projects.[cxxx] It is unclear from this research why such reforms did not shorten time delays. It could be that other research or qualitative observations are misattributing the source of delays; perhaps contracting, not public opposition, is the real problem. Or it could be that it is the nature of public engagement that matters, not simply the time allotted to it. The actual sources of delay deserve closer examination in order to understand what causes (and does not cause) the lengthy approval times of projects. Before time limits on public comment and public hearings are imposed, further study of the reasons why reforms have not sped up development is required.

In our case studies, public discontent was both a source of delay and a reflection of failures in the process through which projects were vetted. When communities felt they were not being listened to in one domain, they sought other ways of voicing their opposition to the projects, such as supporting a statewide ballot measure in Maine to stop the NECEC project[cxxxi] or legal battles in Missouri and Illinois concerning the Grain Belt Express project.[cxxxii]

Community leaders and activists criticized the public hearing process for these projects because it could not incorporate community concerns sufficiently into the design stage. In Missouri and Illinois, loss of farmland emerged as a critical sticking point. In Maine, loss of virgin forest became a focal point for opposition. The location of the lines, unfortunately, was already substantially set by the time public focus turned to these projects. Because public comment and engagement typically comes relatively late in the permitting and siting process, developers do not have the opportunity to learn from the community about how to design the projects to avoid problems that people in the community understood (but the developers did not) or to avoid designs that would provoke significant opposition. An example arises in the NECEC case. The design ran the power line through virgin forest land. The community pointed out that this area is very inaccessible and hard to get to in the event of forest fires, and a better route ran along a state highway.

Approaching public engagement as an opportunity to learn about the best design of a project can in fact lead to better designs with fewer delays. Studies of collaborative decision making in infrastructure design and siting have found that continuous engagement with communities and improved communication can speed up permitting and siting.[cxxxiii] Achieving that, however, will require a change in how many companies approach communities.

B. Societal Perspective

In our interviews across the United States, people expressed a variety of dissatisfaction with current engagement practices. People said that developers did not recognize their right to be where they live, or they tried to do an end run around the communities. People pointed to specific instances where they were shut out of the process, or included so late that the only question was whether to approve the project or not, rather than to make incremental changes. People wanted compensation for their communities, not just the immediate landowners. Many felt that they should have some ownership stake because the transmission lines would become a permanent fixture of the place they live. People felt that they, in the end, would be left to clean up the mess and deal with the disruptions created by the projects.

These observations and objections map into four types of problems, which we frame as advice to developers seeking more productive relationships with people living in the places where they want to build:

(i) Recognition: Acknowledge and respect the communities and people in an area. This is the foundation for establishing the primacy of the rights of people who own property or live in a place.

(ii) Procedure: Establish a transparent and trusted process through which decisions are made. People often say they were not consulted, or they were consulted too late in the process to make a difference. People want a political process that includes their voices in a meaningful way.

(iii) Distribution: Share the benefits and burdens of development in a society and compensate people and communities that are disproportionately affected.

(iv) Restoration: Maintain the land and places as they are to the greatest extent possible and return them to healthy places and ecosystems after development projects are completed or are no longer in use.

The focus of most controversies tends to be on the distribution of proceeds from a project and on environmental restoration. A recent study by Lawrence Susskind and colleagues at MIT found that the most common sources of opposition focus on land values and environmental issues.[cxxxiv] An ambitious cross-national study by Benjamin Sovacool and colleagues found that organized political opposition to energy development in the United States focused on environmental rather than economic or procedural concerns.[cxxxv] As a contextual matter, we note that the focus on environmental challenges could be at least in part a function of the EPA regulations that give communities a specific domain to lodge objections. In other words, members of the public may perceive that their only opportunity to object requires framing concerns as environmental concerns, even when they may also have economic, social, or cultural concerns that do not fit as well into regulatory categories and processes.

In our own interviews, questions of compensation for land or proposals for community co-ownership of power lines were frequently voiced. Public vetting of transmission lines (and most infrastructure development) often results in negotiations between firms and state and local governments, or firms and individual property owners over questions of compensation. In the case of the NECEC power line in Maine, the project developers ultimately agreed to make payments to the state worth $240 million. The original design of the Grain Belt Express case was a 4,000 MW transmission line that delivered very little electricity to the state of Missouri. By the end of the political process, the project had been revamped to become a 5,000 MW transmission line, and half of that capacity could be delivered to the state of Missouri.[cxxxvi] Interviews with local governments and private individuals revealed a wide variety of compensation proposals, including co-ownership of lines or an investment stake in exchange for running the line through private property, renting or leasing property from landowners (rather than purchasing), and providing other public goods, such as carrying broadband internet cables on the path and even on the same towers. A natural question to ask of these projects is whether such solutions could have been found at the outset rather than after years of contentious political wrangling.

Questions of environmental damage and restorative justice are equally poignant. Preservation of land and endangered species was central to the NECEC and Gateway West projects. And, consistent with other research, the Sierra Club was centrally important in raising objections to projects in order to minimize their environmental impacts.

Private citizens, landowners, and local town officials, however, repeatedly expressed to us problems with the basic process of public engagement. They said it often felt pro forma or distant from the concerns of the community. Many expressed frustration and even anger at the process, the developers, and the state officials. Lying behind these concerns are problems of recognitional justice and procedural justice. These are not problems that can be addressed through compensation or redesign of the project. These are feelings of not being heard, of lack of respect, and of the failure of the political process. Social scientists have long recognized that such feelings can sow distrust, and, eventually, political discontent and opposition.[cxxxvii] It is typically the quality of social relationships that form the foundation of such felt disrespect and even disdain. We note that developers also feel disrespected and even disdained in engagement processes as currently practiced.

Communities—however narrowly or broadly conceived—can play an integral part in developing long-distance transmission lines. Landowners, farmers, small towns, consumers, environmental groups, and other community voices all help inform how to develop transmission lines in a way that is appropriate to an area. The key questions are when and how developers engage communities in decision making.

2. When and How Communities Are Engaged

It is often not immediately obvious how companies and governments ought to engage with local communities. Rarely do developers ask communities at the outset how they would like to be engaged, nor do they study the local histories of successful and unsuccessful engagement. Much of the regulatory apparatus around permitting and siting of infrastructure deploys a top-down approach to public engagement. A common mechanism is to hold meetings at government offices. People may show up to those meetings and express their concerns, and once those meetings have been held, the companies have satisfied the requisite public engagement. Such a format creates a cascade of problems: the location may not be convenient, few people may attend, the time for commentary may be limited, or the format of the meeting may not elicit a deeper engagement of people with the project. These meetings present the public with a proposal that often feels like a *fait accompli*. The engagement opportunities come well after the project has been fully developed; there is little opportunity to work through remaining concerns about the project with developers; and there is little opportunity for follow-up after such meetings.

Improving public engagement requires a different approach, one in which communities are treated as partners in developments. There is a robust research literature on community engagement.[cxxxviii] Organizations that have worked closely with communities have developed best practices and guidelines that we think can help improve public engagement around energy infrastructure development.[cxxxix]

One example is the Lowlander Center toolkit, a guide to help communities define more clearly their values and lifestyles that may be threatened by climate change and build connections with other communities.[cxl] This program focuses on organizing the local community and on cultural knowledge, both of which are key to community engagement.

The Lowlander toolkit lays out a set of principles and objectives for learning and problem-solving. These are presented in the table below. They begin with some of the most fundamental questions for a community, especially, how does the community define itself? What are its boundaries, in both physical and cultural terms? What are its values? What are its goals? The toolkit offers resources that communities can use to work through these principles as they engage with external government agencies or firms proposing developments.

Lowlander Center Model for Community Engagement
1. Define your community
2. Define your community values
3. Define your community principles
4. Define your community goal
5. Clearly identify the threats/risks to lifeways
6. Clearly identify how lifeways are challenged by those threats
7. Clearly identify where or how threats/risks to lifeways originate
8. Define in what ways are outside agents/entities exacerbating the threats and risks your community is facing
9. What does the community see as its ideal future?
10. Define what role ecological regeneration plays in the community's future
11. What are the trade-offs from different partnerships?

These questions can also help firms and governments to understand the perspectives of the wide range of communities that may be affected by a development. What are the communities in an area where development is planned? How are they defined? What are their values? *What does a successful infrastructure project look like to you?* The answers to these questions will vary considerably between and within the communities that share stakes in an energy transmission project.

The answers to these questions can shape how communities are approached, how they are engaged with (e.g., what type of meetings are held), and how to interpret participation and non-participation in meetings. If the participants in a forum come disproportionately from one part of a community, how is the non-participation or silence of others to be interpreted? One view is that non-participation means tacit consent. For example, perhaps only large landowners appear at a PUC hearing, but no small landowners appear. Lack of participation, however, may occur because the time or the location of public hearings was inconvenient for many people to attend. It may also signal that participation required technical or legal expertise that was too expensive for some community members. In these circumstances, non-participation would not mean consent, but poor design of the public engagement process.

Before building a project, developers should ask, What does energy mean for this community? Often this question is taken to mean the effect of the grid on the immediate location of the proposed transmission line. Grid builders must first understand their project's impact on an area visually, economically, and environmentally. An area may have historic or cultural significance that spans an entire valley or riverway. Discussions of aesthetics and placement should therefore be accompanied by a full understanding of the cultural and historical understandings of a site's significance. Local historical commissions and, where available, local newspapers can be helpful early-stage sources of information.

Comprehending the meaning of energy for a community also requires that developers and governments take a wider view of the situation. Individual landowners have control and authority over their property and community members hold influence over their local culture and governance, but they are often not in control of their electric grid. Grids operate in a much larger energy system that often spans an interstate network. That network also defines a community of interconnected interests. New energy infrastructure affects those living in the broader area, not just the immediate path of the proposed transmission line. Developers need to understand how their project interacts with the concerns of a wide range of communities that may be mobilized in support or opposition to the development.

The processes through which communities clarify their own interests and goals and through which companies and governments learn from communities takes care and time. Connecting developers, intermediaries, and local communities is extremely difficult, especially when the parties involved use different languages or come from different cultures. This is especially the case for projects that go through areas with high minority or non-English-speaking populations. However, even when project developers mirror local community demographics, they still need to take local culture into consideration. For example, executives in Portland, Oregon, should be attentive to cultural differences when engaging with communities in rural Wyoming. The key is awareness that, in addition to being technical and economic, energy transmission projects are social. It takes good social relations to make them work. Developers who imagine themselves as guests in a new neighbor's home will do better than developers who imagine themselves as doing favors for a community, giving a gift to a community, or educating a community to demonstrate how the project is something they should want.

An illustration of the use of pragmatist social mechanisms[cxl] of community engagement is what followed in the case of Louisiana's LA SAFE climate resilience plan. Though resilience, not energy transition, was the focus, the community engagement process may generalize to other kinds of large projects. In the LA SAFE case, the Louisiana Foundation led a process whereby the actors (the "community") were defined by the people in the underserved areas of the Louisiana Delta. The engagement process itself worked with the daily habits people in the community followed, attending carefully to the scheduling and placement of community engagement events, and compensating participants for their work. Engagement facilitators were able to put resilience decision making within the contexts of everyday livelihoods.

Next, community members were engaged in the definitions of problems in resilience planning through deliberative polling and a series of meetings. Through this process, community members identified challenges and priorities, located areas of opportunity, proposed strategies for improvement, evaluated their current vision of improvement, strategized around risk zones, identified partners, and evaluated different design proposals. Finally, new, creative resolutions were designed and evaluated collaboratively, via a model which prioritized community needs in physical and social infrastructure. This holistic development of community allowed for greater resilience, which will be necessary for the energy transition.[cxli]

An example of how a pragmatist approach to community engagement could have helped with energy infrastructure siting is the case of the Lava Ridge Wind Farm in Idaho. This project proposal included building windmills up to 700 feet high in Nevada and Idaho. While some project opponents were "astroturf" organizers with fossil fuel industry backing, others had genuine concerns about how the turbines would affect the area. This is especially pertinent given the fact that a former Japanese internment camp was on the proposed site. While regulators said the builders of the project "checked all the boxes," there was not enough background knowledge about the region to understand how to negotiate facility placement.

3. Prescriptive Lessons

There are four areas in which public input and engagement can improve the development of transmission lines. These lessons draw substantially on our companion study: *Four Case Studies in Long-Distance Transmission Development*.

A. Constraints on Development

State and federal governments impose constraints a priori on where transmission lines can be placed. These rules can also specify criteria that may be prioritized in the selection of projects. Such criteria include where and how lines are constructed.

For their part, people in the areas where transmission lines are developed are often quite clear about the constraints they would like to impose on transmission lines. In all the case studies conducted in conjunction with this analysis, two constraints were repeated by multiple parties.

First, follow existing rights of way. Transmission lines should avoid forests, farmland, and natural areas and, instead, follow highways, railways, and other infrastructure. The most obvious approach is to build new power lines along corridors where transmission lines already exist or along highways and major roadways. This could involve increasing the capacity of existing lines or building additional power lines along the same corridors. Advantages include easier access for construction and maintenance equipment, and easier responses to fires and other events that might damage lines. In every case, community members, municipal leaders, property owners, and environmental groups encouraged development along existing rights of way, especially along highways.

Second, install transmission lines underground. In every case, people were confused as to why lines were not buried. They do not like aboveground lines, for both aesthetic and environmental reasons. The size of the towers and the width of the easements are significant sources of opposition. Many people we interviewed said that they wanted the lines buried and that they would not object to the developments if they were underground. Simply from the perspective of delay costs, burial seems like a wise option and a feature that might be required by a state.

Burial of transmission lines, however, is potentially very costly. Traditional technologies for burying transmission lines required oils and other chemicals to insulate the lines underground. The chemical insulations can leech into soil, creating environmental hazards. Moreover, this method of burial could cost at least four times as much as an aboveground line.[cxlii] New technologies hold the possibility of lowering these costs substantially, perhaps as low as aboveground lines.[cxliii] Reducing costs would keep the impact of a new line on electricity prices to a minimum. The SOO Green HVDC Link buries cross-linked polyethylene transmission lines beneath rail tracks, reducing costs and taking advantage of existing infrastructure.[cxliv]

Requirements that transmission lines be buried and follow existing rights of way present two examples of development constraints that are popular with the public. The people we interviewed in the Grain Belt Express and the NECEC cases stressed that many of their objections could have been addressed had the lines adhered to existing rights of way and been buried. In the Gateway West case, the lines ran through land on which an endangered species, the sage grouse, lives. Following existing rights of way would have minimized those problems and potentially avoided costly litigation to protect the sage grouse.

Texas may be the exception that proves the rule. The Texas PUC lays out 42 criteria that it prioritizes when selecting transmission projects, including following existing rights of way and respecting community interests. These criteria have not prevented transmission development, as Texas leads the nation in power line construction over the past two decades. Rather, having clear priorities clarifies some of the design features that the public will accept.

Criteria and priorities, of course, should themselves be developed in consultation with the public. That may be done through the normal representative channels, such as the state legislature or the PUC.

An intriguing option, and an approach used in Texas to guide some energy decisions, is to ask the public to advise the government directly. One strategy that states can pursue is to conduct surveys or participatory polls (as discussed in the Texas CREZ case) to determine what features of power line development—including rights of way, burial, and costs—are the highest priorities for the public. Those participatory polls may yield specific guidance about what constraints would be appropriate and which should be given highest priority.

B. Goal Setting

The starting point of any transmission project is identifying what needs or opportunities may be met by building a line. As discussed in Chapter 1, decisions at this initial stage reflect what sort of generation one seeks to connect to the rest of the grid and which consumers a line will immediately serve. Such decisions affect the scope (especially the location) of the project and its scale (such as the capacity of the lines).

These decisions are typically made by firms, such as utilities and merchant operators, or state entities, especially public utility commissions. They reflect the judgments of engineers who are expert in technical aspects of the project; of corporate executives who are expert in the workings of the electricity markets and the financial viability of the project; and of lawyers who are expert in the regulatory requirements that shape the location of lines. This was the process used in Gateway West, Grain Belt Express, and the NECEC. It is the normal process for transmission development: experts and firms set the goals. Rarely is there a role for public input in setting forth what sort of project states and firms ought to develop at the outset.

Again, Texas CREZ provides an interest contrast. In the mid-1990s, the state of Texas committed to building a gigawatt of generation and supporting infrastructure, such as transmission. The state and eight utilities conducted a series of opinion polls and held a series of deliberative processes in which randomly chosen people (akin to a jury) listened to expert and firm reports about different technologies. This process led to a strong and clear recommendation: develop wind in West Texas to serve the needs of the state.

Although Texas only did this process once (in the 1990s), the decisions it made have guided Texas energy development ever since. Choosing wind proved to be a savvy move. The initial gigawatt development provided the foundation for growing a much bigger wind energy industry in the State. Texas currently has an installed wind capacity of over 30 gigawatts.

The lesson is simple: Engage the public to set broad goals for grid development. There are many different models of public engagement, from deliberative polls to participatory budgeting. They can be used by state PUCs or state and federal political leaders to map out in which direction the public wants to go. If done in a careful and inclusive way, such a process can give later projects a certain legitimacy. Equally important, it can establish a community vision of how a project in a specific place serves a broader community (in this case, Texas, a state with a robust cultural identity). Of course, the Texas case was far from perfect, as we discuss in the companion case study.

Public goal setting can improve public acceptance of specific projects. Interviews in Maine and Missouri revealed that people had a hard time accepting the NECEC and Grain Belt lines because there was no bigger picture provided. People want to see how their backyard fits into the overall vision. In this instance, there was no sense that these projects would bring a wider societal benefit or were part of a larger energy transition plan that was important in ways the public understood.

C. Information and Trust

Public support (and opposition) for transmission projects is rooted in public understanding of what the project is and how it will affect local communities, economies, and the ecology. The critical problem for most projects, then, is getting the project in front of people while it is still in draft stage. The public is averse not only to harmful projects but to uncertainties and risks. The lack of public understanding of a project can be as damaging to its prospects as knowing that a project is a bad one.

Information serves at least three ends for the public. First, information assesses whether the benefits of a project indeed outweigh the costs. As discussed in Chapter 2, regulatory reviews of transmission applications do not consider the full range of costs or benefits. For instance, broad economic development benefits, discussed in Chapter 4, are not considered, and environmental harms may be reviewed through multiple regulatory processes run by different government agencies. PUCs or other bodies charged with reviewing a permit application are often overly focused on whether the project will lower energy costs for consumers, with little regard for other factors.

Second, information and a firm's transparency about a project can build or erode trust in the firm and in the project. Any project is developed in the context of past experiences with utilities and other energy firms. If a firm has a good reputation, the public is willing to give it the benefit of the doubt because of the existing level of trust. But if a firm is distrusted, say because of past reliability problems or rate hikes, then the public will be wary, and the lack of trust in the firm prior to the development can be fertile ground for the seeds of opposition. The NECEC case is just such an example. Central Maine Power had developed a bad reputation because of poor service and because of an ongoing controversy about overcharges (which totaled tens of thousands of dollars in some instances). When the NECEC project was announced, Central Maine Power was already embroiled in controversy. The opponents of the NECEC project, including existing electricity firms who would have to compete with this project, exploited the utility's bad reputation in attacking the NECEC transmission line.

Third, information can give the public what they need to help solve unanticipated problems. As developers well know, the problems of designing and building a project cannot be fully anticipated. Many of those problems are only clear once a project is underway, and many of those problems are highly localized and specific. Giving the public information about a project at the draft stage gives people the chance to help developers anticipate and solve problems. But revealing that they do not know everything and need the public's help is uncomfortable for people in powerful positions (running projects, running companies, being an elected official, regulating industry, etc.). Asking for help means sharing power. But sharing power is foundational to successful social relationships.

Providing complete and readily available information about a project, then, is vitally important to establishing trust in a firm and in a project. This can be quite difficult, as it requires meeting with people in communities to show them the plans, often before they are approved by the PUC, in order to build public understanding. In the Grain Belt, Gateway West, and NECEC lines, local communities were not consulted in advance, or, when they were, they did not feel that the projects had been explained in a way that was transparent to community leaders and people in the locale. This produced feelings of disrespect from the firms, which fueled the willingness of people to spend their time to organize against the projects.

It can be difficult for people to find trusted information about a project, especially once the opposition to a project is mobilized. Once the process becomes adversarial, there are two competing streams of information and people must sort out what to believe. These two streams of sometimes conflicting claims usually create more uncertainty about a project, which does not benefit a developer's cause. Both developers and average citizens complained in interviews about the lack of trusted information in the siting and political process.

Here we see an institutional failure. In our interviews with officials in state agencies, we discovered that the state governments are reluctant to provide a clearinghouse of information about projects. One state official said that they want to avoid appearing as boosters for a project, especially before permits are granted. State agencies do not want to appear to have picked a winner. As a result, there is often no official source of information, apart from the developer.

State governments should provide a clearinghouse for information about all proposed (yet to be approved, approved, and rejected) transmission projects. At the very least, such a clearinghouse would provide municipal governments, NGOs, and private citizens some way of gathering information about a project. The information clearinghouse can be funded through additional fees on developers proposing transmission lines, pipelines, and other infrastructure projects.

D. Meaningful Engagement Throughout the Process

Perhaps the most difficult nut to crack is the first step in the process. The earliest stages of development of a project are usually focused on the engineering design and financing. These early phases often do not include effective public engagement and comment on projects, as we highlight in *Four Case Studies*. As a result, new projects often come out of the design and selection process blind to the potential problems and objections from communities, many of which could have been addressed at an early stage of planning. What goes wrong?

Consider the NECEC project in Maine. It was the second-choice project in the initial bidding for the power line. Massachusetts had sent out an RFP for transmission to connect generation in Quebec to Massachusetts. The winning proposal was to locate a line in New Hampshire. The state of New Hampshire reviewed the project and decided it was not in the public interest and declined the permit request. Massachusetts had to scramble, and it turned to the runner-up, the NECEC, giving developers just 90 days to revise its proposal. The NECEC was being developed by Central Maine Power, which tried to get towns along the proposed line to sign memoranda of understanding.

CMP's own communication efforts nearly doomed the project. Towns along the proposed corridor did not feel they had been adequately informed and consulted about the project. According to local leaders, CMP neglected to vet the actual location of the line with the towns. Local leaders felt betrayed and revoked their earlier support for the project. Why hadn't they considered running the line along State Highway 201 instead of through pristine forestland? Why did they refuse to bury the line, even though a similar line in Vermont had been buried? The ensuing fight bogged down the project in legal battles and two state referenda. The examiner of the Maine Public Utility Commission determined that the benefits to Maine (and to low-income communities in particular) outweighed the environmental costs and burdens of the line. The examiner's report of the Maine PUC, however, called out CMP's disregard for the comments and input from stakeholders and affected towns, and the distrust that engendered. "CMP failed," the examiner concluded, "to comply with the core goals of its communications plan."[cxlv]

The Maine controversy exhibits a theme repeated throughout our case studies: communication failures on behalf of companies. A company's unwillingness to engage openly with people can become the fatal flaw in the siting of transmission. Multiple people told us that companies need to be open and honest with people about their plans, talk to them early, and listen. Listening will necessarily involve changes in the details of the technical architecture of plans, such as running the line along an existing highway rather than through forestland. At a high level, those changes appear to be relatively minor, but they tend to make the line less direct. Often it seems company leaders, engineers, and planners do not have in place a way to listen to people and community leaders and incorporate their concerns at the outset of the design of power lines. Sometimes there simply is not enough time from the initial RFP to its submission date to develop designs and to listen. Sometimes such early-stage listening is not included in the RFP itself. Too often the costs associated with delays are self-inflicted wounds. From the outside that seems clear, but we recognize it is hard to broach difficult conversations with town officials and local residents.

Existing institutions and processes make those conversations even more difficult, if not impossible. The time between an announcement of an RFP and the submission deadline is short. There is barely enough time to get the engineering done, let alone conduct a full public engagement campaign. Timelines for utility or RTO planning processes can be similarly tight. The objective of developers is usually to get approvals for the proposed projects, rather than to listen to people's concerns and make adjustments to plans. Even if the companies had the time to engage with communities fully, the RFP and planning processes are not adapted to such engagement. Only after a project is selected in the RFP or planning process does it make sense to engage the public, but by then the project is largely set. There is, in short, a chicken-and-egg problem for public engagement at the beginning of the planning process. Everyone we spoke with—local citizens, energy companies, RTO representatives—told us that the ideal solution would be to bring in the public early in the process. The RFP and planning processes are the problem, and it is tough to untangle these processes in a way that allows for fuller public engagement.

The Texas CREZ case offers some hints about how to make improvements, even if incremental. As part of the CREZ process, firms can put forth about 20 proposals. They set up meetings at local schools, city council meetings, and other public venues to get people's comments. These meetings allow for wider public scrutiny and often uncover specific problems, such as the locations of wells on people's property. The firms can change maps and then choose a plan based not only on an engineering assessment but on public input. The CREZ process is not perfect, and we examine it at greater length in the Texas CREZ case study found in our companion report. But the Texas CREZ process does point to plausible improvements. We would highlight a few changes in the design of the process.[cxlvi]

First, engage the public from the outset. The firms can do this as well as the governmental entities. In fact, we recommend that firms invite affected communities to the drawing table at the very beginning. Be aware that such an invitation is to a *social* event. Social events—like dinner parties hosted by a person who recently moved into a neighborhood—are the occasions in which relationships are formed. The quality of those relationships determines what happens later.

Second, be responsive. Meet with people and listen to their suggestions not just from the narrow perspective of construction costs, but from the perspective of how it will affect people's lives and the well-being of their communities.

Third, these changes will require slowing down the RFP and planning processes. Six months may be too short a time for people to learn about and engage with a project. Allow firms the time to fully engage. The extended time upfront can be offset by shortening or capping appeals or limiting the standing of other companies in the process.

Fourth, engage the "grass tops." The idea of public engagement often assumes that the goal is getting people to show up. But people are busy. They have kids. They work two jobs. They will pay attention when it is urgent. A sense of urgency comes when community leaders bring it to their attention. It is important, then, to engage with leaders in communities—city councils and county commissions, churches, unions, and other organizations—to inform them fully and openly about the possible project and its implications.

Fifth, provide an honest assessment of the implications of the project for the economy, the environment, and the community. Inflated promises of thousands of jobs or low energy prices or environmental sensitivity eventually come home to roost. Over the long run, those inflated expectations become disappointment, which only breeds distrust in the company. Companies need to take a longer-run perspective on the effects of their communication strategies on their reputations.

Sixth, the PUCs should make the quality of the public engagement and communication processes an explicit criterion in the permitting approval process.

E. Limits on Public Engagement

The evidence that the process is not working is time itself. In the case of the three long-distance transmission lines (Gateway West, Grain Belt, and the NECEC), it has taken nearly 15 years to move from initial designs to final approval. This type of lengthy delay is not unusual.[cxlvii]

Long drawn-out permitting fights are exhausting for all involved. Town officials and people in local communities are often drawn into a controversy over a development, only to find that the fight will take a decade or more of their lives. For developers, the costs and uncertainties of protracted permitting and siting conflicts often make projects financially unsustainable. Of course, for many opponents, delay is exactly what is desired. But nearly everyone we interviewed, from community organizations and NGOs to firms to government officials, said that the indefinite delays imposed enormous costs on all involved.

That time frame can be shortened substantially without materially worsening either the quality of the project or the degree of community support and environmental protection. The aim is not to cut the time to gain the relevant permits and site approvals in six months, but perhaps seven years is a more reasonable duration.

Limits on the duration of appeals and contestation of permits would help accelerate progress toward national decarbonization goals. These are subject to active debate over the NEPA permitting rules. Efforts to renegotiate NEPA rules points to a possible compromise on state rules. The limits alone do not guarantee a speedier development process; rather the prospect of limits is the opening gambit for negotiating a design that fits better with community values and environmental needs.

The compromise is this: In exchange for a more public-oriented development, communities and NGOs would agree to limits on the time to grant permits and other necessary approvals. In exchange for limits on the time to complete permit and siting decisions, developers would agree to processes that engage the public in the RFP process and for use of public polling or other participatory mechanisms throughout the design and development process. It is a straight-up trade that we think could facilitate a more reasonable time frame for infrastructure development and ultimately be in the public's interest. But power has to be shared and benefits equitably distributed for communities to believe they are not being taken advantage of.

A more ambitious vision is to bring communities into projects as partners. Numerous community leaders and activists, especially in the Grain Belt case, suggested that communities be brought into the project as co-owners or investors. There are, of course, a wide variety of possible mechanisms for developing investment or co-ownership arrangements, ranging from payments of a small percentage of revenues from electricity to some form of compensation, such as leasing fees or rent on land used. We highlight some of these options in the next chapter.

Conclusions

Long-distance transmission lines routinely get stuck. There is no one part or phase in the process one can point to as the sticking point. Rather it is a matter of *how* they get stuck. The how reduces to information, communication, and engagement. Ultimately, people want to be dealt with honestly and fairly. When a project changes a community or alters valued land, the meaning of compensation more complicated than simply paying the people whose land the line runs through.

Being treated fairly, at least as we understand it from the people we interviewed, means being treated as partners; a commitment to public engagement is the best way to ensure a relationship of shared understandings.

Short of such a robust partnership, it is possible to bring the public into the transmission development process in ways that make projects more acceptable and that will likely speed up permitting and siting decisions. To this end, develop priorities and constraints on the design of transmission lines that align with community values, such as following existing rights of way or burying lines. The simple act of establishing priorities in line with what most people want will reduce the number of objections to lines later in the process.

Chapter Four:
Interregional Transmission, Economic Development and Workforce Opportunities

Introduction

Despite its critical importance to the functioning of the American economy, the economic benefits of transmission are often underemphasized and the workforce that services transmission infrastructure faces many difficulties, including the recruitment and retention of diverse talent. The transformer manufacturing sector—a critical part of the transmission development pipeline—is also confronting significant challenges, including its heavy reliance on overseas production and a critical shortage of skilled workers in key areas such as welding, coil winding, and testing. The sector has also seen a decline in the number of electrical engineers among its ranks, as many are attracted to careers in other fields like computer science.

First, this chapter reviews the broad and specific impacts of transmission buildout on the U.S. economy. Transmission enables other industries to thrive and be competitive via access to low-cost clean energy. These broader economic impacts are important—but as shown in the New England Clean Energy Connect (NECEC) case—can also be contested, with opponents to transmission projects casting doubt on economic benefit projections. The second section of the chapter focuses specifically on the transmission workforce. We discuss the broad range of jobs that are part of building out transmission, along with a variety of current constraints and future opportunities.

By focusing both on the economic and workforce development benefits of transmission, we ground our analysis in people and communities. Discussions of the economic benefits of transmission are too often impersonal. Expanding transmission is not simply a technocratic engineering exercise but is also an investment in people, in communities, and in the vitality of the United States economy.

Broad Estimated Economic Impacts

Grid Expansion and Economic Growth Estimates

New investment in interregional transmission lines will bring widespread economic benefits. Short-term benefits include new jobs and greater GDP generated by new infrastructure development. Medium-term benefits come in the form of more efficient electricity markets—one study cites the possibility of $180 billion in electricity savings.[cxlviii] These benefits have further positive impacts on industries that rely on affordable, dependable electricity.[cxlix] This chapter focuses on the United States, but estimates of large economic impacts from integrated regional grids are not limited to the U.S.

Transmission lines make electricity markets more efficient by connecting consumers to cheaper electricity sources. In the U.S. in 2022, the share of final energy consumption from electricity was around 16%.[cl] This is expected to only increase over time as more renewable energy sources are brought online and more processes are electrified, such as heating and cooling, as we discuss below. Given the importance of electricity as an input, a key driver of broader economic growth will be the price of electricity.

In the current fragmented U.S. grid, there are opportunities for significant cost savings by strengthening the transmission connections between different regions. When regional electric grids are insufficiently connected, congestion costs arise. In these scenarios, consumers must choose a more expensive source of electricity because the cheaper source is inaccessible to the market without more transmission capacity. From 2021 to 2022, congestion costs jumped from almost $14 billion to more than $22 billion.[cli] Even as global conflicts caused the price of fossil fuels to rise, many regions were unable to access cheaper renewable energy because their grids did not have sufficient transmission access to generating sites. As the U.S. comes to rely more on renewable energy, these costs will continue to increase. This is partly because renewable energy will offer cheaper alternatives—but there is no guarantee that consumers will be able to access those alternatives.

Another clear way to understand cost savings on the price of electricity is to look at the amount of renewable energy that must be curtailed because there is insufficient transmission capacity.[clii] Curtailment limits supply, which in turn limits the potential for price decreases even if the marginal cost of energy production from renewables is low. Several regional grids have experienced curtailments increase in recent years.[cliii] Failing to solve curtailment with new interregional transmission lines will force utilities to overbuild renewable energy generation to achieve the same energy production goals. This too will entail much higher energy costs. If the U.S transitions to 100% renewable energy by 2050, it will cost an extra $1 trillion to do so without an extensive, interconnected national electric grid.[cliv]

Alternatively, building more transmission lines between regions can result in significant savings. Under a 50% renewable energy goal, the benefit ratio of connecting the east and west electric grids with new interregional transmission lines is 2.5, and under an 85% renewable goal, that benefit ratio rises to 2.9, saving $29 billion over 35 years.[clv] A more connected national grid will be able to exchange energy resources at lower costs, connecting high demand to high supply.

One analysis examines how the scale of interregional transmission buildout drastically affects the price of electricity in future economies. Under a 100% renewable energy economy, an interregional, nationally optimized transmission system reduces electricity prices by 46%, compared to a grid that is optimized within each state rather than nationally.[clvi] If each state planned its own grid and did not build any additional power lines across its borders, the price of energy would be an average of $134 per MWh. But if states agreed to nationally optimized plans, and built the electric grid to be most efficient on a national scale, the average price of electricity would be $74 per MWh.[clvii] These price effects are due to a mismatch between supply and demand. Regions that are naturally abundant in solar or wind energy, for example, often consume less energy compared to areas with more economic activity. Better transmission minimizes these discrepancies across regions, which in turn lowers costs dramatically.

We highlight a few examples of these dynamics from current transmission projects. The TransWest transmission line, for example, costs $3 billion to build, but is estimated to save more than $9.5 billion over the next 50 years.[clviii] The MISO regional transmission organization estimated that their $10.4 billion investments in thousands of miles of new transmission will save $37 billion over the next 20 years.[clix] Arkolakis and Walsh[clx] estimate that four significant transmission lines, which collectively cost $10 billion, could save $1.5 billion a year. These specific examples are part of a larger opportunity for cost savings. The impact of transmission lines will vary by market, but their potential price effects and impact on economic growth are substantial. In turn, electricity savings make a significant impact on the rest of economic activity. According to one study, saving $1 million in electricity costs leads to between 8 and 11 new jobs in the electricity market and boosts regional GDP by around $1.5 million.[clxi]

Specific Economic Sector Growth

Next we analyze a set of specific economic sectors to consider the impact of increased transmission on their growth: data centers, heavy industry, fossil fuels, and carbon capture. As the service, residential, and transportation sectors electrify, they will benefit from increased transmission capacity that makes electricity cheaper and more reliable. The industries we cover are major sources of local and national revenue. They are also increasingly the main drivers of growth in electricity demand. In 2023, grid planners almost doubled the five-year national forecast for electricity demand, from 2.6% to 4.7% growth, and identified new manufacturing and data center facilities as responsible for the uptick.[clxii] As of now, it is unclear whether the

U.S. grid can meet these demands. We evaluate how new transmission lines will impact growth in these five key industries.

Data Centers

Data centers provide large economic benefits to local and state governments and are key infrastructure for artificial intelligence technologies. But a lack of transmission capacity is a bottleneck to their rapid development.

Data centers are specialized facilities where organizations store their computer systems, servers, and networking equipment; they are the physical infrastructure where data is stored and processed, and where digital services are conducted. In our booming digital age, data centers are a major source of revenue for local and state governments and generated more than $2 trillion in economic activity between 2017 and 2021.[clxiii] A typical data center employs more than 150 workers, contributing more than $30 million to local economies, and paying $1.1 million in public revenue to local and state governments. In northern Virginia, which has the greatest concentration of data centers in the U.S., the industry employs 45,000 workers, contributing $174 million to the state government and $1 billion to local governments.[clxv]

Data centers require abundant electricity. Currently, the sector consumes 22 GW nationally, but consumption is estimated to rise to 33 GW in just a few years.[clxvi] So far, the mid-Atlantic region produces sufficient electricity to power these data centers. But Virginia's largest utility, Dominion, has called for delays in the construction of new data centers because of insufficient transmission line capacity to deliver that electricity. In 2018, construction on a new Amazon data center was delayed until the technology company agreed to pay to bury a contested transmission line that would be necessary for the site to operate. For two months in 2022, Dominion stopped connecting new data centers with the grid until it could better plan how to expand transmission capacity. Dominion has since managed to connect all data centers seeking electricity. However, the industry is worried about powering its plants in the future. At the recent Data Center World conference, keynote speaker Chris Crosby, CEO of Compass Datacenters, claimed that "the most critical issue now is transmission. … The number one thing we can do is build more high-voltage transmission lines." [clxix] The most likely sites for new data centers, from Texas to California to Iowa, are the sites with access to renewable energy and excellent transmission capacity. Meta recently announced plans to double the size of its data center in rural Utah. The project will collectively employ over 2,000 people in its lifetime and will be powered entirely by renewable energy, but its success is dependent on sufficient transmission.[clxx] Utilities are beginning to plan for ways to meet the needs and pace of future data center construction.

Meeting this challenge will only become more significant as technology companies invest in artificial intelligence. The use of AI models requires two to three times more energy than the current data center uses. Training AI models require five to seven times more energy than current uses.[clxxi] Experts from across sectors agree that AI will grow substantially in the coming decades. The recent grid strategies report suggests that powering generative AI could require as much as 7.5% of U.S electricity by 2030.   However, companies may have trouble developing and deploying AI at scale if they do not have the electricity to do it.

Heavy Industry

Heavy industry, including the manufacturing and production of steel, aluminum, paper, and other products, remains a major economic engine across the United States, especially in the

Midwest. In Indiana and Michigan, for example, manufacturing contributes 29% and 19% of the gross state product, respectively.[clxxiii] Manufacturing is also key to reaching national goals, from clean energy to the future of computing. To keep these domestic industries thriving for national objectives and for local prosperity, the U.S. must ensure that these industries have access to steady, cheap electricity. That will be evermore important in a rapidly decarbonizing future, in which industries will be relying less on fossil fuels and more on electricity. As of 2023, 200 new clean-energy manufacturing facilities have been announced, catalyzed by incentives in the Inflation Reduction Act. As a result, parts of the Southeast, Southwest, and Midwest have already experienced new “near-term load growth.”[clxxiv] New transmission is necessary to power these factories and the industrial transformations to come. We now turn to a few key examples from the steel, aluminum, and paper industries.

Steel

Despite declines over time, the steel industry remains an important contributor to the U.S. economy. It is also extremely energy intensive. Nevertheless, steel production is a remarkable case of increased energy efficiency. The energy required to produce a ton of crude steel has dropped by 60% since 1960. Technologies like electric arc furnaces make for even greater efficiency. But energy still represents 20% to 40% of the total cost of steel production.[clxxv] As steel producers decarbonize and electrify more of their processes, that figure is likely to rise. Energy prices could present a bottleneck, blocking advanced steel production, and a congested grid could limit the electricity supply available to a manufacturing center. That is why abundant cheap electricity is key to keeping steel production affordable, especially in a decarbonized future. An extensive grid that can deliver the cheapest clean electricity will be essential for securing low electricity prices.

The need for new transmission lines to enable steel production is already evident. Steel Dynamics recently invested $1.2 billion in Mississippi to build a new steel production site, including a cutting-edge, low-carbon biocarbon manufacturing facility.[clxxvi] This is the largest economic investment in Mississippi's history. At the same time, the Mississippi utility has proposed dramatic new investments in transmission infrastructure across the state.[clxxvii] The Steel Dynamics investment will create about 1,000 jobs paying an average of $93,000. This job growth is possible only if the factory can access dependable, affordable electricity. Thus, transmission buildout is necessary to accompany enhanced steel production.

Aluminum

Aluminum, valuable for its conductivity, malleability, and light weight, is the second-most commonly utilized metal after steel.[clxxviii] Useful across a wide array of sectors, aluminum is a crucial input into a range of renewable energy technologies, which in turn requires manufacturing.[clxxix]

Aluminum production involves extracting, refining, and electrolyzing mineral ores; it is an energy-intensive industry with substantial electricity needs.[clxxx] The industry also generates substantial revenue and jobs. In 2019, the primary aluminum production industry contributed $174 billion to the economy and employed 162,000 workers directly and 692,000 indirectly.[clxxxi] But primary aluminum production was at one time even more prosperous. In 2000, the U.S. was the world's leader in primary aluminum production. Now, it is the ninth-largest producer, with only 2% of global primary aluminum production.[clxxxii]

A major reason for this manufacturing decline is energy costs. Energy inputs account for 40% of the cost of primary aluminum. In the last two decades, this kind of aluminum production relocated to Russia, Canada, the UAE, and other countries with cheaper—but often not cleaner — sources of energy. China accounts for over half of global primary aluminum smelting.[clxxxiii]

Since 2018, when America imposed a 10% trade tariff on aluminum imports, the industry has recovered some revenue and production.[clxxxiv] But going forward, the future of the industry is uncertain. This presents a chance to decarbonize[clxxxv] and rebuild the domestic aluminum industry via cheaper energy inputs that can be facilitated through transmission expansion. To do so, manufacturers must have access to abundant, affordable electricity.

Paper

In 2018, the paper and pulp industry employed approximately 360,000 workers and contributed $57 billion to the U.S. economy. It is the manufacturing sector with the third-highest consumption of energy, behind chemical and petroleum products.[clxxxvi] In 2006, the paper industry spent around $7.5 billion on energy costs, equal to "roughly 20% of the total material cost," writes one report from the Lawrence Berkeley National Laboratory.[clxxxvii] About $4.7 billion of this investment was for fuels, and $2.8 billion was for electricity, but the latter figure will continue to rise as manufacturers decarbonize by electrifying their processes.[clxxxviii] Companies in the European Union are already experimenting with using electrified heat pumps for the drying stage of production instead of using fossil fuels. U.S. manufacturers are the second-largest producer of paper products in the world. If they wish to decarbonize their processes while staying competitive internationally, it's crucial that paper manufacturers have access to abundant, affordable, dependable electricity.

The Fossil Fuel Sector

Moving on from heavy industry, we now turn to the fossil fuel sector. We begin with an example from the shale gas boom. In 2018, the Permian Shale Boom required record use of electricity in West Texas. The regional grid became congested due to the sudden high demand.[clxxxix] Electricity prices rose and state operators were having trouble delivering sufficient electricity to meet demand. So, state planners rapidly built new transmission lines—more than $200 million worth—to enable the industry to continue to grow.[cxc] The new transmission lines secured a sufficient supply of electricity so that the shale extraction operators could use abundant electricity. The fossil fuel sector itself can be energy-intensive, and unless sufficient transmission lines connect them to other, cheaper energy resources, they can be constrained by rising costs. For example, extraction industries in Wyoming are threatened by proposed electricity hikes put forward by the utility Rocky Mountain Power. Doing so could significantly affect production and operational sustainability, which is currently flourishing under low electricity rates.[cxci]

Carbon Capture

Some industrial processes, such as the production of concrete or chemicals, are very difficult to electrify. The easiest solution may be to use point-capture technology to remove the carbon pollution.[cxcii] But carbon capture is also energy intensive. Energy costs have accounted for 33% to 50% of the total operating costs of carbon capture technology.[cxciii] If electricity prices are on the high end of the $74 to $134 per MWh range, it may be difficult for these heavy industries that rely on carbon capture to stay competitive on the world stage.

Direct air capture (DAC) facilities, similar but distinct from point capture, use giant fans and filters to remove carbon from the open air. Several of the first DAC sites are being developed across the states, with help from a $3.5 billion federal investment, and facilities like these could be key to removing the residual emissions from hard-to-decarbonize industries like concrete production.[cxciv] But DAC facilities are also energy intensive: Removing one ton of carbon requires 22 to 1500 kW, and this electricity must be low or zero carbon to have a meaningful decarbonization impact. That is why DAC facility site selection places high emphasis on access to abundant, cheap, low-carbon electricity. At present, that means DAC sites must be located near plentiful renewable energy. But future modeling shows that DAC facilities could be sited at a distance from renewable energy, as long as transmission lines link together the electric grid and provide abundant, cheap, clean energy to them.[cxcv] The Rhodium Group estimates that the construction of an average DAC facility would create more than 1200 jobs, and that its operation would employ more than 300 people.[cxcvi] Any region that seeks these economic benefits must also have a well-connected, energy-abundant electric grid.

Green hydrogen, which is produced using renewable energy, is in a similar position to DAC facilities and must also be located at the same site as renewable energy production or have access to abundant, cheap, clean electricity. As of 2023, proposed hydrogen production facilities require 3.6 gW of electricity, a figure that is expected to rise.[cxcvii] Regions that seek the economic benefits of hydrogen production might ensure co-location to vast renewable energy resources, or an extended grid that has access to cheap and abundant clean electricity.

Landowner Revenue Models

We now turn to economic factors involved in the buildout of long-range transmission in the U.S. Transmission development requires working with local landowners to gain access to vast stretches of land. However, there is no standardized system in place for transmission rights-of-way negotiations between landowners and state-commissioned utility companies. Negotiations are handled on a case-by-case basis and are influenced by a myriad of factors, including developer policies, state and local regulations, and, increasingly, landowner preferences. All such negotiations, however, incorporate an appraisal, a valuation of the land that is translated into landowner compensation. A common principle of the appraisal process is that compensation is based on what the landowner has lost, not the value of the new use of the land.[cxcviii]

The most common revenue model for landowners is easement, which grants a lasting permission for an entity (usually a utility company) to use land or property to construct and maintain a transmission line on private property. Landowners receive compensation for this easement and retain the ability to use their land for various activities, though there are certain limitations outlined in the contract. Although easement is widespread, alternative revenue models also exist. Table 4.1 outlines alternative models to landowner compensation.

Compensating landowners fairly is an inherently difficult task that often undervalues the land in question. Many compensation models undercompensate landowners because they do not consider "anthropocentric valuations," which include "personal preferences, emotional sentiment, community bonds, or suitability of land for particular uses." [cxcix] Moreover, poor compensation has the potential to create substantial financial costs for the state in the case that landowners challenge compensation amounts in court. For example, in Garden Grove, California, a property initially valued at $640,000 (in 2000 dollars) was later acquired by the city for $1,070,000 plus $620,000 in attorney's fees after a legal challenge by the landowner.[cc] Undervaluing properties, therefore, has consequences for both individuals and states and municipalities.

However, we see compensation models as an opportunity to help drive local economic growth. Existing schemes involving rents from renewables or mining, oil, and gas extraction present one way that these developments can inject revenue into local communities. In the case of royalty payment models (described in Table 4.1), these local economic benefits can also come with long time horizons and persist throughout the course of the transmission line's lifetime. While most of this chapter focuses on the value proposition of economic growth as the result of transmission, we also highlight opportunities for economic growth just from providing *land* for transmission.

Table 4.1 Landowner Compensation Models for Transmission Rights-of-Way

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 that collectively bargains 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
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 rights of way.	Cornerstone TransCo LLC uses this approach and has never had to use eminent domain to secure land.	Berry, 2013
Special Purpose	Landowners are given the choice to	The policy has been proposed	Winn, 2014

Development Corporation	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.	by the Center for Rural Affairs and has not yet been enacted.	
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 fair market value payments. Representatives from the route segment boards continue to represent the landowners.	This policy has been proposed by Gerstle but has not been implemented.	Gerstle, 2014

Grid Resiliency for Economic Resiliency

New investments in long-distance, high-voltage transmission infrastructure would also reduce the risk of disastrous blackouts that wreak economic havoc. For example, "to meet the projected energy demand in 2035, the Southwest region — including Nevada — will need between 2.3 and 4.7 gigawatts of additional interregional transfer capacity to maintain electricity reliability during extreme weather events, according to a recent U.S. Department of Energy Report.[cci] That means the Southwest would need to increase its transfer capacity with the Plains region by 914% relative to what's available now."[ccii] While this is just one regional example, it illustrates current vulnerabilities across the grid. Estimates of the economic cost[cciii] of energy interruptions vary but are nonetheless substantial.[cciv] The temporary loss of energy can be damaging to people's health and safety, and can also be financially crippling. Disruptions interrupt business activities and halt industrial processes that take a while to restart after a blackout. Avoiding one hour of blackout can save $.6 - $1 billion in affected areas.[ccv]

The 2021 Texas Winter Storm Uri provides one tragic and disastrous example of an unexpected blackout event that harmed people and cost the state billions of dollars. Many generating systems failed during the extreme cold temperatures, creating a shortage that was exacerbated by the ERCOT region's lack of interconnection with other electricity markets. It could not receive emergency electricity from other regions, resulting in several days of blackouts. Going forward, greater transmission interconnections will be crucial for reducing the risk of blackouts in Texas and across the country. As the nation transitions to renewable energy, interregional transmission and grid updates will help maintain a reliable flow of electricity for people, businesses, and industry.

International Competitiveness

A more resilient grid with sufficient transmission infrastructure is also key to ensuring the U.S. can maintain dependable, affordable production across sectors. Lack of transmission risks delaying development and reducing the country's competitiveness internationally.

The U.S. could be an export leader, selling products made with clean electricity to markets across the world. But domestic manufacturing cannot be internationally competitive without a 21st century grid to deliver cheap power. The U.S. can only bring substantial aluminum production back, for example, if it can be powered at low cost and low emissions. The same is true for other industries. Manufacturers are designing clean ways to produce steel, aluminum, paper, and other products, and developing carbon capture to clean up the dirtiest sectors.[ccvi] And for manufacturing sectors that are internationally traded, carbon tariffs such as the European Union's Carbon Border Adjustment Mechanism will drive up the prices of products that do not decarbonize production. Internet-based businesses that serve global customers rely heavily on infrastructure and data centers, therefore increasing the need for a dependable electric grid.

An efficient grid is crucial for U.S. renewable energy development, which will only thrive alongside modern transmission to bring it to markets. But other, more widespread benefits—in this case, international competitiveness—are often overlooked. Transmission infrastructure is a foundation for domestic industry *and* a key to competitiveness globally. Domestic industries will lose their competitiveness without dependable, affordable energy; transmission lines are essential for a strong, internationally competitive economy.

Workforce

In this section, we turn to the potential workforce benefits that building long-range transmission lines might generate. To accelerate a transition towards net zero and the broad-scale electrification of every sector, the development of a workforce dedicated to the planning, construction, and maintenance of the grid will be essential. The grid workforce is incredibly diverse with a range of occupations, including more traditional roles like line workers and energy compliance specialists. Some of these jobs are require a more mobile workforce, such as those who install towers and hoist lines. As mentioned in the Grain Belt Express case in *Four Case Studies*, this can lead some communities to oppose projects because they may not generate job opportunities for the local workforce.[ccvii] However, other jobs require less mobility and local communities can benefit from adjacent economic development opportunities. Understanding the range and diversity of jobs presented by grid development will be important for moving proposed projects forward.

Occupational Variety

The building, servicing, and maintenance of the transmission grid has led to the creation of other diverse occupations directly and indirectly related to grid activities. Grid-related work includes traditional energy infrastructure jobs, such as line workers and transformer specialists, as well as those in associated fields such as cable manufacturing and legal counsel. All of these workers collectively support the functioning and growth of energy infrastructure. It is important to characterize the diversity of jobs related specifically to the grid. Table 4.2 highlights this diversity and assigns occupations to distinct categories and sub-categories. Although considerable research has outlined the range of energy jobs, there has been less focus on the grid specifically. For instance, the Bureau of Labor Statistics does not calculate employment and wage data for grid occupations. This makes it difficult to accurately determine who is involved in this critical labor force.

Table 4.2 Grid-Related Occupational Variety

Category	Sub-Category	Occupations	Example of Employer
Core Grid Operations & Maintenance	Engineering & Development	Electrical Engineers, Protection Engineers, Grid System Analysts	GridSME (hires Electrical Engineers, Protection Engineers)
	Operations	Power Plant Operators, Substation Operators, Grid Operators, Control Room Operators	Duke Energy (hires Power Plant Operators, Grid System Analysts)
	On-The-Ground Work	Transmission and Distribution Line Workers, Utility Linemen, Maintenance Technicians, Meter Installers and Readers	Pacific Gas and Electric Company (PG&E) (hires Transmission and Distribution Line Workers, Utility Linemen)
Grid Planning & Policy	Environmental and Land Planning	Environmental Planners, Land Acquisition Specialists	HDR (hires Environmental Planners, Land Acquisition Specialists)
	Regulatory and Compliance	Regulatory Affairs Specialists, Safety Inspectors	Southern Company (hires Regulatory Affairs Specialists, Safety Inspectors)
	Policy and Research	Energy Policy Analysts, Research Scientists, Energy Economists	National Renewable Energy Laboratory (NREL) (hires Energy Policy Analysts, Research Scientists)
Customer & Public Relations	Service and Support	Utility Customer Service Representatives, Public Relations Specialists	Xcel Energy (hires Utility Customer Service Representatives)
	Field Work	Meter Installers and Readers	Florida Power & Light Company (hires Meter Installers and Readers)
Technology & Innovation	Renewable Integration	Renewable Energy Specialists	National Grid Renewables (hires Renewable Energy Specialists)
	Storage Solutions	Energy Storage Specialists	AES Energy Storage (hires Energy

			Storage Specialists)
	Cybersecurity	Cybersecurity Experts	Waterfall Security (hires energy-focused Cybersecurity Experts)
	Mapping and Planning	GIS Specialists	Environmental Systems Research Institute (Esri) (hires GIS Specialists)
Administrative & Support Roles	Logistics	Logistics and Supply Chain Managers	FedEx Supply Chain (hires Logistics and Supply Chain Managers)
	Training	Training & Development Specialists	Electric Power Research Institute (EPRI) (hires Training & Development Specialists)
	Legal	Energy Lawyers & Litigators	Latham & Watkins (has a practice in energy law and hires Energy Lawyers & Litigators)

The diversity of employment in the grid workforce is a product of two factors. First, like much of the United States' energy sector, the grid employment requires expertise and labor across various sectors of the economy. Second, the grid itself requires swift adaptation to emerging trends in the economy as a whole (e.g. greater integration with renewable energy and, in recent years, utilization of artificial intelligence and machine learning) and therefore demands a widely skilled and flexible workforce.

In recent years, the "electrify everything" movement has given rise to calls highlighting a pressing need for more electricians. Yet electricians represent only a fraction of the occupations in the grid workforce. The imprecise grouping of occupations related to the grid is particularly evident in the high and ultra-high voltage domains, wherein different occupations such as line workers, tower construction specialists, and transformer manufacturing and installation experts play pivotal yet often poorly defined roles. Although high-voltage workers often undergo similar training to their low- and standard-voltage counterparts, their occupation also requires specialized training and certification to safely operate at higher voltages and utilizes highly specialized tools like insulated cable tools. Finally, alongside these technical disparities, these roles are also confronted with distinct regulatory issues, such as compliance with OSHA's Electrical Safety Standards (29 CFR 1910.269), which specifically regulate electric power generation, transmission, and distribution work, setting forth specific practices for high-voltage work.

Finally, there are also a range of complementary occupations that are integral to the overall functioning of the grid, including but not limited to the manufacturing of cables, the production of steel for towers, and roles in management and legal counsel. Each of these roles is essential in sustaining the intricate framework of the modern electrification movement.

Representation and Diversity

Unions

In the following sections we discuss how opportunities in the grid workforce might reach a diverse set of workers. We turn first to the role of unions. Several key unions are prominently involved in development, playing crucial roles in advancing new projects. These unions include the North America's Building Trades Unions (NABTU), the Utility Workers Union of America (UWUA), the International Brotherhood of Electrical Workers (IBEW), the International Association of Bridge, Structural, Ornamental, and Reinforcing Iron Workers, the Laborers' International Union of North America (LIUNA), the United Mine Workers, and the International Union of Operating Engineers. Two notable projects, the New England Clean Energy Connect and the Cardinal-Hickory Creek Transmission Line, are noteworthy for employing hundreds of union members, thereby fostering an employee-centric approach to grid development.

Veterans

Next we turn to veterans. In recent years, there has been growing acknowledgment of the untapped potential veterans bring to the modern workforce. Organizations such as Troops in Energy Jobs and Veterans in Energy have taken up the cause to facilitate the transition of veterans into the energy workforce. There are also programs, such as Power4Vets, which are focused on supporting veterans by training and credentialing them for jobs servicing the grid. The evidence indicates that these groups are having some success. For example, as of 2020, the utility company National Grid employs over 700 veterans.[ccviii] The U.S. ought to leverage the specialized experiences and proficiencies veterans have and utilize their talents toward building out the grid.

Racial and Socio-Demographic Disparities

Finally we turn to ways that building a new grid workforce may increase racial and economic diversity in the energy sector. Women and people of color are typically underrepresented in the energy sector. This gap creates missed opportunities for innovation, collaboration, and diverse perspectives. While there are some ongoing efforts to bring more women into power systems occupations, there is clearly more work to be done.[ccix] Initiatives like Get Into Energy present positive advances toward increasing diversity in the grid workforce. Other examples include partnerships between stakeholders and Historically Black Colleges and Universities (HBCUs) and other institutions that serve minority populations.[ccx] These collaborations aim to create pathways to introduce underrepresented groups to job opportunities in the energy sector, ensuring they become vital contributors to the grid workforce.

There are likely to be important age-cohort differences to contend with in the transmission sector. Older workers may be less mobile compared to younger workers, potentially reducing their participation in grid build-out. At the same time, older workers have different skill sets, some more and some less transferable to long-range transmission development. Taking these cohort differences into account will be critical for addressing equity issues in the transition (and not just in transmission-related jobs).[ccxi]

Employment: Needs, Challenges, and Impacts

In this section, we focus on the workforce needs and challenges that substantial build-out of long-range transmission lines will likely generate. According to Americans for a Clean Energy Grid, the construction of 22 identified transmission projects holds the potential to create approximately 240,000 direct jobs.[ccxii] They further project that the implementation of an investment tax credit for regionally significant transmission lines could create an estimated 600,000 transmission-related jobs.[ccxiii] According to a 2019 report from the Economic Policy Institute, the economic multiplier of every 100 jobs in the transmission sector is 560 total indirect jobs (supplier and induced jobs).[ccxiv] These projections underscore the substantial impact that grid infrastructure modernization and development can have in fostering employment opportunities and driving economic advancement across sectors.

Although some of these jobs will inevitably be short-term construction and planning roles, a substantial portion of transmission jobs will provide workers with durable employment. Indeed, according to the National Renewable Energy Laboratory, 12% of the jobs related to a transmission project from Wyoming to Colorado were long-term.[ccxv] Moreover, many transmission jobs, short- and long-term, are union jobs that pay prevailing market wages. In short, the employment opportunities present in transmission expansion are durable and valuable to individuals and to the broader economy.

As the grid expands, though, workforce challenges have emerged as a critical area of concern. Before the COVID-19 pandemic, employers in transmission and distribution construction reported experiencing more difficulties in hiring compared to their utility counterparts. However, since in 2020, recruitment has become an even bigger challenge for utility employers.[ccxvi]

The existing workforce training system—which includes building trades apprenticeship programs in the construction industry, utility intern and apprenticeship programs, the community college system, and advanced degree colleges—is robust but will require additional investments to meet growing employment demands. Some training programs are effective at training and retaining workers, and these models ought to be replicated. One example is the Wisconsin Regional Training Partnership, a collaboration that brings together industry, schools and unions to create technical training programs that have resulted in high participant wages.[ccxvii] Such partnerships suggest how to advance workforce training moving forward. Nevertheless, existing networks suffer from a lack of standardized curricula and lack of access to pre-apprenticeship programs.[ccxviii] These challenges underscore the need for industry stakeholders to foster closer collaborations and address barriers to progress. These barriers are not just hindrances to achieving full employment in this sector, but also major impediments to the progress of grid expansion.

Expanding the Workforce

To help fill the gaps between grid workforce needs and individual access to workforce jobs, various training programs have emerged in recent years. In this section, we highlight a few examples. One strategic initiative aimed at broadening access to specialized education in underrepresented regions is the formulation of partnerships with rural educational institutions. Similarly, collaboration with private firms to expand access to online education is gaining momentum. One example is an initiative aimed at upskilling low-voltage workers for occasional high-voltage tasks. Finally, the introduction of licensure layering, such as a lineman license and a commercial driver's license (CDL), is being integrated into training programs to equip workers with multiple certifications.

Line burial

Another strategy for expanding the grid workforce is burying long-range transmission lines. Importantly, line burial represents a more considerable financial investment compared to traditional overhead lines. In Oklahoma, for instance, the cost of line burial was cited as the primary barrier to its implementation, along with other logistical considerations such as right-of-way disputes and the difficulty of finding leaks should they occur. [ccxix] However, line burial *has* been strategically implemented in numerous high-voltage projects recently. A notable example is the Champlain Hudson Power Express.[ccxx]

In addition to many of its aesthetic and safety benefits, evidence presented in our companion report, *Four Case Studies*, also suggests that line burial garners more acceptance within certain political geographies, potentially mitigating community opposition and regulatory obstacles. This trend extends to transmission development beyond the U.S. In the U.K., for instance, empirical evidence suggests that there is strong support from citizens for line burial projects.[ccxxi] In Germany, SuedLink, a 700 kilometer transmission line that is entirely underground, is projected to be operational in 2027. These examples indicate the slow but inevitable growth of this transmission method globally.[ccxxii]

Line burial requires diverse implementation and construction techniques. It involves trenching, horizontal directional drilling, and the use of specialized equipment to lay cables and pipes beneath the surface, requiring workers to be proficient in operating a variety of machinery.[ccxxiii] In addition to these technical skills, a strong understanding of engineering principles, particularly soil mechanics, is essential as different soil types present unique challenges during the burial process. Workers must assess soil conditions, adjusting their techniques to ensure the integrity of the buried lines. The application of concrete to encase and protect utility lines is another critical aspect, demanding skills in mixing, pouring, and understanding how environmental conditions affect the curing process. Coordination with other utility services is often required, necessitating strong communication and collaboration skills to work effectively as part of a team, avoid disruptions to existing services, and ensure worksite safety.[ccxxiv] In summary, the shift towards line burial is expanding the required skill set of the workforce, encompassing a variety of technical, practical, and interpersonal capabilities.

Transformers, Grid Structures, and Grid Monitoring

Workforce challenges have downstream consequences for the build-out of long-range transmission. Consider the case of transformers, which are used to convert electricity to different voltages along the trek between where it is generated to where it is consumed and are crucial for long-distance transmission. Nevertheless, approximately 80% of transformers are manufactured abroad.[ccxxv] In fact, only eight U.S.-based companies currently manufacture transformers domestically.[ccxxvi] Moreover, the transformers which *are* currently servicing the grid are being used up to 15 years beyond their lifespan.[ccxxvii] This is because it takes between 20 and 39 months to procure new transformers.[ccxxviii] The supply of transformers is also affected by climate events like hurricanes, tornados, fires, and floods, which have depleted already limited reserves.[ccxxix]

This scenario is intensified by significant workforce shortages in crucial areas such as welding, coil winding, and transformer testing. The shortage of welders is especially acute.

Recruiting more workers into this field is made even more challenging by the absence of union organizing. This makes it even harder to match the supply and demand for skilled labor. The manufacturing of transformers is also suffering from a lack of electrical engineers, who tend toward careers in computer science.[ccxxx] Such workforce shortages will require targeted strategies to address the diverse set of skills needed in the domestic transformer manufacturing sector.

Transformers and transmission lines are supported by transmission towers, which are a key employment stimulus in the energy sector. Transmission towers bolster employment through manufacturing and maintenance jobs, both of which are long-term employment opportunities. The transmission tower industry—which constitutes roughly 21% of electricity transmission and distribution market revenues worldwide—has an estimated compound annual growth rate of 5.6%, indicating substantial need for such infrastructure in the build-out of transmission lines in the U.S. and globally.[ccxxxi] The manufacturing of transmission towers, which requires about 40,000 to 60,000 pounds of steel per tower (and hence is a strong source of steel demand), has a strong domestic presence and is expanding.[ccxxxii] Most recently, the creation of a transmission tower production facility in Indiana is expected to create 200 full-time jobs and support Indiana's growing energy ecosystem.[ccxxxiii] Transmission towers, although durable, are susceptible to physical weathering and are vulnerable to domestic and foreign threats, both physical and in cyberspace.[ccxxxiv] Hence, the maintenance and protection of transmission towers will also require specialized and technical labor expertise.

Finally, the modernization of the electrical grid is creating a diverse array of new employment opportunities, reflective of advancements in technology and evolving industry needs. With the advent of remote sensing technologies, such as unmanned aerial vehicles (UAV) and even satellites, new specialized roles are emerging to leverage these technologies for enhanced grid monitoring and management.[ccxxxv] Furthermore, the integration of artificial intelligence and machine learning-based tools is creating novel positions focused on optimizing grid performance and reliability through computational approaches. Most of these opportunities await training programs in higher education or elsewhere to prepare workers for this new industry.

Policy: Past, Present, and Future

Passage of the Inflation Reduction Act, 2022 (IRA) will boost investment in transmission projects and the grid workforce. The legislation includes: $2 billion for transmission facility financing, $760 million in grants earmarked to facilitate the siting of interstate transmission lines, and another $100 million for interregional electricity transmission planning and modeling (Sections 50151, 50152, and 50153 IRA). Yet, despite the financial and structural support to enhance transmission development over the next two decades, the IRA still leaves many questions unanswered about how transmission development will operate under its passage.

For instance, the direct loan provision of Section 50151 stipulates that in order to be eligible for a direct loan, a transmission project must be located in a National Interest Electric Transmission Corridor (NIETC), a designation that does not currently exist.[ccxxxvi] Similarly, the grants outlined in Section 50152 depend on the siting authority agreeing to make a final decision on a transmission project within two years, potentially creating bureaucratic challenges to the provision's implementation should a decision not be reached within the window.[ccxxxvii] Additionally, the investment support, which comes in the form of investment tax credits and was initially anticipated for transmission projects, was eventually dropped from the final version of the IRA.[ccxxxviii] Moreover, interconnection credits for projects larger than 5 MW are missing from the legislation.[ccxxxix] Finally, the enticing prevailing wage and apprentice program credit increments (providing a five-fold increase of the base credit rate) that are available for other energy projects (e.g., solar and wind facilities) are absent for transmission projects.[ccxl] In short, despite being an important step forward, the IRA is not sufficient in and of itself to help the U.S. reach its goals in energy transmission.

Nevertheless, other recent developments in energy financing at the federal level seem promising for financing transmission and the grid workforce. In October 2023, for example, the Biden administration announced an unprecedented $3.46 billion investment in strengthening the nation's power grid.[ccxli] A part of President Biden’s “Investing in America” agenda, this investment sets the stage for significant job creation and improves worker conditions across the utility sector. With the allocation of funds to 58 transformative projects spanning 44 states, the initiative is poised to create a surge in employment opportunities, ensuring job security and fostering workforce stability. The government’s collaboration with the International Brotherhood of Electrical Workers (IBEW) in 75% of these projects illustrates a clear commitment to not just creating jobs, but the creation of high-quality, union jobs.

This strategic investment is also targeted towards areas that have been traditionally underserved, ensuring that the benefits of job creation and workforce development reach communities that need them most. The emphasis on projects that support the Biden’s Justice40 Initiative guarantees that at least 40% of the overall benefits of these projects are channeled to disadvantaged communities, fostering a more equitable distribution of employment opportunities.[ccxlii] Furthermore, with a substantial number of projects focusing on modernizing aging infrastructure, workers will have the opportunity to engage with and learn from cutting-edge technologies and innovative practices. This exposure is invaluable, as it means that the workforce is not only meeting the current demands of the industry but is also preparing for future challenges and advancements in the energy sector.

The investment goes hand in hand with Biden's recent creation of the American Climate Corps (ACC). The ACC aims to equip a new, diverse generation with essential skills for burgeoning careers in climate mitigation and clean energy. The program is designed to train and employ about 20,000 individuals, emphasizing the establishment of long-term career pathways in collaboration with unions and various educational institutions. It extends opportunities to a broad demographic of individuals, requiring little to no prior experience or college degrees for most positions, and promotes the incorporation of transferable skills and credentials.[ccxliii] The ACC has the potential to ensure that the grid workforce is robust and diverse.

Policy Recommendations

The preceding analysis sets up a number of policy recommendations that would enable the U.S. to take advantage of the economic and workforce development opportunities associated with expanding interregional transmission.

First, financing prospects for grid build out would be improved if there were tax credits available for transmission, rather than just renewable energy generation. These were dropped from the Inflation Reduction Act in favor of other priorities. Legislative windows to consider this form of stimulus might be narrow or nonexistent, but they remain a policy lever that could help drive build-out.

Second, landowners, along with the communities they live in, can and should benefit from transmission projects that run through their land. Ensuring this happens in transparent and consequential ways will reduce blockages that have stymied earlier efforts. State and federal governments could offer options and guidance for local stakeholders that will negotiate with firms, as well skilled interlocutors that help parties on both sides of a project.

Third, policies should encourage domestic production of key components of the broader interregional grid technology, such as transformers. Programs that stimulate more domestic production of these and other technologies, as well as building next-generation technologies and systems, will help to improve the long-term efficiency and resiliency of the grid. This requires innovations in educational systems ranging from community colleges to elite engineering schools to train a new workforce.

Fourth, it will be important to keep detailed records of changes to the diversification of the grid workforce. Not all grid jobs are the same, and specific employment and wage data collected by the Bureau of Labor Statistics for grid-related occupations will better inform policy and training programs.

Finally, Congress should implement policies that encourage grid-related companies to partner with HBCUs, minority-serving institutions, and veterans' groups to create pathways for enhancing the diversity of the grid workforce. This could happen in a variety of ways, from providing seed grants to private sector or educational partnerships to offering broader tax incentive programs like the Inflation Reduction Act.

Conclusion

The United States needs to expand the capacity of its electric grid substantially over the next 25 years. Simply to meet current projections of demand growth, the nation will need to increase transmission capacity by at least 25% by 2050, and that might be an underestimate. In some areas of the country, demand is growing much faster, and in the near term, these areas may experience sharp increases in electricity prices because existing generation and transmission cannot keep pace with demand. The need to reduce greenhouse gases will increase electricity demand by an order of magnitude. Recent studies of greenhouse gas reduction targets, such as "net zero by 2050," will require substantial expansion of renewable electricity generation to reduce emissions from the power sector and to electrify transportation and industrials. These studies project doubling or even tripling of the network of long-distance transmission lines in the U.S.

Substantial expansion of our electricity system will stress existing regulatory, political, and social institutions that govern grid development today. After robust growth from 1945 to 1970, when the miles of transmission lines increased by more than 5% a year, transmission development over the past 50 years has moved at a glacial pace. Utilities, which own most of the nation's transmission, have little incentive to pursue the ambitious, long-distance projects we need. Transmission expansion can have financial and strategic downsides, and regulatory complexity and permitting delays encourage the industry to pursue small projects. The political and social opposition to siting new transmission lines further clouds the future of major transmission expansion.

The federal system itself is a major source of frustration for developers of long-distance transmission lines. Permitting and siting is done by the states. Each state has its own rules and processes, and developers need to engage in the political and regulatory process in each state separately. Any line that moves electrons across state lines faces the daunting prospect of clearing not one state's rules and regulations but two or more states. There are plenty of risks and challenges getting through one state's permitting and siting process, but those risks are multiplied with each additional state that a line must pass through. The odds are not on the developer's side.[ccxliv] The more states the line runs through the worse the odds of success, as failure or significant delay in any one state may doom the entire project.

The risk for developers is worse still if the opponents choose to take a stand on a segment of the proposed transmission line. If the opponents of a line—be they incumbent energy companies, environmental groups, or local residents—decide to fight and fight hard, they can create lengthy delays. And those delays are costly, as the case studies conducted in conjunction with this report found. Long-distance transmission projects throughout the U.S. have gotten bogged down over controversies focused on small segments of the proposed power lines.

The federal and regulatory systems interfere with development of long-distance transmission in another important way: which benefits and costs are assessed. The decisions of public utility commissions, the FERC, and industry weigh the benefits and costs of any proposal, and they advance projects for which the benefits outweigh the costs. State boundaries, regulatory practice, and industry preferences place guardrails on what counts as a benefit or a cost.

Perhaps the greatest limitations are state boundaries themselves. Interstate transmission lines often conduct electricity generated inside of a state to consumers in other states, or these lines may simply pass through a state. The benefits of lower prices and more reliable service are not registered by the state PUC because the consumers who derive most of the benefit do not reside in the state. Retail prices and reliability are central to PUC decision making, often to the exclusion of other considerations, including economic growth. Development of a robust electricity system and of renewable resources has the potential to stimulate significant new economic sectors, as, for example, the boom in manufacturing that Iowa now enjoys because it embarked on the development of its wind energy sector in the 1990s.

Meeting the demands of an increasingly electricity-driven economy then will require changing the ways that the utility industry and states plan, permit, and site transmission lines. In the cases we have studied, it has taken 15 years to get from initial designs to final approvals. That is too long to meet spiking demand driven by data centers and new manufacturing, and it is even too long to meet the goals of significant reductions in greenhouse gases in the U.S. economy by 2050. Immediate electricity demand and the requirements of longer-term policy goals will create increasing pressure on the state and federal governments to address the limitations of the way that electricity grid development currently takes place.

This report has offered not only our assessment of what the specific pressure points are in the regulatory and political system for permitting and siting, but also ways to improve these processes. While many recent reports have targeted specific areas of regulatory reform, especially reform of NEPA, we see a need for a much broader set of changes.

First, developers need to improve the ways in which they engage with communities. Many developers treat public hearings and other forms of engagement as "a box to be checked." Residents become resentful. Political blowback is inevitable. Developers can improve the ways that they engage with the people in the areas where power lines are proposed. Chapters 1 and 3 offer specific ways that can be accomplished.

Second, state governments must improve permitting and siting procedures. States need to provide better information to the public about proposed transmission lines in order for the public to trust the selection process and to be able to engage with developers about the lines. States also need to reduce the complexity of their regulatory processes.

Third, there is an acute need for regional and interregional grid planning. There have been a few efforts in this direction, but sustained and routine planning of transmission needs and development on regional and interregional levels have been elusive.

Finally, there is an overall lack of vision for the U.S. electricity grid. It is unclear to communities why infrastructure is needed. What is the great mission for which their land is sacrificed? In our interviews, local stakeholders, property owners, and regulators expressed a willingness to support projects if it was clear why a particular project was necessary and if it was transparent as to how the planning process led to the proposed line.

When the U.S. interstate highway system was developed, then-President Dwight Eisenhower articulated the purpose and opportunity for the nation. He saw clearly that the United States needed a modern highway system to meet future transportation demand.[ccxlv] Eisenhower was struck by the projection that 20 years into the future (1975!) there would be 80 million cars on the road—if we could build the highways to support them. Today, the same can be said of the nation's electricity system. America has the opportunity to develop the infrastructure to meet the immediate challenges of rapidly rising demand for electricity and to anticipate the long-term change in the economy that will be driven by a global demand for clean energy.

---

[i] NREL, 2021.
[ii] NREL, 2023.
[iii] U.S. Department of Energy, *U.S. Energy and Employment Report, 2023*, https://www.energy.gov/sites/default/files/2023-06/2023%20USEER%20REPORT-v2.pdf.

[iv] Samantha Gross, *Renewables, Land Use, and Local Opposition in the United States*, Brookings Institution, January, 2020. https://www.brookings.edu/wp-content/uploads/2020/01/FP_20200113_renewables_land_use_local_opposition_gross.pdf; Jim Tankersley, Brad Plumer, Ana Swanson, and Ivan Penn, "The Clean Energy Future Is Roiling Both Friends and Foes," *The New York Times*, August 18, 2023. https://www.nytimes.com/interactive/2023/08/12/climate/wind-solar-clean-energy.html

[v] Evan Halper, "Amid explosive demand, America is running out of power," *The Washington Post*, March 7, 2024. https://www.washingtonpost.com/business/2024/03/07/ai-data-centers-power/ ; Pam Radtke and

[vi] Kristi E. Swartz, "Bitcoin, data centers fuel energy spike, risking climate goals" *Energy News Network* March 19, 2024. https://energynews.us/2024/03/19/bitcoin-data-centers-fuel-energy-spike-risking-climate-goals/; Neil Ford, "Rush for data centers creates US solar hotspots," *Reuters*, February 22, 2024. https://www.reuters.com/business/energy/rush-data-centers-creates-us-solar-hotspots-2024-02-22/

[vii] These organizations vary in size from very small municipal and co-op utilities to large corporations such as Southern Company, and from small municipalities to large regional organizations and federal agencies. According to the American Public Power Association, there are more than 3,000 electricity providers in the United States; 59% are publicly owned utilities, 26% are cooperatives, and 5% are investor-owned utilities. However, the 179 investor-owned utilities, which comprise 5% of all electricity providers, serve 67% of customers. Publicly owned utilities serve 14% of customers, and cooperatives serve an addition 13% of customers. American Public Power Association, *2023 Statistical Report: A supplement of Public Power magazine*. Page 17. https://www.publicpower.org/system/files/documents/2023-Public-Power-Statistical-Report_0.pdf

[viii] From 1960 to 1975, the United States built approximately 7,000 circuit miles of transmission lines annually. Since 1985, the Unite States has built less than 2,000 circuit miles of transmission lines annually. See Pfeifenberger, Johannes, "Transmission Investment Trends and Planning Challenges," the Brattle Group, August 8, 2012; see page 2. https://www.brattle.com/wp-content/uploads/2017/10/6596_transmission_investment_trends_and_planning_challenges_pfeifenberger_aug_8_2012_eei.pdf.

[ix] Brad Plumer and Nadja Popovich, "A New Surge in Power Use is Threatening U.S. Climate Goals," *New York Times,* March 14, 2024. https://www.nytimes.com/interactive/2024/03/13/climate/electric-power-climate-change.html. Jamie Smyth and Eva Xiao, "Resurgent US electricity demand sparks power grid warnings," *Financial Times*, January 12, 2024. https://www.ft.com/content/9892d043-64bd-42f4-a36c-0f6717a255da

[x] Small scale disruptions are common and occur when an animal or construction crew interferes.

[xi]DOE, "Chapter IV: Ensuring Electricity System Reliability, Security, and Resilience," Department of Energy, 2017, https://www.energy.gov/sites/prod/files/2017/01/f34/Chapter%20IV%20Ensuring%20Electricity%20System%20Reliability%2C%20Security%2C%20and%20Resilience.pdf

[xii] Caitlin Murphy, Trieu Mai, Yinong Sun, Paige Jadun, Matteo Muratori, Brent Nelson, and Ryan Jones, *Electrification Futures Study: Scenarios of Power Systems Development and Future Infrastructure Development*, Golden CO: National Renewable Energy Laboratory, 2021. NREL/TP-6A20-72330. https://www.nrel.gov/docs/fy21osti/72330.pdf, especially pages 12 – 18.

[xiii] See also the Princeton Net Zero study.

[xiv] Paul Joskow and Richard Schmalensee, *Markets for Power: An Analysis of Electric Utility Deregulation* (Cambridge, MA: MIT Press, 1988).

[xv] For example, in 1996, FERC issued two orders (Order 888 and 889) which opened up wholesale electricity markets to competition and provided for a formula for cost recovery in competitive markets. In 1999, FERC took a step further when it issued Order 2000 to establish Regional Transmission Organizations (RTOs), which are large areas in which electricity markets can be established. https://www.ferc.gov/major-orders-regulations.

[xvi] "Electric Power Markets," FERC, May 2023, https://www.ferc.gov/electric-power-markets; "U.S. Electricity Grid & Markets," EPA, April 2023, https://www.epa.gov/green-power-markets/us-electricity-grid-markets; "Wholesale Electricity Market Studies and Engagement Program," Grid Deployment Office, https://www.energy.gov/gdo/wholesale-electricity-market-studies-and-engagement-program.

[xvii] "U.S. Electric System Is Made up of Interconnections and Balancing Authorities," EIA, July 20, 2016, https://www.eia.gov/todayinenergy/detail.php?id=27152.

[xviii] The line is paid for by Massachusetts ratepayers.

[xix] See, for example, the MIT Energy Futures studies, dating back to the *Future of Nuclear Power* in 2002. Of the dozen studies, only one, completed in 2011, considered the grid.

[xx] Paul Denholm et al., rep., *Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035* (Golden, CO: NREL, 2022), https://www.nrel.gov/analysis/100-percent-clean-electricity-by-2035-study.html.
[xxi] US DOE, *National Transmission Needs Study,* October 2023. https://www.energy.gov/sites/default/files/2023-12/National%20Transmission%20Needs%20Study%20-%20Final_2023.12.1.pdf.
[xxii] Princeton University. *Net-Zero America: Potential Pathways, Infrastructure, and Impacts,* 2021.https://netzeroamerica.princeton.edu/?explorer=year&state=national&table=2020&limit=200.
[xxiii] See NREL at pages 32 and 44-45, 48, 118.
[xxiv] Brad Johnson, "Out of Sight, Out of Mind? A study on the costs and benefits of underground overhead power lines." A report of the Edison Electric Institute, January 2004.
[xxv] "SOO Green HVDC Link." SOO Green, July 5, 2022. https://soogreen.com/.
[xxvi] "U.S. Electric System Is Made Up of Interconnections and Balancing Authorities," EIA, July 20, 2016, https://www.eia.gov/todayinenergy/detail.php?id=27152. It is always difficult to calculate exactly how many miles of lines exist, as some lines run side by side. Also, the capacity of lines makes them difficult to compare.
[xxvii] NREL (2023), page 45.
[xxviii] Existing power infrastructure also presents opportunities for renewable generation. For instance, an abandoned coal-fired power plant in a coastal city is an ideal location to bring electricity from off-shore wind platforms on shore because the connection to the transmission system is already in place.
[xxix] DOE, National Transmission Needs Study, 2023, page iii.
[xxx] Samantha Gross, "Renewables, Land Use, and Local Opposition in the United States," Brookings Institution Report, January, 2020.
[xxxi] NREL 2023, page 52. Large-scale wind development has further land-use implications as the amount of land used by the towers themselves and the spacing between the towers will be substantial. The towers themselves will take around 8,000 to 9,000 square kilometers of land, but the spacing between them will require 350,000 to 430,000 square kilometers (135,000 to 166,000 square miles). That is comparable to the total amount of land taken by urbanized areas in the United States. NREL 2023, page 52. See Jessica Lovering, Marian Swain, Linus Blomqvist, and Rebecca Hernandez, "Land-use intensity of electricity production and tomorrow's energy landscape." PLoS ONE 17 (2022): *e0270155. https://doi.org/10.1371/journal.pone.0270155.*
[xxxii] See NREL 2023, pages 59-63.
[xxxiii] Parrish Bergquist, Stephen Ansolabehere, Sanya Carley, David Konisky, "Backyard Voices: How Sense of Place Shapes Views of Large-Scale Energy Transmission Infrastructure," *Energy Research & Social Science* 63 (May 2020): 101396, https://doi.org/10.1016/j.erss.2019.101396.
[xxxiv] Mandi Cai, Erin Douglas, and Mitchell Ferman, "How Texas' power grid failed in 2021—and who's responsible for preventing a repeat," *Texas Tribune*, February 15, 2022. https://www.texastribune.org/2022/02/15/texas-power-grid-winter-storm-2021/.
[xxxv] Meghan Sever, "MN Commerce Department and Regional Grid Operators Receive $464 Million from U.S. Department of Energy for Innovative Electric Grid Project," SPP, October 18, 2023, https://www.spp.org/news-list/mn-commerce-department-and-regional-grid-operators-receive-464-million-from-us-department-of-energy-for-innovative-electric-grid-project/. As of 2023, despite the DOE grant, no projects have yet been approved by MISO and SPP. All lines will be in the Eastern Interconnect.
[xxxvi] DOE National Transmission Needs Study, 2023, pages 133-138.
[xxxvii] Robert J. Klee and Sarah Baldinger. Center for Business and the Environmental at Yale*, Review of State Public Utility Commission Statutory Mandates: A Report for the Institute for Market Transformation PUC Mandate Project*, (Aug. 13, 2021), 9-10.
[xxxviii] Claire Wayner, RMI, "Increased Spending on Transmission in PJM – Is It the Right Type of Line?" (March 20, 2023).
[xxxix] Edison Electric Institute, Member List; Stan Mark Kaplan, Congressional Research Service, *Electric Power Transmission: Background and Policy Issues*, (April 14, 2009), 4 (showing that in 2008 IOUs owned at least two-thirds of all transmission operating at 230 kilovolts or above); Federal Energy Regulatory Commission, Form 1 Data (2021) (showing ownership for each IOU).
[xl] Federal Power Commission v. Hope Natural Gas, 320 U.S. 591 (1944).
[xli] Regulatory Assistance Project, Best Practices in Electric Utility Integrated Resource Planning, June 2013, https://www.raponline.org/wp-content/uploads/2016/05/rapsynapse-wilsonbiewald-bestpracticesinirp-2013-jun-21.pdf, 7.
[xlii] *Id.; see also* 16 USC 2602(19) (defining "integrated resource planning").

[xliii] See, e.g., 4 Colo. Code Regs. § 723-3:3617(d) (establishing that regulatory approval of the utility's plan "creates a presumption that utility actions consistent with that approval are prudent" and therefore allows the utility to include project costs in consumer rates).
[xliv] SC Code § 58-37-40; South Carolina Public Service Commission, Order Rejecting Dominion's Integrated Resource Plan, Docket No. 2019-226-E, Order No. 2020-832 (Dec. 23, 2020).
[xlv] *See, e.g., In the Matter of the Integrated Resource Plan Filed by Rocky Mountain Power*, Wyoming Public Service Commission, Docket No. 90000-147-XI-19, 2021 WL 365177, p.145 (January 21, 2021) (noting that regulators had typically accepted IRPs for filing without approving them).
[xlvi] PacifiCorp, 2008 Integrated Resource Plan: Vol. 1, p.17 (May 28, 2009).
[xlvii] PacifiCorp, 2017 Integrated Resource Plan: Vol. 1, p.64 (Apr. 4, 2017).
[xlviii] *In the Matter of PacifiCorp, dba Pacific Power, 2017 Integrated Resource Plan*, Oregon Public Utilities Commission, Order No. 18 138, 2018 WL 2060075 (April 27, 2018).
[xlix] *In the Matter of PacifiCorp, dba Pacific Power, 2017R Request for Proposals*, Order No. 18-178 (May 23, 2018).
[l] See FERC Order No. 1000 Transmission Planning Regions.
[li] Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection, Proposed Rule, 179 FERC ¶ 61,028, p.39 (2022).
[lii] Ari Peskoe, *Is the Utility Transmission Syndicate Forever?* 42 Energy L. J. 1, 47–57 (2021).
[liii] See, e.g., California ISO, 2022-2023 Transmission Plan, at 1 (Apr. 2023) (explaining that California's clean energy policies are driving transmission planning).
[liv] *MISO*, 179 FERC ¶ 61,124 (2022) (summarizing planning process and approving cost-allocation method).
[lv] Protest of The MISO Consumer Alliance, FERC Docket No. ER22-1955, at 4 (June 17, 2022).
[lvi] SB 20 (2005) (amending sections 36.053, 39.203, and 39.904 of the Utilities Code).
[lvii] *Id.* (adding sub-sections 36.053(d) and 39.904(g) to the Utilities Code).
[lviii] Julie Cohn and Olivera Jankovska. Baker Institute for Public Policy Center for Energy Studies, "Texas CREZ Lines: How Stakeholders Shape Major Infrastructure Projects" (Nov. 2020), https://www.bakerinstitute.org/research/texas-crez-lines-how-stakeholders-shape-major-energy-infrastructure-projects, 4.
[lix] *MISO, SPP*, 168 FERC 61,018 (2019), p. 2-4.
[lx] FERC, Report on Barriers and Opportunities for High Voltage Transmission: A Report to the Committees on Appropriations of Both Houses of Congress Pursuant to the 2020 Further Consolidated Appropriations Act (June 2020), 27.
[lxi] *See, e.g.,* Jeff St. John, *Grid Operator MISO's Transmission Plan Would Splits Its Region in Two*, Canary Media (Dec. 7, 2021), https://perma.cc/XB48-Z3YE (explaining that MISO proposed to allocate costs of projects in MISO North only to transmission owners in that region in order to overcome opposition from Entergy, which is in MISO South, that had proposed a cost allocation methodology that might have derail all regional development); *MISO*, 179 FERC ¶ 61,124 (2022) (approving the cost allocation proposal).
[lxii] Newman v. FERC, 27 4th 690 (D.C. Cir. 2022) (describing why PJM-planned PATH transmission project was cancelled).
[lxiii] Emera Maine v. FERC, 854 F.3d 662, 672–75 (D.C. Cir. 2017) (explaining that FERC rejected a proposal to give state officials an official role in selecting regional transmission projects to meet policy goals).
[lxiv] Green Communities Act, added by Chapter 188 of the Acts of 2016 that amended Section 83D of Chapter 169 of the Acts of 2008; Maddy Kroot, *Northern Pass Didn't Pass: The Legal Story of a Contested Transmission Line*, Environmental Law Institute (2018) (noting that 16% of generation capacity in New England was set to retire between 2013 and 2021 and observing that the 2016 law "Implicitly favored large-scale hydropower"); Kyrsti Shallenberg, Utility Dive, "5 Companies Propose Transmission Projects for Massachusetts Clean Energy RFP, July 31, 2017 (reporting that all proposals in response to the RFP were transmission projects that would ship Canadian hydro into the region).
[lxv] Massachusetts Department of Public Utilities, Orders in DPU 18-64, 18-65, 18-66 (Jun. 25, 2019 (approving energy contracts with Hydro Quebec); *Central Maine Power Co.*, 165 FERC 61,034 (2018) (approving transmission contracts with Clean Energy Connect).
[lxvi] *See PJM Interconnection*, 179 FERC ¶ 61,024 (2022) (approving allocation of costs of transmission expansion to meet New Jersey offshore wind goals); NESCOE, Update on Multi-State Transmission Activities (Jun. 22, 2023).

[lxvii] Heidi Werntz, "Let's Make a Deal: Negotiated Rates for Merchant Transmission," 28 Pace Envtl. L. Rev. 421, 443 (2011).
[lxviii] Joseph Rand et al., Queued Up: *Characteristics of Power Plants Seeking Transmission Interconnection*, Lawrence Berkeley Nat'l Lab. (Apr. 2022), https://perma.cc/5A4W-3296 (finding that the "typical duration" for an interconnection process has "increased sharply since 2015" and now exceeds three years).
[lxix] Id.
[lxx] *NECEC Transmission LLC v. NextEra Energy Resources, LLC*, 182 FERC ¶ 61,044, P 5 (February 1, 2023).
[lxxi] *Id.* P 79.
[lxxii] U.S. Court of Appeals for the D.C. Circuit, Case No. 23-1094.
[lxxiii] William K. Jones, *Origins of the Certificate of Public Convenience and Necessity: Developments in the States, 1870–1920*, 70 Columbia L. Rev. 426 (1979).
[lxxiv] See, e.g., CA Pub. Util. Code § 1002 (requiring utility regulators to consider "community values, "recreational and park areas," "historical and aesthetic values," and "influence on environment").
[lxxv] See, e.g., Ohio Rev. Code § 4906.10 (requiring the siting board to consider "need," nature of the probable environmental impact," and that the line "represents the minimum adverse environmental impact"); Sharon B. Jacobs, Agency Genesis and the Energy Transition, 121 Colum. L. Rev. 835, 853–54 (April 2021).
[lxxvi] U.S. Energy Information Administration, Monthly Energy Review, Tbl. 7.2b (November 2023).
[lxxvii] In the Matter of the Application of Grain Belt Express, Missouri Public Service Commission File No. EA-2014-0207 (July 1, 2015).
[lxxviii] In the Matter of the Application of Grain Belt Express LLC, Missouri Public Service Commission, File No. EA-2023-0017 (October 12, 2023).
[lxxix] Me. Rev. Stat. tit. 35-A, § 3132.
[lxxx] Central Maine Power Company, Docket No. 2017-00232, Order Granding Certificate of Public Convenience and Necessity and Approving Stipulation, at p. 64 (May 3, 2019).
[lxxxi] NextEra Energy Resources, LLC v. Maine Public Utilities Commission, 227 A.3d 1117 (Me. 2020).
[lxxxii] N.H. Rev. Stat. Ann. § 162-H:1.
[lxxxiii] N.H. Rev. Stat. Ann. § 162-H:16.
[lxxxiv] In re Appeal of N. Pass Transmission, LLC, 214 A.3d 590 (N.H. 2019).
[lxxxv] Id.
[lxxxvi] Or. Rev. Stat. § 758.015(b).
[lxxxvii] Or. Rev. Stat. § 469.501(3)(a).
[lxxxviii] Matter of Site Certificate for Boardman to Hemingway Transmission Line, 525 P.3d 864 (2023) (upholding the Council's order).
[lxxxix] *In the Matter of Idaho Power Company,* Oregon PUC Order No. 23-225 (June 2023).
[xc] Matter of Site Certificate for Boardman to Hemingway Transmission Line, 525 P.3d 864, 881 (2023).
[xci] Mass. Gen. Laws Ann. ch. 164, §§ 1 & 72.
[xcii] Transcript of the Fifth Meeting of the Joint Federal-State Task Force on Electric Transmission, FERC Docket AD21-15, at pp. 24–25 (Nov. 15, 2022).
[xciii] Mich. Comp. Laws Ann. §§ 460.562 & 460.565, 460.569
[xciv] See, e.g., ME ST T. 35-A § 3136(4).
[xcv] See, e.g., WY ST § 37-2-205(iv) & - (V) (requiring notification of landowners "along the entire length" of the proposed line); 16 Tex. Admin. Code § 22.52(a)(3) (requiring notification of landowners who own a "habitable structure" within 300 feet of a line 230 kV or below and 500 feet for larger lines as well as land that may be obtained as part of the development process).
[xcvi] In Iowa, for instance, a county-level compensation commission determines the fair market value. Its decisions may be appealed to state court.
[xcvii] Alexandra B. Klass, "Takings and Transmission," 91 N.C. L. Rev. 1079, 1105 (May 2013).
[xcviii] *Id.,* 1107.
[xcix] *Id.,* 1125 (2013).
[c] Iowa Code 6A.21.
[ci] See, e.g., SB 508 (2021).
[cii] MO ST 523.256(3).

[ciii] *NECEC Transmission LLC, et al. v. Bureau of Parks & Land, et al.*, 281 A.3d 618, 624-25 (Me. 2022) ("In addition to the CPCN, NECEC . . . obtained multiple authorizations from various government entities before beginning construction on the Project. NECEC applied for permits from the Department of Environmental Protection (DEP) as required under the Natural Resources Protection Act, 38 M.R.S. §§ 480-A to 480-JJ (2017), and the Site Location of Development Act, 38 M.R.S. §§ 483-A, 484, 487-A (2017), as well as for a Site Law Certification from the Land Use Planning Commission (LUPC), see 12 M.R.S. § 685- B (2017). On May 11, 2020, the DEP approved NECEC's permit application in an order that also incorporated the LUPC's certification").
[civ] *Id.,* 622.
[cv] *Id.,* 623.
[cvi] Maine Department of Environmental Protection, Maine DEP lifts suspension order for NECEC project (May 16, 2023), https://www.maine.gov/dep/news/news.html?id=11020845; Black v. Bureau of Parks & Lands, 2022 ME 58, 288 A.3d 346.
[cvii] David Sharp, "Massachusetts Budget Bill Allows Utilities to Recoup Added Cost of Hydropower Corridor Through Maine," Dec. 6, 2023.
[cviii] UT Code Ann. §§ 54-18-301–305; Colo. Rev. Stat § 29-20-108.
[cix] *See, e.g.,* Va. Code Ann. § 56-46.1.C; Iowa Admin. Code § 199.11.4.
[cx] Congressional Research Service, *Federal Land Ownership: Overview and Data* (February 21, 2020).
[cxi] "Boardman to Hemingway Transmission Line," Federal Infrastructure Projects, July 6, 2017, https://www.permits.performance.gov/permitting-project/fast-41-covered-projects/boardman-hemingway-transmission-line.
[cxii] "Document Room," New England Clean Energy Connect, https://www.necleanenergyconnect.org/document-room.
[cxiii] Michael Bennon and Devon Wilson, Environmental Litigation on Large Energy and Transport Infrastructure Projects in the United States, Environmental Law Reporter, *Forthcoming* (July 5, 2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4498938. David E. Adelman, Permitting Reform's False Choice (August 14, 2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4540734.
[cxiv] Sierra Club v. United States Army Corps of Engineers, 997 F.3d 395, 403 (1st Cir. 2021).
[cxv] Congressional Research Service, The National Environmental Policy Act (NEPA): Background and Implementation, p.23 (January 10, 2011).
[cxvi] U.S. Department of Energy, Notice of Proposed Rulemaking, Coordination of Federal Authorizations for Electric Transmission Facilities, 88 Fed. Reg. 55,826 (Oct. 2, 2023).
[cxvii] *See, e.g.,*40 CFR § 1502.14.
[cxviii] Idaho Power Company Reply Testimony of Mitch Colburn (Before the Public Utility Commission of Oregon February 21, 2023), 604.
[cxix] Id. P.41
[cxx] Transmission Line Rights-of-Way (IBLA 2017-103, -104, -125, -126 April 18, 2017).
[cxxi] Morley Nelson Snake River Birds of Prey National Conservation Area Boundary Modification Act of 2017, HR 2104 (introduced Apr. 20, 2017); incorporated into Consolidated Appropriations Act of 2017, HR 244, sec. 431, 131 Stat 135 (codified 16 USCA § 460iii-4).
[cxxii] Hannah Perls, President Biden Issues Long-Awaited Update to Clinton-era Environmental Justice Executive Order (August 3, 2023); Hannah Perls, Key Changes in CEQ's Proposed Phase 2 Regulations Implementing NEPA (August 23, 2023).
[cxxiii] H.R.3746 - Fiscal Responsibility Act of 2023, https://www.congress.gov/bill/118th-congress/house-bill/3746/text
[cxxiv] See the Hydro Quebec-NECEC Case Study #1 in *Four Case Studies of Long-Distance Transmission Development*.
[cxxv] One infamous case is the CU line in Minnesota. Proposed in 1971, the CU line became a focal point for opposition to power lines in rural Minnesota. The development stirred a decade of protests from farmers and small towns along the path of the line. Barry M. Casper and Paul David Wellstone. *Powerline: The First Battle of America's Energy War.* Amherst, MA: The University of Massachusetts Press, 1981.
[cxxvi] See Parrish Bergquist, Stephen Ansolabehere, Sanya Carley, and David Konisky, "Backyard Voices: How sense of place shapes views of large-scale energy transmission infrastructure," *Energy Research and Social Science* 63 (2020): 101396. https://doi.org/10.1016/j.erss.2019.101396.
[cxxvii] See Elinor Ostrom, Governing the Commons. New York: Cambridge University Press, 1990.

[cxxviii] Alshuler and Luberoff, Mega-Projects, 2003. Larry Susskind, et al., "Sources of Opposition to Renewables in the United States," Energy Policy. https://www.mdpi.com/1996-1073/13/1/17; Jed J. Cohen, Johannes Reichl, Michael Schmidthaler, "Re-focusing research efforts on public acceptance of energy infrastructure: A critical review" Energy, 76 (2014): 4-9. https://doi.org/10.1016/j.energy.2013.12.056; David Konisky, Stephen Ansolabehere, and Sanya Carley, "Proximity, NIMBYism, and Public Support for Infrastructure," *Public Opinion Quarterly*, Volume 84, Issue 2, Summer 2020, Pages 391–418, https://doi.org/10.1093/poq/nfaa025; https://www.researchgate.net/profile/Ramakrishna-Nallathiga/publication/272296048_Stakeholders'_Assessment_of_Infrastructure_Project_Delays_and_their_Causal_Factors/links/58996776aca2721f0daf4aa4/Stakeholders-Assessment-of-Infrastructure-Project-Delays-and-their-Causal-Factors.pdf. https://www.nytimes.com/2021/11/28/us/infrastructure-megaprojects.html.

[cxxix]Pall, Goutom K., Adrian J. Bridge, Martin Skitmore, and Jason Gray. "Comprehensive Review of Delays in Power Transmission Projects." *IET Generation, Transmission & Distribution* 10, no. 14 (November 2016): 3393–3404. https://doi.org/10.1049/iet-gtd.2016.0376; Park, Jung Eun. "Schedule Delays of Major Projects: What Should We Do about It?" *Transport Reviews* 41, no. 6 (April 21, 2021): 814–32. https://doi.org/10.1080/01441647.2021.1915897.

[cxxx] Tim Marshall and Richard Cowell, "Infrastructure, Planning, and Command of Time," *Environment and Planning C: Politics and Space*, 34 (2016): https://doi.org/10.1177/0263774X166427.

[cxxxi]Reuters. "Maine Voters Reject Quebec Hydropower Transmission Line | Reuters." November 3, 2021. https://www.reuters.com/world/americas/maine-voters-reject-quebec-hydropower-transmission-line-2021-11-03/.

[cxxxii]Eggert, Timothy. "Illinois Appellate Court Lifts Stay on Grain Belt Express Project." FarmWeek Now, September 22, 2023. https://www.farmweeknow.com/policy/state/illinois-appellate-court-lifts-stay-on-grain-belt-express-project/article_7543dbda-5726-11ee-8184-9ffb084b6d2a.html.

[cxxxiii]Ireland: Hyland, Marie, and Valentin Bertsch. "The Role of Community Involvement Mechanisms in Reducing Resistance to Energy Infrastructure Development." *Ecological Economics* 146 (April 2018): 447–74. https://doi.org/10.1016/j.ecolecon.2017.11.016; Austria: Friedl, Christina, and Johannes Reichl. "Realizing Energy Infrastructure Projects – a Qualitative Empirical Analysis of Local Practices to Address Social Acceptance." *Energy Policy* 89 (February 2016): 184–93. https://doi.org/10.1016/j.enpol.2015.11.027.

[cxxxiv] Lawrence Susskind, Jungwoo Chun, Alexander Gant, Chelsea Hodgkins, Jessica Cohen, and Sarah Lohmar, "Sources of Opposition to Renewable Energy Projects in the United States," Energy Policy 165 (2022): 122922.

[cxxxv] Benjamin K. Savocool, et al., "Conflicted Transitions: Exploring Economic Actors, Tactics, and Outcomes of Social Opposition Against Energy Infrastructure," Environmental Change 73 (2022) 102473.

[cxxxvi]Kite, Allison. "Grain Belt Express, Which Will Transport Clean Energy to Missouri, Wins Final Approval." KCUR, October 13, 2023. https://www.kcur.org/news/2023-10-13/grain-belt-express-which-will-transport-clean-energy-to-missouri-wins-final-approval.

[cxxxvii] Arlie Hochschild, *Strangers in Their Own Land*. The New Press, 2016. Katherine Cramer, *The Politics of Resentment*. University of Chicago Press, 2016.

[cxxxviii] Suboticki, Ivana, et al. "Fostering justice through engagement: A literature review of public engagement in energy transitions." *Energy Research & Social Science* 99 (2023): 103053.

[cxxxix] For more guidance and best practices, see: https://www.mapc.org/wp-content/uploads/2017/08/RECIPEBOOKFINAL8.16.17FINAL.pdf

[cxl] Gross, Neil. "A pragmatist theory of social mechanisms." *American sociological review* 74.3 (2009): 358-379.

[cxli] Moran, Grey. "Gulf Coast communities are solving their own flooding crisis. It could be a model for cities nationwide." Fix Solutions Lab, May 07, 2021. https://grist.org/fix/policy/louisiana-gulf-coast-climate-adaptation-community-participation-la-safe/

[cxlii] H. Doukas, C. Karakosta, A. Flamos, and J. Psarras, "Electric power transmission: An overview of associated burdens," International Journal of Energy Research 35 (2011): 979-988.

[cxliii] Public Service Commission of Wisconsin, "Underground Electric Transmission Lines," Report Electric 11 (05/11). https://psc.wi.gov/Documents/Brochures/Under%20Ground%20Transmission.pdf

[cxliv] Ethan Howland, "SOO Green transmission project faces PJM obstacles: Are grid operators hindering the energy transition?" *Utility Dive* January 13, 2022. https://www.utilitydive.com/news/soo-green-pjm-grid-operators-helping-or-hurting-energy-transition/616966/

[cxlv] State of Maine Public Utilities Commission, "Examiner's Report, Central Maine Power Request for Approval of the CPCN of the New England Clean Energy Connect Consisting of Construction of a 1,200 MW HVDC Powerline from the Quebec-Maine Border to Lewiston Maine (NECEC) and Related Network Upgrades," March 29, 2019. Docket Number 2017-00232, pages 108-110.

[cxlvi] Texas is not the only jurisdiction in the world using such a process for electricity transmission lines. Australia National Electricity Market has developed a Renewable Electricity Zone. Paul Simhauser, "Renewable Energy Zones in the Australian National Electricity Market," Energy Economics 101 (2021) 105446. https://doi.org/10.1016/j.eneco.2021.105446; Taryn Lane and Jarra Hicks, "Community Engagement and benefit sharing in renewable energy development," Analysis and Policy Observatory, Nov. 10, 2017. https://apo.org.au/node/309132.
[cxlvii] Lawrence Susskind, Jungwoo Chun, Alexander Grant, Chelsea Hodgkins, Jessica Cohen, and Sarah Lohmar "Sources of Opposition to Renewable Energy Projects in the United States" Energy Policy vol. 165 (2022): 112922. https://doi.org/10.1016/j.enpol.2022.112922.
[cxlviii] Gregory Brinkman, Dominique Bain, Grant Buster, Caroline Draxl, Paritosh Das, Jonathan Ho, Eduardo Ibanez et al., "The North American Renewable Integration Study: A U.S. Perspective—Executive Summary." National Renewable Energy Laboratory, 2021. https://www.nrel.gov/docs/fy21osti/79224-ES.pdf
[cxlix] Wang, Eva Ruoyun; Yang, Jarome Leslie; Duan, Jinglin; Lan, Tianying. "How does electric transmission benefit you? Identifying and measuring the life-cycle benefits of infrastructure investment," London Economics Institute, 2018. https://wiresgroup.com/wp-content/uploads/2020/06/2018-01-08-London-Economics-Intl-How-Does-Electric-Transmission-Benefit-You.pdf
[cl] Our World in Data, "Electricity as a share of primary energy," Available at: https://ourworldindata.org/grapher/electricity-as-a-share-of-primary-energy.
[cli] Doying, Richard; Goggin, Michael; Sherman, Abby. 2023. "Transmission Congestion Costs Rise Again in US RTOs." Grid Strategies. https://gridstrategiesllc.com/wp-content/uploads/2023/07/GS_Transmission-Congestion-Costs-in-the-U.S.-RTOs1.pdf
[clii] Lucas, Davis W.; Hausman, Catherine; Rose, Nancy L. "Transmission Impossible? Prospects for Decarbonizing the US Grid." Journal of Economic Perspectives 37 (4), 2023
[cliii] Ibid. Combined with particular policy mixes, this can lead to negative prices.
[cliv] Bakke Lew, Debra Jordan; Bloom, Aaron; Brown, Patrick; Caspary, Jay; Clack, Christopher; Miller, Nicholas et al. "Transmission planning for 100% clean electricity: Enabling clean affordable and reliable electricity." IEEE Power and Energy Magazine 19, no. 6 (2021): 56-66.
[clv] Figueroa Acevedo et al, "Design and Valuation of High-Capacity HVDC Macrogrid Transmission for the Continental US," IEEE Transactions on Power Systems, July 2021.
[clvi] Patrick Brown and Audun Butterud. "The Value of Interregional Coordination and Transmission in Decarbonizing the U.S Electricity System." Joule 5, January 2021.
[clvii] Ibid.
[clviii] Brinkman, Gregory, Dominique Bain, Grant Buster, Caroline Draxl, Paritosh Das, Jonathan Ho, Eduardo Ibanez et al., "The North American Renewable Integration Study: A U.S. Perspective—Executive Summary." National Renewable Energy Laboratory, 2021. https://www.nrel.gov/docs/fy21osti/79224-ES.pdf
[clix] MISO, October 2023. "MTEP24 Expedited Project Review." https://cdn.misoenergy.org/20231011%20PAC%20Item%2004a%20Expedited%20Project%20Reviews630438.pdf.
[clx] Arcolakis Costas and Walsh Conor, "Clean Growth." NBER Working Paper No. w31615, August 2023. https://ssrn.com/abstract=4553618.
[clxi] Eva Wang, Ruoyun Yang, Jarome Leslie, Jinglin Duan, Tianying Lan, "How does electric transmission benefit you? Identifying and measuring the life-cycle benefits of infrastructure investment," London Economics Institute, 2018. https://wiresgroup.com/wp-content/uploads/2020/06/2018-01-08-London-Economics-Intl-How-Does-Electric-Transmission-Benefit-You.pdf.
[clxii] John D. Wilson, and Zach Zimmerman. "The Era of Flat Power Demand Is Over." Clean Grid Initiative, December 2023. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf.
[clxiii] PwC, September 2023. "Economic Environmental and Social Impacts of Data Centers in the United States." Prepared for the Data Center Coalition.
[clxiv] U.S Chamber of Commerce, June 2017. "Data Centers – Jobs and Opportunities in Communities Nationwide"
[clxv] Magnum Economics, March 2022. "The Impact of Data Centers on the State and Local Economies of Virginia." Northern Virginia Technology Council. https://www.nvtc.org/topics/data-center-and-cloud/report/.
[clxvi] Adam Wilson, "Data Center Companies Continue Renewable Buying Spree." S&P Global Market Intelligence, March 2023. https://www.spglobal.com/marketintelligence/en/news-insights/research/datacenter-companies-continue-renewable-buying-spree-surpassing-40-gw-in-us.

[clxvii] Adam Wilson, "Data Center Companies Continue Renewable Buying Spree." S&P Global Market Intelligence, March 2023. https://www.spglobal.com/marketintelligence/en/news-insights/research/datacenter-companies-continue-renewable-buying-spree-surpassing-40-gw-in-us.
[clxviii] Antonio Olivo, "Dominion Agrees to Bury Power Lines in Prince William Ending Legal Standoff." Washington Post, March 23, 2018. https://www.washingtonpost.com/local/virginia-politics/dominion-agrees-to-bury-power-lines-in-prince-william-ending-legal-standoff/2018/03/23/4d1e73ee-2e97-11e8-8688-e053ba58f1e4_story.html.
[clxix] Data Center Frontier "The power problem: Transmission Issues Slow Data Center Growth" (2023).. Available at: https://www.datacenterfrontier.com/energy/article/33005221/the-power-problem (Accessed: December 14, 2023).
[clxx] Semerad, T. (2022) "'Big day' for Utah City as Facebook's parent firm plans to nearly double the size of its Data Center," The Salt Lake Tribune. Available at: https://www.sltrib.com/news/2022/09/30/facebooks-parent-firm-nearly/ (Accessed: December 14, 2023).
[clxxi] Jared Anderson and Darren Sweeney. "Power of AI: Surging datacenter load has Dominion bracing for AI's added demand." S&P Global, Market Intelligence, October 17, 2023.
[clxxii] John D. Wilson, and Zach Zimmerman. "The Era of Flat Power Demand Is Over." Clean Grid Initiative, December 2023. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf.
[clxxiii] Foster D., Nabahe S., and Sun Hon Ng B., "Energy and Manufacturing in the United States," MIT Center for Energy and Environmental Policy Research, 2020, p. 4.
[clxxiv] John D. Wilson, and Zach Zimmerman. "The Era of Flat Power Demand Is Over." Clean Grid Initiative, December 2023. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf.
[clxxv] Energy Use in the Steel Industry, World Steel Making Association, April 2021.
[clxxvi] Kristopher White, "Mississippi's Largest Economic Project Holds Hiring Event," WJTV News, October 2023. https://www.wjtv.com/news/state/mississippis-largest-economic-project-holds-hiring-event/.
[clxxvii] MISO, October 2023. "MTEP24 Expedited Project Review." https://cdn.misoenergy.org/20231011%20PAC%20Item%2004a%20Expedited%20Project%20Reviews630438.pdf.
[clxxviii] Rocky Mountain Institute, "Aluminum GHG Emissions Reporting Guide," 12/23.
[clxxix] Moreira, Susana. March 2023. "Cost-competitive low-carbon aluminum is key to the energy transition." World Bank Blog.
[clxxx] DOE, "U.S Energy Requirements for Aluminum Production," February 2007. https://www.energy.gov/eere/amo/articles/us-energy-requirements-aluminum-production.
[clxxxi] Foster David, Sade Nahbahe, and Benny Siu Hon Ng, "Energy Workforce Development in the 21st Century." MIT Center for Energy and Environmental Policy Research, September 2020. https://ceepr.mit.edu/wp-content/uploads/2021/09/The-Roosevelt-Project-WP-7.pdf.
[clxxxii] Watson, Christopher, "Report to Congress on U.S Aluminum Industry." Congressional Research Service, October 26, 2022. https://news.usni.org/2022/11/03/report-to-congress-on-u-s-aluminum-industry.
[clxxxiii] Energy Information Administration, "U.S Primary Aluminum Production Remains Low Despite Slow Increase in Prices," September 2017. https://www.eia.gov/todayinenergy/detail.php?id=32872.
[clxxxiv] Adam Hersh, and Scott, Robert, "Aluminum Producing and Consuming Industries have Thrived under U.S Section 232 Import Measures." Economic Policy Institute, May 2021. https://www.epi.org/publication/aluminum-producing-and-consuming-industries-have-thrived-under-u-s-section-232-import-measures/.
[clxxxv] Aluminum production contributes to around 2% of global greenhouse gas emissions according to the Rock Mountain Institute.
[clxxxvi] Aluminum production contributes to around 2% of global greenhouse gas emissions (Rocky Mountain Institute, 12/23).
[clxxxvii] Foster David, Sade Nahbahe, and Benny Siu Hon Ng, "Energy Workforce Development in the 21st Century." MIT Center for Energy and Environmental Policy Research, September 2020. https://ceepr.mit.edu/wp-content/uploads/2021/09/The-Roosevelt-Project-WP-7.pdf.
[clxxxviii] Klaas Jan Kramer, Eric Masanet, and Ernst Worrell, "Energy Efficiency Opportunities in The U.S. Pulp and Paper Industry." Lawrence Berkeley National Laboratory, 2009. https://www.osti.gov/servlets/purl/970818.
[clxxxix] Ryan Maye Handy, "Another Sign of Permian Boom: Record Electricity Demand." Houston Chronicle, April 3, 2018.
[cxc] Adrian Hedden, "Permian Basin Electrical Grid Continues to Grow amid Oil and Gas Boom." Carlsbad Current-Argus, December 13, 2019.

[cxci] Dustin Bleizeffer, "Oil and Gas Leaders Say Electric Rate Hike Would Shrink Wyoming Production." WyoFile, November 3, 2023.
[cxcii] Adam Baylin-Stern and Niehls Berghout, "Is Carbon Capture Too Expensive? – Analysis." IEA, February 17, 2021.
[cxciii] Paul Butterworth. "Carbon Capture Economics: Why $200 /TCO2 Is the Crucial Figure." Sustainability.crugroup.com, March 20, 2023. https://sustainability.crugroup.com/insights-and-analysis/carbon-capture-economics-why-200-tco2-is-the-crucial-figure/.
[cxciv] DOE, "Biden-Harris administration announces $3.7 billion to kickstart America's carbon dioxide removal industry," December 13, 2022. https://www.energy.gov/articles/biden-harris-administration-announces-37-billion-kick-start-americas-carbon-dioxide.
[cxcv] Elizabeth Abramson, Dane McFarlane, Amy Jordan, Daniel Rodriguez, Jonathan Ogland-Hand, Nathan Holwerda, Matt Fry, Ryan Kammer, and Emma Thomley. "An Atlas of Direct Air Capture: Opportunities for Negative Emissions in the United States." Carbon Solutions LLC & Great Plains Institute, March 2023. https://carboncaptureready.betterenergy.org/wp-content/uploads/2023/03/DAC-Hubs-Atlas-2023.pdf.
[cxcvi] Whitney Jones, Galen Bower, Eric O'Rear, Ben King, Nathan Pastorek, "Direct Air Capture Workforce Development: Opportunities by Occupation." Rhodium Group, October 2023. https://rhg.com/research/direct-air-capture-workforce-development/.
[cxcvii] John D. Wilson, and Zach Zimmerman. "The Era of Flat Power Demand Is Over," Clean Grid Initiative, December 2023. https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf.
[cxcviii] Alison Berry. "Getting Right-of-way Right: Landowner Compensation for Electric Power Transmission Right-of-Way." Lincoln Institute of Land Policy, 2013. https://www.lincolninst.edu/sites/default/files/pubfiles/2335_1675_Berry_WP13AB1.pdf.
[cxcix] Brandon Gerstle, "Giving Landowners the Power: A Democratic Approach for Assembling Transmission Corridors." Journal of Environmental Law & Litigation: Vol. 29 No. 3, 2014. https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/18644/Gerstle.pdf?sequence=1&isAllowed=y.
[cc] Ibid.
[cci] U.S. Department of Energy, "Biden-Harris Administration Announces $3.5 Billion for Largest Ever Investment in America's Electric Grid, Deploying More Clean Energy, Lowering Costs, and Creating Union Jobs." October 18th, 2023. https://www.energy.gov/articles/biden-harris-administration-announces-35-billion-largest-ever-investment-americas-electric.
[ccii] Jennifer Solis. "New NV Transmission Will Slash Energy Costs, Says White House," Nevada Current, October 2023.
[cciii] An online tool provides one window into these costs: https://icecalculator.com/home.
[cciv] Alan H. Sanstad, B. D. Leibowicz, Q. Zhu, P. H. Larsen, J. H. Eto, "Electric Utility Valuations of Investments to Reduce the Risks of Long-Duration Widespread Power Interruptions Part I: Background." Sustainable and Resilient Infrastructure, vol. 8, no. sup1, 2023, pp. 311–22; Madeline Macmillan, Kyle Wilson, Sunhee Baik, Juan Pablo Carvallo, Anamika Dubey, Christine A. Holland, May 2023. "Shedding light on the economic costs of long-duration power outages," Lawrence Berkeley National Laboratory; Shuai Mao, Wang Chengzhi, Yu Shiwen, Gen Hao, Yu Jufang, Hou Hui, 2018. "Review on Economic Loss Assessment of Power Outages." WTISG 2018.
[ccv] Eva Wang, Ruoyun Yang, Jarome Leslie, Jinglin Duan, Tianying Lan, "How does electric transmission benefit you? Identifying and measuring the life-cycle benefits of infrastructure investment," London Economics Institute, 2018. https://wiresgroup.com/wp-content/uploads/2020/06/2018-01-08-London-Economics-Intl-How-Does-Electric-Transmission-Benefit-You.pdf, 22.
[ccvi] IEA, "The world is entering a new age of clean technology manufacturing and countries' industrial strategies will be key to success," 2022. https://www.iea.org/news/the-world-is-entering-a-new-age-of-clean-technology-manufacturing-and-countries-industrial-strategies-will-be-key-to-success.
[ccvii] See Alexander Gazmararian, and Dustin Tingley. "Uncertain Futures: How to Unlock the Climate Impasse." Cambridge University Press, 2023. https://www.uncertainfuturesbook.com.
[ccviii] National Grid. "A second career for army veteran." November 11th, 2020. https://www.nationalgrid.com/stories/community-spirit-stories/second-career-army-veteran.
[ccix] For additional details see NREL's "Women in Power System Transformation" report or the Global PST Consortium's webpage.
[ccx] For more details, see: https://hbcucleanenergy.org/category/solar-energy/.
[ccxi] Brannstrom, Christian, Michael Ewers, and Peter Schwarz. "Will Peak Talent Arrive before Peak Oil or Peak Demand?: Exploring Whether Career Choices of Highly Skilled Workers Will Accelerate the Transition to

Renewable Energy." *Energy Research & Social Science* 93 (November 2022): 102834. https://doi.org/10.1016/j.erss.2022.102834.

[ccxii] Michael Goggin, Rob Gramlich, Michael Skelly, "Transmission Projects Ready to Go: Plugging Into America's Untapped Renewable Resources." Americans for a Clean Energy Grid, April 2021. https://cleanenergygrid.org/wp-content/uploads/2019/04/Transmission-Projects-Ready-to-Go-Final.pdf.

[ccxiii] Michael Goggin and Rob Gramlich, "Investment Tax Credit for Regionally Significant Electricity Transmission Lines." American Council on Renewable Energy, May 2021. https://acore.org/wp-content/uploads/2021/05/Investment-Tax-Credit-for-Regionally-Significant-Electricity-Transmission-Lines-ACORE.pdf.

[ccxiv] Josh Bivens. "Updated employment multipliers for the U.S. economy." Economic Policy Institute, January 23, 2019. https://www.epi.org/publication/updated-employment-multipliers-for-the-u-s-economy/.

[ccxv] NREL. "Economic Development from New Generation and Transmission in Wyoming and Colorado." National Renewable Energy Laboratory, March 2013. https://www.nrel.gov/docs/fy13osti/57635.pdf.

[ccxvi] Foster David, Sade Nahbahe, and Benny Siu Hon Ng, "Energy Workforce Development in the 21st Century." MIT Center for Energy and Environmental Policy Research, September 2020. https://ceepr.mit.edu/wp-content/uploads/2021/09/The-Roosevelt-Project-WP-7.pdf

[ccxvii] Ibid.

[ccxviii] Ibid.

[ccxix] Sarah Terry-Cobo. "Weather Underground: Costs Deter Utilities in Oklahoma from Burying Electrical Lines." Journal Record, Jun 21, 2013. http://search.proquest.com.ezp-prod1.hul.harvard.edu/newspapers/weather-underground-costs-deter-utilities/docview/1371951828/se-2.

[ccxx] Miranda Willson. "How a $6B transmission project made it in New York." E&E News ENERGYWIRE, March 1st, 2023. https://www.eenews.net/articles/how-a-6b-transmission-project-made-it-in-new-york/.

[ccxxi] Matthew, Cotton; Devine-Wright, Patrick. "Discourses of Energy Infrastructure Development: A Q-Method Study of Electricity Transmission Line Siting in the UK." Environment and Planning A: Economy and Space, 2011. https://doi.org/10.1068/a43401.

[ccxxii] Renewable Energy World. "World's longest underground transmission line will transport wind energy to Germany's grid." September 8, 2021. https://www.renewableenergyworld.com/news/worlds-longest-underground-transmission-line-will-transport-wind-energy-to-germanys-grid/#gref.

[ccxxiii] OSHA. "Avoiding Underground Utilities during Horizontal Directional Drilling Operations." Occupational Safety and Health Administration, March 13, 2018. https://www.osha.gov/sites/default/files/publications/shib031318.pdf.

[ccxxiv] NextGen Highways. "Introduction to Buried High-Voltage Direct Current Transmission for Departments of Transportation." November 2022. https://nextgenhighways.org/wp-content/uploads/2023/01/NGH_Introduction-Buried-HVDC-Transmission-DOTs.pdf

[ccxxv] U.S Department of Commerce Bureau of Industry and Security Office of Technology Evaluation. "The Effect of Imports of Transformers and Transformer Components on the National Security." October 15th, 2020. https://www.bis.doc.gov/index.php/documents/section-232-investigations/2790-redacted-goes-report-20210723-ab-redacted/file.

[ccxxvi] Peter Behr. "How a transformer shortage threatens the grid." E&E News Energy Wire, October 20th, 2022 https://www.eenews.net/articles/how-a-transformer-shortage-threatens-the-grid/.

[ccxxvii] U.S Department of Commerce Bureau of Industry and Security Office of Technology Evaluation. "The Effect of Imports of Transformers and Transformer Components on the National Security." October 15th, 2020. https://www.bis.doc.gov/index.php/documents/section-232-investigations/2790-redacted-goes-report-20210723-ab-redacted/file.

[ccxxviii] U.S Department of Commerce Bureau of Industry and Security Office of Technology Evaluation. "The Effect of Imports of Transformers and Transformer Components on the National Security." October 15th, 2020. https://www.bis.doc.gov/index.php/documents/section-232-investigations/2790-redacted-goes-report-20210723-ab-redacted/file; Robert Walton. "Utilities sound alarm over distribution transformer shortage as procurement times surpass 1 year and costs triple." Utility Dive. December 19th, 2022 https://www.utilitydive.com/news/distribution-transformer-shortage-appa-casten/639059/?utm_source=pocket_reader.

[ccxxix] Rodriguez, Gabriela, and Johan Cavert. "Powering the Nation: How to Fix the Transformer Shortage - Niskanen Center." Niskanen Center, January 20, 2023. https://www.niskanencenter.org/powering-the-nation-how-to-fix-the-transformer-shortage/.

[ccxxx] Ibid.

[ccxxxi] Statista. "Electricity transmission and distribution market revenue worldwide in 2021, with forecasts for 2025 and 2030, by product type (in billion U.S. dollars)." Chart. June 30, 2022. The Brainy Insights. https://www-statista-com.ezp-prod1.hul.harvard.edu/statistics/1350494/forecast-electricity-transmission-and-distribution-global-market-revenue-by-product-type/.

[ccxxxii] Abel, Amy, Paul W. Parfomak, and Dana A. Shea, "Electric Utility Infrastructure Vulnerabilities: Transformers, Towers, and Terrorism." Congressional Research Service, April 9th, 2004. https://sgp.fas.org/crs/homesec/R42795.pdf; AISI, "New & Expanding Demand For Steel In Energy." No Date. American Iron and Steel Institute. https://www.steel.org/steel-markets/energy/.

[ccxxxiii] NUCOR. "Nucor Announces Location for Second Utility Structures Production Facility." June 14, 2023. https://nucor.com/news-release/19931.

[ccxxxiv] Amy Abel, Paul W. Parfomak, and Dana A. Shea, "Electric Utility Infrastructure Vulnerabilities: Transformers, Towers, and Terrorism." Congressional Research Service, April 9th, 2004. https://sgp.fas.org/crs/homesec/R42795.pdf.

[ccxxxv] TC Energy. "Drones, Unmanned Vehicles and (No) Fires, Oh My!" February 3rd, 2022. https://www.tcenergy.com/stories/2022/2022-02-02-drones-unmanned-vehicles-and-no-fires-oh-my/.

[ccxxxvi] Adam Vann. "The Legal Framework of the Federal Power Act." Congressional Research Service, January 22nd, 2020. https://crsreports.congress.gov/product/pdf/IF/IF11411.

[ccxxxvii] Ashley Lawson. "Electricity Transmission Provisions in the Inflation Reduction Act of 2022." Congressional Research Service, August 23, 2022. https://crsreports.congress.gov/product/pdf/IN/IN11981.

[ccxxxviii] Hagai Zaifman, John T. Schaff, Aaron S. Mitchell, "Inflation Reduction Act: Overview of Energy-Related Tax Provisions – An Energy Transition 'Game Changer'." Sidley Austin, August 18th, 2022. https://www.sidley.com/en/insights/newsupdates/2022/08/inflation-reduction-act-an-energy-transition-game-changer.

[ccxxxix] Allan Zhang. "Explainer: How Does the Inflation Reduction Act Relieve Doubts About Clean Energy Tax Credits?" Clean Energy Finance Forum, Yale University Center for Business and the Environment, January 12th, 2023. https://www.cleanenergyfinanceforum.com/2023/01/12/explainer-how-does-the-inflation-reduction-act-relieve-doubts-about-clean-energy-tax.

[ccxl] IRS, "Prevailing wage and apprenticeship requirements." Internal Revenue Service, September 1, 2023. https://www.irs.gov/credits-deductions/prevailing-wage-and-apprenticeship-requirements.

[ccxli] U.S. Department of Energy, "Biden-Harris Administration Announces $3.5 Billion for Largest Ever Investment in America's Electric Grid, Deploying More Clean Energy, Lowering Costs, and Creating Union Jobs." October 18th, 2023. https://www.energy.gov/articles/biden-harris-administration-announces-35-billion-largest-ever-investment-americas-electric.

[ccxlii] The White House. "Justice40 A Whole-Of-Government Initiative." Accessed November 2023. https://www.whitehouse.gov/environmentaljustice/justice40/.

[ccxliii] Kate Yoder and Grist. "The American Climate Corps Wants You." *Scientific American,* September 28th, 2023. https://www.scientificamerican.com/article/the-american-climate-corps-wants-you/.

[ccxliv] If the chance of getting approved by one state is, say, .5, then the chance of getting through two states (assuming those states act independently of each other) is just .25 (i.e., .5 times .5). Three states? The probability of all three approving is only .125 (i.e., .5 times .5 times .5). The number .5 is invented for this example, but it expresses the simple math behind the risk that the developer faces when trying to develop a long-distance transmission line in a federal system.

[ccxlv] President's News Conference, February 10, 1954. https://www.fhwa.dot.gov/interstate/audiotext.cfm.

CLIMATE ACTION ACCELERATOR
Salata Institute for Climate and Sustainability
Harvard University