

Planning for and Development of Electrical Transmission Lines: A Discussion of Best Practices

A thesis submitted by

Kelan Koncewicz

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Advisor: Jon Witten

Reader: Mary Davis

Abstract

The development of electrical transmission is essential if the United States is to bring large scale renewable energy projects online and meet greenhouse gas emission reduction goals. Transmission projects are currently experiencing substantial challenges with permitting, where timely development is often elongated by public opposition to projects. Four case studies, Northern Pass in New Hampshire, New England Clean Energy Connect in Maine, Great Northern Transmission Line in Minnesota, and Champlain Hudson Power Express in New York were analyzed for key variables that led to projects being successfully permitted and progressing into construction. Identified best practices included early stakeholder engagement and public outreach before filing permits, siting projects in rural areas, underground, and/or within existing rights-of-ways, and prioritizing transmission of clean renewable energy sources like wind and solar.

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Abbreviations

AC – Alternating current

ACSR – Aluminum conductor steel reinforced

CHPE – Champlain Hudson Power Express

CMP – Central Maine Power Company

CO₂ – Carbon dioxide

CWA – Clean Water Act

DC – Direct current

DOE – U.S. Department of Energy

EA – Environmental Assessment

EIA – Energy Information Administration

EIS – Environmental Impact Statement

EJ – Environmental Justice

EPA – U.S. Environmental Protection Agency

EMF – Electric and Magnetic Fields

ERCOT – Electric Reliability Council of Texas

ESA – Endangered Species Act

FERC – Federal Energy Regulatory Commission

FONSI – Finding of no significant impact

FWS – U.S. Fish and Wildlife Service

GHG – Greenhouse gas

GIS – Geographic information system

GNTL – Great Northern Transmission Line

HVAC – High-voltage alternating current

HVDC – High-voltage direct current

HVTL – High-voltage transmission line

IOU – Investor-owned utility

IPCC – International Panel on Climate Change

ISO – Independent service operator

kV – Kilovolts

MassDOER – Massachusetts Department of Energy Resources

MDEP – Maine Department of Environmental Protection

MW – Megawatts

NECEC – New England Clean Energy Connect

NEPA – National Environmental Policy Act

NERC – National Energy Resource Council

NHPA – National Historic Preservation Act

NHSEC – New Hampshire Site Evaluation Committee

NIETC – National interest electrical transmission corridors

NIMBY – Not in my backyard

NOPR – Notice of proposed rulemaking

POU – Publicly-owned utility

PSC – Public service commission

PUC – Public utility commission

RES – Renewable energy sources

RFP – Request for Proposal

RTO – Regional transmission organization

SPNHF – Society of the Protection of New Hampshire Forests

TDI – Transmission Developers, Inc.

U.S. – United States

USACE – U.S. Army Corps of Engineer

Table of Contents

Abstract.....	ii
Acknowledgements.....	iii
Abbreviations.....	iv
List of Figures	viii
List of Tables	ix
Introduction	1
Background	1
Research Question	2
Goal	3
Literature Review	4
GHG Emissions	4
Reduction Targets	4
Emissions by Sector and Source.....	5
Overview of Electricity System	6
Generation	7
Transmission	9
Distribution	16
Transmission Development	17
Planning	17
Payment	19
Permitting	21
Public Opinion	26
Health.....	27
Environment.....	28
Economics	29
Psychology	30
Methodology.....	32
Literature Review.....	32
Case Studies	32
GIS Mapping.....	33

Analysis	34
Case Studies / Findings.....	35
Northern Pass	35
Overview	36
Siting and Permitting	37
Public Opinion	38
New England Clean Energy Connect (NECEC)	40
Overview	41
Siting and Permitting	42
Public Opinion	45
Great Northern Transmission Line (GNTL).....	46
Overview	47
Siting and Permitting	47
Public Opinion	49
Champlain Hudson Power Express (CHPE).....	50
Overview	51
Siting and Permitting	52
Public Opinion	53
Results.....	56
Discussion	59
Best Practices and Lessons Learned.....	59
Policy and Planning Recommendations.....	62
Limitations and Future Research	68
Conclusion.....	71
Appendix A: Interviews and Questions	73
Bibliography	74

List of Figures

Figure 1 – U.S. GHG emissions by sector in 2020 (U.S. EPA, 2022).....	5
Figure 2 – U.S. electricity generation by source in 2021 (EIA, 2021a).....	6
Figure 3 – Variation of overhead transmission and distribution structures (International Sign Association, N.D.).....	10
Figure 4 – Comparison between HVDC and HVAC transmission structures (Electrical Deck, 2021).....	11
Figure 5 – Map of U.S. electrical power regions, authorities, and interconnections (EIA, 2022b).....	14
Figure 6 – Electricity system overview (Brown and Sedano, 2004).....	17
Figure 7 – Costs associated with spurline and bulk transmission build-out needed to reach U.S. GHG emission goals by 2035 (Goldman School of Public Policy, 2020).....	19
Figure 8 – Cost per mile comparison of newly constructed overhead and underground transmission in urban, suburban, and rural areas (Hall, 2009).....	21
Figure 9 – Map of transmission siting authority by state (Smith Jr., 2021).....	24
Figure 10 – Map of Northern Pass project route.....	35
Figure 11 – Map of NECEC project route.....	40
Figure 12 – Map of GNTL project route.....	46
Figure 13 – Map of CHPE project route.....	50
Figure 14 - American Clean Power Association map of RES and battery storage projects in development or construction as of the third quarter of 2022 (St. John, 2022a).....	66

List of Tables

Table 1 – Fundamental electricity terms and definitions.	7
Table 2 – U.S. electricity generation by generating type in 2021 (EIA, 2021c).....	8
Table 3 – GIS data sources and shapefiles used for project maps.....	34
Table 4 – Qualitative comparison of case study variables.....	56
Table 5 – Key takeaways from interviews.....	58
Table 6 – Interviews.....	73

Introduction

Background

Electrical transmission will need to increase 60 percent by 2030 if the United States (U.S.) is to meet its net-zero greenhouse gas (GHG) emission goal by 2050 (Seltzer, 2020). Building out transmission is essential to connect electricity generated by large scale renewable energy sources (RES), such as solar, onshore wind, offshore wind, and hydroelectric generation, to population centers that require electricity to function. Renewable energy represents a key and reliable strategy to reduce GHG emissions generated by fossil fuel sources, combat climate change, and meet future state and national GHG emission goals.

The need for increased transmission is critical to achieving climate goals. Americans for a Clean Energy Grid identified 22 “shovel-ready” high-voltage transmission line (HVTL) projects in the U.S. that would increase wind and solar generated electricity by 50 percent of current levels, providing clean energy to consumers, creating jobs, and bringing reliability and resilience to the electrical grid (Goggin et al., 2021). Yet, barriers exist to construct and bring HVTL projects online and transmit renewable energy to the population centers where needed. Transmission can be challenging to plan, fund, site, and permit because utility corridors with HVTLs are long, linear, fragmented landscapes, and cross multiple jurisdictional boundaries, whether it be municipalities, counties, states, or countries (Eto, 2016). Also, public opinion of overhead transmission lines is usually not favorable (Bertsch and Fichtner, 2015). For example, in 2021, approximately 60 percent of voters in Maine supported a referendum to stop construction of the New England Clean Energy Connect (NECEC) transmission project,

attempting to deliver hydroelectric power from Quebec, Canada through Maine to Massachusetts (Schultz, 2021). Similarly, in 2011, the Northern Pass transmission project proposed the same initiative through New Hampshire and was eventually defeated in 2018 following intense public opposition.

Research Question

This thesis addresses the following question: What best practices exist for developing successful transmission projects that receive both community support and result in construction? To answer this question, I reviewed case studies of several successful and failed transmission projects in the U.S. to assess what factors contributed to their outcome. Specifically, this thesis focused on the role of project locations, stakeholder engagement and public outreach, siting technique, and permitting strategy in the transmission development process. Stakeholder engagement refers to agreements made with landowners who directly abut the project but can also refer to coordination with those involved in decision-making for the project, including municipal officials, land management agencies, regulators, tribes, or community members (Hietter, et al., 2018). Public outreach refers to coordination with residents of a community where the project is located, those not directly tied to project decision-making. Interviews were conducted with transmission planners, regulators, and consultants of successful transmission projects to explore when public outreach was conducted along the project timeline.

Goal

The goal of this thesis is to develop best practices for stakeholder engagement and public outreach that utilities, state regulators, and specifically transmission developers could use to plan successful transmission projects. Massive amounts of time, money, and resources are spent on transmission projects that fail and do not or cannot be constructed because of public opposition. This thesis is a playbook of sorts, to facilitate effective public participation at specific steps along the transmission development process, with the objective to construct transmission projects that benefits both stakeholders and the broader population with the transmission of renewable energy. With increased transmission, utilities can bring more RES onto the electrical grid, reduce GHG emissions from fossil fuel sources, and begin to meet state and national GHG emission goals.

Literature Review

GHG Emissions

Reduction Targets

In 2018, the International Panel on Climate Change (IPCC), an international body for assessing science relating to climate change, published a special report indicating that carbon dioxide (CO₂) emission must achieve net-zero by 2050 if the planet is to limit warming to below 1.5 degrees Celsius of pre-industrial level (IPCC, 2018). Additionally, GHG emissions, including other gases beyond CO₂ must achieve net zero by 2070 to maintain warming below 1.5 degrees Celsius. The more climate is disrupted, the greater the risk for severe, pervasive, and irreversible impact to the planet, including increased land and ocean temperatures, hot inhabitable areas, heavy precipitation, and drought (IPCC, 2018). Currently, the IPCC estimates global warming between 0.8 and 1.2 degrees Celsius of pre-industrial levels.

The U.S. has historically been the greatest GHG emitter, contributing to approximately 25 percent of global GHG emissions, more than any other country. In 2021, President Biden set a goal for the U.S. to achieve 100 percent carbon pollution-free electricity by 2035, with net-zero GHG emission economy-wide by 2050 (The White House, 2021). Numerous states across the U.S. have GHG emission reduction goals. In 2020, Massachusetts released the 2050 Decarbonization Roadmap to guide the state in achieving net-zero GHG emission by 2050. In 2022, Massachusetts released the Clean Energy and Climate Plan for 2025 and 2030, a requirement of the state's 2008 Global Warming Solutions Act, setting limits on economy wide GHG emissions to a 33 percent reduction from 1990 levels in 2025, and a 50 percent reduction

in 2030 (Commonwealth of Massachusetts, 2022). To reach GHG emission goals, Massachusetts Department of Energy Resources (MassDOER) released in 2017 the Massachusetts Clean Energy request for proposal (RFP) in response to the state’s 2016 Energy Diversity Act calling for competitive procurements of 9.45 million megawatt-hours of renewable energy (Serreze, 2018). Massachusetts has since released multiple RFPs for renewable energy such as with offshore wind, and other states have used similar solicitations to attract RES bids from developers to reach state GHG emission goals. The 2017 Massachusetts Clean Energy solicitation is central to two case studies that are examined in later sections.

Emissions by Sector and Source

As of 2020, the electricity sector in the U.S. made up approximately 25 percent of its total GHG emission (U.S. EPA, 2022) (Figure 1). In 2021, fossil fuels sources, including natural gas and coal made up approximately 60 percent of electricity generation, while RES, including wind, hydroelectric, solar, wind biomass, and geothermal made up approximately 20 percent (EIA, 2021a) (Figure 2).

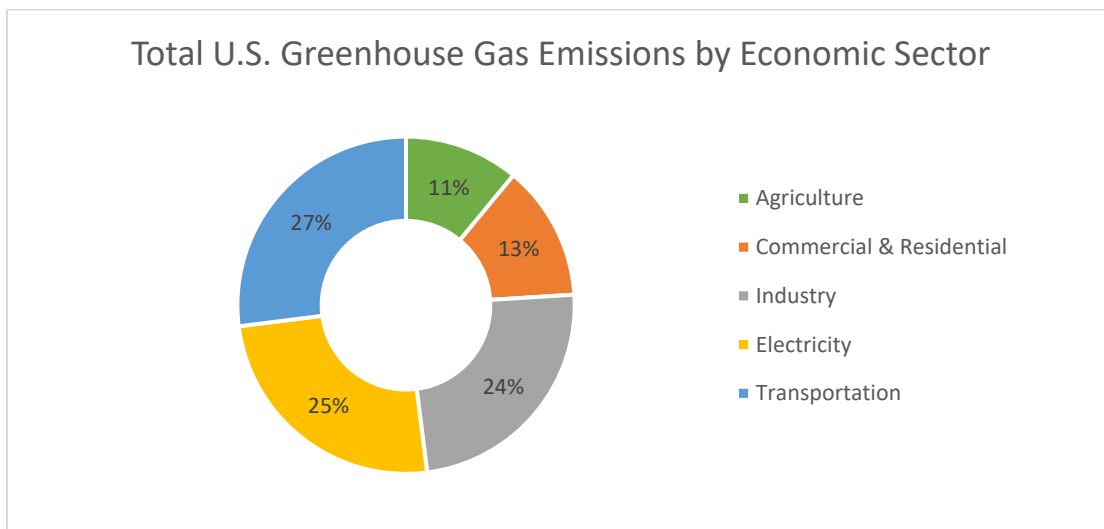


Figure 1 – U.S. GHG emissions by sector in 2020 (U.S. EPA, 2022).

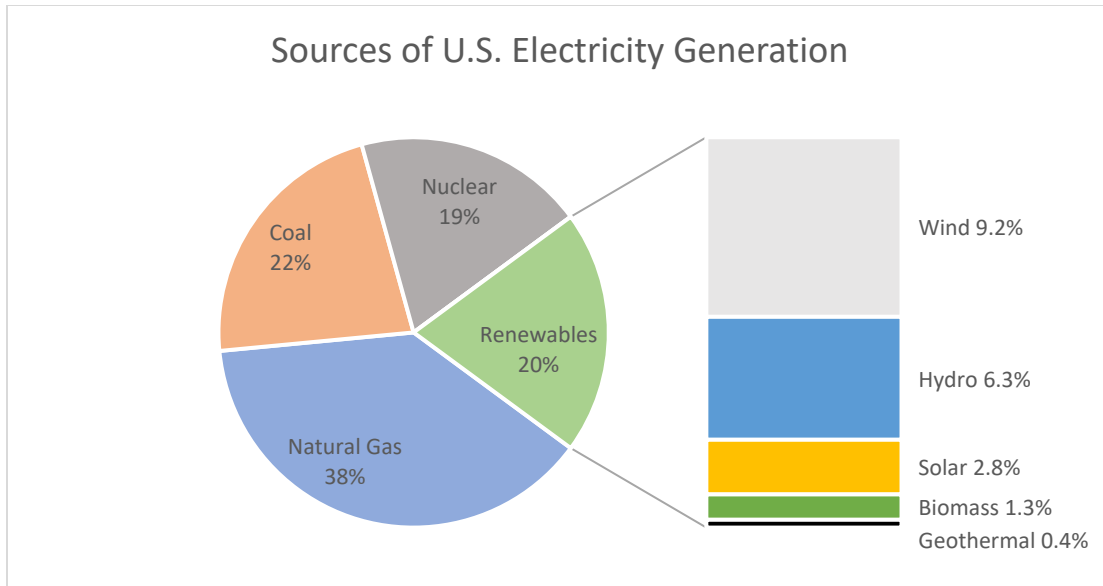


Figure 2 – U.S. electricity generation by source in 2021 (EIA, 2021a).

While fossil fuel sources emit large amounts of CO₂ and other GHG emissions that contribute to climate change, RES heavily reduces GHG emissions when generating electricity, helping states and the country to reach GHG emission goals. Clean energy is often used interchangeably with but is a subset of RES that includes wind, solar, and nuclear energy¹ that emit zero GHG emission when generating electricity. In the first half of 2022, electricity generation from RES increased to approximately 24 percent, representing the fastest growing electricity generation source in the U.S. (EIA, 2022d).

Overview of Electricity System

The electricity system is made up of three distinct systems that transfers electricity from its point of creation to end use. Generation is the creation of electricity, transmission is the movement of high-voltage electricity over long distances, and distribution is the movement of

¹ Nuclear energy is created by nuclear fission spinning steam turbine (EIA, 2021a). While steam has no GHG emissions, the byproduct of nuclear fission, radioactive and hazardous waste must be handled properly.

low-voltage electricity to an electricity consumer (Table 1). The maximum amount of electricity generated by a power plant is called capacity, which is measured in megawatts (MW), or one million watts (Wallender, 2022). A watt is the rate of power flow, when one ampere, (amps) the volume of electrons in an electrical circuit is subject to one volt, the speed that electrons travel past a point in an electrical circuit (Wallender, 2022) (Table 1). The movement of electricity in transmission and distribution is measured in kilovolts (kV).

Table 1 – Fundamental electricity terms and definitions.

Term	Definition
Generation	Creation of electricity (through spinning a turbine).
Transmission	Movement of high-voltage electricity over long distances.
Distribution	Movement of low-voltage electricity to consumers/end use.
Capacity	The maximum amount of electricity a generating source can provide.
Watt (W)	Rate of power flow, when one amp flows through a circuit ($V \times A = W$).
Ampere (A)	Base unit measuring the volume of electrons moving through a circuit.
Volt (V)	Base unit measuring the speed of electrons moving through a circuit.
Circuit	Closed system (power line) within which energy flows.

Generation

The electricity system starts at generation, converting a form of mechanical energy into electricity. Electricity is generated using a turbine to spin a generator. The most common types of generating turbines include steam, combustion, hydroelectric, and wind. In 2021, steam turbines produced approximately 45 percent of the U.S. electricity generation, including nuclear power reactors, coal-fired power plants, and some natural gas and biomass power plants (EIA, 2022c). Combined-cycle power plants produce approximately 33 percent of U.S. electricity, using natural gas to generate electricity through steam and combustion turbines that improve overall efficiency of generation (EIA, 2022c) (Table 2). Power plants are either continual “baseload plants” or intermittent “peaker plants”, the latter used to generate electricity only

when needed during peak demand. Power plants could be forced to temporarily halt electricity generation for maintenance, time-of-year restrictions, or during unexpected shutdowns from technology failure or natural disasters, where having flexibility in electricity generation is important (Brown and Sedano, 2004). Another type of electricity generation is solar, where photovoltaic cells convert sunlight directly into electricity, accounting for approximately 3% of U.S. electricity generation (EIA, 2022c). Electricity is generated at a voltage between 11-25 kV and will then “step-up” or increase in voltage using a transformer to transmit to the next phase of the electricity system.

Table 2 – U.S. electricity generation by generating type in 2021 (EIA, 2021c).

Generator	Plant Type	Main Fuel/Energy Source	Share of Annual Electricity Generation
Steam Turbine	Single Cycle	All Sources	45.3%
		<i>Coal</i>	<i>21.6%</i>
		<i>Nuclear</i>	<i>18.9%</i>
		<i>Natural Gas</i>	<i>2.4%</i>
		<i>Biomass and Other</i>	<i>2.3%</i>
Multiple	Combined Cycle	Natural Gas	32.8%
<i>Combustion Turbine</i>			<i>20.7%</i>
<i>Steam Turbine</i>			<i>10.5%</i>
<i>Dual/Single Shaft</i>			<i>1.6%</i>
Combustion Gas Turbine	Single Cycle	Natural Gas	3.4%
Wind Turbine	All Types	Wind	9.2%
Hydroelectric Turbine	Conventional	Water	6.1%
Photovoltaic	All Types	Solar	2.7%
Others		Various	0.5%
Storage System		Various	-0.1%

Transmission

Electrical transmission includes two components: (1) HVTLs, that transmit electricity from the generating source; and (2) transformers, that “step-down” electricity from HVTLs to low-voltage distribution lines in a facility known as a substation (Brown and Sedano, 2004). More than 640,000 miles of HVTLs make up the U.S. transmission system (Carley et al., 2019). Transmission lines generally range in voltage from 69-765 kV, with more than 150,000 miles of HVTLs greater than 230 kV in the U.S. (OSHA, N.D.). Power lines 33-69 kV are known as sub-transmission, providing electricity to regional distribution substations, or tapped for industrial or large commercial use (OSHA, N.D.). Power lines greater than 765 kV are known as extra- or ultra-high voltage. Electricity transmitted through high voltage is the most efficient way to transport electricity over long distances (Warwick, 2002). Typical HVTL cables are aluminum conductor steel reinforced (ACSR), composed of strands of aluminum wrapped around steel wires (Rashmi et al., 2017). ACSRs cables are cheaper in cost from other electrical conductors like copper but experience thermal expansion at increased temperatures that can impact line safety (Rashmi et al., 2017). Underground power lines are buried in a trench, tunnel, or conduit, and must be insulated to manage overheating caused by electric charge from high voltage. Overhead structures supporting HVTLs are made of wood or steel, carrying numerous cables that make up a single, double, or multiple circuits (Figure 3).

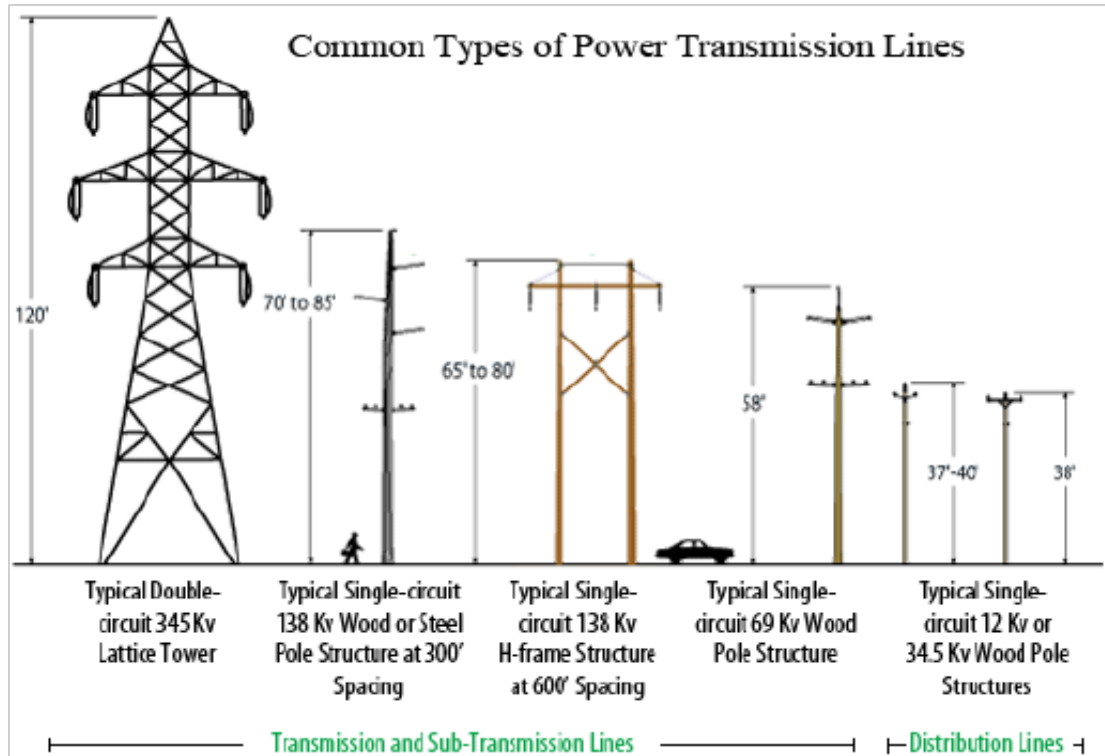


Figure 3 – Variation of overhead transmission and distribution structures (International Sign Association, N.D.).

The electrical grid, including the transmission and distribution systems, uses alternating current (AC) electricity, while direct current (DC) electricity connects grids (Brown and Sedano, 2004). AC is used by the grid because electricity can easily be converted to higher and lower voltages by transformers, and electrical infrastructure maintenance is accessible and affordable (Harnden, 2014). High-voltage AC (HVAC) cables are always in clusters to optimize efficiency and utilize a three-phase system.² DC is typically more efficient than AC, aligned in pairs in a two-phase system (Figure 4), having a greater capacity to carry electricity and losing less electricity though its electric and magnetic fields (EMF) (Harnden, 2014). High-voltage DC (HVDC) is often used to bring electricity from a generation source closer to population centers,

² In HVAC transmission lines, three cables make up one circuit.

such as low-cost hydroelectric power from Canada down to the U.S. (Brown and Sedano, 2004). A converter rectifies electricity between AC and DC electricity, which can be expensive to install and maintain.

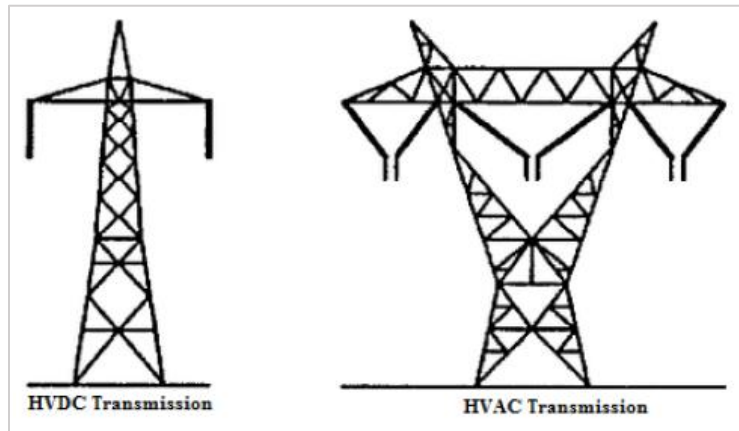


Figure 4 – Comparison between HVDC and HVAC transmission structures (Electrical Deck, 2021).

Transmission lines are located in utility corridors across the U.S. known as rights-of-ways (ROWs), varying in width based on the amount of HVTs traversing the area. Transmission lines can travel for hundreds of linear miles, spanning urban, suburban, and rural landscapes, traversing land used for agriculture, parks and recreation, historical sites, natural resources (wildlife, wetlands, or watersheds), transportation (road, rail, or air), and/or housing (Smith Jr., 2021). Easements or other permissions such as long-term leases are needed to cross private property not owned by the transmission company, which could include individual landowners, private or nonprofit groups, local governments, or state or federal agencies (Smith Jr., 2021). An easement is a contract agreed on by two or more parties, the “grantor”, who owns the land and the “grantee”, who is granted an interest in the grantor’s land (Public Service Commission of Wisconsin, 2002). Easements used for transmission lines and structures grant the grantee

defined rights to construct, operate, and maintain structures on the ground, in the air, or subsurface (Irvin, 2010). The grantee will always negotiate for easements in perpetuity for the transmission of electricity (Irvin, 2010). The terms of easement agreements are set by the parties, but there is no standard system of negotiating transmission ROW easements (Berry, 2013). Public utilities are required by law to negotiate in good faith, where some factors that may be considered in an easement negotiation include value of nearby properties, constraints on future income or use of the land, cost to replace any existing structures, or value of planned development on the land (Minnesota Department of Commerce, 2014). While studies quantifying the negative impacts to property from transmission projects are inconclusive, easement compensation is fundamentally determined by what the grantor has lost from a negotiated easement (Berry, 2013). The fair market value that utilities typically offer for transmission easements is 80-90 percent of the easement value placed upon a property, but this value can vary based on a specific property and landowner (Irvin, 2010). Public utilities will negotiate a one-time lump sum payment for easement agreements, while private developers can negotiate annual payments for easements (Irvin, 2010). The Rocky Mountain Farmers Union (2013) found that to many landowners' one-time payments are not just compensation for income losses incurred annually for transmission structures on their property (Berry, 2013). Leasing land for energy generation (wind or solar) by private developers often provides better compensation in the form of annual payments based on electricity generated or revenue earned (Berry, 2013).

In cases when a grantor does not wish to negotiate with the grantee, the desired private parcel of land can be condemned and acquired through eminent domain for public use. After

obtaining a certificate of need for the proposed project, a public utility or private transmission developer has the right of eminent domain because they're acting in the public interest to provide safe, reliable, and affordable electricity service to the public (Public Service Commission of Wisconsin, 2002). The condemnation process is different in every state but will typically begin by filing a petition with the appropriate District Court and a subsequent hearing (Minnesota Department of Commerce, 2014). The landowner is subject to reasonable compensation for the land taking, which is determined through appraisal of the property for fair market value (Minnesota Department of Commerce, 2014). It's often in the best interest of the transmission developer to negotiate easements with landowners and avoid eminent domain because it can be a timely and more costly process (Berry, 2013). Some power administrations (utilities) in western U.S. have condemnation rates of less than three percent for thousands of properties crossed, some due to the lack of clear title of the land rather than an unsuccessful negotiated easement agreement (Berry, 2013).

There are numerous entities that govern transmission in the U.S. The Federal Energy Regulatory Commission (FERC) is an independent regulatory agency made up of five commissioners that regulates transmission, sets just and reasonable wholesale rates for the transmission of electricity (and natural gas), and promotes the reliability of the transmission system. FERC also oversees hydroelectric generating facilities, sites natural gas facilities and pipelines, and enforces its rules and regulations. Since its creation in 1977, FERC has governed by passing orders to promote its goals. In 1999, FERC passed Order 2000 that set the guidelines for transmission-owning utilities to form Regional Transmission Organizations (RTOs) to promote development of regional transmission plans for multi-state efficiency and reliability

purposes, along with pricing models to encourage competition in the wholesale electricity market (Brown and Sedano, 2004). There are nine RTOs and Independent System Operators (ISOs) across the U.S., each with different governance structures to accommodate various stakeholders, including transmission owners, electricity generators, end-use customers, consumer advocates, renewable energy developers, energy financiers, environmental or public interest groups, and public power entities (Brown and Sedano, 2004). The nine RTOs fit into three interconnections in the U.S. electricity grid: Eastern Interconnection, Western Interconnect, and Electric Reliability Council of Texas (ERCOT) (Figure 5). RTOs coordinate with transmission owners and FERC when setting electricity rates, while ERCOT, Alaska, and Hawaii function independently from FERC (Brown and Sedano, 2004).

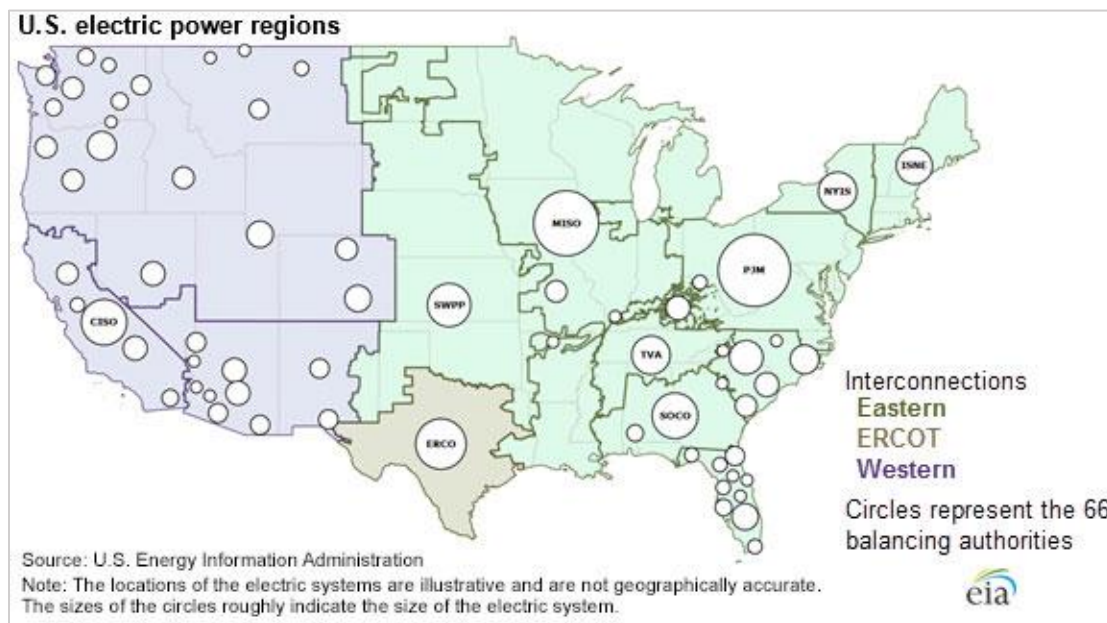


Figure 5 – Map of U.S. electrical power regions, authorities, and interconnections (EIA, 2022b).

Transmission is essential for the function of the modern electrical grid. Transmission allows for reliability of the grid, both in adequacy, the ability for the grid to supply electricity to

its customers, and security, the ability for the grid to withstand sudden disturbances or failures to part of the system (Brown and Sedano, 2004). Adequacy and security standards are set by the North American Electric Reliability Council (NERC). Transmission gives customers flexibility, allowing access to multiple electricity generators despite where they may be located. Electricity generation often occurs far away from population centers that need electricity, and transmission allows energy resources like hydroelectric, wind, solar, and coal to be efficiently transmitted across regions and provide electricity to transmission constrained areas (Brown and Sedano, 2004). Transmission also increases competition when generators of all kinds are plugged into the grid to compete and sell a lower-cost electricity on the market, insulating customers from price spikes (Brown and Sedano, 2004).

Transmission is also susceptible to numerous challenges and threats. The transmission system can be constrained by its engineering limit, where transmission ACSR cables and transformers are only engineered for so much voltage to pass through before the power line or equipment starts to malfunction, melt, or combust (Brown and Sedano, 2004). Contingencies are often in place in the transmission system so power lines are not overloaded and can accept additional capacity, in the case that one HVTL drops out of service and electricity flow shifts to another HVTL³ (Brown and Sedano, 2004). If greater voltage is transmitted through an ACSR cable, the additional capacity can cause the overhead line to heat and sag beyond safety limits that could lead to blackouts, making clearance and vegetation maintenance underneath power lines critical (Rashmi et al., 2017). Transmission congestion is a concern as well, where physical

³ For a HVTL capable of carrying 2,000 MW, the capacity of the line would be capped at around 1,400 MW (Brown and Sedano, 2004).

limitations can prevent affordable electricity from reaching certain areas (Brown and Sedano, 2004). Recent challenges to modernizing the electrical grid includes siting new transmission line, determining who pays for interconnects, connection of RES, and protecting the grid from physical and cyber-attacks (EIA, 2022b).

Distribution

The final phase of the electricity system is distribution, delivering low-voltage electricity to households and businesses for usage (Figure 6). Voltage of distribution lines are typically 13 kV or lower for primary customers but can increase to 33 kV for sub-transmission customers who require a higher voltage of electricity (Brown and Sedano, 2004). Secondary customers such as households will receive distributed electricity at 240-120 volts. Electricity is commonly distributed by overhead power lines atop wooden utility poles, while distribution lines may be located underground in some dense urban areas. Massachusetts law (M.G.L. c.166 §22D) authorizes municipalities to require power companies to bury overhead utilities underground. In turn, the power company is authorized to recover costs by increasing costs to ratepayers, limited to seven percent per year (Troy, 2014). This approach has been used by some municipalities for storm resilience or to improve aesthetics, but the high costs and technological limitations pose a challenge to most undergrounding projects.

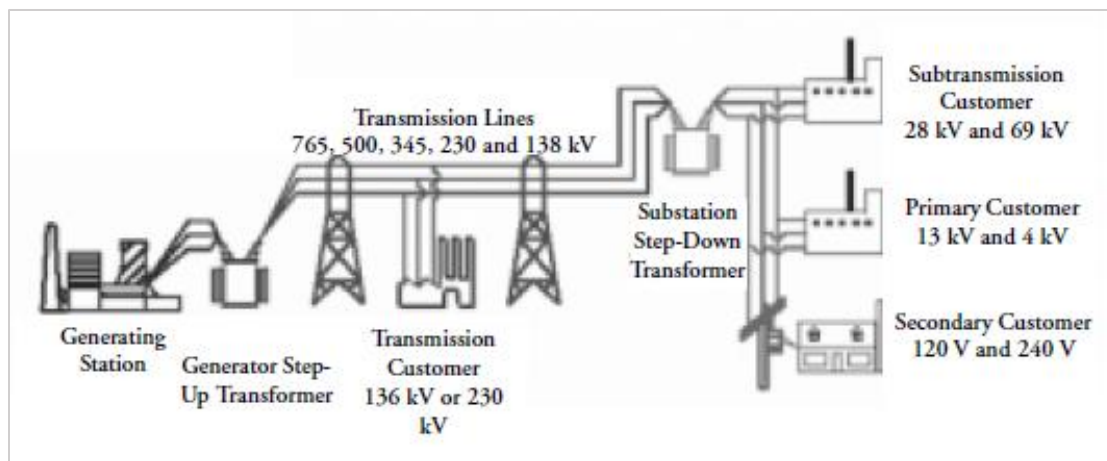


Figure 6 – Electricity system overview (Brown and Sedano, 2004).

Transmission Development

There are multiple steps a proposed transmission line project must take before it can transmit electricity from a generating source to an end consumer. Transmission development is deciding where a proposed project will be located, which involves a multi-phased process of planning (forecasting), determining who pays for the project, and permitting (Goggin et al., 2021). On average, major transmission projects require ten or more years to plan, permit, and construct, which underscores the importance of efficient transmission development in the transition to clean electricity and reaching net-zero GHG emission goals (Weiss et al., 2019).

Planning

First, the “need” for a transmission line must be identified. The demand for electricity and need for increased transmission could occur from three changes: Population growth in a certain region, new electrical generating facilities, and new efficiencies to optimize the transmission system (Brown and Sedano, 2004). Regional transmission planning is led by RTOs

and ISOs with oversight from FERC. Planning is meant to optimize grid operations as a single entity, even when the grid is owned by multiple entities (Warwick, 2002).

A utility or developer will ultimately propose construction of a new transmission line. Utilities can be either public, as with a publicly owned utility (POU), or private, as with an investor-owned utility (IOU) (Warwick, 2002). POU's can be owned by a municipality or cooperative of members, operating in the best interest of their customers, who run the POU. IOU's are private, selling stock to investors and owned by their shareholders. IOU's are regulated by a public service commission (PSC) or public utility commission (PUC), who set electricity rates and ensure IOU's are responding to customer demand. Of the approximate 3,200 utilities in the U.S., approximately 200 are IOU's that provide 70 percent of consumers in the U.S. with electricity (Warwick, 2002). Utilities can vary in size and scale, owning or operating any part of generation, transmission, and/or distribution. Often, POU's don't own their electricity generation or transmission, while IOU's don't own enough generation to meet customer demands, which creates opportunity for electricity to be bought and sold on the market (Warwick, 2002).

With planning transmission, there always lies the debate whether a HVTL is needed instead of generating electricity closer to population centers. Unlike fossil fuel power plants where energy sources like coal or natural gas can be transported to the plant, RES generation from wind and solar are often located far from population centers, requiring substantial transmission infrastructure to connect the RES generated electricity to the grid (St. John, 2021). When transmission of RES electricity cuts through multiple municipalities or entire states, animus could ensue as some bear the physical burden of HVTLs while others benefit from the

RES electricity (Iaconangelo, 2021). RES developers have been a leading entity proposing transmission projects from RES to the grid. This spurline transmission will be needed at quantities higher than bulk transmission, the overall transmission system carrying high-voltage electricity across the U.S. to meet 90 percent carbon-free electricity targets by 2035 (Goldman School of Public Policy, 2020) (Figure 7). Beyond 2035 looking towards 2050, bulk transmission investment to an aging and more electrified grid will be needed to meet demand.

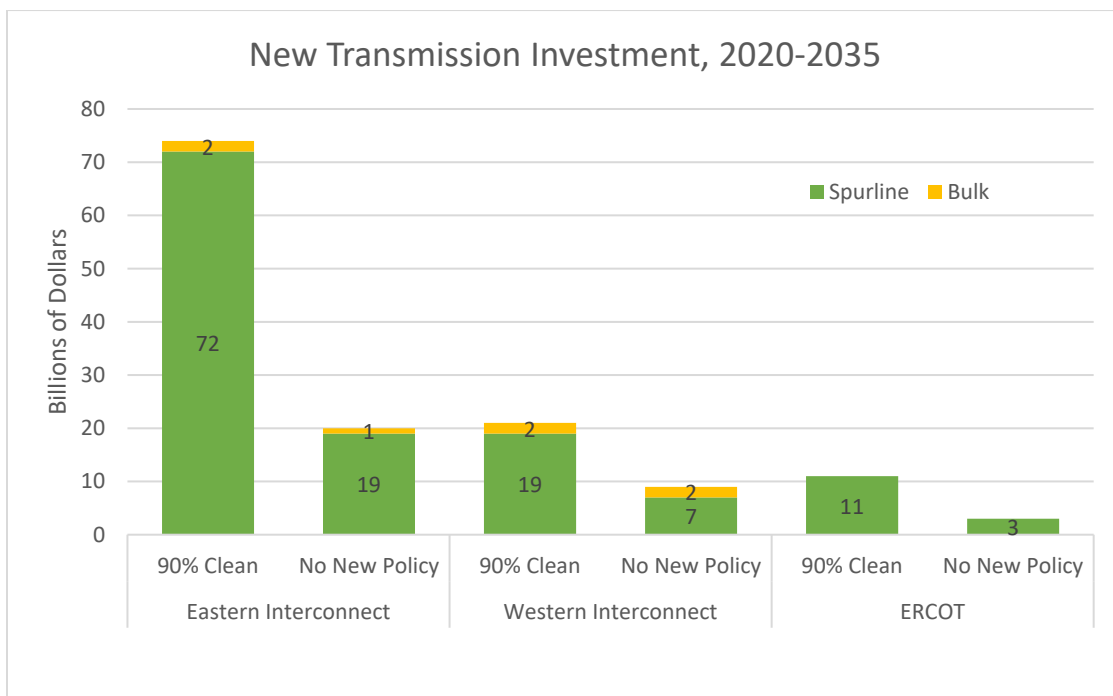


Figure 7 – Costs associated with spurline and bulk transmission build-out needed to reach U.S. GHG emission goals by 2035 (Goldman School of Public Policy, 2020).

Payment

Not surprisingly, which entity pays for transmission projects and upgrades for RES interconnection is a critical question. Either participant funding occurs, where the generating company connecting to the grid pays, or socialization occurs, where the transmission company that operates and maintains the grid pays, and thus its ratepayers when costs are passed on

(Brown and Sedano, 2004). In 2003, FERC Order 2003 allowed RTOs and ISOs to pass the cost of connecting and upgrading the electrical grid onto the RES developers, with the goal of limiting cost-sharing with IOUs and their customers. RES interconnection to the grid now makes up 90 percent of new requests (St. John, 2021). While grid upgrades traditionally cost about ten percent of total project cost for natural gas facilities, RES facilities can be anywhere from 50-100 percent of project costs (St. John, 2021). This becomes an issue because developers must justify a high investment and lengthy timelines to build transmission to financiers (Brown and Sedano, 2004). When costs become too high for an RES to interconnect, a proposed project will drop out of the queue and cause grid operators to reassess interconnection studies (St. John, 2021). As transmission upgrades are passed along to the next developer, both needs and costs accumulate. New tax credits and economic incentives are being proposed to encourage HVTL construction from developers, specifically projects that are difficult to build but provide net benefits for consumers (Goggin et al., 2021).

Burying HVTLs subsurface, or “undergrounding” can be a strategic tactic used when locating a proposed transmission project because of the lack of visual impacts of overhead HVTL structures (Willson, 2023). Beyond aesthetical value, undergrounding provides increased reliability, durability, and reduced outages from overgrown vegetation or extreme weather to the transmission system (Hall, 2009). However, undergrounding comes with tradeoffs. While operation and maintenance can be less frequent, repairing and restoring electricity to damaged underground HVTLs can be lengthy and costly (Hall, 2009). A study from Edison Electric Institute (2009) concluded high installation costs are the most significant obstacle to burying HVTLs, costing five to ten times more than constructing overhead HVTLs (Hall, 2009). It is important,

though, to distinguish between proposed HVDC and HVAC transmission projects. Recent technological advances in HVDC cables and converter stations have made buried HVDC cost-competitive with overhead HVAC transmission⁴ (Putnam and Rogers, 2022). Buried HVDC is now estimated to cost two to four times more than overhead HVDC (Putnam and Rogers, 2022) (Figure 8).

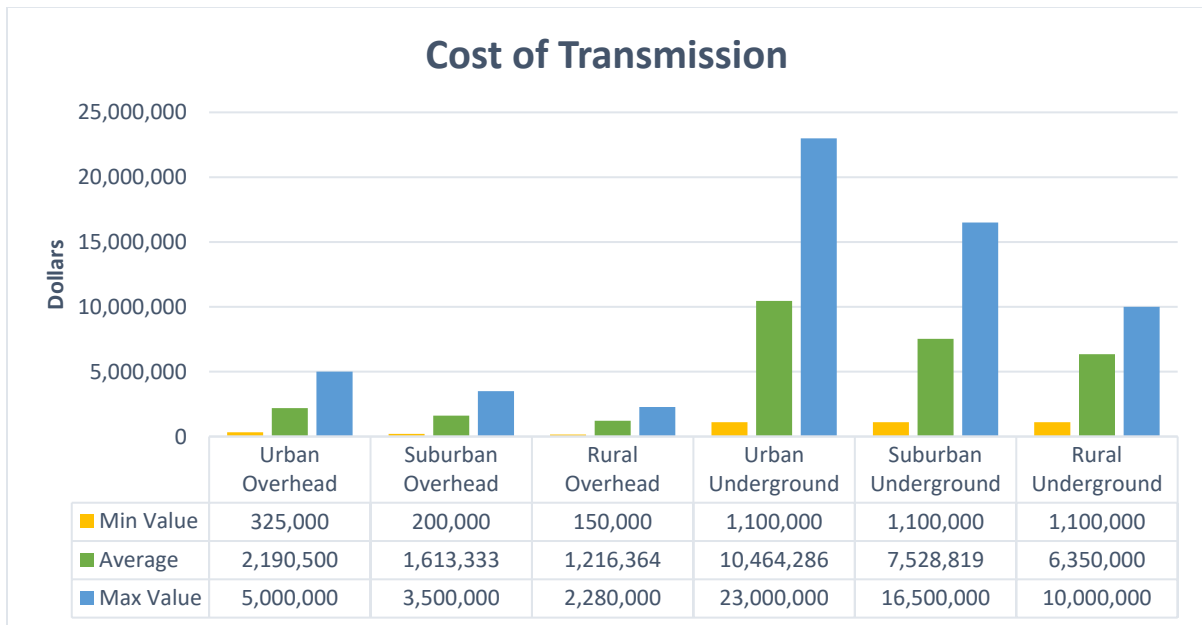


Figure 8 – Cost per mile comparison of newly constructed overhead and underground transmission in urban, suburban, and rural areas (Hall, 2009).

Permitting

Permitting, obtaining governmental approvals for HVTL projects is costly, lengthy, and often determines the fate of the project. Siting and routing processes must identify a specific route for a proposed project before it can be permitted, involving coordination with stakeholders. Stakeholders mostly include affected landowners where the project easement

⁴ In the past decade, cable costs have fallen from over \$3 million to \$1-2 million per mile, while converter costs have fallen from \$300 million to an estimated \$200 million (Putnam and Rogers, 2022).

would be located but could also include landowners in the vicinity of or who abut the proposed project, municipal officials, land management agencies, regulators, tribes, or community members⁵ (Hietter, et al., 2018). Because overhead HVTL projects are long, linear, and can fragment large landscapes, the number of stakeholders can be substantial. Stakeholder engagement can determine whether a project succeeds or fails, where open and transparent two-way communication between the utility and stakeholder is encouraged (Hietter, et al., 2018). Projects that are fully formed before engaging with stakeholders presents a fait accompli⁶, which often yields immediate opposition and lawsuits (Hietter, et al., 2018). Noticing is typically the first outreach conducted with stakeholders to inform them about the proposed project, either posted on site, within newspapers, websites, or via mailings (Hietter, et al., 2018). Meetings or workshops then occur with a targeted audience to share project objectives, gauge reactions, and understand local values of specific resources (Hietter, et al., 2018). Meetings and a public comment period could be voluntary or statutorily required by a permitting agency, state and/or federal.

The siting and routing process varies in every state, which could be overseen at the local or state level or by quasi-independent authorities such as siting boards or public utility commissions (Brown and Sedano, 2004) (Figure 9). Each state has certain thresholds on voltage or length of the proposed transmission line that requires state permitting. Low voltage or short transmission lines are usually exempt from state level approvals and will only require local

⁵ For the purpose of this paper, engagement with community members and the general public not directly tied to project decision-making is referred to as public outreach.

⁶ Fait accompli is an event or decision that is completed without knowledge or consent of the affected parties, often leaving them no choice but to accept the outcome.

permitting (Smith Jr., 2021). For high-voltage or long transmission lines that traverse municipalities or states, state siting boards or PUCs possesses authority to override and issue all state and local permits required for a project (Smith Jr., 2021). The purpose is to grant state authority to balance all aspects of public interest for important energy projects when local decisions conflict with state energy needs, policies, and objectives (Smith Jr., 2021). Public interests typically include reliability of electricity supply, minimizing environmental impacts,⁷ and providing electricity at the lowest cost (Smith Jr., 2021). Notwithstanding, the limitations imposed on local government's authority regarding high-voltage or long transmission lines, local governments play an important role in siting. Some states employ Dillon's Rule, only granting municipalities powers designated by the state, where large HVTL projects may not require local approvals (National League of Cities, 2016). Other states that employ Home Rule grant municipalities local autonomy and often do have a say in large HVTL projects located within their jurisdiction (National League of Cities, 2016).

⁷ Effects to geology, wetland, wildlife, forestry, and historic or cultural resources (Smith Jr., 2021).

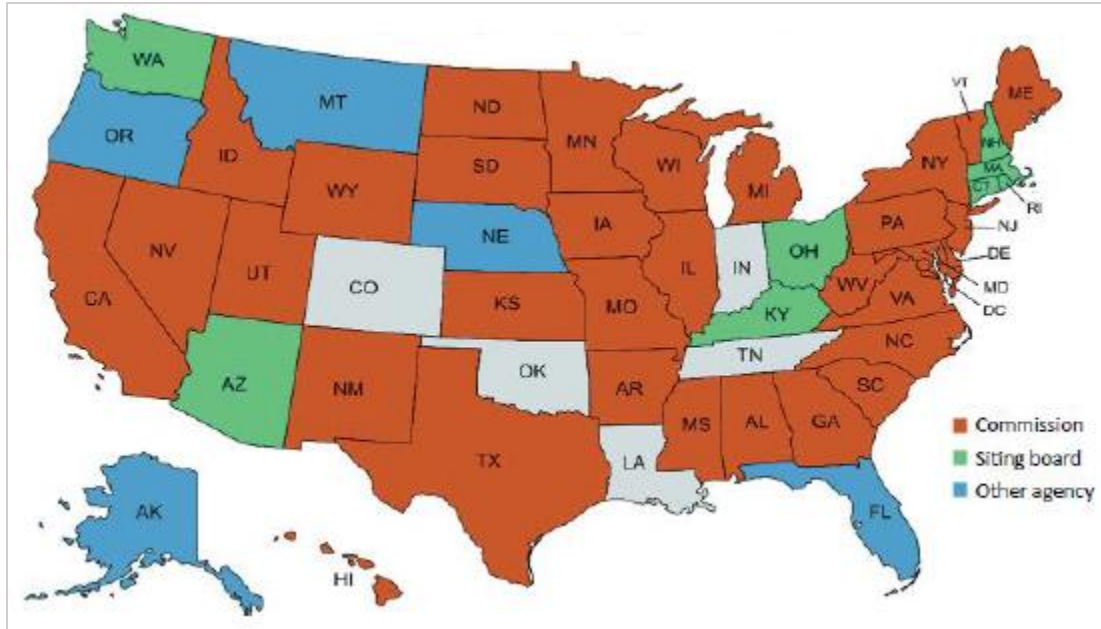


Figure 9 – Map of transmission siting authority by state (Smith Jr., 2021).

In some states, a certificate of need for a proposed transmission line is required to address reliability and cost. NERC sets reliability standards for transmission to ensure the grid can withstand failures (Brown and Sedano, 2004). Persistent congestion is when transmission need is required due to high costs instead of reliability in a transmission constrained region (Brown and Sedano, 2004). Approving agencies must also be aware of “gold plating”, when more utility investment in the electrical grid is proposed than what’s necessary for reliability (Brown and Sedano, 2004). In the case with spurline transmission, bringing RES onto the electricity grid is not necessary for reliability, but instead to bring low-cost electricity online and address GHG emission goals (Goldman School of Public Policy, 2020).

Physical permits will always be needed for HVTL project and will vary based on the state. Unless a proposed transmission project spans international borders, waters of the U.S., or federal land, federal law delegates siting authority to the states. The Presidential permit,

administered by the U.S. Department of Energy (DOE) is a federal permit required when crossing internationally to/from Canada or Mexico (Brown and Sedano, 2004). Other required federal permits could include but are not limited to filing under Section 404 of the Clean Water Act (CWA), Section 6 of the National Historic Preservation Act (NHPA), and Section 7 of the Endangered Species Act (ESA).

The National Environmental Policy Act (NEPA) was signed into law in 1970 to provide a framework to include human and place-based values in decision-making, giving opportunity to those who bear the economic, social, and environmental impacts of a decision (Hendry, 2004). Projects undertaking “major federal actions significantly affecting the quality of the human environment” are subject to NEPA (Orford, 2013). The federal agency with the most significant permitting authority over the project, not the project applicant, is the lead permitting agency responsible for complying with NEPA (Orford, 2013). In most energy projects the lead agency is DOE, but the Bureau of Land Management, Department for Housing and Urban Development, Federal Highway Administration, U.S. Forest Service, U.S. Army Corps of Engineers (USACE), or other federal agencies could also be the lead for the NEPA process (Hendry, 2004).

If projects do not meet a categorical exclusion for the involved agencies, the project applicant must complete an Environmental Impact Statement (EIS) (Orford, 2013). The EIS must discuss actual and alleged direct, indirect, and cumulative impacts of the project, as well as alternative routes and a “no-build” option (Orford, 2013). NEPA does not prescribe a format for public hearings, but requirements are in place to provide public notice of hearings or meetings about the project and solicitation of appropriate information from the public (Lee and Cunningham, 2013). Once a final EIS is complete, the lead agency will decide whether to

approve the proposed project (Hendry, 2004). Groups in opposition of a proposed project can claim an agency's positive decision is in violation of NEPA and file a lawsuit, potentially delaying project construction or causing eventual denial of the project altogether (Orford, 2013).

In lieu of an EIS, project developers could complete an Environmental Assessment (EA) to evaluate significant adverse impacts, but the process is subject to judicial review and there is a possibility that courts would require an EIS anyways (Orford, 2013). EAs are typically 10-15 pages long (excluding appendices) and are much more concise than the detailed, long, and costly analysis required by the rigorous EIS process (Hendry, 2004). If a proposed project is found to not result in significant adverse impacts, the lead agency can issue a finding of no significant impact (FONSI) and approve the project (Hendry, 2004). A mitigated alternative FONSI could also be issued by the lead agency if measures are proposed that would prevent a project from having significant impacts on the environment (Hendry, 2004). Lead agencies have issued mitigated FONSI determinations strictly to avoid the hefty expense and time commitments required by the EIS process, subverting much of the public participation intention in NEPA (Hendry, 2004).

Public Opinion

A transmission project's success is tethered to understanding and addressing public concerns about the project. Consumers of electricity are often intolerant of interruptions, where the positive symbolism of transmission from when consumers lacked adequate electricity have declined (Furby et al., 1998). There has been a shift in energy policy over the past 20 years. Along with economic competitiveness, environmental sustainability, and security

of supply, public acceptance has played a larger role in decision-making (Bertsch and Fichtner, 2015). Organized public opposition to transmission projects has frequently impacted project development, altering the project route, increasing costs, and extending project schedules or cancelling projects altogether (Eto, 2016). In general, the public has a low acceptance of electrical grid expansion projects, but conversely highly value environmental sustainability and electricity security (Bertsch and Fichtner, 2015). The utility may consider public opinion towards a proposed project in its planning, siting, and permitting phases. Below are a series of concerns to health, environment, economics, and psychology that are raised with proposed transmission line development.

Health

The primary health concern attributed to transmission lines is from EMF, waves of electric and magnetic energy moving together, emanating from power lines. In 1999, a U.S. National Institute of Health report found weak evidence linking health problems to low-frequency EMF from power lines, with “no consistent pattern of biological effects” (Cain and Nelson, 2013). Conversely, a 2001 study from the International Agency for Research on Cancer found EMFs as possible human carcinogens (Cain and Nelson, 2013). Despite links between EMF and health effect being inconclusive, EMF continues to influence public opinion of HVTLs. In one study, EMF risks were ranked as the greatest concern of HVTLs, among interference with property rights, visual and noise effects, environmental damages, and accidents and safety (Elliott and Wadley, 2012). While HVTLs can create fire hazards from lightning strikes, routine maintenance from equipment and machinery, and overgrown vegetation contact with power lines, their ROWs can act as fire breaks from the spread of forest fires (Elliott and Wadley,

2012). Corona noise is a crackling or hissing sound heard from HVTLs⁸, typically registering at 40-50 A-weighted decibels, similar to ambient noise in an average home or rural area (Aspen Environmental Group, N.D.).

Environment

Environmental concerns from proposed transmission projects can be numerous, including impacts to individual threatened or endangered species, wetland or forest habitats, or regional watersheds. Transmission ROWs typically support low-growing plant communities that can increase species richness in an area, specifically for small mammals, reptiles, and birds (Duncan, 2014). Despite some benefits, tree clearing is often required for projects and is a major concern from transmission opponents, whether it be within an existing ROW or along a new project route, creating visual scar lines in the landscape. Habitat fragmentation from HVTLs can impact terrestrial animals and insects, or local biodiversity and ecosystems (Elliott and Wadley, 2012). Environmental impacts are often raised during the local permitting process or NEPA review during the EA or EIS review. The NEPA process typically fails to substantially change the scope of a project, used as a compliance requirement rather than a tool for improved decision-making (Hendry, 2004). The burden of proof often falls to the public to prove EAs wrong and that environmental impacts are greater than represented (Hendry, 2004). Public disapproval of NEPA decisions have advanced environmental awareness and activism among landowners and community members that yield lower-impact projects in the future (Cain and Nelson, 2013). State permitting processes can offer mechanisms to oppose projects

⁸ Corona noise is caused by the breakdown of air molecules into charged particles from EMF at the surface of the power line wire (Aspen Environmental Group, N.D.).

on environmental grounds, which are usually more sensitive to local environmental concerns or having stricter regulations than federal agencies.

Personal beliefs and attitudes towards climate change and environmental policy can influence public support for a proposed transmission project (Carley et al., 2019). As with electric vehicles or recycled household products, preference towards RES generation versus fossil fuel generation can differ based on one's prioritization of reducing GHG emission and willingness to pay for it (Carley et al., 2019). One study found that if a proposed transmission project is known to carry electricity generated by RES, stakeholders are more likely to support the project than if electricity was generated from fossil fuel sources, or if not informed at all about the electricity source (Carley et al., 2019).

Economics

The cost of electricity is a direct economic factor evaluated with proposed transmission projects. Increased transmission can bring benefits of electrification to more homes and businesses, including electricity from RES. As early as 1977, younger generations had greater willingness to pay for pollution-free energy than earlier generation (Furby et al., 1988). The presence of HVTLs and their structures can also impact real estate and property values. In a review of studies from 1964 to 2009 with empirical data, the presence of existing transmission lines had little to no effect on home sales price, where the 2-9 percent price difference diminished with time and distance (Jackson and Pitts, 2010). It's possible the time variable explains the limited price effect, as most transmission line ROWs in the U.S. have been around since the early 1900's (Brown and Sedano, 2004). Properties with transmission line easements also contain additional open space that could be viewed as desirable (Jackson and Pitts, 2010).

When looking at vacant lots (which reduce outlier influence over property value) adjacent to power lines in Pickens County, South Carolina from 2000 to 2016, the study found a 44.9% pricing discount (Wyman and Mothorpe, 2018). No significant discounting was found for properties beyond 1,000 feet away from the proposed project, supporting the finding that property value dissipates with distance from the HVTL (Wyman and Mothorpe, 2018).

Psychology

Community based opposition of HVTLs can be attributed to numerous factors, including perceived high safety risk of transmission lines, or distrust in the utility or developer of a project (Cain and Nelson, 2013). Risk aversion in particular plays into public opinion with any proposed project, as new developments always have perceived risks that could impact one's health, the environment, or their economic situation. Risks that are undetectable, involuntary, or from unfamiliar technology are less acceptable than risks that are detectable, voluntary, and from familiar technology (Cain and Nelson, 2013). Risk calculations are usually rooted in emotions rather than technical details, where most of the public will overvalue the threat of HVTLs (Cain and Nelson, 2013). Risk also influences public perception when it comes to the economics of transmission. When offered involvement opportunities with an onshore wind and grid development project, residents of impacted communities preferred financial compensation through a community benefits scheme, without sharing ownership and risk of the proposed project (Hyland and Bertsch, 2018). Landowners typically act as rational maximizers when handling proposed projects, aiming to minimize financial risks (Schively, 2007). This is also true with place-based attachments, where HVTLs can be viewed as a symbolic intrusion on personal property and violate one's sense of space leading to "not in my backyard" (NIMBY) sentiments

(Cain and Nelson, 2013). With transmission projects, benefits typically accrue to a dispersed number of beneficiaries in a region of the electrical grid, where immediate project stakeholders like landowners and those residing in impacted communities often have little incentive to support a particular project (Cain and Nelson, 2013)

Trust in institutions and fairness of the siting process play a significant role in proposed transmission projects. Trust in government is often correlated with greater support for a project, and likewise lack of trust yields opposition (Cain and Nelson, 2013). Distrust heightens the perception of risk of a project, which intensifies public reaction to risk signals and promotes political activism (Cain and Nelson, 2013). Procedural justice, including public participation and consultation with impacted stakeholders are important factors in gaining support within host communities (Joalland et al., 2018). Those who view the siting process as fair are more likely to accept results that are opposite their perceived interests (Cain and Nelson, 2013). Consistency in outcomes and requiring sufficient analyses of potential impacts for permitting can help build trust in the siting process (Schively, 2007).

Methodology

Literature Review

To answer my research question, a review of existing U.S. and international literature relating to GHG emissions, the electricity system, transmission line development, and public opinions of transmission lines was conducted. Literature regarding permitting and public outreach for linear HVTL projects was prioritized for analysis and reviewed.

Case Studies

Next, four recent case studies of successful and failed transmission projects were evaluated to offer a sample of projects from which the public planning process in transmission development was analyzed. Case studies included: (1) Northern Pass in New Hampshire; (2) New England Clean Energy Connect (NECEC) in Maine; (3) Great Northern Transmission Line (GNTL) in Minnesota; and (4) Champlain Hudson Power Express (CHPE) in New York. These case studies were selected based their geographical relevance, known opposition from multiple stakeholders, varying siting technique and project alignment, project development in the past decade, and familiarity with available literature. Northern Pass and NECEC were selected because they were two heavily opposed transmission projects proposed locally in New England. GNTL was analyzed due to familiarity and connection with project personnel to see what steps were taken on a successful transmission project with limited public opposition. CHPE provided insight into a recently permitted HVTL with unique siting and routing techniques compared to the other case studies.

Of the successful transmission projects that have been permitted and are currently in construction, selective qualitative interviews were conducted with one to three project members involved with the planning, permitting, and stakeholder engagement to inform what aspects of the project contributed to its success. Target interviewees included federal and/or state regulators in the state(s) of the proposed transmission line, project managers of the proposed project, subconsultants who assisted with permitting, stakeholder engagement, or public outreach, and/or attorneys involved in proceedings. Interviews were used to inform the research and literature analyses for each project. A detailed table of those interviewed and questions that were asked during each interview are provided in Appendix A.

GIS Mapping

Geographic Information System (GIS) mapping was used to spatially depict case studies that were chosen. Maps were created to inform the reader of each project's geographical location, scale in comparison to the size of each state, and display consistent attributes across case study maps. GIS mapping was not used as part of geospatial analysis. Data sources for each map was obtained from publicly available state databases, while publicly available federal data was used across every map (Table 3). GIS maps include state boundaries, existing transmission lines, urban areas (densely settled 2010 census block groups between 500,000 and 1,500,000 people), the proposed project route, and aerial imagery showing natural resource areas and roadways in each state.

Table 3 – GIS data sources and shapefiles used for project maps.

Project	Data Source	Shapfiles
Northern Pass	New Hampshire Geodata Portal (NH GRANIT)	New_Hampshire_State_Boundary New_Hampshire_Congressional_District_Boundaries
NECEC	Maine Geolibrary	Maine_State_Boundary_Polygon_Feature NECEC_Centerline_Layer
GNTL	Minnesota Geospatial Commons	shp_bdry_state shp_bdry_mn_city_township_unorg
CHPE	NYS GIS Clearinghouse	NYS_Civil_Boundaries_3799341976107507149
All Projects	U.S. Energy Atlas	U.S._Electric_Power_Transmission_Lines USA_Urban_Areas

Analysis

Based on the findings and results from the case studies, techniques from the successful transmission projects were compared to ongoing and failed projects. A table of variables was compiled and used in a qualitative comparative analysis between case studies. Best practices and lessons learned were identified that could increase the likelihood of successful transmission projects in the future using criteria from each case study. Next, policy and planning recommendations were made for how planning, payment, or permitting could be optimized during transmission development to benefit the project and stakeholders based on findings. Finally, limitations and future research were discussed.

Case Studies / Findings

Northern Pass

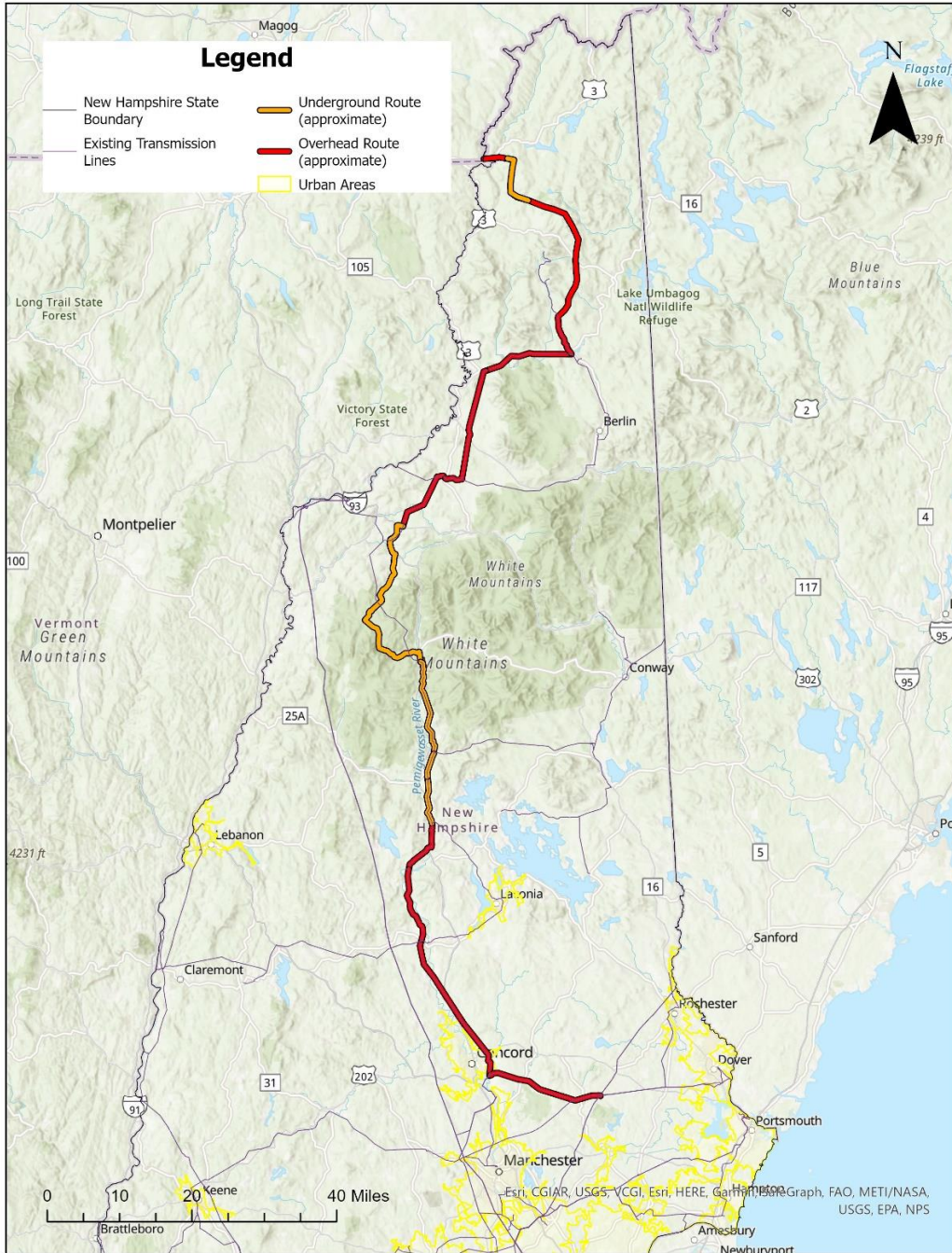


Figure 10 – Map of Northern Pass project route.

Overview

The Northern Pass project was proposed in 2010 by Northern Pass Transmission, LLC, a subsidiary of Northeast Utilities and NSTAR, (which later merged to form Eversource Energy), in collaboration with Hydro-Quebec. The project intended to bring cost effective, low-carbon hydroelectric power generated in Canada into Massachusetts to help the state meet its ambitious decarbonization target (Serreze, 2018). Northern Pass was a proposed HVTL through New Hampshire, carrying hydroelectric power 192 miles south from Pittsburg, NH, located on the international border with Canada to an existing substation in Deerfield, NH (Federal Register, 2017). The HVTL would travel 158 miles via DC voltage at 1,200 MW⁹ from the Canadian border to a converter station in Franklin, NH, then continue 34 miles via AC voltage at 345 kV to Deerfield, NH (Federal Register, 2017). Along with the converter station, six transition substations were proposed along the project route (Federal Register, 2017). Transmission structures would range from 80-135 feet tall, taller than average trees in New Hampshire that ranges from 40-80 feet tall (Piedra, 2015).

The proposed project was initially estimated to cost \$1.1-1.4 billion and create approximately 1,200 construction jobs (Piedra, 2015). The completed project would generate \$300 million a year in revenue for the state and help reduce New England's current reliance on fossil fuels for electricity (Piedra, 2015). The project was anticipated to be completed by 2020 (Brooks, 2019).

⁹ In an August 2015 amendment, the Project capacity was altered from 1,200 MW to 1,000 MW, along with other design and siting changes (Federal Register, 2017).

Siting and Permitting

The concept of the Northern Pass project was first developed in 2008 and gained public interest in October 2010 when the project was publicly announced following submission of its Presidential permit application (Keir and Ali, 2014). As the issuing authority of the Presidential permit, DOE prepared the EIS for the project in compliance with NEPA regulations. The scoping period for fact-finding during the EIS process was open from February 2011 to November 2013, representing the bulk of the public outreach when solicitation of public comments occurred (Keir and Ali, 2014). Across all public hearings and meetings, 299 comments were collected from residents and organizations where attendees grew to nearly 300, 400, and over 650 at three separate meetings (Keir et al., 2014). In total, DOE received 1,037 comments on the draft EIS (Federal Register, 2017). Due to public comments, the Presidential permit application was amended in July 2013 and August 2015, representing DOE's preferred alternative to bury 52 miles of the HVTL in public roadways located in northern New Hampshire (Federal Register, 2017). Despite continued strong opposition, the Presidential permit was issued in November 2017 (Federal Register, 2017).

In January 2018, MassDOER selected the Northern Pass project as the winner of its Clean Energy RFP, in response to the state's 2016 Energy Diversity Act (Serreze, 2018). Among dozens of proposals from transmission developers,¹⁰ Northern Pass was selected for its ability to reduce emissions, benefit ratepayers, and meet other criteria outline in the RFP (Serreze, 2018). Despite obtaining the Presidential permit and other federal approvals from U.S. Fish and

¹⁰ Other projects that vied for the Massachusetts Clean Energy RFP included NECEC from CMP through Maine, Granite State Power Link from National Grid through northern Vermont and New Hampshire, New England Clean Power Link from TDI through Vermont, and others (McQuiston, 2018).

Wildlife Service (FWS) per Section 7 of the ESA, U.S. Forest Service, and state historic preservation offices per Section 6 of the NHPA, the project still required state approval from the New Hampshire Site Evaluation Committee (NHSEC).¹¹ Because of public opposition to the project, the Northern Pass project was unanimously rejected by the NHSEC in February 2018 (Brooks, 2019). The decision from NHSEC was upheld in state superior court later that year (The Supreme Court of New Hampshire, 2019). Eversource spent more than \$318 million over a decade attempting to gain approvals for the project (Brooks, 2019).

Public Opinion

The Northern Pass project received opposition almost from its inception because of insufficient planning, poor siting, and lack of public involvement (Schultz, 2021). The nature of the project meant the state of New Hampshire would absorb virtually all environmental impacts, while Massachusetts residents would receive the benefits of a RES and cheap electricity. Despite direct compensation to landowners, funding energy efficiency programs, and providing assistance to low-income residents in New Hampshire, many residents still saw the project as unfair and opposed it (Brooks, 2019).

With siting, Northern Pass was proposed mostly within existing ROWs, but required rights to build on protected and ecologically fragile land within the White Mountain National Forest. Many New Hampshire residents believe that siting an overhead HVTL within the National Forest would irreparably harm the landscape and evidentially tourism, the state's second largest industry (Piedra, 2015). The Society of the Protection of New Hampshire Forests

¹¹ The NHSEC is the state equivalent of a PSC or PUC that decides state siting decision for HVTL projects.

(SPNHF) opposed the project for impacts to two dozen tracts of conservation land, while the Conservation Law Foundation opposed the degradation of wilderness habitat and increase of GHG emissions from the HVTL itself and hydroelectric power from Canada (Piedra, 2015). SPNHF strategically acquired and placed conservation easements on parcels of land in northern New Hampshire to ensure Northern Pass developers would have difficulty siting the project though 40 miles of new ROW (Piedra, 2015). In 2012, the State of New Hampshire passed HB 648 that further restricted the use of eminent domain, geared towards the Northern Pass project (Piedra, 2015). The law prohibited eminent domain by public utilities for projects not eligible for regional cost allocation by ISO New England and established a commission to investigate such procedures (House Bill 648, 2012). These collective efforts caused the project to propose siting within ROWs along local and state roadways in collaboration with the state Department of Transportation (Piedra, 2015). With this, the final project route would be located 80 percent within existing ROW corridors (Serreze, 2018).

Public outreach for Northern Pass was limited, as shown by the number of public comments received during the draft EIS and NEPA review. In the Northern Pass project, almost one-third of public comments were related to procedural justice, inclusion in the planning and siting process over impacts to the environment, local economy, aesthetics, health, property value, and lack of alternatives (Keir et al., 2014). Entrenched positions can be an inhibitor for consensus building, and Northern Pass took place over adversarial forums that only grew opposition for the project (Keir and Ali, 2014). In the end, 30 of 31 communities where the project was routed through voted to oppose Northern Pass (Piedra, 2015).

New England Clean Energy Connect (NECEC)

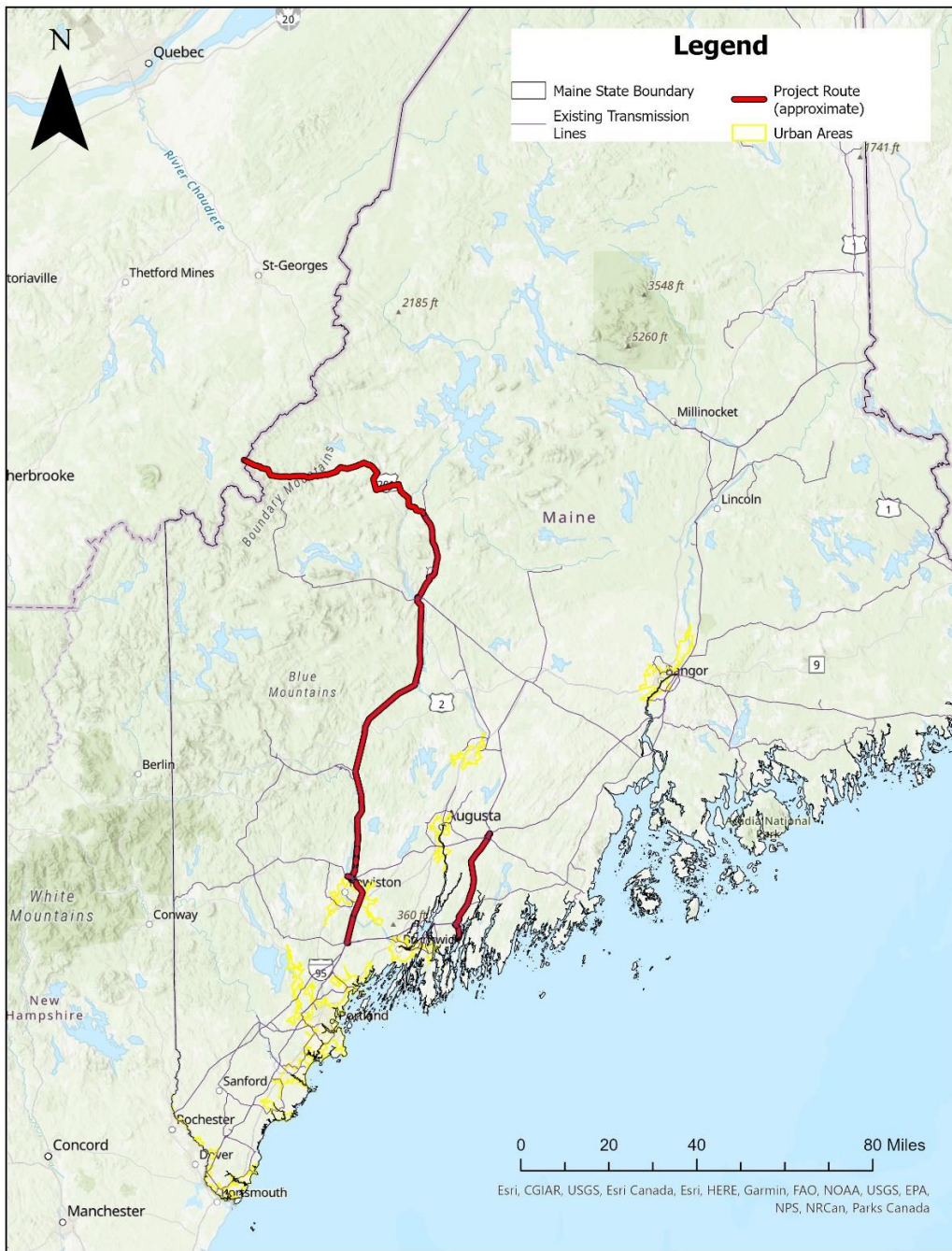


Figure 11 – Map of NECEC project route.

Overview

New England Clean Energy Connect (NECEC) is a current project proposed by Central Maine Power Company (CMP), owned by AVANGRID, a member of the Iberdrola Group, one of the world's largest electric utilities, in collaboration with Hydro-Quebec to transmit hydroelectric power from Canada into the U.S. (NECEC, 2020b). Following the failed attempt of Northern Pass, MassDOER selected the NECEC project as the runner up to its Clean Energy RFP, offering the state the next cheapest option to meet its GHG emission goals (McQuiston, 2018). As part of the agreement, the project had a contractual deadline to provide electricity to Massachusetts (Sharp, 2022a). State officials questioned whether RES and battery storage alone could meet state electricity demand and GHG emission goals, especially considering decommissioning of nuclear power plants in the region¹² (Iaconangelo, 2021). NECEC would allow the state to meet approximately 17 percent of its electricity demand through low-carbon renewable hydroelectric power, where currently about two-thirds of Massachusetts electricity production is sourced from natural gas (Iaconangelo, 2021).

NECEC is a proposed 145-mile-long utility corridor for an overhead HVTL through Maine from the Canadian border to the New Hampshire state line, 53 miles of which is new construction through forests (Schultz, 2021). The project proposed to avoid sensitive environmental and scenic areas (NECEC, 2020b). The existing CMP-owned ROW for the project ranges from 300-500 feet wide, where currently approximately 150 feet of trees would need to

¹² Vermont Yankee Nuclear Power Plant in southern Vermont closed in 2014, Pilgrim Nuclear Power Station in eastern Massachusetts closed in 2019, and Indian Point Energy Center along the Hudson River in New York closed in 2021. Two remaining nuclear plants in the New England region include Seabrook Station Nuclear Power Plant in southern New Hampshire and Millstone Nuclear Power Plant in Connecticut (Ropeik, 2021).

be cleared to co-locate the proposed HVTL in the ROW (NECEC, 2020b). The proposed project route is the shortest and lowest cost of all identified routes from Quebec to Lewiston, Maine, located within the existing ROW for over half the project length (NECEC, 2020b). NECEC would deliver up to 1,200 MW of renewable hydroelectric power from Quebec to New England (NECEC, 2020b). Electricity would travel via DC voltage to a converter station in Lewiston, Maine, transitioning to AC voltage at 345 kV and interconnecting to the existing electricity grid. Numerous transmission substation improvements are proposed along the project route (NECEC, 2020b). Approximately 850 structures, mostly steel monopoles would be installed along the project route, with average structure height of 95 feet (NECEC, 2020b).

NECEC was initially proposed at \$950 million, nearly \$1 billion (Schultz, 2021). The project was unable to distribute electricity to municipalities along its path due to its HVDC design making interconnection unfeasible (Schultz, 2021). Massachusetts electricity customers would pay for the project, with annual savings estimated at \$150 million (NECEC, 2020b). Benefits to Maine residents would include \$40 million in costs savings of wholesale energy costs over 20 years, \$4-18 million in property tax revenue per year to host communities, and 1,000-1,700 new jobs during the five-year permitting and construction phase (NECEC, 2020b). Benefits would also include increased fiber optic access in rural areas, expanded snowmobile and recreational trails, and 40,000 acres of conservation land (AVANGID, 2022). Construction was anticipated to begin in 2019, with the project in-service by 2022 (NECEC, 2020b).

Siting and Permitting

In tandem with filing permit applications for the project, CMP deployed an outreach campaign for targeted landowners along the project route. The communication plan developed

by CMP intended to manage and minimize impacts to environmental, social, and recreational resources in western Maine's commercial forest land before the project connected to existing ROWs (NECEC, 2020a). Direct stakeholder engagement through one-on-one meetings began in 2017 before permit application filings and was planned to continue post-filing and throughout construction to build trust and awareness for the project (NECEC, 2020a). The project was intentionally kept confidential from larger public groups until its external announcement was made (NECEC, 2020a).

CMP filed its Presidential permit application for NECEC in July 2017, followed by DOE publishing notice of the project and inviting public comments in the Federal Register in September (DOE, 2021). DOE received two comments following the close of the comment period and subsequently declined to consider them (DOE, 2021). DOE considered potential environmental effects of the project in its EA, including reviewing permit approvals from Maine PUC in May 2019, Maine Land Use Planning Commission in January 2020, Maine Department of Environmental Protection (MDEP) in May 2020, and USACE per Section 404 of the CWA (with consideration of Section 7 of the ESA and Section 106 of the NHPA) in November 2020. Agreements with Maine municipalities along the project route were also under negotiation (NECEC, 2020b). In January 2021, DOE issued a FONSI for the EA, therefore not requiring EIS review (DOE, 2021). DOE also determined NECEC would not have negative impacts on the reliability of the U.S. electric grid, consistent with NERC policies and standards and ISO New England system impact study (DOE, 2021).

As with Northern Pass, NECEC has been besieged with initiatives to stop the project (Schultz, 2021). In a 2021 state ballot initiative, 59% of Maine residents voted to ban

construction of the project, while requiring two-thirds approval from the state legislature for similar projects in the future (Iaconangelo, 2021). Ultimately, the referendum was the costliest in Maine history, exceeding \$90 million (Sharp, 2022b). Supporters included AVANGRID and Hydro-Quebec, while opponents included nuclear and fossil fuels companies NextEra, Vistra Energy, and Calpine Corporation who have competing interests in the region (Iaconangelo, 2021). Following the referendum, MDEP halted ongoing construction after issuing its permit in 2020. However, since the referendum NECEC has received favorable decisions to resume the project. In July 2022, the MDEP citizen board unanimously upheld the permit for the project, with an additional requirement to conserve 10,000 acres of land to offset wildlife habitat loss (Sharp, 2022a). In November 2022, Maine Supreme Judicial Court unanimously ruled in Russell Black et al. v. Bureau of Parks and Lands et al. ME 58 (2022) that Maine Bureau of Park and Lands acted within its authority when it leased a one-mile stretch, totaling 32 acres of land to CMP for the project (Sharp, 2022b). In August 2022, the Maine Supreme Judicial Court remanded the decision over the constitutionality of the 2021 referendum to a Maine trial court in NECEC Transmission LLC et al. v. Bureau of Parks and Lands et al. ME 48 (2022). The decision involved whether construction of the project to date constitutes good faith expenditures creating constitutionally protected vested rights¹³ that can't be retroactively taken by the state referendum (Porter, 2022). In April 2023, the judge for the case ruled in favor of project opponents to seat a jury to make the determination on vested rights (Snyder, 2023). However,

¹³ Vested rights are a property and land use law concept allowing a landowner or developer to proceed with a project under rules and regulations in place at the time of rights “vested”, intended to provide developers with a reasonable degree of certainty that initial rules and regulations governing their project will not change (Calandrillo et al., 2017).

later that month the jury sided with CMP and ruled the project did begin construction in good faith and could proceed (Damiano, 2023). In a tangentially related matter, NextEra was ordered by FERC to install a circuit breaker¹⁴ at its Seabrook Station Nuclear Power Plant in New Hampshire in February 2023, a needed upgrade for the transmission system in the region that would transmit electricity from NECEC (Howland, 2023).

Public Opinion

Opposition to NECEC followed a similar path to Northern Pass regarding planning, siting, and public participation, but another dynamic included the existing relationship with the project developer and local utility. CMP is a deeply distrusted utility in the state (Schultz, 2021). Public discontent with CMP was already prevalent in Maine, as evident in recent J.D. Power surveys, and the referendum on NECEC could be viewed more of a referendum on the unpopular utility than the project (Iaconangelo, 2021). Consensus from state residents was CMP and other RES developers should do a better job at listening to local knowledge, engaging with Mainers from the outset, and offering local benefits prior to sustained opposition (Iaconangelo, 2021). Building transmission should be done with meaningful public participation, insulation from political pressure, high-quality data and modeling, alternate analyses and co-location with existing infrastructure where possible, minimizing environmental impacts, and verifiable reductions in GHG emissions (Schultz, 2021). Conservationists claimed the project would fragment wildlife habitats and spoil the state's iconic wilderness, while First Nations in Canada opposed hydroelectric power being generated on unceded land (Iaconangelo, 2021).

¹⁴ A circuit breaker is a device used to control and protect against electricity capacity overloads in a circuit.

Great Northern Transmission Line (GNTL)

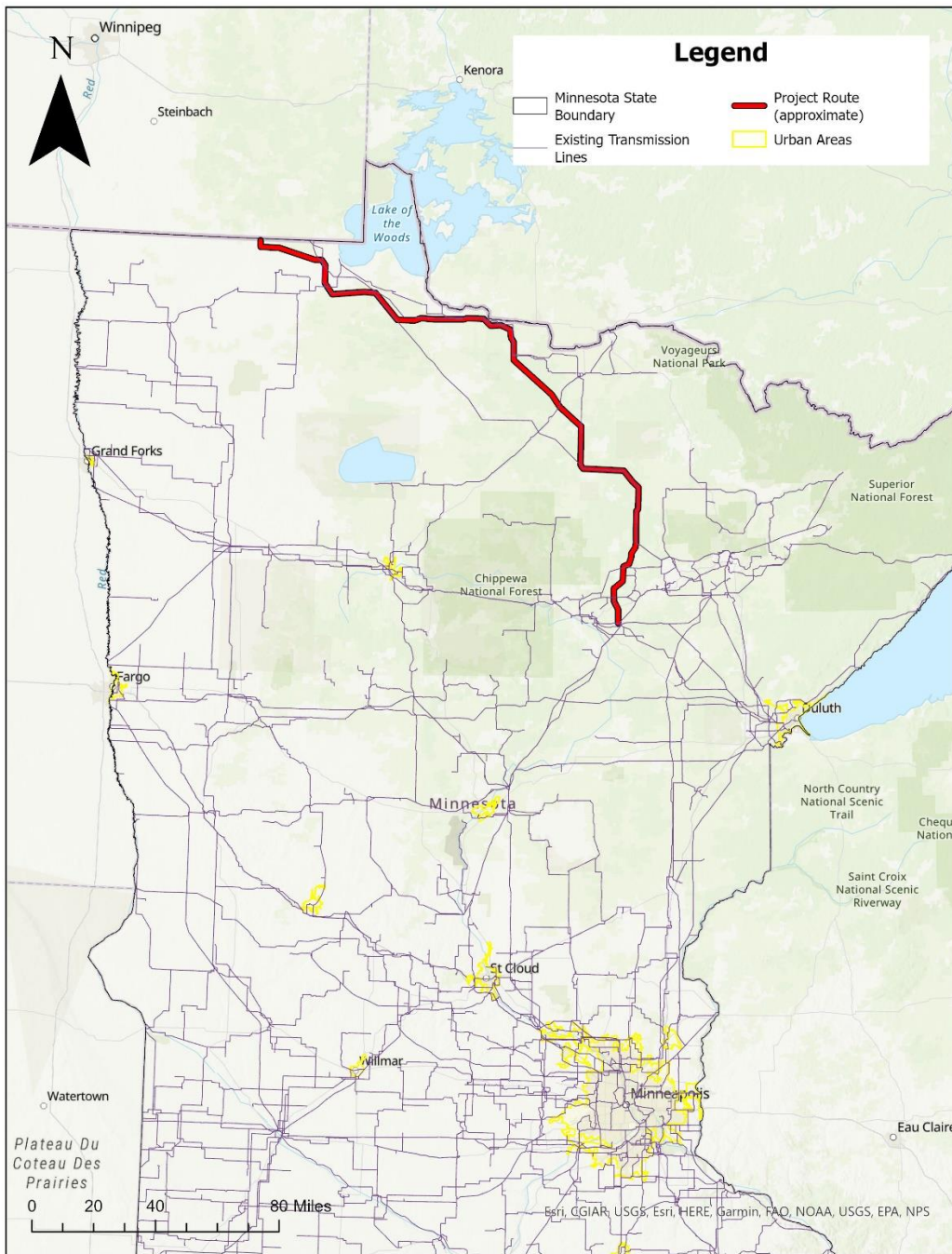


Figure 12 – Map of GNTL project route.

Overview

The Great Northern Transmission Line (GNTL) project is located in Minnesota, developed by Minnesota Power, a utility division of ALLETE, Inc., in coordination with Manitoba Hydro. GNTL was a proposed 500 kV single circuit AC transmission line approximately 225 miles in length from Manitoba, Canada to the Blackberry substation near Grand Rapids, Minnesota. The project was sited within mostly new ROW easements through undeveloped land, with a proposed width of 200 feet and approximately 2,745 acres of forest and shrubland conversion proposed along the project route (NS Energy, N.D.). The project consisted of 800 structures, ranging in height from 110-150 feet (NS Energy, N.D.).

The project would provide 50 percent renewable energy to 145,000 Minnesota Power customers within 15 municipalities (Minnesota Power, 2020). GNTL was required by June 2020 to allow the transfer of up to 883 MW of electricity between Manitoba and the U.S. (Winter and Panigrahi, 2017). GNTL is unique by balancing electricity supply and demand between Minnesota and Manitoba, transferring wind generation from the U.S. into Canada and hydroelectric power from Canada into the U.S. when needed, reducing carbon emission (Minnesota Power, 2020). The initial cost estimate for the Minnesota portion of the project was \$560 million (NS Energy, N.D.).

Siting and Permitting

The planning process for GNTL started in 2008, when Minnesota Power proposed a 250 MW purchase of hydroelectric power from Manitoba Hydro (Minnesota Power, 2020). Minnesota Power began siting and permitting in 2012, engaging with federal, state, and local agencies, the sovereign Red Lake Nation and other tribes, and landowners along the proposed

project route (Minnesota Power, 2020). Outreach was conducted with four major groups: The public (landowners and interested parties), local municipalities (country boards, city officials, towns), tribes (local and regional), and agencies (federal, state, and local) (Minnesota Power, N.D.). Methods of outreach occurred simultaneous, including input/comments over hotline, internet, GIS, and mail, open house, and workshop meetings (Minnesota Power, N.D.). Outreach occurred over email, mailings, phone call, and newsletters, while using the project website to share project information and updates (Minnesota Power, N.D.). Comments received during open house meetings throughout the project significantly contributed to the development of project corridors (Minnesota Power, N.D.). Two route alternatives were proposed, referred to as the orange and blue routes, along with two additional route segments as alternatives, J2 along the orange route and C2 along the blue route (U.S. DOE, 2016). The preferred project route was selected in April 2016 after 75 voluntary public meetings and other outreach forums (Minnesota Power, 2020).

State permits obtained for the project included a Certificate of Need and Route Permit from Minnesota PUC, approved in June 2015 and April 2016, respectively (Winter and Panigrahi, 2017). The state of Minnesota reserved all permitting rights required for this project, where local governments were preempted from regulating transmission projects (Minnesota Department of Commerce, 2014). Following approval of the Presidential permit from DOE in November 2016, Section 404 of the CWA from the USACE in December 2016, and FWS permit in January 2017, construction began in early 2017 (Minnesota Power, 2020). Despite the typical 10-year timeframe to develop a transmission project, GNTL was completed in approximately 8 years in February 2020, ahead of schedule and under budget (Minnesota Power, 2020).

Public Opinion

While opposition over GNTL certainly existed, negative press or literature in opposition to the project was difficult to find while researching. Conservationists and public resource agencies expressed concerns over the proposed project impacts to wild lands and natural resources along the proposed route, but no formal complaints or comments were registered (Duluth News Tribune, 2015). Although the project didn't cross tribal lands, Minnesota Power worked with Red Lake Nation to ensure their nearby lands would not be adversely impacted (Midwestern Governors Association, N.D). Minnesota Power actively engaged the public in their outreach campaign early in project development, listening to their concerns and using community input to direct project decisions.

Champlain Hudson Power Express (CHPE)



Figure 13 – Map of CHPE project route.

Overview

The Champlain Hudson Power Express (CHPE) project is a 339-mile DC transmission line proposed within the state of New York. CHPE is being developed by Transmission Developers, Inc. (TDI), funded by private equity firm Blackstone, partnered with Hydro-Quebec (Hydro-Quebec, 2021). The project will be fully buried, from the Canadian border through the waterway of Lake Champlain, terrestrially within railroads and roadway ROWs near Schenectady and Albany, before traveling downstate within the Hudson River and Harlem River before reaching an AC/DC converter station in Astoria, Queens (Hydro-Quebec, 2021). By utilizing hydroelectric power, CHPE will provide a reliable baseload of RES electricity, 1,250 MW to New York City (Wade, 2022).

New York City's 8.5 million residents are at an inflection point. Currently, approximately 85 percent of its electricity supply comes from fossil fuel sources,¹⁵ many being oil or natural gas facilities located in low-income, disadvantaged communities of color (Gallucci, 2022). Residents around these peaker plants in environmental justice (EJ) communities experience higher rates of asthma and other negative health effects (Teirstein, 2022). With the Indian Point Nuclear Power Plant closure in 2021, approximately 25 percent of clean energy provided to New York City and the Hudson Valley went offline (Teirstein, 2022). RES generation and transmission is required to maintain grid reliability in New York City, especially considering New York State's goal of 70 percent RES electricity statewide by 2030 (NYS, 2022). CHPE will provide RES electricity for more than one million homes, reduce air pollution in EJ communities, and cut

¹⁵ In comparison to New York City, upstate New York's electricity grid is sourced by 88 percent renewable and clean energy (Teirstein, 2022)

carbon emission by 37 million metric tons (Gallucci, 2022). CHPE is expected to bring \$3.5 billion in economic benefits to New York State residents and create 1,400 union jobs (NYS, 2022). The project includes creating a \$40 million Green Economy Fund, intended to support disadvantaged frontline and EJ communities with job training opportunities in the renewable energy and green economy space (Hydro-Quebec, 2021). A \$117 million Environmental Trust Fund will also be created to focus on the health of Lake Champlain, the Hudson River, and Harlem River (Hydro-Quebec, 2021). CHPE is expected to cost \$4.5 billion, all privately funded, and be operational by spring 2026 (Gallucci, 2022).

Siting and Permitting

CHPE was considered fully permitted and construction-ready prior to New York State selecting the project (Hydro Quebec, 2021). TDI first announced plans for CHPE in February 2010. The project received Section 404 of the CWA / Section 10 of the Rivers and Harbors Act of 1899 Permit Application permits, jointly filed with the USACE and New York State Department of Environmental Conservation, New York State Office of General Services, and New York State Department of State in December 2010. In January 2013, Section 401 of the CWA Water Quality Certification was received from New York State PSC. The Presidential permit was issued by DOE in October 2014 after an EIS for NEPA was completed in August 2014. Approval from the USACE to bury subaqueous submarine power cables in Lake Champlain, Mohawk River, Hudson River, Harlem River, East River, and unnamed wetlands in New York State occurred in April 2015. Over the following years, TDI conducted an extensive outreach campaign to engage the 35 communities along the project route (Willson, 2023). In September 2021, CHPE was selected as part of New York State Energy Research and Development Authority's Tier 4 renewable energy

solicitation, in part to reach the state's 100 percent zero-emissions electricity by 2024 goal outlined in its 2019 Climate Leadership and Community Protection Act (Hydro Quebec, 2021). The Certificate of Environmental Compatibility and Public Need pursuant to Article VII of the New York State PSC was received in April 2022, allowing CHPE to begin construction management planning with contractors and communities along the project route.

Public Opinion

TDI shaped much of the public opinion around CHPE over the course of its twelve-year permitting timeline. In Rockland County, north of New York City, TDI altered the project route to include a 7.7-mile terrestrial segment, avoiding an ecologically sensitive portion of the Hudson River, Haverstraw Bay (Willson, 2023). After opposition from potential historic site and public safety impacts in Rockland County, TDI again altered the project route to avoid areas of concern and agreed to a \$31 million community benefits agreement including capital improvement projects in the region (Willson, 2023). Ultimately, every community along the project route enacted resolutions that supported the project (Willson, 2023). With additional community outreach to eliminate project opposition, estimated cost of the project rose to \$6 billion by the financial close of the project in 2022 (Willson, 2023).

Sustained opposition to CHPE is focused on the project's route within waterways of New York State and the hydroelectric power source. The project proposes dredging HVTL cables seven feet below riverbeds, which could release toxins and pollution found deep in riverine soil not remediated by cleanup efforts from General Electric Company's industrial dumping years prior (Gallucci, 2022). While CHPE would not be located within the most contaminated northern portions of the Hudson River, 200 miles of the river is considered an EPA Superfund site

(Willson, 2023). The proposed project could also impact estuarine habitat in the Hudson and drinking water for about 100,000 nearby residents (Wade, 2022). Burying the line risks impacts to the habitat of endangered Atlantic sturgeon in the Hudson River (Center for Biological Diversity, 2020).

Oppositions to hydroelectric power has increased in recent years, ever since Northern Pass and NECEC. The nonprofit Riverkeepers have opposed the project after initially supporting it, arguing Canadian hydroelectric dams and reservoirs have a history of destroying rivers, damaging indigenous communities, and causing more carbon emission than initially believed (Gallucci, 2022). The Innu Nation of Labrador is also opposed to the project and its hydroelectric power source, citing eradication of Atlantic salmon spawning runs, loss of boreal forests and wetlands, and increased emission of CO₂ and methane from decaying organic matter (Center for Biological Diversity, 2020). The reservoirs created from damming rivers floods otherwise forested areas upstream and decomposes the organic trees and plants over time that create carbon emissions. An MIT study found hydroelectric dams can emit more than 1,000 grams of CO₂ per kilowatt-hour of electricity generated, similar to that of a coal-burning power plant (Wade, 2022). Hydro-Quebec countered this study that their emissions are approximately 34 grams of CO₂ per kilowatt-hour because the high levels of emissions cited in the study were from dams in warmer climates (Wade, 2022). GHG emission impacts from dam reservoirs also occurred decades ago when the dams were created (Wade, 2022). Hydro-Quebec also claims to

have signed over 50 agreements with indigenous communities to avoid, mitigate, and compensate tribes for its hydroelectric dam impacts¹⁶ (Willson, 2023).

¹⁶ The Mohawk Council of Kahnawá:ke is a co-owner with Hydro Quebec on the Hertel-New York interconnection line in Canada, connecting to the CHPE project at the international border (Willson, 2023).

Results

Table 4 – Qualitative comparison of case study variables.

	Northern Pass	NECEC	GNTL	CHPE
Owner/Developer (type)	Northern Pass Transmission, LLC (IOU)	Central Maine Power (IOU)	Minnesota Power (IOU)	Transmission Developers Inc. (Private)
Electricity Type (DC/AC)	1,200 MW DC 345 kV AC	1,200 MW DC 345 kV AC	500 kV AC	1,250 MW DC
Length (miles)	192	145	225	339
Siting Technique (OH / UG)	66% Overhead / 33% Underground	100% Overhead	100% Overhead	100% Underground
Structure Height (feet)	80-135	95 average	110-115	0
Alignment (new / existing ROW)	20% new ROW / 80% existing ROW	37% new ROW / 63% existing ROW	100% new ROW	60% waterways / 40% existing ROW
Impacted Communities	31	37	17	35
Stakeholder Engagement / Public Outreach	0 years (post-permit filings)	2 years (during permit filings)	18 months (pre-permit filings)	5 years (pre-/during permit filings)
Estimated Cost	\$1.1-1.4 billion	\$950 million	\$560 million	\$4.5-6 billion
Timeline (start-end)	2010-2018	2017-present	2012-2020	2010-present
Status (energization)	Defeated (was anticipated 2020)	In construction (was anticipated 2022)	Complete (2020)	In construction (anticipated 2026)

Several variables were most important in determining success and failure of each case study project (Table 4). First, owner/developer appeared to contribute at least partially to project success, as a private transmission developer like TDI had more monetary resources than a typical IOU to engage stakeholders and manage public opinion of the transmission project over a greater timeline, leading to successful permitting of CHPE (Table 5). Electricity type varied for each project in DC capacity and AC voltage but neither appeared to directly influence project success, as project opposition didn't preference electricity type. Project length didn't appear to impact opposition, where CHPE was successfully permitted despite being the longest case study observed, while NECEC was the shortest case study and experienced litigation and

setbacks before ultimately prevailing. Siting technique was identified as a determining variable, as both Northern Pass and NECEC experienced staunch opposition from visual impacts of overhead lines and structure height. CHPE was successful in part to being fully buried underground and didn't receive the level of opposition as other case studies, despite fears that dredging in waterways could impact water quality and drinking water. Alignments in new and existing ROWs varied widely between case studies and is difficult to attribute particular alignments to project success. Northern Pass and NECEC were both sited in new and existing ROWs, while GNTL was entirely within new ROW. The number of impacted communities from a project route played a major factor in project success, where GNTL was sited in the fewest and most rural communities away from urban areas, while Northern Pass, NECEC, and CHPE were routed through more than 30 communities each. The most important variable identified from the case studies was timing and duration of stakeholder engagement/public outreach. The lack of early outreach for Northern Pass appeared to doom the project, where altering alignment into existing ROWs had little to no effect on opposition. NECEC conducted more outreach than Northern Pass over 2 years and was eventually able to continue with construction, where collaboration with the Maine Bureau of Parks and Land may have allowed the project to follow an expedited project timeline and skirt early public opposition. GNTL conducted a meaningful 18-month pre-permitting outreach with impacted stakeholders and community member to determine its project route, which evidently mitigated for the impact of overhead structures in new ROW (Table 5). CHPE conducted persistent outreach throughout a 5-year process as the project route was amended several times, leading to a project that communities supported

(Table 5). Lastly, estimated cost, timeline, and status are all factors controlled by previously discussed variables and don't appear to influence project success.

Table 5 – Key takeaways from interviews.

Interviewee	Expertise	Key Takeaways
Dan Belin	Presidential permit for Northern Pass and GNTL	States preempt local towns and counties. Early public outreach and agency coordination can expedite the permitting process.
David Moeller	Legal proceedings for GNTL	Engaging with stakeholders allowed for discovery of constraints and opportunities for the project route. Conduct outreach with a message and purpose.
Jennifer White	Stakeholder engagement and public outreach for CHPE	Community outreach is essential to limit project opposition.
Donald Jessome	Project development for CHPE	Amendments to the project route were made throughout its development. Relationships between stakeholders and project developers matter.
Christopher Lawrence	Permitting with DOE	Projects can never have zero risk, but having stable financing, permits in-hand, and early coordination with agencies minimizes risk.

Discussion

Best Practices and Lessons Learned

Perhaps the most important takeaway from the case study analysis is that stakeholder engagement and public outreach is essential in developing HVTL projects. A clear distinction between Northern Pass and GNTL was the point at which public outreach occurred. As with Northern Pass and NECEC, utilities or developers are often unwilling to engage with the public, which is essential for building trust and avoiding entrenched positions from stakeholders (Keir and Ali, 2014). The “decide, announce, defend” strategy typically deployed by transmission developers undermines the intent of NEPA and other regulatory schemes for public outreach, as it uses public participation as an end to the process instead of the means for decision-making (Hendry, 2004). Engaging with stakeholders “downstream” of key project decisions is deeply problematic and raises EJ concerns when projects are sited in disadvantaged communities without their meaningful input (Keir et al., 2014). To prevent litigation from landowners or community members, the planning process should be designed to encourage consensus building during early development of HVTLs with key stakeholders, focusing on project specific concerns instead of larger regional needs (Keir and Ali, 2014). Agencies must establish trust with stakeholders and cede some of its power to allow for joint decision-making (Hendry, 2004). With GNTL, stakeholder engagement and public outreach was baked into the project timeline, working backwards from the stipulated in-service date, planning sufficient time for the 18-month outreach period prior to permit filings. Outreach was conducted with a purpose, showing the public the need for the project and the benefits from job creation, increased property taxes for local governments, and overall economic development. GNTL also framed

the project in a productive manner by presenting options and listening to various constraints and opportunities along the two alternative color-coded routes to site the HVTL. Once GNTL went to permitting, the project stood up to scrutiny and exhibited public support because of the relationships and trust Minnesota Power built with impacted communities through early outreach. This kind of intentionality with the transmission planning and development process matters immensely. Research has found that it's not only the physical aspects of energy infrastructure that explain public opposition, but the process of how stakeholders engage in decision-making (Keir et al., 2014). The public often ranks procedural justice as a higher priority than distributive justice because fair processes yield outcomes that are understood (Keir et al., 2014). Procedural justice emphasizes process attributes during and within decision-making, raising EJ considerations when those impacted aren't heard or allowed to participate (Keir et al., 2014). Distributive justice speaks to the proportionality of proposed project benefits to their costs (Keir et al., 2014). Its focus is on equitable outcomes from decision-making can prompt NIMBY self-interest responses (Keir et al., 2014). Furthermore, developers should utilize information gathered from stakeholders and communities to meaningfully address project concerns to mitigate or avoid project impacts altogether (Eto, 2016). If developers can build in upfront outreach and application of public feedback into their project schedules, the process can be incorporated into transmission development timelines and ultimately reduce risks of opposition and lengthy, costly lawsuits against projects.

Siting technique and project location were other important aspects of the case studies. Northern Pass and NECEC both experienced opposition for creating new ROWs to locate their overhead HVTLs, causing fragmentation of forest habitats, impacts to pristine wilderness, and

potential ramifications to the tourism industry in their respective states. CHPE was conversely sited entirely underground, within waterways and existing railroad and roadway ROW. The co-founder of TDI designed the project because of two central problems with building large transmission lines: Nobody wanted to see or pay for them (Willson, 2023). CHPE was still not without opposition, but its design and financing effectively eliminated those concerns, and the project was able to mitigate its impacts. Even with altering the project route and siting a portion underground, Northern Pass was unable to overcome the initial opposition that it created from insufficient public outreach. Northern Pass also suffered from land acquisitions from SPNHF to intentionally block the linear project route. NECEC, GNTL, and CHPE all coordinated easements with their respective landowners, whether it was federal, state, or private property. While some HVTL projects can be constrained by location of existing ROWs, smart siting techniques, such as undergrounding should be implemented when feasible.

The final takeaway from analyzing the case studies was that hydroelectric power still experiences opposition despite being a RES. While hydroelectric didn't appear to be a primary concern for Northern Pass or GNTL, more recent projects of NECEC and CHPE have been opposed by environmental groups in the U.S. and First Nations in Canada. Canadian hydroelectric power has a long and devastating history of damming rivers and flooding unceded indigenous land to fill reservoirs, even though these impacts occurred decades ago and GHG emissions from these facilities are debated (Gallucci, 2022). What's appealing about hydroelectric is that it's a reliable and dispatchable baseload of RES for Massachusetts, New York City, or other states or cities to consume 24 hours a day (Wade, 2022). Hydroelectric turbines can consistently turn and supply electricity (unless under severe drought), while wind

and solar are intermittent RES (Wade, 2022). However, the more that HVTL projects can utilize clean energy sources like wind and solar over hydroelectric power the more accepting the project will likely be with the public.

Overall, best practices for HVTL development includes: (1) Begin stakeholder engagement and public outreach as soon as possible before any permit is filed for the project. Outreach should be done “early and often”, where public input should be used to alter the project route or mitigate its impacts; (2) When possible, given the project location and budget, site the HVTL in rural areas, underground, and/or within existing ROWs to avoid potential impacts to nearby residents, landscapes or scenic vistas, and habitats or natural resource areas; and (3) Prioritize electricity transmission from clean RES like wind and solar.

Policy and Planning Recommendations

Considering the typical ten plus year timeline to develop a transmission project and the public opposition that projects like Northern Pass and NECEC received, there are numerous policy and planning recommendations that could support HVTL development. As noted in earlier sections, early action in stakeholder engagement and public outreach is essential to developing a durable transmission project. However, regulatory requirements for public outreach vary based on a project’s federal permitting strategy and required state permits. Each case study began outreach at a different point of the NEPA process. Often transmission developers and utilities engage with stakeholders and the public only as much as statutorily required by permits and agencies (Hendry, 2004). If meaningful public outreach can occur before significantly developing a HVTL project route, it’s more likely projects will be constructed

without opposition. GNTL showed that effective stakeholder engagement and public outreach can be conducted in an 18-month period, and transmission projects can be built under the typical timeline for HVTL projects. But even the lengthy timeline to build transmission is a concern if the U.S. is to meet its GHG emission goals. Recent legislation proposed by Congress aimed to reduce NEPA review of large infrastructure projects to an average of two years, halving the current review time (Christian, 2023). Many developers and business groups believe NEPA has evolved to allow the public to oppose large infrastructure projects to an unreasonable extent (Gearino and Tigue, 2023). Others believe staffing shortages at federal agencies hold up permit applications and review periods, and any rollback of NEPA will impact the public's ability to raise environmental concerns about a project, particularly in EJ communities (Gearino and Tigue, 2023). While there's disagreement with the extent of permitting reform, reform must strike a balance between timely review and necessary public involvement. With developing large HVTL projects that often take longer than presidential administrations, it's essential to have consistency and durability in NEPA process and permitting as a whole (Gearino and Tigue, 2023).

Energy and environmental issues are among the riskiest and most contentious decisions in modern society (Kinsella, 2004). Without public participation and outreach, the decisions made by a project developer could fail to address the interests of those most affected by its construction (Kinsella, 2004). Part of a successful stakeholder engagement and public outreach campaign is educating the public on the science of a proposed project so they can substantively participate in the decision-making process (Kinsella, 2004). Technical experts play an essential role, acting as equal partners with the public to educate and bridge the participation gap that is

often muddied with specialized concepts, jargon, acronyms, and complicated legal or regulatory details (Kinsella, 2004). A shared dialogue between a developer and stakeholders allows for discovery of shared individual and community values, and evidentially a more durable and favored project (Kinsella, 2004). Initiatives to educate the public and encouraging public participation on large scale energy projects are in progress. Recently, DOE initiated the Building a Better Grid Initiative to prioritize stakeholder collaboration, permitting efficiencies, and transmission line planning to promote more transmission build-out (Department of Energy, 2022). In 2021, FERC created the Office of Public Participation to facilitate greater participation, transparency, and responsiveness with consumers, landowners, and community groups on technical and complex FERC proceedings (Healey et al., 2021). Even though FERC is not directly involved with transmission siting and permitting, this initiative to familiarize more stakeholders with transmission planning and wholesale rates of electricity is increasing public competency in the electricity sector that's necessary to participate in decision-making of HVTL projects. Perhaps even more important, education on the local level, whether discussed by PUCs or in local town meetings is essential to encourage residents to consider where the energy and electricity they consume comes from, and how it's sited within their municipality. Education forces the public to evaluate NIMBY concerns regarding the costs and siting of necessary electricity infrastructure.

Northern Pass and NECEC were both in response to the Massachusetts Clean Energy RFP, where both projects grappled with bearing siting and environmental burdens in their host states for a project that would primarily benefit Massachusetts and its electricity customers. These projects show the need for a regional strategy and coordination across states,

particularly for New England states to each meet their decarbonization goals (Iaconangelo, 2021). Nationally, in April 2022 FERC released a notice of proposed rulemaking (NOPR) for RTOs and ISOs to undertake long-term, forward-thinking planning to meet transmission needs from changes to resource mix and demand (St. John, 2022b). Federal, state, and local decarbonization targets, economic factors causing a shift from fossil fuel sources to RES, demand from electric vehicles, and high-impact low-frequency events like extreme weather would all have to be considered in the 20-year long-term planning process (St. John, 2022b). Enormous amounts of RES projects are waiting to be developed in the coming years that will need transmission to be brought online (Figure 14). While the rulemaking doesn't directly address backlogs in the interconnection queue or costs for grid upgrades, it's laying the groundwork for a more reliable and resilient grid (St. John, 2022b). Sharing electricity and RES across regions replaces higher cost electricity and reduces risk from weather events causing spikes in electricity demand or limited RES generation (St. John, 2022b). It all starts with forward thinking grid development and long-term transmission planning.

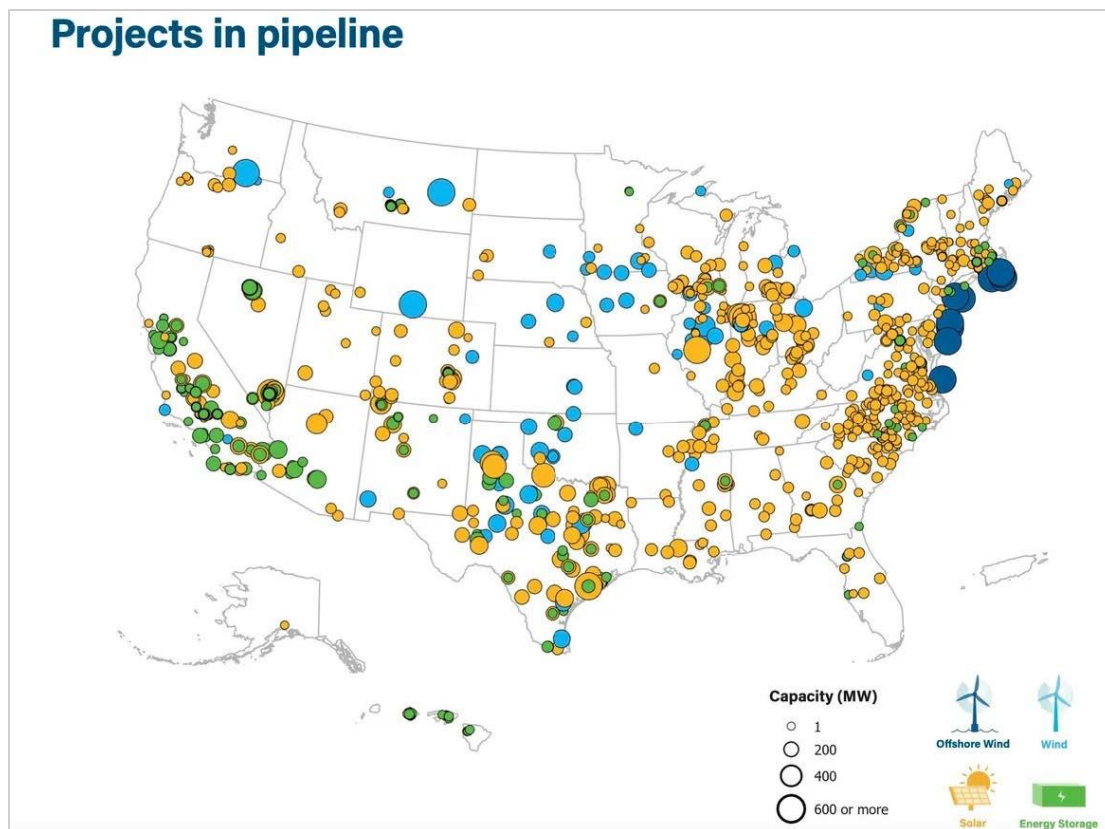


Figure 14 - American Clean Power Association map of RES and battery storage projects in development or construction as of the third quarter of 2022 (St. John, 2022a).

Shoring up funding for HVTL projects is essential for the build-out of transmission. As displayed in CHPE, having access to private capital offers a project financial stability, provided that the project has a consumer for the RES electricity and the financier is patient as the project meanders through stakeholder engagement, public outreach, siting, and permitting. It's not possible for all new transmission to be proposed by private developers, where utilities must justify cost allocation to its consumers and many uncertainties regarding interconnection can balloon overall project costs (St. John, 2021). Transmission is beginning to receive attention and funding on the federal level. In 2022, DOE created the Grid Deployment Office to invest more than \$20 billion from the Inflation Reduction Act to modernize and expand the capacity of the

grid (Department of Energy, 2022). DOE prioritizing transmission and providing grants for projects is a good start, and more opportunities are needed to finance transmission considering the total costs of HVTL projects and interconnection. Discussions are occurring to have the federal government act as “anchor tenants,” bearing the upfront costs of constructing transmission and selling contracted transmission capacity to RES developers seeking to use the power line (Goggin et al., 2021). This strategy would reduce risk and provide certainty for HVTL projects.

Lastly, the way transmission developers and utilities interact with existing stakeholders regarding project siting can play a massive role in increasing transmission. As with long, linear transmission ROWs, highways, railroads, and pipeline ROWs offer an opportunity to co-locate¹⁷ HVTLs. As seen in the case studies, CHPE deployed co-location within railroad and roadway ROWs through collaboration with the private and municipal owners. Several states have utilized highways to site fiber optic cables for improved broadband and telecommunication access, but only Wisconsin, Maine,¹⁸ and New Hampshire¹⁹ have adopted laws to co-locate electrical transmission within interstate highways (Putnam and Rogers, 2022). In April 2021, the Federal Highway Administration removed barriers for these types of projects, encouraging state Departments of Transportation to accommodate co-location for public needs relating to climate change, equitable communications access, and energy reliability (Putnam and Rogers, 2022).

¹⁷ Co-location is strategically siting HVTLs along existing public or private ROWs, including federal or state highways or roadways, railroads, or natural gas or oil pipelines (Putnam and Rogers, 2022).

¹⁸ In 2010, a Maine law designated energy corridors for transmission development along certain highway and pipeline ROWs (Putnam and Rogers, 2022).

¹⁹ In 2016, a New Hampshire law designated portions of Interstate-89, -93, -95, and NH Route 101 as energy infrastructure corridors (Putnam and Rogers, 2022).

Buried HVDC transmission technology has also matured and costs for underground HVDC and converter stations have become cost-competitive with overhead AC transmission (Putnam and Rogers, 2022). While there are challenges with co-location along urban corridors, including existing stormwater systems, wetlands, bridges, and interchange crossings, and potential safety or security concerns, longitudinal utility installation along highways is an untapped opportunity to limit impacts from siting HVTLs and to construct much needed transmission (Putnam and Rogers, 2022).

Limitations and Future Research

Multiple opportunities exist to expand my research conducted on best planning practices for transmission development. First, an even greater selection of case studies would offer more examples of useful planning practices and siting techniques to employ on HVTL projects. Stakeholder engagement and public outreach practices could be examined from other linear infrastructure project as well, including natural gas or oil pipelines, roadways or highways, or even large urban redevelopment projects. Human psychology around HVTLs is a fascinating topic that can be explored more, helping determine what aspects of public participation, voltage, length, siting technique, alignment, or project impacts yield the most opposition. Negotiated ROW easement agreements with landowners or community benefit agreements with impacted municipalities could also be researched, looking for patterns of consistency and identifying what a standard community benefits agreement may look like for a HVTL project of varying scale and impact. After all, social acceptance of large energy projects is most simply accomplished by compensating stakeholders by monetary means or positive

outcomes from the project, or by mitigating negative aspects of the project (Cohen et al., 2014).

Critical future research into permitting reform will prove important for transmission development, identified as a key to unlocking the urgent transmission needs for the U.S. electricity grid. Some states like Massachusetts are exploring ways to expeditiously permitting of electric decarbonization infrastructure projects while prioritizing EJ and frontline communities (House No. 3215, 2023). Federally, DOE released a draft national transmission need study in February 2023 identifying the pressing need for transmission infrastructure, increasing interregional transmission, and shifting demand over time (Grid Deployment Office, 2023). In December 2022, FERC issued a NOPR to section 216 of the Energy Policy Act of 2005 to provide the agency jurisdiction in siting interstate transmission projects in national interest electrical transmission corridors (NIETC), known as backstop transmission siting authority (McCarthy et al., 2022). The rulemaking change reverses limitations to FERC authority from Piedmont Environmental Council v FERC 558 F.3d 304 (2009) that denied FERC backstop siting authority when states affirmatively deny a project's application (McCarthy et al., 2022). This initiative offers an expedited pathway to develop HVTL projects in areas that experience transmission congestion or capacity constraints (McCarthy et al., 2022). While backstop siting authority has the feel of eminent domain and the federal government overreach to site transmission, the proposed rulemaking has some guardrails. The NOPR includes similar rules and application requirements that FERC applies to interstate natural gas projects, including evidence of stakeholder engagement, an EJ public engagement plan, notice to affected landowners, and resource reports consistent with NEPA regulations (McCarthy et al., 2022). The

power to designate NIETCs also lies with DOE, who intends to identify them through a route specific, applicant-driven basis from developers rather than planners (Howland, 2022). FERC noted that backstop siting authority isn't the solution to building cost effective transmission and emphasized the importance of working with states towards outcomes that stakeholders and customers support (Howland, 2022). If we are to expand transmission by 60 percent by 2030 and triple by 2050 to meet GHG emission goals, local, state, and federal actors will need to collaborate to find effective ways to permit HVTL projects, while prioritizing the people and communities they're located in (Howland, 2022).

Conclusion

Increasing transmission line development in the U.S. is essential if the nation is to meet its aggressive GHG emission reduction goals. However, significant barriers to developing HVTL projects in all regions of the U.S. exist. Case studies Northern Pass and NECEC showed that if stakeholder engagement and public outreach is not conducted early in project development, before permit filings, public opposition to projects can be substantial from lack of procedural justice. GNTL showed that early outreach to impacted stakeholders can substantially limit public opposition toward the project further along its development timeline. CHPE showed how smart siting techniques and financial resources from investors can mitigate most public opposition towards the project.

Moving forward, permitting reform, education on HVTLs and overall electrical infrastructure siting, smart siting practices, long-term transmission planning, and shoring up funding sources will all contribute to U.S. transmission build-out over the next thirty years. NIETC and FERCs backstop siting authority could also play a notable role. Developing more transmission remains a massive challenge in the U.S., yet it's an opportunity to build a reliable and resilient electrical grid that future generations will depend on. Will we fail to construct enough transmission to bring RES online to meet GHG emission goals? Will we succeed with transmission build-out but fail to address community concerns with projects? Will projects be sited through early outreach and planning with fair easement agreements with landowners, or through eminent domain, backstop siting authority, and insufficient stakeholder engagement with minimal public acceptance, repeating how the federal government sited highways in the mid-1900's? Or can the U.S. construct needed transmission while prioritizing stakeholder

engagement and public outreach, smart siting practices to limit project impacts, and address community concerns with meaningful project changes in a timely manner? This is the challenge ahead for transmission, and if done intentionally and thoughtfully it can build an electrical grid that citizens need and support.

Appendix A: Interviews and Questions

Table 6 – Interviews

Name	Company	Title	Date	Method	Area of Expertise
Dan Belin	VHB	Energy Market Lead	3/7/23	In-Person	Presidential permit for Northern Pass and GNTL
David Moeller	ALLETE	Senior Regulatory Council	3/13/23	Webex	Legal proceedings for GNTL
Jennifer White	TDI	VP/External Affairs	3/27/23	Phone	Stakeholder engagement and public outreach for CHPE
Donald Jessome	TDI	Founder	3/28/23	Phone	Project development for CHPE
Christopher Lawrence	Western Area Power Administration	Acting Chief of Staff to the Administrator and Legislative Liaison	3/30/23	Microsoft Teams	Permitting with DOE

Questions that were asked during interviews:

1. Tell me about your role in the project. Who else was involved as the project team?
2. Specifically, how was stakeholder engagement conducted? What forum yielded the most questions or comments for the proposed project?
3. At what point did questions and comments from stakeholders or the public yield a project change?
4. When did stakeholder engagement and public outreach occur along the project timeline? How long did the process take?
5. What challenges did the project encounter? How did the project team deal with opposition? What strategies were used to handle opposition?
6. What innovative stakeholder engagement or public outreach approaches were deployed for the project or its planning?

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