U.S. DEPARTMENT OF ENERGY

Transmission Impact Assessment

Power Sector Infrastructure Deployment to Reduce Costs, Improve Reliability, and Lower Pollution

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Executive Summary

A robust transmission system is critical to economic, energy, and national security objectives. It helps lower the cost of power to end-use customers and improves the reliability of supply including during extreme weather events. A more efficient transmission system also results in greater use of lower emitting resources and lower overall greenhouse gas emissions. Yet, despite the wide-ranging benefits of building out the grid, the Nation has—over the last decade—failed to do so at the pace or scale of demonstrable current and future need.[1]

Additional actions to support the efficient buildout of transmission to meet grid needs could address key challenges relating to efficient regional and interregional transmission infrastructure planning, permitting, and cost allocation. This paper includes an analysis of the potential impacts of generic actions to facilitate the buildout of transmission infrastructure through addressing these key challenges at the national level.

The scenarios modeled include policies existing as of January 2024 in addition to varying transmission assumptions that reflect relaxation of constraints on deployment. Beyond variations in transmission assumptions, this analysis does not include any emissions or clean energy deployment policies implemented after January 2024.

The analysis concludes that generic actions taken to facilitate new transmission infrastructure can reduce system costs while improving reliability and decreasing emissions. Under an enhanced transmission scenario that addresses a subset of key bottlenecks to both regional and interregional transmission buildout[2], this report finds:

- By enabling access to low-cost generation and sharing reliability resources over broader regions, electricity consumers could save $320 billion in present-value costs through 2050 relative to a future with restricted transmission growth.
- America's long-distance transmission network could grow by 18% above its current size by 2035, 25% by 2040, and 37% by 2050, as opposed to 1% in 2035, 3% in 2040, and 4% in 2050 in the restricted scenario.
- Added transmission would be beneficial during periods of grid-system stress when the reliability of electricity supply
  is at risk.
- If cost savings from enhanced transmission lines are reinvested in reliability improvements, 5.5 million fewer households are estimated to lose power for an hour each year.
- Peaking power plant capacity could be reduced by 68 GW by 2041 relative to a restricted transmission future, reducing pollution that disproportionately impacts disadvantaged communities across the country.
- Clean electricity will grow more rapidly, reducing cumulative power sector carbon dioxide equivalent (CO_2e) emissions by 3,420 million metric tons through 2050. Cumulative emissions are 18% lower in an enhanced transmission scenario than they are in a restricted transmission scenario.
- Climate and human health benefits through 2050, when monetized, sum to $730 billion and $50 billion in present-value terms, respectively, relative to a restricted transmission future.

Policies that primarily address permitting and coordination challenges to regional transmission—without a strong focus on interregional lines—also have economic and societal benefits, though those benefits are smaller than those estimated above when constraints to interregional transmission are relieved. In contrast, when policies that support both regional and interregional transmission are paired with a tax credit for new longer-distance transmission, estimated impacts and benefits further increase.

The Multiple Benefits of New Transmission

The transmission network is the backbone of the power sector and central to the country's economic prosperity, national security, and clean energy goals. This is especially true in the face of the robust load growth and more-frequent extreme weather that the U.S. power system has already begun to experience and that are expected to accelerate—both of which strain power networks.

The U.S. Department of Energy (DOE) has recently synthesized the vast literature on power system needs, concluding that the benefits of transmission often exceed the costs by enabling access to low-cost and diverse generation resources over broader geographies, thereby helping to maintain system reliability and avoiding power outages.[1] Electric transmission infrastructure serves an especially critical role during extreme weather and supply disruptions, allowing regions to share resources at times of acute need, as illustrated in recent years during winter storms Uri and Elliot. Moreover, with load growth now accelerating after a decade of stasis, enhanced grid infrastructure will be central to maintaining a low-cost and reliable power system. As stated by the North American Electric Reliability Corporation (NERC), "A strong, flexible transmission system that is capable of coping with a wide variety of system conditions is key for the reliable supply and delivery of electricity."[3] Finally, accelerated deployment of clean energy—including wind and solar—is contingent on transmission expansion.[4]

Empirical data support these conclusions. Recent research by Lawrence Berkeley National Laboratory shows significant congestion-relief value from new transmission, especially for links that cross physical and market seams.[5] Transmission value is highly concentrated in the top 5% of highly congested hours, demonstrating the benefit of transmission during times of system stress. Importantly, the analysis concludes that new interregional links tend to be more balanced in the expected direction of power flow, illustrating the value of transmission to both sides of a connection. Congestion relief is only one of many benefits from new transmission, and the study finds that benefit alone far exceeds the expected cost of many newly built and proposed transmission lines, especially those that cross regional boundaries.

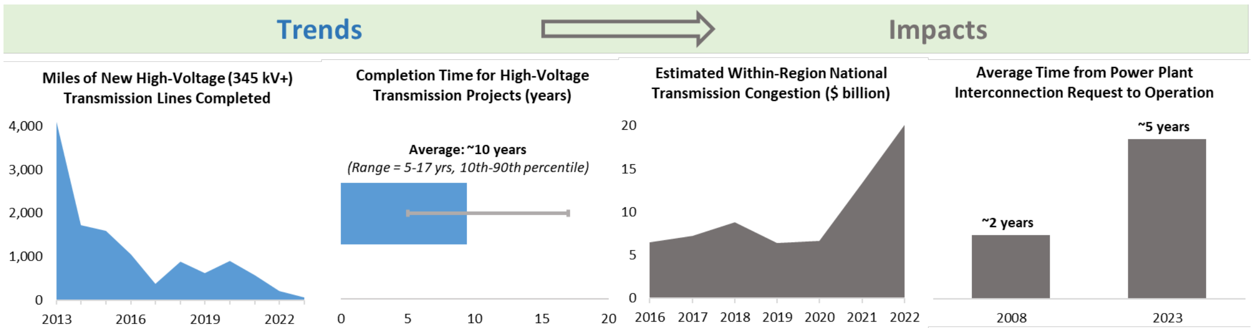
Ultimately, in its synthesis of the literature, DOE concludes that within-region transmission deployment must increase by over 60% by 2035 to meet the most-likely future transmission needs, while interregional transmission must roughly double.[6] DOE further finds that while transmission need varies regionally, each region of the country can benefit from an expanded transmission network.[1]

Gridlocked: Historical Trends in Transmission Lead to an Inefficient Power System

Despite the wide-ranging benefits of building out the grid, over the last decade, the country has failed to do so efficiently,[1] indicating that deficiencies in planning, siting, and cost allocation processes have hampered the buildout of otherwise valuable infrastructure.

Though considerable financial resources have been dedicated to grid investments, the number of miles of newly built high-voltage transmission has declined precipitously over the last decade, from an average of 2,500 miles each year from 2013–2015 to just 56 miles in 2023 (Figure 1).[7] This is the lowest annual amount built over the last decade. DOE's 2023 National Transmission Needs Study demonstrates that this decline is a nationwide phenomenon and is even more acute for large-scale interregional lines.[1] The dramatic decline in high-voltage transmission development is, in part, the result of a piecemeal transmission planning and deployment process that has tended to focus on incremental reliability needs.[1]

Figure 1. Evidence of transmission gridlock and its impacts



Sources: see references 1, 6, 7, 9.

Relatedly, the time required to develop, permit, and build transmission is excessively long. A review of over 30 transmission projects initiated since 2005 found that new transmission takes, on average, around 10 years to complete, with some projects requiring 15 years or more to complete.[8] One particularly notable example is the SunZia Transmission project now under construction in New Mexico and Arizona: with a planned in-service year of 2026, it will have taken nearly 20 years to complete.

In part because of these trends, the transmission network is increasingly congested, unable to serve load with the least-cost set of resources, including at times of acute need such as when extreme weather strains the reliability of the power grid. A recent report estimated that within-region congestion costs equaled more than $13 billion in 2021 and $20 billion in 2022, up from around $7 billion in previous years.[9] A report from Lawrence Berkeley National Laboratory similarly finds that transmission congestion is substantial, and even more so across regional boundaries.[10]

As further indication of the gridlock, 2,600 gigawatts (GW) of new generation and storage capacity is waiting in interconnection queues seeking transmission access.[11] Wait times have increased dramatically with the average duration from interconnection request to commercial operation reaching nearly 5 years in 2023, up from less than 2 years in 2008. Interconnection costs have also increased, again suggestive of an inadequate transmission grid.[12]

Unblocking Grid Infrastructure through Federal Policy and Programs

There is an urgent need to refresh the Nation's approach to regional and interregional transmission infrastructure, by tackling challenges related to permitting, planning, and cost allocation that have—so far—resulted in a fragmented grid that is not delivering full value.

Important new programs and policies have already been initiated to address this problem, though they are not explicitly modeled in this analysis. The *Bipartisan Infrastructure Law* and *Inflation Reduction Act* both contain financial assistance programs and authorities to help kick-start new transmission. DOE's Transmission Facilitation Program[13] was provided $2.5 billion to support new transmission through loans, capacity contracts, and public-private partnerships; DOE's Transmission Facility Financing Program[14] was provided $2 billion to support new transmission through loans; and DOE's Grid Resilience and Innovation Partnerships (GRIP) program was provided $10.5 billion to support projects that use new technology and approaches to develop transmission, storage, and distribution infrastructure.[15] In 2024, DOE issued a final rule to establish the Coordinated Interagency Transmission Authorizations and Permits program to accelerate Federal environmental review and permitting processes for qualifying transmission facilities.[16] DOE also issued a final rule to create a faster process for completing environmental reviews of upgrades to existing transmission lines.[17] In addition, DOE released a preliminary list of 10 potential National Interest Electric Transmission Corridors (NIETC) to accelerate the development of transmission projects in areas that present an urgent need for expanded transmission.[18]

Even with these significant measures over recent years and months, there are additional actions which could support the new infrastructure needed to maintain the country's economic prosperity, support national security, meet new electricity demands, and facilitate clean energy deployment. There are a handful of common approaches, themes, and actions which could facilitate more efficient transmission deployment:

- **Improved planning and cost allocation,** to ensure comprehensive analysis of transmission benefits during planning and in recognition that costs should be paid by those who benefit.
- **Increased efficiency in permitting,** while ensuring robust environmental reviews and strong community engagement.
- **Support for grid enhancing technologies,** by ensuring planners consider technologies that can unlock capacity on the existing transmission system.
- **Increased interregional transmission,** including minimum thresholds, to ensure that large regions have adequate connections to their neighbors, especially at times of extreme system stress.
- **Investment tax credit for larger-scale transmission lines,** to help address concerns about the upfront cost of transmission buildout and related challenges with cost allocation.

Modeling the Potential Benefits of Additional Action to Facilitate Transmission

To assess the possible impacts of recent executive actions in combination with additional policy action, DOE used an advanced planning model that identifies low-cost power sector investment portfolios—the Regional Energy Deployment System (ReEDS) model, developed at the National Renewable Energy Laboratory (NREL).[19] ReEDS has a high degree of spatial and temporal resolution, making it suitable for the scoping-level analysis summarized below. ReEDS captures possible transmission needs between 134 distinct geographic zones, between 11 major planning regions, and across the Nation's three synchronous interconnections. It also includes local spur lines needed to connect individual generators to the transmission grid, interconnection, and transmission reinforcement needs within each of the 134 zones.

Four scenarios were modeled, summarized below and in Table 1. The 'restricted transmission' case reflects a situation in which major bottlenecks remain. The three 'enhanced transmission' cases progressively loosen those restrictions under an assumption that Federal transmission policy actions are implemented. The analysis does not explicitly model any specific policy action but instead reflects the possible aggregate impact of three different levels of ambition of Federal actions to facilitate new transmission infrastructure.[20,21,22]

Restricted Transmission: In this case, line-level transmission costs are generally assumed to be 30% higher than in the enhanced cases. This is justified based on lengthier completion times due to permitting, planning, and cost allocation challenges; piecemeal and inefficient transmission expansion due to fragmentation; longer transmission distances (relative to straight line) due to siting and permitting processes that result in less than optimal routing; and limited use of grid-enhancing technologies.[23] The restricted case further assumes that no significant new transmission is able to be built between the 11 planning regions or between the three large synchronous interconnections. It otherwise allows regional transmission between the 134 ReEDS zones, but not starting until 2035. It limits sharing of resource adequacy among regions to historical levels based on NERC data.[24]

Enhanced Transmission: Three enhanced transmission scenarios are modeled and summarized in Table 1:

- Enhanced Transmission 1 presumes that policies lead to improved siting, permitting, planning, and cost allocation for regional and local lines, with less emphasis on interregional transmission. The cost adders in the restricted case are removed for local and regional lines. Regional lines are allowed to be completed in 2032, earlier than the restricted case, while interregional lines that do not cross interconnections are allowed in 2038. The limit to resource adequacy sharing is removed in 2038 within the three interconnections.
- Enhanced Transmission 2 case goes further, removing the cost adder for interregional lines. Interregional lines can be built earlier, in 2032, and include lines that cross the three interconnections (inclusive of back-to-back high-voltage direct-current facilities). The limit to resource adequacy sharing is also removed in 2032 and, in this case, is allowed across interconnections. A 30% minimum transfer capacity floor is established in 2035 between the 11 planning regions, excluding ERCOT. Together, these elements are a proxy that reflects, in part, the possible impacts of policies that improve interregional transmission planning processes.
- Enhanced Transmission 3 adds a 30% investment tax credit to new regional and interregional lines, in addition to the elements described in Enhanced Transmission scenarios 1 and 2 above.

While recent transmission development has most closely reflected the assumptions in the Restricted Transmission scenario, it is important to emphasize that the Enhanced Transmission scenarios do not reflect any specific policies. Rather, the range of Enhanced Transmission scenarios 1 through 3 represent the range of possible impacts of more effective implementation of policies and programs along with more ambitious scope of future possible policies to impact transmission permitting, planning, cost allocation, and ultimately transmission deployment.

Table 1. Summary of modeling scenarios reflecting varying transmission assumptions

RESTRICTED TRANSMISSION
• New regional transmission between 134 geographic zones not allowed until 2035 • No new interregional transmission between 11 planning regions or across three interconnections • Firm capacity import into NERC regions limited to historical values; none across interconnections • Line-level investment costs 30% higher for new transmission
ENHANCED TRANSMISSION 1
• New regional transmission between 134 zones within 11 planning regions allowed beginning in 2032 • New interregional lines between 11 planning regions (not across interconnections) allowed in 2038 • Limit to firm capacity import into NERC regions lifted in 2038 within three interconnections • No line-level cost multiplier for local and regional lines (still applies to interregional)
ENHANCED TRANSMISSION 2
• New interregional lines between 11 planning regions and across interconnections allowed in 2032 • Limit to firm capacity import into NERC regions lifted in 2032, including across interconnections • No line-level transmission cost multiplier for interregional lines • 30% minimum transfer capacity between 11 planning regions, starting in 2035 (except ERCOT)
ENHANCED TRANSMISSION 3
• All elements of Enhanced Transmission 2 • 30% investment tax credit for all new regional and interregional transmission

The analysis does not consider every aspect of transmission buildout, and some transmission enhancements and associated benefits that were not directly reflected in the modeled scenarios could further increase the value of realizing enhanced transmission deployment. One such benefit is reduction in interconnection costs and timelines for new generation resources. Interconnection has become a significant and well-recognized barrier to generation deployment.[25] In addition to facilitating greater exchange of energy between regions, as was explicitly modeled, more coordinated and proactive transmission deployment can make points of grid interconnection more readily available. Also not modeled comprehensively in the current analysis were long-distance point-to-point HVDC transmission lines that cross multiple balancing regions or regions. HVDC lines can carry large quantities of power and connect distant regions and interconnections, with reduced losses and smaller physical footprints. DOE's National Transmission Planning Study is evaluating the incremental benefit of HVDC lines (HVDC lines are modeled in this analysis in the Enhanced Transmission 2 and Enhanced Transmission 3 scenarios to the extent they connect interconnections but could be deployed more widely).[26] Finally, note that some of the elements within the Enhanced Transmission scenarios require effective implementation from stakeholders outside of the Federal government. For example, mechanisms to facilitate resource adequacy coordination between regions likely require increased cooperation between ISOs, RTOs, and other balancing authorities, and possibly action from NERC.

Transmission Enhancement: Cost, Reliability, and Emissions Impacts

The analysis shows that a suite of recent and generic future actions could significantly accelerate the construction of new transmission infrastructure, thereby reducing overall power-system costs, improving reliability, and reducing harmful pollutants.

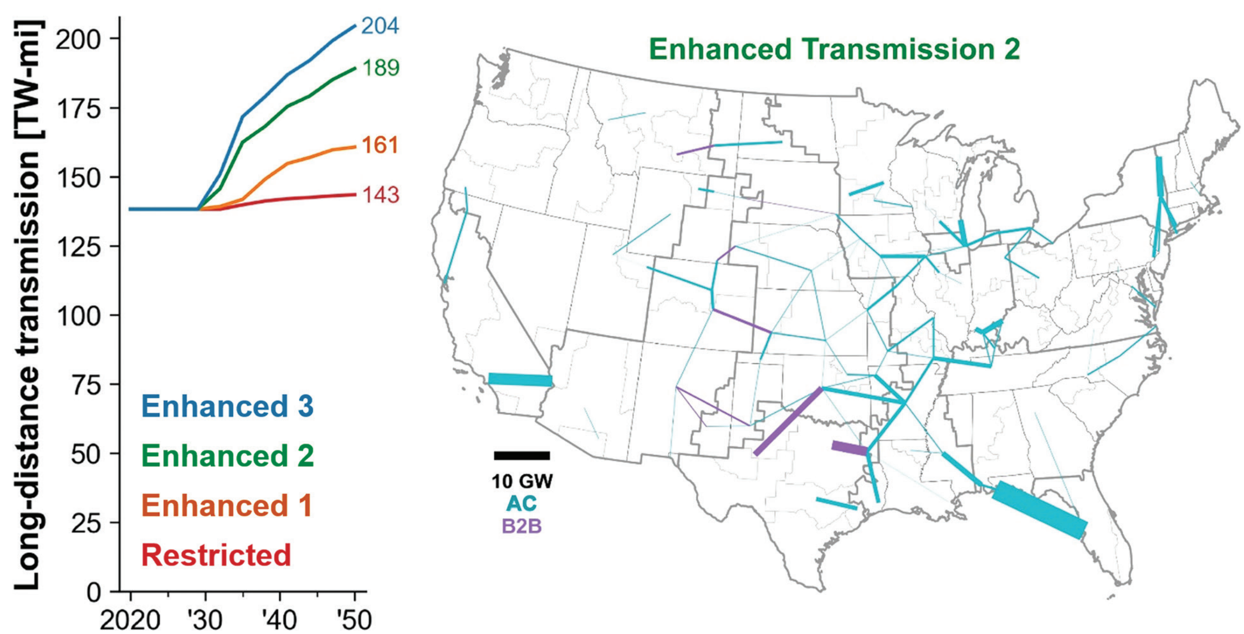
Transmission Expansion

Federal policies can lower power system costs, enhance reliability, and reduce carbon emissions by accelerating new transmission construction. Figure 2 shows modeled transmission expansion to reach these goals under the restricted- and enhanced-transmission scenarios.

Under the restricted case, total long distance (i.e., the sum of regional and interregional, but excluding local spur line, interconnection, and transmission reinforcement) transmission capacity increases very modestly: by 1% in 2035, 3% in 2040, and 4% in 2050, relative to current levels, reaching 143 TW-miles in 2050. The annual average future growth implied by these figures is less than 50% the rate of growth the U.S. has seen over the last ten years for larger (345+ kilovolt) lines.

The enhanced transmission cases see considerably more new build, with growth relative to 2023 equaling 3–24% by 2035, 11–33% in 2040, and 16–48% by 2050, reaching as much as 204 TW-miles in 2050. The annual growth predicted in these cases is as much as three times higher than the average witnessed over the last ten years, though is well below the single highest yearly figure achieved since 2009. Federal actions are shown to have a potentially meaningful impact on new transmission, with the largest impacts occurring when a comprehensive set of policies is established that covers the full suite of barriers that currently constrain development.

Figure 2. Long-distance transmission growth across modeled scenarios (left) and illustrative new transmission under the Enhanced Transmission 2 scenario by 2050 (right)



Notes: New transmission depicted in right graphic is illustrative between-ReEDS zones and does not signal specific routes. B2B refers to back-to-back high-voltage direct-current facilities that cross the three U.S. interconnections.

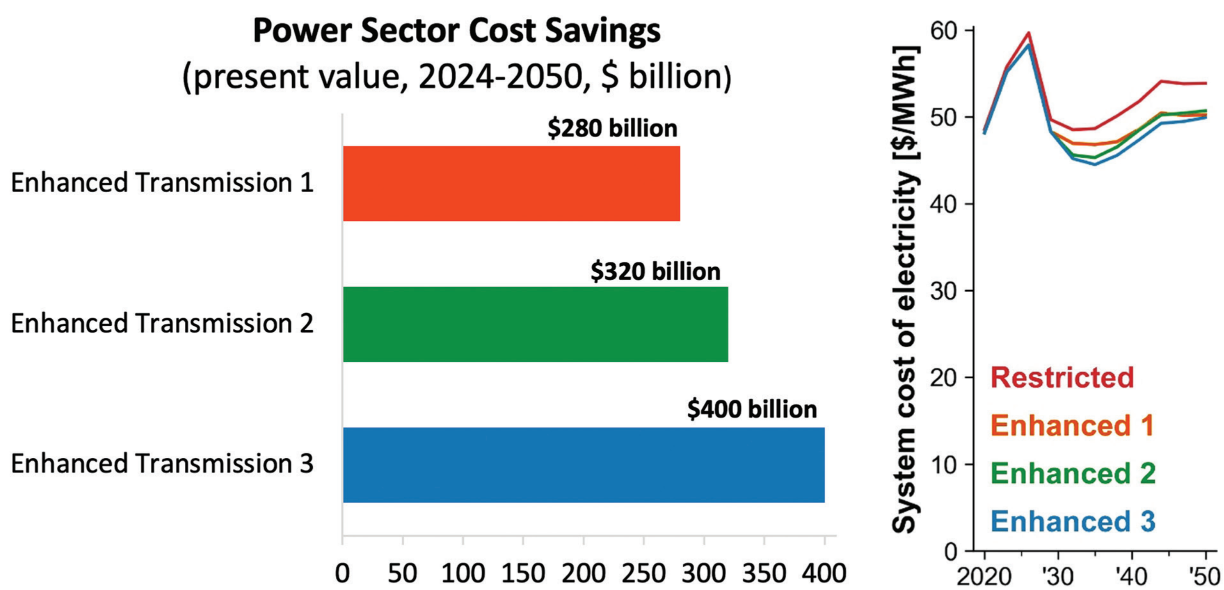
Figure 2 also includes a map of total new transmission built between ReEDS zones in the Enhanced Transmission 2 scenario. While solely illustrative and not intended to signal specific routing, as shown, transmission expansion occurs in all regions, both within all 11 regions and across regional boundaries.[27]

Power Sector Cost Savings

New transmission can lower total power sector costs by enabling access to low-cost generation and by sharing reliability resources over broader geographic regions—the latter being especially valuable at times of grid system stress.

As shown in Figure 3, relative to the restricted case, the enhanced transmission scenarios result in $280 billion to $400 billion lower bulk-power system costs.[28] When denominated in $/MWh terms, the system cost of electricity averages 6% to 8% lower from 2035 to 2050, again relative to the restricted case. Unsurprisingly, cost savings increase under the Enhanced Transmission 2 scenario, which shows cost savings that are about 15% higher than the Enhanced Transmission 1 scenario.

Figure 3. Cost savings with enhanced transmission (left) and system costs across scenarios (right)

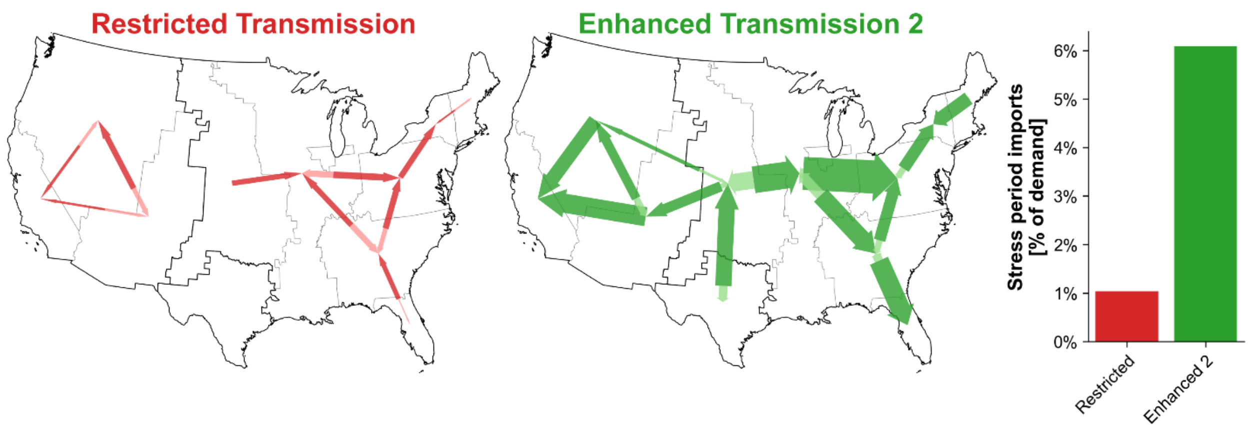


Grid Reliability

New transmission can improve power sector reliability and resilience by enabling resource sharing over broader geographic regions. Figure 4 shows modeled transmission use during periods of grid-system strain, illustrating greater resource sharing under an enhanced transmission scenario.

Increased utilization of regional and interregional transmission during such periods of grid stress can lower system operating costs and decrease the risk of power outages when local resources are unavailable. For example, analysis of potential import and export capability requirements between regions found that greater interregional transmission could have reduced power outages by 58% in the Mid-Atlantic, Southeast, and Carolinas during an event such as winter storm Elliot. [29]

Figure 4. Modeled transmission flow in 2050 across periods of grid system stress



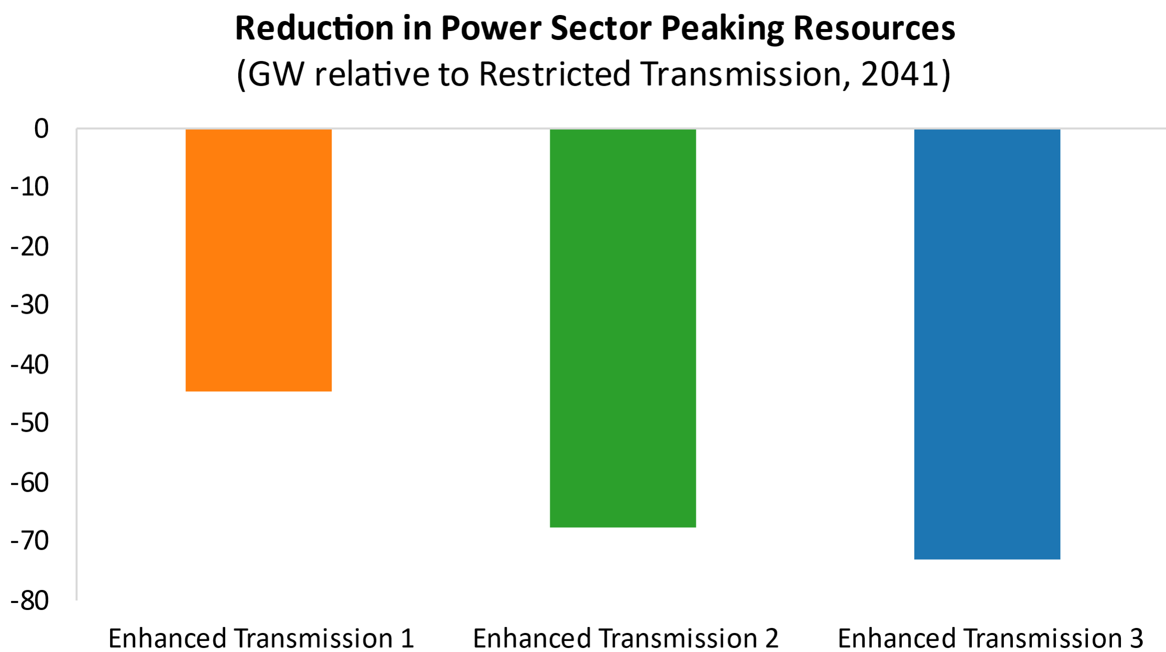
Notes: Flows are averaged over 18 days with a high risk of unserved energy (identified using NREL's Probabilistic Resource Adequacy Suite[30]) drawn from hourly 2007–2013 weather data, referred to here as "stress periods." The width of the arrows is proportional to the average interface flow in the indicated direction over these days. Bidirectional arrows indicate bidirectional flows, with the length of the arrow scaled by the proportion of flows in the indicated direction. The right panel shows total regional imports at the 11-planning-region level divided by total demand over the same 18 days.

Under the core analysis presented in this paper, modeled reliability is held constant across all scenarios, with enhanced transmission reducing the cost of maintaining that reliability compared to the restricted transmission scenario. Total thermal power plant capacity in 2050 in the restricted case is estimated at 865 GW. The enhanced transmission cases, on the other hand, feature roughly 13% less thermal plant capacity (a total of 750-765 GW) due to the ability to share generation resources across broader regions—thus yielding lower costs to maintain the same level of system reliability. To illustrate possible reliability benefits, an additional modeling scenario was developed wherein the cost savings from the Enhanced Transmission 2 case were reinvested in reliability improvements via increased planning reserve margins. This results in an equivalent improvement in reliability of 5.5 million fewer households losing power for an hour each year from 2035 through 2050 in the Enhanced Transmission 2 scenario relative to the Restricted Transmission scenario.

Reduction in Required Peaking Resources

Improved grid reliability associated with increased transmission deployment benefits disadvantaged communities historically exposed to high concentrations of air pollution by reducing reliance on peaking power plants, or peakers, that worsen local air quality. Transmission infrastructure helps regions access additional generation during critical hours of system stress. The availability of increased import capability and reduced congestion in local regions reduces the need for peakers, including natural gas combustion turbines, oil and natural gas steam turbines, and future hydrogen combustion turbines. Figure 5 shows that by 2041, increased transmission deployment can decrease required peaker capacity by 44-73 GW relative to what would be necessary in the Restricted Transmission scenario. While these peakers operate at relatively low capacity factors, they often contribute to pollution in disadvantaged communities. Communities with greater concentrations of people representing historically disadvantaged racial or ethnic groups are on average located closer to peakers. These communities are exposed to a variety of pollutants, that have direct negative health impacts, including respiratory and cardiovascular effects. When they do operate, peakers emit higher rates of pollution per unit of electricity generated.[31] Improving the capacity of the transmission network and decreasing reliance on peaker plants reduces community exposure to harmful pollutants and improves air quality, particularly in disadvantaged communities.

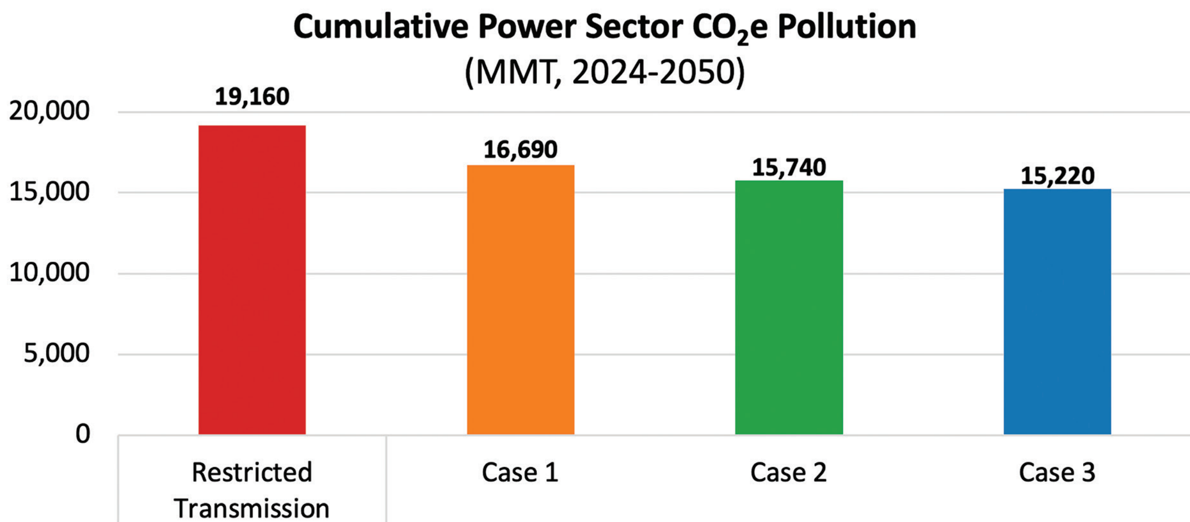
Figure 5. Reduction in power sector peaking capacity relative to the Restricted Transmission scenario (GW, 2041)



Health and Climate Benefits

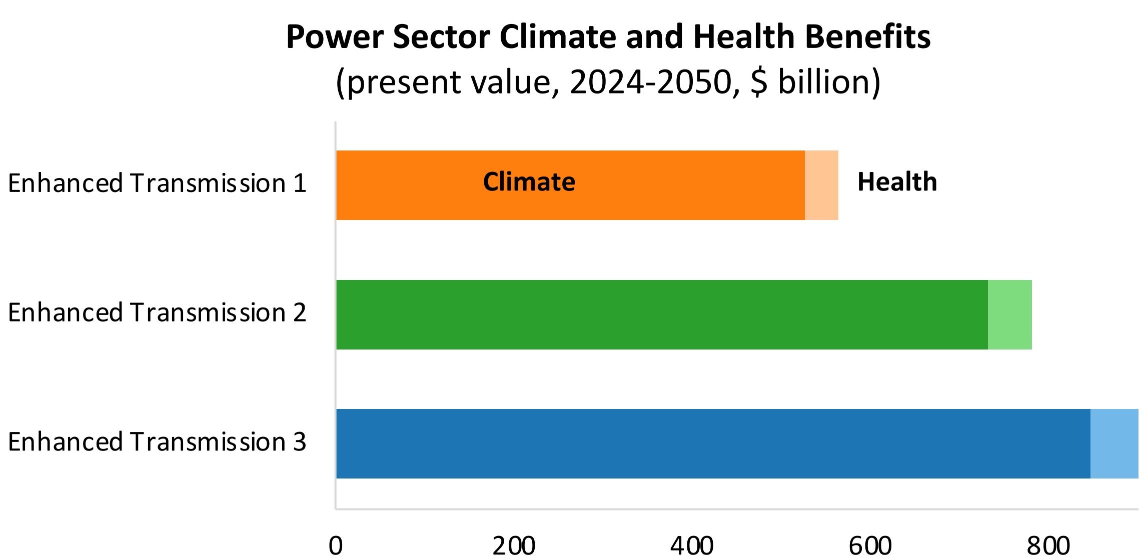
Transmission infrastructure also enables accelerated growth of clean electricity, reducing power sector pollution. Modeled future clean electricity shares are high across all scenarios and enhanced transmission enables stronger growth of these low-emissions resources. The restricted case reaches 66% renewable electricity in 2035 whereas the enhanced cases reach as much as 72%. As a result of transmission increasing clean resources and more efficient use of existing resources, cumulative power sector CO_2 equivalent (CO_2e) emissions are 2,500–3,940 million metric tons (MMT) (13–21%) lower in the enhanced transmission scenarios than in the restricted case (Figure 6).[32] In the Enhanced Transmission 2 scenario, annual CO2e emissions savings are 99 MMT/year in 2035. While not modeled explicitly, additional transmission has been demonstrated to enable reaching higher levels of clean electricity at significantly lower cost than if transmission expansion is restricted.[28]

Figure 6. Carbon dioxide equivalent emissions relative to the Restricted Transmission scenario (MMT, 2024-2050)



As shown in Figure 7, applying recent estimates of the damages caused by carbon pollution, the present-value benefits of the greenhouse gas emission reductions enabled by enhanced transmission are $530 billion to $850 billion. Enhanced transmission is similarly found to reduce sulfur dioxide and nitrogen oxide pollution, thereby avoiding 4,500–6,800 premature deaths, with a monetized value of $40 billion to $60 billion.[33,34,35,36]

Figure 7. Power sector climate and health benefits of enhanced transmission



Conclusion

The benefits of a modernized grid can be fully realized with a whole-of-government and all-of-society approach. Federal agencies, regional planning organizations, grid operators, utilities, states, non-governmental organizations, and the private sector will all play important roles, given their engagement in planning, regulating, and implementing interconnection procedures and transmission expansion. Governmental bodies at all levels will determine the structure and pace of the transmission permitting process, as will impacted communities. But recent history proves that transmission is not expanding at a pace and scale consistent with national need.

Policies and programs that facilitate transmission deployment, as analyzed in this paper, hold promise to reduce electricity costs, improve reliability, and cut pollution. Recent actions by DOE and other stakeholders, combined with new actions that support both regional and interregional transmission buildout will result in additional cost savings for consumers, improved reliability, and greater climate and human health benefits.

Endnotes

[1] DOE. 2023. "National Transmission Needs Study." U.S. Department of Energy. https://www.energy.gov/gdo/national-transmission-needs-study

[2] Regional transmission is defined here as transmission between 134 geographic zones but within 11 planning regions, whereas interregional transmission is defined as transmission between the 11 major planning regions.

[3] NERC. 2023. "2023 Long-Term Reliability Assessment." North American Electric Reliability Corporation.

[4] DOE. 2022. "Queued Up… But in Need of Transmission." U.S. Department of Energy.

[5] Kemp et al. 2024. "Electric transmission value and its drivers in United States power markets." Working Paper. Lawrence Berkeley National Laboratory.

[6] A transmission need is defined as the existence of present or expected electric transmission capacity constraints or congestion.

[7] Shreve et al. 2024. "The US Transmission Grid in the 2020s." https://cleanenergygrid.org/wp-content/uploads/2024/07/GS_ACEG-Fewer-New-Miles-Report-July-2024.pdf

[8] For data and sources, see: Moch. 2022. "Review of transmission lines since 2005." https://doi.org/10.7910/DVN/MDQ6ME, Harvard Dataverse, V1.

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[11] Rand et al. 2024. "Queued Up: 2024 Edition. Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2023." Lawrence Berkeley National Laboratory. https://emp.lbl.gov/publications/queued-characteristics-power-plants-1

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[16] DOE. 2024. "Coordinated Interagency Transmission Authorizations and Permits Program." https://www.energy.gov/gdo/coordinated-interagency-transmission-authorizations-and-permits-program

[17] NEPA Environmental Policy Act Implementing Procedures, 89 FR 34074 (April 2024). https://www.federalregister.gov/documents/2024/04/30/2024-09186/national-environmental-policy-act-implementing-procedures

[18] DOE. 2024. "National Interest Electric Transmission Corridor Designation Process." https://www.energy.gov/gdo/national-interest-electric-transmission-corridor-designation-process

[19] NREL. 2024. "Regional Energy Deployment System." National Renewable Energy Laboratory. https://www.nrel.gov/analysis/reeds/

[20] Modeling assumptions related to electrical load, generation cost inputs, state policies, and more are consistent across all restricted and enhanced transmission scenarios. Most of these assumptions derive from NREL's "2023 Standard Scenarios Report: A U.S. Electricity Sector Outlook." The present analysis assumes greater electrification and associated demand growth than NREL and is derived from the "RIO-REPEAT" moderate Inflation Reduction Act impacts scenario from Evolved Energy Research's "Annual Decarbonization Perspective: Carbon Neutral Pathways for the United States 2023." The analysis also assumes no phaseout of the clean electricity tax credits from the Inflation Reduction Act during the modeled timeframe to better isolate the impacts of transmission.

[21] Gagnon et al. 2024. "2023 Standard Scenarios Report: A U.S. Electricity Sector Outlook." National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy24osti/87724.pdf

[22] Haley, B., Jones, R., Williams, J., Kwok, G., Farbes, J., Bentz, D., Schivley, G., and Jenkins, J. 2023. "Annual Decarbonization Perspective: Carbon Neutral Pathways for the United States 2023." Evolved Energy Research. https://www.evolved.energy/2023-us-adp.

[23] Representative transmission paths in ReEDS have an average length-to-straight-line-distance of 1.15, while MISO (representing an approximation of current trends) assumes 1.3. Additionally, using construction financing calculations in ReEDS and other assumptions, there is a 1.15 cost ratio between an 11-year development and financing process and 8-year process. These two factors alone lead to a 30% cost difference.

[24] NERC. 2023. "2023 Long-Term Reliability Assessment." North American Electric Reliability Corporation. https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2023.pdf

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[26] DOE. 2024. "National Transmission Planning Study." Forthcoming. https://www.energy.gov/gdo/national-transmission-planning-study

[27] Offshore transmission routes, like all specific transmission routes, are not depicted in the figure. These lines represent one option for realizing the increased transmission capacity modeled for coastal regions. See NREL's Atlantic Offshore Wind Transmission Study for more information about offshore transmission: https://www.nrel.gov/docs/fy24osti/88003.pdf.

[28] Monetary values here and elsewhere in the paper are in present-value terms, in 2023 real $, using a 2% real discount rate.

[29] Botterud et al. 2024. "Evaluating the Impact of the BIG WIRES Act." MIT Center for Energy and Environmental Policy Research. https://ceepr.mit.edu/wp-content/uploads/2024/01/MIT-CEEPR-RC-2024-01.pdf

[30] NREL. 2024. "Probabilistic Resource Adequacy Suite." https://www.nrel.gov/analysis/pras.html

[31] U.S. Government Accountability Office. 2024. "Electricity: Information on Peak Demand Power Plants." https://www.gao.gov/assets/gao-24-106145.pdf

[32] Emissions estimates are inclusive of direct carbon dioxide emissions and the equivalent global warming potential from upstream methane leakage associated with natural gas production and delivery, with assumptions consistent with those described in NREL's "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035."

[33] Climate damages from power sector CO2 and related fugitive methane (CH4) are estimated using Environmental Protection Agency (EPA) 2023 updated values, with a 2% discount rate. Health impacts from criteria air pollutants are calculated using the EASIUR model and ACS concentration response function, using an EPA-recommended value of statistical life. More details on methane leakage and health impact calculations are provided in NREL's "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035."

[34] U.S. Environmental Protection Agency. 2023. "Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances." https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf

[35] U.S. Environmental Protection Agency. 2024. "Mortality Risk Valuation." https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatvalue

[36] Denholm et al. 2022. "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035." National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy22osti/81644.pdf

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