Montana Regional Transmission Connectivity Study

Strategic Roadmap to Enhance Montana's Connection with the West

Final Report

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Prepared by:

ENERGY STRATEGIES

About the Study

The *Montana Regional Transmission Connectivity Study* is a transmission planning study aimed at exploring upgrades that will increase regional access to Montana generation resources and enhance Montana interties to neighboring states. The study evaluated a series of resource deployment scenarios that reflect feasible ranges of generation resource expansion in Montana. Power system modeling was used to assess transmission needs under these scenarios and identify strategic transmission expansion solutions that are coordinated and phased. These solutions include greenfield lines, reconductoring, high-capacity conductors, and high voltage direct current (HVDC) transmission lines and create synergies with existing and planned transmission facilities across the West.

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Disclaimers

This work product utilizes information obtained from publicly available sources and, in some cases, has relied upon subscription data and other third-party information available to Energy Strategies. While these sources and our independent analysis are considered reliable, Energy Strategies does not recommend that the information contained herein be the sole source of information for decision-making purposes. The findings and observations contained in this report are based on Energy Strategies' independent analysis and do not represent the views of the NW Energy Coalition.

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Study Summary

The *Montana Regional Transmission Connectivity Study* ("Study") explores phased and strategic transmission expansion options that improve Montana's connectivity with the broader Western grid and enable regional access to new generation resources. These expansion strategies also support in-state load growth, system resiliency, and long-term reliability. Given the significant uncertainty facing the electric sector – including the pace, location, and scale of resource development among other factors – the Study does not prescribe a single transmission buildout, avoiding a take-it-or-leave-it conclusion. Instead, it identifies a series of coordinated transmission investments that can be deployed incrementally over many years, allowing Montana's grid to scale over time, preserving both near-term optionality and long-term value. The Study is intended to inform long-term regional transmission planning, investment prioritization, policy development, and engagement with stakeholders and transmission rightsholders. It evaluates the feasibility of multiple transmission expansion options, including upgrades to existing corridors, new high-voltage lines, routing options, and new interconnection points with surrounding states.

Although the purpose of this study was to evaluate upgrades that could transmit resources from Montana to the west, any new transmission upgrades have the potential for importing power into Montana as well. Those import capabilities were not studied.

The study examined three scenarios of increasing resource deployment in Montana—Low (3 GW), Medium (9 GW), and High (12 GW)—with corresponding transmission portfolios. The table below (*Figure 1)* summarizes the scale of new resources integrated, required new transmission investment, and miles of new and upgraded lines in each to accommodate resources in each scenario.

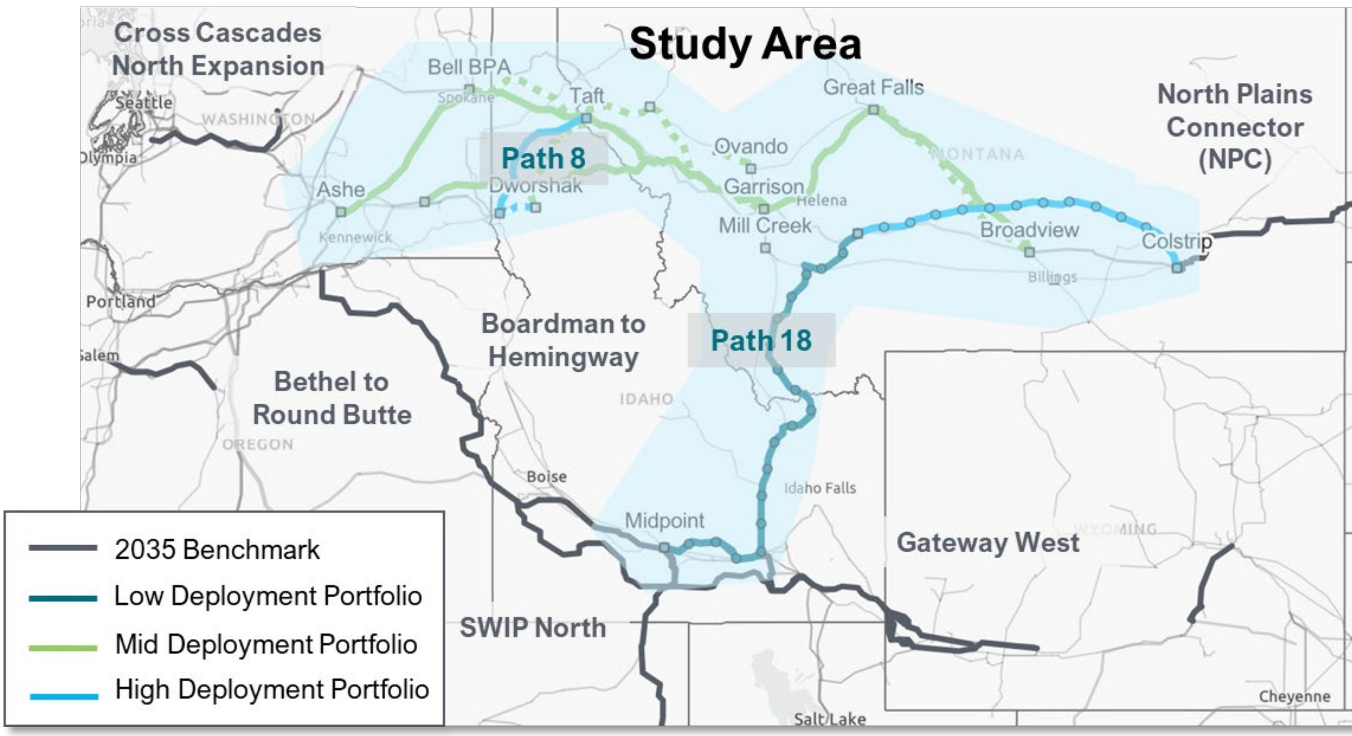
Figure 1: Summary of Resource Deployment Scenarios and Resulting Transmission Portfolios

Deployment Scenario	Transmission Portfolio Summary			
	New Montana Resources Integrated (MW)	Required Transmission Investment ($B)	New Lines (mi)	Reconductor or Rebuild Lines (mi)
Low	3,000	$3.1	432	-
Medium	9,000	$10.7	1,647	437
High	12,000	$13.9	2,021	467

To supplement the transmission modeling, the study team conducted a high-level routing analysis to evaluate the siting feasibility of transmission identified in the Low, Medium, and High Deployment scenarios. The routing analysis considered environmental constraints, land use, terrain, proximity to existing corridors, transmission costs, and sensitivities that explored the impact of avoiding sensitive lands. This effort informed estimates of potential routings, line mileage, and capital costs, and is designed to support early-stage planning and diligence, highlighting corridors where early engagement with communities – including tribes – may be helpful.

Figure 2, below, shows the location and type of major transmission upgrades included in each portfolio. The transmission required for the **Low Deployment** scenario would be built first and would offer the ability to accommodate 3,000 MW of new capacity in Montana. The **Medium Deployment** portfolio would be built out second, accommodating an additional 6,000 MWs of resources (9,000 MW total). Finally, the **High Deployment** portfolio would be implemented, resulting in a system that supports the integration and regional delivery of 12,000 MWs of new generation. Critically, the Study views this expansion as a long-term endeavor – many of the projects identified would take many years to plan, refine, permit, and ultimately construct.

Figure 2: Study Transmission Portfolios in Context with the 2035 Benchmark Regional Grid



Key findings from the Study include:

1. **Montana's export capability is already constrained under current conditions.** Existing interstate transmission paths including the Colstrip system, Montana-Northwest, and Montana-Idaho corridors are fully subscribed, leaving essentially no long-term available transfer capacity to accommodate new resource exports. Without new infrastructure, even modest amounts of incremental generation exports cannot be accommodated.

2. **Phased transmission investments allow Montana's grid to scale with resource growth and market demand.** The study identified a series of coordinated transmission upgrades that enable incremental resource additions over time. This phased approach avoids overbuilding, aligns infrastructure with evolving generation and market dynamics, and preserves flexibility

under future uncertainty.

3. **A new Montana-Idaho intertie provides a high-impact starting point.** For the Low Deployment scenario, a new HVDC line between the Colstrip transmission system and Idaho offers an efficient solution for unlocking a large tranche of interstate connectivity. When paired with minor upgrades in Montana, the portfolio costs roughly $3.1 billion and represents a strategic option to integrate capacity, improve market access, and enhance regional reliability.

4. **Achieving 9 GW of total resource deployment requires further strategic transmission expansion in Montana.** Building on the Low Resource Deployment scenario, additional investments of $7.6 billion ($10.7 billion total) include new 500-kV AC lines, reconductoring projects, and advanced conductors. These projects expand Montana's ties to the Pacific Northwest and prevent corridor congestion, resulting in the integration of 9 GW of new resources.

5. **A high resource deployment future of 12 GW calls for long-term HVDC and AC backbone upgrades throughout the state.** A long-term expansion plan totaling $13.9 billion adds a Colstrip–Townsend HVDC line and further 500-kV expansion. These upgrades accommodate higher resource development, particularly around Colstrip, and represent a long-term (15-year or more) buildout strategy. This plan can be adapted and optimized as nearer-term projects are implemented and uncertainty decreases.

6. **Building HVDC early may reduce future upgrade costs.** Constructing the Montana–Idaho intertie as HVDC offers flow control benefits that avoid redundant upgrades in higher-deployment scenarios. Results suggest that upfront cost premiums associated with building HVDC are outweighed by long-term efficiency, avoiding $108 million in additional upgrades in the High Deployment case. However, while the study identifies efficiency opportunities with an HVDC configuration of this line, it did not consider all operational, supply chain, or planning complexities and more work is needed in those areas. An AC expansion in this corridor is a viable and beneficial option that may have less near-term risk.

7. **Montana transmission expansion can integrate with and enhance other major regional transmission projects**. The transmission portfolios identified in the Study align with major planned transmission projects across the West—such as Gateway West, Boardman-to-Hemingway, SWIP North, and the North Plains Connector (NPC)—working together to support a stronger, more resilient regional grid.

8. **A mix of technologies maximizes system performance and limits land impacts.** The transmission portfolios include a mix of HVDC, advanced conductors, reconductoring, and flow-control technologies that increase efficiency and flexibility while minimizing new right-of-way needs.

9. **Route optimization reduces—but cannot eliminate—impacts to sensitive lands and difficult terrain.** Routing analysis prioritized existing corridors and low-impact paths, reducing environmental and land disturbances. However, Montana's challenging terrain and many land use sensitivities mean that impacts cannot be fully avoided, especially in higher-deployment scenarios where more transmission is required.

10. **Tribal collaboration is essential for future corridor planning.** Current datasets are insufficient to properly incorporate tribal preferences and culturally sensitive areas into routing; deeper, direct coordination with tribal nations is needed to identify preferred corridors. (See *Figure 21, p. 30,* for proximity of high-deployment portfolios to reservations.)

Taken together, the study findings offer a roadmap for improving Montana's transmission connectivity in a scalable, efficient, and regionally integrated manner. By identifying phased transmission portfolios tied to specific levels of generation deployment, the study equips planners, policymakers, and developers with a framework to align infrastructure investments in Montana with future system needs. We hope that this study provides a technical foundation to support future planning efforts and emphasizes the need for continued collaboration across jurisdictions, utilities, tribes, and stakeholders to ensure timely and effective transmission development in Montana, the Northwest and beyond.

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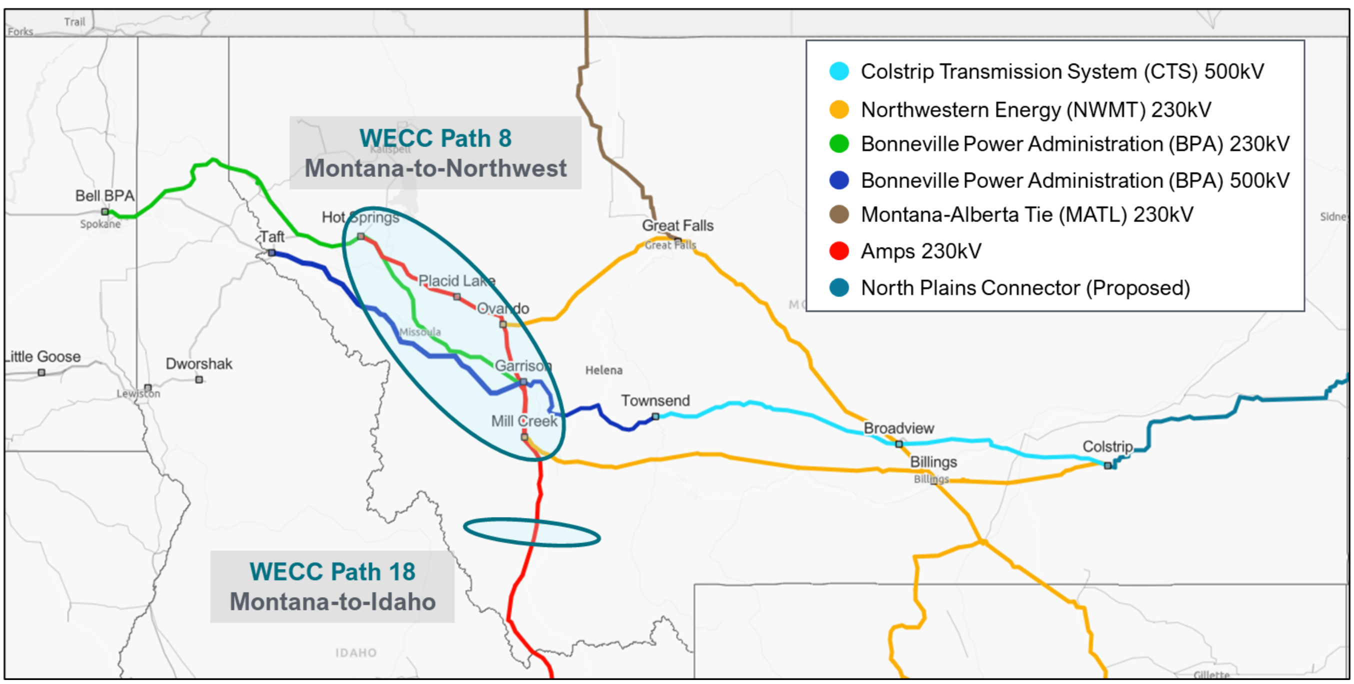
1. Background and Study Objective

Montana's electric grid has evolved from its beginnings supporting early 20th-century hydropower development powering mining and industrial centers like Butte and Great Falls. The construction of the jointly owned Colstrip Generating Station and the associated 500 kV Colstrip Transmission System (CTS) in the 1980s marked a pivotal moment, enabling large-scale exports of coal-fired power westward to utilities in Montana and across the Pacific Northwest region.

Today, most of the Montana high-voltage transmission system (*Figure 3*) is owned and operated by a mix of entities including NorthWestern Energy – the primary investor-owned utility in Montana – as well as Bonneville Power Administration (BPA), various municipal and cooperative utilities, and the CTS joint owners. The Montana grid has grown in response to load growth, new resource need, and the state's growing role as a participant in Western energy markets. Long transmission corridors spanning sparsely populated areas create challenges around stability, voltage control, and complex transmission entitlements. Joint ownership of transmission is common in Montana, especially as it relates to the interstate connections.

Figure 3: Montana's High-Voltage Transmission Grid



Several regional utilities' resource plans and long-term planning studies have identified Montana as a high-quality resource state—particularly for wind development in central and eastern parts of the state.[1] Recent policy and market trends, including data center deployment, growing demand for capacity and resource diversity, and market expansion have accelerated interest in the state's power production potential. These factors, plus plans to interconnect Montana to the Eastern Interconnection via the proposed HVDC North Plains Connector project (*Figure 3)* will place additional stress on the Montana transmission system.

Montana loads have an increasing need to import power from out of state as evidenced by the December 2022 Arctic blast when 41% of demand was serviced via imports at very high prices from out of state resources per Northwestern Energy's 2023 Integrated Resource Plan.

There is increasing recognition across the Western U.S. of the strategic importance of expanding Montana's transmission connectivity. Montana's existing interstate transmission pathways are constrained, with limited available transfer capacity, aging infrastructure, and an outdated design originally built to transfer discrete amounts of coal generation from source points. These challenges have brought renewed attention to the need for broader resource access, expanded interties, and deeper integration with the broader Western Interconnection. Thus, Montana's geographic position and evolving role in the Western energy mix place it at the center of ongoing regional discussions about how to reliably and efficiently move energy across the West.

1.1 Study Purpose and Objectives

The purpose of the *Montana Regional Transmission Connectivity Study* is to assess how strategic, phased transmission investments can connect Montana to regional markets and position it as a valuable regional player in the evolving Western grid. With rising electricity demand across the West, a proposed interconnection from the North Plains Connector at Colstrip, and growing interest from the Pacific Northwest in the state's generation resources, the study seeks to identify transmission pathways for reliable, cost-effective access to Montana's energy resources.

With this purpose in mind, the *Montana Regional Transmission Connectivity Study* was guided by the following objectives:

1. Define plausible future resource deployment scenarios for Montana
2. Assess near-term transmission availability on key interties to establish a transmission availability baseline and ensure efficient usage of the existing system
3. Identify phased transmission expansion portfolios that support each resource deployment scenario and expand connectivity to the western grid
4. Evaluate a range of transmission technologies including HVDC and advanced conductors
5. Coordinate transmission portfolios with planned regional upgrades

[1] For example: Puget Sound Energy (https://www.pse.com/en/IRP/Past-IRPs/2023-IRP) or Avista IRPs (https://www.myavista.com/-/media/myavista/content-documents/about-us/our-company/irp-documents/2025/draft-avista-2025-electric-irp.pdf)

6. Consider environmental and land factors when performing preliminary routing of potential transmission buildouts and
7. Estimate capital costs

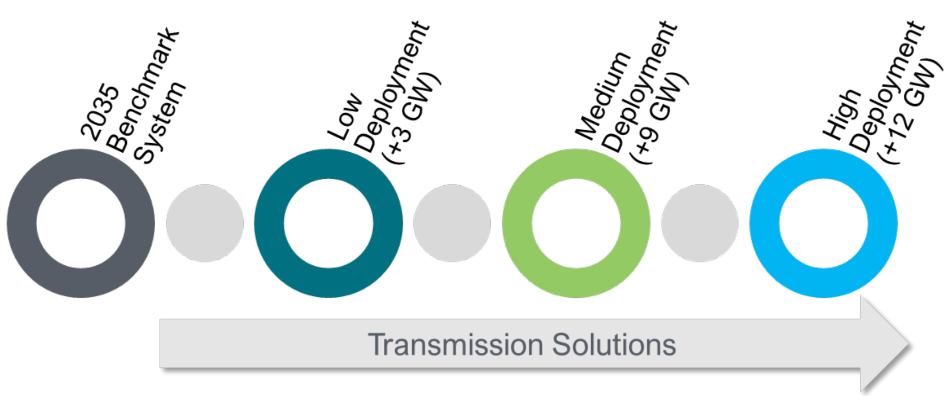
The study scope included evaluation of Montana's high-voltage transmission system and its primary connections to the Pacific Northwest and Idaho (shown in *Figure 3* as the Montana-Northwest and Montana-Idaho corridors; WECC Paths 8 and 18). It did not include lower-voltage facilities, local systems, or the need for generator interties. Evaluation of the transmission paths that connect Montana to Wyoming and Alberta (WECC Paths 80 and 83) were likewise out of scope for this study but remain important areas for future analysis.

Given the significant uncertainty facing the electric sector – including the pace, location, and scale of resource development among other factors – the study does not prescribe a single plan, avoiding a take-it-or-leave-it conclusion**. Instead, it identifies a *roadmap* consisting of a series of coordinated transmission investments that can be deployed incrementally over many years, allowing Montana's grid to scale efficiently over time while preserving near-term optionality and long-term value.**

2. Approach & Key Assumptions

To develop a phased transmission plan, the study identified transmission portfolios for three scenarios. These scenarios represent increasing levels of resource deployment in Montana, with each resource and transmission portfolio building on the last.

Figure 4: Scenario Architecture



For each scenario, power system models were developed to represent Montana's grid. These models capture system constraints and limitations as resource deployment levels increased. When transmission reliability violations occurred, transmission solutions were identified using exploratory studies of system performance, insight on cost efficiencies, experience with various technology types, and practitioner judgment of transmission planning engineers, resulting in a tailored solution portfolio for each scenario.

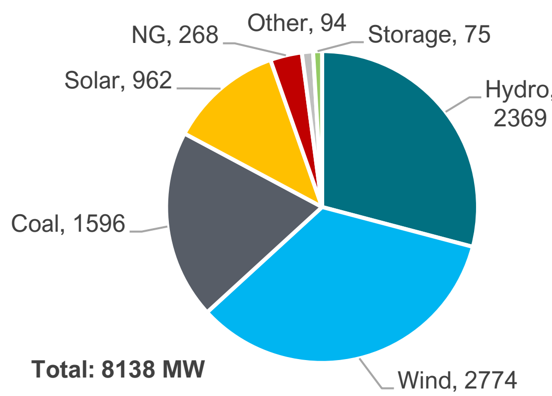
The remainder of *Section 2* describes the key components of the study's methodology. Resulting transmission portfolio for each resource deployment scenario are outlined in *Section 3*, and the Study's key takeaways are covered in *Section 4*.

2.1 2035 Benchmark System

The first step in the *Montana Regional Transmission Connectivity Study* involved developing power system models to reflect a 2035 Benchmark System. This 2035 Benchmark served as the starting point for all other models and analyses. The model was developed from the WECC 2035 Heavy Summer (HS) power flow case, which represents west-wide grid operations & flows at a snapshot in time under stressed summer conditions.

Model assumptions were adopted to reflect (1) planned transmission and generation expected to be in-service by 2035 and (2) load and resource dispatch decisions reflecting high-export conditions that stress inter-state transmission paths.

Figure 5: Montana Resource Nameplate Capacity (MW) in 2035 Benchmark (Western Interconnection only)



Benchmark Resources

A review of planned Montana generation, storage, and transmission was performed from sources including utility resource plans, interconnection queues, and S&P Global Market Intelligence. In addition to Montana resources reflected in the WECC 2035 HS case, approximately 1,023 MW of generation projects were identified and included. These resources have demonstrated a high likelihood of being built, for example a signed Large Generator Interconnection Agreement (LGIA) or have another form of contractual arrangement with a Transmission Provider or began construction after the WECC 2035 HS model was built. The study assumed that Colstrip Generating Station units 3 & 4 remain online and were dispatched to serve in-state loads based on current information about unit ownership. *Figure 5* shows the total in-service nameplate capacity of Montana resources assumed operational in the 2035 Benchmark.

The utility and developer-led transmission projects modeled in the 2035 Reference are summarized in *Figure 6*. These upgrades were modeled to reflect in-service timing and topology changes as understood at the time of the study. Notably, we did not explicitly include BPA's Montana-to-Washington project proposed on July 10th, 2025 as development of the 2035 Benchmark Case had been completed by that time. Those projects are effectively included in the deployment scenario results.

Figure 6: Summary of Transmission Projects Included in Benchmark

Project Name	Ownership	In-Service Date
North Plains Connector	NPC	2032
Loco Mountain Substation (i.e., P310lx)	NWE	2027
Gateway West (Segments D3, E and E8)	PacifiCorp	2028 – 2030
Longhorn to Hemingway (Formerly Boardman to Hemingway)	PacifiCorp/ Idaho Power	2026
SWIP-North	LS Power	2027

A detailed list of assumptions included in developing the Benchmark Case is provided in *Appendix A*.

Load and Dispatch Decisions to Simulate Stressed Conditions

Load and dispatch were adjusted to reflect the Montana grid in a high generation and off-peak load condition. This has been identified in WECC studies as a critical condition for Montana's inter-state paths. Load was reduced from 2,614 MW to 1,747 MW to obtain stressed export flows, and generation dispatch in the 2035 Benchmark was increased to maximize flows on Path 8 East-to-West and Path 18 North-to-South.

This combination of reduced load and increased generation amounted to a 2,268 MW net output (i.e., Montana generation minus load) increase from the WECC model, and that additional power was scheduled outside of Montana to the Pacific Northwest, Idaho, Utah and Nevada, by decreasing generation in those areas. This resulted in an increase of approximately 1,600 MW in Montana export flows on Path 8 and Path 18.

Baseline View of Long-Term Transmission Availability

The baseline assessment of long-term transmission availability examined how much additional generation (e.g., unplanned generation) Montana can export without major new infrastructure. Using Available Transfer Capability (ATC) and Total Transfer Capability (TTC) data from transmission providers' OASIS platforms, Energy Strategies reviewed the Colstrip Transmission System, BPA's Eastern Intertie, and WECC Paths 8 and 18 over a 10-year period (2025–2035). This commercial-data approach, rather than power flow simulation, confirmed that existing firm rights are largely subscribed, with only nominal ATC (155 MW to Avista beginning in 2026) available. Beyond that, no meaningful headroom exists for exports to BPA, PacifiCorp, or Idaho Power. The findings show that, under current plans, new generation will require new transmission infrastructure even under modest generation growth scenarios, and modeled assumptions in the 2035 Benchmark were cross-checked against observed ATC/TTC ceilings to ensure consistency.

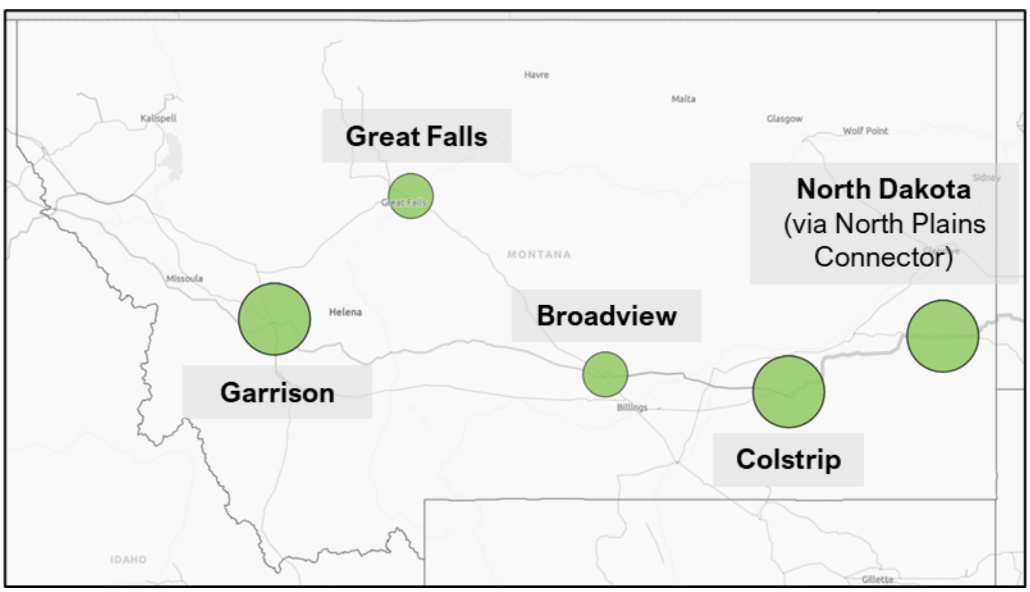
2.2 Define Resource Deployment Scenarios

The next step in the *Montana Regional Transmission Connectivity Study* involved designing plausible future scenarios for generation development (on top of the 2035 Benchmark) in Montana. The total incremental capacity added in the scenarios ranges from 3 GW to 12 GW. Recent studies exploring long-term resource demand in the West forecast the addition of *hundreds* of GWs of new resources over the approaching 10- and 20- year periods. [2] Thus, the 12 GW of assumed long-run demand for Montana resources – a fraction of this total – is reasonable given the pace of load growth and resource deployment in the region.

These scenarios do not attempt to forecast the buildout of specific generation projects but rather are designed to stress the transmission system in meaningful and realistic ways that can inform long-term infrastructure planning. *Figure 7* below provides a summary of each of the three Resource Deployment Scenarios and how they compare to the Benchmark Case that formed the study baseline.

Generation injection locations were selected based on a combination of factors, including proximity to existing high-voltage infrastructure, commercial development interest, and resource quality. Five key development zones – Colstrip, Garrison, Broadview, Great Falls, and NPC (modeled at Colstrip) – were chosen to reflect plausible future buildout across Montana.

Figure 7: Resource Zones Considered in Study



These locations, shown in *Figure 7*, were informed by interconnection queue data, integrated resource plans (IRPs), public announcements of new generation projects, and developer activity tracked through 3rd party databases. While the study does not forecast specific generation projects (outside of

[2] See https://connectedwest.org/ and WECC's Western Assessment of Resource Adequacy 2024 available

those planned projects included in the Benchmark Case), it allocates new generation in a way that reflects industry trends.

The study and its findings are highly sensitive to assumptions made regarding the (1) amount of resources included in each scenario; (2) their location. Notably, the study was performed in a resource-agnostic manner, so the results will generally hold true regardless of the technology type.

Figure 8: Resource Deployment Scenario Overview

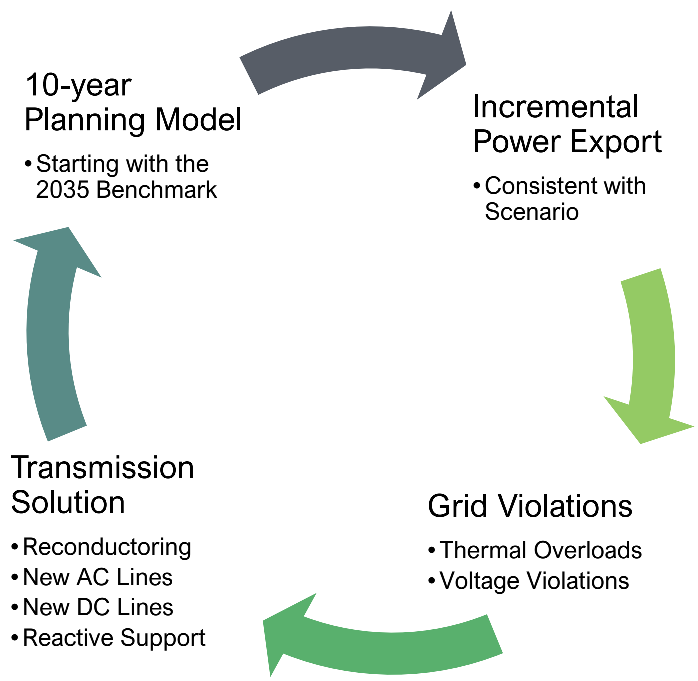
Scenario	Description	Incremental Generation Capacity	Key Purpose
Benchmark	Reflects 2035 system conditions including known generator retirements and planned transmission upgrades	~2,268 MW increase over WECC base case reflection regional resource plans (not additional from study scenarios)	Establish baseline export conditions and identify pre-existing constraints
Low Deployment (+3 GW)	Adds 3,000 MW via the North Plains Connector[3] (NPC), modeled as a new HVDC import at Colstrip	+3,000 MW	Stress transfer paths and test export limits using planned infrastructure
Medium Deployment (+9 GW)	Builds on Low with 6,000 MW of additional resources, allocated across Montana, totaling: ○ 3 GW at Colstrip ○ 3 GW at Garrison ○ 1.5 GW at Broadview ○ 1.5 GW at Great Falls	+9,000 MW total (Low + 6,000 MW)	Identify transmission needs for broader resource buildout across multiple zones
High Deployment (+12 GW)	Adds 3,000 MW to the Medium scenario, testing the upper bounds of expansion, totaling: ○ 6 GW at Colstrip ○ 3 GW at Garrison ○ 1.5 GW at Broadview ○ 1.5 GW at Great Falls	+12,000 MW total (Medium + 3,000 MW)	Identify long-term infrastructure required for full-scale clean energy export

[3] The North Plains Connector (NPC) is a project planned by Grid United, which is a 3,000 MW, 525 kilovolt high voltage direct current (HVDC) transmission line, extending approximately 432 miles from substations in North Dakota to the existing Colstrip Substation in Montana. Construction is expected to begin in 2028, and the line is expected to be operational in 2032. For this study, the NPC was modeled by adding a 3 GW generator (injection) at Colstrip. The NPC was included in all three deployment scenarios.

2.3 Identify Transmission Needs and Solutions

The primary study approach relied on transfer analysis, which is a study method that evaluates the ability of a transmission system to reliably accommodate the injection and subsequent transfer of generation across the transmission system. For the *Montana Regional Transmission Connectivity Study*, each scenario—representing 3, 9, or 12 GW of incremental Montana generation—was evaluated by injecting incremental power at the five Montana locations discussed above – Colstrip, Broadview, Garrison, Great Falls, and NPC – while proportionally reducing generation in neighboring sink areas, including the Pacific Northwest (i.e., PGE & BPA), Idaho, Utah, and Nevada. This approach stressed east-to-west transfers and allowed the study to evaluate the feasibility of these conditions.

Figure 9: Transmission Solutioning Process



To perform the study, generation was increased incrementally until system performance violated North American Electric Reliability Corporation (NERC) Transmission Planning Performance (TPL) Requirements. At that point, targeted transmission upgrades were developed and added to relieve the limiting constraint. This iterative process continued until the full generation injection target for the scenario was reached. Transmission expansion options were then re-evaluated at this point. The study was performed using the PowerGem TARA software, and all scenario models assumed the same line monitoring, contingencies, and reliability criteria used in the 2035 Benchmark.

Each deployment scenario was evaluated against NERC TPL-001-5 planning criteria under both normal (N-0) and single-contingency (N-1) conditions. Elements were monitored for:

- Thermal overloads: 100% of continuous rating for N-0 and emergency rating for N-1
- Voltage deviations: ±5% from nominal unless otherwise specified by utility guidance
- Voltage drop: Post-contingency voltage drops exceeding 8% were flagged

The contingency set included all applicable N-1 outages of transmission lines, transformers, and other monitored equipment ≥115 kV, with a focus on the Montana export paths and adjacent systems. Current WECC path ratings were also included as a constraint in the study.

Transmission Solution Options and Strategy

Energy Strategies considered a wide range of transmission solutions when attempting to resolve grid violations, including:

- New greenfield transmission projects
- Reconductoring or rebuilding of existing lines
- High-capacity conductors
- Storage as a transmission asset
- Powerflow control devices
- Dynamic line ratings
- Series compensation and voltage support (e.g., capacitor banks)

The primary factor in selecting technologies to meet a given need was performance – Energy Strategies considered only those solutions that were technically viable. In instances where multiple strategies could be used to meet the need, costs and other factors were considered. The Study drew comparisons between the viable alternatives to inform recommendations on which are likely to be the preferred expansion option based on their cost effectiveness and ability to meet the needs of the system. The analysis considered cost, development feasibility, development timeline, and other qualitative factors influencing selection of a transmission alternative.

In each case, only the minimum set of upgrades required to enable the next tranche of generation were included, consistent with a phased and modular investment strategy. This stepwise method was applied across all three deployment scenarios to ensure scalability and optionality.

2.4 Optimize Routing and Estimate Costs

Transmission Routing

All line routes of the resulting portfolios were identified by project collaborators Montara Mountain Energy and Evolved Energy Research, using their geospatial routing tool to determine the optimal-cost-path for each transmission project.[4] The routing tool utilized geospatial cost surfaces to identify the most cost-effective route between two points on the grid, tailored for each portfolio.

Standard per-mile base transmission costs were drawn from the MISO per-unit cost guides and UC Berkley's Energy Institute at Haas advanced conductor report, specific to technologies considered in the study and voltage level. [5] The routing tool included additional cost factors based on terrain, land use, and the ability to use existing rights of way. To respect tribal lands, we applied a cost multiplier to areas identified as USGS Native American reservation lands so that optimal routes would avoid these areas wherever practicable. The cost surface used to route transmission lines was developed to

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[4] Methods were consistent with WECC EDWG, Georgia Tech and EPRI (2006), and Wu et al (2023).
[5] Caron, J., & Bistline, J. E. (2023). Accelerating Transmission Expansion by Using Advanced Conductors in Existing Right-of-Way (Working Paper No. 343). Energy Institute at Haas, University of California, Berkeley. https://haas.berkeley.edu/wp-content/uploads/WP343.pdf

capture a reasonable balance between environmental and cultural sensitivities and construction cost efficiencies.

Solution Cost Estimation

Each new network upgrade recommended for the three deployment scenarios consists of substation equipment upgrades and transmission line upgrades.

Substation equipment upgrades include one or more of the following:

- Building a new substation with 6 positions
- Adding a new position to an existing substation
- Adding one or more new transformers
- Adding voltage support devices such as switched capacitor banks and reactors
- Adding new or upgrading existing series capacitors
- Adding HVDC converter stations and associated AC substation upgrades

Energy Strategies developed cost estimates using the 2025 MISO MTEP per unit costs for all substation equipment, except series capacitors which were sourced from NREL. [6] [7]

The transmission line upgrades considered are either reconductoring an existing AC line or building a new AC or HVDC line. Montara Mountain Energy developed the cost estimate for all transmission line upgrades. These values were provided to Energy Strategies who compiled them into comprehensive transmission portfolio costs.

3. Study Results

This section presents the technical results from the study's transmission planning analyses. For each of the resource deployment scenarios, narratives are provided that discusses the nature of system constraints encountered when pursuing the resource injection levels associated with each resource deployment portfolio. Each section also describes the upgrade options considered and developed in response, and summaries are presented of the resulting portfolios, plus their preliminary routings, line mileage, and their cost. Each transmission portfolio builds on the infrastructure of the preceding one, enabling a phased investment approach.

3.1 Low Deployment Scenario

Starting from the 2035 Benchmark, the transfer analysis found that without any network upgrades, the Montana system could only support 179 MW of injection (or imports via the NPC) before Path 8 reached its rated capacity under system-intact (N-0) conditions. This limited headroom highlights the need for upgrades to support the 3,000 MW objective of the Low Deployment Scenario.

[6] "Transmission Cost Estimation Guide for MTEP25", Midwest ISO, June 6, 2025
[7] "Electrical Infrastructure Cost Model for Marine Energy Systems", Aryana Y. Nakhai, NREL, September 2023

To address this constraint, the study team evaluated a suite of transmission projects already proposed or considered in regional planning efforts. Among the most prominent was a new transmission corridor between Montana and Idaho (Path 18), a concept dating back to the 2008 Mountain States Transmission Intertie (MSTI) proposal by NorthWestern Energy. The MSTI project originally sought to relieve transmission bottlenecks, improve reliability, meet growing demand for electricity resources, provide regional energy diversity, and develop a positive economic impact.

Given that NPC introduces HVDC infrastructure to Montana for the first time, the study evaluated both AC and DC configurations for a new Montana-Idaho project. Ultimately, an HVDC configuration was recommended for its greater export capability per dollar of long-run investment, though the AC configuration also performs well and remains viable. The HVDC Montana–Idaho line enhances Montana's export potential by providing a parallel transmission path to the Colstrip system and improved access to the Idaho transmission system, including the Energy Gateway and Boardman to Hemingway (B2H) projects. In selecting the HVDC configuration of the project for this study, we observed that unlike AC lines, HVDC line converter stations can better control flows, sending power south to Idaho rather than through the constrained Path 8. By building the Montana-Idaho line with HVDC instead of AC, there is potential to avoid seven upgrade projects in the High Deployment scenario, totaling $108 M in avoided costs.[8]

In addition to the new Montana–Idaho line, the transmission portfolio included a set of planned Path 8 upgrades to support full injection under the Low Deployment Scenario:

- Garrison–Townsend 500 kV series capacitors upgraded to 2,000 MVA
- 800 MVAR shunt capacitor added at Garrison 500 kV
- 200 MVAR reactor added at Hot Springs 230 kV
- Colstrip–Broadview 500 kV series capacitors uprated
- Additional reactive support at Broadview, Townsend, the new P310 substation, and the NPC terminus

Together, these upgrades enabled the full 3,000 MW injection, with total export flow increasing by 2,730 MW. The full transmission portfolio is estimated to cost $3.1 billion and is summarized in *Figure 10* and *Figure 11* below.[9]

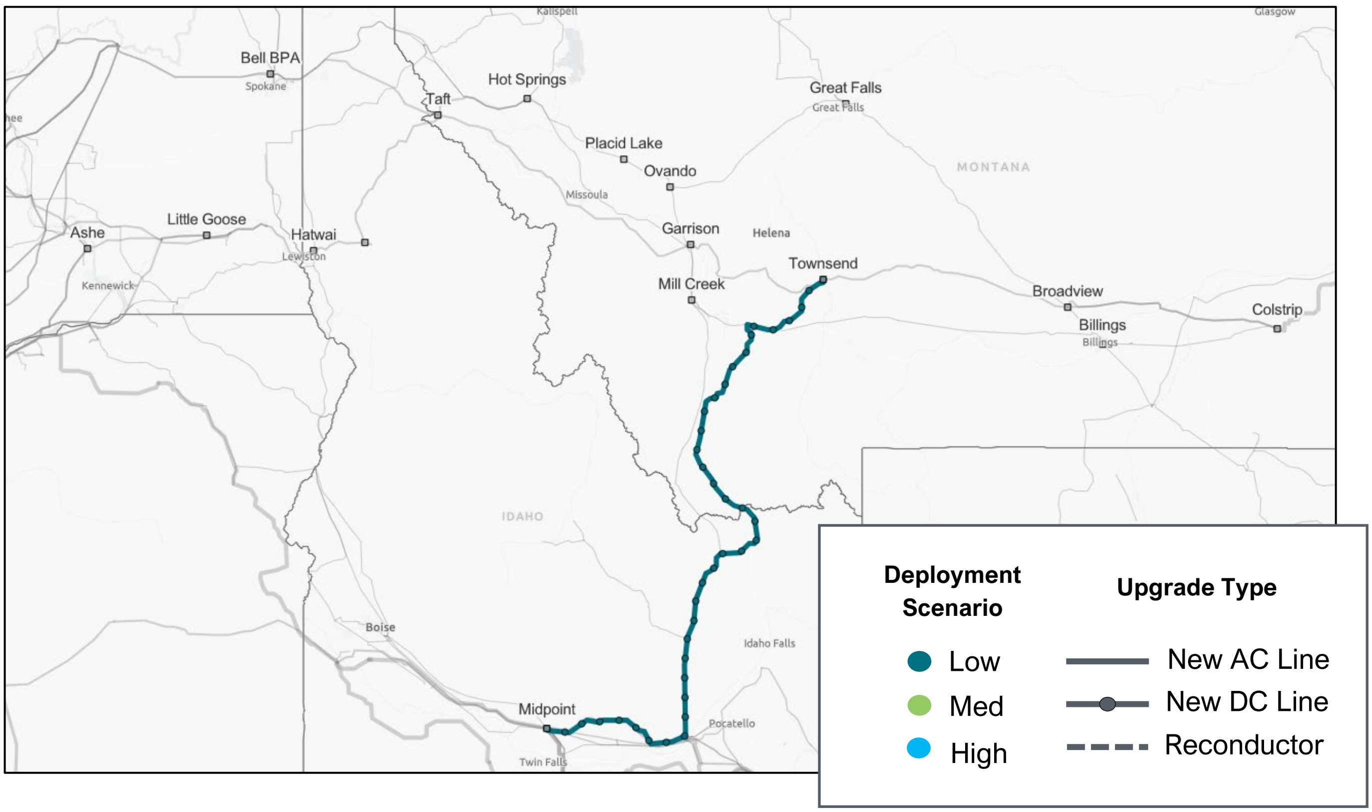
Figure 10: Low Deployment Scenario Transmission Portfolio List

Transmission Upgrade	Miles	Cost ($M)
New Townsend-Midpoint HVDC line (M2I)	432	$2,933
Garrison-Townsend 500kV #1 and #2 Series Capacitors	-	$60

[8] The study did not assess several factors that could affect an AC–versus–DC build decision for the Montana–Idaho corridor, including HVDC supply-chain constraints, potential operational complexities of a new HVDC line, and additional reliability scenarios outside the study scope.
[9] All map figures of transmission portfolios show lines upgrades only, and do not show series capacitor or reactive support upgrades.

Transmission Upgrade	Miles	Cost ($M)
Broadview-Colstrip 500kV #1 and #2 Series Capacitors	-	$43
Reactive Support	-	$50
Total	**432**	**$3,086**

Figure 11: Low Deployment Scenario Transmission Portfolio Map



3.2 Medium Deployment Scenario

For the Medium Deployment Scenario, an incremental 6 GW of generation resources were added at five locations in Montana, for a total of 9 GW from the benchmark – see *Section 2.2* for details on the location of resource additions for each scenario. Transmission upgrades developed for the Low Deployment Scenario were assumed in-service for this scenario.

To accommodate the incremental 6 GW of injection, a combination of new greenfield transmission between Montana and the Northwest was identified, with different line termination points that prevent introducing new transmission bottlenecks or "common corridor" concerns. It also includes reconductoring of existing transmission lines. The recommended portfolio of projects consists of six greenfield transmission lines, totaling about 1,215 miles, and reconductoring five existing lines, totaling about 437 miles. A proposed partial reconductoring of the Taft – Dworshak line is also reflected in BPA's Montana-to-Washington project, reflecting synergies with this expansion plan and in-flight projects already being pursued in the region.

The transmission expansion for this scenario required new lines reaching into the Great Falls area. This expansion is heavily driven by assumptions made regarding the location of resources.

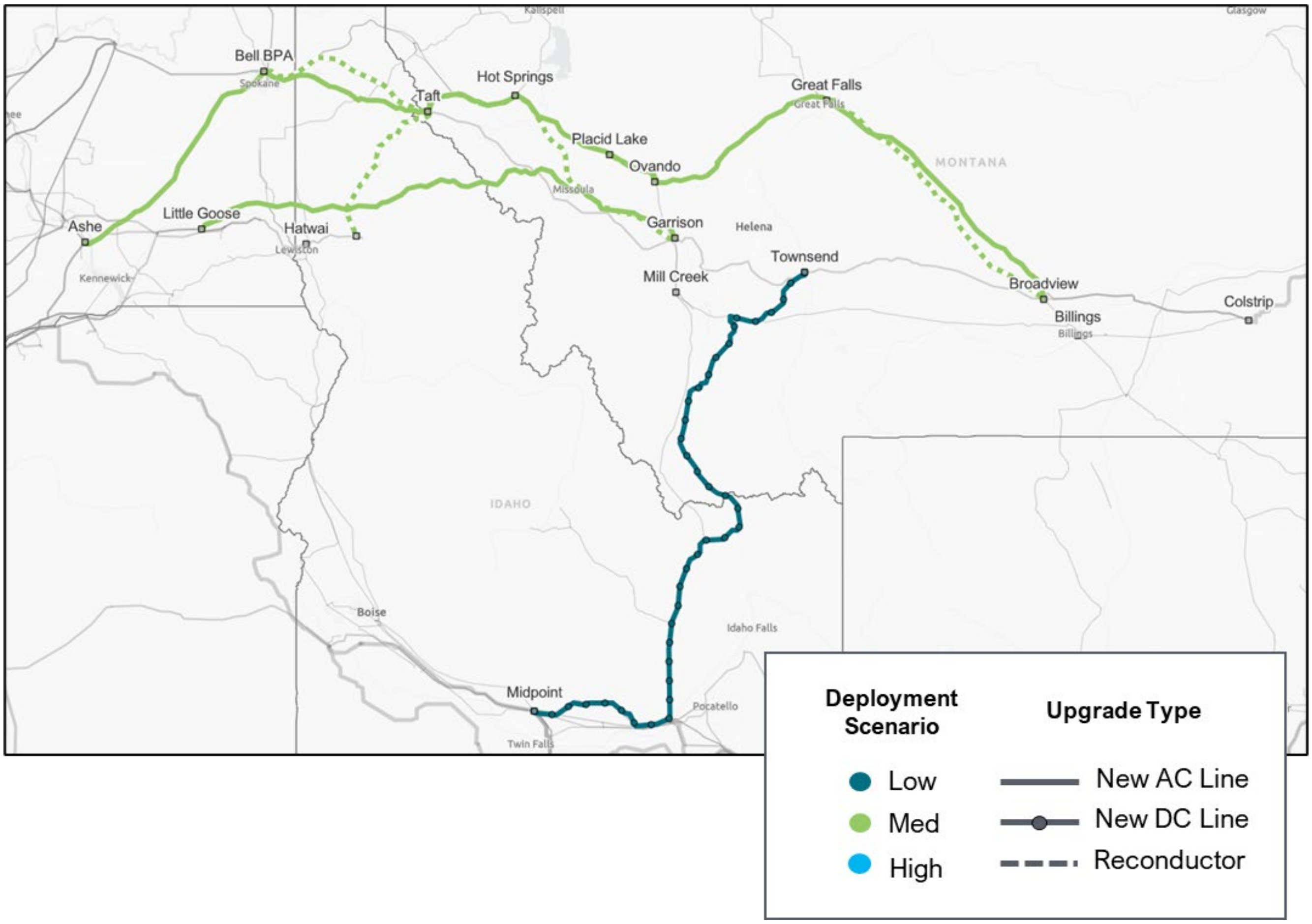
The estimated cost of the upgrades is $7.6 billion. The upgrades are described in *Figure 12* and shown in *Figure 13*.

Figure 12: Medium Deployment Scenario Transmission Portfolio List

Transmission Upgrade	Miles	Cost ($M)
New Garrison-Little Goose 500kV line	294	$2,032
New Great Falls 500kV substation and two 500/230kV transformers	-	$60
New Great Falls-Broadview 500kV and New Great Falls-Taft 500kV lines	425	$2,284
New Taft-Bell 500kV #2 line	97	$700
New Bell-Ashe 500kV line	136	$777
New Great Falls-Taft 500kV #2 line	263	$1,354
Reconductor Great Falls-Broadview 230kV line	169	$104
Reconductor Landers Fork-Ovando-Placid Lake 230kV line	57	$43
Reconductor Taft-Bell 500kV #1 line	85	$81
Reconductor Thompson Falls-Burke 115kV A and B lines	32	$12
Reconductor Taft-Dworshak 500kV line	94	$121
Medium Deployment Scenario	**1,652**	**$7,568**
Low Deployment Scenario	432	$3,086
Low + Medium Deployment Scenarios	**2,084**	**$10,654**

All of the new lines are recommended to use advanced conductors to maximize power carrying capabilities. The portfolio of upgrades enabled the 9,000 MW of cumulative injection in the Medium Deployment Scenario and increased the export flows by another 6,660 MW over the Low Deployment Scenario, resulting in export flows of 9,243 MW.

Figure 13: Medium Deployment Scenario Transmission Portfolio Map



3.3 High Deployment Scenario

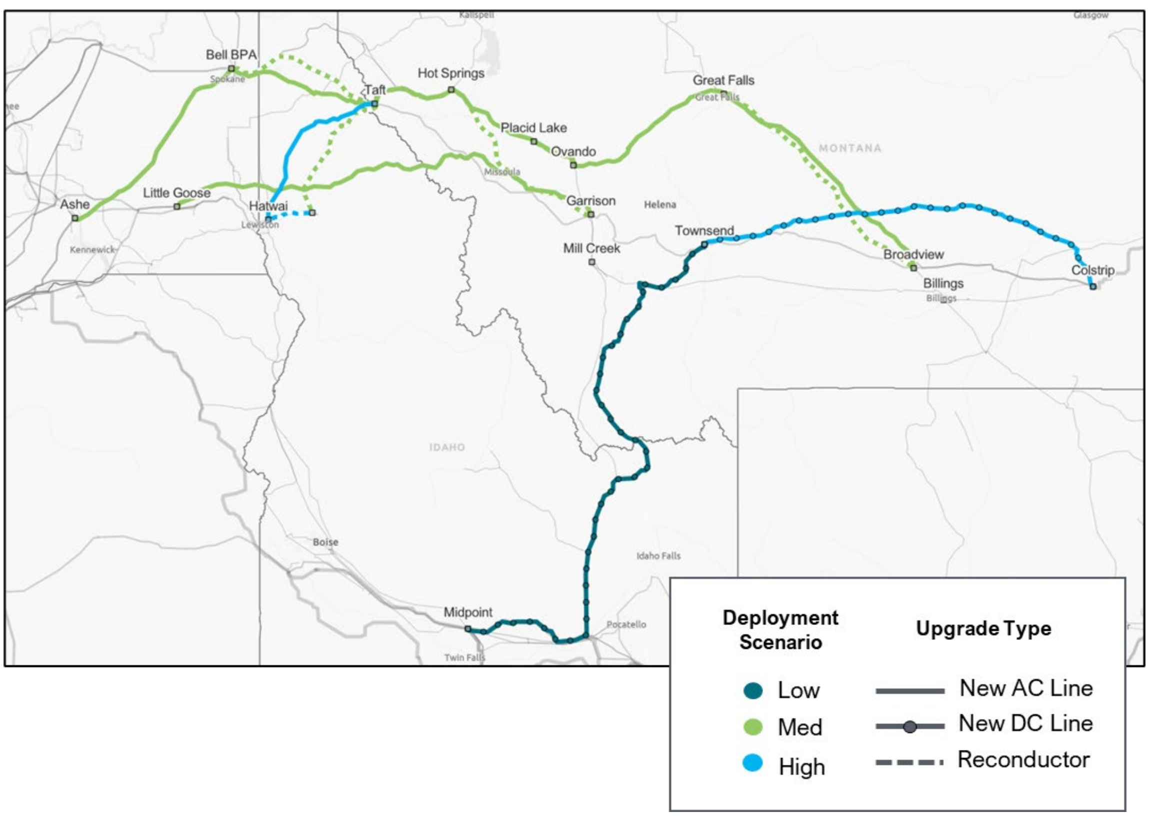
The High Deployment Scenario builds upon the prior scenarios by modeling a total of 12 GW of new capacity in Montana, representing the most aggressive development trajectory considered in the study. This includes the 3 GW of injection from the North Plains Connector (NPC) modeled at Colstrip in the Low Deployment Scenario, and the 6 GW from the Medium Deployment Scenario—split between 3 GW at Garrison, 1.5 GW at Broadview, and 1.5 GW at Great Falls. To reach the 12 GW target, an additional 3 GW of new generation was modeled at Colstrip, bringing total injections at that location to 6 GW. All transmission upgrades identified in the Low and Medium Deployment Scenarios were assumed to be in place for this case, forming the foundation for assessing the need for additional system reinforcements.

Major upgrades in this portfolio include a new Colstrip to Townsend HVDC line (connecting NPC and the Montana-Idaho HVDC project identified in the Low Deployment portfolio), and a new Taft-Hatwai 500-kV line. The AC lines are built with advanced conductors to maximize their power throughput. The new HVDC line is driven by need for efficient and more controlled transfer power from resources located at Colstrip.

Figure 14: High Deployment Scenario Transmission Portfolio List

Transmission Upgrade	Miles	Cost ($M)
New Colstrip-Townsend HVDC line	262	$2,219
New Taft-Hatwai 500kV #2	112	$841
Reconductor Dworshak-Hatwai 500kV	30	$48
Upgrade Garrison-Taft 500kV #1 and #2 Series Capacitors	-	$74
Reactive Support	-	$68
High Deployment Scenario	**404**	**$3,251**
Low Deployment Scenario	432	$3,086
Medium Deployment Scenario	1,652	$7,568
Low + Medium + High Deployment Scenarios	**2,488**	**$13,905**

Figure 15: High Deployment Scenario Transmission Portfolio Map



3.4 Land and Routing Considerations

Conceptual routes were developed for all transmission line solutions for the Low, Medium, and High deployment scenarios using the optimal-cost-path considerations outlined in *Section 2.4*. Each deployment scenario routes were also analyzed under different 'avoidance' conditions representing the degree of restriction placed on pathing to avoid environmental and cultural impacts. These levels of avoidance correspond to the Environmental Exclusion Categories used in Power of Place studies which have sought to enumerate and aggregate environmental land-use impacts associated with renewable development across the US. The low avoidance, medium avoidance, and high avoidance conditions correspond to Power of Place Categories 1, 2, and 3 respectively where 3 (high avoidance) is the most protective of environmental areas. Finally, certain Columbia Plateau specific datasets were additionally included in this study for more precise regional analysis. For the Washington State University composite data, we filtered to identify areas classified as high-conflict, medium-conflict, and low-conflict for each data type (conservation, farmland, ranchland). High-conflict areas were treated as Category 1, medium-conflict areas were treated as Category 2, and low-conflict areas were treated as Category 3. The combined categories are broken down as follows and are inclusive of the previous level:

- **Low Avoidance:** Restrictions on legally protected areas such as National Parks or National Wildlife Refuges. These geographies would be difficult or impossible to develop and are thus excluded as a baseline where no other restrictions are applied. These avoidance areas are given high-cost multipliers that effectively force any potential transmission routes to prefer alternate paths.
- **Medium Avoidance:** Low avoidance plus restrictions on administratively protected lands such as Critical Habitats, wetlands, and Sage Grouse Priority Habitat Management Areas. These are areas where development typically triggers additional environmental review processes or lands owned by conservation groups and NGOs. While transmission development may be possible on these lands the impacts are more significant and may also be slower and more complex.
- **High Avoidance:** Low and medium avoidance plus restrictions on land identified as of high conservation value determined through existing ecoregional analysis. These are geographies such as Important Bird Areas, Prime Farmland, big game habitat and corridors, and Ecologically Core Areas. This additional level of avoidance seeks to incorporate conservation priorities into development decisions even where legal or administrative protections may not exist. Without formal protections, these areas are more likely to have development, however this screen shows development under the most conservation-conscious conditions.

Of the lines in the study, the proposed low-deployment line (Montana-to-Idaho) has a relatively low technical cost multiplier, due to the route's avoidance of mountainous terrain and access to flat agricultural, shrub and scrub land, among patches of forest. The lines in the northern part of the study area tend to have higher technical cost multipliers due to the very steep mountainous terrain, where some areas have the top 1% steepest slopes in the country. The route optimization has identified route modifications that alleviate cost, for example following existing highway, river, and transmission ROW corridors. Often these existing linear features have already identified flatter smoother areas with more ease of construction, and in many places the transmission route optimization does follow these linear features.

Figure 16 below summarizes key siting characteristics as a percent of total line miles in each portfolio/sensitivity. Existing Corridor (%) is the share of route miles that run within ~1 km of existing transmission rights-of-way, indicating opportunities to co-locate or parallel existing corridors. High Environmental Risk (%) is the share of route miles intersecting a wide variety of possible high-sensitivity areas (Categories 1-3) where conservation conflicts and permitting friction are likely higher. Difficult Terrain (%) is the share of route miles crossing mountainous/steep terrain where construction techniques and costs are more challenging. High Fire Risk (%) is the share of route miles through elevated wildfire-risk landscapes, which can influence design, hardening, and operations.

Figure 16: Line Routing Land Metrics

Avoidance Sensitivity	Deployment Scenario	Line Length (mi)	Existing Corridor (%)	High Environmental Risk (%)	Difficult Terrain (%)	High Fire Risk (%)
Low Avoidance	Low (+3GW)	432	58%	2%	18%	38%
	Medium (+9GW)	2,074	75%	9%	36%	21%
	High (+12GW)	2,484	65%	8%	36%	24%
Medium Avoidance	Low (+3GW)	432	58%	2%	18%	38%
	Medium (+9GW)	2,074	75%	7%	34%	23%
	High (+12GW)	2,478	65%	6%	34%	25%
High Avoidance	Low (+3GW)	432	58%	2%	18%	38%
	Medium (+9GW)	2,111	77%	8%	35%	24%
	High (+12GW)	2,533	67%	7%	36%	21%

Increasing the avoidance level did not significantly change results suggesting that there are few options for routing many lines due to the topographically constrained, mountainous environment. Accordingly, the routed lines would likely need to follow corridors like those identified in this study that parallel existing transmission lines or roads. Even so, lines still often encountered difficult terrain and high fire risk. For a full geospatial routing analysis—including methods, datasets, and additional detail on environmental sensitivity—see the companion *Geospatial Analysis for the Montana Regional Transmission Connectivity Study*.

4. Study Findings

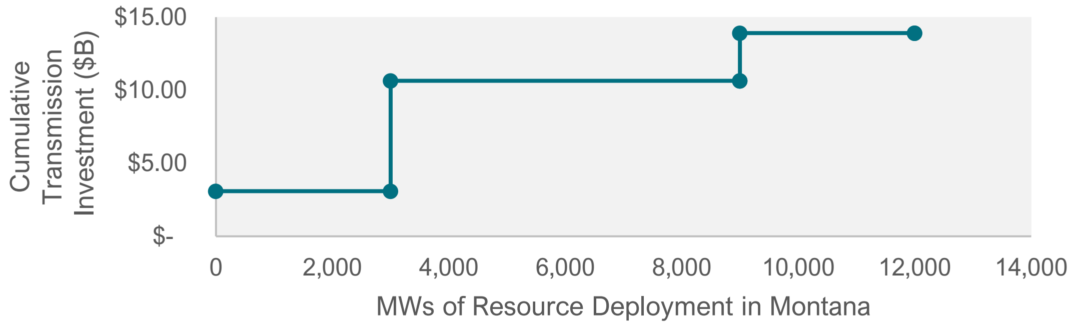
This study highlights the growing need for strategic and coordinated transmission investment to unlock Montana's energy potential and enhance its regional connectivity. Based on the resource deployment scenarios, transmission analysis, and environmental routing and line costing study, the findings outlined in this section aim to inform planners, policymakers, tribal representatives, and other interested stakeholders about near-, medium- and long-term transmission strategies for Montana that can help accommodate generation access and regional reliability. They are intended to help guide a phased transmission expansion approach that is resilient to uncertainty and responsive to evolving system needs and market dynamics.

Key findings for the study include:

1. **Montana's export capability is constrained and insufficient for forecasted levels of resource deployment:** The Montana system is unable to accommodate the study's resource deployment scenarios which forecast 3, 9 and 12 GW of new capacity in Montana. Existing transmission paths (Path 8, Path 18, Colstrip system, etc.) are fully subscribed with negligible long-term available transfer capacity (ATC) to deliver new resources to neighboring systems and states, including BPA, PacifiCorp and Idaho Power. The study considered existing transmission commitments as well as major planned regional transmission projects (and forecasted generation additions in Montana) in assessing this transmission deficiency.

2. **Phased and coordinated transmission expansion can unlock Montana's resource development potential:** Expansion within Montana and new connections into neighboring states support the resource development scenarios explored in this study. Strategic sequencing of upgrades allows for incremental investment over time, aligning infrastructure expansion with resource development timelines and long-term market demand. *Figure 17* below, which summarizes the cumulative investment cost associated with unlocked incremental tranches of resource access, demonstrates how transmission investments can be sequenced and coordinated to accomplish a long-term goal through short-term actions.

Figure 17: Transmission Cost Supply Curve for Montana Resource Deployment Scenarios



3. **The Low Resource Deployment scenario (+3 GW) is enabled with a new Montana-Idaho intertie:** To accommodate the Low Deployment scenario, a transmission portfolio featuring a new HVDC line connecting the Colstrip transmission system to the Midpoint substation in Idaho was identified as the most efficient expansion strategy. The portfolio also includes series capacitor upgrades along Path 8, effectively mirroring upgrades from BPA's planned Montana-to-Washington project. This greenfield line into Idaho provides an alternative electrical path to the Pacific Northwest, access to other western markets at Midpoint, and improves system reliability. The HVDC bi-pole line was selected primarily due to its ability to avoid transmission needed in the Medium and High Resource Deployment scenarios. The Low Resource Deployment transmission portfolio costs roughly $3.1 billion and features 432 miles of HVDC transmission expansion plus capacitor upgrades on two existing lines and reactive support.

4. **The Medium Deployment (+9 GW) scenario requires $7.6B of additional upgrades:** Including the upgrades in the Low Deployment portfolio, transmission investment in the Medium Deployment scenario totals $10.7 billion, featuring 1,647 miles of new transmission and 437 miles of reconductoring projects. Major upgrades in this portfolio include a new Garrison-Little Goose 500-kV line, a new 500-kV system through Great Falls, and a new Taft-Bell-Ashe 500-kV line. All of these lines are built with advanced conductors to maximize their power throughput and use of the right-of-way. Proposed reconductoring of the Taft – Dworshak line is also reflected in BPA's Montana-to-Washington project. Expansion into the Great Falls area is heavily driven by assumptions made regarding the location of resources. The portfolio includes multiple greenfield AC corridors between Montana and Pacific Northwest, with different line termination points, to prevent any transmission bottlenecks or "common corridor" concerns.

5. **The transmission portfolio for the High Deployment scenario (+12 GW) represents a long-term expansion plan for the state:** Building upon upgrades in the Low and Medium deployment scenarios, the transmission portfolio for the High Deployment scenario totals $13.9 billion, featuring 2,021 miles of new transmission and 467 miles of reconductoring projects. Major upgrades in this portfolio include a new Colstrip to Townsend HVDC line, and a new Taft-Hatwai 500-kV line. The AC lines are built with advanced conductors to maximize their power throughput. The new HVDC line is driven by need for efficient and more controlled transfer

power from additional resources located at Colstrip. Assumptions about the incremental 3 GW of capacity at Colstrip drive this portion of the transmission expansion. Ultimately, this transmission portfolio should be considered a long-term expansion plan and would be subject to revaluation through many planning processes.

6. **The HVDC line between Montana and Idaho could help avoid longer-term upgrades at higher resource deployment levels:** The Montana-Idaho line in the Low Deployment scenario is foundational to increasing Montana export capacity as it provides an alternative and redundant route between Montana and other western markets, including the Pacific Northwest. An HVDC line, while having slightly higher upfront costs, may provide significant cost reductions on future transmission infrastructure needed at higher resource deployment levels. This is because, unlike AC lines, HVDC line converter stations can better control flows, sending power south to Idaho and its highly connected grid rather than through the constrained Path 8. Avoided transmission infrastructure due to constructing DC instead of AC includes the Garrison-Taft 500kV #1 line reconductor and additional reactive support. By building the Montana-Idaho line with HVDC instead of AC, we forecast the potential to avoid seven projects in the High Deployment scenario, totaling $108M in avoided costs. An HVDC line on the Montana-Idaho corridor also has synergies with large-scale needs from resources injecting at Colstrip or from the Eastern Interconnection.

Figure 18: Comparison of Total Portfolio Costs Assuming AC vs. DC on Montana-Idaho Corridor

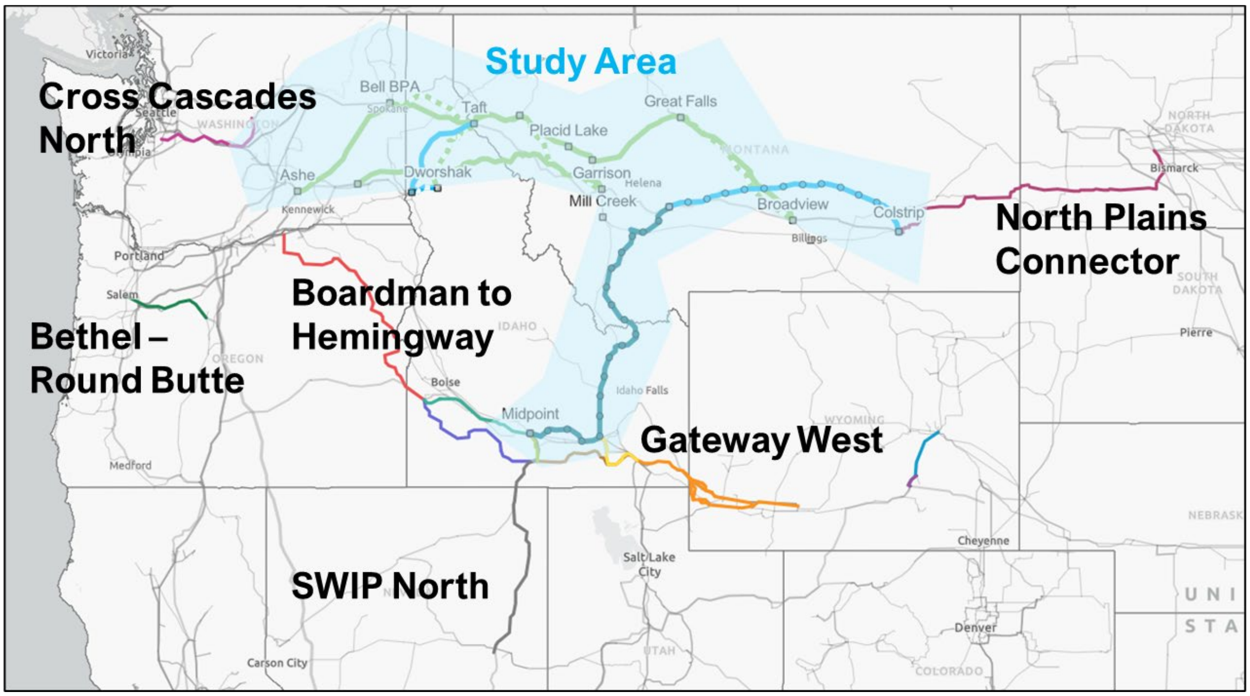
Deployment Scenario	Total Power Flow Out of Montana (MW)	Number of Transmission Upgrades Needed	Cost of Transmission Upgrades ($M)
Existing	2,583	0 (10-yr Planned Tx Included)	
Low (M2I AC)	4,850	8	$2,929
Low (M2I HVDC)	5,311	7	$3,086
Medium (M2I AC)	7,034	26	$10,834
Medium (M2I HVDC)	9,243	16	$10,654
High (M2I AC)	13,086	32	$14,013
High (M2I HVDC)	13,108	25	$13,905

Savings: $108 M

Due to this efficiency, this study assumed an HVDC configuration. However, an AC configuration could be more efficient assuming either (1) a low deployment future for Montana or (2) a near-term focus for grid expansion

7. **The transmission portfolios increase the connectivity of the Western grid:** The transmission expansion portfolios identified are strategically aligned with several major projects currently planned or under construction across the West. By linking these new Montana upgrades with recently completed and anticipated projects—including Gateway West, Boardman-to-Hemmingway, SWIP North, and North Plains Connector—these portfolios strengthen the regional transmission network. The resulting configurations enable Montana resources to access a broader set of markets with the added benefit that Montana can also source electricity from other markets. Collectively, the portfolio investments establish a new high-voltage backbone from North Dakota to Washington, increasing the West's ability to integrate resources and loads across the region.

Figure 19: Transmission Portfolio Integration with Planned Projects



8. **A diverse set of transmission technologies improves portfolio efficiency and flexibility:** The study found that deploying a mix of transmission technologies enhanced the performance, efficiency, and flexibility of the transmission portfolios. As summarized in *Figure 20* below, the transmission solutions adopted in each scenario varied, with higher deployment scenarios leveraging a broader range of technologies to address system needs.

Figure 20: Summary of Technologies Adopted by Portfolio

Deployment Scenario	Solution Type Adopted in Each Transmission Portfolio							
	Greenfield AC	Greenfield HVDC	Reconductor or rebuild	Advanced conductors	Powerflow control devices	Reactive support	Dynamic line ratings	Storage as a transmission asset
Low	✗	✓	✗	✗	✓	✓	✗	✗
Medium	✓	✓	✓	✓	✓	✓	✗	✗
High	✓	✓	✓	✓	✓	✓	✗	✗

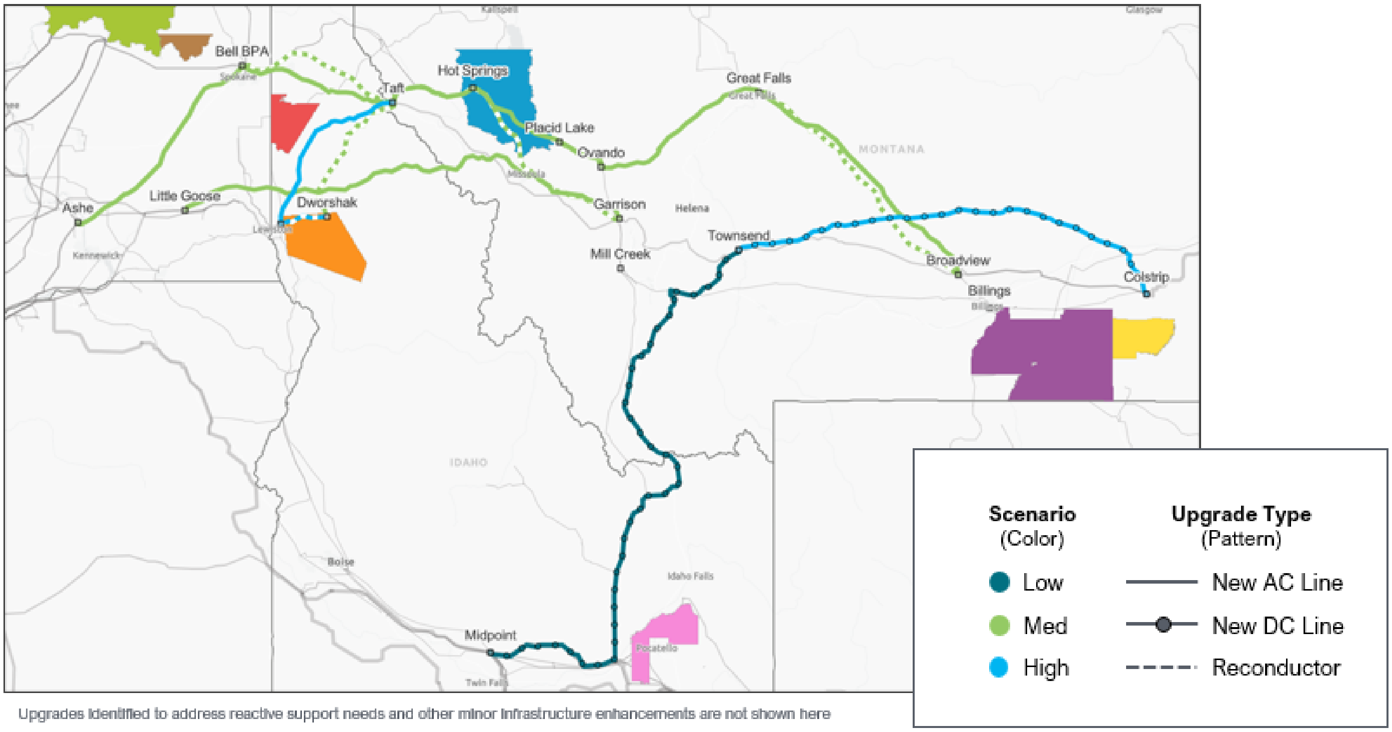
Where feasible, existing rights-of-way were prioritized for reconductoring or rebuilding to minimize land use and permitting hurdles. In some cases, new AC and HVDC corridors were added to create parallel paths, to avoid creating new reliability issues, or to connect new portions of the system. Advanced conductors and power flow control devices were introduced in higher build scenarios to optimize transfer capabilities and reduce congestion impacts. Finally, storage-as-transmission and dynamic line ratings were evaluated but ultimately excluded from the portfolios. These technologies were deemed ineffective in providing sufficient incremental capacity to support Montana's needs under the study's assumptions. In the case of storage, operations in charging or discharging mode were unable to increase the transfer capability of the system – a requirement for delivering the resource portfolios. Since the most limiting grid conditions were studied, dynamic line ratings also did not offer any capacity increase.

9. **Environmentally and culturally sensitive areas can be reduced and avoided, but impacts cannot be avoided altogether:**
   Using least cost path analysis, we identified low, medium, and high impact avoidance scenarios. Putting maximum emphasis on avoiding environmentally sensitive areas increases cost by ~6%, but helps avoid 15% of sensitive areas. Similarly, cost increases for lines traversing mountainous terrain can be reduced, often by following linear features like rivers and roads, but they cannot be eliminated altogether. Using least cost path analysis, this study identified line routes that avoid some but not all areas of difficult terrain, wildfire risk, and environmental and cultural sensitivity.

10. **Much work remains to improve consideration of tribal lands in transmission planning:**
    The study's line routing methods took into account Native American Indian reservation lands treating these culturally sensitive areas as avoidance areas. *Figure 21* shows the proximity of this study's high deployment scenario to tribal reservations.

    The study did not introduce any strict constraints to avoid reservations, nor did the study's authors have datasets regarding sensitive tribal lands or cultural resources that may be outside of reservation boundaries. For these reasons, and others, the study's results offer only a preliminary look at how tribal lands interface with the proposed modeled transmission projects. Further engagement with tribal representatives is needed to develop better understanding and to develop corresponding data regarding preferred corridors for avoidance of cultural sensitivities in this region.

Figure 21: Tribal Reservation Lands and High Deployment Transmission Portfolio



Study Limitations & Additional Considerations

Readers should recognize that this study, like all transmission assessments, has certain technical limitations that add context to the findings and analysis covered in this report. Several of these limitations are covered below.

Remedial Action Schemes (RAS)

The study did not assume expanding the Colstrip/MT RAS to make additional resources deliverable under N-1 conditions. Our objective was to identify transmission that can reliably transfer resources without curtailment during single contingencies, so those resources can count for regional resource adequacy and be relied on during times of system stress (including grid stress). A corollary is that new transmission reduces reliance on RAS. We did not perform transient/dynamic stability studies (e.g., oscillatory stability, voltage recovery, fault ride-through); so, these results should be interpreted as steady-state power-flow findings.

Transmission Scope

As outlined in Appendix A, the portfolios do not identify all transmission that may be needed over the planning horizon and may therefore understate total investment. We did not evaluate upgrades downstream of line termini (e.g., internal reinforcements in receiving systems) or focus on local T&D

constraints (distribution, local reliability criteria, protection settings). The study excludes lower-voltage facilities, local systems, and generator tie-lines, and it does not model expanded demand response/behind-the-meter storage as substitutes for transmission or perform detailed market-design analyses.

Directional Emphasis

The analysis did not evaluate delivering resources into Montana; routing and transfer assumptions emphasized deliveries from Montana to the PNW and beyond, which influences the distribution of modeled benefits and constraints. While not evaluated in this study, each of the transmission expansion phases would likely provide substantial improvements in grid stability and reliability for Montana customers, as well as providing transfer capacity for economic needs such as new data center and industrial facilities.

Data and Siting Uncertainties

Corridor expansion versus reconductoring/rebuild was assessed with imperfect information. The geospatial screening and cost surfaces simplify real-world constraints; permitting, environmental, cultural, and land-use outcomes may differ in detailed development. Results are sensitive to 2035 Benchmark resource and transmission assumptions, which are outlined in detail in *Appendix A*. Different siting, timing, or policy pathways could change optimal routes and benefits.

5. Appendix A

Study Scope

This study focuses on Montana's high-voltage transmission system (>200 kV) and its primary interfaces with the Pacific Northwest and Idaho. Specifically, the analysis covers:

- The Colstrip Transmission System
- WECC Path 8 (Montana–Northwest)
- WECC Path 18 (Montana–Idaho)
- BPA's Eastern Intertie
- BPA's West of Hatwai flowgate
- Other in-state transmission facilities above 200 kV

The study does **not** evaluate:

- Transmission in Montana on inter-state seams that is less than 200-kV
- Local transmission issues on Northwestern's system
- Generator interties required to interconnect the generation explored in the study
- WECC Path 80, which connects Montana and Wyoming[10]
- WECC Path 83 (Montana-Alberta)
- Other upgrades necessary in Idaho, Oregon, or Washington necessary to deliver resources to load centers in the Pacific Northwest

Montana Transmission Intertie Definitions

The two primary WECC paths and their definition and current transfer limits for these areas are summarized below.

Figure 22: WECC Path 8 & 18 Elements and Ratings

Path	Elements	Rating
8	• Broadview-Garrison 500kV #1 • Broadview-Garrison 500kV #2 • Mill Creek-Garrison 230kV • Mill Creek-Anaconda 230kV • Ovando-Garrison 230kV • Rattlesnake-Dixon 230kV • Rattlesnake-Garrison 230kV • Kerr-Kalispell 115kV • Thompson Falls-Burke 115kV	East-to-West: 2,200 MW West-to-East: 1,350 MW

[10] Due to the relatively small size of energy markets in Wyoming, increasing Path 80 capacity was not a focus of the study but is something that would similarly support Montana reliability and import/export capability.

Path	Elements	Rating
	• Crow Creek-Burke 115kV • Placid Lake-Hot Springs 230kV	
18	• Dillon Salmon – Big Grassy 161 kV • Peterson Flats – AMPS 230 kV	North-to-South: 383 MW South-to-North: 256 MW

Transmission Included in Benchmark Case

Figure 23: Planned Transmission Projects

Project Name	Ownership
Bell-Boundary 230kV Line #3 Upgrade	BPA
Northern Mid-Columbia Area Replacement	BPA
North Plains Connector	NPC
Great Falls Eastside tie-in	NWE
Three Rivers 161/100kV Transformer Upgrade	NWE
Trident-Belgrade West 50kV Cutover to 161kV	NWE
Bitterroot Initiative - Hamilton Heights Banks	NWE
Bitterroot Initiative - South Side Capacitor	NWE
Helena Forestvale Substation	NWE
Loco Mountain Substation	NWE
Gateway West (Segments D3, E and E8)	PacifiCorp
Longhorn to Hemingway (Formerly Boardman to Hemingway)	PacifiCorp/ Idaho Power
Add a second 500/345kV transformer to Midpoint station	Idaho Power
Add Kinport – Midpoint 345kV Series Capacitor	Idaho Power
Hemingway - Bowmont #2 230 kV line	Idaho Power
Hubbard - Bowmont 230 kV line	Idaho Power
Upgrade Hemingway – Midpoint 500kV series capacitor	Idaho Power
Burns 500kV Reactor Station Replacement	PacifiCorp

Project Name	Ownership
Corral (Full Circle) to Grassland Annex (Apex) 500kV Line	PacifiCorp
Corral (Full Circle) to Snow Goose 500kV Line	PacifiCorp
Grassland Annex (Apex) to B2H Tap (Maverick) Substation 500kV Line	PacifiCorp
Walla Walla Add 3rd 230/69kV Transformer	PacifiCorp
Garden Springs Station	Avista
Lolo Transformer Replacement	Avista
SWIP-North	LS Power

Montana Generation Included in Benchmark Case

Figure 24: Planned and Anticipated Generation Included in Benchmark Case

Gen Name	MW Max	Fuel Type	POI Substation
Apex Solar + ES	200	Solar + BESS	Dillon Salmon 161kV
Basin Creek	53.1	NG	Butte MHD 161kV
BGI Gen	65	NG	Billings Exxon 50kV
Big Timber Wind	25	Wind	Columbus-Rapelje – Big Timber 161kV
Black Eagle	30	Hydro	Great Falls Riverview 100kV
Canyon Ferry	58.5	Hydro	Canyon Ferry 100kV
Clearwater Wind	775	Wind	Colstrip 500kV
Cochrane	66	Hydro	Crooked Falls 100kV
Colstrip 3	740	Coal	Colstrip 500kV
Colstrip 4	740	Coal	Colstrip 500kV
Dave Gates	150	NG	Mill Creek 230kV
Fairfield Wind	10	Wind	Power 69kV
Fort Peck	108	Hydro	Fort Peck 69kV
Glacier Wind	210	Wind	Glacier SWYD 115kV
Gordon Butte Wind	20	Wind	Gordon Butte 100kV
Greenfield Wind	25	Wind	Power 69kV
Hardin	116	Coal	Hardin Auto 115kV
Hauser	20	Hydro	Hauser 69kV

Gen Name	MW Max	Fuel Type	POI Substation
Horseshoe	9	Wind	Horseshoe Tap 100kV
Holter	60	Hydro	Holter 100kV
Judith Gap Wind	135	Wind	Judith Gap South 230kV
Libby	604	Hydro	Libby 230kV
Madison	15	Hydro	Madison 100kV
Montana One	41.5	Unknown	Montana One 115kV
Moroney	49	Hydro	Crooked Falls 100kV
MT Sun	82	Solar	Alkali Creek 230kV
Musselshell	20	Wind	Broadview-Harlowton 100kV Line
Mystic	12	Hydro	Line Creek 50kV
Noxon Rapids	578	Hydro	Noxon 230kV
Pryor Mountain Wind	230	Wind	Pryor Mountain 230kV
Rainbow	62	Hydro	Crooked Falls 100kV
Rimrock	189	Wind	Rimrock East 230kV
Ryan	69	Hydro	Crooked Falls 100kV
Seli's Ksanka Qlispe' (formerly Kerr)	212	Hydro	Kerr 115kV
South Peak	80	Wind	Spion Kop SWYD 230kV
Spion Kop	40	Wind	Spion Kop SWYD 100kV
Stillwater	80	Wind	Columbus-Rapelje – Wilsall 230kV
Tiber	8	Hydro	Tiber 115kV
Thompson Falls	94	Hydro	Thompson Falls 115kV
Toston Dam	10	Hydro	Broadwater 100kV
Turnbull	13	Hydro	Turnbull 69kV
Two Dot	11	Wind	Two Dot Tap 100kV
Yellowstone Energy	52	Petroleum	Laurel Auto 100kV
Yellowtail	300	Hydro	Yellowtail East 230kV
Battle Butte	130	Solar + BESS	Columbus-Rapelje 230kV
Beaver Creek	315	Wind + BESS	Columbus-Rapelje – Wilsall 230kV

Gen Name	MW Max	Fuel Type	POI Substation
Broadview Solar	380	Solar + BESS	Broadview 230kV
Glacier BESS	75	BESS	Glacier Switchyard 115kV
Haymaker Wind	600	Wind	Broadview-Townsend 500kV
Judith Gap Solar	150	Solar + BESS	Judith Gap Tap 100kV
Meadowlark Solar	20	Solar	Alkali Creek 161kV