Montana's Electric Transmission and Distribution Grid

The electric transmission and distribution grid serves the vital function of moving power from generating plants to customers and their electric loads (demand).[49]The grid reliably provides this service even when individual elements of the transmission grid are out of service. Ownership and the rights to use the transmission system are complex matters. The use is further complicated by line congestion on in-state and interstate lines. The methods by which electricity flows on the lines is changing over time. Electric transmission also faces increasing regulation at the national level, new markets at the regional level, and increasing amounts of variable generation on the system. The construction of new in state and out-of-state transmission lines to expand the capacity of the current grid and make new Montana power generation possible also provides a challenge, raising questions about property rights, economic development, and whether new lines are actually needed.

Basics of the Grid

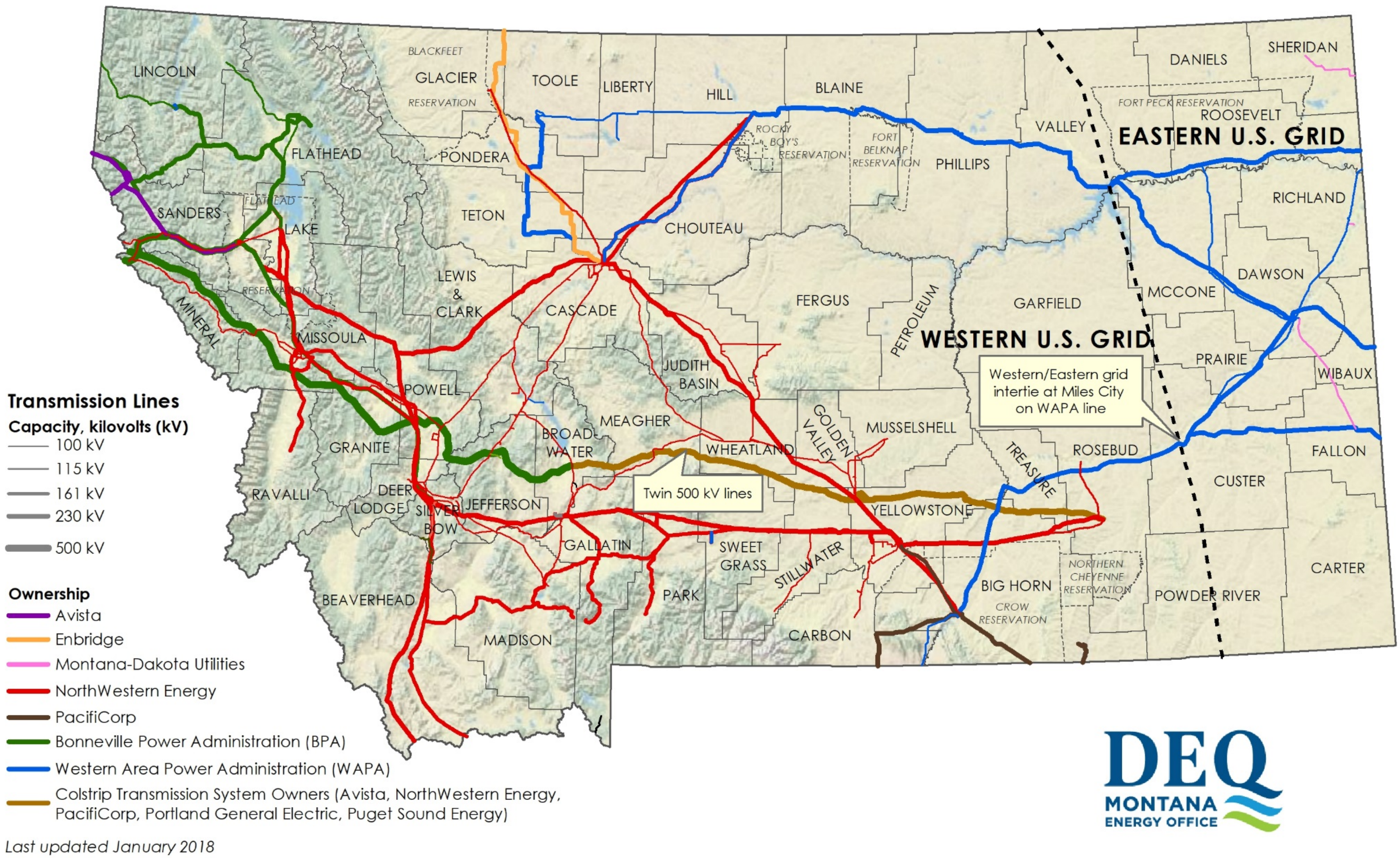
- Transmission lines are high voltage lines, usually 69 kV and above, that deliver electricity over long distances. The power on these lines is usually stepped down to a lower voltage to serve demand. Distribution lines are those lines that are smaller than 69 kV and deliver power directly to cities, homes, and businesses. Transmission lines are typically seen on large metal or wooden structures high above the ground. Distribution lines are typically found in neighborhoods and along highways on much smaller wooden poles.
- NorthWestern Energy runs the largest transmission balancing area in Montana. The Bonneville Power Administration operates a large system in the northwest part of the state. The Western Area Power Administration runs part of that system in the northeast and eastern region of the state. Most distribution in Montana is operated by NorthWestern Energy, one of 25 coops, or Montana Dakota Utilities. Montana spans parts of both the Eastern Grid and Western Grid.

Transmission in Montana

The transmission network in Montana, as in most places, initially developed because of local decisions in response to a growing demand for power. The earliest power plants in Montana were small hydroelectric generators

[49] Electric loads are referred to as electricity demand.

Montana Transmission Lines



DEQ MONTANA ENERGY OFFICE

and coal-fired steam plants built at the end of the nineteenth century to serve local needs for lighting, power, and streetcars. The earliest long-distance transmission lines were built from the Madison hydroelectric plant, near Ennis, to Butte and from Great Falls to Anaconda. The latter was, at the time of construction, the longest high-voltage (100 kilovolt or kV) transmission line in the country, and is still operational today. These first lines were built to service the mining and smelting operations in the Butte-Anaconda area.

The Montana Power Company (MPC) presided over Montana's first integrated transmission system. As the transmission system grew, the MPC expanded its network to include 161 kV lines and ultimately a 230 kV backbone of lines. The federally owned Western Area Power Administration (WAPA) electric transmission system in Montana began to transport electricity to Fort Peck in the 1930s during construction of the dam there and then to move power to markets following construction of the generators at the dam. WAPA's system continued to grow in northern and eastern Montana as its needs to serve rural electric cooperatives expanded.

Long-distance interconnections between Montana and other states did not develop until World War II. During the war, the 161 kV Grace Line was built from Anaconda south to Idaho. Later, BPA extended its high-voltage system into the Flathead Valley to interconnect with Hungry Horse Dam and to serve the now-defunct aluminum plant at Columbia Falls. In the mid-1980s, a double-circuit 500 kV line was built from the Colstrip generating plant in eastern Montana to the Idaho state line near Thompson Falls where it connects into two separate 500 kVs lines that head into Washington State. The double circuit 500 kV lines are Montana's largest. By 2002, the MPC sold its generation, transmission, and energy holdings, becoming Touch America. Its transmission assets were purchased by NorthWestern Energy (NWE) and most of its generation was sold to PPL Montana.[50]

Most intrastate electric transmission in Montana is currently owned by NWE and WAPA. BPA has major interstate lines in northwest Montana and PacifiCorp owns a few smaller interstate lines as does Avista. WAPA lines in eastern Montana cross into North Dakota and serve local Montana loads in the eastern portion of the state. In most cases, MDU's distribution service uses WAPA transmission lines and in a few cases co-owns the line. The electric distribution cooperatives in Montana not served by a major utility use the NWE, MDU, BPA, and WAPA lines for transmission.

[50] In 2014, PPL Montana sold its hydroelectric generation assets to NorthWestern Energy.

Montana is an electricity export state. Currently, the state's net electricity exports are almost equal to the amount of electricity consumed in the state each year. For example, in 2015, Montana generated 29,104 GWh and consumed just 14,207 GWh.[51] There are four primary electric transmission paths that connect Montana to the rest of the Western Interconnect and larger markets in the West.[52] These paths are:

- Montana to the Northwest – Path 8
- Montana to Idaho – Path 18
- Montana Southeast – Path 80[53]
- Montana to Alberta—Path 83

Typically, power flows from east to west over Path 8, north to south over Paths 18 and 80, and varies on Path 83. Directionally, energy on these transmission lines typically flows from Montana to out-of-state loads, although on occasion electricity flows into Montana on these same lines. There is no official "path" leaving the most eastern portion of the state. It is important to note that Path 8 is very large, rated at 2200 MW east-to-west, whereas Path 18 is rated at 383 MW north-to-south. The Montana Alberta Tie Line path is rated at approximately 300 MW in both directions at this time and the transfer between Western and Eastern grids at Miles City are rated at 200 MW. It is also important to note that these path ratings change over time.

As U.S. and Canadian utilities grow increasingly dependent on each other for support and reliability, the North American transmission network has developed into two major interconnected grids, divided roughly along a line that runs through eastern Montana south to Texas. The western United States is a single, interconnected, and synchronous electric system that will be referred to in this chapter as the U.S. Western Grid. Most of the eastern United States is a single, interconnected, and synchronous electric system as well (U.S. Eastern Grid). Texas and parts of Quebec are exceptions. Texas is considered a separate interconnection with its own reliability council and is referred to as ERCOT.

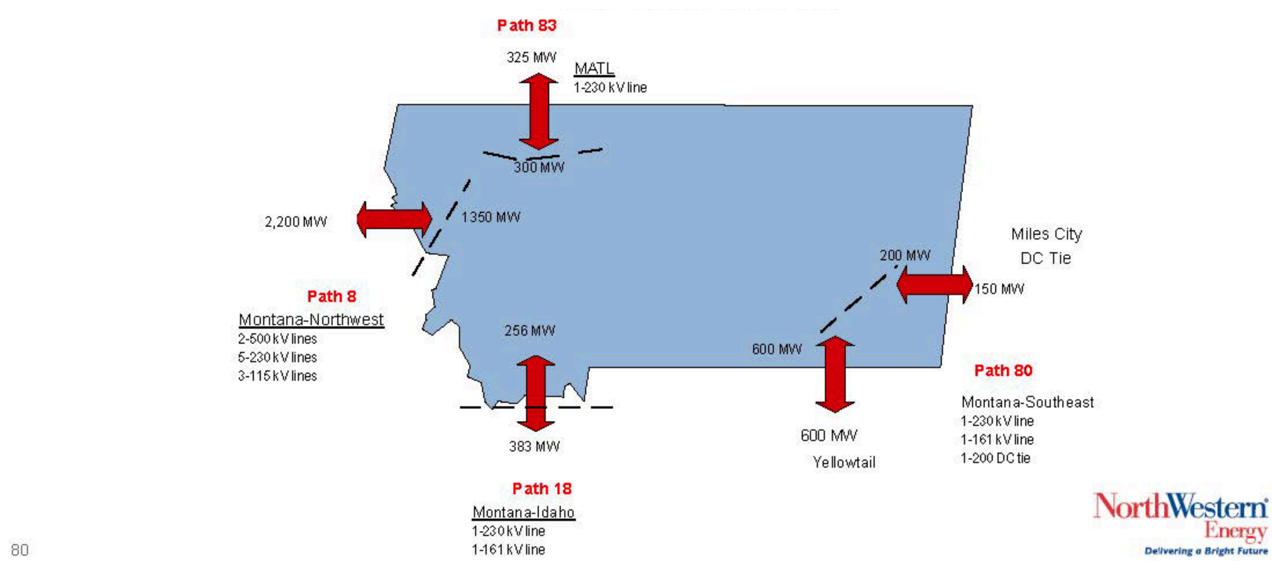
---

[51] U.S. EIA; "consumed" referred to electricity sales. It is possible that slightly more was actually consumed in-state

[52] Transmission "paths" are groups of parallel transmission lines that carry power within the same general areas.

[53] WECC 2013 Path Rating Catalog, http://www.wecc.biz/library/Pages/Path%20Rating%20Catalog%202013.pdf.

Figure 7. WECC-Rated Paths



Source: NorthWestern Energy. Note the MW capacity numbers could change over time

The Eastern and Western grids are not synchronous with each other. The two grids are only weakly tied to each other with converter stations. One of these stations is located at Miles City. The station is capable of transferring up to 200 MW of electricity in either direction from one grid to another.[54] Depending on transmission constraints, a limited amount of additional power can be moved from one grid to the other by shifting hydroelectric generation units at Fort Peck Dam.

Figure 8. U.S. Western Interconnection-Major Lines

Most of Montana is integrally tied into the U.S. Western Grid. The easternmost part of the state, with less than 10 percent of total Montana load, is part of the U.S. Eastern Grid and receives its power from generators located in that grid, including generators as far away as the east coast.

Certain transmission lines in Montana are regulated under the Montana Major Facility Siting Act (MFSA) administered by the Montana Department of Environmental Quality (DEQ). MFSA works to ensure the protection of the state's environmental resources, ensure the

[54] Donald G. Davies, Chief Senior Engineer, Western Electricity Coordinating Council.

consideration of socioeconomic impacts from regulated facilities, provide citizens with an opportunity to participate in facility siting decisions, and establish a coordinated and efficient method for the processing of all authorizations required for regulated facilities. In general, electrical transmission lines greater than 69 kV and longer than ten miles in length are covered under MFSA if they meet certain criteria. Historically, the Montana PSC has jurisdiction over cost recovery for new transmission projects that serve Montana retail customers, but not over siting decisions.

How the Transmission System Works

There are big differences between the physical properties and economics of a typical alternating current (AC) electrical transmission system, as well as between its commercial operation and management. The flow of power on a transmission network (the charge of electrons) obeys the laws of physics. The commercial transactions that ship power across the grid follow a different, and not fully compatible, set of rules from the actual flow of power.

Transmission "paths" are generally groups of more or less parallel transmission lines that carry power within the same general areas. A given transmission path can consist of one or more transmission lines that transport electricity from one major electricity "node" to another. Nodes may consist of large generators, large loads, or a major substation. For example, the two transmission lines that run from the Dillon, MT area into Idaho, the Grace line and the AMPS line, form what is called "Path 18".

The transmission grid is sometimes described as an interstate highway system for electricity, but the flow of power on an AC grid differs in very significant ways from the flow of most physical commodities. When power is sent from one point to another on the transmission grid, the power will flow over all connected paths on the entire network (e.g. The Western Grid), rather than a single path (the scheduled path) or even the shortest distance path. A power transmission from one point to another will distribute itself so that the greatest portions of that power flow over the paths (transmission lines) of lowest resistance. The resistance or impedance of a given transmission line depends on its voltage and current. Power flows generally cannot be constrained to any particular physical or contract path, but instead follow the laws of physics. It should be noted, however, that there are tools available to redirect some flows of power under certain economic or extreme circumstances.

Electric power flows in opposite directions also net against each other. If traffic is congested in both directions on an interstate highway, it will come to a halt in all lanes and not a single additional vehicle will be able to enter the flow. By contrast, if 100 MW is shipped westbound on a given transmission line from point A to point B and 25 MW is sent simultaneously eastbound on that same line from point B to point A, the actual measured flow on the line is 75 MW in a westbound direction. If 100 MW is sent in each direction on the same line at the same time, the net measured flow is zero. In this situation, additional power could still physically flow in either direction up to the full capacity of the line in that particular direction.

Electric power also travels near the speed of light and is generally consumed at the same moment it is generated. Almost all generated power distributed over the grid must be consumed instantaneously off of the grid.[55] Unlike gas, oil, coal, and other energy sources, electricity currently cannot yet be stored economically as inventory in large quantities. As a result, transmission operators constantly balance electricity supply (generation) and demand (consumption) in every moment. This is a complicated process that involves significant labor and technology, complicated balancing routines, numerous transmission jurisdictions, and federal and state oversight.[56] The fact that almost all power generated on the grid must be consumed instantaneously is the reason why steady generation sources fueled by coal or flexible resources such as natural gas (that can ramp up and down) are often easier to manage than some renewable sources such as wind and solar, whose generation levels vary with the weather and are not under the control of grid operators. It is, in part, because of the constant need to balance supply and demand that the electric transmission system has been called the most complicated machine on the planet. As battery technology quickly progresses, higher levels of electricity storage are becoming a reality, but still remain a small fraction of total power being delivered.

The actual physical flows on a grid are the net result of all generators and all loads (electricity demands) on the network at a given instant in time. In any real transmission network, there are many generators located at hundreds of different points on the network and many loads of varying sizes located at thousands of different locations. Because of netting flows, actual path loadings at any given moment depend on the amounts and locations of electric generation and load as opposed to the contracted schedules in place at a given time. Actual path capacity loads are also impacted by congestion of certain lines or paths on the grid and outages on the grid. For example, Path 8 has a 2,220 MW path rating east to west under ideal conditions, but often has a lower rating under various grid and weather conditions.

In contrast with the physical reality of the transmission network, management of transmission flows has historically been by "contract path". A transaction involving the shipment of power between two points, referred to as the contract path, is allowed to occur if space has been purchased on any path connecting the two points. Purchasers include the utilities or companies

---

[55] With current technology, a small fraction of generated power can be stored in flywheels, in salt caverns (usually associated with wind power), in melted salts (solar farms), in large batteries, and in pumped storage.

[56] There are several high-tech and human mechanisms for balancing supplies and demand on the entire Western Grid and within individual operating areas, like NWE's balancing authority in Montana. There are also new technologies being developed to economically allow the storage of large quantities of electricity on the grid, but they are not available yet.

owning the lines or the entities holding rights to use those wires along that path at any given hour of the year (firm rights). Purchasers may also include entities that do not own firm rights, but want to use the grid on a short-term basis when available.

In a perfect world, such transactions flow on the contract path agreed to by the interested parties. Due to the laws of physics that ultimately govern the grid and grid conditions at any given time, however, portions of any contracted transaction flow along other paths aside from the contracted path. These are "unscheduled flows". An unscheduled flow is the result of the difference between the physics of the transmission system and the scheduling paradigm (contract rights). Inadvertent flows are also flows that are not scheduled but can be caused by a variety of events, including, but not limited to unplanned loss of generators or load, data errors, and scheduling errors.[57]

On the Western Grid, major unscheduled flows occur around the entire interconnection at any given moment. For example, power sent from hydroelectric dams in Washington to California loads flows directly south over the contracted pathways, but also flows clockwise through Idaho, Utah and Colorado into New Mexico and Arizona and then west to California. Power sent from Colstrip in eastern Montana to Los Angeles flows mostly west on Path 8 to Oregon and Washington, via the double-circuit 500 kV line that runs through Garrison and Taft, and then south to California. This westerly path is its contracted path. However, a small amount of Colstrip power also flows over other paths on its way to California including south through Wyoming on Path 80.

Unscheduled flows may interfere with the ability of transmission path owners to make full use of their contractual rights. The Western Electricity Coordinating Council (WECC) addresses unscheduled flows with an unscheduled flow mitigation plan. Utilities (or other transmission owners) whose wires are affected accommodate a certain amount of this unscheduled flow by reducing their available transmission capacity. If further reductions are necessary, the path owners can request an adjustment of flows throughout the interconnection. Path owners can also call for curtailment of schedules across other paths that affect their ability to use their own path.[58]

If scheduled flows do not exhaust a path rating (fill up the line), the unused capacity may be released as "non-firm" transmission capacity. Non-firm capacity is available during only some hours of the year, not during all hours as with firm capacity. Non-firm capacity is generally not purchased far in advance. Owners of transmission capacity who do not plan to use extra room on their lines can in some instances release it early. Owners, however, are often reluctant to do so because of needs for flexibility or a desire to withhold access to markets from competitors.

---

[57] Byron Woertz, WECC, Manager, System Adequacy Planning

[58] Ibid.

At least some of Naturener's wind farm power in north-central Montana has used non-firm transmission line room in the past to move power to the coast.

Transmission adds monthly charges to electricity bills and can result in different electricity costs across regions. Electricity prices are impacted by the cost of transmission service to move power from one area to another. For example, a generator in Montana who wishes to sell to the Mid-Columbia (Mid-C) market, the major electricity trading hub closest to Montana and located in Washington, pays transmission charges on the NWE system and then on either the BPA or Avista system. These charges are necessary to transmit, or "wheel", the power from the NWE system area to Mid-C. [59] These additional costs mean that the wholesale-priced power from generation in NWE's territory for local Montana consumption is generally sold in Montana at a discount relative to the Mid-C market price for electricity because of the avoided transmission charges of sending that power into the Mid-C hub. In this manner, transmission pricing is integrally linked to electricity pricing throughout the region and the country. If transmission in a certain area tends to be congested, this can lead to higher electricity prices in areas that import that electricity (such as Southern California).

Jurisdiction over transmission rates resides both with state utility regulators and with the Federal Energy Regulatory Commission (FERC), depending on circumstances. In the case of NWE, transmission rates for bundled retail customers are determined by the Montana PSC. Wholesale transactions that use NWE's transmission facilities pay the FERC-regulated transmission price. A standard feature of FERC-regulated transmission service is the Open Access Transmission Tariff (OATT). Each FERC-regulated transmission provider, including NWE and BPA, posts the terms and conditions of its transmission service in its FERC-approved OATT. The OATT identifies various transmission product offerings, including network integration service, point to point (PTP) transmission service, and ancillary services.

PTP transmission service allows a transmission customer to wheel power to and from distinct locations. Ancillary services are services needed to support transmission service and maintain reliable operation of the transmission system. Each transmission provider's OATT includes terms and pricing for ancillary services that are required to support transmission service and maintain system balance. In general, FERC's treatment of these services is standardized across the country.

---

[59] In electric power transmission, **wheeling** is the transportation of electric energy (megawatt-hours) from within an electrical grid to an electrical load outside the grid boundaries. The two types of wheeling are a wheel-through, where the electrical power generation and the load are both outside the boundaries of the transmission system and a wheel-out, where the generation resource is inside the boundaries of the transmission system but the load is outside. Wheeling often refers to the scheduling of the energy transfer from one Balancing Authority to another. https://en.wikipedia.org/wiki/Wheeling_(electric_power_transmission)

Grid Capacity and Reliability

The amount of power that a transmission line can carry is limited by several factors, including its thermal limit. When electricity flows get high enough on a particular line, the wire heats up and stretches, eventually sagging too close to the ground or to other objects. Arcing -- electricity traveling to the ground -- may result. When that happens, the transmission line can fail, instantly stopping electricity flow and affecting the rest of the grid. Inductive characteristics on a line are associated with magnetic fields that constantly expand and contract in AC circuits wherever there are coils of wire, including transformers. This is not an issue for DC transmission lines.

The most important reason for determining the total amount of power that a line can carry is reliability. Reliability is the ability of the transmission system to provide full, uninterrupted service to its customers despite the failure of one or more component parts of that system. The transmission network is composed of thousands of elements that are subject to failure. Causes include lightning, ice, pole collapse, animals shorting out transmission lines, falling trees, vandalism, and increasingly terrorism (including cyber-attacks). Reliability of the grid is ensured by building redundancy into it. The grid is designed to withstand the loss of key elements and still provide uninterrupted service to customers.

Reliability concerns limit the amount of power that can be carried over a line or path to the amount of load that can be served with key elements out of service on the grid. Within NWE's service area in Montana the reliability of the transmission system is evaluated by computer simulation through long-term transmission planning. The network is simulated at future load and generation levels while taking key individual elements out of service. The simulation determines whether all loads can be served with voltage levels and frequencies within acceptable ranges. If acceptable limits are violated, the network must be expanded and strengthened. Typically, this entails adding transmission lines to the system, replacing components of the system, or rebuilding existing lines to higher capacities.

Most major paths are rated in terms of the amount of power they can carry based on their strongest element being unavailable. In some cases, the reliability criteria require the ability to withstand having two or more elements out of service. The Colstrip 500 kV lines west of Townsend are a double-circuit line, but they cannot reliably carry power up to their thermal limit because one circuit may be out of service and because both circuits are on the same towers (increasing the chance of a wildfire or other catastrophic event taking out both paths). As a result, they carry significantly less power than their thermal limit in either direction.

The actual rating on a path can change hourly and depends on several factors, including ambient air temperature, other lines service status, and various load and supply conditions on the larger grid. The Montana transmission lines heading west toward the Idaho panhandle and Washington are called the Montana-Northwest path (Path 8). The Montana-Northwest path is generally limited to 2,200 MW east to west and 1,350 MW west to east. These are the maximum ratings under ideal conditions, and the ratings on these paths are often lower. The Montana-Northwest path leads to the West of Hatwai path, which is larger and is composed of a number of related lines west of the Spokane area.

Ownership and Rights to Use the Transmission System

Rights to use the transmission system are held by the transmission line owners or by holders of long-term contract rights. Rights to use rated paths have been allocated among the owners of the transmission lines that compose the paths. In addition, the line owners have committed to a variety of contractual arrangements to ship power for other parties. Scheduled power flows by rights holders are not allowed to exceed the path ratings.

The FERC issued Order 888 in April 1996, which requires that transmission owners functionally separate their transmission operations and their power marketing operations. This means that all generators have the right to access utilities' transmission systems. If the transmission system in place does not have sufficient capacity to accommodate a bona fide request for transmission service, the utility must begin the process to build the needed upgrades, if the transmission customer pays for the incremental cost of the upgrades.

Power marketing occurs when transmission owners that own generation market it off-system to make money or to reduce costs for their native loads. These transmission line owners must allow other parties to use their systems under the same terms and conditions as their own marketing arms. Each transmission owner must maintain a public website called the Open Access Same-Time Information System (OASIS) on which available capacity is posted.

Available transmission capacity (ATC) is the available room on existing transmission lines to move power during every hour of the year. ATC is calculated by subtracting committed uses and existing contracts from total rated transfer capacity on existing transmission lines. ATC may change on an hourly basis depending on grid conditions. These existing rights and ATC are rights to transfer power on a firm basis every hour of the year. The owners of transmission rights on rated paths may or may not actually schedule power during every hour. When they don't, the unused space may be available on a non-firm basis. As of 2018, a small amount of ATC is available on most major rated paths on the U.S. Western Grid, including those paths leading west from Montana to the West Coast. The rights to use the existing capacity on these lines are for the most part fully allocated and tightly held.

In terms of ATC, incremental export capacity out of Montana is extremely limited. There is no incremental firm export capacity out of Montana to the Southwest (Path 18) and limited incremental export capacity out of Montana to the Northwest (Path 8). The retirement of Colstrip units 1 and 2 could change this situation and open up room on the Colstrip transmission lines and beyond. The retirement of Montana coal-fired power plants, particularly Colstrip units 1 and 2, would potentially allow new generation to use transmission capacity previously used for the state's coal generation. High level studies by the Northern Tier Transmission Group have suggested that wind power using the 600 MW of freed up transmission capacity from Colstrip to the west would not cause major problems on the grid. However, more rigorous studies would need to be conducted to make definitive statements.

ATC is also constrained in state on NWE's system--especially in the area south of Great Falls. Where ATC is available in-state, it is typically to move power within Montana or wheel power through Montana to interstate lines.

Despite little ATC availability, most transmission paths on the Western Grid are fully scheduled for only a small portion of the year, and non-firm space is often available. However, non-firm access cannot be scheduled far in advance, and its access cannot be guaranteed. Non-firm access is a workable way to market excess power for existing generators. Non-firm availability may be a reasonable way to develop new firm power transactions if backup arrangements can be made to cover the contracts in the event that the non-firm space becomes unavailable. Financing new generation may be difficult, however, unless the power can be shown to move to market via firm transmission space.

Congestion

Transmission constraints are often referred to as transmission 'congestion'. Transmission congestion raises the price of delivered power. It often prevents low-cost power from reaching the areas where it is needed. Low-cost power has little value if it cannot be transmitted to a location where energy is needed. For example, because most existing Montana transmission is fully contracted, future generators in Montana may be prevented from selling their power into a number of wholesale markets except by using non-firm rights or paying for new lines to be built. When transmission congestion exists, generators may be forced to sell into other locations where buyers pay less for power.

In general terms, additional transmission capacity allows more generators to access the grid, promoting competition and lowering prices. Conversely, limited capacity necessitates either transaction curtailment or re-dispatch from a generator that bypasses the bottleneck in the system. Areas with consistently the highest electricity prices, like southern California, experience the greatest degrees of transmission congestion year round due to a variety of factors including huge demands, huge peaking demands during hot weather, and the necessity of large imports from other states.

Transmission congestion can be defined in several ways. A transmission path may be described as congested if no rights to use it are for sale. Congestion may mean that a path is fully scheduled and no firm space is available, or it could mean that the path is fully loaded in the physical sense.

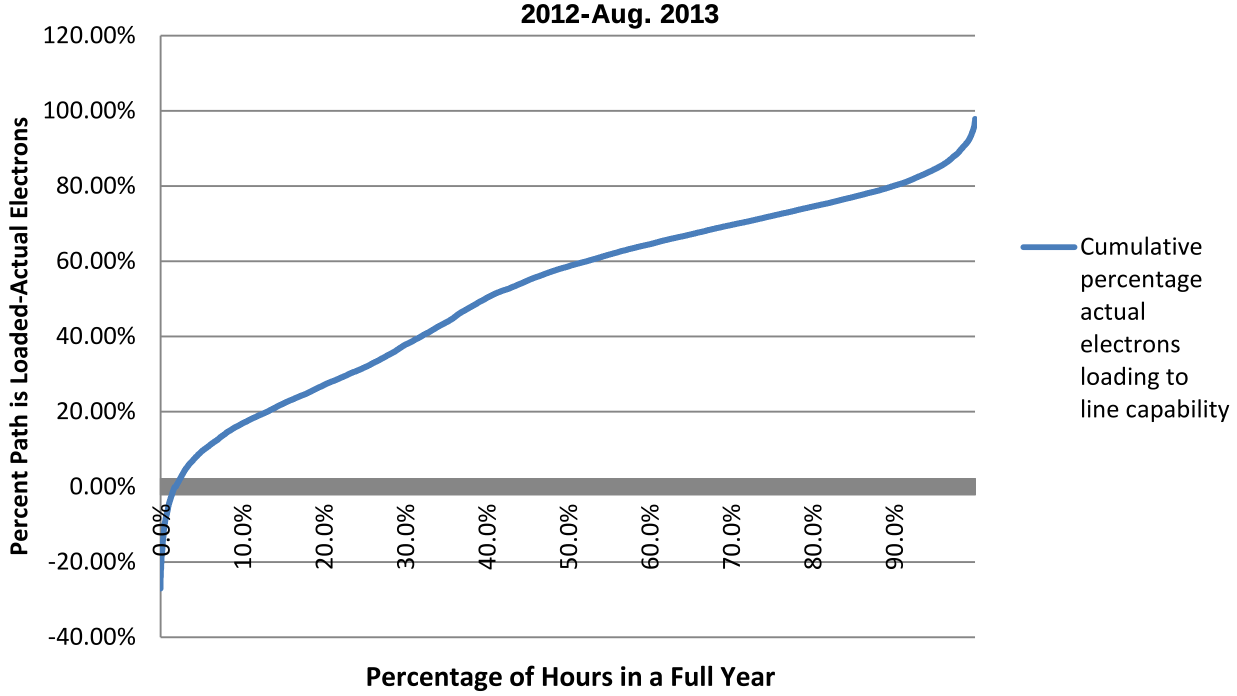
By the first definition, the paths through which generators in Montana send their power west are mostly congested and few firm rights are currently available for those paths. By the second definition, the paths west of Montana are congested during a few hours of the year. Contract holders fully use their scheduling rights only a small fraction of the time; the rest of the time they use only portions of their rights.

By the third definition, the lines are almost never physically congested. Even when the lines are fully scheduled, the net flows are almost always below path ratings. The third definition is based on actual loadings. Actual loadings are different from scheduled flows because of the difference between the physics and the management of the grid.

As mentioned above, schedules are contract-path-based. In contrast, actual loadings follow the laws of physics, are net-flow-based and include inadvertent flows. Actual flows on the paths west of Montana are almost always below scheduled flows because of the inadvertent flows and loop flows in that part of the grid. **Figure 9** shows that from September 2012 to August 2013 the highest actual physical loadings on the Montana-Northwest path (Path 8) were loaded at or above 90 percent of the path capacity for only a few hours. For most hours, the path was not heavily loaded.[60] On the other hand, the path was 60 percent loaded or more about 50 percent of all hours in that time period, indicating that Path 8 is actually one of the most heavily used in the Western Interconnect. Even a well-used line, however, usually has physical space available for more electrons.

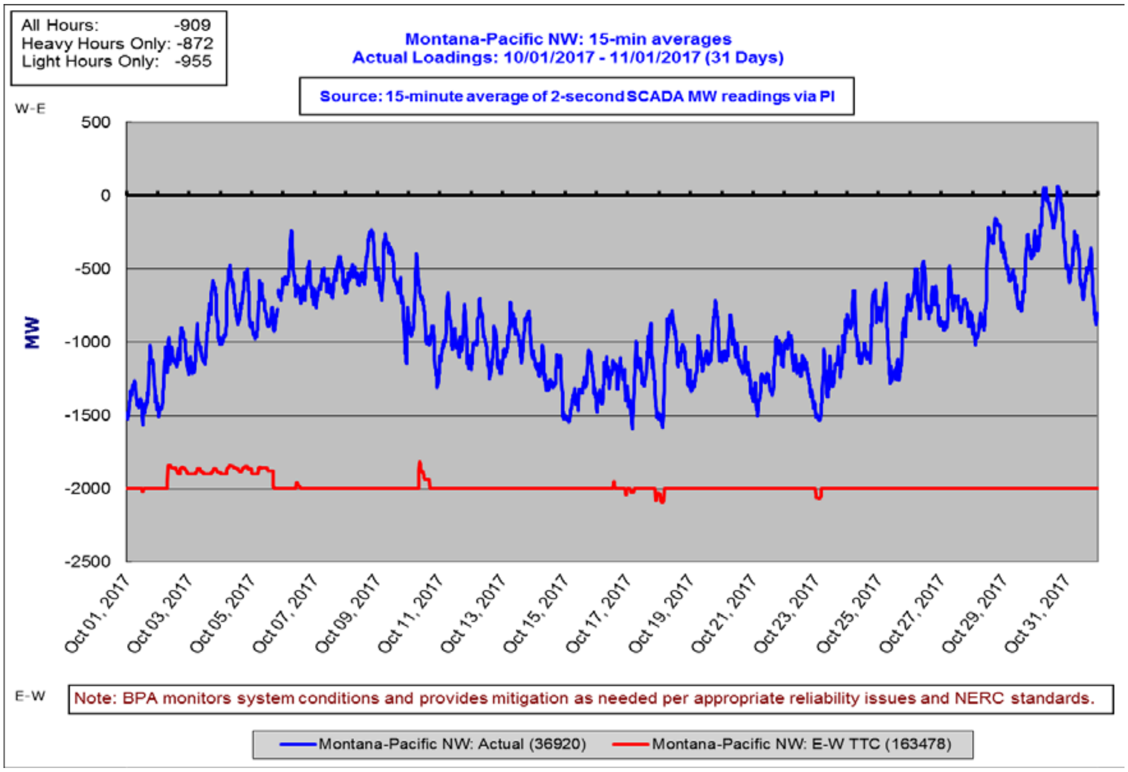
60 https://transmission.bpa.gov/Business/Operations/Paths/ .

Figure 9. Montana-Northwest Cutplane cumulative loading curve Sept. 2012-Aug. 2013



The most recent month of data from the NorthWest-Montana cutplane also shows actual flows (in blue) well below Total Transmission Capacity (Path 8). This figure should be read upside-down in the sense that the red line is the capacity level and anything above it is electricity loading below capacity.

Figure 10. Montana-Pacific Northwest 15-minute averages



Source: BPA, https://transmission.bpa.gov/Business/Operations/Paths/

Path 18 from Montana to Idaho consists of two transmission lines. According to WECC, Path 18 is not historically congested based on actual electricity flows over the line.[61] Although Path 18 is not congested based on actual flows on the lines, it is heavily utilized from a scheduling standpoint. Actual flows are not high relative to the path rating due to the path being scheduled in both directions.

A considerable amount of existing capacity on transmission lines is not available for use because it is held off the table for reliability reasons when paths are rated. Uncertainty affects the transmission needs of utilities because they don't know in advance what hourly loads will be or which generating units may be unavailable. The need for flexibility affects transmission needs because utilities want the right to purchase power to serve their loads from the cheapest source at any given time.

[61] 10-Year Regional Transmission Plan: WECC Path Reports, WECC, approved by the Board of Directors September 22, 2011.

Grid Management by a Regional Transmission Organization

A large portion of the electric load in the U.S. is procured through market transactions overseen by various Regional Transmission Organizations (RTO) and Independent System Operators (ISO). These organizations are independent entities that emerged as a result of guidelines prescribed in FERC Orders 888 and 889 with which FERC sought to introduce competition and efficiency into electricity markets. RTOs and ISOs are charged under these orders with promoting nondiscriminatory access to transmission lines and fostering a competitive environment in restructured electricity markets. These organizations are responsible for developing a platform for the oversight of transmission capacity, transmission access scheduling, and congestion management.[62]

While most of Montana's service area is not part of an RTO, the Midwest Independent Transmission System Operator (MISO), which covers much of the Midwest, controls the region of eastern Montana that lies in the U.S. Eastern Grid. In the U.S. Western Grid, the Alberta Electric System Operator (AESO) operates in Alberta and CAISO operates in California.

In Montana, discussions surrounding an independent body operating and controlling access to the transmission system have been underway since the mid-1990s among transmission owners and other stakeholders in the Pacific Northwest. The stakeholders include NWE and the BPA, among others. An RTO would allow all parties to signal their willingness to pay for transmission access and theoretically make efficient use of the grid. In addition, RTO management would result in congestion price signals that would encourage economy-based decisions on the location of new generation and on the expansion of capacity on congested transmission paths.

Several western stakeholders are involved in ongoing discussions of expanding CAISO, and developing aspects of ISOs such as Energy Imbalance Markets. PacifiCorp, which operates as a retail electric utility in pockets across the Western Interconnect, including parts of Wyoming that neighbor Montana, has been working with CAISO to evaluate the steps needed to integrate CAISO and the balancing authorities operated by PacifiCorp. The Mountain West Transmission Group, a group of electricity service providers, covers Colorado and parts of four other western states, is exploring joining the Southwest Power Pool's regional transmission organization.

Recent History of Transmission Lines in Montana

In the past decade, several stakeholders have voiced interest in developing additional transmission capacity to export Montana's generation potential to other markets. Montana's large energy resources and small in-state electricity demand make it a hot spot for proposed transmission projects to export power out of state. The largest electricity market in the Western Interconnect is California. In addition, substantial electricity load exists in Arizona, Colorado,

[62] *Markets for Power in the United States,* Paul L. Joskow, The Energy Journal, Vol. 27, No. 1, 2006, page 17.

Oregon, Utah, and Washington. Although electricity growth in most areas is flat, these markets will need substantial new resources in order to replace retiring generation and meet environmental goals. Renewable resource mandates also suggest that a significant portion of newly built resources will be renewable.

The Montana Alberta Tie Ltd (MATL) came online in September 2013. It is the first direct interconnection between the Alberta and Montana balancing areas and is capable of carrying 300 MW in either direction.

In the last decade, few rebuilds of existing lines have taken place in Montana, including a WAPA 115 kV line between Great Falls and Havre built to 230 kV specifications and a rebuild of BPA's 115 kV line from Libby to Troy. NWE replaced a 50 kV line between Three Forks and the Four Corners area with a new 161 kV line. NWE also upgraded to a 161 kV line between Four Corners and Big Sky. At this time, MDU has indicated it has no major plans for electric transmission upgrades in Montana.

The BPA has prepared preliminary engineering and partially completed an Environmental Impact Statement on relatively low-cost improvements that would expand capacity on the Montana-Northwest path (Path 8) by 500-700 MW, specifically the double circuit 500 kV line. This upgrade is called the Montana to Washington project (M2W) and could be used by new generators to access West Coast markets. Similar upgrades on the Colstrip lines have been discussed for central Montana. The project would not require a new right of way, and would utilize existing poles. Additional developers looking at projects in Montana have expressed interest in utilizing the potential upgraded BPA capacity that would be created by the project but the project only removes one transmission bottleneck in the region. Additional transmission constraints exist to the west of this segment in Washington state. These bottlenecks would need to be dealt with separately to move power to the specific load centers that Montana developers are interested in reaching.[63]

New lines connecting Montana to the rest of the Western Grid could increase competition among Montana energy suppliers. Increasing supplier competition in Montana's market could lower or stabilize electricity prices to Montana ratepayers in the near and distant future, although the extent and significance of such savings are unknown.

New high-voltage transmission lines can be difficult and contentious to site. Siting the Colstrip double-circuit 500 kV lines in western Montana, particularly in the areas of Boulder, Rock Creek, and Missoula, required much work with a variety of entities.[64] As a result, the route was sited away from the interstate highway corridor, opening new corridors through forested areas.

[63] Mark Reller, BPA

Recent experience with the MATL and proposed MSTI lines show Montana citizens and landowners are concerned about interference with farming practices, visual impacts, reductions in property values, potential human health effects, and the use of private land rather than public land for electric transmission purposes.

Rural growth and residential construction in western Montana since the Colstrip lines were sited in the early 1980s may compound siting challenges for additional new lines sited through the western portion of the state. Siting opportunities are limited by actual and contemplated wilderness areas and Glacier National Park in the western region. Siting and routing a new line out of the state in a westerly direction would likely prove extremely challenging due to geographical, wilderness, and political issues. Due to these difficulties, the most likely routes for new transmission in and out of Montana are north toward Canada, south toward Wyoming and Idaho, and possibly alongside existing transmission lines to the west.

Regional Transmission Planning in the Western Interconnection

NTTG

The Northern Tier Transmission Group (NTTG) is a group of transmission providers and customers formed under FERC Order 890. They are involved in the sale and purchase of transmission capacity on the power grid that delivers electricity to customers in the Northwest and Mountain states. The NTTG coordinates individual transmission systems operations, products, business practices, and planning of their high-voltage transmission network to meet and improve transmission services that deliver power to customers. Their work establishes a plan for general transmission improvements needed for feasible system operation at times of transmission stress years in the future.

FERC Order 1000

In July 2011, FERC issued Order 1000, titled Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities. The order reforms the current transmission planning processes for new transmission lines and outlines new cost allocation principles for transmission lines approved for purposes of cost allocation. Order 1000 requires regional planning groups to consider transmission that is necessary for reliability, economics, and achievement of federal or state laws and regulations when developing regional plans. Order 1000 also requires interregional coordination on transmission planning. It requires that each region have coordinated procedures for the evaluation of transmission projects that span multiple regions. Order 1000 addresses cost allocation for new transmission facilities.

Committee on Regional Electric Power Cooperation (CREPC)

CREPC is a joint committee of the Western Interstate Energy Board and the Western Conference of Public Service Commissioners. CREPC is composed of the public utility commissions, energy agencies, and facility siting agencies in the western states and Canadian provinces in the western electricity grid. It works to improve the efficiency of the western electric power system.[65] CREPC's main issues are integrating more renewable energy into the system, the energy imbalance market, future transmission plans, and current changes in the structure of WECC.

Current Transmission Issues

There are a number of issues affecting the changing uses of the transmission system and the need for and ability to complete new transmission projects. These include the way reliability criteria are set, the limited number of hours the system is congested, the increasing costs of building new lines, ways to meet growing power needs without building new lines, problems involved in siting high-voltage transmission lines, the energy imbalance market, increasing renewable penetration, and cyber security.

Western Electricity Coordinating Council Bifurcation

Reliability criteria for the Western Interconnection are set by the WECC. In the wake of large power outages on Sept. 8, 2011, many industry stakeholders voiced concerns with what they saw as lax criteria at WECC. The Arizona and Southern California system disturbance left 2.7 million customers without power and the NERC and the FERC issued a joint report identifying deficiencies in WECC's management of its reliability responsibilities and concluded that those deficiencies contributed to the blackout. WECC's current responsibilities include serving as the regional entity for Western Interconnection development and enforcing reliability standards for the bulk electric system in the Western Interconnection. Concern arose that housing both the regional entity and reliability coordinator roles within WECC affects the group's ability to fulfill both responsibilities. In 2013, the WECC approved a resolution to bifurcate WECC. Under this new structure the reliability coordinator and interchange authority functions in the Western Interconnection became a separate entity from WECC.[66] WECC is now the Regional Entity responsible for compliance monitoring and enforcement.

Peak Reliability (Peak) was formed in 2014 as a result of the bifurcation of the Western Electricity Coordinating Council (WECC) into a Regional Entity (WECC) and a Reliability Coordinator (Peak). The bifurcation of WECC received final approval from the Federal Energy Regulatory Commission (FERC) on February 12, 2014. Peak, a company wholly independent of

[65] http://www.westgov.org/wieb/site/crepcpage/.

[66] Northwest Power and Conservation Council, July 2, 2013, http://www.nwcouncil.org/media/6868113/p2.pdf.

WECC performs the Reliability Coordinator function in the Western Interconnection.[67] Peak, as the reliability coordinator, works closely with each of the balancing authorities in the western grid to maintain real-time, situational awareness of the operation of the Western Grid.

Merchant lines

Efforts by FERC to open electricity markets through approval of merchant transmission projects are meant to stimulate independent investment in transmission facilities, allowing for greater competition among power producers. Starting in 2000, FERC began approving applications by parties proposing market-based transmission rates known as merchant transmission projects. Merchant transmission is a model under which transmission costs are recovered through market-based or negotiated rates as opposed to traditional cost-based rates. Merchant transmission projects are a means to bring forward new capital investment to reduce transmission congestion and to link regional markets in situations in which the prospect of cost-based rate recovery proves to be insufficient to spur transmission development.

As a matter of basic economics, transmission congestion leads to disparate power prices. While these disparities may produce an incentive to construct new generation, it is plausible that new transmission priced at market rates would be a less expensive solution. Such projects may not necessarily be proposed under the traditional model of cost-based ratemaking. The issues confronting proposed merchant generation plants are different from those faced by traditional utilities. Utilities plan, finance, and build transmission and generation together and recover costs from ratepayers. Private generation developers, under the merchant model, must absorb the risk or convince another party to absorb that risk. The development of state renewable energy standards has given added impetus to merchant transmission, as parties seek to bring remote renewable energy to populated load centers.

Transmission Construction Cost

High-voltage transmission lines are expensive to build. A typical single-circuit 500 kV line may cost $2 million per mile or more. A double-circuit 500 kV line may cost $3.1 million or more per mile. A 500 kV substation costs $50 million to $75 million, depending on its location on the network. If series compensation is required, 500 kV substations may cost up to $100 million. However, 230 kV lines are somewhat cheaper, about half the cost per mile of 500 kV lines, and substation costs run nearly $25 to $30 million each.[68]

DC lines are cheaper still, but the equipment required to convert AC to DC is extremely expensive. Consequently, DC technology is generally used only for very long-distance transmission with no intermediate interconnections. At present there are only two major DC

---

[67] Text taken from https://www.peakrc.com/aboutus/Pages/History.aspx

[68] Craig Williams, WECC, Market Interface Manager.

lines in the Western Interconnection – the Pacific DC Intertie from Celilo in northern Oregon to Sylmar near Los Angeles and the IPP line from the Intermountain Power Project generating station in Utah to the Adelanto substation near Los Angeles. Neither line has any intermediate connections.

Alternatives for Meeting Increasing Electricity Demand

Increasing costs and siting difficulties for new transmission lines, are leading to the development of alternative methods to strengthen the grid. Some existing lines can be upgraded with new equipment to increase capacity without building a new corridor through a new right of way such as the M2W project. Lines can be rebuilt on existing rights-of-way and one new line built on the grid could allow higher ratings on other lines in the grid. Energy conservation at the consumer level can also forestall the need for new lines. Many utilities implement demand-side management programs, energy efficiency programs, and interruptible rates to lower peak demands on the system. Generation plants can be located near their loads, eliminating some need for long-distance transmissions of electricity.

Storage projects utilizing pumped hydro technology also assist in balancing the system.

Montana based, Absaroka Energy, LLC, is developing the Gordon Butte Pumped Storage Hydro Project located on private land in Meagher County. The 400 megawatt, 3,400 megawatt-hour plant is designed to take advantage of the unique geological features of Gordon Butte to create a new closed-loop pumped storage hydro facility. This facility would provide ancillary and balancing capabilities to utilities and generation owners, as well as, provide multiple services to facilitate stability, reliability, growth and longevity to existing energy infrastructure and resources in the state and region. [69]

Transmission Capacity to Accommodate New Generation in Montana

There is a "chicken and egg" problem in developing new transmission projects. If no transmission capacity is available to reach markets, generation developers may have a difficult time financing projects. Yet without financing, potential generators probably can't make firm commitments to encourage utilities to invest on their own in new transmission capacity projects.

New generation plants need firm power purchase agreements (PPA) to build in order to obtain financing. Occasionally, generation plants are built to market their energy into wholesale markets, but such facilities more common in deregulated electricity markets. With low spot prices across the West and tightened lending requirements, the majority of projects slated for construction in the western U.S. in the next decade will have firm power purchase agreements

[69] Gordon Butte Pumped Storage

before ground is broken. Because Montana is already a net exporter of electricity and because NorthWestern Energy's Renewable Portfolio Standard is already largely met, demand for new generation built in Montana would mostly likely come from out of state. The challenge that Montana projects—like all projects—face is contracting to produce power for customers at a price that is both profitable to the project developer and competitive with other energy sources, including sources potentially closer to the end-consumer. Transmission charges could be high enough between Montana resources and West Coast load centers to challenge the competitiveness of Montana-based projects. Low electricity prices and the ISOs and RTOs add uncertainty to the process.

Numerous proposed transmission lines in the Western U.S. are not constructed due in part to this problem.

The regulatory structure in Montana requires proving a need for new transmission projects that are 230kV or larger and longer than ten miles. Such projects must meet the standards outlined under MFSA (75-20-104(8)(a)(i), MCA).

California Renewable Portfolio Standard

While California is not the only renewable market in the West, California's RPS will require more renewable energy than the rest of the western states combined. It is likely that many wind developments proposed in Montana and other western states intend to sell into the California market. California has a statutory 50 percent RPS requirement by 2030 for all large utilities in the state. While other states are mostly meeting RPS standards and California utilities are on track to meet their 2020 RPS targets, by 2030 California utilities will require twice as much renewable energy as the other Western states combined. Corporate buyers and community choice aggregators are growing sources of demand for renewable energy as well, but their market impacts could prove to be less regional in nature if they look to procure near the communities they serve.[70] Recent changes to California's RPS rules place some additional burdens on out-of-state wind resources. These changes could negatively impact developers' interest in pursuing wind resources in Montana and could decrease interest in new transmission.

Western Electricity Coordinating Council Energy Imbalance Market

An Energy Imbalance Market (EIM), as proposed by WECC aggregates the variability of generation and load over balancing authorities and reduces the total amount of required reserves for a balancing area. An EIM more easily allows participants to use the lowest-cost

[70] RETI 2.0 Western States Outreach Project Report, Prepared by Energy Strategies, LLC for submission under Agreement with the Western Interstate Energy Board October 12, 2016

generation in the market to balance loads and generation. In some ways, an EIM serves some of the functions an ISO or RTO might serve.

The EIM initiative is a comprehensive market-based proposal to address generator imbalances in the West. It is a regional economic dispatch tool that supplies imbalance energy within transmission and reliability constraints. The EIM would be a 5-minute, security-constrained economic dispatch model using locational marginal pricing for energy imbalances. The EIM could utilize physically available transmission space and would reduce the costs of integrating variable energy resources. The EIM would allow the deviations from electricity schedules to be resolved using the most cost-effective, physically deliverable resource. A variety of groups are currently exploring the possibility of implementing this market, but it is not yet being used in Montana.

EIM is a real-time energy market that operates what is called a "security constrained economic dispatch" (SCED). The model is similar to an auction. Utilities submit a schedule of the resources they anticipate serving their consumer demand as they move into the operating hour to the independent operator of the market. At the same time, those utilities and other owners of power plants submit incremental bids of their plants' capacity -- essentially, an offer to move up or down as certain plants go up and down, and as the same type of volatility happens to consumer demand.[71]

The EIM operator then allows the least-cost resources to meet any given utility's demand, so long as there is space available on the transmission system. In addition to this, the automation present in a SCED allows the grid to more flexibly absorb or replace unanticipated over- or under-production of weather-dependent renewables. These two things -- least-cost dispatch and renewable integration -- make up the value proposition of EIM. Basically, without it, the system functions on bilateral trading that lacks the visibility of multiple players coming together to form a multi-party "bid stack." The system also lacks the automation that allows for bids to happen in real time. This is opposed to the current situation of the hourly schedules that dominate the western interconnection outside the EIM.

Smart Grid

A smart grid is a modernized electrical grid that uses information and communications technology to gather and act on information in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.[72] "Smart grid" generally refers to a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation. These systems are made possible by two-way communication technology and computer processing that has been used for decades in other industries. Smart Grid technologies are

---

[71] This paragraph and the next one are taken from an email response from Commissioner Travis Kavulla, Montana Public Service Commission.

[72] Department of Energy

beginning to be used on electricity networks, from power plants and wind farms to the consumers of electricity in homes and businesses. A smart grid can alert customers to real time prices in order to promote conservation and allow for tiered electricity pricing. This technology can also help grid management from many places and sensors rather than one central location, and potentially lead to lower restoration times after a blackout. Concerns about the smart grid include cost, cybersecurity, and personal privacy.

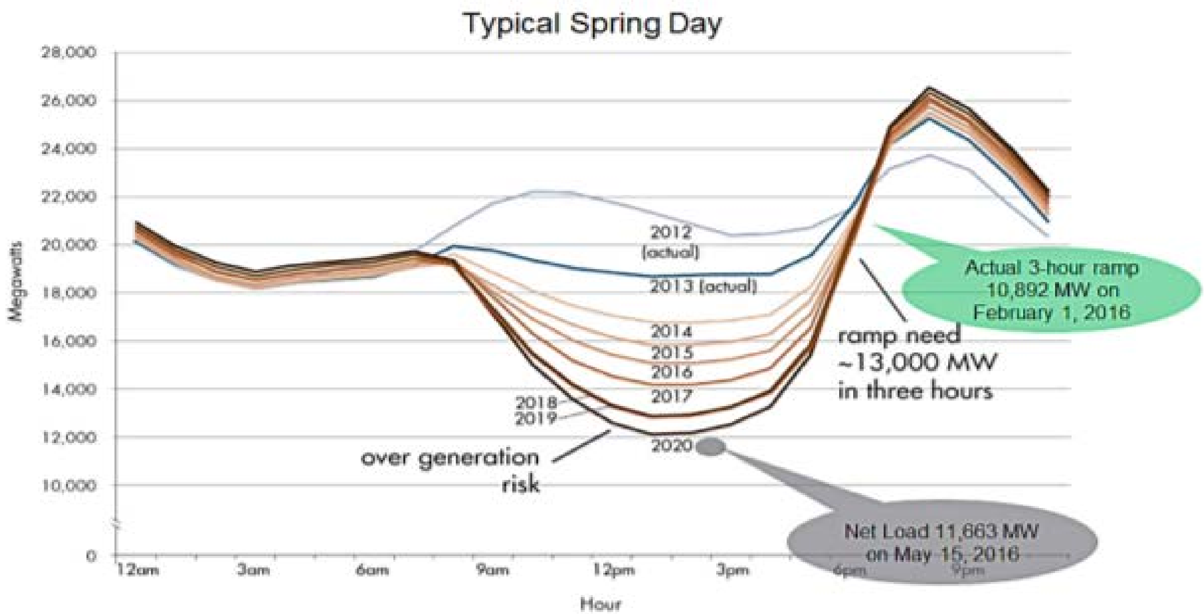
Increasing Renewables: Duck Curve and Inertia[73]

Historically, the California ISO (CAISO) directs conventional, controllable power plant units to move up or down with instantaneous or variable demand. With the growing penetration of renewables on the grid, there are higher levels of non-controllable, variable generation resources. Because of that, the ISO must direct controllable generation resources to match both variable demand and variable supply. Variability must also be managed intra-hour and from day-to-day. The ISO needs a resource mix that can react quickly to adjust electricity production to meet the sharp changes in electricity net demand. These resources feature ramping flexibility and the ability to start and stop multiple times per day. To ensure supply and demand match at all times, controllable resources need the flexibility to change output levels and start and stop as dictated by real-time grid conditions.

CAISO created curves for every day of the year from 2012 to 2020 to illustrate how the net load following need varies with changing grid conditions. The net load curve or duck chart in Figure 2 illustrates the steepening ramps expected during the spring. The duck curve is so-named due to the shape of net load during the day in California. The chart shows the system requirement to supply an additional 13,000 MW, within approximately three hours, to replace the electricity lost by solar power as the sun sets. Oversupply occurs when all anticipated generation, including renewables, exceeds the real-time demand. During oversupply times, wholesale prices can trend low and even negative in which generators have to pay utilities to take the energy. In almost all cases, oversupply is a manageable condition, but it is not a sustainable condition over time. The duck curve in Figure 11 shows that oversupply is expected to occur during the middle of the day as well. Because the ISO must continuously balance supply and demand, steps must be taken to mitigate oversupply risk.

[73] California ISO-What the Duck Curve Tells us About Managing a Clean Grid, https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

Figure 11. The Duck Curve



Source: CAISO

The following actions avoid oversupply conditions:

1.) increasing demand by expanding the ISO control area beyond California to other states so low-cost surplus energy can serve consumers over a large geographical area;

2.) increasing participation in the western Energy Imbalance Market in which real-time energy is made available in western states;

3.) transitioning our vehicles to electricity;

4.) offering consumers time-of-use rates that promote using electricity during the day when there is plentiful solar energy and the potential for oversupply is higher;

5.) increasing energy storage; and

6.) increasing the flexibility of power plants to more quickly follow ISO instructions to change its generation output levels.

Cybersecurity

An adversary with the capability to exploit vulnerabilities within the U.S. power grid might be motivated to carry out a cyber-attack under a variety of circumstances. An attack on the power grid could be part of a coordinated military action, intended as a signaling mechanism during a crisis, or as a punitive measure in response to U.S. actions in some other arena. A cyberattack could cause power losses in large portions of the United States that last days in most places and several weeks in others.

Attacks on power grids are no longer a theoretical concern. In 2015, an attacker took down parts of a power grid in Ukraine. Although attribution was not definitive, geopolitical circumstances and forensic evidence suggest Russian involvement. A year later, Russian hackers targeted a transmission level substation, blacking out part of Kiev. In 2014, Admiral Michael Rogers, director of the National Security Agency, testified before Congress saying China and other countries likely had the capability to shut down the U.S. power grid. Attacks could inflict damage on the many health and safety systems that depend on electricity. Given the fragility of many industrial control systems, even reconnaissance activity risks accidentally causing harm.[74]

Today, the electric power industry is forging ahead with a series of initiatives to safeguard the electric grid from threat and is partnering with federal agencies to improve sector-wide resilience to cyber and physical threats. The industry also collaborates with the National Institute of Standards and Technology, the North American Electric Reliability Corporation, and federal intelligence and law enforcement agencies to strengthen its cybersecurity protocols.

[74] Council on Foreign Relations, “A Cyberattack on the U.S. Power Grid”, https://www.cfr.org/report/cyberattack-us-power-grid