

CHAPTER 9 NEW RESOURCES

New Resources Evaluated for the 2015 Plan

New Resources Overview

The 2015 Plan focuses on thermal, hydro capacity upgrades, wind and solar PV resources as plausible additions to the resource portfolio. The planning process involved analysis and contributions from outside consultants (Lands Energy Consulting (“Lands”), Ascend Analytics, LLC (“Ascend”)) and other sources, and input from members of ETAC¹.

Thermal Resources

Natural gas-fired generation has the capability to operate with flexibility, and the selection of the type of unit depends on the need of the portfolio. The thermal resource analysis for this Plan considered baseload, intermediate, and peaking operations. One key operating characteristic of thermal units is heat rate, a measure of thermal energy required to produce electrical energy, expressed in this Plan as the higher heating value (“HHV”) heat rate. Internal combustion engines (“ICEs”) provide the ability to ramp quickly and have heat rates in the range of 8,500-10,500 Btu/kWh. Combined cycle combustion turbines (“CCCTs”) provide better efficiency, with a heat rate around 6,500-7,000 Btu/kWh, but have slower ramp rates and are best used in baseload functions. Simple cycle combustion turbines (“SCCTs”) have the ability to ramp quickly yet are not as efficient as CCCTs. Aero-derivative SCCTs have heat rates in the range of 8,500-10,500; while frame SCCT heat rates are above 11,000 and are dispatched only in hours of high market prices. The quick ramp capability allows SCCTs and ICEs to provide response to generation and load changes.

¹ Materials from ETAC meetings and contracted studies are included in Volume 2.

Internal Combustion Engines

ICEs are analogous to diesel engines and use the combustion of natural gas to drive pistons, turning a generator to create electricity. ICEs have the ability to ramp quickly to full output and can be used for intermittent resource and load following functions. NorthWestern modeled the Wartsila 18V50SG reciprocating engine for the 2015 Plan. The Wartsila engine has a heat rate of 8,300 with capital costs of \$1,280 \$/kilowatt (“kW”) and variable Operation and Maintenance (“O&M”) costs of \$5/MWh. Basin Creek utilizes nine Caterpillar ICEs for peaking, supplying reserves, and serving load.

Combined Cycle Combustion Turbines

CCCTs are turbines which ignite natural gas to produce electricity and waste heat. The waste heat is injected into a heat recovery steam generator to create additional electricity. The combined use of natural gas and waste heat increases efficiency. NorthWestern modeled the GE 7F.05 for a CCCT. The 7F.05 is the latest in the series of CCCT units and offers a better heat rate and higher capacity than the 7F.03 and 7F.04. The costs modeled for the 7F.05 and the duct firing are shown in Table 9-1 below.

Simple Cycle Combustion Turbines

SCCTs are natural gas turbines that rely on combustion alone to produce power and cannot generate electricity from waste heat. SCCTs have the ability to start and ramp quickly to full output. This flexibility provides for use during peak times and during changes in load and generation. The SCCTs that NorthWestern analyzed in the 2015 Plan were the GE LMS 100, GE Frame 7EA, and the Pratt & Whitney FT-8. The LMS100 provides the most efficiency, but has the highest capital and fixed O&M costs. The Frame 7EA has the lowest capital costs, but has a heat rate above 11,000. The Pratt & Whitney FT-8 turbines have the lowest variable and fixed O & M charges, but are not as efficient as the LMS100. All of these are available today with no major product improvements or cost changes since the 2013 Plan. DGGs features three generating units that utilize a total of six aero-derivative SCCTs to meet regulation requirements.

Defining New Gas-Fired Resources

As part of the due diligence process in determining the best alternatives for new generation in the portfolio, NorthWestern has taken steps toward defining the most suitable equipment, location, and implementation for new gas-fired plants.

Lands was contracted to analyze natural gas-fired resources and develop equipment parameters for inclusion in the modeling for this Plan. They provided a summary of operating characteristics, costs, and suggested dispatch scenarios for several current technology models. Results presented to ETAC on June 4, 2015 (see Volume 2, Chapter 1) included recommended manufactured units for Aero-derivative and Frame SCCT, CCCT, and ICE generator types. NorthWestern used Lands' recommendations to narrow the scope of stochastic modeling, utilizing the most suitable technology currently available. In addition, these units were used as examples in additional pre-feasibility studies. Table 9-1 below details the resource cost and descriptions for all resources that were modeled.

Table 9-1 Resource Cost Summary (2015\$)

Resource Description	Fuel Source	Technology	Net Capacity (MW)	Capital Cost (\$ / kW)	Fixed O&M (\$ / kW-yr)	Variable O&M (\$ / MWh)	HHV Heat Rate (Btu/kWh)	Escalation Rate (%/year)
CCCT (1x1)	Natural Gas	GE 7FA.05 ACC ¹	308	\$1,400	\$10	\$3	6,528	2.0%
CCCT (Duct Firing)	Waste Heat	GE 7FA.05 ACC ¹	40	\$0	\$12	\$0	8,546	2.0%
SCCT - Small Aeroderivative	Natural Gas	PW FT8	53	\$1,017	\$6	\$5	10,500	2.0%
SCCT - Large Aeroderivative	Natural Gas	GE LMS100	93	\$1,187	\$17	\$3	8,867	2.0%
SCCT - Frame	Natural Gas	GE 7EA	79	\$997	\$12	\$3	11,286	2.0%
ICE - Internal Combustion Engine	Natural Gas	Wartsila 18V50SG	18	\$1,280	\$11	\$5	8,314	2.0%
Utility Scale Solar PV ²	Solar		25	\$3,176	\$43	\$1		-1.0%
Wind ³	Wind		40	\$1,980	\$38	\$2		-0.5%

Table Notes:

Capacity for natural gas-fired resources estimated at 3,500 ft. elevation

¹ ACC = Air Cooled Condenser

² Solar fixed O&M is priced in \$/kWdc.

³ Based on build-transfer bids received in NWE's 2015 CREP RFP

Natural Gas-Fired Resource Siting

CB&I Stone & Webster, Inc. (“CBI”) was contracted in 2013 to provide a site study (Volume 2, Chapter 6) for a new CCCT plant of about 250 MW² capacity to handle future load growth. These analyses provide input into the modeling. However, this information will be updated with much more detail for any actual development.

Table 9-2 CBI Study Potential Locations

CBI Study Potential Locations	
Anaconda (existing Mill Creek site)	Highwood
Big Sandy (Verona sub)	Kalispell
Billings Area	Main Line 1 / Cut Bank
Corette	Missoula
Dry Creek Storage	Silver Bow
Great Falls/ MFM	Telstad/Shelby
Havre Pipeline	Warren
Helena	

NorthWestern supplied a list of 15 potential locations throughout Montana based on current gas supply and electric transmission capabilities, load centers, and population/load growth which are listed in Table 9-2. Site-specific attributes considered include availability of NorthWestern property (Anaconda Mill Creek site, Dry Creek, Main Line 1/Cut Bank, Telstad/Shelby), proximity to existing generation infrastructure (Corette, Great Falls, Highwood), and proximity to major gas pipelines (Havre, Warren).

² Prior to the Lands Energy Consulting study on thermal resource specifications, NorthWestern supplied a general estimate of 250 MW in nameplate capacity for a potential gas-fired plant to CBI for siting considerations.

Table 9-3 CBI Study Scoring

CBI Study Scoring	
Selection Category / Criteria	Weighting Factor
System electric transmission	20
Gas supply	20
Water supply	15
Air quality issues	15
Local stakeholder support	5
Land use/ setting	10
Constructability	5
Ecology	10
Total	100

CBI performed a preliminary screening based on eight weighted criteria shown in Table 9-3. For each category, a value from “1” to “5” was assigned indicating the suitability of that location ranging from “complications for site development” up to “favorable development conditions” respectively. A comparison of the highest total weighted scores resulted in a short list of the five most attractive sites. These sites were further evaluated on a basis of an expanded, more detailed set of criteria that included assigning a degree of potential costs for some criteria. This analysis resulted in a list of the three most favorable locations: Billings, Anaconda/Mill Creek, and Great Falls.

NorthWestern continued this analysis by determining infrastructure requirements, issues, and associated costs for natural gas supply and transmission, and electric transmission and interconnection at each location. To provide a more focused study, the potential plants were restricted to a 50-MW ICE plant and a 250-MW CCCT plant. Choosing a conservatively high heat rate among models recommended from the Lands report, gas supply and transmission requirements were established including identification of a suitable supply connection point, installation of pipeline from this point to the new facility, and construction of compressor stations. On the electric side, determinations were made

regarding the need to re-conductor existing lines or construct new 230-kV transmission lines as well as modifying or building new associated substations. Pre-feasibility-level cost estimates associated with these infrastructure requirements were supplied by NorthWestern's Transmission department (Volume 2, Chapter 6). Using these infrastructure cost estimates, a corresponding levelized cost of natural gas (\$/dekatherm) and levelized cost of electricity (\$/kWh) were determined for each location. The results suggest that, on a gas and electric infrastructure cost-basis, the Billings area is the least-costly location for new gas generation, at a 50-MW or 250-MW capacity.

A second pre-feasibility cost-estimate study was conducted between the following two scenarios: building one 308-MW GE 7FA.05 CCCT facility located in the Billings area, or building five smaller Wartsila 18V50SG-B facilities geographically dispersed around the state (Billings, Butte, Great Falls, Havre, and Warren). These locations were selected primarily on the results of the above study with the added intent to minimize costs related to gas and electric transmission limitations and provide greater system reliability. Recommended units and costs from the Lands report were used to provide a more accurate representation of capital costs, fuel use, annual generation, variable and fixed costs, and carbon emissions-related costs. Infrastructure requirements and costs from the previous study were adjusted to more accurately reflect the operational characteristics of the units used in each of these plants. The resulting costs (found in Volume 2, Chapter 6) were used to calculate potential levelized costs (\$/MWh). This study suggests that one CCCT facility in the Billings area would be much less costly to build and operate than five separate smaller plants dispersed around Montana.

These ongoing studies in conjunction with stochastic modeling results will be used to help define the most appropriate choices for developing new gas-fired resources in the supply portfolio. The next steps being taken are discussed in the Action Plan in Chapter 14.

Renewable Resources

Wind and small hydroelectric projects are the principle non-utility-owned renewable resources currently in the resource portfolio. Commercial scale solar PV resources have not been in operation yet in Montana, but have experienced both a decline in costs and development throughout the region. NorthWestern includes this resource for consideration in the 2015 Plan, but it is not selected in the optimization.

Hydroelectric Upgrades

Hydroelectric generation is the ultimate renewable resource; not only does it use a renewable form of energy, but the fuel (water) has the potential to be used many times over in a system of resources, as occurs on the Madison- Missouri River system. In the 1990s and early 2000s previous owners of the Hydros system (PPL and Montana Power) identified opportunities to increase the generating capacity at facilities throughout the system. Certain projects, including the Rainbow Dam powerhouse and the Mystic turbine replacement project, were successfully completed and entered service prior to NorthWestern ownership. Additional opportunities remain. NorthWestern is evaluating these projects in the context and scope of the Supply resource portfolio and the utility system needs these resources would serve. This requires complete legacy study updates. These potential projects were not assigned any value in the analyses of the Hydros purchase.

Optimization

Timing and sequencing of resource development and optimization activities has been a key consideration of NorthWestern throughout the 2015 planning cycle. Beginning in 2014, after the purchase of the Hydros was approved, NorthWestern considered initiatives to identify and develop operational alternatives for specific hydroelectric facilities as part of a broader resource fleet optimization program. One goal of the optimization is to identify and evaluate the use of all Hydros to expand their operating role in providing additional

ancillary services while continuing to provide reliable baseload generation, while operating within all fish and wildlife parameters. In the context of developing a resource procurement plan, these activities needed to be advanced before embarking on the work to evaluate new resources, including those represented by capacity expansion at existing facilities. By assessing existing capabilities NorthWestern is able to establish the proper foundation of future economic and operational efficiency and properly define future resource needs accordingly.

The scope of the capacity expansion plan for the hydroelectric system includes the rehabilitation and development projects shown in Table 9-4 below. For each project, the generating capacity increase has been reasonably defined. The energy values shown represent historic estimates that are under review and consideration by the generation staff and are subject to revision and update. NorthWestern anticipates completing the re-evaluation of project costs and subsequent assignment of priority in 2016. The seven rehabilitation projects will not trigger FERC license amendments, but the two development projects will be required to go through the process of obtaining FERC license amendments which can take several years.

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Table 9-4 Hydroelectric Capacity Expansion Potential

Hydroelectric Capacity Expansion Potential		
Development Projects	Additional Capacity (MW)	Additional Energy (MWh)
Hebgen	6.0	38,000
Ryan Unit 7	40.0	120,000
Rehabilitation Projects		
Black Eagle	1.8	3,000
Cochrane	6.0	24,000
Hauser	2.5	8,000
Holter	8.0	14,000
Morony	8.0	23,000
Ryan	8.0	37,000
Thompson Falls	4.0	15,000
Net Total	84.3	282,000

NorthWestern will place a high priority on additional work to define costs, timing, and size of these renewable resource expansion projects due to their potential to provide increased capacity and generation. The generation group is currently performing operational testing of hydro system capabilities and defining a work plan to review, evaluate, and update previous studies of the hydroelectric system.

Utility Scale Solar PV

Solar energy technologies capture energy from the sun and convert it to usable energy. One form of solar technology is photovoltaic technology that converts the sun’s energy directly into electricity through the use of solar panels. Solar PV technology has been around for many years, but has not been widely adopted at least in Montana due to its intermittent nature and the high cost of the technology. The Department of Energy developed the SunShot initiative in an effort to make solar energy cost-competitive with other forms of electricity by the end of the decade. The reduction in costs and improvements in technology will make solar PV more competitive with other resources in the future.

At the time of writing this plan, six solar PV generation developers have expressed an interest in negotiating multiple QF contracts. A definitive number of locations has not yet been specified.

Solar resources are intermittent in nature. The movement of clouds can change solar production from maximum output to zero production in a matter of seconds. Solar resources also do little to provide peak capacity for NorthWestern’s winter peak days as the peak occurs after the sun has set during the winter. They do provide some capacity during NorthWestern’s summer peak. However, this peak occurs late in the day and the contribution is only a small percentage of its installed capacity. To develop a greater understanding of solar PV resources, NorthWestern contracted with DNV KEMA Renewables, Inc. (“DNV-GL”) and Clean Power Research (“CPR”).

CPR provided weather data for seven sites in Montana. The sites cover all six NorthWestern operating divisions and were selected to develop a greater understanding of the diversity of solar PV generation in Montana and the regulation required to integrate solar PV. The seven sites are located near Anaconda, Bozeman, Broadview, Great Falls, Missoula, Moore and Townsend.

DNV-GL supplied NorthWestern with a generic scalable solar PV resource designed to be suitable for Montana locations. Other than specifying that the proxy resource be sized somewhere around 3 MW, DNV-GL was left to determine the appropriate size, components, etc. Lastly, NorthWestern asked DNV-GL to model annual production using hourly Anaconda weather data supplied by CPR.

DNV-GL’s indicative design is a 3.02 MW_{DC} (2.5 MW_{AC}) solar PV project using Canadian Solar polycrystalline silicone-based modules and SMA Sunny Central inverters. The

design uses single-axis tracking with conventional backtracking. DNV-GL also applied estimates for soiling losses (which includes snow cover), shading losses, and energy losses associated with equipment failures, unplanned outages, planned downtime, and solar PV degradation over time. DNV-GL provided NorthWestern with capital cost estimates for the indicative design and modeled the first year production using PVsyst and hourly weather data provided by CPR. The modeled cost of utility scale solar PV is shown in Table 9-1. The DNV-GL report, “Indicative Design, Energy, and Cost Estimation for 2.5 MW_{AC} Photovoltaic Project” is provided in Volume 2, Chapter 5. NorthWestern will also gain additional information on solar costs, output, and the intermittent nature of the output with the proposed commercial projects discussed earlier.

Wind

Wind is an intermittent generation resource, meaning that generation levels fluctuate greatly in a short time period. It is not uncommon for actual generation to deviate considerably from forecasted generation within the hour. Wind provides little peaking resource capacity as the turbines are not rated to operate during the winter peak period and during the summer peak there is normally very little wind.³ The modeled cost of wind is shown in Table 9-1.

Small Hydroelectric

Small hydroelectric projects have been in NorthWestern’s portfolio for many years. NorthWestern has over 44 MW nameplate capacity of small hydro in its portfolio. Some of the small hydro facilities are schedulable resources with very little hour-to-hour or day-to-day variability. There is some variability around yearly precipitation and seasonal water flows. Some of the small hydroelectric facilities contribute winter and summer peaking capacity.

³ As noted in NorthWestern’s 2013 Electricity Supply Resource Procurement Plan, the combined wind resources at that time (237.3 MW nameplate capacity) provided approximately 0.6 MW (0.25%) of peak capacity in winter and 5.2 MW (2.2%) of peak capacity in summer.

Research and Development

Demand Response

Demand Response (“DR”) is a voluntary and temporary reduction in electricity consumption by customers during periods when the power system is stressed and in need of additional peaking resources. DR is technically not considered a “resource” but essentially fulfills the same purpose as a physical peaking resource such as an internal combustion peaking unit. DR can, therefore, offset or defer the need for new peaking resources. DR programs are not new.⁴ What is new is the recent surge of interest in DR programs as the region becomes increasingly capacity constrained.

The NWPCC’s 7th Plan identifies 3,500 MW of DR savings for winter peak and 3,300 MW for summer peaks by the end of the study period. Of the DR savings identified for 2035, 48% of the achievable savings are from residential, 8% from commercial, and 44% from agricultural and industrial consumers. A simple extrapolation of the regional DR savings to NorthWestern would indicate that NorthWestern can achieve significant peak savings through DR. However, NorthWestern has significantly different retail load characteristics when compared to the region or other regional utilities.

NorthWestern has a limited ability to take advantage of DR. Forty-eight percent of the DR savings that NWPCC identified is obtained from Residential DR programs, with the largest percentages obtained by controlling electric space heating and electric water heaters. However, the penetration rates for these two uses of electricity differ widely between the region as a whole and NorthWestern’s service area. The Council identifies a 33% penetration rate for residential electric space heat, while NorthWestern estimates an overall penetration rate of about 3% for residential electric space heat. Similarly, the Council

⁴ The Montana Power Company received approval for an Electric Industrial Retention/Interruptible Rate for Stauffer Chemical Company in the mid-1980s (Docket No. 85.9.40).

assumes a 57% penetration rate for residential electric water heat, while NorthWestern end-use studies show a 21% penetration rate for residential electric water heat.

Forty-four percent of the 2021 savings identified by the NWPCC were from the agricultural and industrial customer classes. Most of the industrial customers in NorthWestern’s Balancing Authority are “choice” customers and do not purchase electricity from NorthWestern, and thus NorthWestern has a very limited resource within their customer group from which to purchase DR.

In July of 2015, NorthWestern surveyed 54 large key account customers regarding their ability, and willingness, to participate in a DR program⁵. The surveyed customers represented a combined non-coincident peak of over 550 MW. Of those surveyed, eighteen were choice customers. The respondents estimated that a cumulative total of between 34 MW and 36 MW may be subject to interruption for any one load reduction event. NorthWestern will follow up on this survey with these customers, but for the reasons above has no other current plans to implement DR.

Microgrid

NorthWestern is piloting a Microgrid project comprised of 80 kVA/183.4 kWh of battery storage and 40.26 kW of solar PV generation. A description of this project and related costs is included in Volume 2, Chapter 5.

⁵ The Survey and Survey Results are included in Chapter 3, Volume 2 of the 2015 Plan.