

2018



Status of Wind Energy in Montana

MONTANA STATE UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING - WIND APPLICATIONS CENTER

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Contents

Contents..... 1

Abstract..... 2

National Electrical Production Overview..... 3

National Wind Energy Production Overview..... 5

Montana Electrical Production Overview..... 6

Montana Wind Energy Production Overview..... 7

 Wind Energy Benefits..... 8

 Wind Resource Potential..... 9

 Montana Wind Power Production..... 10

 Operational Utility Scale Wind Energy Facilities..... 12

 Judith Gap Wind Energy Center..... 13

 Glacier Wind Energy..... 15

 Rim Rock Energy..... 18

 Musselshell Wind Project..... 20

 Spion Kop Wind Farm..... 23

 Fairfield Wind..... 25

 Greenfield Wind Project..... 27

 Gordon Butte Wind..... 29

 Horseshoe Bend Wind Park..... 31

 Diamond Willow Wind..... 33

 Big Timber (Greycliff) Wind..... 35

 Two Dot Wind..... 37

 Martinsdale Colony Wind..... 40

 Utility Scale Wind Energy Facilities - *Under Construction and Proposed*..... 42

 Mud Springs Wind Ranch..... 43

 Vivaldi Springtime Wind Project..... 44

Appendix..... 45

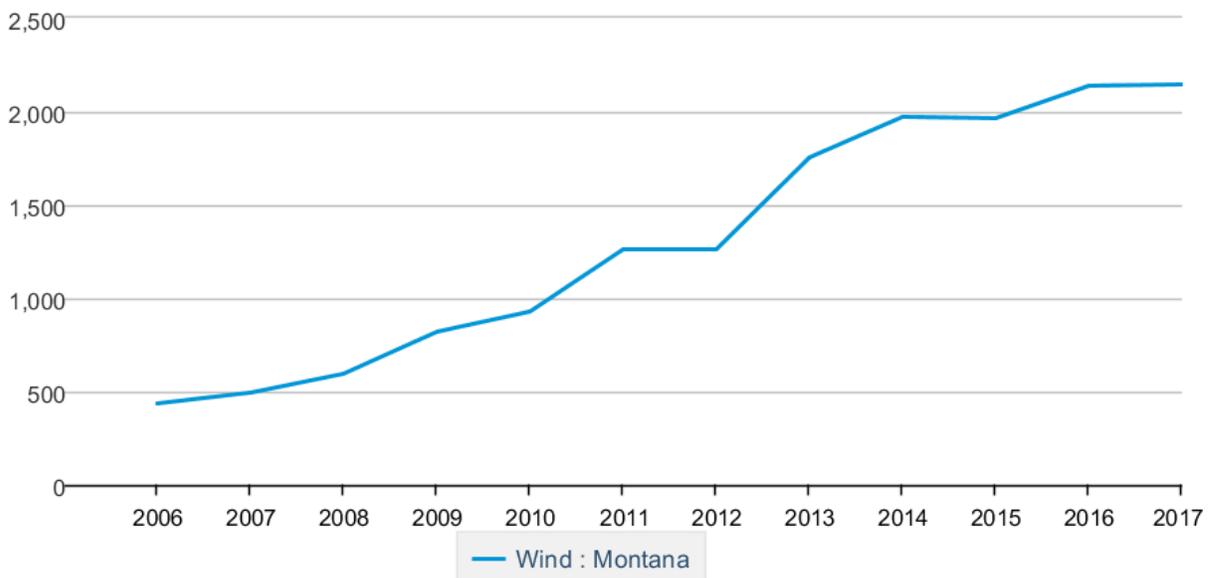
Abstract

Nationally, renewable energy sources are growing rapidly and are on track to surpass coal fired energy production shortly before 2040. In Montana, roughly 45% of the energy produced is from renewable energy, 7.5% from wind energy. Montana ranks 24th in the nation for installed wind energy production capacity, with 720MW. According to the National Renewable Energy Laboratory, Montana is ranked 5th for estimated potential onshore wind power¹. Taking advantage of that potential, wind energy in Montana has grown rapidly in the last decade. The installed wind energy capacity of Montana should be up to 800MW by the end of 2018, and up to 1200MW by 2020.

This report looks at information from the U.S. Department of Energy, Energy Information Administration, American Wind Energy Association, and other sources in order to summarize the status of wind energy in Montana. The summaries of each operational utility scale wind energy project include information about the site and the turbines used, as well as production information when available.

Montana Wind Energy Generation

thousand megawatthours



Source: U.S. Energy Information Administration

Figure 1 - EIA Montana Wind Energy Generation (Yearly)

¹ <https://www.nrel.gov/docs/fy12osti/51946.pdf>

National Electrical Production Overview

For a long time the nation's electricity was generated mostly by coal. In recent years natural gas has surpassed coal, and according to the Annual Energy Outlook, renewables will surpass coal sometime near 2030. The US Energy Information Administration released the 2018 version of the Annual Energy Outlook on 2/6/18². The AEO "provides modeled projections of domestic energy markets through 2050, and it includes cases with different assumptions regarding macroeconomic growth, world oil prices, technological progress, and energy policies." Graphs from the 2018 AEO, figures 3, 4, and 5 below, are used to explore the status of electrical energy production at a national level.

One energy policy that plays a role in many of the predictions in the report is the Clean Power Plan, introduced by President Obama in 2015. "The CPP was promulgated under Section 111 of the Clean Air Act. Section 111 of the Clean Air Act authorizes the EPA to issue nationally applicable New Source Performance Standards (NSPS) limiting air pollution from "new sources" in source categories that cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare."³ In figures 3 and 4 below there are predictions with and without the CPP standards, which mainly impact coal fired power plants. Due to concerns from 27 states as well as a variety of companies the US Supreme Court issued a stay of the Clean Power Plan implementation on 2/9/16, pending judicial review⁴. On 3/28/17 President Trump signed the Executive Order on Energy Independence. Section 4 of this executive order calls for a review of the Clean Power Plan⁵. The Environmental Protection Agency filed a proposal to repeal the CPP on 10/16/17⁶.

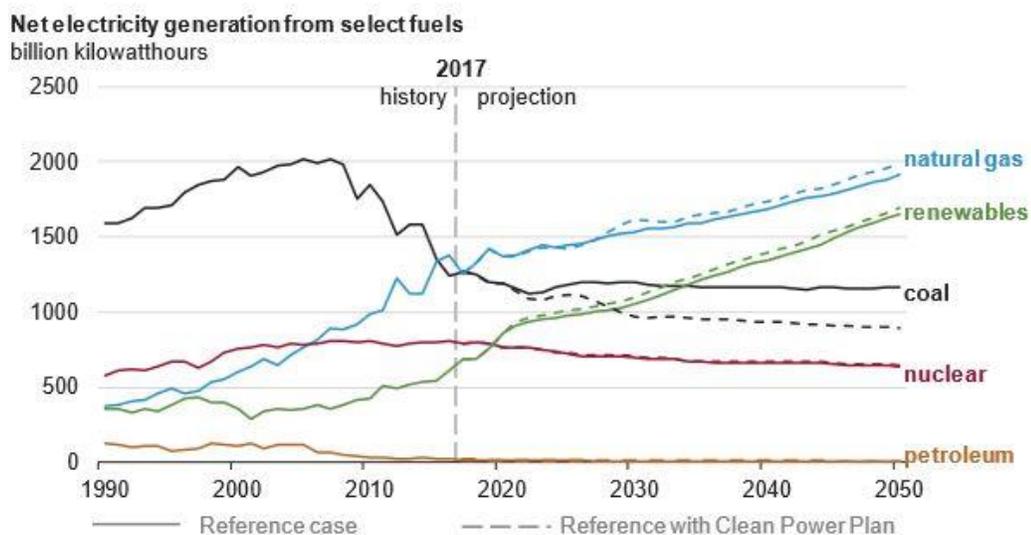


Figure 2 - AEO Electricity Generation Projections

² <https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf>

³ <https://www.federalregister.gov/documents/2017/04/04/2017-06522/review-of-the-clean-power-plan>

⁴ <https://www.epa.gov/sites/production/files/2017-10/documents/eo-13783-final-report-10-25-2017.pdf>

⁵ <https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/>

⁶ <https://www.gpo.gov/fdsys/pkg/FR-2017-10-16/pdf/2017-22349.pdf>

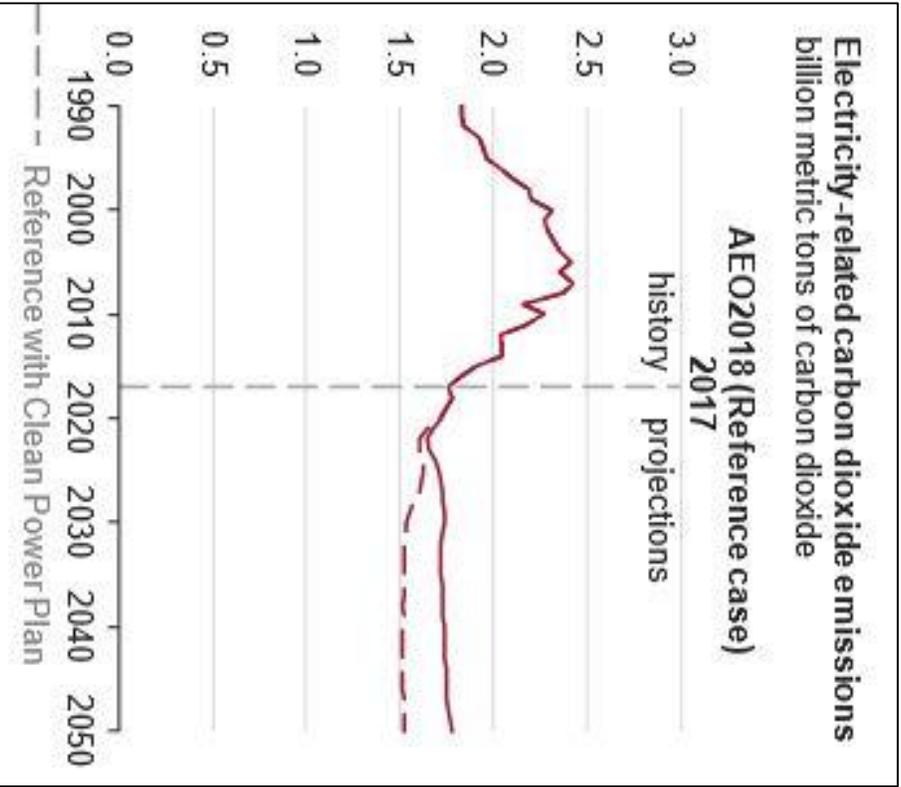


Figure 3 - AEO Electricity Related Carbon Emissions

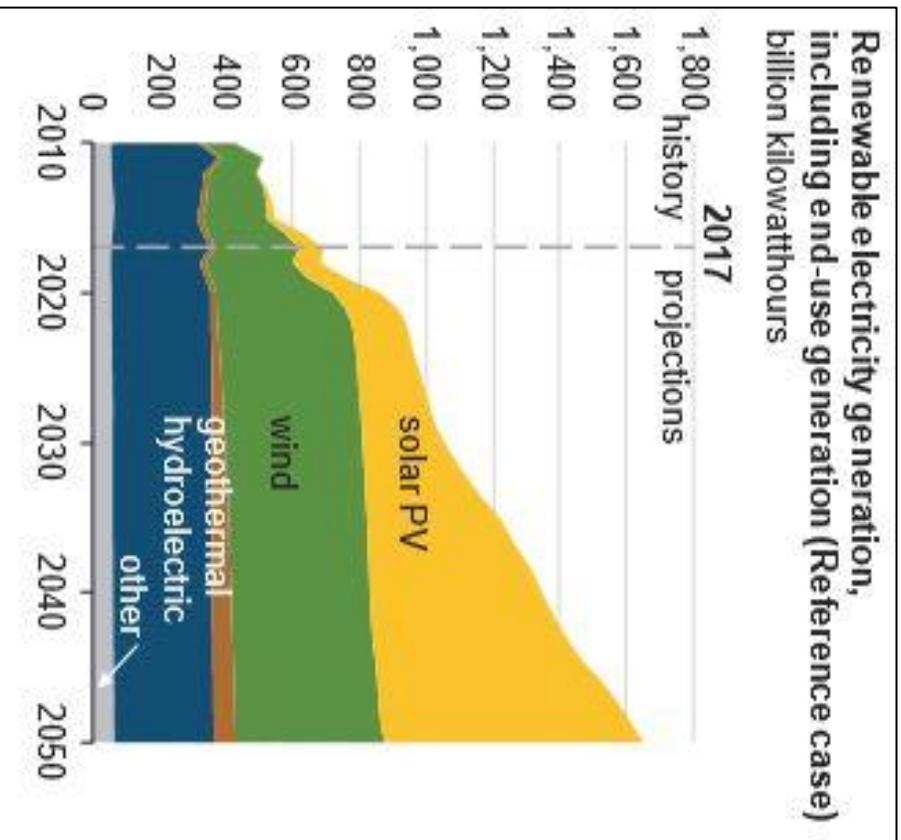


Figure 4 - AEO Renewable Electricity Projections

National Wind Energy Production Overview

In 2017, wind energy accounted for 6.3% of the nation's total energy production. According to the American Wind Energy Association, there are over 54,000 turbines with a combined nameplate capacity of 89,379MW. The top three wind producing states are Texas (22,799MW), Oklahoma (7,495MW), and Iowa (7,312MW)⁷. Montana (720wMW) is ranked 24th and produces 0.8% of the nation's wind energy⁸.

Wind Energy - Percentage of Total National Production

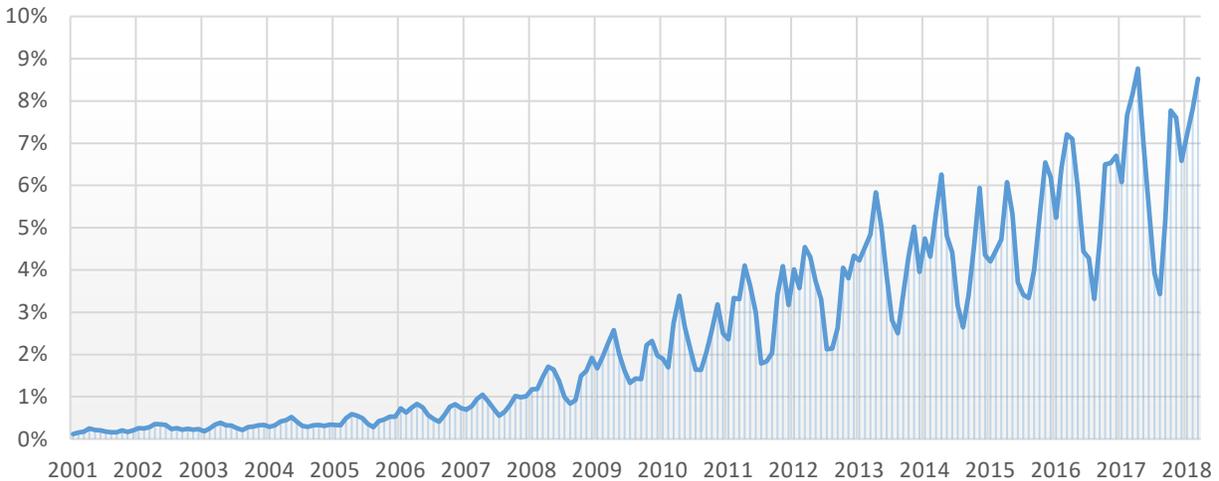
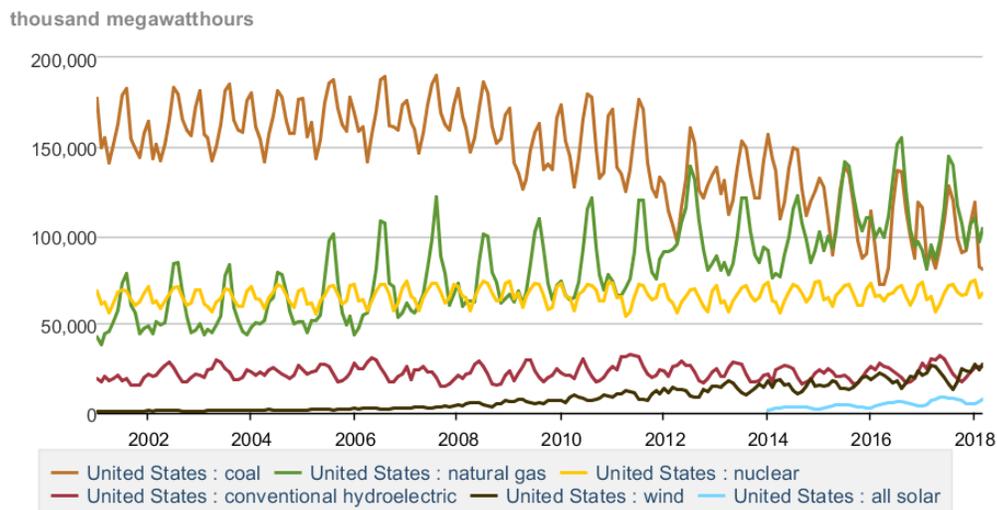


Figure 5 - Wind Percentage of National Production

National Energy Production



Data source: U.S. Energy Information Administration

Figure 6 – EIA National Energy Production (Monthly)

⁷ <https://www.awea.org/windenergyfacts.aspx>

⁸ <http://awea.files.cms-plus.com/FileDownloads/pdfs/Montana.pdf>

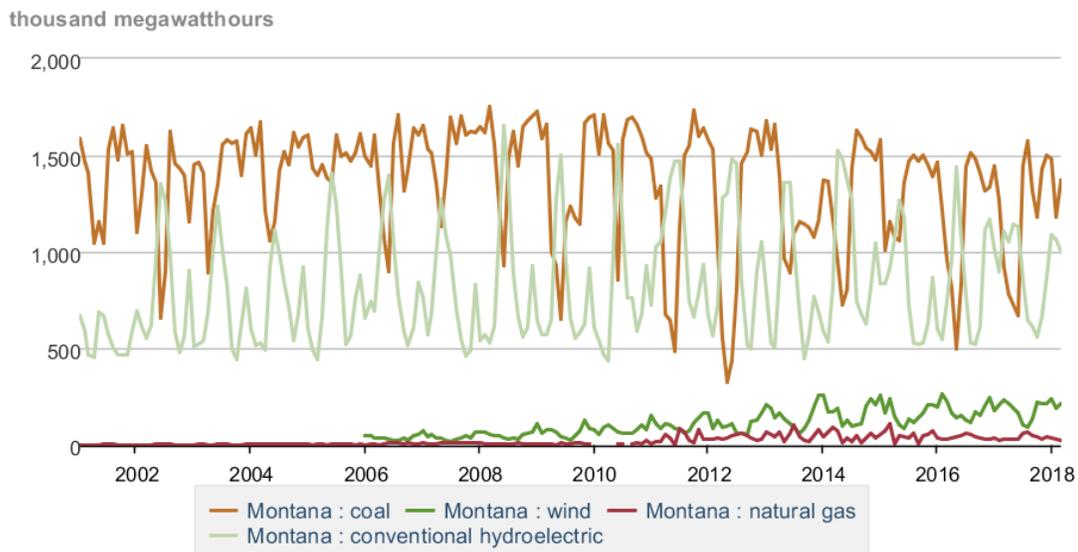
Montana Electrical Production Overview

The majority of the electricity in Montana is produced by coal and hydroelectric facilities, with about 7.5% produced by wind. Montana is a net energy exporter, selling roughly 50% of the energy produced to neighboring states like Washington and Oregon⁹.

In April 2005, as part of the Montana Renewable Power Production and Rural Economic Development Act, the Renewable Portfolio Standard required utility companies to obtain 15% of the energy they sold from renewable sources¹⁰. Northwestern energy, the state's largest utility company, produced about 60% of the energy they sold in 2017 from renewable sources¹¹.

Montana has a variety of residential and commercial renewable energy tax credits and loan programs available, as well as other renewable energy incentive programs. Net metering, which is required by law in Montana for installations less than 50kw, allows surplus energy produced by a customer's renewable system to be sold back to the utility company for energy "credits."¹² Montana also requires utility companies to offer customers a green power option to purchase energy from renewable sources¹³. Northwestern Energy's green power option program is called "E+ Green" and allows customers to pay \$2 per month per 100kWhrs of renewable sourced energy.

Montana Energy Production



Data source: U.S. Energy Information Administration

Figure 7 - EIA Montana Energy Production

⁹ <https://leg.mt.gov/content/Publications/Environmental/2014-understanding-energy.pdf>

¹⁰ <http://programs.dsireusa.org/system/program/detail/384>

¹¹ <http://www.northwesternenergy.com/save-energy-money/business-services/business-services-montana/renewable-energy/e-green>

¹² <http://deg.mt.gov/Energy/renewableenergy/netmeterrenew>

¹³ <http://programs.dsireusa.org/system/program/detail/26>

Montana Wind Energy Production Overview

Montana currently has 13 operational utility scale wind energy projects that encompass 20 different sites, and have a cumulative nameplate capacity of 721.6MW. When the Stillwater site goes online later in 2018, that total will be raised to 800.6MW. In 2016 wind energy accounted for 7.57% of Montana’s energy production, enough to power roughly 197,000 homes¹⁴.

MT Rated Wind Power Capacity

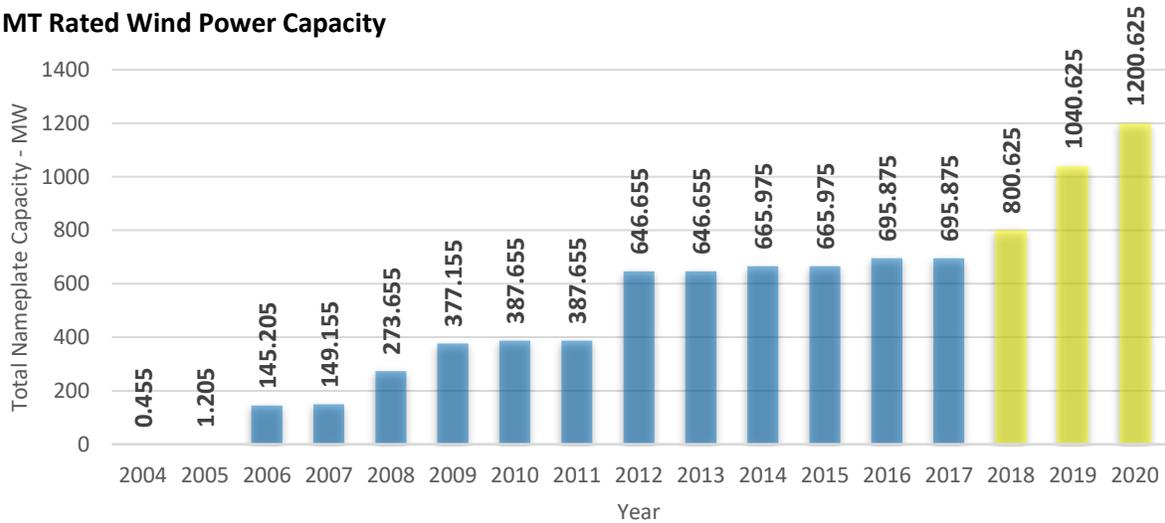


Figure 8 - MT Rated Wind Power Capacity

Wind Energy - Percentage of Total Montana Production

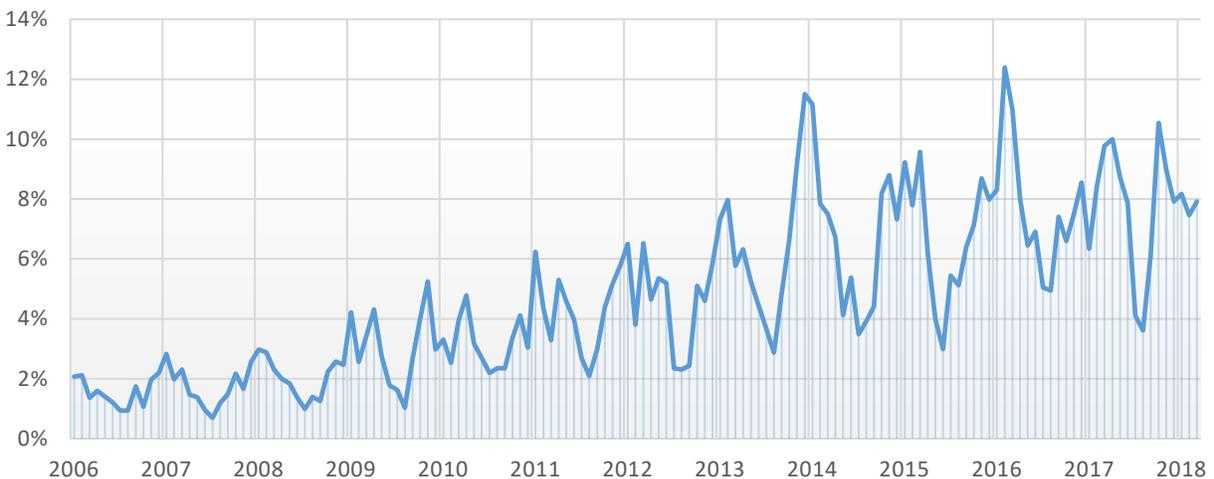


Figure 9 - Wind Percentage of Montana Production

¹⁴ <http://awea.files.cms-plus.com/FileDownloads/pdfs/Montana.pdf>

Wind Energy Benefits

In 2015 the US Department of Energy released the Wind Vision report. The report showed that wind power could produce 10% of the nation's energy by 2020, 20% by 2030, and 35% by 2050¹⁵. The American Wind Energy Association (AWEA) and the Wind Energy Foundation used the data from the 2015 Wind Vision report to produce the Montana Wind Vision Fact Sheet¹⁶. In this document the AWEA states that achieving the DOE's Wind Vision goal for Montana would have the benefits described in the figures below.

Table 1 - AWEA Montana Wind Vision Facts

Consumer Benefits in Montana	Cumulative through 2050	
Electricity bill savings	\$677 million	
Savings through lower natural gas prices	\$1.12 billion	
Economic Benefits in Montana	By 2020	By 2030
Annual property tax revenue	\$25.72 million	\$126.13 million
Annual land lease payments	\$10.43 million	\$51.14 million
Environmental benefits in Montana	By 2020	By 2030
Annual water use avoided, in gallons	900.67 million	7.19 billion
Annual carbon pollution avoided, in metric tons	1.68 million	11.7 million
Annual carbon pollution avoided, in equivalent cars worth of emissions	354,000	2.46 million

17

Table 2 - Renewables NW Fact Sheet Data

Project	County	Capital Investment (Million \$)	Construction Jobs	Permanent Jobs
Judith Gap	Wheatland	\$203	200	12
Horseshoe Bend	Cascade	\$15	20	1.5
Martinsdale Colony	Meagher	\$5	10	0.5
Diamond Willow	Fallon	\$45	100	4
Glacier Wind	Toole	\$550	486	40
Gordon Butte	Meagher	\$20	20	1
Rim Rock Wind	Glacier	\$400	300	20
Spion Kop	Judith Basin	\$86	100	4
Musselshell 1	Wheatland	\$20	38	2
Musselshell 2	Wheatland	\$20	37	1

18

¹⁵ <https://www.energy.gov/eere/wind/maps/wind-vision>

¹⁶ <http://awea.files.cms-plus.com/FileDownloads/pdfs/Montana.pdf>

¹⁷ <http://windenhttp://awea.files.cms-plus.com/FileDownloads/pdfs/Montana.pdf>
www.windenergyfoundation.org/wp-content/uploads/wind-vision-fact-sheet-MT.pdf

¹⁸ <https://renewablenw.org/sites/default/files/pdfs/montana%20wind%20power%20factsheet%202012Mar6.pdf>

Wind Resource Potential

The AWEA also states in the fact sheet that “the latest data from the DOE finds that wind energy could provide 89.8% of Montana’s electricity by 2020 and increase to 403.5% by 2030. The wind energy produced in Montana alone would power the equivalent of 6.4 million average American homes by 2030.” The roughly 1000% increase in wind energy production Montana would have to make to confirm these predictions is impossible. However, the National Renewable Energy Laboratory (NREL) data for wind energy potential in Montana shows that there is possibility for a large amount of growth. NREL states that the land based technical wind potential for the state at an 80m hub height is 687,977 MW¹⁹. Although it is likely not possible to reach this full potential due to power transmission, ecological, and economic conditions, NREL’s research on wind resource potential shows that Montana has plenty of opportunity for future wind resource development.

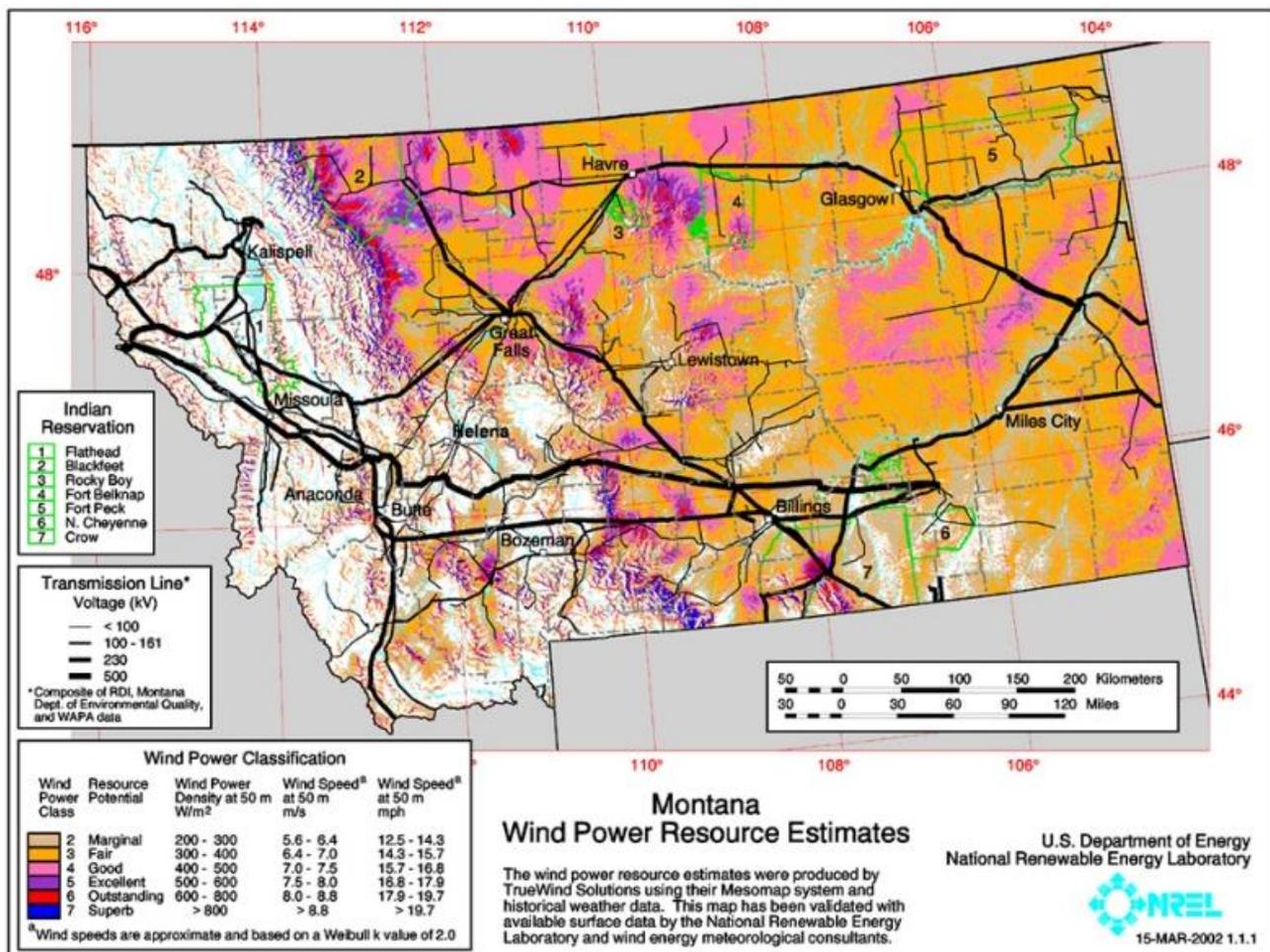


Figure 10 - NREL Wind Resource Map (50m)

¹⁹ <https://windexchange.energy.gov/states/mt>

Montana Wind Power Production

The power produced by wind facilities fluctuates due to varying wind speeds, or the total lack of wind. As a result the actual power produced by wind facilities will be different than their nameplate capacity.

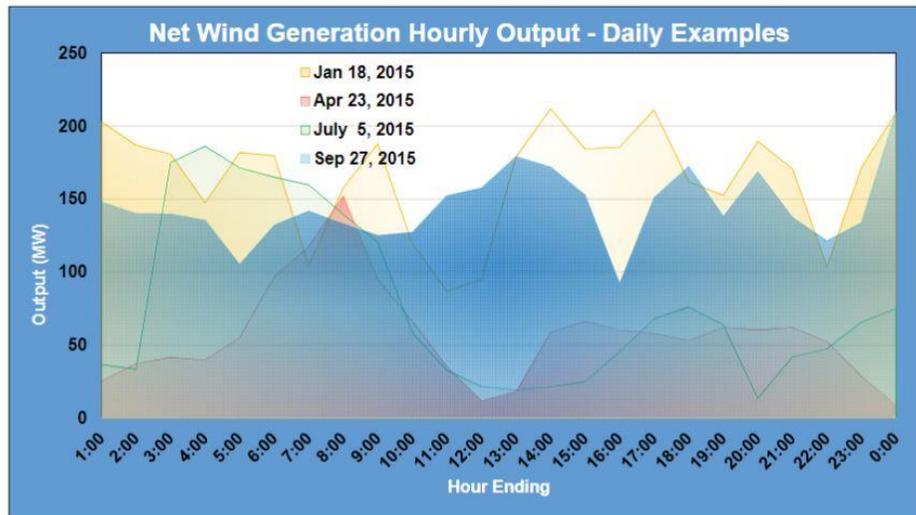


Figure 11 - NWE Hourly Wind Generation Examples

The capacity factor of a wind facility, or of an individual turbine, is the percentage of the nameplate capacity power that was actually produced over a period of time. The map below shows where in Montana a capacity factor of 35% or higher can be expected, based on wind speed and meteorological data. The average historical capacity factor for utility scale wind energy facilities in Montana, based on Energy Information Administration data, is 33%.

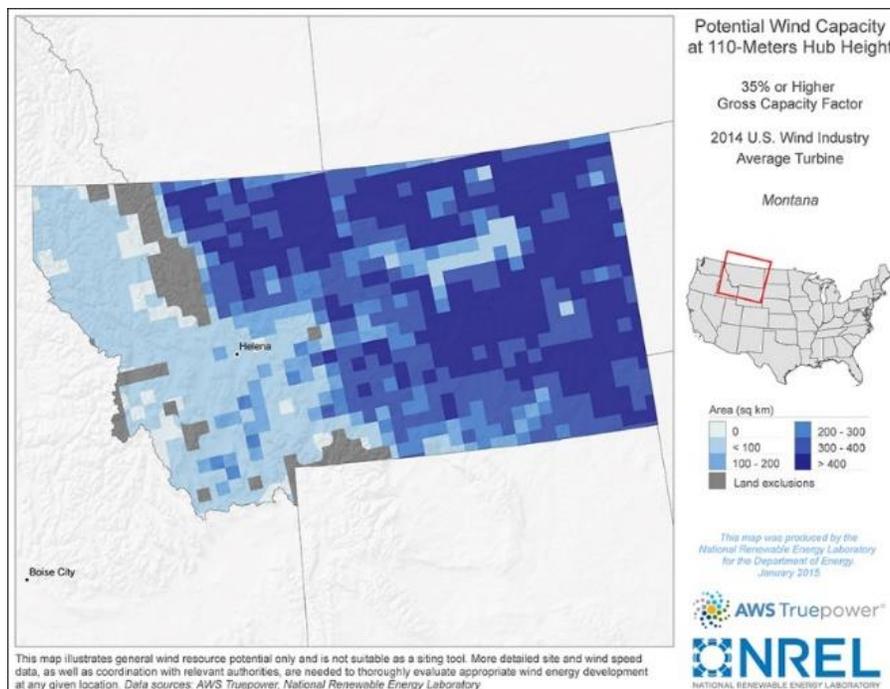


Figure 12 - NREL Wind Capacity Map (110m)

Average Capacity Factor - Montana

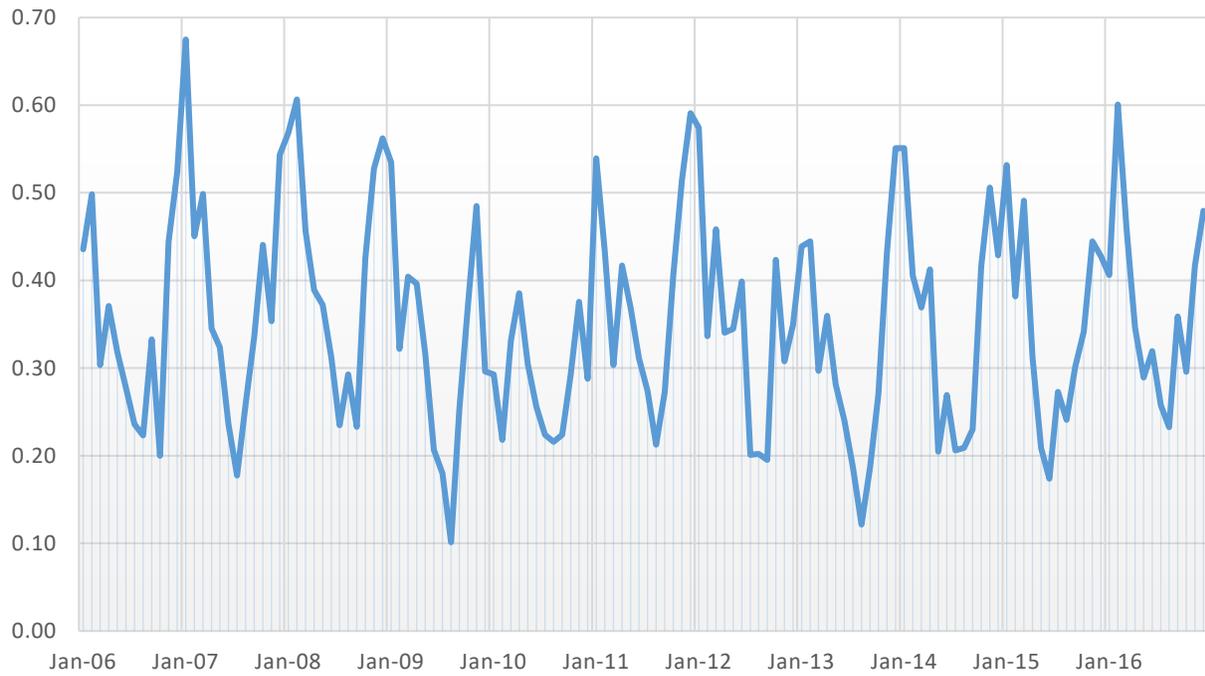
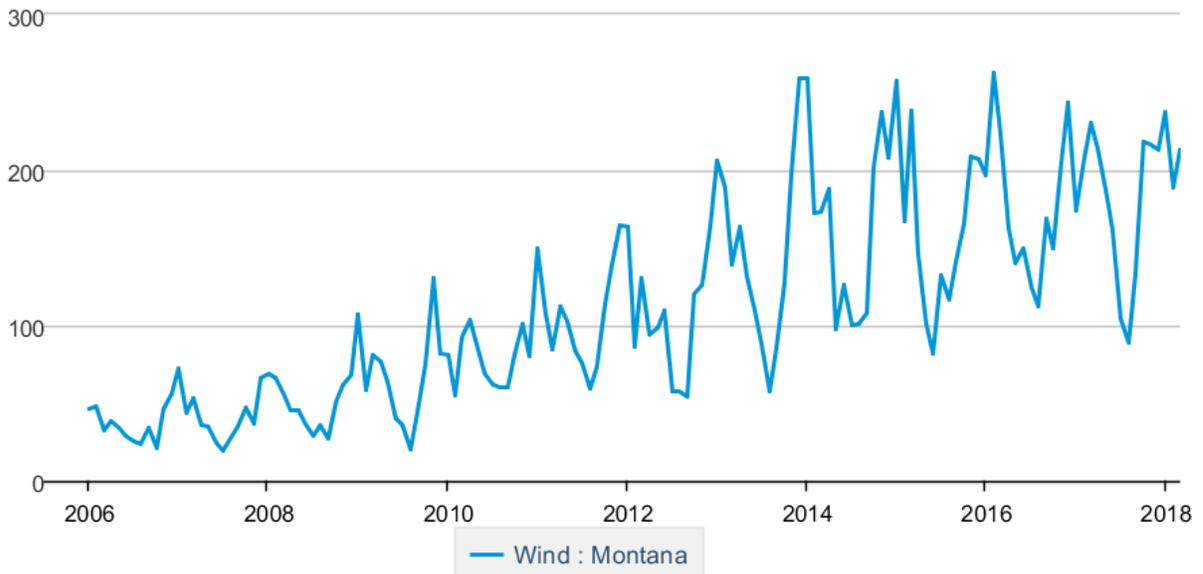


Figure 13 - Montana Average Capacity Factor

Wind Energy Production - Montana

thousand megawatthours



eia Source: U.S. Energy Information Administration

Figure 14 – EIA Montana Wind Energy Production (Monthly)

Operational Utility Scale Wind Energy Facilities

Table 3 - MT Operational Wind Facilities

Project	Site Name	Nameplate Capacity	Online Date	Historical Capacity Factor
		(MW)		
Big Timber Wind (Greycliff)	Greycliff Wind	25	2018	0.27*
Diamond Willow Wind	Diamond Willow Wind (07)	1.5	2007	0.35
	Diamond Willow Wind (08)	18	2008	
	Diamond Willow Extension	10.5	2010	
Fairfield Wind	Fairfield Wind	9.6	2014	0.38
Gordon Butte Wind	Gordon Butte Wind	9.6	2012	0.51
Greenfield Wind	Greenfield Wind	29.9	2016	0.24*
Horseshoe Bend Wind Park	Horseshoe Bend Wind Park	9	2006	0.30
Judith Gap Wind Energy Center	Judith Gap Wind Energy Center	135	2006	0.40
Musselshell Wind Project	Musselshell Wind 1	10.5	2012	0.26
	Musselshell Wind 2	10.5	2012	0.29
Glacier Wind Energy	Glacier Wind Farm 1	106.5	2008	0.29
	Glacier Wind Farm 2	103.5	2009	0.30
Rim Rock Energy	Rim Rock Wind Farm	189	2012	0.32
Spion Kop Wind Farm	Spion Kop Wind Farm	40	2012	0.38
Two Dot Wind	Two Dot Wind Farm	9.72	2014	0.38
	Sheep Valley Ranch	0.5	2004	0.19**
	Moe Wind Farm	0.5	2007	0.15**
Martinsdale Colony	Martinsdale Colony North	0.8	2005	0.065**
	Martinsdale Colony South	2	2007	0.25**
Montana	Total:	721.62	Average:	0.33

Links to EIA data used to calculate capacity factor are included in the summary for each site unless noted otherwise.

*The Big Timber and Greenfield sites have not been online long enough to have an appropriate amount of data to calculate accurate capacity factors. These values are still included when calculating the Montana average capacity factor.

**EIA production data is not available to calculate capacity factor. These values were obtained from North Western Energy's 2015 Electricity Supply Resource Procurement Plan²⁰.

²⁰ <http://www.northwesternenergy.com/docs/default-source/documents/defaultsupply/plan15/volume1/chapter8existingresources>

Judith Gap Wind Energy Center



[\(Invenergy\)](#)



Near Judith Gap, Wheatland County

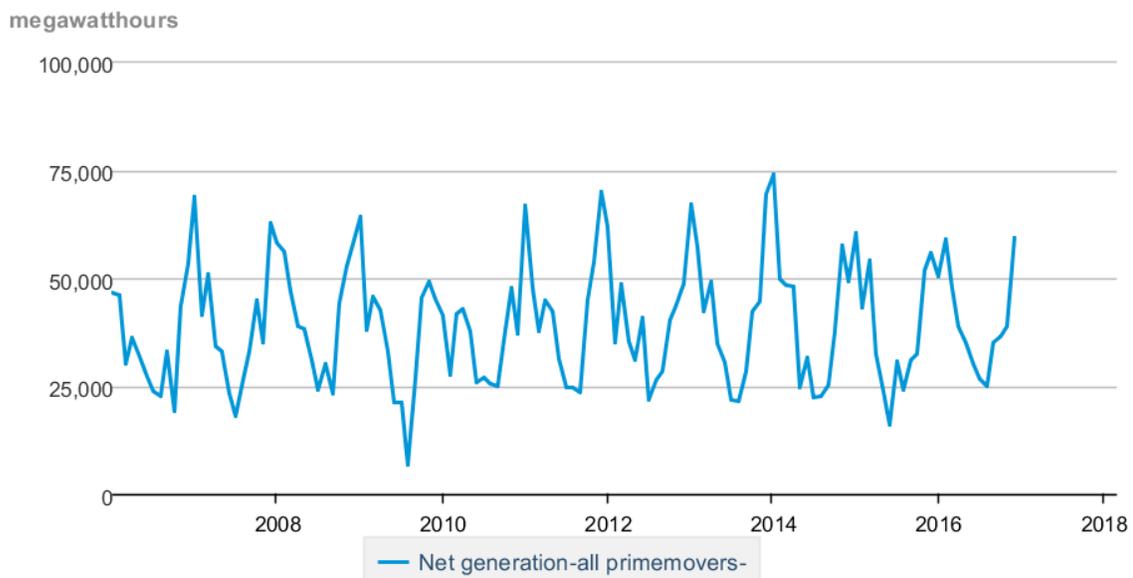
The 135MW Judith Gap Wind Energy Center, located near Harlowton, began operation in 2006. Judith Gap was the first utility scale wind energy facility rated above one megawatt in Montana. The site sells power to Northwestern Energy.

Phase 2 of the Judith Gap Wind Energy Center is in the proposal process, and would produce an additional 52.5MW of rated power.

Wind Farm Information	
Rated Power	135 MW
Turbine Quantity	90
Online Date	2006
Historical Capacity Factor	0.395
Owner	Invenergy LLC
Operator	Invenergy LLC
Developer	Invenergy LLC
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$31.71 (20yrs)

Turbine Information	
Manufacturer	GE
Model	1.5sle
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	15 m/s

21 22 23



Source: U.S. Energy Information Administration

Figure 15 - EIA Judith Gap Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatt hours)	50320	58793	47563	38641	34937	30096
²⁴	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	26489	24956	34947	36349	38660	59346

²¹https://www.thewindpower.net/windfarm_en_3073_judith-gap.php

²²https://www.thewindpower.net/turbine_en_57_ge-energy_1.5sle.php

²³http://psc2.mt.gov/Docs/ElectronicDocuments/pdfFiles/D2005-2-14_6633b.pdf

²⁴<https://www.eia.gov/electricity/data/browser/#/plant/56377/?freq=M&pin=>

Glacier Wind Energy



naturener.us



Near Ethridge, Glacier and Toole Counties

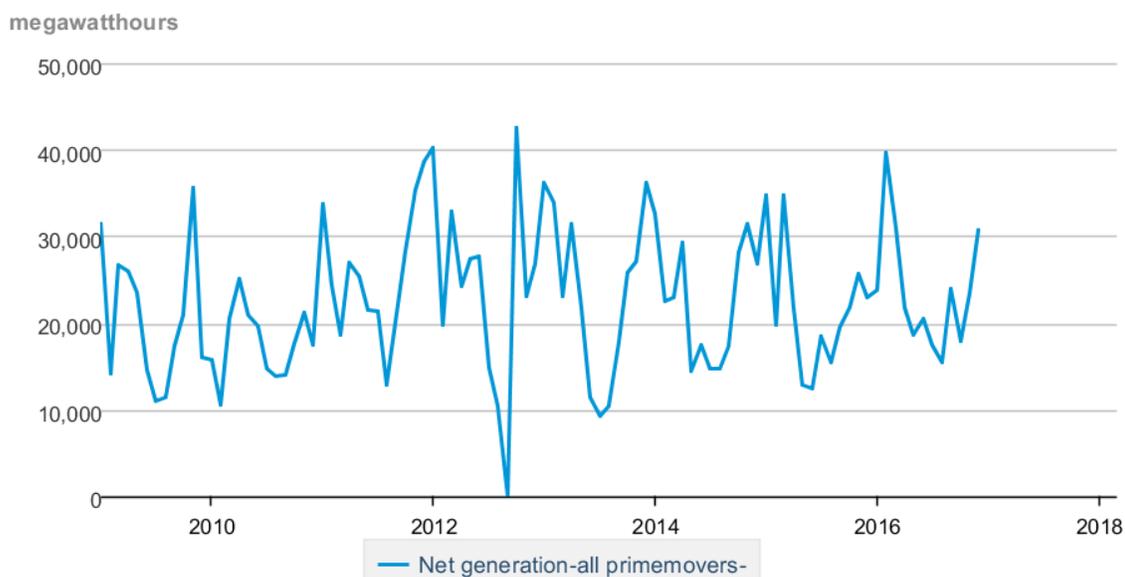
NaturEner purchased Glacier Wind Farms 1 and 2, as well as the Rim Rock Wind Farm project, from Great Plains Wind & Energy LLC in 2006. Glacier Wind Farm 1 went online in 2008 with 71 Acciona turbines, and Glacier Wind Farm 2 went online in 2009 with 69 turbines. Together the two sites are rated to a total of 210MW. Power produced by the Glacier Wind Farm sites is purchased by San Diego Gas & Electric.

Glacier Wind Farm 1

Wind Farm Information	
Rated Power	106.5 MW
Turbine Quantity	71
Online Date	2008
Historical Capacity Factor	0.290
Owner	NaturEner
Operator	NaturEner
Developer	Mortenson
Power Purchaser	San Diego Gas and Electric
Power Price (\$/MWhr)	Confidential (15yrs)

Turbine Information	
Manufacturer	Acciona
Model	AW-1500/77
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	11.1 m/s

²⁵ ²⁶ ²⁷



Source: U.S. Energy Information Administration

Figure 16 - EIA Glacier 1 Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	23775	39766	31011	21825	18709	20457
²⁸	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	17552	15501	23946	17926	23388	30710

²⁵ https://www.thewindpower.net/turbine_en_180_acciona_aw-1500-77.php

²⁶ https://www.thewindpower.net/turbine_en_180_acciona_aw-1500-77.php

²⁷ <http://www.mortenson.com/wind/projects/glacier-wind-farm-phase-i-and-ii>

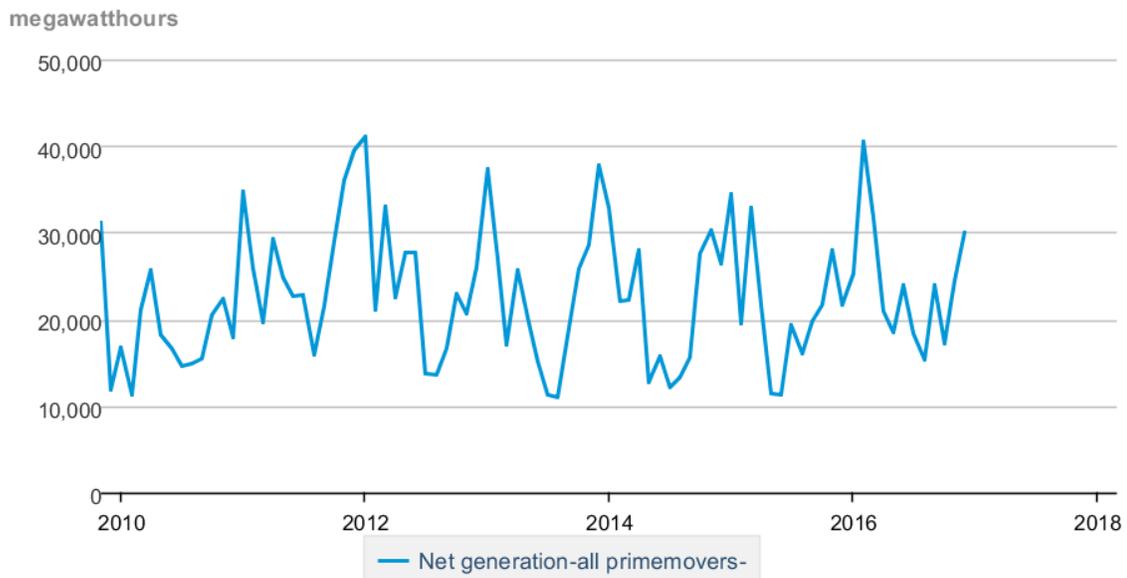
²⁸ <https://www.eia.gov/electricity/data/browser/#/plant/57049/?freq=M&pin=>

Glacier Wind Farm 2

Wind Farm Information	
Rated Power	103.5 MW
Turbine Quantity	69
Online Date	2009
Historical Capacity Factor	0.300
Owner	NaturEner
Operator	NaturEner
Developer	Mortenson
Power Purchaser	San Diego Gas and Electric
Power Price (\$/MWhr)	Confidential (15yrs)

Turbine Information	
Manufacturer	Acciona
Model	AW-1500/77
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	11.1 m/s

²⁹ ³⁰



Source: U.S. Energy Information Administration

Figure 17 - EIA Glacier 2 Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatt-hours)	25320	40548	31819	20890	18520	23930
³¹	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	18418	15327	23921	17206	24350	30054

²⁹ https://www.thewindpower.net/windfarm_en_7111_glacier-ii.php

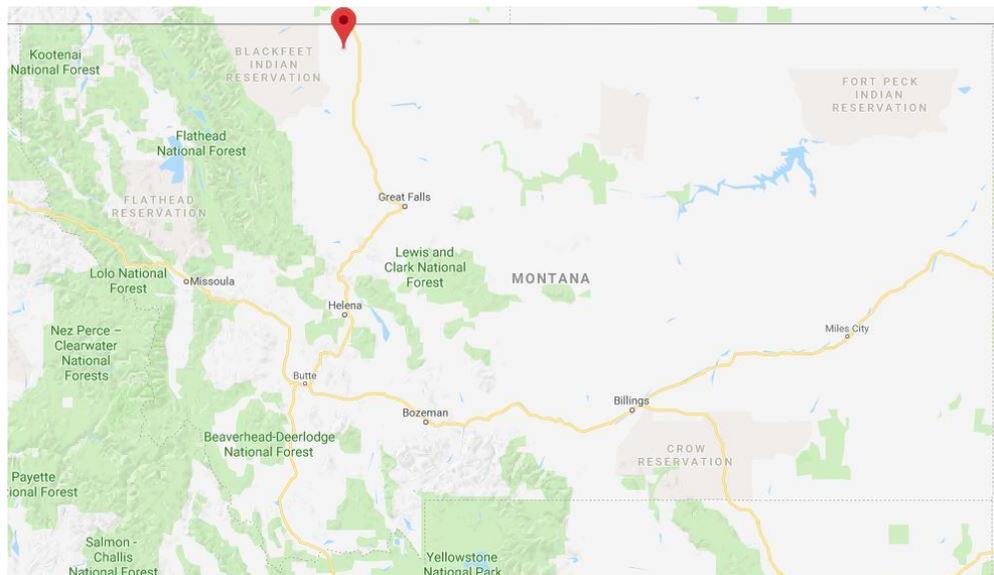
³⁰ http://docs.cpuc.ca.gov/PublishedDocs/PUBLISHED/FINAL_RESOLUTION/106028.htm

³¹ <https://www.eia.gov/electricity/data/browser/#/plant/57050/?freq=M&pin=>

Rim Rock Energy



(Mortenson)



Near Kevin, Toole County

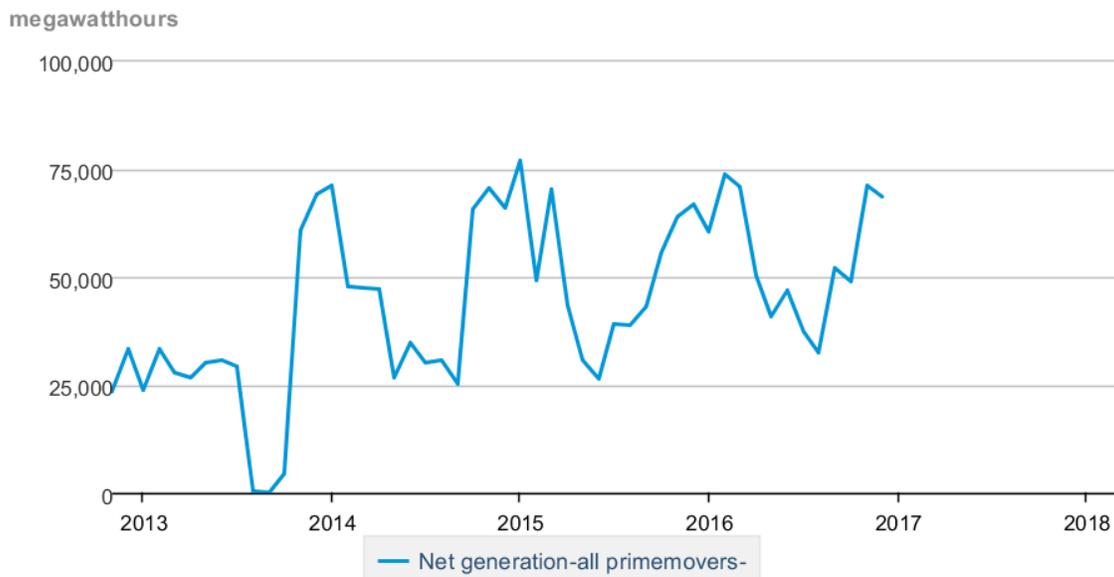
The 189MW Rim Rock wind farm project went online in 2012, and is currently the largest wind farm in Montana. During peak generation, Rim Rock Wind Energy produces enough electricity to power roughly **60,000** homes. Shortly after construction, 25 of the 126 turbines were relocated about half a mile away from their original installation site to accommodate raptors nesting in the area.³² Power produced by the Rim Rock wind farm site is purchased by San Diego Gas & Electric.

³² http://www.altenerg.com/back_issues/julyaug2013-story3.htm

Wind Farm Information	
Rated Power	189 MW
Turbine Quantity	126
Online Date	2012
Historical Capacity Factor	0.321
Owner	NaturEner
Operator	NaturEner
Developer	Mortenson
Power Purchaser	San Diego Gas and Electric
Power Price (\$/MWhr)	Confidential (15yrs)

Turbine Information	
Manufacturer	Acciona
Model	AW-1500/77
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	11.1 m/s

33 34 35



Source: U.S. Energy Information Administration

Figure 18 - EIA Rim Rock Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatt-hours)	60443	73771	70841	50262	40664	46954
³⁶	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	37262	32393	52146	48838	70929	68401

³³ https://www.thewindpower.net/windfarm_en_21306_rim-rock.php

³⁴ http://docs.cpuc.ca.gov/PublishedDocs/PUBLISHED/FINAL_RESOLUTION/110403.htm

³⁵ <http://www.mortenson.com/wind/projects/rim-rock-wind-project>

³⁶ <https://www.eia.gov/electricity/data/browser/#/plant/57995/?freq=M&pin=>

Musselshell Wind Project



(Mortenson)



Near Shawmut, Wheatland County

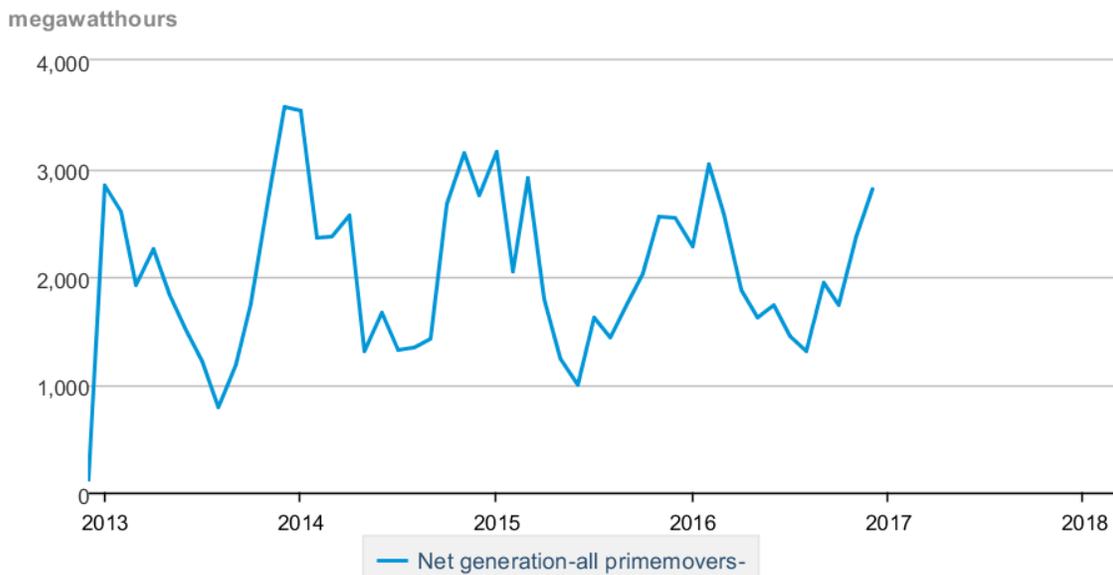
The Musselshell Wind Project consists of two sites that are rated to a total of 21MW. Both sites went online in 2012, and each site consists of 7 Goldwind turbines. The Goldwind turbines feature their proprietary Permanent Magnet Direct Drive (PMDD) technology, which is designed to increase efficiency and reduce maintenance costs. Power from the Musselshell site is purchased by Northwestern Energy.

Musselshell Wind Farm 1

Wind Farm Information	
Rated Power	10.5 MW
Turbine Quantity	7
Online Date	2012
Historical Capacity Factor	0.265
Owner	Goldwind
Operator	Musselshell Wind Project LLC
Developer	Mortenson, Volkswind USA
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$69.04

Turbine Information	
Manufacturer	Goldwind
Model	GW87/1500
Nameplate Capacity	1500 kW
Rotor Diameter	87 m
Hub Height	100 m
Rated Wind Speed	9.9 m/s

³⁷ ³⁸ ³⁹



Source: U.S. Energy Information Administration

Figure 19 - EIA Musselshell 1 Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	2277	3041	2582	1877	1621	1732
⁴⁰	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	1443	1303	1947	1734	2364	2808

³⁷ https://www.thewindpower.net/windfarm_en_21305_musselshell-wind-project-i.php

³⁸ <https://www.goldwindamericas.com/15-mw-pmdd>

³⁹ <http://www.northwesternenergy.com/docs/default-source/documents/defaultsupply/plan15/volume2/windresourcepricing>

⁴⁰ <https://www.eia.gov/electricity/data/browser/#/plant/57963/?freq=M&pin=>

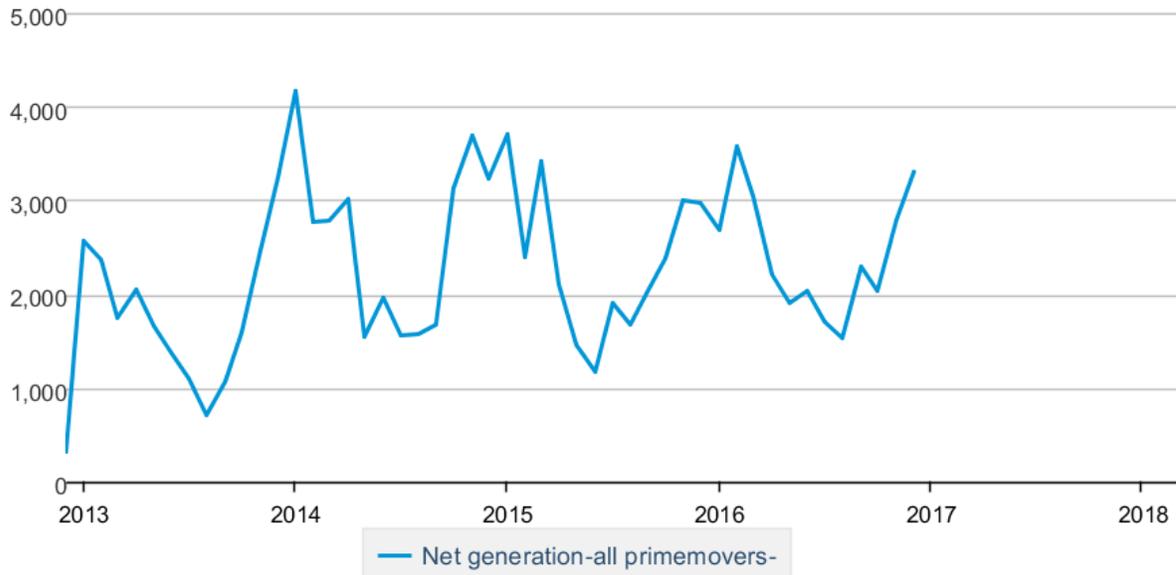
Musselshell Wind Farm 2

Wind Farm Information	
Rated Power	10.5 MW
Turbine Quantity	7
Online Date	2012
Historical Capacity Factor	0.265
Owner	Goldwind
Operator	Musselshell Wind Project LLC
Developer	Mortenson, Volkswind USA
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$69.04

Turbine Information	
Manufacturer	Goldwind
Model	GW87/1500
Nameplate Capacity	1500 kW
Rotor Diameter	87 m
Hub Height	100 m
Rated Wind Speed	9.9 m/s

41

megawatthours



Source: U.S. Energy Information Administration

Figure 20 - EIA Musselshell 2 Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	2685	3586	3044	2213	1911	2043
	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	1702	1537	2296	2044	2787	3311

42

⁴¹ https://www.thewindpower.net/windfarm_en_21648_musselshell-wind-project-ii.php

⁴² <https://www.eia.gov/electricity/data/browser/#/plant/57965/?freq=M&pin=>

Spion Kop Wind Farm



(City of Bozeman)



Near Geyser, Judith Basin County

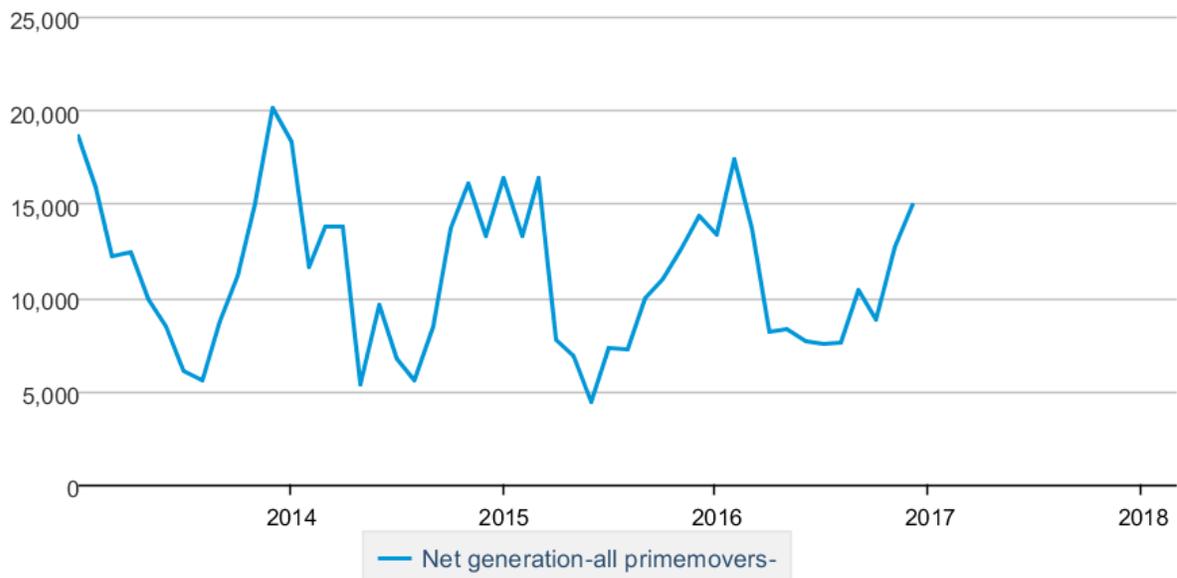
The Spion Kop windfarm is a 40MW facility with 25 GE turbines located near the town of Geyser. The project was developed by Colorado based Compass Energies, and then purchased by Northwestern Energy. Although many Montana wind farms sell their power to Northwestern Energy, this is the only commercial wind facility owned by NWE.

Wind Farm Information	
Rated Power	40 MW
Turbine Quantity	25
Online Date	2012
Historical Capacity Factor	0.384
Owner	Northwestern Energy
Operator	Northwestern Energy
Developer	Compass Energies
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$52.40

Turbine Information	
Manufacturer	GE
Model	1.6-82.5
Nameplate Capacity	1600 kW
Rotor Diameter	82.5 m
Hub Height	80 m
Rated Wind Speed	12 m/s

43 44

megawatthours



Source: U.S. Energy Information Administration

Figure 21 - EIA Spion Kop Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	13383	17383	13731	8146	8293	7642
⁴⁵	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	7553	7624	10386	8835	12699	14986

⁴³ [https://www.thewindpower.net/windfarm_en_24684_spion-kop-\(us\).php](https://www.thewindpower.net/windfarm_en_24684_spion-kop-(us).php)

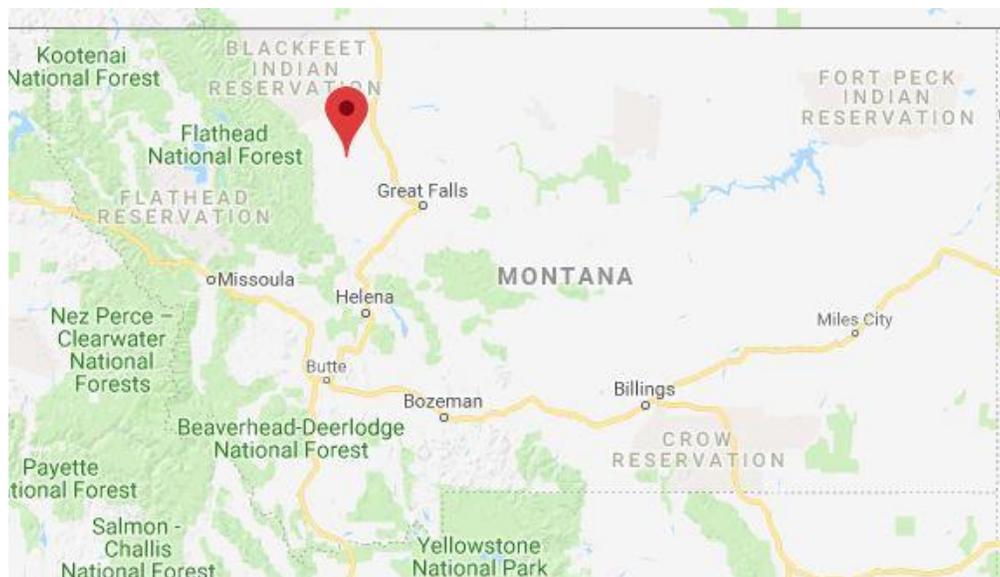
⁴⁴ https://www.thewindpower.net/turbine_en_380_ge-energy_1.6-82.5.php

⁴⁵ <https://www.eia.gov/electricity/data/browser/#/plant/58218/?freq=M&pin=>

Fairfield Wind



([Foundation Windpower](#))



Near Fairfield, Teton County

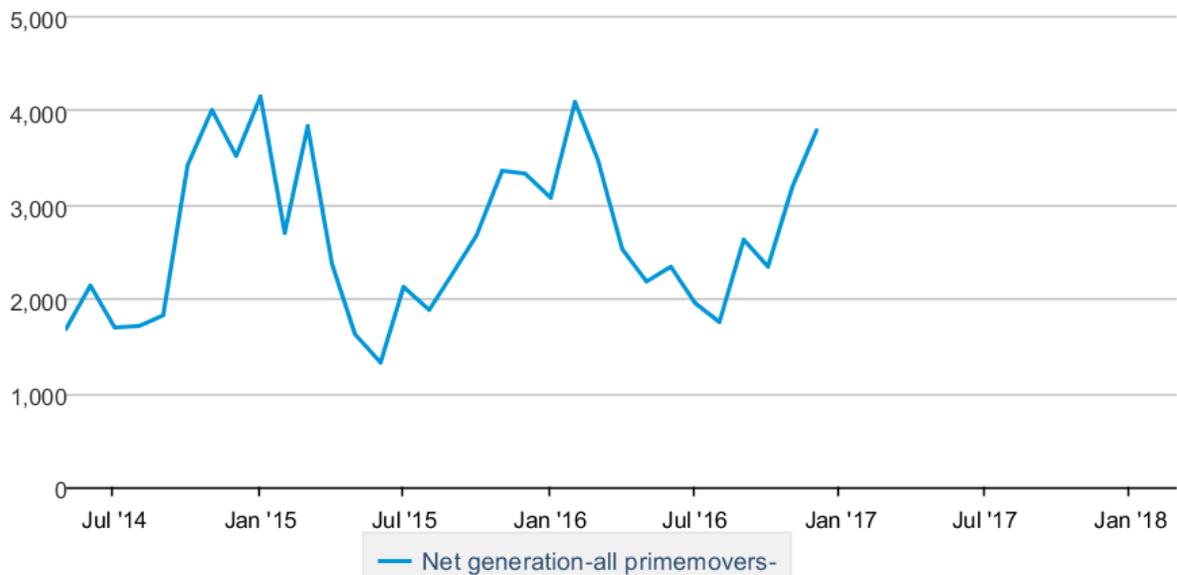
Foundation Windpower purchased the Fairfield Wind project from Fairfield Wind LLC in 2013 while the project was in late state development. The 9.6MW began operation in 2014 with six GE 1.6xle turbines. Fairfield, and its sister site Greenfield Wind Project, are both currently owned and operated by Greenbacker Renewable Energy Company.

Wind Farm Information	
Rated Power	9.6 MW
Turbine Quantity	6
Online Date	2014
Historical Capacity Factor	0.378
Owner	Greenbacker Renewable Energy
Operator	Greenbacker Renewable Energy
Developer	WINDData LLC
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$73.93

Turbine Information	
Manufacturer	GE
Model	1.6xle
Nameplate Capacity	1600 kW
Rotor Diameter	82.5 m
Hub Height	80 m
Rated Wind Speed	11 m/s

46 47

megawatthours



Source: U.S. Energy Information Administration

Figure 22 – EIA Fairfield Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	3067	4097	3478	2528	2184	2333
⁴⁸	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	1944	1755	2623	2335	3184	3782

⁴⁶ https://www.thewindpower.net/windfarm_en_20963_fairfield.php

⁴⁷ https://www.thewindpower.net/turbine_en_670_ge-energy_1.6xle.php

⁴⁸ <https://www.eia.gov/electricity/data/browser/#/plant/58966/?freq=M&pin=>

Greenfield Wind Project



(Dick Anderson Construction)



Near Fairfield, Teton County

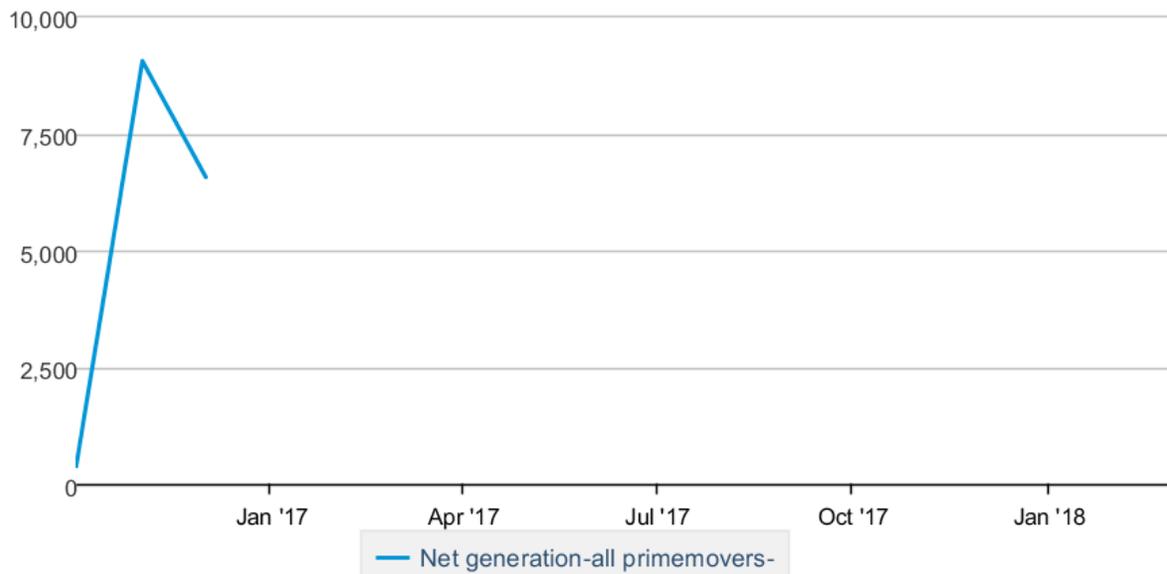
The Greenfield Wind Project is the sister project of the nearby Fairfield Wind Farm. Both sites were owned by Foundation Windpower and developed by WINData, and then purchased by Greenbacker Renewable Energy Company. Greenfield went online in 2016 with 13 GE 2.3-107 turbines, which are currently the largest turbines in the state.

Wind Farm Information	
Rated Power	29.9 MW
Turbine Quantity	13
Online Date	2016
Historical Capacity Factor	0.245
Owner	Greenbacker Renewable Energy
Operator	Greenbacker Renewable Energy
Developer	WINData LLC
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$50.49

Turbine Information	
Manufacturer	GE
Model	2.3-107
Nameplate Capacity	2300 kW
Rotor Diameter	107 m
Hub Height	80 m
Rated Wind Speed	14 m/s

49 50

megawatthours



Source: U.S. Energy Information Administration

Figure 23 – EIA Greenfield Energy Production

Month	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
Energy Produced (megawatthours)	-	-	-	374	9045	6552

51

⁴⁹ https://www.thewindpower.net/windfarm_en_23962_greenfield.php

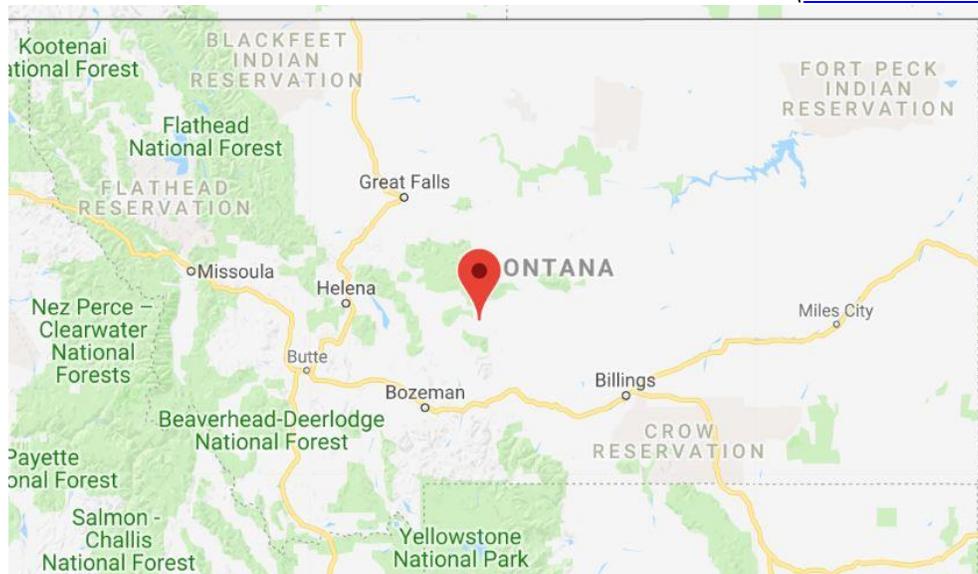
⁵⁰ https://www.thewindpower.net/turbine_en_1007_ge-energy_2.3-107.php

⁵¹ <https://www.eia.gov/electricity/data/browser/#/plant/60486/?freq=M&pin=>

Gordon Butte Wind



(Dick Anderson Construction)



Near Martinsdale, Meagher County

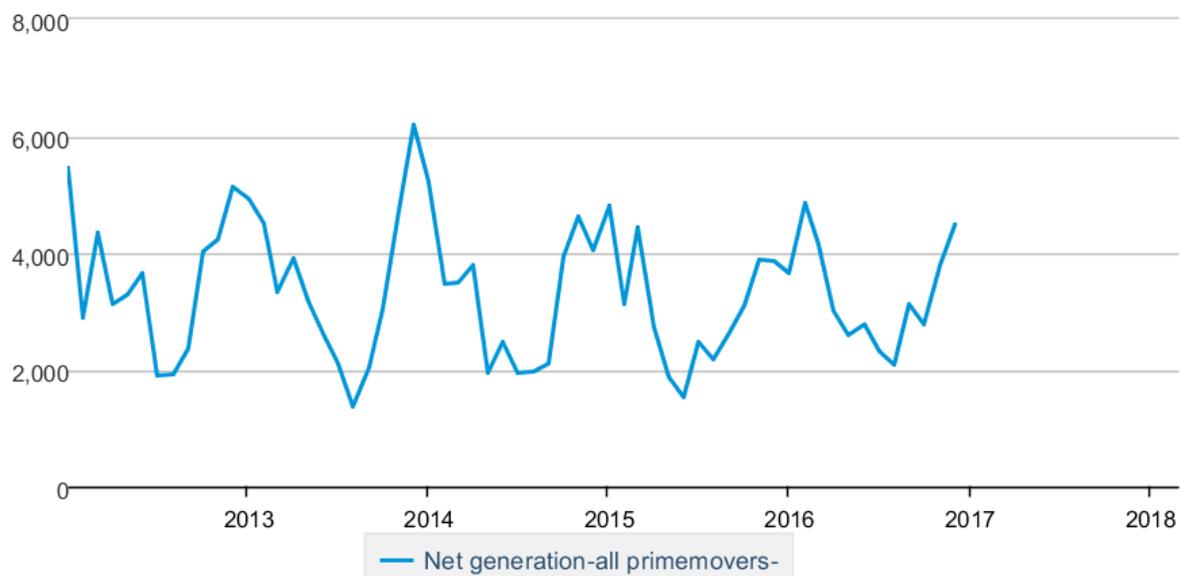
The 9MW Gordon Butte Wind farm, near Martinsdale, operates 6 GE 1.5sle turbines. Power from the Gordon Butte site is sold to Northwestern Energy. According to the Energy Information Administration data, Gordon Butte has the highest historical capacity factor in the state.

Wind Farm Information	
Rated Power	9 MW
Turbine Quantity	6
Online Date	2012
Historical Capacity Factor	0.506
Owner	Gordon Butte Wind LLC
Operator	Gordon Butte Wind LLC
Developer	Oversight Resources LLC
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$67.83

Turbine Information	
Manufacturer	GE
Model	1.5sle
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	15 m/s

52

megawatthours



Source: U.S. Energy Information Administration

Figure 24 – EIA Gordon Butte Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	3641	4864	4129	3002	2593	2770
	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	2309	2084	3115	2773	3781	4491

53

⁵² https://www.thewindpower.net/windfarm_en_18735_gordon-butte.php

⁵³ <https://www.eia.gov/electricity/data/browser/#/plant/57748/?freq=M&pin=>

Horseshoe Bend Wind Park



(Google Maps)



Near Great Fall, Cascade County

The 9MW Horseshoe Bend Wind Park is just west of the Great Falls airport, and operates 6 GE 1.5sle turbines. 5MW of Power from Horseshoe Bend is sold to Idaho Power, the rest is used by United Materials of Great Falls⁵⁴. The site was developed by United Materials and Exergy Development Group in 2006, and was purchased by Sansur Renewable Energy in 2009. Sansur has plans to expand the site, adding an additional 140MW.

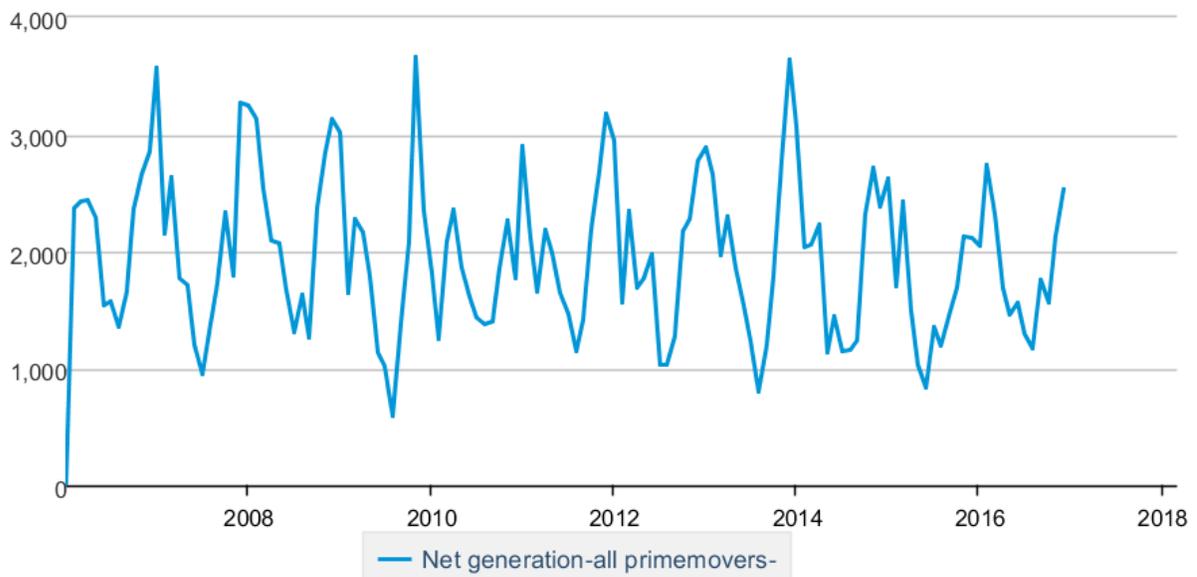
⁵⁴ <http://deg.mt.gov/Energy/renewableenergy/resourcesandtechnology/Wind/windprojectsmt>

Wind Farm Information	
Rated Power	9 MW
Turbine Quantity	6
Online Date	2006
Historical Capacity Factor	0.298
Owner	Sansur Renewable Energy
Operator	United Materials of Great Falls Inc
Developer	Exergy Development Group
Power Purchaser	UM, Idaho Power
Power Price (\$/MWhr)	

Turbine Information	
Manufacturer	GE
Model	1.5sle
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	15 m/s

55

megawatthours



eia Source: U.S. Energy Information Administration

Figure 25 - EIA Horseshoe Bend Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	2050	2739	2325	1690	1460	1560
	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	1300	1173	1754	1561	2129	2529

56

⁵⁵ <https://renewablenw.org/node/horseshoe-bend-wind-park>

⁵⁶ https://www.thewindpower.net/windfarm_en_3072_horseshoe-bend.php

Diamond Willow Wind



(Montana-Dakota Utilities)



Near Baker, Fallon County

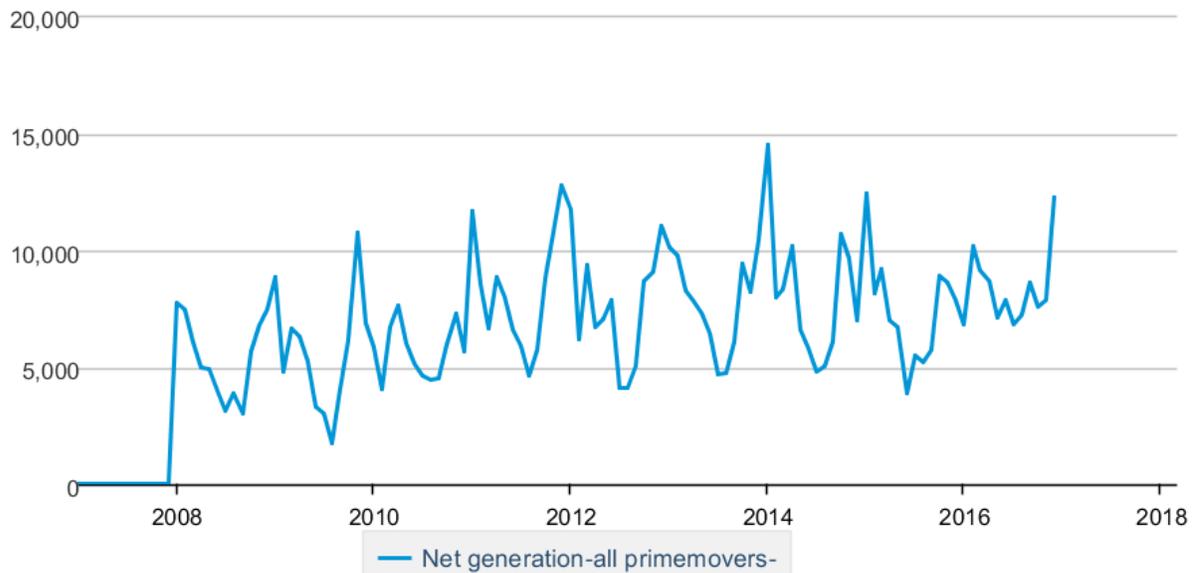
Montana Dakota Utilities developed, operates, and receives power from the 30MW Diamond Willow Wind project. A single GE 1.5sle turbine went online in 2007, followed by 12 more in 2008. The Diamond Willow Extension site went online in 2010 with 7 more turbines.

Wind Farm Information	
Rated Power	30 MW
Turbine Quantity	20
Online Date	2007,2008,2010
Historical Capacity Factor	0.352
Owner	Montana Dakota Utilities
Operator	Montana Dakota Utilities
Developer	Montana Dakota Utilities
Power Purchaser	Montana Dakota Utilities
Power Price (\$/MWhr)	

Turbine Information	
Manufacturer	GE
Model	1.5sle
Nameplate Capacity	1500 kW
Rotor Diameter	77 m
Hub Height	80 m
Rated Wind Speed	15 m/s

57 58 59

megawatthours



Source: U.S. Energy Information Administration

Figure 26 - EIA Diamond Willow Energy Data

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	6802	10188	9140	8687	7088	7856
⁶⁰	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	6842	7230	8613	7594	7835	12244

⁵⁷ [https://www.thewindpower.net/windfarm_en_3071_diamond-willow-wind-\(07\).php](https://www.thewindpower.net/windfarm_en_3071_diamond-willow-wind-(07).php)
⁵⁸ [https://www.thewindpower.net/windfarm_en_3070_diamond-willow-wind-\(08\).php](https://www.thewindpower.net/windfarm_en_3070_diamond-willow-wind-(08).php)
⁵⁹ https://www.thewindpower.net/windfarm_en_11043_diamond-willow-extension.php
⁶⁰ <https://www.eia.gov/electricity/data/browser/#/plant/56782/?freq=M&pin=>

Big Timber (Greycliff) Wind



[\(BayWa r.e.\)](#)



Near Greycliff, Sweet Grass County

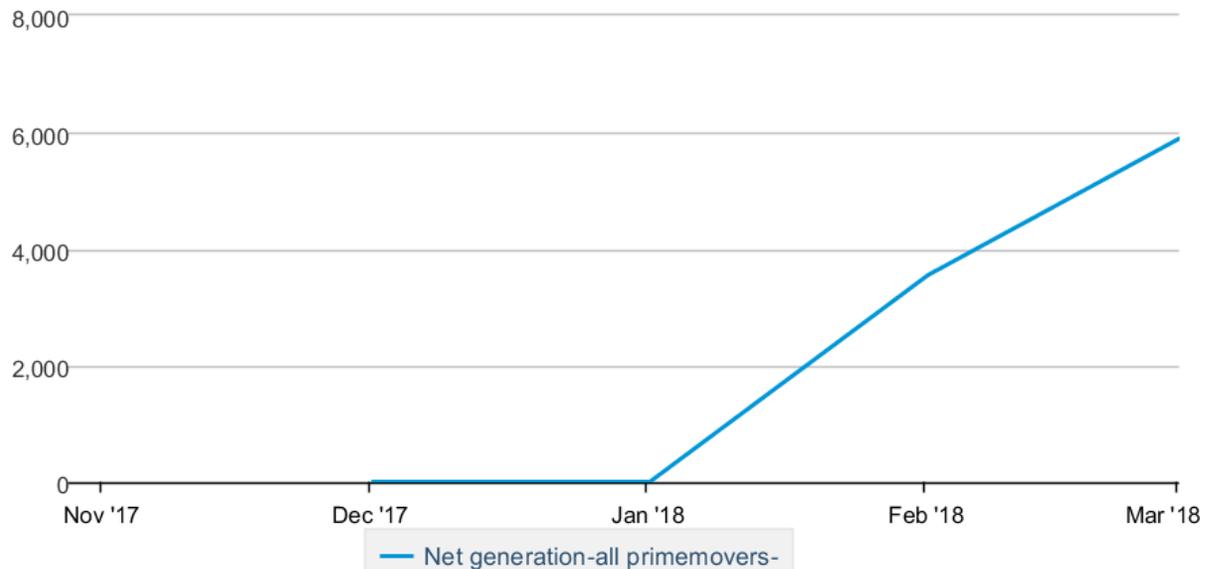
Big Timber Wind LLC, currently a subsidiary of Con Edison, operates the 25MW Big Timber Wind Farm. The site is located on the Hobble Diamond Ranch, and is the newest utility scale wind project in Montana.

Wind Farm Information	
Rated Power	25 MW
Turbine Quantity	14
Online Date	2018
Historical Capacity Factor	0.271
Owner	Con Edison Development
Operator	Big Timber Wind LLC
Developer	BayWa r.e., Montana Wind Resources
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$45.49

Turbine Information	
Manufacturer	GE
Model	1.79-100
Nameplate Capacity	1790 kW
Rotor Diameter	80 m
Hub Height	80 m
Rated Wind Speed	11 m/s

61 62 63

megawatthours



Source: U.S. Energy Information Administration

Figure 27 - EIA Big Timber Energy Production

Month	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
Energy Produced (megawatthours)	-	-	0	0	3550	5895

64

⁶¹ <http://www.greycliffwind.com>

⁶² <https://us.baywa-re.com/en/case-studies/americas-cases/?f=wind&c=big-timber>

⁶³ <http://psc2.mt.gov/Docs/ElectronicDocuments/pdfFiles/D2015864FO7436d.pdf>

⁶⁴ <https://www.eia.gov/electricity/data/browser/#/plant/61155/?freq=M&pin=>

Two Dot Wind



(EDF Renewables)



Near Two Dot, Wheatland County

New Jersey Resources Clean Energy Ventures purchased the project from Two Dot Wind LLC in 2012. The 9.72MW site went online in 2014, and sells power to Northwestern Energy. Two Dot Wind LLC also operates two smaller sites located near the NJRCEV Two Dot Wind Farm site, and helped develop the Martinsdale Colony sites. The Sheep Valley Ranch and Moe Wind Farm sites are not represented in the EIA energy generation data on the next page.

Two Dot Wind Farm

Wind Farm Information	
Rated Power	9.72 MW
Turbine Quantity	6
Online Date	2014
Historical Capacity Factor	0.376
Owner	NJRCEV
Operator	NJRCEV
Developer	OWN Energy, Mortenson
Power Purchaser	Northwestern Energy
Power Price (\$/MWhr)	\$58.83 (25yrs)

Turbine Information	
Manufacturer	GE
Model	1.62-87
Nameplate Capacity	1620 kW
Rotor Diameter	87 m
Hub Height	80 m
Rated Wind Speed	-

⁶⁵ ⁶⁶

megawatthours



Source: U.S. Energy Information Administration

Figure 28 - EIA Two Dot Energy Production

Month	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Energy Produced (megawatthours)	3273	4372	3711	2698	2330	2490
⁶⁷	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
	2075	1873	2799	2492	3398	4036

⁶⁵ https://www.thewindpower.net/windfarm_en_22169_two-dot.php

⁶⁶ <http://www.mortenson.com/wind/projects/two-dot-wind-project>

⁶⁷ <https://www.eia.gov/electricity/data/browser/#/plant/59003/?freq=M&pin=>

Sheep Valley Ranch

Wind Farm Information	
Rated Power	0.5 MW
Turbine Quantity	7
Online Date	2004
Historical Capacity Factor	0.19
Owner	
Operator	
Developer	Two Dot Wind LLC

Turbine Information	
Manufacturer	Windmatic
Model	
Nameplate Capacity	
Rotor Diameter	
Hub Height	
Rated Wind Speed	

⁶⁸

Moe Wind Farm

Wind Farm Information	
Rated Power	0.5 MW
Turbine Quantity	6
Online Date	2007
Historical Capacity Factor	0.15
Owner	
Operator	
Developer	Two Dot Wind LLC

Turbine Information	
Manufacturer	Vestas
Model	
Nameplate Capacity	
Rotor Diameter	
Hub Height	
Rated Wind Speed	

⁶⁹

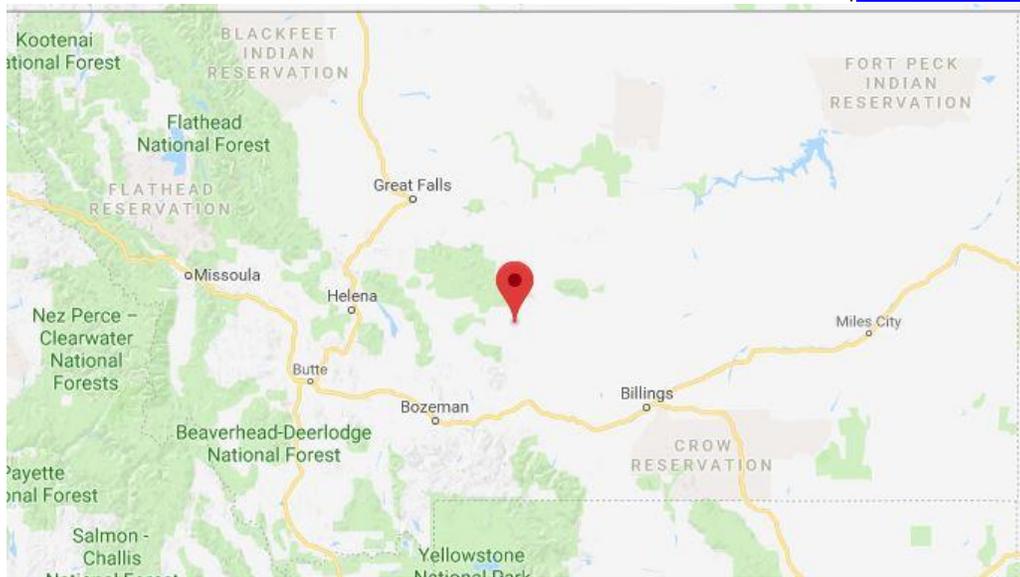
⁶⁸ https://openei.org/wiki/Sheep_Valley_Ranch

⁶⁹ https://openei.org/wiki/Moe_Wind_Farm

Martinsdale Colony Wind



(Billings Gazette)



Near Martinsdale, Meagher County

The Hutterite colony in Martinsdale, with development assistance from Two Dot Wind LLC, installed 11 turbines in 2005, and 8 more in 2007. The refurbished Nordtank turbines provide a total nameplate capacity of 2.8MW between the two sites.⁷⁰

⁷⁰ https://billingsgazette.com/business/wind-harvest-hutterite-colony-boasts-state-s-biggest-wind-farm/article_a53aaca1-262d-5755-9c17-bbf45f743a12.html

Martinsdale Colony North

Wind Farm Information	
Rated Power	0.8 MW
Turbine Quantity	11
Online Date	2005
Historical Capacity Factor	0.065
Owner	Martinsdale Hutterite Colony
Operator	Martinsdale Hutterite Colony
Developer	Two Dot Wind LLC

Turbine Information	
Manufacturer	Refurbished Nordtanks
Model	
Nameplate Capacity	
Rotor Diameter	
Hub Height	
Rated Wind Speed	

⁷¹

Martinsdale Colony South

Wind Farm Information	
Rated Power	2 MW
Turbine Quantity	8
Online Date	2007
Historical Capacity Factor	0.25
Owner	Martinsdale Hutterite Colony
Operator	Martinsdale Hutterite Colony
Developer	Two Dot Wind LLC

Turbine Information	
Manufacturer	Refurbished Nordtanks
Model	
Nameplate Capacity	
Rotor Diameter	
Hub Height	
Rated Wind Speed	

⁷²

⁷¹ https://openei.org/wiki/Martinsdale_Colony_North

⁷² https://openei.org/wiki/Martinsdale_Colony_South

Utility Scale Wind Energy Facilities - *Under Construction and Proposed*

Under Construction

Project	Site Name	Rating	Online Date
Mud Springs	Mud Springs Phase I - Pryor Cave Wind	80	
	Mud Springs Phase II - Mud Springs Wind	80	
	Mud Springs Phase III - Horse Thief Wind	80	
Stillwater (Vivaldi Springtime)	Stillwater (Vivaldi Springtime)	79.8	2018
			2018

*Proposed**

Project	Site Name	Status	Rating	Online Date	Developer
Crazy Mtn (Coyote) Wind	Crazy Mtn Wind	Approved	80	2019	Pattern Development
South Peak Wind	South Peak Wind	In Permitting Process	80	2019	ALLETE Clean Energy
Beaver Creek^{73 74}	Beaver Creek	Proposed	100		Chafin
Clearwater Energy⁷⁵	Clearwater Energy	Proposed	300		Orion Renewable Energy
Haymaker Ranch Wind⁷⁶	Haymaker Ranch Wind	Proposed	355		Haymaker Wind LLC
Horseshoe Bend Wind Park	Horseshoe Bend Phase 2	Proposed	140		Sansur Renewable Energy
Judith Gap Wind Energy Center	Judith Gap Phase 2	Proposed	52.5		Invenergy Services LLC
Martinsdale Wind Farm	Martinsdale Wind Farm	Proposed	80		EDP Renewables
Meadow Peak	Meadow Peak	Proposed	122		Wind Chasers LLC
Renaissance Wind	Renaissance Wind	Proposed	135		PowerWorks (Pacific Winds)
Teton Ridge⁷⁷	Teton Ridge - Phase I	Proposed	20		Windpark Solutions
	Teton Ridge - Phase II	Proposed	20		Windpark Solutions

78

*Many more proposed wind projects were found when researching this list, many of them from the data available at renewablenw.org. The projects that made this list either had an additional source, cited below, or a listed development company that is already active in the region.

⁷³<http://www.pnmselby.com/Tiger%20III%20grant%20pdf/Montana's%20Late%20Stage%20Wind%20Farm%20Developments.pdf>

⁷⁴<https://www.ferc.gov/CalendarFiles/20170907160338-QF17-673-000.pdf>

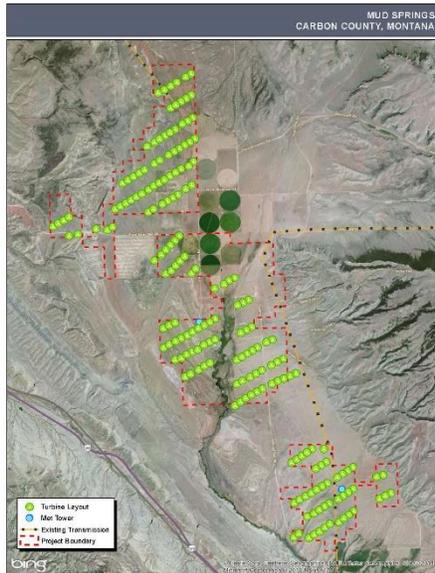
⁷⁵<http://leg.mt.gov/content/Committees/Interim/2015-2016/Energy-and-Telecommunications/Meetings/July-2016/clearwater-overview.pdf>

⁷⁶<https://haymakerwind.com/project-overview/>

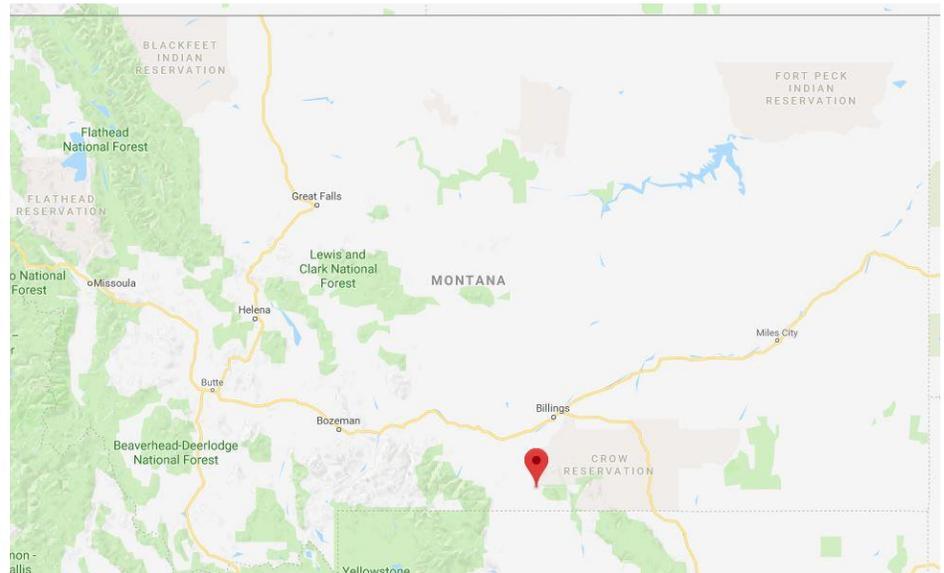
⁷⁷<https://www.wind-watch.org/news/2016/07/28/3rd-wind-farm-proposed-in-teton-county/>

⁷⁸https://renewablenw.org/project_map

Mud Springs Wind Ranch



(EverPower)



Near Bridger, Carbon County

EverPower’s Mud Springs Wind Ranch will consist of three sites that total 240MW, making it the largest wind energy project in Montana. The Prior Cave, Mud Springs, and Horse Thief sites will all have 32 Gamesa G114 2.5MW turbines. Power Generated from the Mud Springs sites will be sold to PacifiCorp.

Wind Farm Information	
Rated Power	240 MW
Turbine Quantity	96
Online Date	
Owner	EverPower Wind Holdings
Operator	EverPower Wind Holdings
Developer	Mud Springs Wind LLC
Power Purchaser	Rocky Mountain Power

Turbine Information	
Manufacturer	Siemens Gamesa
Model	G114
Nameplate Capacity	2500 kW
Rotor Diameter	114 m
Hub height	100 m
Rated Wind Speed	14 m/s

79 80 81 82

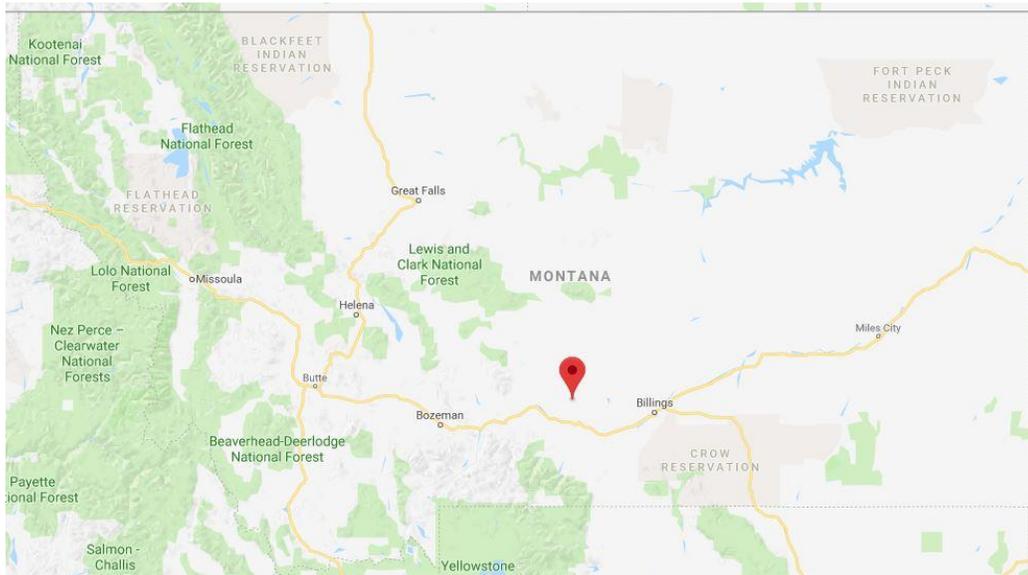
⁷⁹ <http://co.carbon.mt.us/construction-issues/mud-springs-wind-project/>

⁸⁰ <http://www.jsbmarketresearch.com/construction/everpower-mud-springs-wind-farm-240-mw-montana-project-profile>

⁸¹ <https://everpower.com/mud-springs-mt/>

⁸² <https://www.windpowerengineering.com/turbine/gamesa-g114-2-5mw/>

Vivaldi Springtime Wind Project



Pattern Energy’s 80MW Vivaldi Springtime Wind Project will have 31 Siemens Gamesa turbines. Five of these turbines have a nameplate capacity of 2.3MW, and a rotor diameter of 108m. The other 26 will have a nameplate capacity of 2.625MW, and a rotor diameter of 120m. The 120m turbines will be the largest in the state.

Wind Farm Information	
Rated Power	79.75 MW
Turbine Quantity	31
Online Date	2018
Owner	Pattern Energy
Operator	
Developer	Pattern Development
Power Purchaser	Northwestern Energy

83

Turbine Information		
Quantity	5	26
Manufacturer	Siemens Gamesa	Siemens Gamesa
Model	2.3-108	2.6-120
Nameplate Capacity	2300 kW	2625 kW
Rotor Diameter	108 m	120 m
Hub height	80 m	85 m
Rated Wind Speed	11m/s	11m/s

84 85

⁸³<https://patterndev.com/en/media/press-releases/pattern-development-completes-financing-stillwater-wind-proj/>

⁸⁴ [Siemens Gamesa](#) – Full URL in Appendix ?

⁸⁵ <https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/brochures/product-brochure-swt-2-3-108.pdf>

Appendix

Primary Sources

US Dept. of Energy – Wind Exchange	https://windexchange.energy.gov/
Energy Information Administration	https://www.eia.gov/electricity/data/browser/
American Wind Energy Association	http://www.awea.org/resources/statefactsheets.aspx?itemnumber=890
Renewables Northwest	https://renewablenw.org/project_map
The Wind Power	https://www.thewindpower.net/
Open EI	https://openei.org/wiki/Map_of_Wind_Farms
Northwestern Energy	https://www.northwesternenergy.com/

Other Links

Stillwater Turbine Information⁷⁰	https://www.siemens.com/content/dam/webassetpool/mam/tag-siemens-com/smdb/wind-power-and-renewables/onshore-wind-power/documents/infographic-data-sheet/siemens-wind-power-onshore-g geared-turbine-swt-2-625-120-data-sheet-en.pdf
Montana Wind Speed Data	http://deq.mt.gov/Energy/renewableenergy/resourcesandtechnology/Wind/winddata

Ecological Impact Links

Wind Exchange Sources	https://windexchange.energy.gov/projects/wildlife
FWS Wind Energy Guidelines	https://www.fws.gov/ecological-services/es-library/pdfs/WEG_final.pdf
Renewable NW Sage Grouse Report	https://renewablenw.org/node/956
Mud Springs Biological Impact Plan	http://co.carbon.mt.us/wp-content/uploads/2015/11/16-Mud-Springs-Wind-Bio-Cons.pdf
Judith Gap Bat Fatality Monitoring	http://docs.wind-watch.org/AvianBatFatalityMonitoring-JudithGapMT.pdf
Identifying Low Impact Areas for Wind Development	http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0041468
Ecological Risk Assessment of Wind Energy Development in Montana	https://www.nature.org/media/montana/wind-report.pdf

List of Figures

Figure 1 - EIA Montana Wind Energy Generation (Yearly)	2
Figure 2 - AEO Electricity Generation Projections	3
Figure 3 - AEO Electricity Related Carbon Emissions	4
Figure 4 - AEO Renewable Electricity Projections.....	4
Figure 5 - Wind Percentage of National Production.....	5
Figure 6 – EIA National Energy Production (Monthly).....	5
Figure 7 - EIA Montana Energy Production	6
Figure 8 - MT Rated Wind Power Capacity	7
Figure 9 - Wind Percentage of Montana Production.....	7
Figure 10 - NREL Wind Resource Map (50m).....	9
Figure 11 - NWE Hourly Wind Generation Examples	10
Figure 12 - NREL Wind Capacity Map (110m).....	10
Figure 13 - Montana Average Capacity Factor	11
Figure 14 – EIA Montana Wind Energy Production (Monthly).....	11
Figure 15 - EIA Judith Gap Energy Production	14
Figure 16 - EIA Glacier 1 Energy Production	16
Figure 17 - EIA Glacier 2 Energy Production	17
Figure 18 - EIA Rim Rock Energy Production	19
Figure 19 - EIA Musselshell 1 Energy Production	21
Figure 20 - EIA Musselshell 2 Energy Production	22
Figure 21 - EIA Spion Kop Energy Production	24
Figure 22 – EIA Fairfield Energy Production	26
Figure 23 – EIA Greenfield Energy Production	28
Figure 24 – EIA Gordon Butte Energy Production	30
Figure 25 - EIA Horseshoe Bend Energy Production.....	32
Figure 26 - EIA Diamond Willow Energy Data.....	34
Figure 27 - EIA Big Timber Energy Production.....	36
Figure 28 - EIA Two Dot Energy Production.....	38
Figure 29 - NREL National Capacity Factor	48
Figure 30 - NREL Montana Average Wind Speed	49

Image Source Hyperlinks

Judith Gap	https://inveneryllc.com/projects/overview
Glacier	http://www.naturener.us/2017/06/26/grid-when-wind-is-the-firmerst-thing/
Rim Rock	http://www.mortenson.com/wind/projects/rim-rock-wind-project
Musselshell	http://www.mortenson.com/wind/projects/musselshell-wind-project
Spion Kop	https://www.bozeman.net/government/sustainability-climateprotect-/clean-energy/utility-scale-renewable-energy
Fairfield	http://foundationwindpower.com/p-northwest-energy-fairfield.html
Greenfield	http://daconstruction.com/greenfield-wind-project/
Gordon Butte	http://daconstruction.com/project/gordon-butte-wind-project-phase-1/
Horseshoe Bend	Google Maps
Diamond Willow	https://www.montana-dakota.com/rates-and-services/electric-generation
Big Timber	https://us.baywa-re.com/en/about-us/news/details/baywa-re-sells-its-montana-project-to-con-edison/
Two Dot	https://www.edf-re.com/project/two-dot-wind-farm/
Martinsdale Colony	https://billingsgazette.com/business/wind-harvest-hutterite-colony-boasts-state-s-biggest-wind-farm/article_a53aaca1-262d-5755-9c17-bbf45f743a12.html
Mud Springs	https://everpower.com/mud-springs-mt/

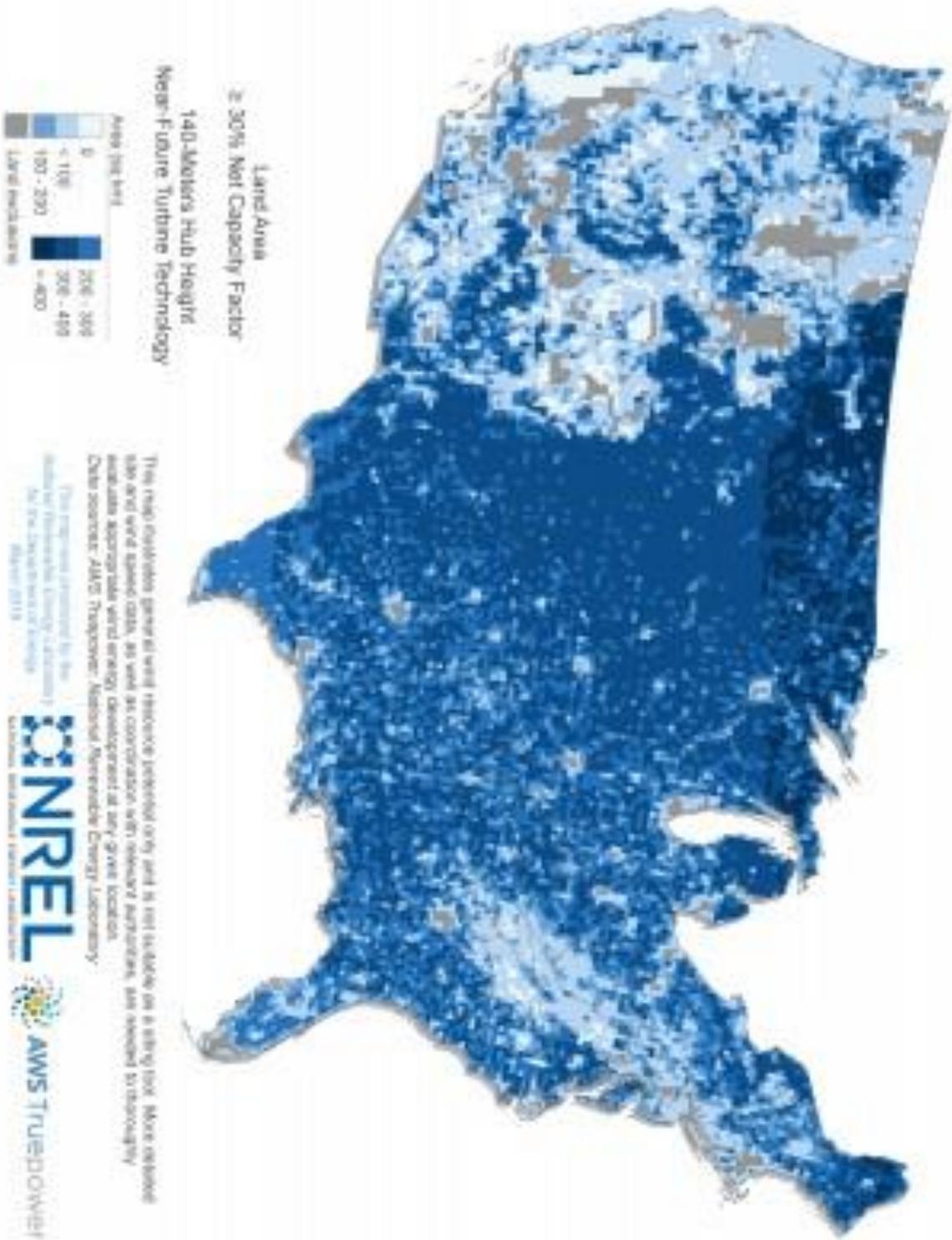


Figure 29 - NREL National Capacity Factor

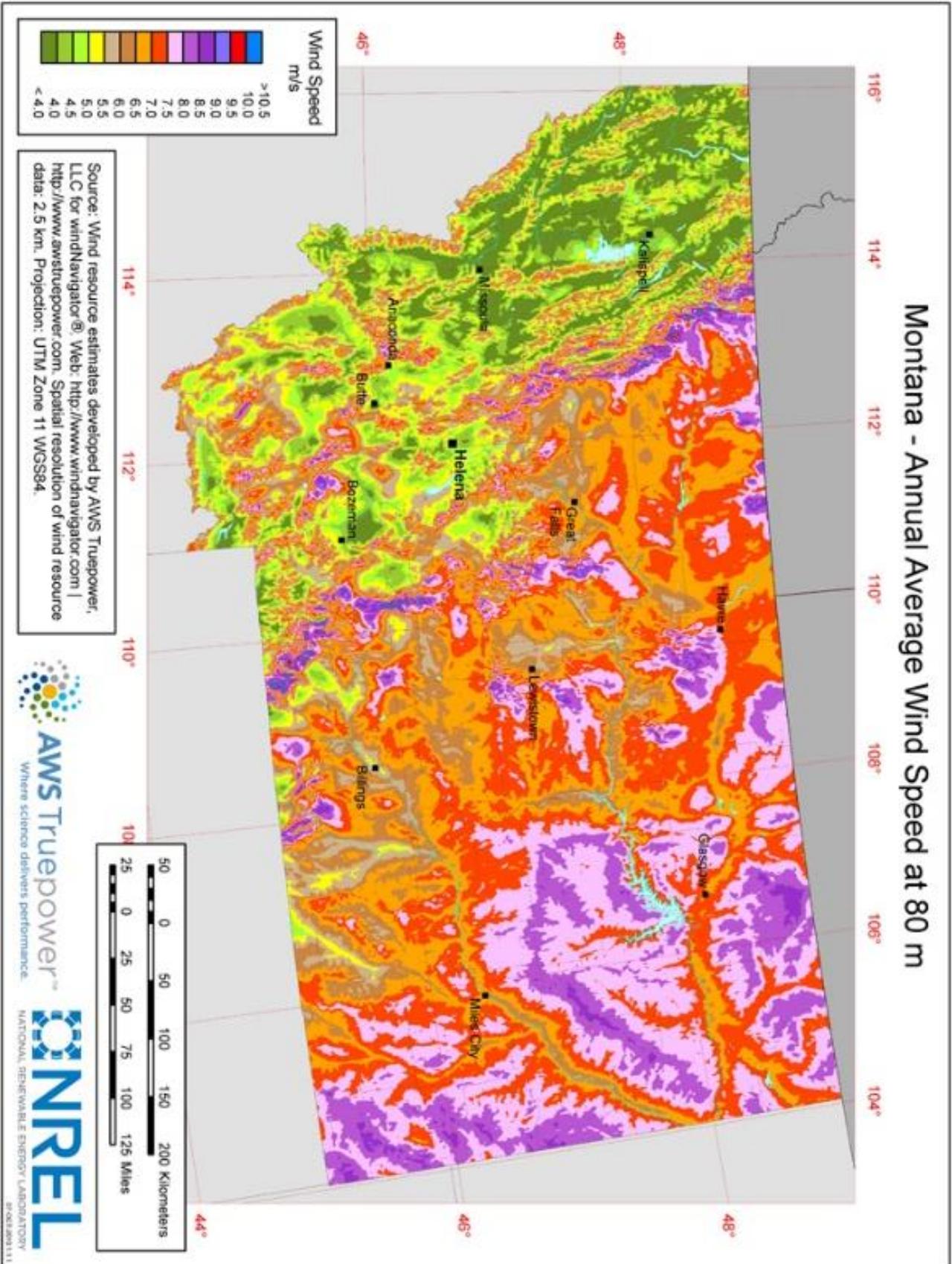


Figure 30 - NREL Montana Average Wind Speed