

SPOTLIGHT ON

NORTH  DAKOTA
ENERGY

2019 ANNUAL REPORT

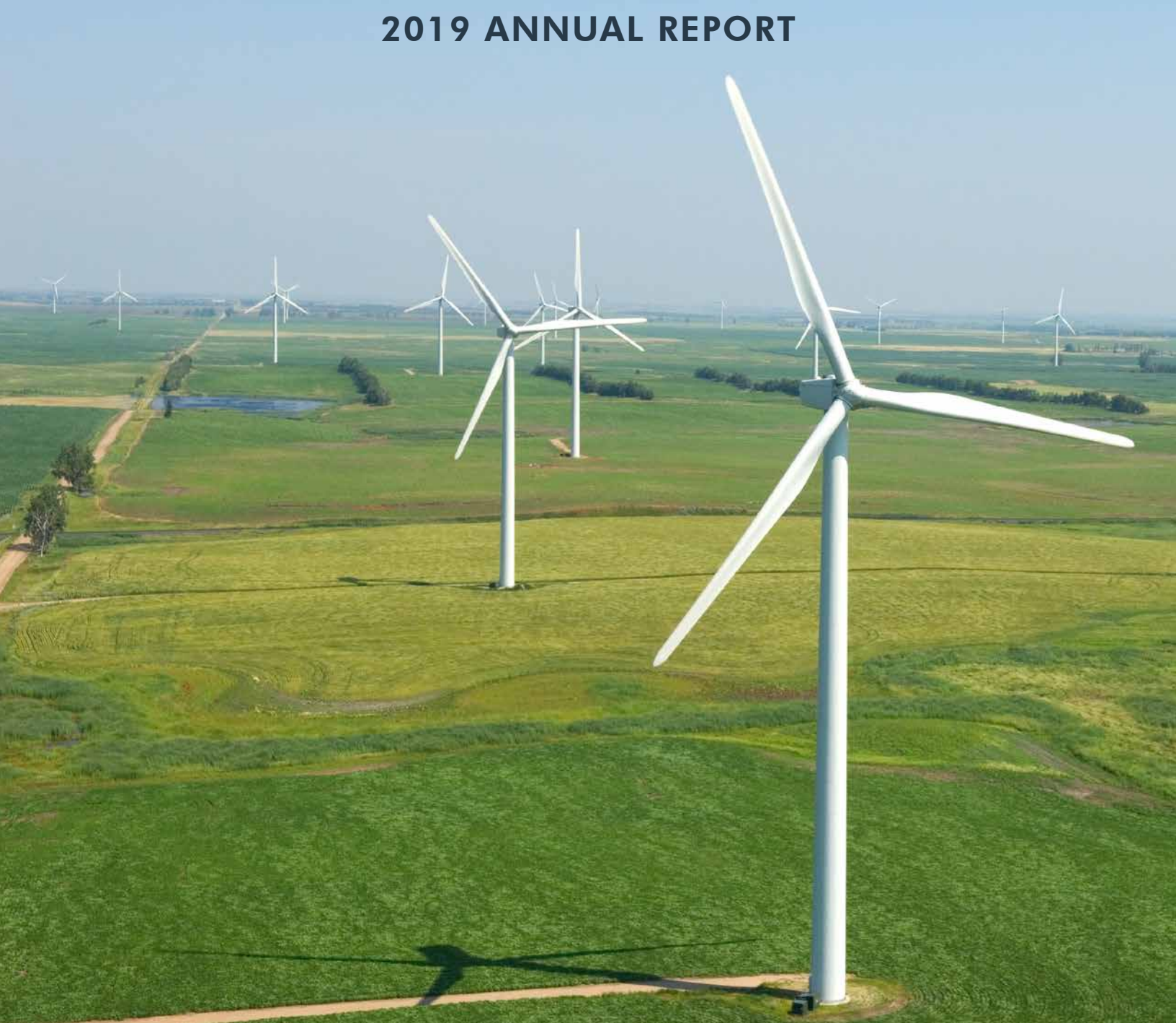


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The Great Plains Energy Corridor, housed at Bismarck State College’s National Energy Center of Excellence, works with partners in government, education, and the private sector to promote and enhance North Dakota’s energy development. Together we provide information, education, outreach programs and special events on a wide range of energy topics.

www.energyND.com

from the DIRECTOR

Thank you for picking up the 2019 edition of the Great Plains Energy Corridor's Spotlight on North Dakota Energy! This report is a statistical overview of all forms of energy in North Dakota for the year 2019. It's updated annually and usually distributed at the end of the first quarter of the following year.

Here's a quick look at some of the highlights from 2019:

▶ Solar energy continues to grow across the state. A project on the Standing Rock Sioux Reservation was placed into service in July 2019.

▶ Basin Electric Power Cooperative, Bismarck, N.D., announced in the fall of 2019 that it will purchase 128 megawatts of solar generation by 2023.

▶ The development of wind projects in North Dakota continues. Several projects were either announced or placed in service in 2019. The state has some of the best wind resources in the nation. Over the past 15 years, more

than 3,000 megawatts of wind generation have been installed.

▶ In 2019, The U.S. Department of Energy awarded another \$15 million to Project Tundra. This is in addition to \$6 million the department awarded in 2018, along with \$15 million from the North Dakota Industrial Commission (through the Lignite Research Program). Project Tundra is a research project designed to capture carbon dioxide from an existing North Dakota coal-based power plant. Project Tundra is being developed at Minnkota Power Cooperative's Milton R Young Station near Center. The goal of Project Tundra is to remove 90 percent of carbon-dioxide emissions from one of the plant's two units.

▶ The development and expansion of natural gas processing plants will continue which allows North Dakota to catch up on processing capacity through 2021, but additional plants or expansions will be needed in the future.

I would like to thank Daryl Hill, who assisted with gathering the information you find in this document. Together, with our industry partners and the EmPower North Dakota Commission, we are able to provide up-to-date information for this year's report.

Thank you for your continued readership!



Kimberly Kranz

Kimberly Kranz, Director
Great Plains Energy Corridor
Bismarck State College

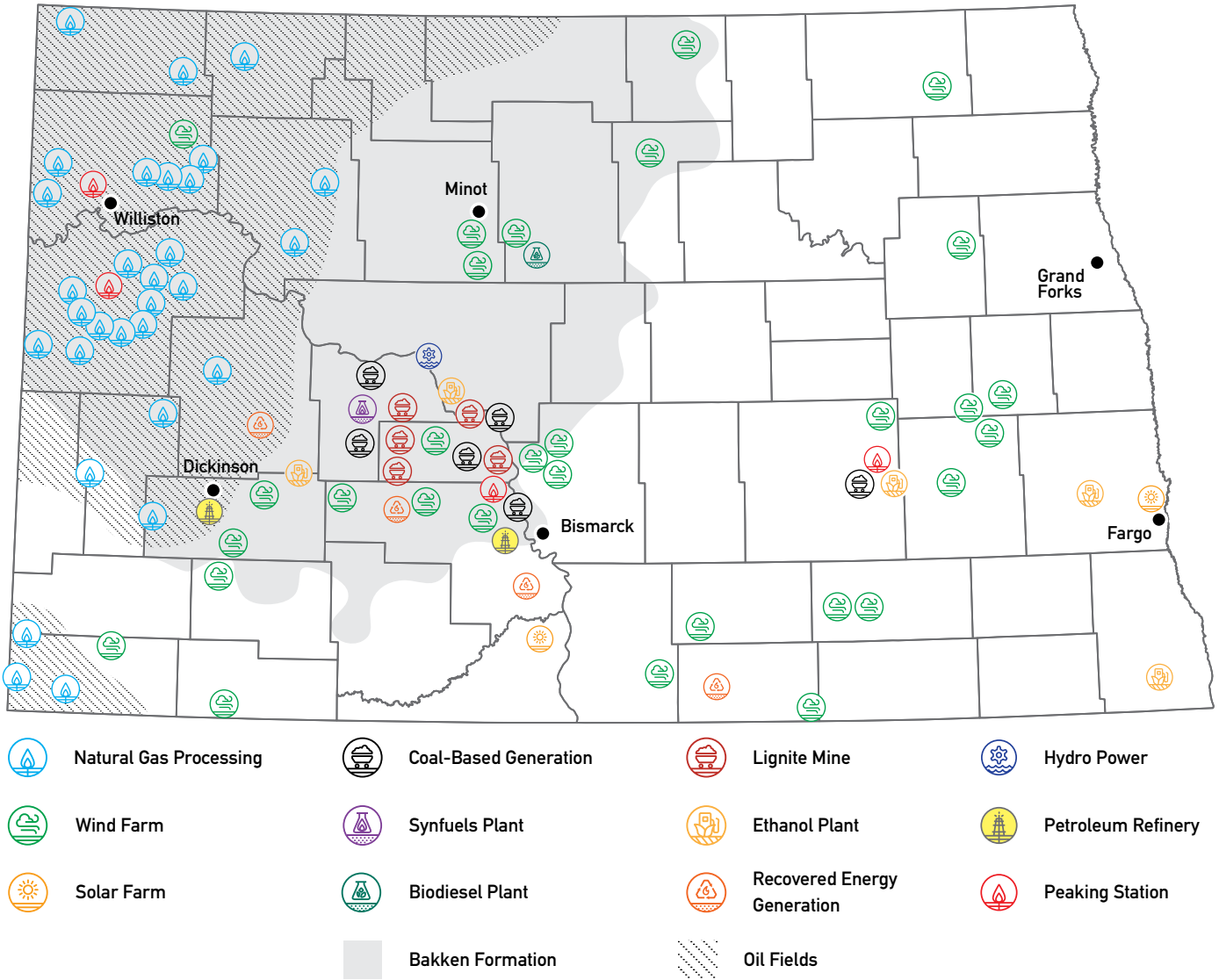
+ DIRECTOR'S NOTE: *The information presented in this publication is based on data as of the end of 2019. It's important to note, however, that during the first few months of 2020, the COVID-19 pandemic had a profound effect on the state's energy industry and economy. Therefore some of the data in this issue regarding employment, oil development, tax revenue, and other benefits to the state's economy from energy development may see significant change throughout 2020.*

NORTH
Dakota | **EMPOWER**
Be Legendary.™

North Dakota is one of the only states with a multi-resource energy policy, guided by the EmPower North Dakota Commission. Through the EmPower North Dakota Commission, leaders from all major energy industries in North Dakota meet with one common goal: to be critical thinkers for the development of the state's energy resources.

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energy sites of NORTH DAKOTA

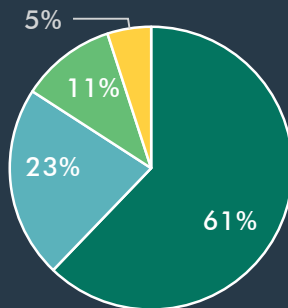


+ Map courtesy of Bismarck State College National Energy Center of Excellence.

A View From Above

According to the U.S. Energy Information Administration, North Dakota ranks sixth in the nation for total energy production – a total of 3,691 trillion BTU. The state ranks third in the country for total energy consumption per capita at 836 million BTU.

North Dakota Total Energy Production

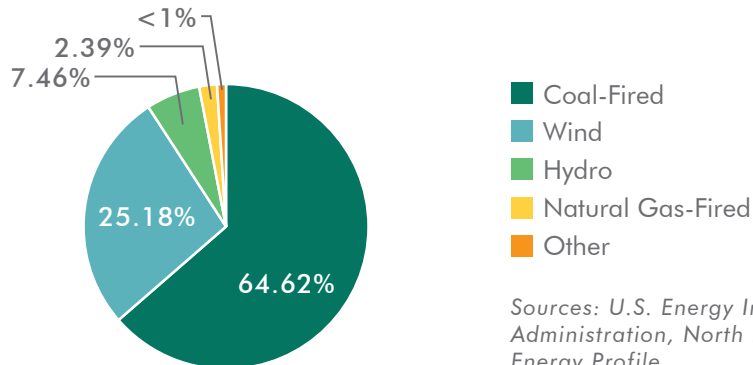


- Crude Oil
- Natural Gas
- Coal
- Renewables

Source: U.S. Energy Information Administration, State Profile and Energy Estimates

north dakota GENERATION

North Dakota Electricity Production



Sources: U.S. Energy Information Administration, North Dakota State Energy Profile

North Dakota produces electricity from a wide variety of sources, including coal-based baseload power plants, the hydroelectric turbines at Garrison Dam, a growing statewide network of wind turbines, natural gas and fuel oil peaking plants, heat recovery units that capture waste heat from pipeline compressor stations, and even a small amount of solar power. There is also work being done to explore the potential of geothermal generation in western North Dakota.

According to the U.S. Energy Information Administration, North Dakota had the fifth (ranking 44th) lowest-cost electricity for residential use. The average residential electricity price in October 2019 in North Dakota was 10.51 cents/KWh compared to the national average of 12.84 cents/KWh.

More than 51 percent of the state's total electricity supply is provided to the interstate electricity trade.

Electricity is very unique. It is an "instant-use product," which means that the moment it is produced (generated), it's being used. It is not stored (on a regional or commercial basis) or warehoused for use at a later time. Electricity that we use in our homes, businesses, and schools is generated as needed and when needed. The demand for electricity varies considerably during the day, during the different seasons, etc. Regardless, a power plant has to be operating to produce the electricity needed.

There are many different ways to produce electricity such as:

- Coal-based power plants
- Nuclear plants
- Wind projects
- Natural gas plants
- Solar projects
- Geothermal
- Hydroelectric

Power plants can be classified as baseload, peaking, intermediate, and intermittent. Baseload plants are designed to run all the time. These would be the coal-based, combined-cycle natural gas, and nuclear plants (North Dakota does not have any nuclear power plants). Peaking stations are usually fired with natural gas. These are designed to start operating if the demand for electricity outstrips the capacity of the baseload plants, and can be started on a moment's notice, while coal-based plants require several hours from start to full load. Coal-based and nuclear plants operate most efficiently at full load and are usually the "backbone" of a generating mix. An intermediate plant can be used as a peaking station or baseload. These plants are usually fueled with natural gas. There aren't

any intermediate plants in North Dakota. Intermittent plants are typically comprised of renewable energy sources such as wind or solar, and operate when the resource is available and can supplement the other sources.

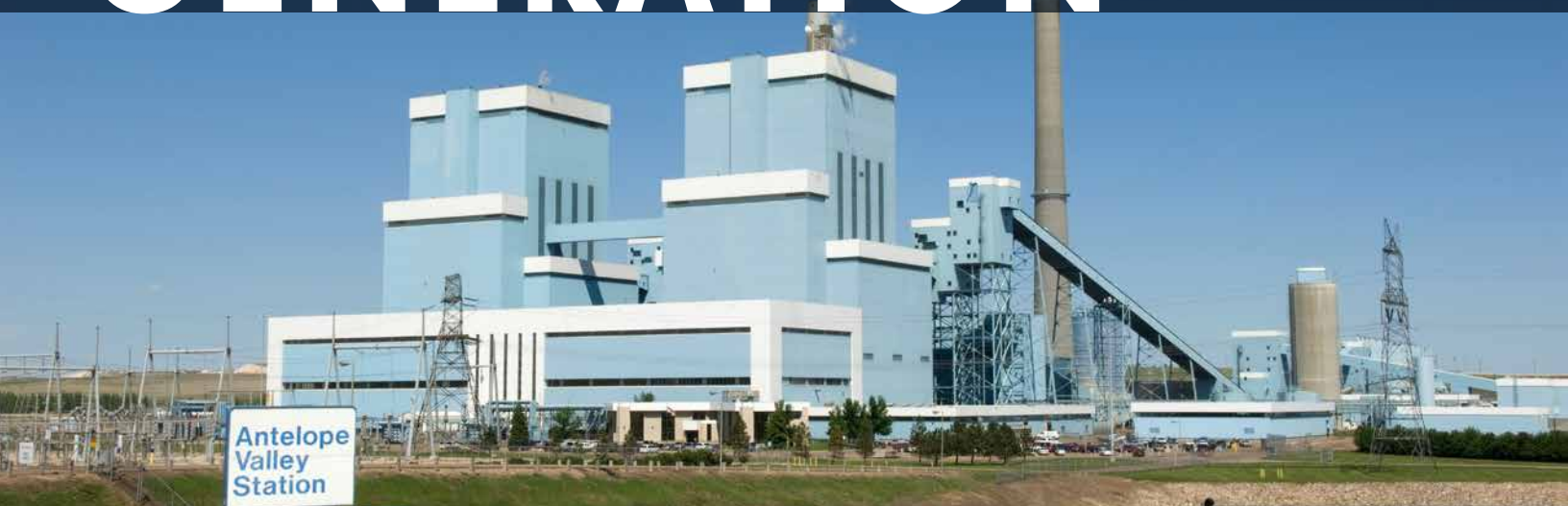
The most common sources in North Dakota are coal-based plants and wind projects. It makes no difference how electricity is produced, it's all the same product. It just comes from different sources.

Every establishment that uses electricity – and there are millions of them – is connected or "hard wired" to a power plant – someplace – through the electric grid. That plant may be around the corner, down the block or several hundred miles away.

All the plants are interconnected, so if one source isn't able to produce electricity, the other sources can "cover" for the source that isn't producing.

The fact of the matter is, electricity must be produced instantly, 24 hours a day, 7 days a week, 365 days a year. It must be produced even when temperatures range from below zero, or above 100 degrees.

GENERATION



+ The Antelope Valley Station is a coal-based power plant near Beulah, N.D. It has two, 450-megawatt capacity generating units. The first unit began operating in 1984, the second unit in 1986. The plant is operated by Basin Electric Power Cooperative, Bismarck, N.D. Photo courtesy of Basin Electric.



COAL-BASED

Great River Energy's Stanton Station, near Stanton, N.D., was shut down in February 2017. Demolition began that fall and was completed in the fall of 2019. The restoration (reclamation) phase of the project began in 2019 and should be complete in 2020.

One megawatt-hour (MWh) is enough electricity to serve more than 800 homes with an hour's worth of power.

North Dakota's power plants have invested around \$2 billion in technology to reduce emissions and increase efficiencies. These investments account for 20 to 30 percent of a power plant's costs.

North Dakota is currently one of only 15 states that meet all of the U.S. Environmental Protection Agency's federal ambient air quality standards.

The lignite industry employs 3,800 workers directly and another 10,200 indirect workers.

Lignite industry companies (power plants and coal mines) contribute more than \$130 million annually through total annual taxes, including sales, personal, and corporate income taxes.

Plant	Operating Company	Capacity by MW
Coal Creek Station	Great River Energy	1,146
Antelope Valley Station	Basin Electric Power Cooperative	900
Milton R. Young Station	Minnkota Power Cooperative	705
Leland Olds Station	Basin Electric Power Cooperative	669
Coyote Station	Otter Tail Power Company	427
Heskett Station	Montana-Dakota Utilities Co.	100
Spiritwood Station*	Great River Energy	99
Total		4,046

* Spiritwood Station is a combined heat and power plant. Its primary product is steam, which is sold to the Dakota Spirit Ethanol biorefinery at Spiritwood Energy Park near Jamestown. The plant also produces some electricity for the regional grid.



+ The Falkirk Mining Company was granted a permit to excavate lignite coal in an area that included Coal Lake, southeast of Underwood. The company chose to preserve the woody draws around the lake that provide cover, food, and water for animals, and not mine the coal stored under them. The above picture shows the mining activity around Coal Lake. Photo courtesy of North American Coal.

MINING

North Dakota has the second-largest known reserves of lignite in the world (behind only Australia) with an estimated 25 billion tons of recoverable resources. It is estimated that the state's reserves would last more than 800 years at the current rate of consumption.

North Dakota lignite mines produced 27.2 million tons in 2019. Nearly 80 percent of lignite is used to generate electricity. The other 20 percent is used to make fertilizers, synthetic natural gas, and other products at the Great Plains Synfuels Plant.

Mine	Annual Production	Location	Facilities Served	Owner/Operator
Freedom Mine	13.5 million tons	8 miles northwest of Beulah	Antelope Valley Station and Great Plains Synfuels Plant, Beulah; and Leland Olds Station, Stanton	The Coteau Properties Company*
Beulah Mine	419,000 tons	5 miles southwest of Beulah	Heskett Station, Mandan	Dakota Westmoreland Corporation
Center Mine	4.1 million tons	4 miles southeast of Center	Milton R. Young Station, Center	BNI Coal Ltd.
Falkirk Mine	7.4 million tons	Underwood	Coal Creek Station, Underwood; Spiritwood Station, Spiritwood	Falkirk Mining Company*
Coyote Creek Mine	1.7 million tons	5 miles south of Beulah	Coyote Station, Beulah	Coyote Creek Mining Company*

*Owned by North American Coal Corporation



+ Mining companies must reclaim mined land and return it to its original use and production. After mining around Coal Lake (see photo on page 7), Falkirk Mine and its customer Great River Energy donated more than 700 acres to the NDDOT, creating the Coal Lake Wildlife Management Area. Photo courtesy of North American Coal.

MINING

There are also two Leonardite mines in North Dakota – the American Colloid Mine near Scranton and the Leonardite Products Mine near Williston. Leonardite is a highly oxidized form of lignite that is used as a soil amendment and by the oil industry as a drilling additive. Both mines have a processing plant associated with them.

Lignite coal and commercial leonardite are taxed at a flat rate of 37.5 cents per ton by the state of North Dakota. An additional 2-cent per ton tax is levied for the Lignite Research Fund.

More than \$1 billion in tax revenue has gone to the state of North Dakota since 1975 from the lignite severance and coal conversion taxes.

RECLAMATION

North Dakota lignite mines practice contemporaneous reclamation, which means simultaneously mining and reclaiming land.

Mining companies typically have three years to reclaim mined land by grading and respreading the soil and seeding the land. After that, mines keep reclaimed land under performance bond for at least 10 years to prove reclaimed land produces crops or forages as good as or better than before mining.

Between 1,500 and 2,000 acres of land are disturbed by coal mining and reclaimed each year. Mining companies spend an average of \$30,000 to reclaim one acre of land, but costs can be as high as \$60,000 an acre in some instances.

More than 28,500 acres of permitted land in the state have gone through final bond release – the equivalent of around 44 square miles.

The Falkirk Mine was the nation's first surface coal mine to operate a survey drone for reclamation. Pre-mining surveys are used to plan for water management and to determine elevation and placement of topsoil and subsoil. Drones provide an innovative way to retrieve topographical maps of large areas. Time is saved in the field because the drone surveys around 400 acres per 50-minute flight. The data is downloaded to a computer and can be interpreted in a few hours.

Source: Lignite Energy Council, Great River Energy, Basin Electric Power Cooperative, MDU Resources Group, Inc., Otter Tail Power Company, Minnkota Power Cooperative, U.S. Environmental Protection Agency, Falkirk Mining Company

GENERATION



+ Pioneer Generation Station northwest of Williston, N.D., was built by Basin Electric Power Cooperative to serve an increasing demand for electricity in northwest North Dakota. The station has three, natural gas-based units each with a generating capacity of 45 megawatts. The station also features 12 natural gas-based reciprocating engines each with a generating capacity of 9.3 megawatts. Photo courtesy of Basin Electric.



PEAKING PLANTS

Peaking plants provide power generation companies with rapid response to regional “peaks” to meet the demand for electricity. The additional generating capacity that these smaller facilities provide can be used in extreme weather conditions when demand for electricity exceeds the capacity of baseload facilities. They are also used to provide power when other resources are not available. They can be powered up from stand-by status to full load very quickly and, in most cases, are operated from a remote site. In North Dakota, the peaking plants are fueled by either natural gas or fuel oil.

Basin Electric Power Cooperative, Bismarck, operates two natural gas-fired peaking stations to help provide electrical stability in western North Dakota.

- Lonesome Creek Station, located west of Watford City, has five, 45-MW units, for a total generating capacity of 225 MW.

- Pioneer Generation Station is located northwest of Williston, and has a total generating capacity of 247 MW.

- Both stations employ General Electric LM 6000 combustion turbine generators.

Montana-Dakota Utilities has an 88 MW natural gas-fired unit, Heskett 3, located next to its coal-based Heskett Station near Mandan. The unit uses a General Electric 7EA combustion turbine.

Otter Tail Power Company has two fuel oil combustion turbines in Jamestown that have a total capacity of 40.2 MW.

Sources: Basin Electric Power Cooperative, MDU Resources Group, Inc., Otter Tail Power Company

GENERATION



+ *The Foxtail Wind Project located in southeast North Dakota Dickey County is owned by Xcel Energy, Minneapolis. It began operating in November 2019, and is one of the newest wind projects in the state. The project consists of 75 wind turbines and has a generating capacity of 150 megawatts. Photo courtesy of Xcel Energy.*



WIND

North Dakota has more than 3,000 MW of wind energy capacity installed throughout the state, consisting of more than 1,900 wind turbines.

In per-capita terms, North Dakota continued to have the most installed renewable electricity capacity, followed by Washington and Montana. North Dakota continued to have the highest wind installed electricity capacity per capita.

Wind developers have expressed an interest in building more than 7,000 MW of additional wind generation in North Dakota in the next several years. While these projects have not been approved or permitted, it is an expression of interest to the transmission system operators of potential projects.

While the national wind capacity factor averaged 37 percent in 2017, North Dakota wind projects typically see higher rates between 40 – 50 percent.

North Dakota ranks 9th for installed wind capacity, getting 25.18 percent of its net electricity generation from wind resources.

Xcel Energy's Foxtail Wind in Dickey County will be among of the first wind projects in the state to use new lighting technology to protect aircraft while keeping night skies dark. The technology activates lights only when radar is detected, alerting aircraft as they approach the project area. The system helps keep skies in the rural area dark while also keeping pilots and passengers safe.

The economic impact of wind energy development in North Dakota in 2016 was more than \$170 million. This includes \$60 million in personal income, 500 jobs, and \$7.7 million in property taxes.

The 2018 federal wind energy Production Tax Credit (PTC) provides wind developers a credit of 2.4 cents per KWh for the production of electricity from utility-scale turbines during the project's first 10 years of operation, for projects qualified in year 2016. The PTC is phased down in future years to 80 percent of its present value for projects qualified in 2017, 60 percent for those qualified in 2018, and 40 percent for those qualified in 2019, then it was projected to go to zero. The Tax Extender and Disaster Relief Act of 2019 extended the PTCs at the 2018 level of 60 percent for one more year. As before, the law allows wind projects to qualify for the PTC in the year that they start construction.

The Thunder Spirit Wind project was expanded by 48 MW in 2018. ALLETE Clean Energy, the original developer of the project, sold it to Montana-Dakota Utilities in October 2018.

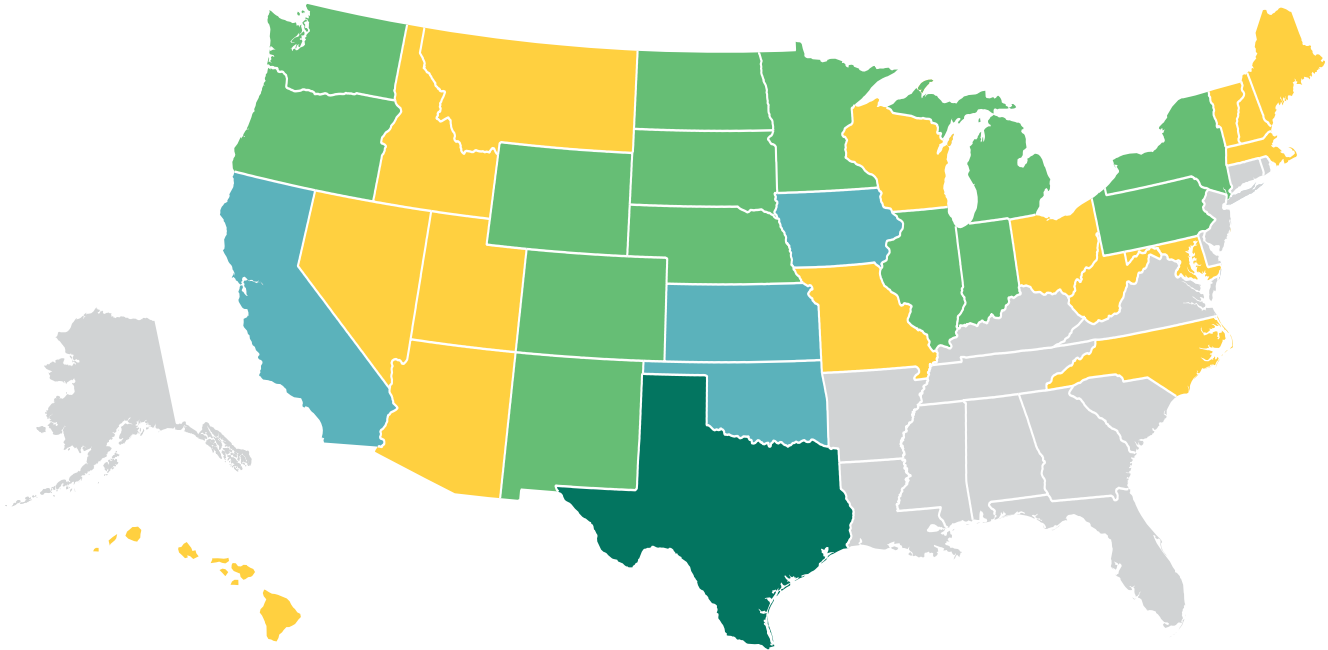
ALLETE Clean Energy completed the 106-MW Glen Ullin Energy Center wind farm in Morton and Mercer counties in December 2019. The site is owned and operated by ALLETE Clean Energy, and electricity produced is supplied to Xcel Energy under a power purchase agreement.

CAPACITY FACTOR:
Capacity factor is the actual electricity output of a power generating facility, divided by the maximum output it could provide if it ran at full output 100 percent of the time for a full year. In other words, if the capacity factor of a wind farm averages 38 percent, that means the total generating capacity of that wind farm is available 38 percent of the time on average.

Otter Tail Power Company is constructing the 150-MW Merricourt Wind Project in McIntosh and Dickey counties that is expected to be completed in the fourth quarter of 2020. The project is being developed by EDF Renewable Development, Inc. and will ultimately be owned by Otter Tail.

Sources: North Dakota Public Service Commission, NextEra Energy, Minnesota Power, Acciona Wind Energy, Iberdrola Renewables, MDU Resources Group, Inc., Basin Electric Power Cooperative, Minnkota Power Cooperative, American Wind Energy Association, U.S. National Renewable Energy Laboratory, Wind Powering America, U.S. Energy Information Administration

Installed Wind Capacity 2019



- Installed Wind Capacity**
- 10,000+ MW
 - 5,001-10,000 MW
 - 1,001-5,000 MW
 - 101-1,000 MW
 - 0-100 MW

+ Map created by Bismarck State College National Energy Center of Excellence using data from the American Wind Energy Association, current through the fourth quarter of 2019.

Wind Facility	County
Ashtabula Wind Energy Center I (2008)	Barnes
Ashtabula Wind Energy Center II (2009)	Griggs, Steele
Ashtabula Wind Energy Center III (2010)	Barnes
Ashtabula Wind Farm (2008)	Barnes
Baldwin Wind Energy Center (2010)	Burleigh
Bison Wind Energy Center 1 (2012, 81.8 MW) Bison 2 and 3 (2013, 210 MW) Bison 4 (2015, 204.8 MW)	Oliver, Morton
Border Winds Project (2016)	Rolette
Brady Wind I Energy Center (2016, 150 MW) Brady Wind II Energy Center (2016, 150 MW)	Stark, Hettinger
Cedar Hills Wind Farm (2010)	Bowman
Courtenay Wind Project (2016)	Stutsman
Emmons/Logan (2019)	Emmons, Logan
Foxtail Wind Energy Center (2019)	Dickey
Glen Ullin Energy Center (2019)	Mercer, Morton
Langdon Wind Energy Center (2007)	Cavalier
Langdon Wind Energy Center I (2007, 118.5 MW) Langdon II (2009, 40.5 MW)	Cavalier
Lindahl Wind Project (2017)	Williams
Luverne Wind Farm (2009)	Steele
North Dakota Wind Energy Center – Edgeley (2003)	LaMoure
Oliver Wind Energy Center I (2006, 50.6 MW); Oliver II (2007, 48 MW)	Oliver
Oliver Wind III Project (2016-2017)	Oliver, Morton
Petersburg Wind Project (Infinity Wind Energy) (2002)	Nelson
PrairieWinds 1 (2009)	Ward
Rugby Wind Power Project (2009)	Pierce
Sunflower Wind Project (2016)	Morton, Stark
Tatanka Wind Farm <i>Turbines span across two counties in N.D. (~90 MW) and one county in S.D. (180 MW).</i>	Dickey
Thunder Spirit Wind (2015-2018)	Adams
Valley City Wind Project (Infinity Wind Energy) (2002)	Barnes
Velva Wind Farm (2005)	McHenry
Wilton Wind Energy Center I (2006, 49.5 MW); Wilton II (2009, 49.5 MW)	Burleigh
Statewide demonstration and privately owned projects	
Total	

Owner Company	Power Purchaser <i>(if other than project owner)</i>	Capacity (by MW)
NextEra Energy	Minnkota Power	148.5
NextEra Energy	Great River Energy (51 MW), Minnkota Power (69 MW)	120
NextEra Energy	Otter Tail Power Company	62.4
Otter Tail Power Company		48
NextEra Energy	Basin Electric Power Cooperative	102.4
Minnesota Power		496.6
Xcel Energy		150
NextEra Energy	Basin Electric Power Cooperative	300
Montana-Dakota Utilities Co.		19.5
Xcel Energy		200.5
NextEra Energy	Great River Energy	200
Xcel Energy		150
Allete Clean Energy	Xcel Energy	106
Otter Tail Power Company		40.5
NextEra Energy	Minnkota Power Cooperative (139.5 MW), Otter Tail Power Company (19.5 MW)	159
Tradewind Energy	Basin Electric Power Cooperative	150
Otter Tail Power Company		49.5
NextEra Energy	Basin Electric Power Cooperative (40 MW), Otter Tail Power Company (21 MW)	61
NextEra Energy	Minnesota Power	98.6
NextEra Energy	Minnkota Power Cooperative	100
Minnkota Power Cooperative		0.9
Basin Electric Power Cooperative		122.6
Iberdrola Renewables		149.1
Novatus Energy	Basin Electric Power Cooperative	104
Acciona Wind Energy	Midwest Independent System Operator (MISO)	91.5
Montana-Dakota Utilities Co.		155.5
Minnkota Power Cooperative		0.9
Acciona Wind Energy	Xcel Energy	12
NextEra Energy	Basin Electric Power Cooperative	99
N/A		Approx. 3
		3,501



GEOTHERMAL

According to the National Renewable Energy Laboratory, western North Dakota has favorable locations for deep enhanced geothermal systems (EGS). EGS is a technology that uses heat from the earth to turn water into steam, which drives a turbine generator to produce electricity.

The University of North Dakota Petroleum Research Center continues to study the feasibility of using oil well sites in the Bakken to generate up to 300 MW of electricity using geothermal energy. According to a recent study, (bit.ly/UNDgeothermal) advances in technology for producing electricity have made

the basin’s geothermal resources economically feasible. The report suggests that identification and testing of resources with positive results could lead to large scale geothermal development.

Sources: National Renewable Energy Laboratory, University of North Dakota Department of Geology and Geological Engineering



HYDROELECTRIC

The only producer of hydroelectric power in North Dakota is Garrison Dam, run by the U.S. Army Corps of Engineers – Omaha District. It has been operating since 1955.

Garrison Dam has five turbines with a total installed capacity of 583 MW.

In 2019, the dam produced 3.2 million MWh of electricity.

The electricity from Garrison Dam is marketed by the Western Area Power Administration. Customers in North Dakota include municipal utilities, Native American tribes, state agencies, the two Air Force bases, educational institutions, irrigation districts and rural water entities, and electric power cooperatives. Much of the electrical power generated at Garrison Dam is marketed to customers outside North Dakota, including customers in the states of Minnesota, Iowa, Montana,

South Dakota and Nebraska. The Western Area Power Administration is one of four power-marketing administrations within the U.S. Department of Energy whose role is to market and transmit electricity from multi-use water projects.

Lake Sakakawea, created by the Garrison Dam, is the third largest reservoir in the United States by volume.

Sources: U.S. Army Corps of Engineers, Western Area Power Administration



SOLAR

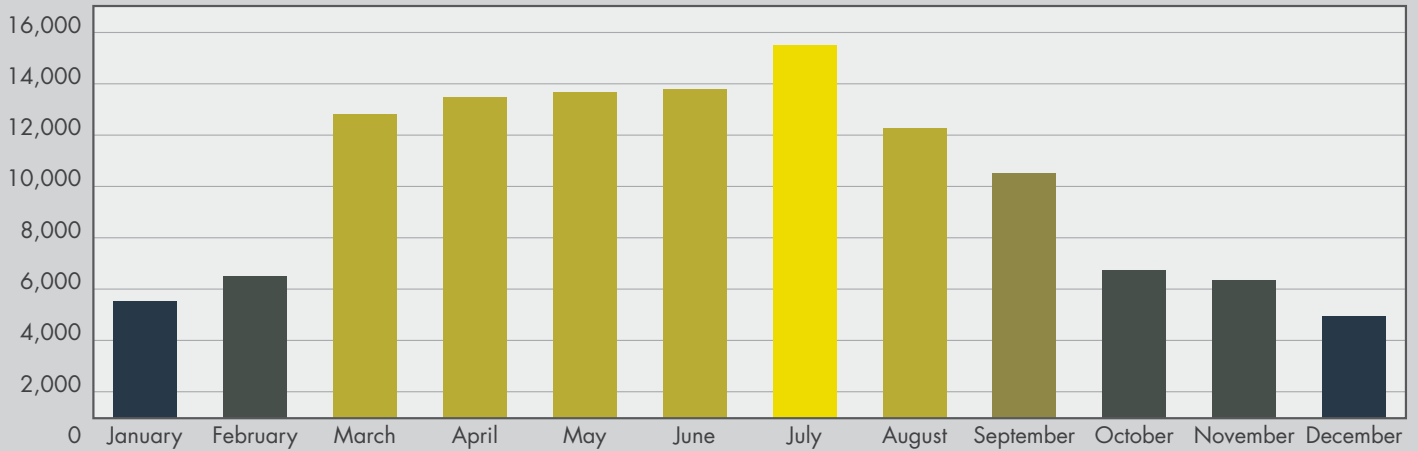
Solar energy technology is based on two main types – photovoltaics (PV), which is the most common way of producing solar electricity in North Dakota, and concentrated solar power (CSP). CSP typically uses mirrors to concentrate the sun’s rays and create heat that, in turn, drives a heat or steam engine. PV power uses the sun’s rays to create direct current electricity.

Bismarck State College has an 8-KW PV solar array on campus composed of both crystalline and thin panel solar systems so students have the opportunity to study both.

Verendrye Electric Cooperative, Velva, N.D., has the largest solar program in the state with more than 300 solar-powered water pumps throughout its service territory, including more than a dozen systems installed in 2019. The pumps are primarily used in pasture wells in remote areas where building power lines is cost prohibitive.

GENERATION

Annual Solar Output (kWh)



+ Cass County Electric Cooperative in Fargo installed a 102-KW solar array in 2016, called Prairie Sun Community Solar. It is the first community solar project in the state and consists of 324 solar panels located on land owned by the city of Fargo. Prairie Sun Community Solar produced 119,317 kWh in 2019, which would give it a capacity factor of 13.3 percent. Graph created using Prairie Sun Community Solar data.



SOLAR

Northern Plains and Dakota Valley Electric Cooperatives installed a 16-panel solar system at Northern Plains' Carrington office in 2015. The total rated output is 6.56 KW, and the cooperatives monitor real time data from the system as a demonstration of what might be used on a small farm, residence, or business. The solar project operated as expected in 2017, saving 8,675 kWh of energy.

Whiting Petroleum uses PV in North Dakota for some systems in the petroleum extraction process, like automation controls, programmable logic controllers, flare igniters, and combustor controls. These systems allow an operator to start up, monitor, and shut down operations as needed.

Another solar project, still in development by Geronimo Energy, Bloomington, Minn., is the Harmony Solar Project. Geronimo received a permit to construct in 2019. When operational, Harmony will be the largest utility-scale solar project in the state. Harmony is located in Cass County, N.D., and is estimated to be up to 200 MW. It's anticipated the project will provide over \$20 million in economic benefits during the first 20 years of operations, including new tax revenue, construction jobs, new full-time jobs, landowner income and charitable giving.

Sources: National Renewable Energy Laboratory, Verendrye Electric Cooperative, Bismarck State College, Cass County Electric Cooperative, Minnkota Power Cooperative, Whiting Petroleum



+ Photo above shows Northern Plains and Dakota Valley Electric Cooperatives' demonstration solar array. Total output is rated at 6.56 KW. Photo courtesy of Northern Plains Electric Cooperative.



RECOVERED ENERGY

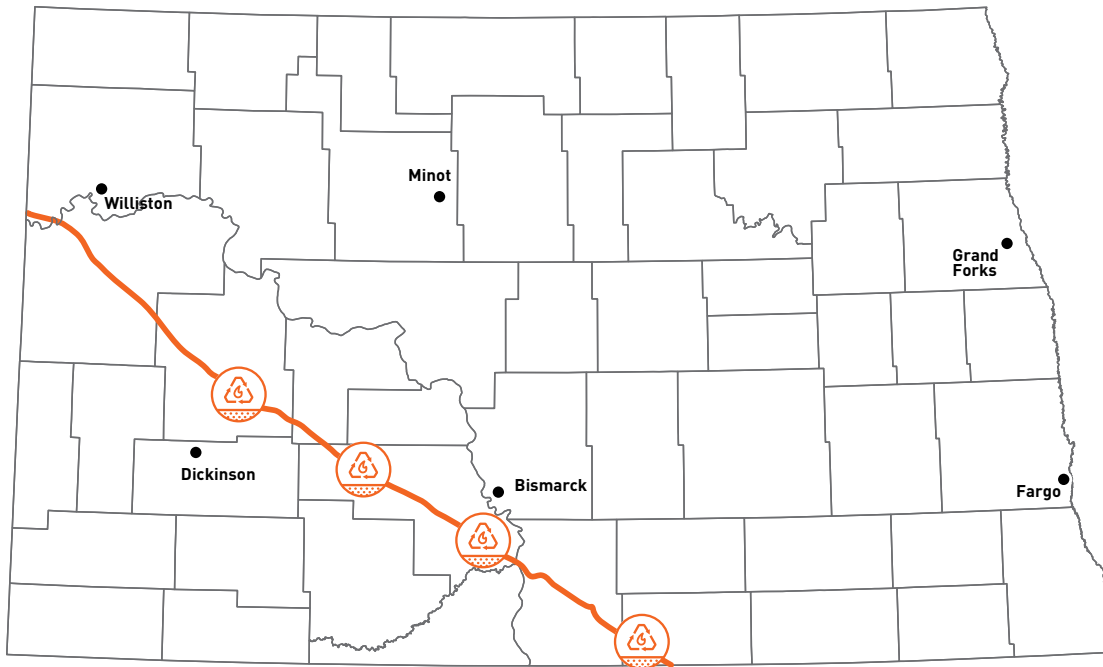
Recovered energy generation (REG), also known as heat-recovery generation or waste heat energy, is a process of capturing the heat from hot exhaust to drive a turbine and create electricity.

There are four REG sites in North Dakota. Basin Electric Power Cooperative purchases the electricity from three sites near Manning, St. Anthony, and Zeeland (5.5 MW each); and Montana-Dakota Utilities owns one site near Glen Ullin (5.3 MW).

The sites produce electricity using exhaust from compressor stations on the Northern Border Pipeline. The Northern Border Pipeline is a natural gas transportation system of 1,398 miles that links the Midwest with reserves in Canada.

A subsidiary of Ormat Technologies developed the recovered energy generation. This is the first use of this technology on a natural gas pipeline in the United States.

Sources: Basin Electric Power Cooperative, MDU Resources Group, Inc.



Recovered Energy Generation
Northern Border Pipeline

+ Map courtesy of Bismarck State College National Energy Center of Excellence.



TRANSMISSION & DISTRIBUTION

The North Dakota Transmission Authority was established by the state legislature in 2005 to facilitate, finance, and develop transmission in North Dakota to accommodate new energy development.

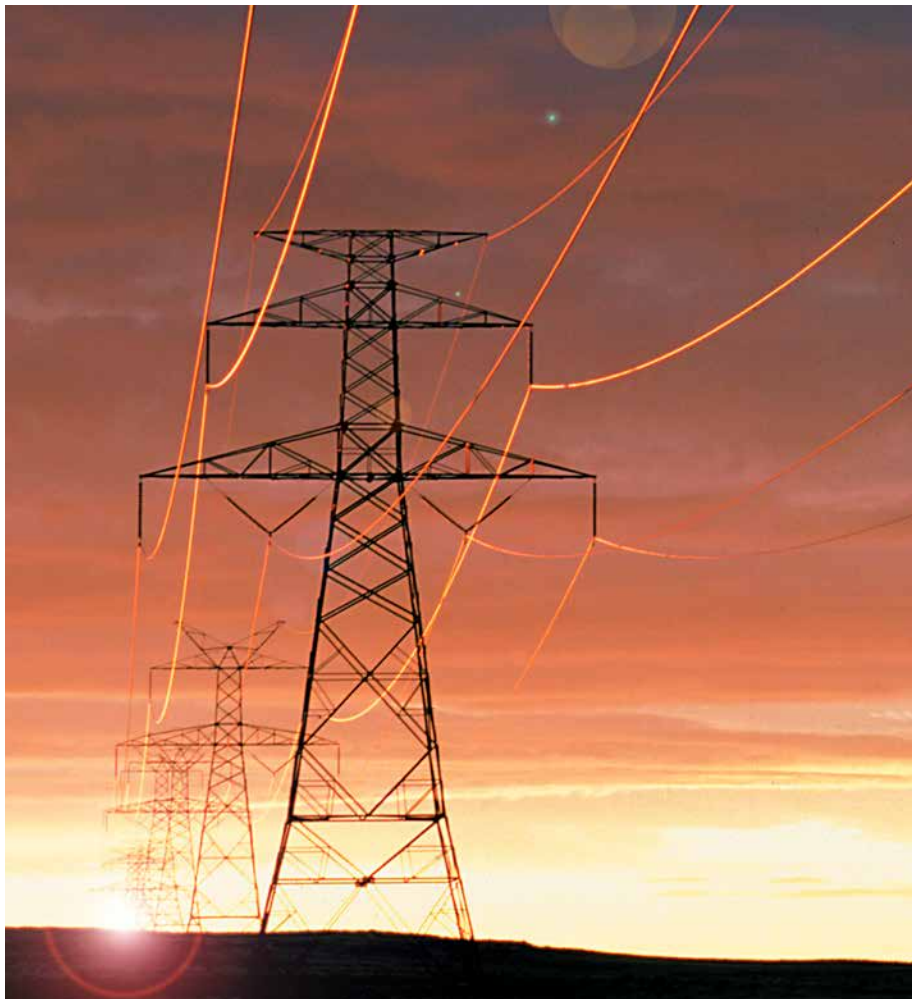
Otter Tail Power Company and Montana-Dakota Utilities Co. constructed the 163-mile Big Stone South to Ellendale transmission line. The 345-KV line connects the new Big Stone South Substation near Big Stone City, S.D., to the new Ellendale Substation near Ellendale, N.D. The line was energized in February 2019.

North Dakota continues to pioneer the use of unmanned aerial systems (UAS)—or drones—to safely and efficiently inspect energy infrastructure, including wind projects and transmission and distribution lines. North Dakota and Xcel Energy have been selected to participate in the Federal Aviation Administration’s Integration Pilot Program. This program is an opportunity for state, local and tribal governments to partner with private sector entities, such as UAS operators or manufacturers, to accelerate safe UAS integration.

A 400-kilovolt direct current transmission line extending from the Coal Creek Station, Underwood, N.D., went through an upgrade to the inverters at each end of the line during a major outage in the spring of 2019. The upgrade improves reliability and increases line capacity.

Transmission costs vary depending on voltage, terrain type, right-of-way costs, and many other factors. Average transmission costs for a new 345-KV line can be \$1.5 – \$2 million per mile.

Sources: North Dakota Transmission Authority, Otter Tail Power Company, MDU Resources Group, Inc., ALLETE Clean Energy, Minnkota Power Cooperative, Basin Electric Power Cooperative



+ The transmission line above is a double circuit AC transmission line. It carries 345,000 volts of electricity from the Antelope Valley Station, Beulah, N.D., to its sister station, the Leland Olds Station near Stanton, N.D. Notice there are three wires on each side of the tower. A typical AC transmission line has three conductors. The towers shown here are carrying two AC transmission lines. There are also two wires at the very top of the towers. These two wires are called overhead ground wires. In the event a tower is struck by lightning, the OHGW directs the energy from the strike to ground.



MODES OF HIGH VOLTAGE ELECTRIC TRANSMISSION



+ *The transmission line above is a 400,000-volt DC transmission line. It carries electricity from the Coal Creek Station, Underwood, N.D., to a delivery point in Minnesota. Notice there are only two conductors, as opposed to three for an AC line. As with an AC line, this DC line has two OHGW wires to dissipate energy from a lightning strike.*

North Dakota has more than 65,000 miles of transmission and distribution lines. Transmission lines are high-voltage lines that carry large volumes of electricity long distances. Distribution lines carry lower-voltage electricity from a local substation to nearby homes.

The electricity that we use in our homes, offices and factories is alternating current (AC). It is named as such because the voltage goes from positive to negative 60 times per second. Electricity that is generated by rotating generators is generated as AC. Transformers can easily be used to change to high voltage for efficient transmission and then back to lower voltages that are useful for our houses, offices and factories. Transmission of electricity is more efficient at higher voltages. Voltages of 115,000, 230,000, and 345,000, are typical in North Dakota. In other areas, 500,000 and even 750,000 volts are used to meet needs. These lines operate in a three-phase mode so you will see sets of three wires on high-voltage transmission lines. At the home and office, 120 volts and 240 volts are most common.

The other type of high-voltage transmission that is becoming more common in long distance lines is direct current (DC). Those lines operate with one wire at positive voltage and the other wire at negative voltage. Therefore, DC lines are characterized by sets of two wires. There are only two DC transmission lines in North Dakota. Voltages for DC transmission can also vary. One of the DC lines in North Dakota operates at 250,000 volts, while the other operates at 400,000 volts. A DC line requires a converter station at each end to convert the power from AC current to DC current and then back to AC at the other end. It is expensive to build the converter stations, but the line construction is less expensive. The lines are much more efficient than AC transmission of an equivalent amount over an equal distance, meaning there's less line loss. The higher efficiency pays for the expense of building the converters if the distance is over about 300 miles. DC voltage cannot be changed easily without converting back to AC. DC transmission has been demonstrated in uses over 4,000 miles.

PETROLEUM



+ Two ConocoPhillips wells located near Keene in McKenzie County are shown in operation. ConocoPhillips holds approximately 620,000 net acres in the Bakken, and had more than 775 operating wells on line at year-end 2018.



OIL & GAS PRODUCTION

North Dakota's oil and gas industry has continued steady growth even with sustained lower prices. According to the North Dakota Department of Mineral Resources, the price of sweet crude oil was at \$48.35 a barrel in December 2019, as compared to the all-time high price in July 2008 of \$136.29 per barrel. Prices in the last half of 2019 have ranged from \$40 – \$48 a barrel. Despite this, increased efficiencies and technology have enabled operators to continue production and remain competitive at lower prices.

In 2012, North Dakota surpassed both California and Alaska to become the second largest oil producer in the nation, behind only Texas. North Dakota is also among the top 20 oil producers in the world.

In December 2019, gas production reached 94,854,574 million cubic feet or 3,059,835 MCF/day. Oil production reached 45,746,231 barrels or 1,475,685 barrels per day.

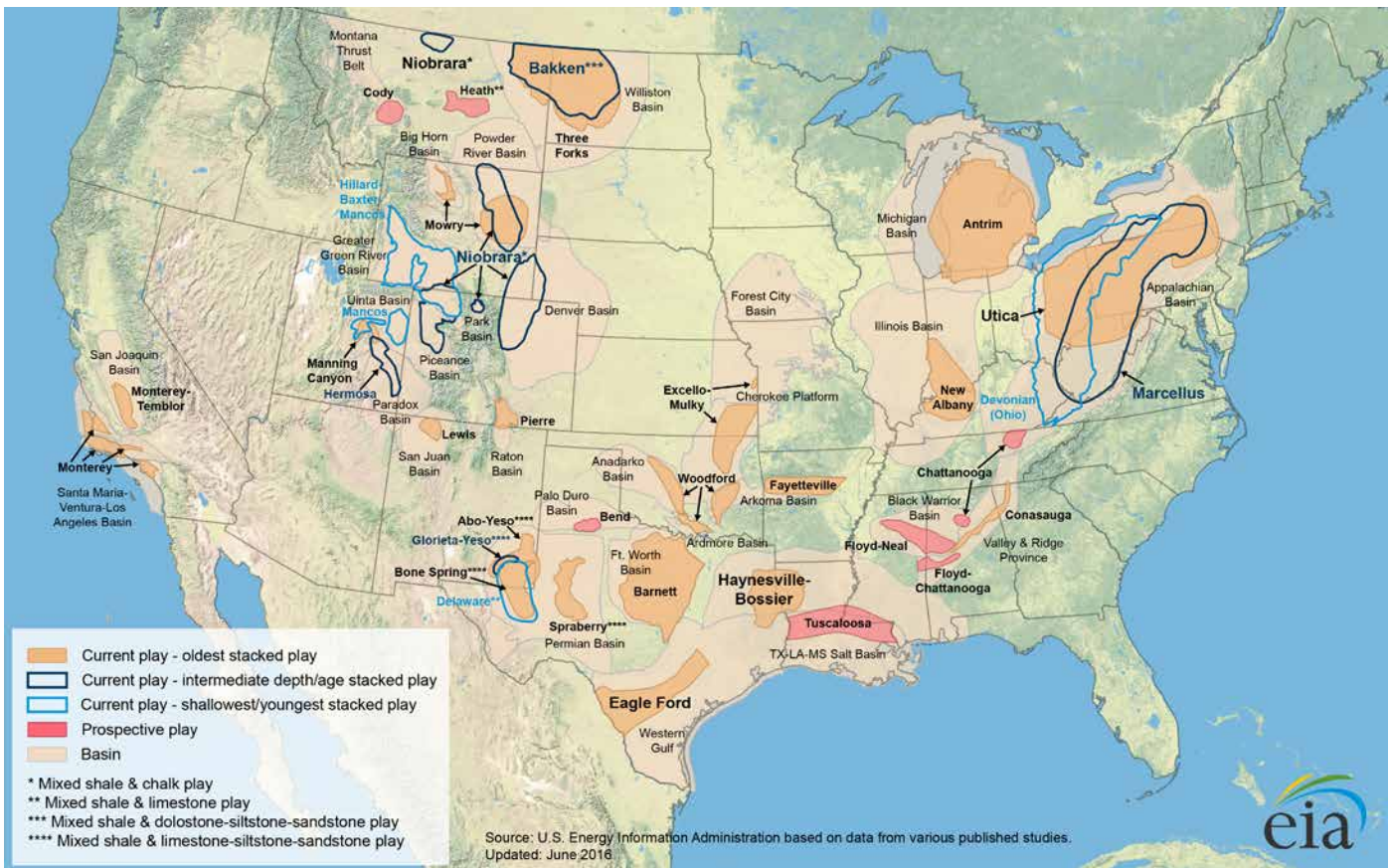
Average rig count in 2019 was 61 rigs, a decrease of one from the previous year. The all-time high was 218 rigs in May 2012. Newer, more advanced rigs operating today are able to drill new wells faster. Each rig can drill about twice as many wells in a year compared to 2012. More than 98 percent of drilling takes place in the Bakken and Three Forks formations.

As of December 2019, there were 15,979 producing wells, with 93 percent of those in the Bakken Formation.

Leasing activity for new drilling sites continues to be very low in North Dakota, consisting mostly of renewals and top leases in the Bakken-Three Forks area. Multiple wells are being added to existing drill pads as the production stays in "harvest" mode. Three or more horizontally drilled wells can be placed on one existing pad and as many as 25 wells on some pads.



OIL & GAS PRODUCTION



+ The above map shows the placement of shale plays around the Lower 48 states. Map courtesy of U.S. Energy Information Administration.

A typical North Dakota Bakken well will produce for more than 30 years. However, favorable economic conditions, enhanced oil recovery efforts, and other factors can extend the life of the well. Based on an average oil price of \$50 per barrel, the average Bakken well:

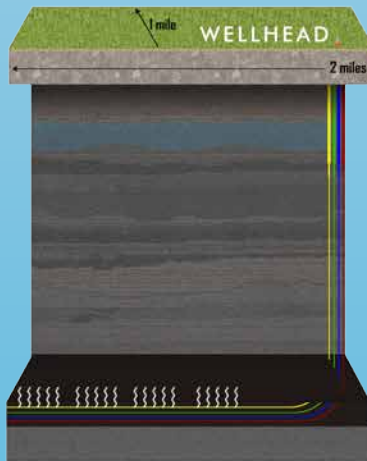
- Produces approximately 1,170,683 barrels of oil.
- Generates about \$31 million net profit.
- Pays approximately \$5,083,579 in taxes.
 - \$2,796,340 gross production taxes
 - \$2,094,794 extraction tax
 - \$192,445 sales tax

- Pays royalties of \$9,487,516 to mineral owners.
- Pays salaries and wages of \$2,128,669.
- Pays operating expenses of \$1,900,977.
- Costs \$7,072,184 to drill and complete.

After a well has stopped producing economically, state law requires the operator to plug the well or get it back into production within six months.

Plugging the well involves cementing the production and surface casing at several different depths to ensure no hydrocarbons or saltwater may pass to the surface, in addition to cutting off the surface casing about four feet below the ground. Topsoil and subsoil that were removed during the initial well construction are returned to the site and the land is returned to its pre-drilling contours and reclaimed as close as practicable to the way it was prior to drilling.

PETROLEUM



7 Empire State Buildings
800 stories
10,000 feet

EMPIRE STATE BUILDING
Height: 1,454 feet



+ Horizontal drilling in the Bakken allows companies to drill down two miles into the Bakken formation, turn at a 90-degree angle and drill horizontally for as far as four miles. Diagram courtesy of North Dakota Petroleum Council and North Dakota Department of Mineral Resources.



SHALE ENERGY TECHNOLOGY

The Bakken shale play was previously undeveloped because conventional drilling methods were not able to access the trapped oil and gas. Technological advances, including horizontal drilling and the process of hydraulic fracturing have made it possible for companies to economically drill for oil in the Bakken Formation.

With horizontal drilling, operators are able to drill more wells from a single location, thereby accessing more of the oil and gas resources in the Bakken while using as much as 90 percent less surface area than with traditional vertical drilling.

Hydraulic fracturing (also called “fracking”) is a process that pumps a specially blended liquid into a well under high pressure, creating fractures in the underground rock to allow the flow and recovery of oil and natural gas.

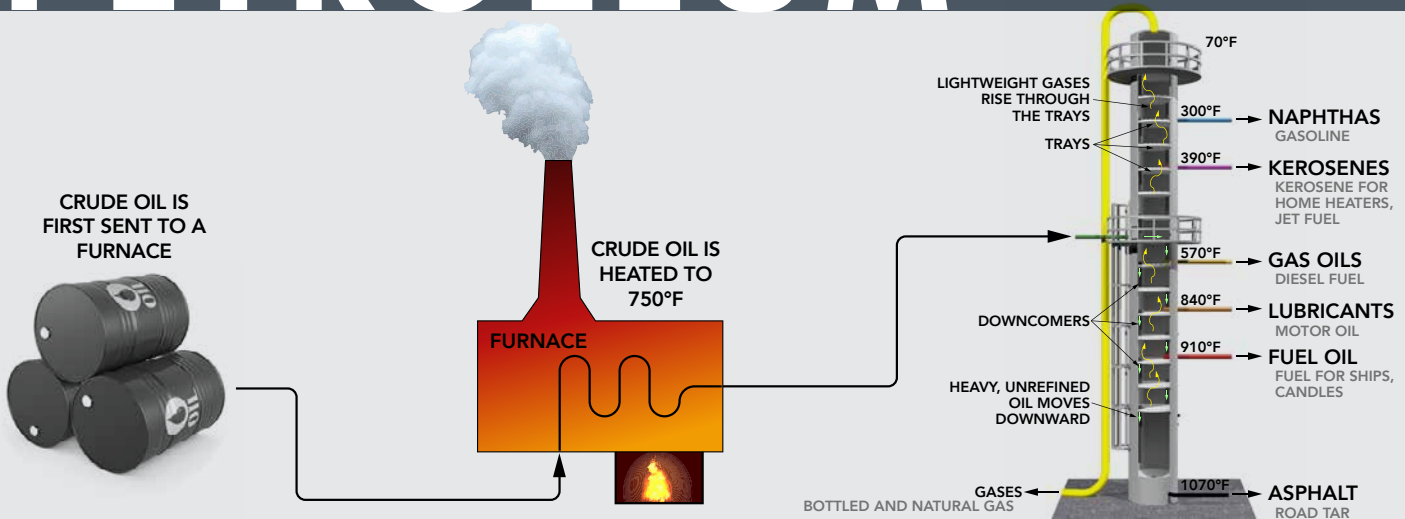
The fluid used in the hydraulic fracturing process is a 98-99.5 percent water and sand mixture. Varieties of chemical additives are used, depending on the well conditions, to limit the growth of bacteria, prevent corrosion of well casing, and increase efficiencies.

The state of North Dakota requires disclosure of the additives that companies use via FracFocus.org, a website that provides public access to reported chemicals used in fracking and to provide information on the fracking process.

The amount of water needed to hydraulically fracture a well continues to increase. In 2006, the average Bakken well required 2-4 million gallons of water for hydraulic fracturing. In 2018, that average increased to nearly 8-10 million gallons per well, with a small handful of wells using a technique that required 20 million gallons.

Sources: North Dakota Petroleum Council, North Dakota Department of Mineral Resources, U.S. Energy Information Association, FracFocus, Energy & Environmental Research Center

PETROLEUM



+ Oil from the Bakken is a light, “sweet” oil, which means that it is a high-quality oil containing little or no hydrogen sulfide. Refiners prefer sweet crude oil because it yields high-value products such as gasoline, diesel fuel, jet fuel, and heating oil. This diagram of a typical refinery’s distillation tower shows how the petroleum is heated and separated into different product streams. Graphic courtesy of Bismarck State College National Energy Center of Excellence.

REFINING

There are two oil refineries in North Dakota – one in Mandan, the other is near Dickinson.

The Mandan refinery is now owned by Marathon Petroleum Corp. (It was previously owned by Tesoro, and then Andeavor.) Marathon purchased the refinery from Andeavor in April 2018. It began operations in 1954 and is the largest refinery in the state. The refinery has a crude oil processing capacity of 71,000 barrels per day (bpd). One barrel is equal to 42 gallons.

Because of high demand for diesel fuel in the region, in 2012 the Mandan refinery expanded its Distillate Desulfurization Unit capacity by 5,000 barrels of diesel per day to bring the plant’s total diesel hydrotreating capacity to 22,000 bpd.

Marathon processes Williston Basin crude oil from North Dakota to refine into gasoline, diesel fuel, jet fuel, heavy fuel oils and liquefied petroleum gas. Products are trucked and railed from Mandan and also shipped east via pipeline to eastern North Dakota and Minnesota.

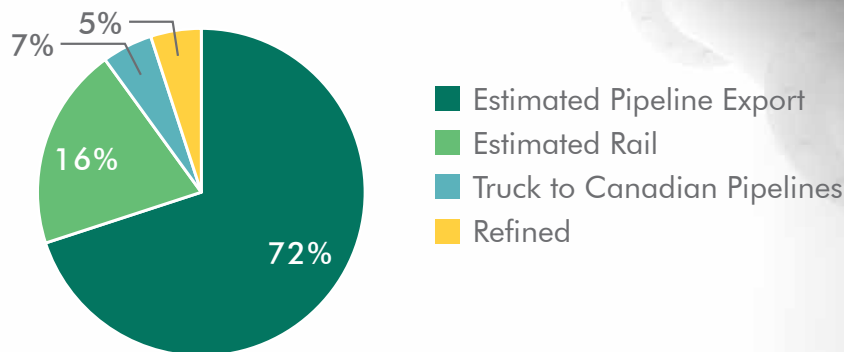
Marathon employs about 290 people in the Bismarck-Mandan area and more than 100 employees in western North Dakota and eastern Montana with the Tesoro High Plains Crude pipeline system.

Marathon purchased its Dickinson Refinery in 2018 from Andeavor (its original name was Dakota Prairie Refining). That refinery was constructed by WBI Energy, and subsequently purchased by Andeavor in 2016. It was the first greenfield diesel refinery to be built in the U.S. since the late 1970s and came online in May 2015. Located near Dickinson, the refinery can process 19,000 barrels per day of Bakken crude oil into diesel fuel and other petrochemical components. The diesel fuel is marketed within North Dakota, while the other components are shipped to out-of-state customers or to other refineries for further processing.

Source: Marathon

PETROLEUM

Williston Basin Crude Oil Transportation



+ Transportation of Williston Basin crude oil changes depending on the Brent – WTI (West Texas Intermediate) price spread. With additional pipeline capacity and market conditions, the region has seen increased use of pipelines over rail transportation. Data courtesy of the North Dakota Pipeline Authority.

PIPELINES

The North Dakota Pipeline Authority was created by the state legislature in 2007 to assist development of pipeline facilities to support energy-related commodities.

There are more than 30,000 miles of gathering and transmission pipelines in North Dakota. The United States has the largest network of pipelines in the world.

North Dakota makes use of three product types of pipelines: 17 major crude oil pipelines, nine major natural gas pipelines, and one carbon dioxide pipeline.

A 100,000-barrel-per-day pipeline would be equal to 500 truckloads per day or about 140 rail cars.

Several additional pipeline expansion projects to transport the increased oil and gas production in the state have been proposed or are in the planning stages.

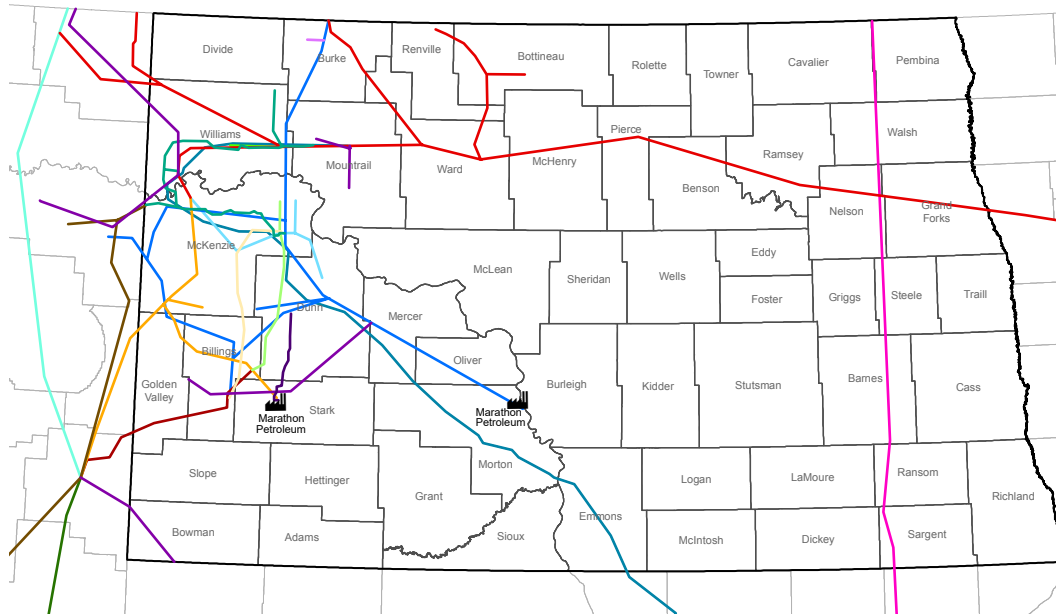
Bakken natural gas has a high content of natural gas liquids (NGL), such as ethane, propane, butane, and natural gasoline. Updated forecast calculations from the North Dakota Pipeline Authority estimate a potential of 1.2 -1.3 million barrels per day of NGL production from North Dakota during the coming decades.

Pipelines remain the safest mode of energy transportation according to the U.S. Department of Transportation with more than 99.99 percent of all petroleum and natural gas products safely reaching their destinations.

During construction of a pipeline, topsoil and subsoil are removed and stockpiled nearby. After pipeline installation, the topsoil and subsoil are returned to the site, and the land is returned to its pre-construction contours and production. This includes getting land into condition for crop production or grazing, or working with wildlife groups to plant native grasses or other vegetation for wildlife forage or habitat.

Sources: North Dakota Pipeline Authority, North Dakota Petroleum Council

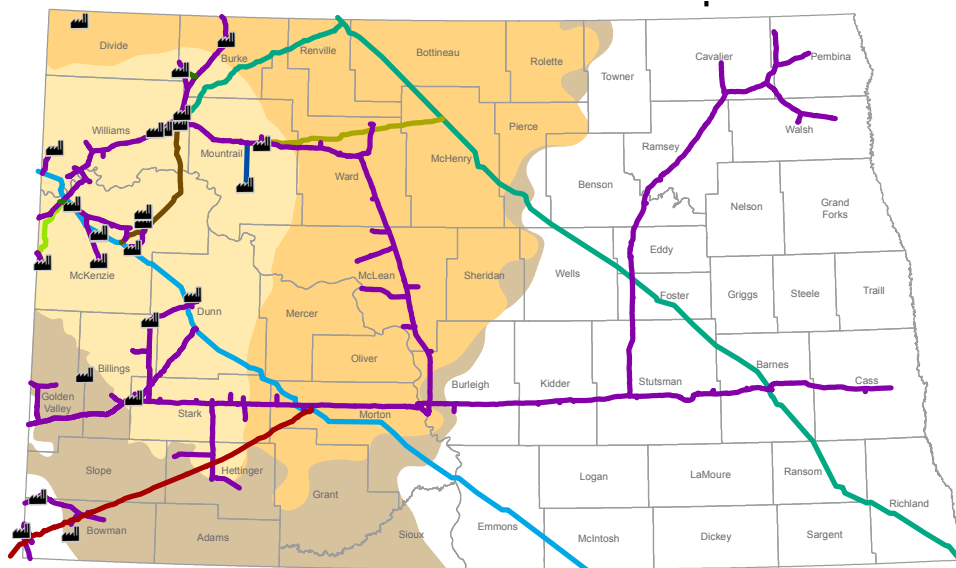
North Dakota Crude Oil Pipelines



- | | | | | | |
|--------------------|---------------|---------------|------------|-------------------|----------|
| Refinery | Baseload | Butte | Double H | Hiland | Bridger |
| Bakken Oil Express | Belle Fourche | Crestwood | Enbridge | Keystone Pipeline | Targa |
| BakkenLink | Bridger | Dakota Access | Four Bears | Little Missouri | Marathon |

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North Dakota Natural Gas Pipelines



- | | | | | |
|------------|-----------------|------------|--------|---------------|
| Gas Plants | Alliance | Hess | ONEOK | Bakken Mature |
| Aux Sable | Kinder Morgan | WBI Energy | Bakken | Three Forks |
| Bison | Northern Border | Whiting | | |

Updated: February 2018. Disclaimer: Neither the State of North Dakota, nor any agency, officer, or employee of the State of North Dakota warrants the accuracy or reliability of this product and shall not be held responsible for any losses caused by reliance on this product. Portions of the information may be incorrect or out of date. Any person or entity that relies on any information obtained from this product does so at his or her own risk.

+ Maps courtesy of North Dakota Pipeline Authority.

PETROLEUM



+ The above photo shows the Great Plains Synfuels Plant in the foreground. The plant is owned by Dakota Gasification Company, a subsidiary of Basin Electric Power Cooperative, and is located north of Beulah, N.D. In the background (blue buildings) is the Antelope Valley Station, a 900-MW capacity coal-based electric generating station. The two plants represent a \$4-billion investment in North Dakota's energy development. Photo courtesy of Basin Electric Power Cooperative.



SYNTHETIC NATURAL GAS

The Dakota Gasification Company's Great Plains Synfuels Plant, north of Beulah, is the only commercial-scale coal gasification plant in the United States that manufactures synthetic natural gas from lignite coal. It produces up to 175 million cubic feet of natural gas a day, which is shipped via the Northern Border Pipeline to the eastern United States and used for heating homes and industrial feedstock.

The plant uses about 18,000 tons of lignite coal each day, supplied via the Freedom Mine. Besides synthetic natural gas, it produces many additional products that are marketed throughout the United States and worldwide, including fertilizers and petrochemicals.

The Synfuels Plant supplies carbon dioxide to the world's largest carbon capture and storage project, delivering between 2-3 million metric tons of carbon dioxide per year that it pipes to the aged Weyburn oil fields in Canada for use

in enhanced oil recovery. The Synfuels Plant has delivered approximately 38 million metric tons of carbon dioxide since October 2000.

Weyburn oil field operators in Saskatchewan predict that injecting carbon dioxide can extend the life of the Weyburn field by about 30 years.

Contractors broke ground on a urea facility in July 2014 at Dakota Gasification Company's Great Plains Synfuels Plant. The project was completed in early 2018 and produces about 1,100 tons of urea a day. About 185,000 gallons per day of diesel exhaust fluid are also produced and sold, as well as liquid nitrogen.

The Synfuels Plant recorded its highest-ever average capacity factor in 2018 at 94.8 percent. The previous record was set in 1998 at 94.6 percent and predated current environmental flaring limitations.

Urea is the 13th product produced at the gasification plant. Besides natural gas and urea, these products include:

- Cresylic acid
- Phenol
- Tar oil
- Ammonium sulfate (agricultural fertilizer)
- Anhydrous ammonia (agricultural fertilizer)
- Carbon dioxide and liquefied carbon dioxide
- Krypton/xenon gases
- Nitrogen
- Naphtha
- Diesel exhaust fluid

Sources: Basin Electric Power Cooperative, Dakota Gasification Company

PETROLEUM



+ Two operators monitor operations at the Tioga Gas Plant in Williams County. The plant is owned and operated by Hess Corporation. Hess employs 480 people in North Dakota.



NATURAL GAS PROCESSING

The North Dakota Pipeline Authority recently updated its natural gas forecast which estimates North Dakota could be producing 4.5-5.5 billion cubic feet of natural gas each day in the late 2030s. This is up from the 2019 natural gas production of roughly 2.5 billion cubic feet per day.

North Dakota currently has 32 natural gas processing plants operating in western North Dakota, and six other new facilities are planned or under construction.

A challenge of the petroleum industry is capturing the natural gas co-produced with oil. As of December 2019, 19 percent of the natural gas produced in North Dakota was being burned off, or “flared,” due to lack of pipelines or challenges on existing infrastructure. In September 2015, the North Dakota Industrial Commission revised the 2014 natural gas targets for Bakken and Three Forks production as follows:

- 74% Capture – Oct. 1, 2014 - Dec. 31, 2014
- 77% Capture – Jan. 1, 2015 - Mar. 31, 2016
- 80% Capture – Apr. 1, 2016 - Oct. 31, 2016
- 85% Capture – Nov. 1, 2016 - Oct. 31, 2018
- 88% Capture – Nov. 1, 2018 - Oct. 31, 2020
- 91% Capture – beginning Nov. 1, 2020

According to the North Dakota Department of Mineral Resources, private industry has invested more than \$20 billion in additional natural gas gathering and processing infrastructure to reduce flaring, and another \$3.3 billion is planned in the coming years.

Since 2010, natural gas processing capacity in North Dakota has grown nearly 387 percent, increasing from 491 MMCFD to 3,162 MMCFD in year-end 2019. Additional capacity is planned for 2020 and later.

The state’s first liquefied natural gas plant is near Tioga. Liquefied natural gas is natural gas that has been converted to a liquid form for easier storage and transportation.

Source: North Dakota Pipeline Authority, ONEOK

Owner Company	Natural Gas Facility	County	Processing Capacity – Million Cubic Feet Per Day (MMCFD)
1804 Ltd	Spring Brook	Williams	70
Arrow Field Services	Arrow	McKenzie	150
Aux Sable – Chicago, IL	Prairie Rose	Mountrail	126*
Caliber Midstream	Hay Butte	McKenzie	10
Hess	Tioga	Williams	265
Kinder Morgan	Norse	Divide	25
Kinder Morgan	Badlands	Bowman	40
Kinder Morgan	Roosevelt	McKenzie	200
Kinder Morgan	Watford City	McKenzie	90
Liberty Midstream Solutions	County Line	Williams	30
Marathon	Robinson Lake	Mountrail	150
Marathon	Belfield	Stark	35
Oasis	Wild Basin	McKenzie	320
ONEOK	Lonesome Creek	McKenzie	240
ONEOK	Stateline I	Williams	120
ONEOK	Stateline II	Williams	120
ONEOK	Garden Creek I	McKenzie	120
ONEOK	Garden Creek II	McKenzie	120
ONEOK	Garden Creek III	McKenzie	120
ONEOK	Grasslands	McKenzie	90
ONEOK	Bear Creek	Dunn	130
ONEOK	Demicks Lake	McKenzie	200**
ONEOK	Demicks Lake II	McKenzie	200**
Petro Hunt	Little Knife	Billings	27
Steel Reef	Lignite	Burke	6
Targa/Hess JV	LM4	McKenzie	200
Targa Resources	Badlands	McKenzie	90
True Oil	Red Wing Creek	McKenzie	15
USG Midstream Bakken	DeWitt	Divide	3
Whiting Oil & Gas	Ray	Williams	25
XTO – Nesson	Ray	Williams	25
Total			3,362

*Aux Sable facility has capacity to transport and process up to 110 MMCFD of North Dakota natural gas at its Chicago facility.

**ONEOK facilities are under construction with an expected 2020 in service date.



PETROLEUM MARKETING / PROPANE

According to the North Dakota Petroleum Marketers Association, there are more than 400 petroleum marketers in North Dakota. The list includes service station dealers, convenience stores and truck stops. These operations deal in every aspect of refined petroleum and renewable fuel products ranging from wholesale and supply to the numerous retail outlets scattered across the state.

In 2019, retail petroleum dealers sold 447,427,251 gallons of taxable gasoline in the state, as well as 738,600,588 gallons of taxable special fuels other than propane (mostly diesel). North Dakota petroleum marketers continue to support research and development of renewable fuels as viable sources of alternate energy.

North Dakota petroleum marketers also supply another fuel critical to the state – propane. Propane is a 100 percent domestic fuel, serving to fortify national and energy security. Propane supplies have grown dramatically in recent years because of the numerous oil shale plays in the United States. Propane serves a variety of residential, commercial and industrial needs. It is used as the prime heating source in 16 percent of homes in North Dakota. In 2019, the state’s propane marketers sold roughly 167.0 million gallons of propane.

Source: North Dakota Petroleum Marketers Association; ND State Tax Commission



ETHANOL

North Dakota’s five ethanol plants have an annual production capacity of nearly 525 million gallons, which is more than double the production a decade ago.

The state’s ethanol industry contributes \$623 million in economic activity each year and directly employs more than 230 workers in rural communities across the state.

The five plants process approximately 50 percent of the state’s annual corn production (160-180 million bushels) into a high-quality fuel and valuable co-products, including corn oil and distiller’s grains.

Plant	Location	Employees	Ethanol Capacity (million gallons)	Corn Used (million bushels)	DDG (tons)
Midwest Ag Energy – Blue Flint Ethanol	Underwood	42	73	25	200,000
Hankinson Renewable Energy, LLC	Hankinson	47	145	51	440,000
Red Trail Energy, LLC	Richardton	48	63	23	180,000
Tharaldson Ethanol	Casselton	56	175	65	500,000
Midwest Ag Energy – Dakota Spirit	Spiritwood	40	75	25	200,000
Totals		233	531	189	1,520,000

BIOFUELS



+ The Dakota Spirit ethanol plant, owned by Midwest AgEnergy, is co-located with Great River Energy's Spiritwood Station near Spiritwood, N.D. Steam from the Spiritwood Station is used to power the refining process.



ETHANOL

One-third of every bushel of grain used for ethanol production returns to the animal feed market in the form of dried distillers grains (DDGs). More than 1.5 million tons of DDGs are produced in the state annually.

Approximately 10 percent of the ethanol produced annually in North Dakota is blended with gasoline and sold within the state. The remaining 90 percent is shipped primarily to the east or west coasts.

In a modern ethanol facility, one bushel of corn produces 2.8 gallons of ethanol, 18 pounds of livestock feed (DDGs), 18 pounds of carbon dioxide, and up to one pound of corn oil.

Unleaded 88 is approved for year round use in all 2001 and newer cars and light-duty vehicles, as well as flex-fuel vehicles. These vehicles make up nearly 90 percent of the light duty vehicles on the road today.

North Dakota is a national leader in the installation of flex-fuel blender pumps, which allow most vehicle owners the option of

a 15 percent ethanol blend, and higher percentage ethanol blends for owner/operators of flex-fuel vehicles. There are more than 40 locations statewide that offer E15 – E85 fuel blends, with nearly 25 of those locations offering E15 specifically. Nearly all retail gasoline dealers offer E10 fuel.

Source: North Dakota Ethanol Council



BIOMASS / BIODIESEL

Biomass includes all plant and animal matter, such as wood waste, energy crops, crop residues, and other forms of organic waste. Harvested biomass can be used to generate various forms of energy, such as heat, electricity and biofuels.

Biodiesel is a domestically produced, renewable fuel that can be manufactured from new and used vegetable oils, animal fats, and recycled restaurant grease. Biodiesel's physical properties are similar to those of petroleum diesel, but with significantly reduced greenhouse gas emissions and toxic air pollutants. Biodiesel can be blended and used in many different concentrations. The most common biodiesel blend is B20

(20 percent biodiesel, 80 percent petroleum diesel), which qualifies for fleet compliance under the federal Energy Policy Act of 1992.

North Dakota's only biodiesel production facility is located near Velva. The ADM plant has the potential to produce 85 million gallons of biodiesel per year. The facility is currently producing biodiesel with canola oil provided by an adjacent crushing plant. Because of low in-state usage, most of the produced biodiesel is shipped to other states or to Canada.

At the Marathon Oil refinery in Dickinson, production began in June 2018 to co-process renewable feedstock along with Bakken crude oil to produce a 5

percent renewable diesel blend. A retrofit of the plant allows co-processing of up to 16,800 gallons per day of renewable feedstock using regionally-sourced soybean oil and distillers corn oil from ethanol plants.

Research is being done on biomass availability from crop residues, and the potential use of oilseed crops like carinata, canola, and camelina to produce jet fuel for military and commercial aviation uses. The field research is being conducted at the USDA Northern Great Plains Research Laboratory in Mandan.

Sources: Great River Energy, Clean Cities (DOE), City of Bismarck, USDA Northern Great Plains Research Laboratory, Marathon (formerly Andeavor)

ENERGY RESEARCH

North Dakota energy industry partners are working with officials from the state and the U.S. Department of Energy on carbon solutions for the electric generation industry. The Lignite Energy Council, BNI Energy, Minnkota Power Cooperative, the Energy & Environmental Research Center, and Basin Electric Power Cooperative are collaborating to develop these technologies for both electricity generation and carbon dioxide capture, including the Allam Cycle and Project Tundra.

The Allam Cycle is a new technology for generating electricity. It consists of gasifying lignite coal to produce synthetic natural gas, which would be combusted along with oxygen to produce supercritical carbon dioxide to drive a turbine generator. Because of its design, this power cycle would have the ability for full carbon dioxide capture. Research and development for this technology continues, with a pilot plant operating in Texas to test the power block.

The Energy & Environmental Research Center's (EERC) CarbonSAFE Initiative (Carbon Storage Complex Feasibility Study) is a research project investigating the feasibility of taking captured carbon dioxide emissions from coal-fired plants, compressing it, and injecting it a mile-deep underground into the Broom Creek Formation in Oliver and Mercer counties, preventing the carbon dioxide from being emitted into the atmosphere.

The EERC was designated as the State Energy Research Center by the North Dakota legislature in 2019.

Several other projects underway at EERC include:

- The Intelligent Pipeline Integrity Program (iPIPE) is an industry-led consortium focusing on emerging technologies to prevent and detect and ultimately eliminate leaks from underground pipelines.
- The Plains CO₂ Reduction (PCOR) Partnership (established in 2003) is one of seven Regional Carbon Sequestration Partnerships awarded by DOE. The partnership, is laying the



✦ Xcel Energy recently completed a five-mile, 115-kilovolt transmission line within the City of Fargo. The line provides increased reliability of electric service in the Fargo area by reducing overloads on neighboring lines and transformers. A drone was utilized for the first time on this project to assist in stringing the lead line for the conductor. Photo courtesy of Xcel Energy.

groundwork for permanent, safe, and practical underground storage of carbon dioxide from industrial facilities in the PCOR Partnership region.

- The Bakken Production Optimization Program is to improve Bakken system oil recovery and reduce its environmental footprint. The results of the program have increased well productivity and the economic output of North Dakota's oil and gas resources, decreased environmental impacts of wellsite operations, and reduced the demand for infrastructure construction and maintenance.

The EERC began investigating carbon capture, utilization, and storage (CCUS) as a way to reduce the carbon dioxide emissions associated with ethanol production. Reducing emissions at an ethanol facility makes the produced fuel more valuable to states that have low-carbon fuel programs and could qualify for federal tax credits for capturing and storing CO₂ in deep geologic formations. Research has been ongoing since 2016.

Preliminary technical and economic feasibility of CCUS technology with ethanol production has been successfully demonstrated at the Red Trail Energy facility near Richardton, N.D.

In other research studies, the University of North Dakota's Department of Civil Engineering is teaming up with Great River Energy and two regional construction firms to determine whether fly ash from lignite-based power plant can be used as a mineral filler in asphalt pavement.

EERC is also conducting research on extracting rare earth elements from lignite coal. While 90 percent of rare earth elements are produced in China, EERC has received more than \$3.5 million in funding to find a way to extract those elements from lignite. Rare earth elements include europium, dysprosium, erbium, terbium, neodymium, holmium, scandium, lutetium, and yttrium, among others. They're used in everyday items, such as computer memory chips, rechargeable batteries, DVDs, cell phones, catalytic converters, magnets, fluorescent lighting, electronics and more. Critical for defense, they are used by the military in night-vision goggles, precision-guided weapons, GPS, and electronics. They are also essential for green energy applications such as wind turbines and hybrid/electric vehicles.

SkySkopes, Grand Forks, N.D., is developing new technology for the energy industry by using drones, commonly referred to as unmanned aircraft systems (UAS). Sophisticated UAS drones are increasingly being used for power line inspections, optical gas imaging (used for detecting fugitive gas emissions), mapping and imaging, 3-D modeling of terrain and rights-of-way, engineering applications, transportation planning, and pipeline monitoring.

The North Dakota Industrial Commission, through its Renewable Energy Program, provided funding for the following research projects in 2019:

- New Implementation of Stack Heat Recovery Technology to Increase Efficiency and Production at Existing Ethanol Production Facility (\$500,000)
- Enterprise Autonomy - Secure, Remote, Autonomous, Multi-Drone Operations within the Renewable Energy Sector (\$500,000)
- Portable Solar Array Modules Phase II (\$500,000)

Sources: ALLETE, Basin Electric Power Cooperative, Energy & Environmental Research Center

ENERGY EFFICIENCY

The North Dakota Department of Commerce has an Office of Renewable Energy and Energy Efficiency that promotes efficiency activities within the state in both the public and private sectors.

According to the North Dakota Department of Commerce, 646 housing units were weatherized in North Dakota in 2019. Homeowners achieve an average of 7-18 percent lower energy costs (about \$283/year). Clients can expect savings of over \$4,000 during the lifetime of the measures installed. Additional health benefits bring the total savings to over \$13,000.

North Dakota Department of Commerce administers the Energy Conservation Grants, which is funded by a one-half of 1 percent of the oil extraction tax deposited in the Resources Trust Fund up to \$1,200,000 for the current biennium. Grants can be used for energy efficiency projects in public buildings. To date, 97 completed projects have received funding, at an average project cost of \$60,888 and average savings of \$8,069 per project each year.

According to Auto Alliance, North Dakota's ranking of electrical vehicle sales for 2016 was 48th in the nation with .04 percent of the market. While electric vehicles are not commonplace in North Dakota, there are charging stations located in 16 communities around the state.

ELECTRIC VEHICLES IN NORTH DAKOTA

According to the North Dakota Department of Transportation, more than 150 electric vehicles are registered in North Dakota, and another 150 plug-in hybrids. While the state lags behind many others in the adoption of electric vehicles, recent developments have provided EV owners options to charge their vehicles.

There are four levels of charging stations commonly used

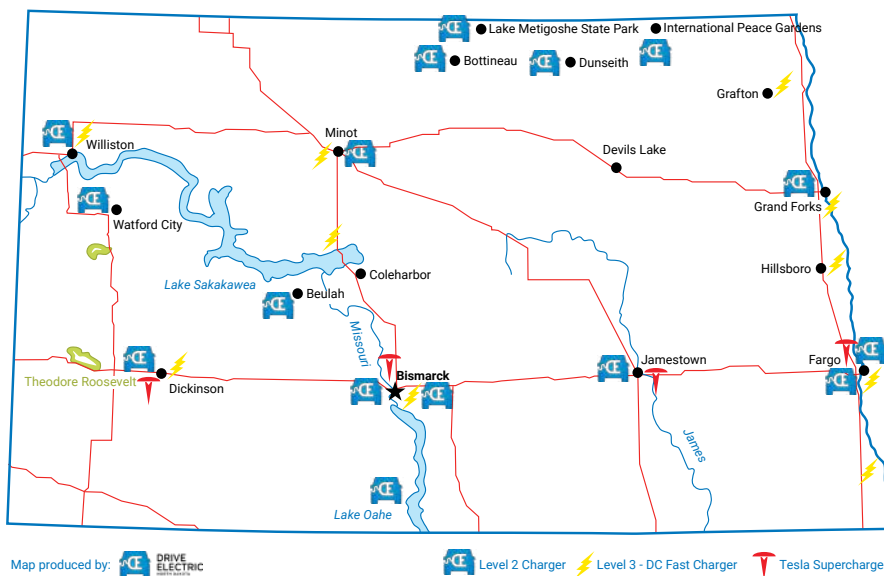
in homes, public places and the workplace. It is important to note that charging speeds are dependent upon several factors including kilowatts per hour, type of connection and battery being charged.

In 2017, Volkswagen entered into a multi-billion-dollar settlement with the federal government regarding diesel emissions reporting errors. As

part of the settlement, North Dakota received \$8.1 million and set up a grant process to distribute the funds. In late 2019, the Department of Environmental Quality announced that grants have been awarded to construct 17 Level 3s (DC Fast Chargers) across the state using VW Settlement Funds. Tesla is planning on bringing a total of 32 Tesla Superchargers online in 2020, with eight each in Fargo, Jamestown, Bismarck and Dickinson. Tesla also pulled permits in Grand Forks (6) and Pembina (8), but no timeframe has been set for their construction.

Sources: North Dakota Department of Commerce, DriveElectric ND, PlugShare.com, Auto Alliance

+ Electric vehicle drivers in North Dakota have numerous options to charge their vehicle away from home. Major cities like Bismarck, Mandan, Fargo, Grand Forks, Williston and Jamestown all have public charging stations.



NORTH DAKOTA TAXES

According to the Office of State Tax Commissioner, North Dakota remains on a path of modest, steady growth. Oil prices continue at a sustainable, profitable level around \$50 per barrel, adequate to support an all-time record production level in the month of October 2019.

Unemployment rates throughout the state – especially its metro areas – remain very low with ample available jobs. Taxable sales and purchases for the first three quarters of 2019 were up 7 percent over the same period in 2018. Income tax collections – both individual and corporate – continue to exceed expectations pointing to strong employment and a healthy business climate.

The Legacy Fund was established in 2010 as the state’s “nest-egg” and is funded by 30 percent of the state oil and gas production taxes. At the end of January 2020, the Legacy Fund had received \$5.561 billion in deposits. Interest earnings from the Legacy Fund are transferred to the State General Fund. In the 2017-19 biennium, the first transfer of interest earnings to the State General Fund totaled \$455.2 million. Legislators can spend the principal of the fund with a two-thirds majority vote in each house. There is an additional limitation restricting any expenditure of Legacy Fund principal to a maximum of 15 percent in any biennium.

Sources: North Dakota Tax Department, North Dakota Office of Management and Budget

NORTH DAKOTA JOBS

The North Dakota Department of Mineral Resources estimates that, depending on the price of oil, an additional 40,000-45,000 wells will be drilled over the next 30 years or so. The state could see a peak of about 87,000 oil related jobs near 2030, with about 70,000 of those jobs being long term.

Job Service North Dakota (JSND) data (Quarterly Census of Employment & Wages 2018) shows that in 2018 an estimated 25,741 workers were in direct or support positions for the industries of oil and gas extraction, coal mining, utilities and pipeline transportation, with an estimated annual wage of approximately \$110,957. These statistics do not reflect employment or wages in ancillary businesses or industries working in the energy field, such as trucking, construction, engineering, manufacturing, and repair services.

There continue to be numerous job opportunities in the state. Data from JSND’s Online Job Openings Report showed a total 14,899 openings in December 2019. The two occupational groups most closely associated with opportunities in the oil patch (Construction & Extraction and Transportation & Material Moving) accounted for 1,452 of those openings statewide. These figures reflect a year-over-year increase in total openings across the state and a year-over-year decrease in the 17 oil and gas

producing counties. The 17 oil and gas producing counties saw a 10.5 percent decrease in total job openings over-the-year and a 55.6 percent decrease over the past five years.

Sources: Job Service North Dakota, North Dakota Department of Mineral Resources



+ Donald Drake, an operator-technician, is shown in the control room at the Lonesome Creek Station, near Watford City, N.D. The station consists of five, 45-megawatt capacity generating units. The plant is owned by Basin Electric Power Cooperative, Bismarck, N.D. Photo courtesy of Basin Electric.



+ The National Energy Center of Excellence at Bismarck State College challenges students enrolled in energy programs with state of the art learning labs, interactive learning tools and automations. (Pictured from near to far: Trevor Schimke, Ethan Van Vleet and Juwaun Speed)

EDUCATION / WORKFORCE TRAINING

Energy Hawks is a premier research program for students to better understand North Dakota's current energy landscape and focus on future energy challenges and opportunities. Established in 2018, the University of North Dakota Energy Hawks is a group of graduate and undergraduate students from a wide range of disciplines focused on adding value to North Dakota's energy industry through a broad range of concepts. Through research, interviews, and travel in North Dakota, these students study the opportunities and challenges of the energy industry and develop a series of initiatives for further research and consideration.

The Bismarck State College (BSC) National Energy Center of Excellence (NECE) has been training the current and future workforce for the energy industry since 1970. With 12 program areas offering degree or certificate options, BSC provides expertise in facility operations and technician (instrument, mechanical, energy services) roles across the industry. These include traditional and renewable power generation facilities, electrical transmission, distribution, linework, system operations, petroleum production, oil & gas processing and refining facilities, and water & wastewater technology. In addition, BSC's Bachelor of Applied Science degree in Energy Management focuses on providing incumbent employees the

necessary skill-sets to become the future leaders in supervision and management roles within their organization.

- Approximately 800 students are enrolled in a BSC energy program either on campus or online every semester, utilizing world-class lab equipment, online simulations and animations, and real-time lab sessions.
- In 2019, 327 students earned a degree or certificate in one of the BSC NECE programs.
- Of those graduates that replied to a BSC Career Services survey, 98 percent were continuing their education or were employed. Recent graduates who were employed reported salaries ranging from \$20 – \$40 or more per hour.
- BSC's NECE also provides customized training for regional, national and international energy companies and training academies to maintain certification/training requirements, educate new hires and to supplement existing training programs.
- In FY 2019, BSC provided non-credit training to 677 individuals representing 176 unique companies and hosted 183 training events.

The Harold Hamm School of Geology and Geological Engineering at the University of North Dakota provides education and research in petroleum geology and related fields.

Lake Region State College in Devils Lake offers a wind energy technician program that utilizes a 1.6 MW wind turbine near the campus.

North Dakota State University in Fargo offers a number of programs in engineering, geology, agriculture and other degrees that prepare students for career paths in many fields, including energy. Other state higher education institutions, including Williston State College, Minot State University and the North Dakota State College of Science at Wahpeton, provide a variety of degree programs that prepare graduates for careers in energy fields.

Bismarck State College, Williston State College, Lake Region State College and North Dakota State College of Science are partners in TrainND, which works with businesses to provide tailored training programs in a variety of energy fields, including oil and gas operations, lease operators, well servicing, wind energy, welding, etc.



+ During a Confined Space Rescue lesson, Bismarck State College students measure and record whether a confined space shows the presence of toxic gasses.

The Energy & Environmental Research Center (EERC), located at the University of North Dakota in Grand Forks, is a world leader in providing solutions to energy and environmental challenges. The EERC has a multidisciplinary team of 200 highly skilled engineers, scientists and support personnel. The EERC employs and mentors students in many disciplines. Its core priorities include coal utilization, carbon dioxide management, oil and gas, alternative fuels and renewable energy, and energy-water management.

The University of North Dakota offers Master's and Doctoral degrees in both Energy Engineering and Environmental Engineering. In addition to the traditional offering, these programs are available totally on-line to meet the needs of working professionals.

Via a partnership between the energy industry, the North Dakota Industrial Commission, the State Historical Society of North Dakota, and the Great Plains Energy Corridor at BSC, energy curriculum was added to the 4th and 8th grade North Dakota Studies courses. The two-week curriculum offers photos, videos, maps and animations related to North Dakota's energy resources and is available online at www.ndstudies.gov.

Sources: Bismarck State College, University of North Dakota Energy & Environmental Research Center



+ ENERGY: Powered by North Dakota provides 4th and 8th grade energy curriculum for North Dakota students.



ENERGYND
great plains energy corridor



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ACKNOWLEDGMENT AND DISCLAIMER

This material is based upon work supported in part by the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, under Award Number DE-EE0007482, and funded in part by the North Dakota Department of Commerce Office of Renewable Energy and Energy Efficiency.

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NORTH DAKOTA'S ENERGY RANKINGS IN THE US



**Crude Oil
Production**

2



**Wind
Production**

4



**Total Energy
Production**

6



**Coal
Production**

8



**Ethanol
Production**

10



**Natural Gas
Production**

10



**Total Net Electricity
Generation**

34

Sources: U.S. Energy Information Administration, American Wind Energy Association, Renewable Fuels Association

ABBREVIATIONS:

- BTU - British Thermal Unit
- KV - Kilovolt
- KW - Kilowatt
- KWh - Kilowatt-hour
- MW - Megawatt
- MWh - Megawatt-hour

On the cover: The North Dakota Wind Energy Center, just west of Edgeley, N.D., began operating in the fall of 2003. It was the first commercial wind project consisting of 27 wind towers and had a generating capacity of 40 megawatts. Since that time, more than 3,600 megawatts of wind generating has been installed in the state consisting of almost 2,000 wind towers. The Edgeley project is owned and operated by FPL Energy, Juno Beach, Fla. The electricity produced by the project is purchased by Basin Electric Power Cooperative, Bismarck, N.D. Photo courtesy of Basin Electric.