SPOTLIGHT ON

NORTH DAKOTA ENERGY

2021 ANNUAL REPORT

BISMARCK STATE COLLEGE | North Dakota's Polytechnic Institution

ENERGYND
great plains energy corridor

table of CONTENTS

ENERGYND
great plains energy corridor

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

editor's COMMENTS

Thank you for picking up the 2021 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 2021. 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 2021:

- A sixth 45-megawatt generating unit at the Lonesome Creek Station west of Watford City, N.D., was placed in operation in 2021. It is fueled with natural gas and is owned and operated by Basin Electric Power Cooperative.

- In July of 2021 Great River Energy, based in Maple Grove, Minn., announced that Bismarck-based Rainbow Energy Marketing Corp. would purchase the Coal Creek Station near Underwood, N.D.

- In a move to increase carbon dioxide storage in North Dakota, the state's Public Service Commission approved a pipeline to transport carbon dioxide from the Great Plains Synfuels Plant near Beulah to a series of proposed wells where the gas would be injected underground and stored.

- In August of 2021, Basin Electric Power Cooperative signed a letter of intent with Bakken Energy to sell the Great Plains Synfuels Plant near Beulah, N.D. If the sale goes forward, it is expected to close in 2023.

- The North Dakota Public Service Commission approved the testing of a new material called foamed sand to fill the voids left from abandoned underground mines in the state. Foamed sand resembles shaving cream and is composed of sand, water and foaming agent. After it dries, only the sand remains.

- The North Dakota Clean Sustainable Energy Authority met for the first time in 2021 after it was created by the state legislature. The energy authority could fund projects submitted to it for review ranging from fossil fuels to renewable energy projects.

- A milestone for carbon capture technology was achieved when state regulators permitted a project at Red Trail Energy facility near Richardton, N.D., to capture and store underground carbon emissions from its ethanol plant.

- No new wind projects were placed in service in 2021.

- It's anticipated that North Dakota's natural gas production will exceed 4 billion cubic feet per day. 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!

Alicia Uhde
Director
Great Plains Energy Corridor

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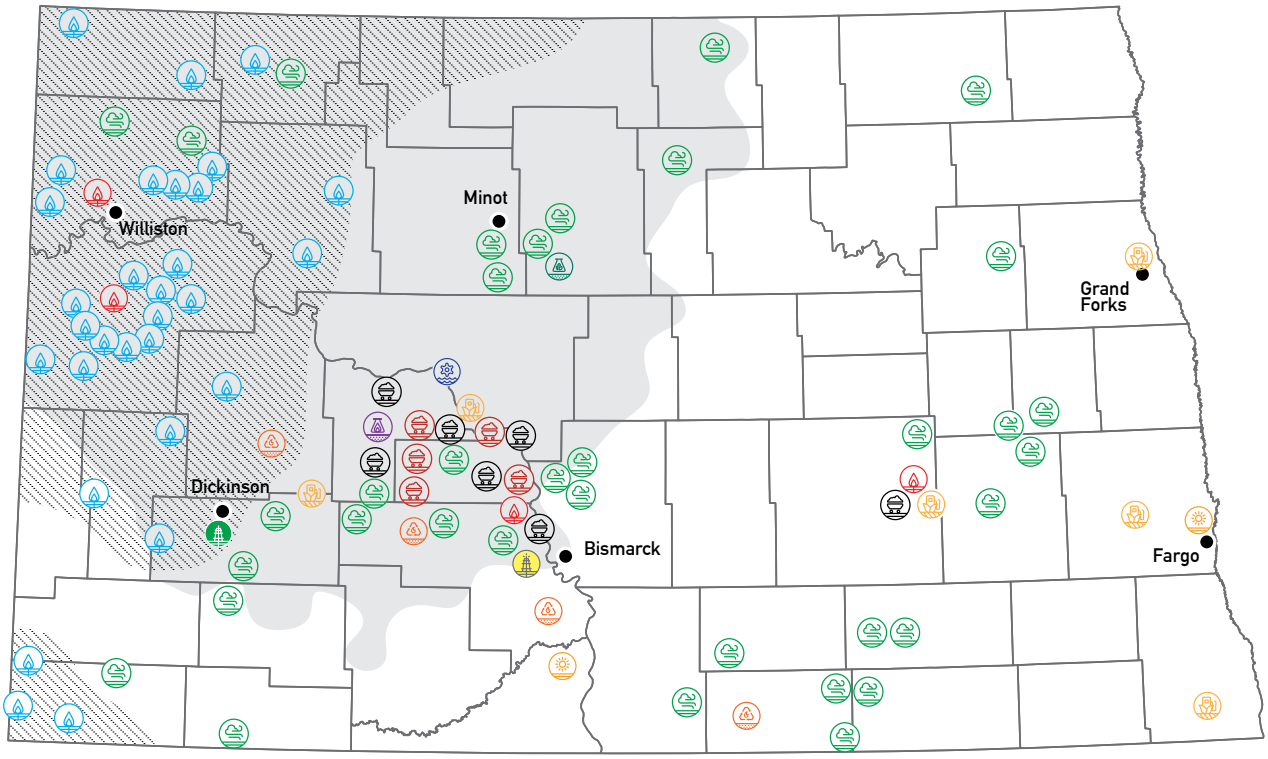
North Dakota is one of the only states with a multi-resource energy policy, guided by the EmPower North Dakota Commission. Through the EmPower North Dakota Commission, leaders from all major energy industries in North Dakota meet with one common goal: to be critical thinkers for the development of the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

www.EmPowerND.com

energy sites of NORTH DAKOTA

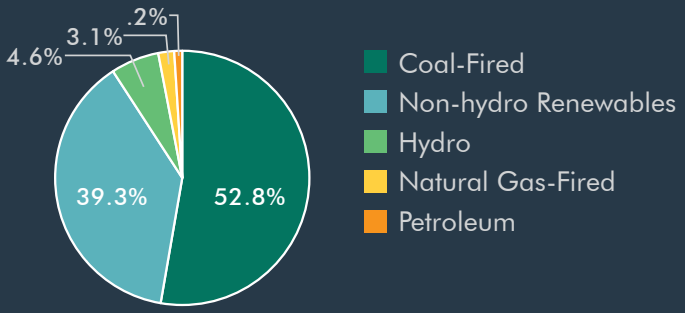


+ *Map courtesy of Bismarck State College National Energy Center of Excellence.*

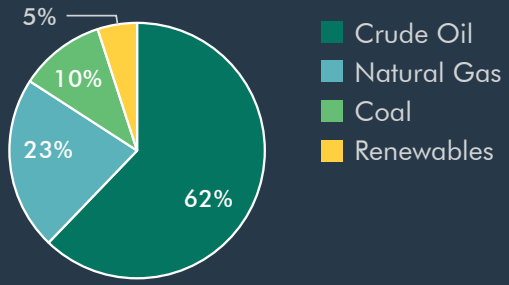
A View From Above

According to the North Dakota Commerce Department, North Dakota ranks second in the nation for total energy production from all sources including coal, natural gas, oil, hydro, and renewables.

North Dakota Electricity Production



North Dakota Total Energy Production



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

north dakota GENERATION

North Dakota produces electricity from a wide variety of sources, including coal 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, 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 website chooseenergy.com, North Dakota had the eighth (ranking 42nd) lowest-cost electricity for residential use in 2021, at 11.61 cents/KWh. This compares to the national average of 14.11 cents/KWh. The highest cost for residential electricity among the 50 states is Hawaii at 34.28 cents/KWh.

An 80-year weather event in February 2021 caused an unprecedented energy crisis. The extreme weather conditions covered a vast geographic area from Canada to Texas, including North Dakota. It prompted controlled power interruptions with little or no notice provided. A resource alert was issued by the Southwest Power Pool to prevent the transmission system from collapsing.

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 is connected or "hard wired" to a power generation source – someplace – through the electric grid. That source may be around the corner, down the block or several hundred miles away.

All the generating sources are interconnected through a power pool and a regional transmission operator. There are two power pools that operate in North Dakota – one is the Southwest Power Pool (SPP); the other is Midcontinent Independent System Operator (MISO). These power pools connect generating sources from many utilities, so if one source isn't able to produce electricity, the other sources can "cover" for the source that isn't producing. It also allows for utilities to purchase power from less expensive sources (when available) in an effort to maintain stable rates. (There's a more detailed description of power pools on page 20).

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.

+ *Shown above is Missouri Quest, one of three draglines at the Freedom Mine, about eight miles north of Beulah, N.D. It has a bucket capacity of 123 cubic yards. In an open pit coal mine, draglines are used to remove the overburden that covers a seam of coal after topsoil and subsoil have been removed and stockpiled. Draglines operate 24 hours a day, seven days a week. The Freedom Mine is owned and operated by North American Coal Corporation. Photo courtesy of Lights Out Images.*

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 26.6 million tons in 2021. 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	12.6 million tons	8 miles northwest of Beulah	Antelope Valley Station and Great Plains Synfuels Plant, Beulah; Leland Olds Station, Stanton	The Coteau Properties Company*
Beulah Mine	399,000 tons	5 miles southwest of Beulah	Heskett Station, Mandan	Dakota Westmoreland Corporation
Center Mine	3.9 million tons	4 miles southeast of Center	Milton R. Young Station, Center	BNI Coal Ltd.
Falkirk Mine	7.7 million tons	Underwood	Coal Creek Station, Underwood; Spiritwood Station, Spiritwood	Falkirk Mining Company*
Coyote Creek Mine	2 million tons	5 miles south of Beulah	Coyote Station, Beulah	Coyote Creek Mining Company*

*Owned by North American Coal Corporation

+ *The Falkirk Mining Company was granted a permit to excavate lignite coal in an area that included Coal Lake, southeast of Underwood. After mining, Falkirk Mining Company reclaimed the mined land and returned it to its original use and production. Photo courtesy of North American Coal Corporation.*

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 about 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, Falkirk Mining Company

GENERATION

The Milton R. Young Station is located near Center, N.D. It has two generating units. Unit 1, with a generating capacity of 250,000 kilowatts (KW), began operating in 1970. It is owned and operated by Minnkota Power Cooperative, Grand Forks, N.D. Unit 2 has a generating capacity of 455,000-KW and began producing electricity in 1977. It is owned by Square Butte Electric Cooperative and operated by Minnkota. Coal for the station is provided from the nearby Center Mine, owned and operated by BNI Coal. Photo courtesy of Levi Nelson.

COAL-BASED

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 17 states that meet all of the U.S. Environmental Protection Agency's federal ambient air quality standards.

The lignite industry employs 3,388 workers directly and another 11,000 indirect workers.

Lignite industry companies (power plants and coal mines) contribute more than $125 million annually through total annual taxes, including sales, personal, and corporate income taxes.

Plant	Operating Company	Capacity by MW
Coal Creek Station	Rainbow Energy Marketing Corp.	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	666
Coyote Station	Otter Tail Power Company	432
Heskett Station*	Montana-Dakota Utilities Co.	100
Spiritwood Station**	Great River Energy	99
Total		**4,048**

* The Heskett Station is scheduled to be retired in March 2022.
** 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.

GENERATION

+ *The Lonesome Creek Station, a natural gas-based peaking station west of Watford City, N.D., is owned and operated by Basin Electric Power Cooperative, Bismarck, N.D. The station consists of six units, each with a capacity of 45 megawatts (MW). Photo courtesy of Basin Electric Power Cooperative.*

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 six, 45-MW units, for a total generating capacity of 270 MW. A sixth, identical unit was placed in operation in 2021. Lonesome Creek started commercial operation in 2013. The plant was built to serve the increasing demand for electricity by member cooperatives in northwest North Dakota. Lonesome Creek is used primarily to support the local transmission system and serve loads developing in the area.
- Pioneer Generation Station is located northwest of Williston, and has a total generating capacity of 241.8 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.

A new, 88-MW combustion turbine will be constructed adjacent to Heskett 3. It is expected to be online in 2023.

Otter Tail Power Company has two fuel oil combustion turbines in Jamestown that have a total capacity of 41.5 MW.

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

GENERATION

+ *This is the 106-MW Glen Ullin Energy Center wind farm in Morton and Mercer counties. It is operated by ALLETE Clean Energy. The electricity produced is supplied to Xcel Energy under a power purchase agreement. Photo courtesy of ALLETE Clean Energy.*

WIND

North Dakota has more than 4,000 MW of wind energy capacity installed throughout the state, consisting of more than 2,200 wind turbines.

Wind developers have expressed an interest in building more than 6,200 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.

An additional 2,290 MW of wind generation is listed in the MISO queue, all requesting to be in service by the end of 2026.

While the national wind capacity factor averaged 41 percent in 2019, North Dakota wind projects typically see higher rates between 40-50 percent.

North Dakota ranks 7th for installed wind capacity, getting 31 percent of its net electricity generation from wind resources.

In 2017, the North Dakota legislature passed a law requiring wind projects to install 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 New Frontier Wind Energy Project was the first wind project in the state to incorporate this technology in December 2018.

In December 2021, the North Dakota Public Service Commission granted a waiver to Basin Electric Power Cooperative for incorporating lighting technology at its Prairie Winds 1 project near Minot, N.D. The wind project is close to the Minot Air Force Base. The Air Force was concerned that radar-based light mitigation technology could pose security and safety threats around the intercontinental ballistic missile sites in the northwest part of the state.

The economic impact of wind energy development in North Dakota in 2020 included $12 million in state and local taxes; $20-30 million in extra income to landowners; $37 million in state and local taxes; and provided between 3,000-4,000 jobs.

The 2018 federal wind energy Production Tax Credit (PTC) provides wind developers a credit of 2.4 cents per KWh (the PTC has now been adjusted to 2.5 cents/KWh to adjust for inflation) 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 was

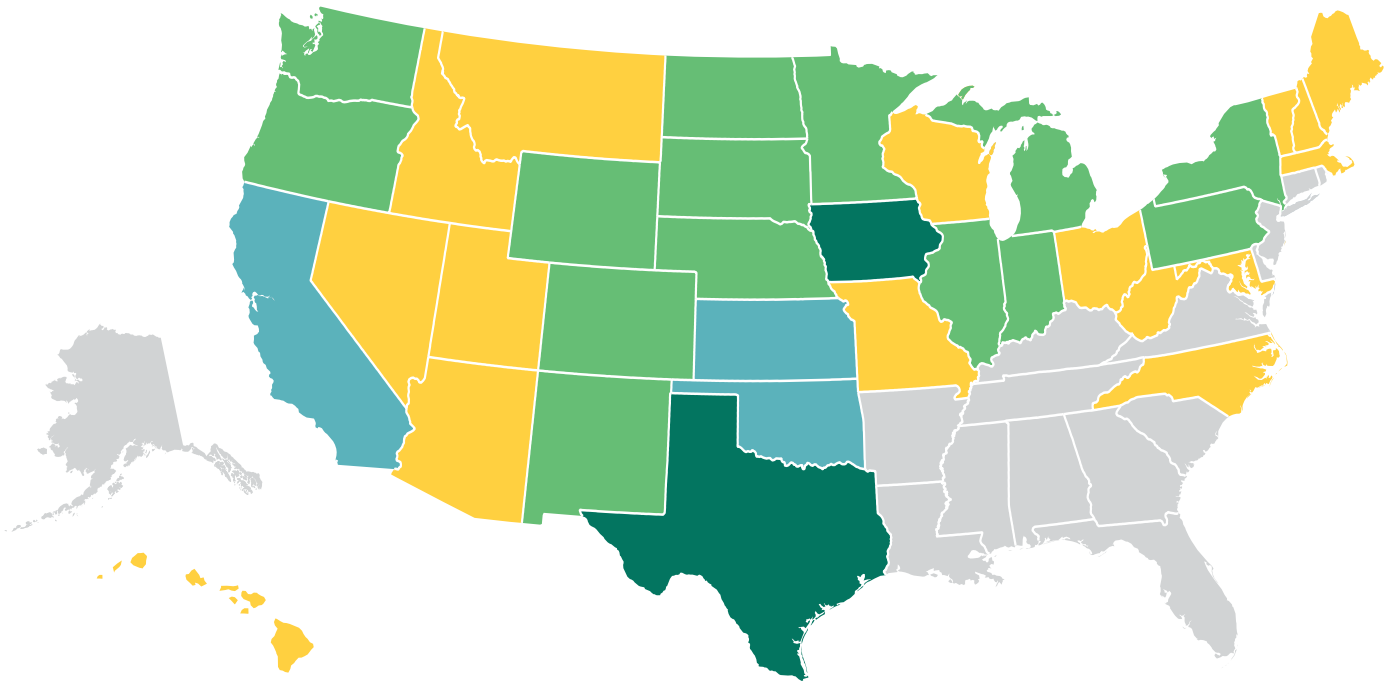
phased down in future years to 80 percent of its present value for projects qualified in 2017, 60 percent for those qualified in 2018, and 40 percent for those qualified in 2019, then it was projected to go to zero. The Tax Extender and Disaster Relief Act of 2019 extended the PTCs at the 2018 level 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.

Sources: North Dakota Public Service Commission, NextEra Energy, ALLETE Clean 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

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.

Installed Wind Capacity 2021



Installed Wind Capacity

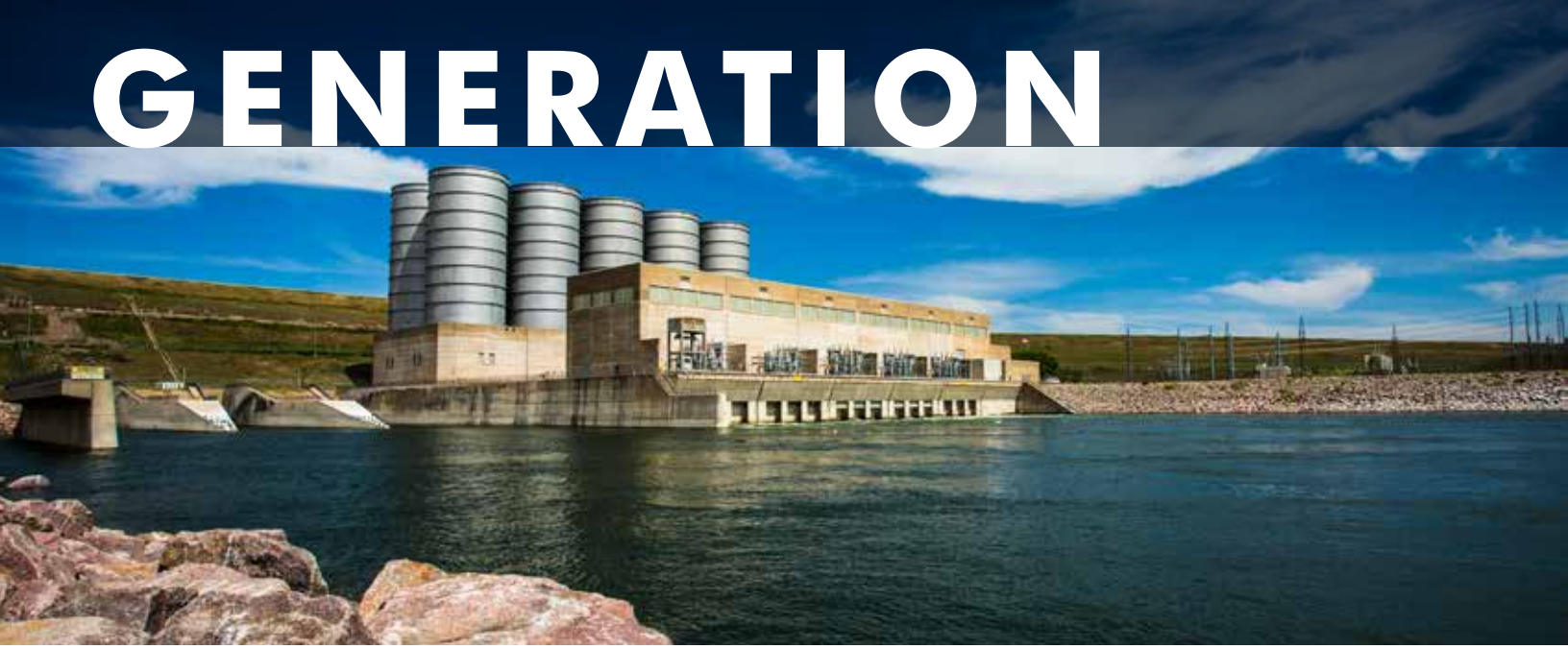
- 10,000+ MW
- 5,001-10,000 MW
- 1,001-5,000 MW
- 101-1,000 MW
- 0-100 MW

+ *Map created by Bismarck State College National Energy Center of Excellence using data from the American Clean Power Association, current through the fourth quarter of 2021.*

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
Aurora Wind Project (2021)	Williams
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
Merricourt Wind Energy Center (2020)	McIntosh, Dickey
New Frontier Project (2019)	McHenry
North Dakota Wind Energy Center – Edgeley (2003)	LaMoure
Northern Divide Wind Energy (2020)	Burke
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 *Turbines span across two counties in N.D. (90 MW) and one county in S.D. (180 MW).*	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 *(if other than project owner)*	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
Tradewind Energy	Basin Electric Power Cooperative (142 MW), Gap, Inc (90 MW)	299.4
NextEra Energy	Basin Electric Power Cooperative	100
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	216.1
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
Otter Tail Power Company		150
Meadowlark Wind I, LLC		100
NextEra Energy	Basin Electric Power Cooperative (40 MW), Otter Tail Power Company (21 MW)	61
NextEra Energy	Basin Electric Power Cooperative	197.9
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)	90
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
		4,260.5

GENERATION



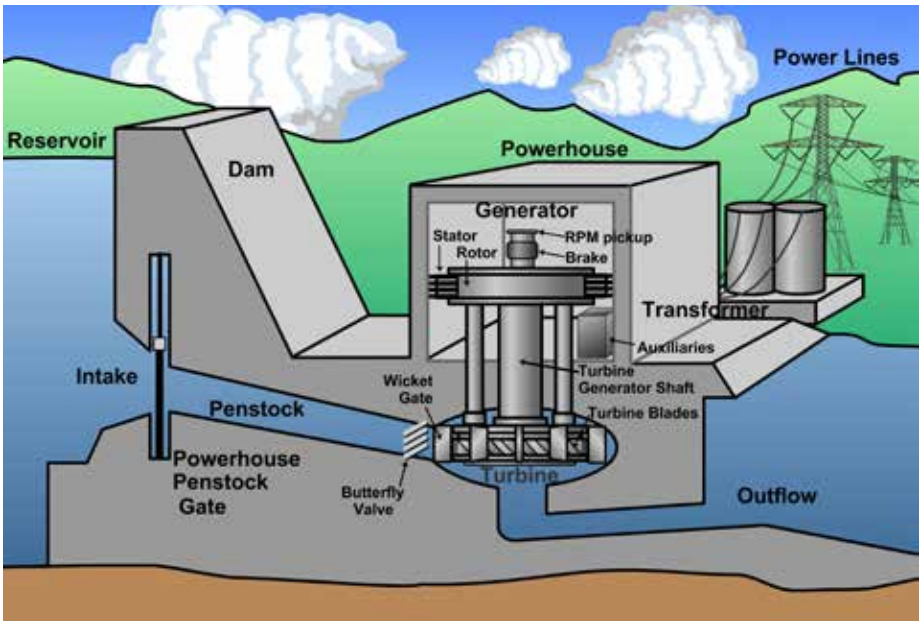
+ *The generator deck of the Garrison Dam, shown above, houses the five generators that produce electricity. The pressure of the water behind the dam drives the generators that have a total capacity of 583,000 KW. The dam is located near Riverdale, N.D., and was constructed by the U.S. Army Corps of Engineers from 1947 to 1953. The reservoir impounded by the dam is Lake Sakakawea. Photo courtesy of Kris Oyen, U.S. Army Corps of Engineers.*

HYDROELECTRIC

The only producer of hydroelectric power in North Dakota is Garrison Dam, operated by the U.S. Army Corps of Engineers – Omaha District.

Garrison Dam has five turbines with a total installed capacity of 583 MW. The first unit began operating in January 1956.

In fiscal year 2021, the dam produced 2 million MWh of electricity.



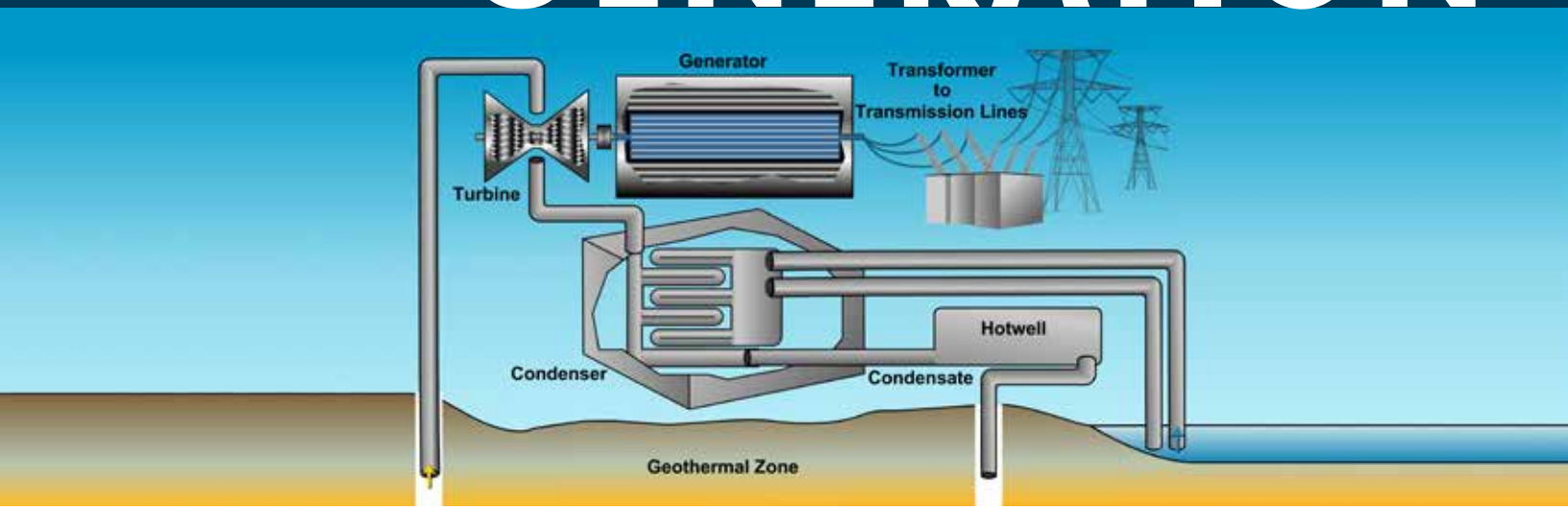
+ *This hydropower electric generating plant graphic is courtesy of Bismarck State College National Energy Center of Excellence.*

The electricity from Garrison Dam is marketed by the Western Area Power Administration (WAPA). 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 serves customers in North Dakota and customers in the states of Minnesota, Iowa, Montana, South Dakota and Nebraska. WAPA 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

GENERATION



+ *This geothermal electrical generation system graphic is courtesy of Bismarck State College National Energy Center of Excellence.*

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.

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

GENERATION

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. The pumps are primarily used in pasture wells in remote areas where building power lines is cost prohibitive. Photo courtesy of Verendrye Electric Cooperative.

SOLAR

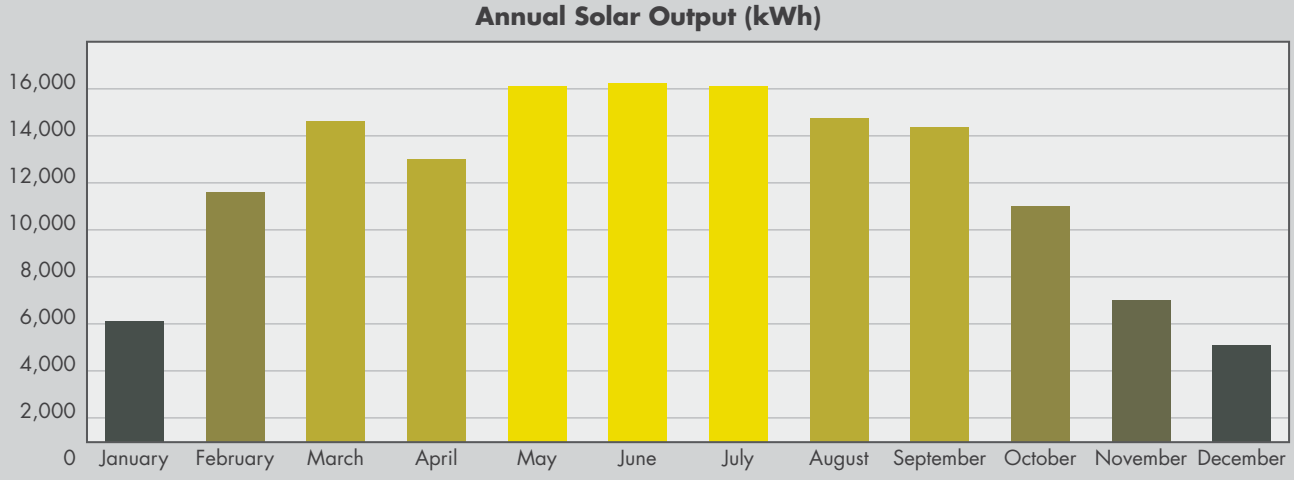
Solar energy technology is based on two main types – photovoltaics (PV), which is the most common way of producing solar electricity in North Dakota, and concentrated solar power (CSP). CSP typically uses mirrors to concentrate the sun's rays and create heat that, in turn, drives a heat or steam engine.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

A 300-kilowatt capacity solar project on the Standing Rock Sioux Reservation was placed into service in July 2019.

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.

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.

Photo courtesy of Bismarck State College.



+ *Cass County Electric Cooperative in Fargo, N.D., 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. In 2021, it produced 146,125 KWh, which would give it a capacity factor of 16.5 percent. Graph created by Bismarck State College National Energy Center of Excellence using Prairie Sun Community Solar data.*

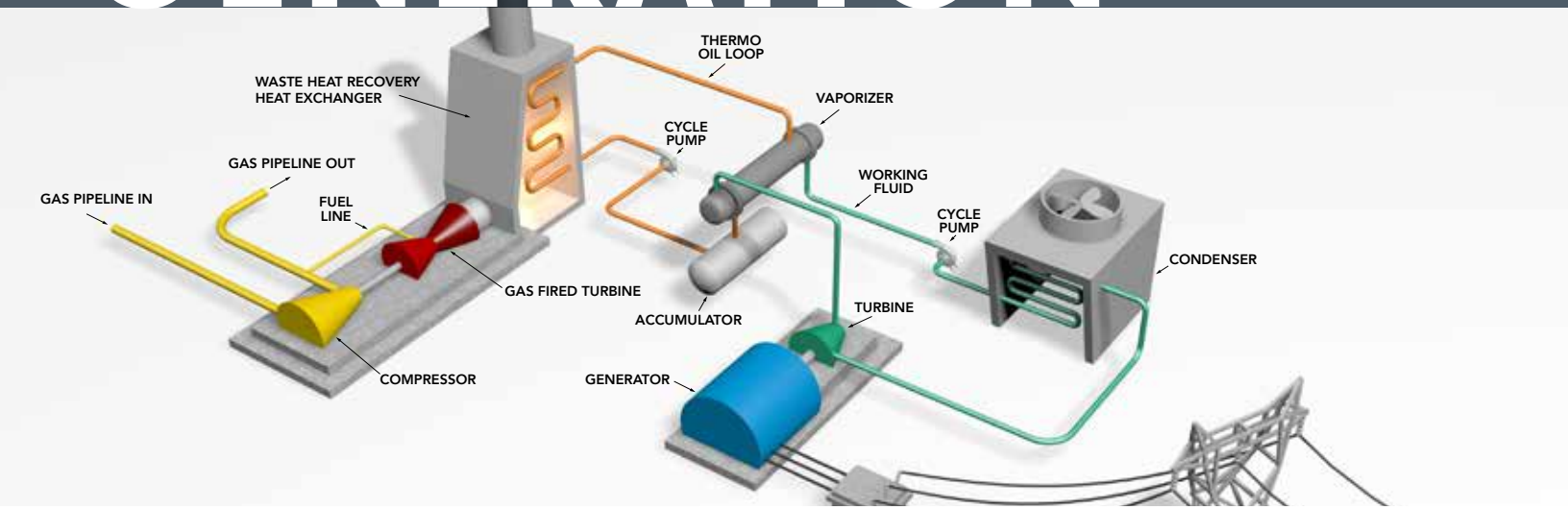
Whiting Petroleum uses PV in North Dakota for some systems in the petroleum extraction process, like automation controls, programmable logic controllers, flare igniters, and combustor controls. These systems allow an operator to start up, monitor, and shut down operations as needed.

Another solar project, still in development by National Grid Renewables, formerly known as Geronimo Energy, is the Harmony Solar Project. The Harmony Solar Project is located in Cass County, N.D., and is estimated to produce up to 200 MW, making it the largest utility-scale solar project in the state. It's anticipated the project will provide over $20 million in economic benefits during the first 20 years of operation, including new tax revenue, construction jobs, new full-time jobs, landowner income and charitable giving.

+ *Photo courtesy of Northern Plains Electric Cooperative.*

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

GENERATION



+ *The heat recovery graphic above is courtesy of Bismarck State College National Energy Center of Excellence.*

RECOVERED ENERGY

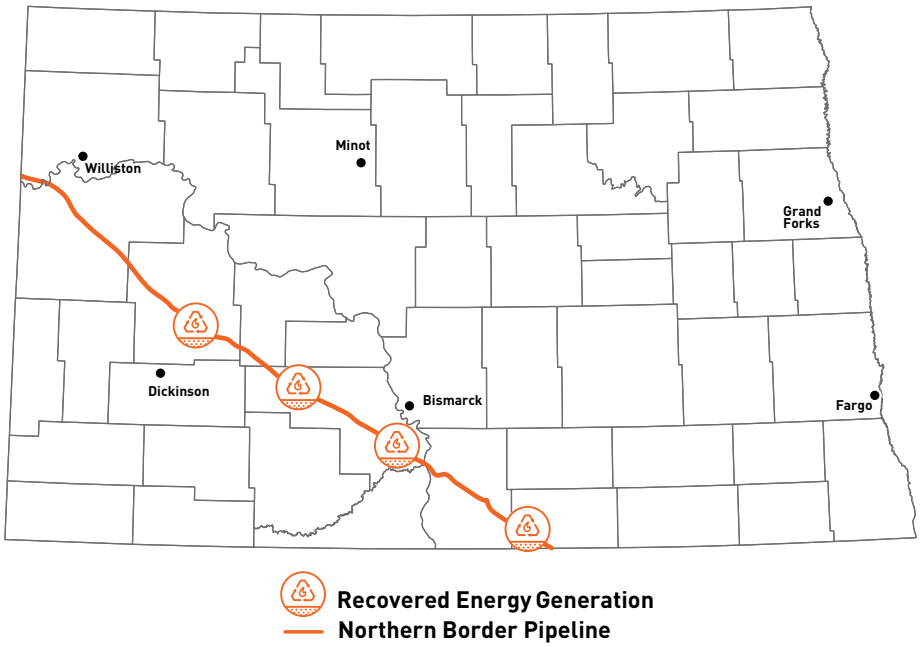
Recovered energy generation (REG), also known as heat-recovery generation or waste heat energy, is a process of capturing the heat from hot exhaust to drive a turbine and create electricity.

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.



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

GENERATION

+ *The transmission line shown above is a single circuit alternating current (AC) transmission line. Photo courtesy of EERC.*

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.

Approximately 50 percent of the state's total electricity supply is provided to the interstate electricity trade.

The exported electricity is delivered into a power pool where it can be delivered to markets beyond a utility's normal service territories. By joining a power pool, a utility has the ability to sell and buy electricity from other generating sources and utilities.

There are two power pools in North Dakota: Southwest Power Pool and Midcontinent Independent System Operator (see map on page 20).

According to americasgenerators.com, a power pool is described as such: When a power utility enters a power pool, it is joining and communicating with a coalition of other power generation facilities. This cooperation leads to less expensive and more reliable energy throughout the power pool's region. The World Bank describes the benefits of these agreements, explaining, "Regions with low-cost generation resources could become net exporters of power, while electricity customers in high-cost areas could benefit from cheaper imports."

The basic function of a power pool or regional transmission operator, is to ensure electricity is delivered reliably and affordably to the millions of people within a defined service territory.

A power pool can be likened to "air traffic controllers" of the electric power grid. Power pool operators do not own the power grid; they independently operate the grid minute-by-minute to ensure that power gets to customers and to eliminate power shortages. Operators "balance" electricity supply and demand, ensuring there is sufficient generation to meet the demand for electricity.

Regional Transmission Operators (RTOs) and Independent System Operators (ISOs) ensure that transportation of traded power is open and fair for all parties. These organizations are independent and non-profit, which aids them in planning and developing current and future transmission that benefits all members of an energy pool.

United States Power Pools Map

+ *Map courtesy of Federal Energy Regulatory Commission.*

In power pools, communication and joint planning can include sharing of reserves and using the lowest-cost energy option within the power pool first. These joint ventures come with positives, as discussed above. There are also negatives. These include the time required to come to joint decisions and the loss of autonomy or flexibility for individual utilities.

North Dakota is poised to have significant load growth. This has the potential to necessitate additional generation and corresponding transmission to serve the load. North Dakota has a very stable and adequate generation and transmission system. Because of the interconnections within a power pool, occurrences in other parts of the pool (other states) can have a dramatic effect on other areas. There may be weaknesses – as in inadequate transmission capacity – well beyond the borders of North Dakota that will cause disruptions for electric consumers in other parts of the power pool.

Engineering models of the power grid are revealing weakness in the grid and lack of capacity to meet the changing generation resources for which developers are asking for access to the grid. These additions to the grid must be well planned to efficiently meet the needs. Average transmission line costs easily reach $1.5 million to $2 million per mile. Estimate of the future needs within the independent system operators that serve North Dakota are in the tens of billions of dollars. From planning to operation often takes 8-10 years. Cost allocation for new transmission is also not clearly defined at this time.

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

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 over head ground wires to dissipate energy from a lightning strike. Photo courtesy of Great River Energy.

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. 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

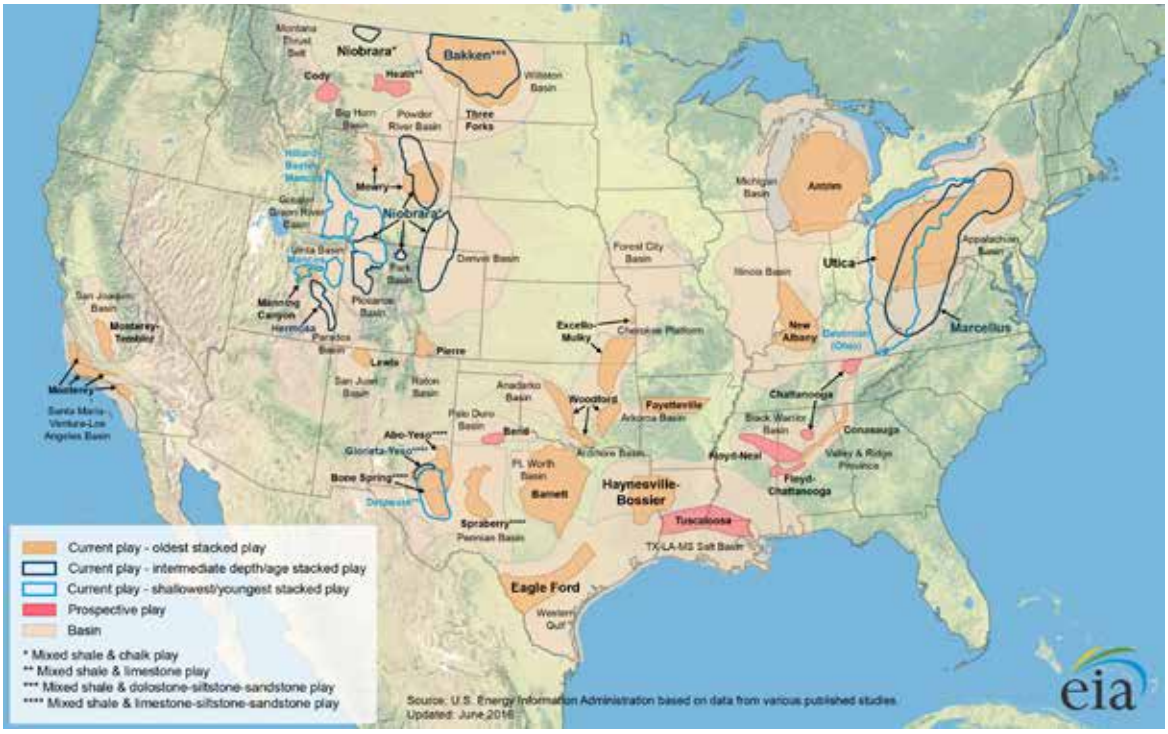
Located near Dickinson, N.D., the refinery shown above is a renewable diesel facility with a capacity of 12,000 barrels per day. It is owned and operated by Marathon Petroleum Corporation and processes corn oil and soybean oil to produce renewable diesel and naphtha, primarily for the California market. Photo courtesy of Marathon.

OIL & GAS PRODUCTION

According to the North Dakota Department of Mineral Resources, the price of sweet crude oil was $65.46 a barrel in December 2021, as compared to the all- time high price in July 2008 of $136.29 per barrel. Throughout 2021, the private and public sectors have slowly been recovering from the 2020 pandemic and spring-2020 price collapse.

The Bakken formation is now considered "mature" by industry – meaning that many of the operators in the state are dedicated to producing their acreage on a consistent and steady pace but that radical growth in production is less likely. Much of the new investments will be in value added industries to capture by-products from the oil and gas production.

- North Dakota is now the third-largest oil producer in the nation behind Texas and New Mexico. North Dakota held rank as the second-largest oil producer from 2012 to mid-2021.
- In December 2021, gas production was 93,857,331 million cubic feet or 3,027,656 MCF/day. Oil production was 35,494,960 barrels or 1,144,999 barrels per day.
- Average rig count in 2021 was 22 rigs, a increase of 2 rigs from the previous year in large part due to the slow recovery from the 2020 pandemic and oil price collapse. The all-time high was 218 rigs in May 2012. Newer, more advanced rigs operating today are able to 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.
- There were 17,200 producing wells in December 2021, with 87 percent of those in the Bakken Formation and the remaining 13 percent from legacy conventional pools.
- Leasing activity for new drilling sites is extremely low in North Dakota. Any activity consists of renewals and top leases in the Bakken-Three Forks area. Focus as prices recover will be less about adding new wells and more about completing wells that have been sitting waiting for frac crews. Completing DUC – "Drilled but Uncompleted Wells" – is more cost efficient for some operators at this time.



+ *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:

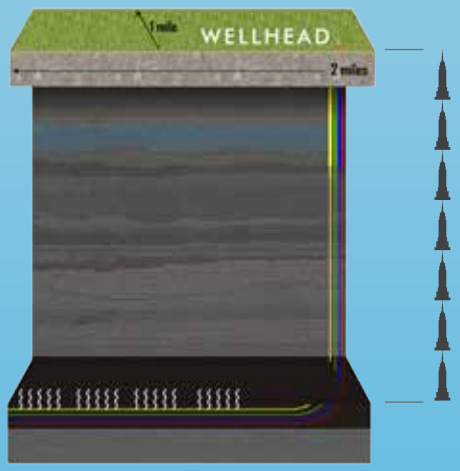
- Produces approximately 1,170,683 barrels of oil.
- Generates about $31 million net profit.
- Pays approximately $5,083,579 in taxes.
  - $2,796,340 gross production taxes
  - $2,094,794 extraction tax
  - $192,445 sales tax
- Pays royalties of $9,487,516 to mineral owners.
- Pays salaries and wages 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.

+ *Photo courtesy of EERC.*

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.

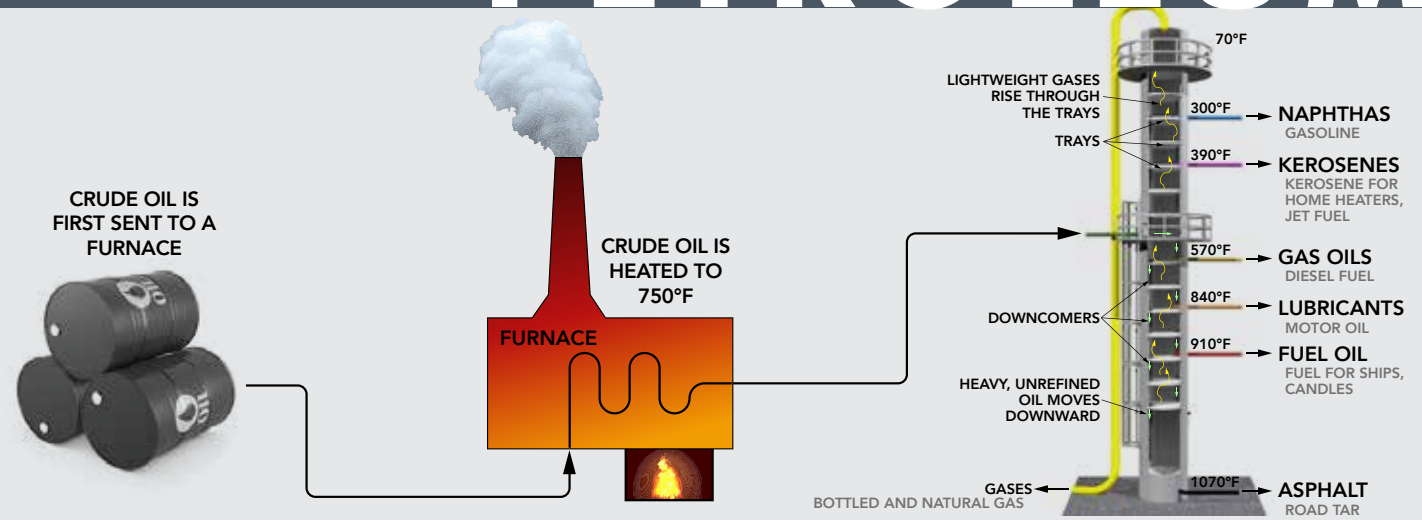
The fluid used in the hydraulic fracturing process is a 98-99.5 percent water and sand mixture. Varieties of chemical additives are used, depending on the well conditions, to limit the growth of bacteria, prevent corrosion of well casing, and increase efficiencies.

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.

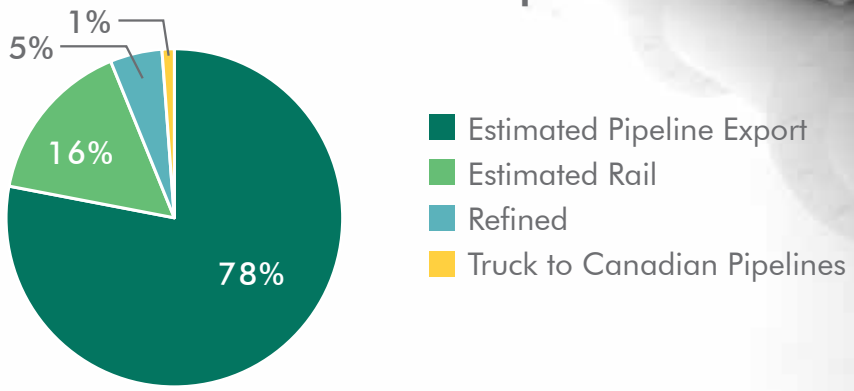
Marathon purchased its Dickinson Refinery in 2018 from Andeavor (its original name was Dakota Prairie Refining). That refinery was constructed by WBI Energy, and subsequently purchased by Andeavor in 2016. It was the first greenfield diesel refinery to be built in the U.S. since the late 1970s and came online in May 2015. Located near Dickinson, the refinery was converted to produce renewable diesel from refined soy oil and other organically derived feedstocks in late 2020 and became a 100 percent renewable diesel facility by reaching the design production capacity of 184 million gallons a year in the second quarter of 2021.

The refinery has about 90 employees.

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 with 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 BPD 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 BPD of NGL production from North Dakota during the coming decades.

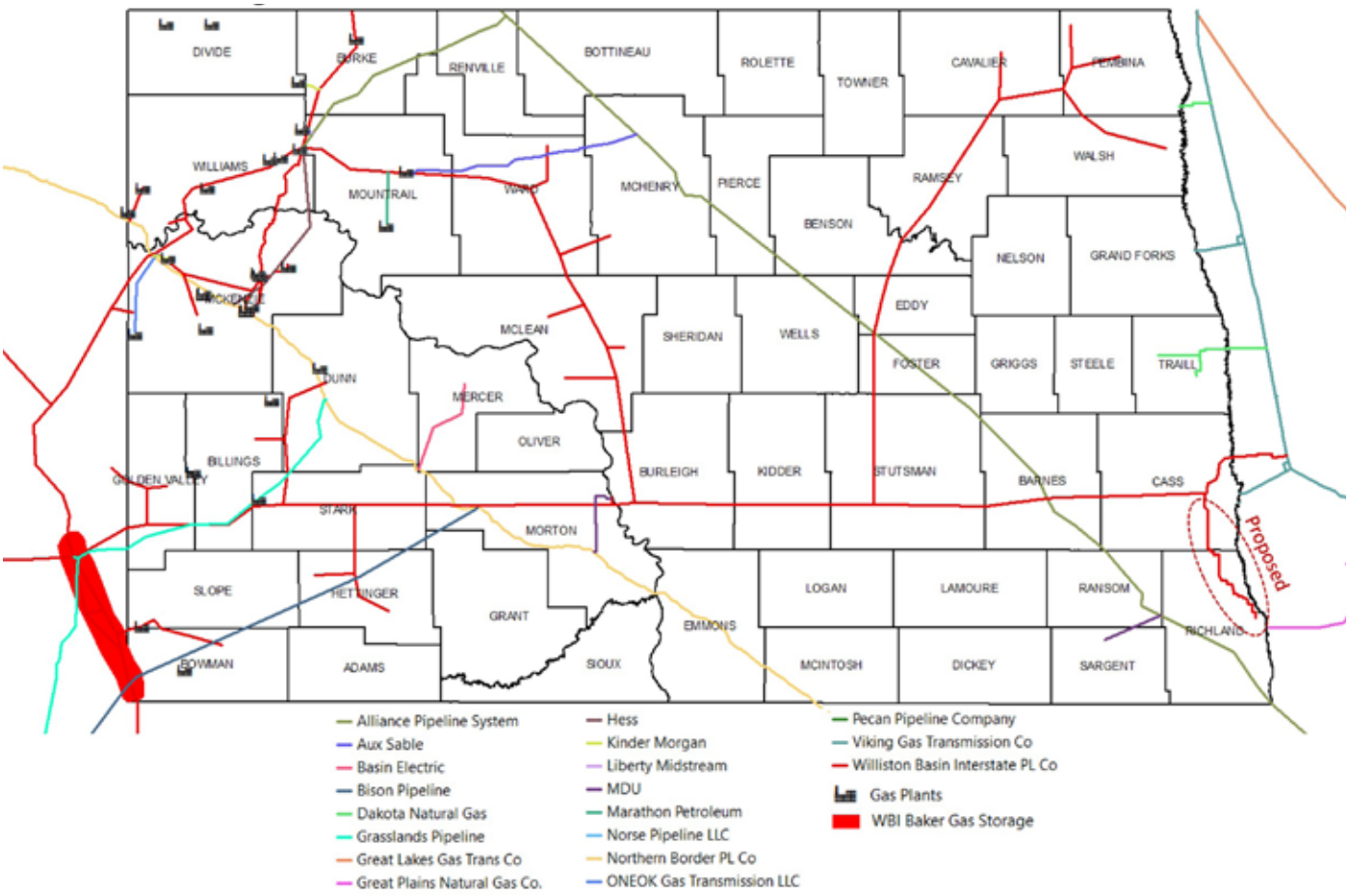
Pipelines remain the safest mode of energy transportation according to the U.S. Department of Transportation, with more than 99.99 percent of all petroleum and natural gas products safely reaching their destinations.

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

Major Natural Gas Infrastructure

updated November 2021



+ *Map 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, N.D., is the only commercial-scale coal gasification plant in the United States that manufactures synthetic natural gas from lignite coal. It produces up to 170 million cubic feet of natural gas a day, which is shipped via the Northern Border Pipeline to market.

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 is part of one of the largest carbon dioxide sequestration projects in the world delivering approximately 2 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 captured approximately 41 million metric tons of carbon dioxide since 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. The plant has the capability to produce up to 64 million gallons of diesel exhaust fluid a year. Up to 200 tons per day of food-grade liquid carbon dioxide can also be produced.

In August of 2021, Basin Electric Power Cooperative signed a letter of intent with Bakken Energy to sell the Great Plains Synfuels Plant near Beulah, N.D. If the sale goes forward, it is expected to close in 2023. Plans include making the plant part of a hydrogen "hub" that would harness and process the abundant natural gas resources in the state.

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. Photo courtesy of Hess Corporation.*

NATURAL GAS PROCESSING

The North Dakota Pipeline Authority recently updated its natural gas forecast which estimates North Dakota could be producing 5.5-6.5 billion cubic feet of natural gas each day in the late 2030s. This is up from the 2020 natural gas production of roughly 2.9 billion cubic feet per day.

North Dakota currently has 32 natural gas processing plants operating in western North Dakota, with many additional expansion projects being planned or under construction.

A challenge of the petroleum industry is capturing the natural gas co-produced with oil. As of November 2021, 6 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:
  Nov. 1, 2020 - Present

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 $10-$15 billion will be needed in the coming years.

Since 2010, natural gas processing capacity in North Dakota has grown nearly 722 percent, increasing from 491 MMCFD to 4,037 MMCFD in year-end 2021. Additional capacity is planned for 2023 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

Owner Company	Natural Gas Facility	County	Processing Capacity – Million Cubic Feet Per Day (MMCFD)
1804 Ltd	Spring Brook	Williams	70
Andeavor	Robinson Lake	Mountrail	150
Andeavor	Belfield	Stark	35
Arrow Field Services	Arrow	McKenzie	150
Aux Sable – Chicago, IL	Prairie Rose	Mountrail	126*
Caliber Midstream	Hay Butte	McKenzie	10
Hess	Tioga	Williams	415
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
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	Bear Creek II	Dunn	200
ONEOK	Demicks Lake	McKenzie	200
ONEOK	Demicks Lake II	McKenzie	200
ONEOK	Demicks Lake III	McKenzie	0
Outrigger Energy II		Williams	250
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	100
Total			**4,037**

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

PETROLEUM

+ *There are more than 400 petroleum marketers in North Dakota.*

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 423,652,068 gallons of taxable gasoline in the state, as well as 579,439,196 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 14 percent of homes in North Dakota. In 2021, the state's propane marketers sold almost 118.0 million gallons of propane.

Source: North Dakota Petroleum Marketers Association, North Dakota State Tax Commission, EERC

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. Photo courtesy of Midwest AgEnergy.

ETHANOL

North Dakota's six ethanol plants have an annual production capacity of more than 550 million gallons.

The state's ethanol industry contributes $623 million in economic activity each year and directly employs more than 275 workers in rural communities across the state.

North Dakota ethanol 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. In addition, more than 550,000 tons of byproduct, including sugar beet tailings and potato processing waste,

Plant	Location	Employees	Ethanol Capacity (million gallons)	Corn Used (million bushels)	DDG (tons)	Corn Oil (million gallons)
Midwest Ag Energy – Blue Flint Ethanol	Underwood	42	73	25	200,000	2.5
Hankinson Renewable Energy, LLC	Hankinson	52	154	52	450,000	6.0
Red Trail Energy, LLC	Richardton	48	63	23	180,000	2.4
Tharaldson Ethanol	Casselton	60	175	59	450,000	6.3
Midwest Ag Energy – Dakota Spirit	Spiritwood	40	75	25	200,000	2.5
Red River Biorefinery	Grand Forks	35	16.5	*	*	*
Totals		**277**	**556.5**	**184**	**1,480,000**	**20**

*Red River Biorefinery uses 550,000 tons of byproduct, including sugar beet tailings and potato processing waste, as feedstock. In addition to ethanol, it produces 100,000 tons of livestock feed.

is purchased from processing facilities across the region.

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). Nearly 1.5 million tons of DDGs are produced in the state annually.

North Dakota's ethanol industry is a national leader in efforts to decrease its carbon footprint and that of other industries as well. Corn-ethanol's carbon footprint is currently a third less than gasoline and continues to decrease with increased carbon-conscious efforts from corn growers and ethanol plants, such as carbon sequestration and storage projects underway at two North Dakota ethanol plants. In addition, the corn oil produced is used in the production of renewable diesel to lower the carbon intensity of that product.

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 3 gallons of ethanol, 15 pounds of livestock feed (DDGs), 18 pounds of carbon dioxide, and up to one pound of corn oil.

Unleaded 88 (E15) is approved for use in all 2001 and newer cars and light-duty vehicles, as well as flex-fuel vehicles. These vehicles make up more than 95 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. State fleet vehicles are authorized to use Unleaded88 (E15) when cost effective and available. There are more than 40 locations statewide that offer E15-E85 fuel blends, with nearly 25 of those locations offering E15 fuel 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.

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

+ *The Project Tundra facility is designed to capture CO2 at a rate of about 90 percent from either unit at the Milton R. Young Station located in Center, N.D. The CO2 would then be stored more than a mile underground. If the project moves forward, North Dakota would be a world leader in the development of next-generation energy technologies. Graphic courtesy of Project Tundra.*

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, and the Energy & Environmental Research Center are collaborating to develop these technologies for both electricity generation and carbon dioxide capture.

The vision for Project Tundra is a carbon-dioxide-capture retrofit to equip the coal-based Milton R. Young Station with next-generation technologies to capture approximately 4 million tons of the facility's carbon dioxide (CO2) emissions. The CO2 would then be safely and permanently stored in deep geologic formations more than a mile underground. State and federal grant funding was utilized in 2020 to support a Front-End Engineering and Design (FEED) study, research of the underground storage facility and the refinement of project economics. It is anticipated that the research and evaluation process will be completed in 2021 and a decision will be made on whether to move forward with the project later that year.

The Energy & Environmental Research Center's (EERC) North Dakota CarbonSAFE Initiative (Carbon Storage Complex Feasibility Study) is assessing permanent, commercial-scale geologic storage of carbon dioxide to manage CO2 emission from coal-based energy facilities. In 2020, researchers drilled a 10,000-foot exploratory hole at the Milton R. Young Station to extract rock samples (cores) and other data from the target formations and the overlying seals. These samples will be tested to determine if they meet the criteria for safe, permanent geologic storage of CO2. The CarbonSAFE Initiative is working in conjunction with Project Tundra.

A carbon capture project that was started at the Coal Creek Station has now been transferred to the EERC.

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. iPIPE was recognized by the American Petroleum Institute with its Industry Innovation award. iPIPE is managed by the EERC, and its consortium members

include Dakota Access Pipeline, DCP Midstream, Enbridge, Equinor, Goodnight Midstream, Hess, MPLx, Oasis Midstream, ONEOK, TC Energy, and Whiting Petroleum.

- The Plains CO2 Reduction (PCOR) Partnership Initiative (established in 2003) addresses regional capture, transport, use, and storage challenges facing commercial carbon capture, utilization, and storage (CCUS) deployment. The partnership is led by the EERC, and funded by the U.S. Department of Energy, the North Dakota Industrial Commission, and participating member organizations.
- The Bakken Production Optimization Program (BPOP) is to improve Bakken system oil recovery and reduce its environmental footprint. Led by the EERC, the program is funded by its members, the U.S. Department of Energy and the North Dakota Industrial Commission (NDIC). 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.

Red Trail Energy (RTE), which owns an ethanol plant near Richardton, N.D., and the EERC began investigating 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 through low-carbon fuel programs and federal tax credits for capturing and storing CO2 in deep geologic formations. In partnership with the North Dakota Industrial Commission (NDIC) through the North Dakota Renewable Energy Program and with the U.S. Department of Energy (DOE), research has been ongoing since 2016. Following successful demonstration of technical and economic feasibility, a carbon storage permit application was developed and submitted to the North Dakota Department of Mineral Resources in February 2021. This permit was subsequently approved in October 2021. Approval brings RTE closer to becoming the first North Dakota commercial CCUS facility.

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 plants can be used as a mineral filler in asphalt pavement.

The Williston Basin CORE-CM (WB CORE-CM) project is focused on future expansion and transformation of Williston Basin coal use to include the production of rare-earth elements (REEs), critical minerals (CMs), and nonfuel carbon-based products. The Williston Basin has a long history of developing and accelerating the production of critical resources for our nation, as most recently evidenced by Bakken oil recovery. REEs and CMs have special properties that make them essential for the manufacture of high-technology products, such as smart phones, catalysts, hard drives, hybrid and plug-in electric vehicles, lasers, magnets, medical devices, wind turbines, solar panels, and televisions. What makes these materials critical is that the supply chain is vulnerable to disruption; the United States is currently 100 percent reliant on imports of REEs. WB CORE-CM is laying the groundwork for extracting REEs and CMs from the Williston Basin's coal resources and energy-generation byproducts.

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. Project sponsors include the U.S. Department of Energy, the North Dakota Industrial Commission Lignite Research Program, BNI Energy, Great River Energy, North American Coal, Minnkota Power, and Great Northern Properties.

Sources: Basin Electric Cooperative, Energy and Environmental Research, Great River Energy, Minnkota Power, Project Tundra

ELECTRIC VEHICLES IN NORTH DAKOTA

According to the North Dakota Department of Transportation, more than 180 electric vehicles are registered in North Dakota, and another 150 plug-in hybrids. Recent developments have provided EV owners options to charge their vehicles across the state.

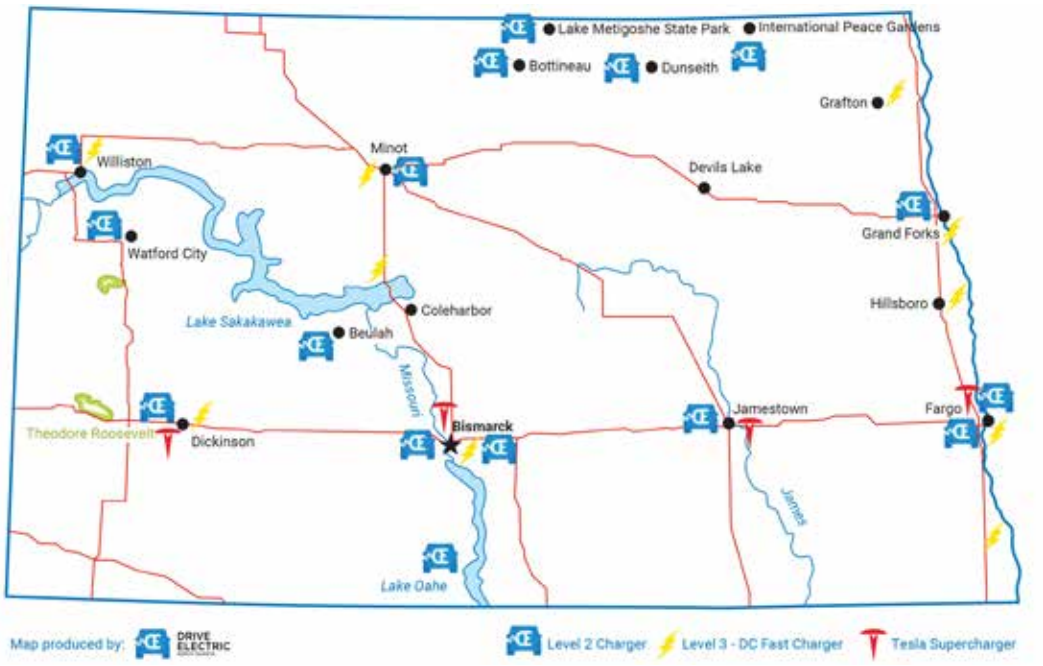
There are four levels of charging stations commonly used in homes, public places and the workplace. It is important to note that charging speeds are dependent upon several factors including kilowatts per hour, type of connection and battery being charged.

- Level 1 (NEMA 14-50) – These are your standard wall outlets or 220v connections. These can be found in homes, RV parks and campgrounds. Level 1 charging will "fill" an EV battery in about 24 hours.
- Level 2 (J1772) – There are approximately 30 Level 2s in North Dakota. A Level 2 charger will top off an average EV battery in about 12-14 hours. Many EV owners have a Level 2 installed in their home.
- Level 3 (DC Fast Charger) – Level 3 charging stations are commonly found in public places like shopping malls and other gathering spaces. DC Fast Chargers take only 2 hours to charge up a standard EV battery.
- Tesla Superchargers – These charging stations are for Tesla car owners exclusively. Typically, it takes less than an hour to fully charge a Tesla vehicle using a Supercharger.

In late 2019, the Department of Environmental Quality announced that grants stemming from the federal 2017 Volkswagen settlement have been awarded to construct 17 Level 3s (DC Fast Chargers) across the state. Currently about half of those have been energized. Tesla has activated a total of 32 Tesla Superchargers online in 2020, with eight each in Fargo, Jamestown, Bismarck and Dickinson. Tesla chargers are also planned for Grand Forks in 2021.

In response to the growing electric vehicle interest in North Dakota, the 2019 State Legislature attached a $120 additional registration fee on EVs registered in North Dakota. This is approximately equivalent to the amount of state gasoline tax paid by automobiles driving 12,000 miles annually. The Interim Agriculture & Transportation Committee conducted a study of charging infrastructure in North Dakota to help determine if any involvement by the State is needed to further EV growth in North Dakota.

Sources: DriveElectric ND, Laventure



+ *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

North Dakota is experiencing an upward trend in economic growth, showing the strength of our economy. Oil prices continue to rise from the unprecedented negative levels in the early summer months of 2020 to over $90 per barrel in late February 2022. The impacts of the coronavirus pandemic and statewide drought continue in the state, though taxable sales and purchases are steadily growing. In the third quarter of 2021, taxable sales and purchases increased 12.1 percent, compared to the same timeframe in 2020. The unemployment rate in the state is 3.1 percent as of December 2021, decreasing by one percent since December 2020. Income tax collections for corporate and individual income have increased in the last year.

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 taxes. At the end of December 2021, the Legacy Fund's value was $8.735 billion. In the 2019-21 biennium, earnings transferred to the General Fund from the Legacy Fund totaled $871 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 Retirement and Investment Office

NORTH DAKOTA JOBS

The North Dakota Department of Mineral Resources estimates that, depending on the pace it takes for the price of oil to rebound, 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.

+ *Wayne Bentz, lead lineman from Basin Electric Power Cooperative's Menoken Transmission System Maintenance outpost, is a graduate of Bismarck State College's Lineman program. Photo courtesy of Basin Electric.*

Job Service North Dakota (JSND) data (Quarterly Census of Employment & Wages 2021) shows that in 2020 an estimated 20,280 workers were in direct or support positions for the industries of oil and gas extraction, coal mining, support activities for mining, utilities and pipeline transportation, with an estimated annual wage of approximately $115,805. 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 of 16,618 openings in January 2022. The two occupational groups most closely associated with opportunities in the oil patch (Construction & Extraction and Transportation & Material Moving) accounted for 1,681 of those openings statewide. These figures reflect a year-over-year increase in total openings across the state and a year-over-year increase in the 17 oil and gas producing counties. The 17 oil and gas producing counties saw a 39 percent increase in total job openings over-the-year and a 20.1 percent increase over the past five years.

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

+ *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.*

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.

Bismarck State College, a Polytechnic Institution, has been training the current and future workforce for the energy industry since 1970. BSC offers certificates, associate and bachelor degree options in 13 disciplines expanding from facility operations and technicians to managers and supervisors. The education and training within the 13 disciplines include industrial operations, mechanical, instrumentation, automation, and energy service technicians to support traditional power stations, wind and solar facilities, electrical transmission, distribution, linework, system operations, petroleum production, oil & gas processing, refining facilities, ethanol, biofuels, and water and wastewater technology. As learners pursue these highly technical skilled programs, they engage in hands-on learning grounded in the principles of STEAM (Science, Technology, Engineering, Arts and Science) preparing them to solve complex social, economic and community problems and achieve success in the real world.

- Approximately 750 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 2021, 305 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 2021, BSC provided non-credit training to 744 individuals representing 180 unique companies and hosted 141 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.

The Energy & Environmental Research Center (EERC), located at the University of North Dakota in Grand Forks, is a global 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 research priorities include coal utilization, carbon dioxide management, oil and gas, alternative fuels and renewable energy, and energy–water management. The EERC was legislatively designated as the state energy research center in 2019.

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.*

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

ENERGYND
great plains energy corridor

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NORTH DAKOTA'S ENERGY RANKINGS IN THE US

Total Energy Production	**#2**
Crude Oil Production	**#3**
Coal Production	**#5**
Wind Production	**#8**
Ethanol Production Capacity	**#10**
Natural Gas Production	**#10**
Total Net Electricity Generation	**#36**

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: *Shown on the cover is the Coyote Station, located south of Beulah, N.D. It has one unit with a generating capacity of 432 MW. It began operating in 1981. The plant is owned by Otter Tail Power Company, Fergus Falls, Minn.; Montana-Dakota Utilities Company, Bismarck; Northern Municipal Power Agency, Thief River Falls, Minn.; and Northwestern Energy, Huron, S.D. It is operated by Otter Tail Power Company. Photo courtesy of Lights Out Images.*