ENERGY: POWERED BY NORTH DAKOTA

ATURAL GAS • ETHANOL • BIOMASS • SOLAR • LIGNITE • TRANSMISSION • GEOTHERMAL • PETROLEUM • WIND • HYDROP

NORTH DAKOTA
STUDIES

This Project is Supported By:

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Welcome to Energy: Powered by North Dakota

What an exciting project this has been! What you're holding in your hands (or reading on the web) is the product of a great collaboration driven by energy and education stakeholders eager to get balanced and factual information on North Dakota's energy resources into the hands of our future leaders. North Dakota has become an economic powerhouse in recent years, much to the credit of the expanding energy industry within the state. Never before has our state experienced the recognition as we do today, breaking all kinds of records and topping all types of top ten lists.

Flip through the following pages to see highlights, maps, and photos from each of North Dakota's energy sectors. Much of the material contained in this book can be used with and is drawn from the web-based curriculum of *Energy: Powered by North Dakota* found at **www.ndstudies.gov.** Enjoy!

Emily McKay,
Project Manager

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Energy: Powered by North Dakota

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with contributions by Emily McKay

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Cover photo courtesy of Basin Electric Power Cooperative

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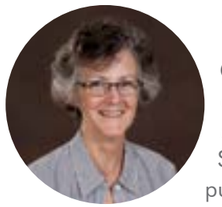
Emily McKay is the Director of the Great Plains Energy Corridor at Bismarck State College's National Energy Center of Excellence. McKay joined the Energy Corridor in 2011 and is responsible for the Corridor's communications, event planning and grant administration. A former Peace Corps volunteer, McKay has worked in the energy industry for more than nine years, most recently at Basin Electric Power Cooperative. McKay also serves as Project Director of the TREND Consortium at Bismarck State College which supports training and education for energy careers in North Dakota.



Gail Christianson

Gail Christianson earned a B.A. in geography from Moorhead State College. She has taught in both public and private schools in Jamestown and Bismarck, ND. Mrs. Christianson spent 28 years as an elementary classroom teacher, primarily in 5th grade, in the Bismarck Public School (BPS) system. She served as a K-3 math coach for BPS for three years before retiring in 2013.

Gwyn S. Herman, Ph.D.

Gwyn S. Herman, Ph.D. is a co-developer for the *Energy: Powered by North Dakota* curricula for fourth and eighth grades. Dr. Herman, a native of Beulah, North Dakota, has 39 years of teaching experience in elementary and high schools as well as the University of Mary. Dr. Herman and co-author, Laverne Johnson, have been developing North Dakota Studies curricula since 2006, working with the State Historical Society of North Dakota to research and write six grade four North Dakota Studies books with accompanying activities and teacher resource guides.

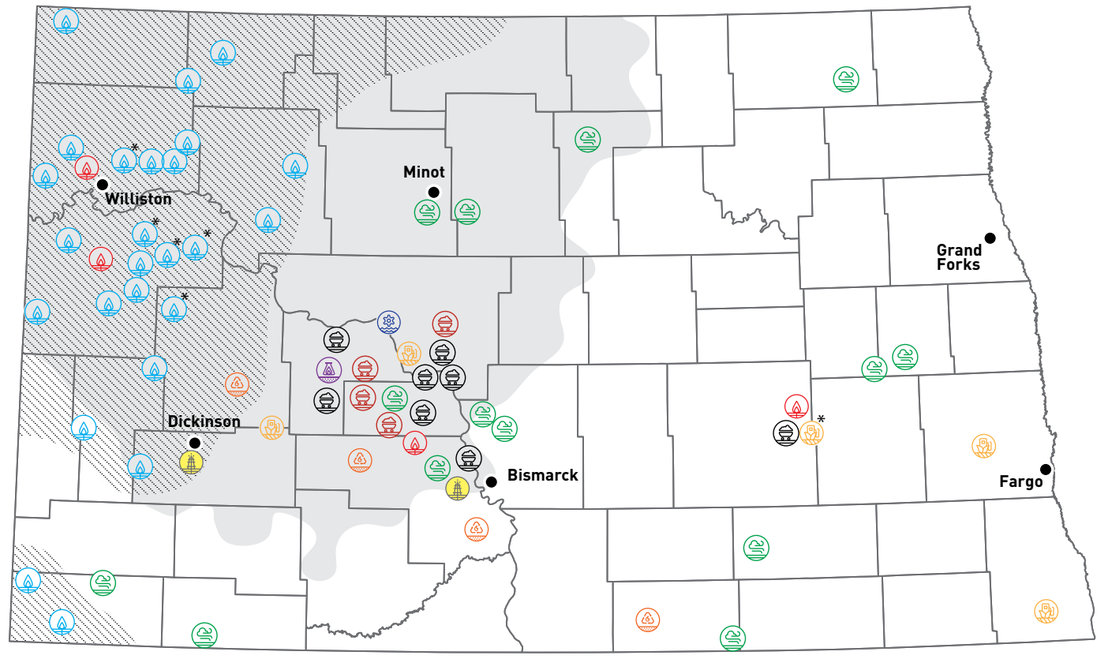
Kim Christianson

Kim Christianson has many years of experience working with programs related to North Dakota energy, most recently as Director of the Great Plains Energy Corridor office at Bismarck State College (BSC). Prior to his position with BSC, Mr. Christianson was the Manager of the Office of Renewable Energy and Energy Efficiency for the North Dakota Department of Commerce, supervising the managers of the state's Weatherization program and State Energy Program, along with the activities of the state energy engineer. He also administered the state buildings energy efficiency program, was actively involved with wind energy development in North Dakota, and tracked state and federal legislation pertaining to energy efficiency and renewable development.

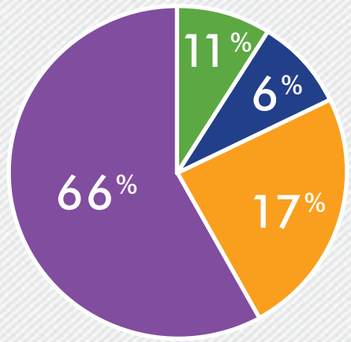
Laverne A. Johnson, M.S.

Laverne Johnson, M.S. is a co-developer for the Energy: Powered by North Dakota curricula for fourth and eighth grades. Ms. Johnson grew up on a farm in central North Dakota and has lived in the state for most of her life. Her educational experience includes 23 years as an elementary and middle school teacher, ten years as a high school speech/language pathologist, and eight years at the university level. Ms. Johnson and associate, Gwyn Herman, have worked as curriculum developers for North Dakota Studies since 2006, co-authoring six fourth grade books with accompanying activities and teacher resource guides.

NORTH DAKOTA ENERGY SITES



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



North Dakota's Total Energy Production

- Renewables
- Natural gas
- Crude oil
- Coal

According to US Energy Information Administration, 2012 Data

Antelope Valley Station, Great Plains Synfuels Plant and the Freedom Mine are shown in this aerial photo, courtesy of Basin Electric Power Cooperative.

■ According to the National Oceanic and Atmospheric Administration (NOAA), North Dakota has the coldest average winter temperatures of the lower 48 states, which contributes to increased energy usage for heating purposes.

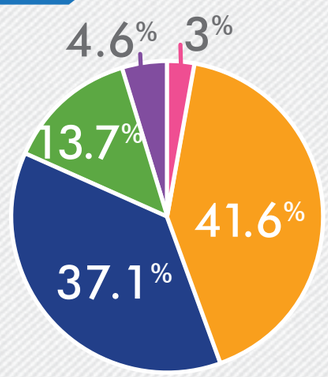
■ The two main sources of home heating fuel in North Dakota are natural gas and electricity. The prices for these fuels are among the lowest in the country, as reported to the US Energy Information Administration:

- ▹ Residential electricity prices rank 50th out of 51 (states plus the District of Columbia)
- ▹ Natural gas prices rank 49th out of 49 states that reported.

■ In North Dakota, three companies distribute natural gas to residential customers:

- ▹ Montana-Dakota Utilities Company
- ▹ Great Plains Natural Gas Company (a division of MDU Resources Group, Inc.)
- ▹ Xcel Energy

Source: US Energy Information Administration, State Energy Data 2011: Production



Home Heating Fuels

North Dakotans use the following house heating fuels:

- Fuel Oil Kerosene
- Bottled, Tank or LP gas
- Electricity
- Utility Gas
- Other

According to US Census Bureau, 2012

The Creation of Electricity

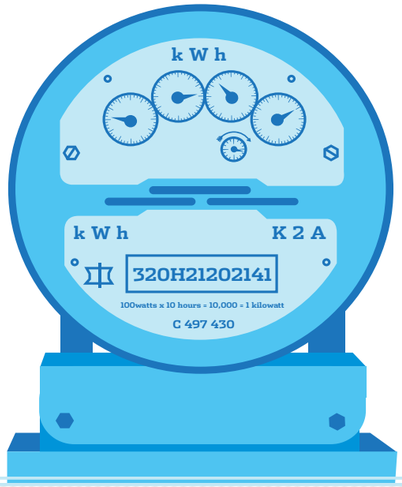
■ North Dakota has a wide variety of electricity generation facilities including:

- ▹ Coal-fired power plants
- ▹ Hydroelectric turbines at Garrison Dam
- ▹ A growing network of wind energy turbines
- ▹ Natural gas and fuel oil peaking plants
- ▹ Heat recovery units that capture waste heat from pipelines
- ▹ Compressor stations
- ▹ A small amount of solar power
- ▹ Explorations into the potential for geothermal electrical generation

■ North Dakota ranks 50th out of 51 (states and the District of Columbia) in home electric costs. As of December 2013, the average residential electricity price in North Dakota was 8.55 cents per kilowatt hour (kWh). The national average was 11.72 cents per kWh.

■ Even though the need for electricity in North Dakota is rapidly increasing, the state continues to produce about three times more electricity than it needs. The excess energy is exported to other states.

Tom Jesperson, Energy Advisor for Verendrye Electric, teaches students about solar panels Verendrye members use to power pumps to water cattle. Photo courtesy of Verendrye Electric Cooperative.



What is a watt?
A watt is a unit for measuring electrical power.

How do you calculate a kilowatt?
Multiply one watt by 1,000 (1,000 watts = 1 kilowatt.)

kWh stands for kilowatt hour.
This is an amount of electrical energy equal to one hour of using electricity at the rate of 1,000 watts/hour. kWh stands for kilowatt hour.

A 100-watt bulb that is turned on for 10 hours uses 1 kWh of electricity (100 watts x 10 hours =1000 watt-hours divided by 1000 watts/kilowatt = 1 kWh)

In North Dakota it costs 8.55 cents to burn one 100 watt bulb for 10 hours.

Source: rapidtables.com, OGE Energy Corp.

A closer look inside the turbine bay at Stanton Station near Stanton, ND.
Photo courtesy of Great River Energy.

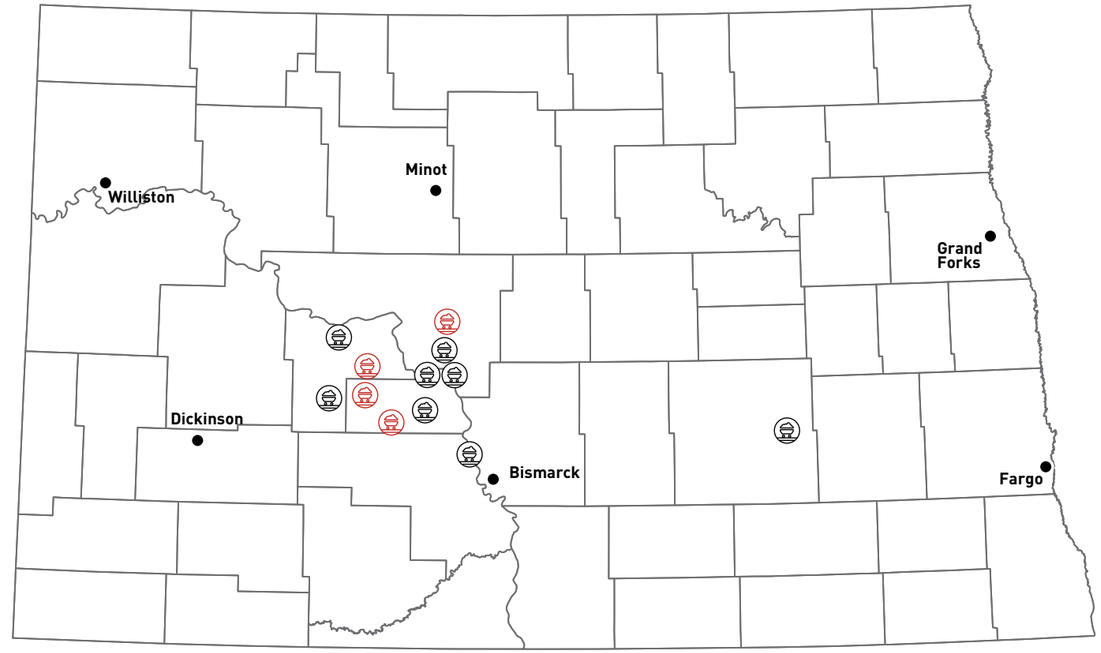
COAL

North Dakota has eight power plants that convert coal to electricity.

PLANT	OPERATING COMPANY	CAPACITY by megawatts (MW)
Coal Creek Station	Great River Energy	1,140
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
Stanton Station*	Great River Energy	188
Heskett Station	Montana-Dakota Utilities	100
Spiritwood Station	Great River Energy	99
TOTAL:		4,228

**Stanton Station uses subbituminous coal from the Cloud Peak's Energy Spring Creek Mine in Montana. All other plants use lignite coal from North Dakota to produce electricity.*

Coal Power Plants and Mines



A megawatt is equal to 1,000 kilowatts of power.

1 kilowatt = 1000 watts
1 megawatt = 1000 kilowatts = 1,000,000 watts

Megawatts are used to

describe the large amounts of electricity produced by power plants and the amount of electricity used by cities.

One megawatt hour

is enough energy to serve 800 homes for one hour.

Aerial view photos show the former Indian Head Mine west of Beulah during mining activity and after the land was reclaimed. Photos courtesy of the North American Coal Corporation.

■ There are four active coal-mining operations in North Dakota.

■ Since 1988, an average of approximately 30 million tons of lignite coal has been mined each year.

■ North Dakota has the second-largest known reserves of lignite in the world (Australia has the largest reserves), with an estimated 25 billion tons of recoverable lignite.

■ It has been estimated that North Dakota's reserves will last more than 835 years.

■ Nearly 80 percent of the lignite is used to generate electricity, 13 percent is used to make synthetic natural gas, and 7 percent is used to produce fertilizer products.

■ Fly-ash is a by-product of burning coal and is used to make concrete and other material.

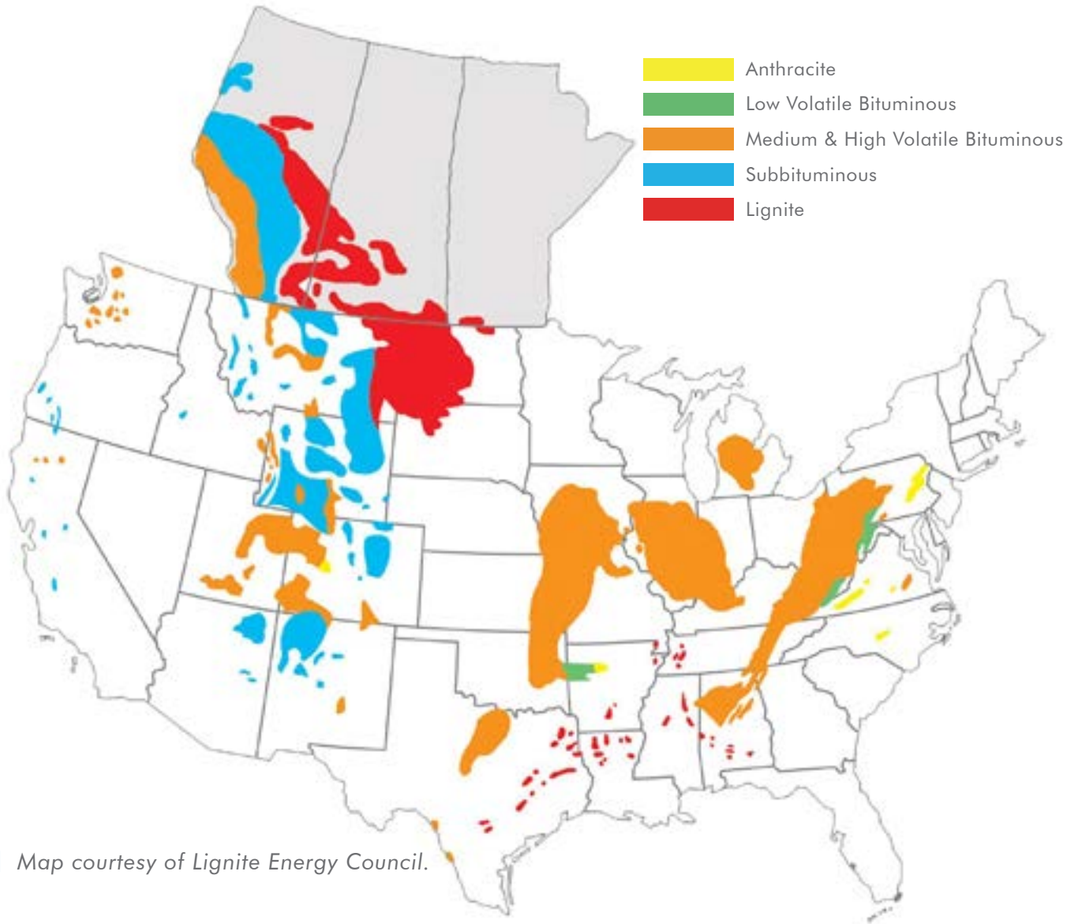
■ Great River Energy Spiritwood Station and Coal Creek Station are combined heat and power plants. The steam produced by the burning of the coal will be used to generate electricity and steam for other uses.

■ North Dakota is one of only seven states that meet all federal air quality standards.

■ Power companies have invested nearly $1 billion in technology to reduce emissions and increase efficiency.

Sources: Lignite Energy Council, Great River Energy, Basin Electric Power Cooperative, MDU Resources Group, Inc., US Environmental Protection Agency

US Coal Deposits



Map courtesy of Lignite Energy Council.

Reclamation

■ Reclamation is the process of restoring land after coal has been removed.

■ Between 1,500 and 2,000 acres of land are disturbed by coal mining and reclaimed each year.

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

■ Mining companies spend an average of $30,000 to reclaim one acre of land. Some costs can be as high as $60,000 per acre.

■ Since 1986, North Dakota mining companies have received 15 national reclamation awards.

Pioneer Generation Station has three units of 45 MW of generating capacity each. Photo courtesy of Basin Electric Power Cooperative.

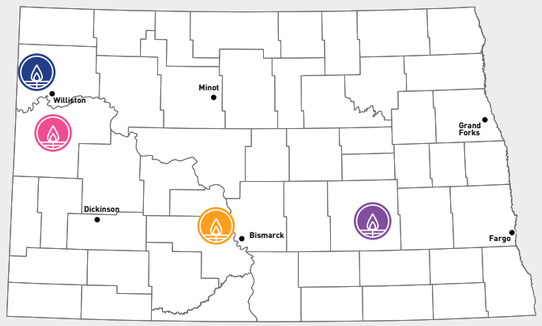
PEAKING PLANTS

■ Peaking plants provide additional electricity during times of extra high demand. This additional generating capacity can be used in extreme weather conditions. For example, when summer temperatures are much higher than normal, more electricity than usual is needed for air conditioning homes and business.

■ Peaking plants are smaller than large, coal-fired power plants. They can be powered up very quickly, and they can even be operated from a remote site. In North Dakota, the peaking plants are fueled by natural gas or fuel oil.

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

Peaking Plants in North Dakota



Lonesome Creek Station
(Basin Electric Power Cooperative)
135 megawatt (MW) capacity

Pioneer Generation Station
(Basin Electric Power Cooperative)
135 MW capacity

Montana-Dakota Utilities
88 MW capacity

Otter Tail Power Company
41.5 MW capacity

WIND

■ Thanks to the robust winds in North Dakota, the state ranks high in both potential for wind energy and in the wind energy already developed.

■ In 2014, North Dakota will have more than 1,000 wind turbines providing nearly 2,000 megawatts (MW) of power with several more in the planning stages.

■ North Dakota is ranked twelfth in the nation for potential wind energy development.

■ North Dakota is ranked sixth in the nation for the amount of wind energy already developed.

■ Nearly 16 percent of the electricity produced in North Dakota comes from wind energy.

■ Wind turbines in North Dakota operate at 42 to 44 percent capacity, which is much higher than the national average of 34 percent.

A close-up look at a "dino tail" on a wind turbine blade. Photo courtesy of Minnesota Power.

A wind turbine nacelle is loaded off a ship in Duluth Harbor. Photo courtesy of Minnesota Power.

Capacity factor is a measure of how much electricity a wind turbine actually produces compared to the maximum it could produce at continuous full power operation.

A wind turbine with a capacity of 1 megawatt (MW) would produce 8,760 megawatt hours per year (1 x 24 x 365) if the wind blew at the same high speed 24 hours a day, every day.

However, because North Dakota winds do not blow at a consistently high speed, a more realistic amount of electricity would be closer to 40 percent of the possible amount. For the same 1 MW turbine, 3,504 MWH is a more realistic measure of electricity produced on average. (8,760 MWH x .40)

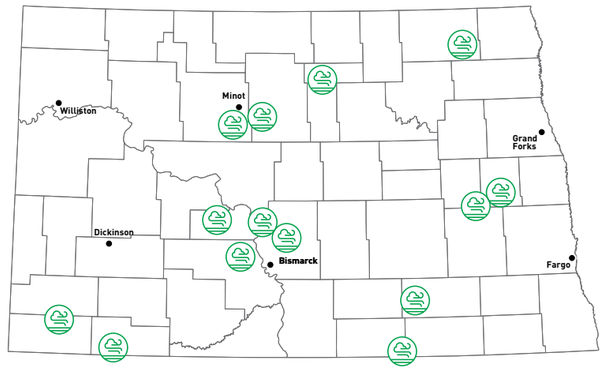
■ The largest turbine blades can be up to 185 feet long (more than half the length of a football field).

■ Speed at the tip of the blade can be over 100 mph.

■ Some of the blades at Bison Wind Farm use "dino tails" – a spiked ridge on the blades used to reduce noise and make blades more efficient as they spin.

■ The Benedictine Sisters of Sacred Heart Monastery near Richardton were pioneers of wind energy development in North Dakota. In 1977, they installed two small wind turbines, which are still operational today.

North Dakota Wind Farms



FACILITY	COMPANY	CAPACITY (BY MW)
Bison Wind Energy Center	Minnesota Power	496.6
Ashtabula Wind Energy Center	NextEra Energy	379
Langdon Wind Energy Center	NextEra Energy/Otter Tail Power Company	199.5
Rugby Wind Power Project	Iberdrola Renewables	149.1
PrairieWinds ND 1	Basin Electric Power Cooperative	122
Thunder Spirit Project (2015)**	Thunder Spirit Wind, LLC	108
Baldwin Wind Energy Center	NextEra Energy	102.4
Wilton Wind Energy Center	NextEra Energy	99
Oliver Wind Energy Center	NextEra Energy	98.6
Tatanka Wind Farm*	Acciona Wind Energy	90
North Dakota Wind Energy Center – Edgeley	NextEra Energy	61.5
Luverne Wind Farm	Otter Tail Power Company	49.5
Cedar Hills Wind Farm	Montana-Dakota Utilities	19.5
Velva Wind Farm	Acciona Wind Energy	12
Petersburg Wind Project	Minnkota Power Cooperative	.9
Valley City Wind Project	Minnkota Power Cooperative	.9
Statewide demonstration and privately owned projects	NA	Approximately 3
TOTAL:		1,991.7

**Tatanka Wind Farm straddles the North Dakota/South Dakota border with turbines across two counties in North Dakota and one county in South Dakota. The wind farm is 180 MW total with 90 MW in North Dakota.*

*** Under Construction*

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, Amerian Wind Energy Association, National Renewable Energy Laboratory, Wind Powering America

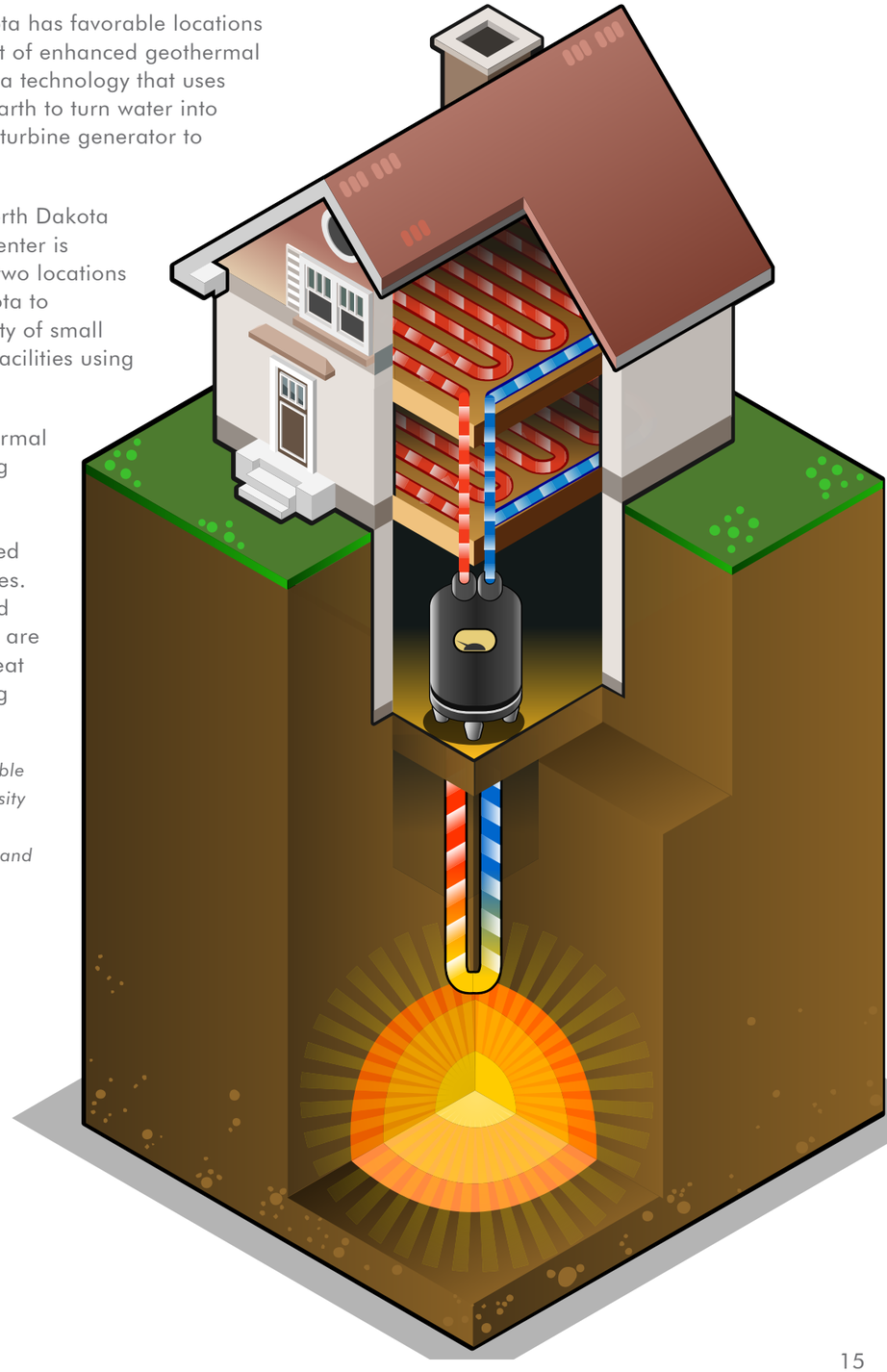
GEOTHERMAL

■ Western North Dakota has favorable locations for future development of enhanced geothermal systems (EGS). EGS is a technology that uses heat from within the earth to turn water into steam, which drives a turbine generator to produce electricity.

■ The University of North Dakota Petroleum Research Center is conducting studies at two locations in western North Dakota to determine the feasibility of small electricity generation facilities using geothermal energy.

■ Even though geothermal energy is not yet being used to generate electricity in North Dakota, it is being used to heat and cool homes. Many new schools and other public buildings are adding geothermal heat pumps to their heating systems.

Sources: National Renewable Energy Laboratory, University of North Dakota Harold Hamm School of Geology and Geological Engineering



HYDRO POWER

■ The only producer of hydroelectric power in North Dakota is the Garrison Dam, run by the US Army Corps of Engineers.

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

■ Nationwide, there are 75 hydroelectric power plants operated by the Corps of Engineers. They produce a total of 40,474 MW, which is about one-third of the total hydropower produced in the United States.

■ From 2004 to 2013, the Garrison Dam produced an average of 1.76 billion kilowatt hours (kWh) of electricity annually.

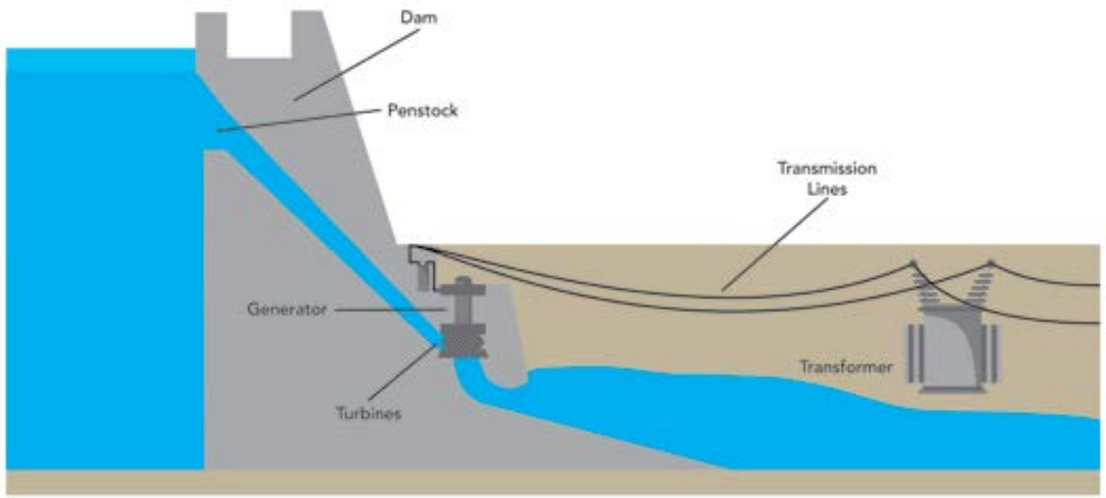
■ Lake Sakakawea, the lake created by Garrison Dam, is the third largest reservoir by volume in the U.S.

■ Electricity produced by the Garrison Dam is marketed to many different customers. Much of this electricity is sold to customers in Minnesota, Iowa and Nebraska. In North Dakota, those customers are:

- ▹ Municipal utilities
- ▹ American Indian tribes
- ▹ State agencies
- ▹ Educational institutions
- ▹ Electric power cooperatives

An aerial view of Garrison Dam and its spillway. Photo by Sgt. Brett Miller, ND National Guard Visual Information.

Sources: US Army Corps of Engineers, Western Area Power Administration



Hydropower is the process of changing the energy of moving water into electrical energy. Graphic courtesy of Bismarck State College National Energy Center of Excellence.

A solar panel at work next to an oil well site. Photo courtesy of Whiting Petroleum.

SOLAR POWER

■ Solar power is the process of changing the energy of the sun into a useful form of energy.

■ There are two main types of solar electric generation:

- ▹ Photovoltaic (PV) is the type used in North Dakota. It uses the sun's rays to create direct current electricity.
- ▹ Concentrated Solar Power (CSP) uses mirrors to concentrate the sun's rays and create heat that drives a steam engine.

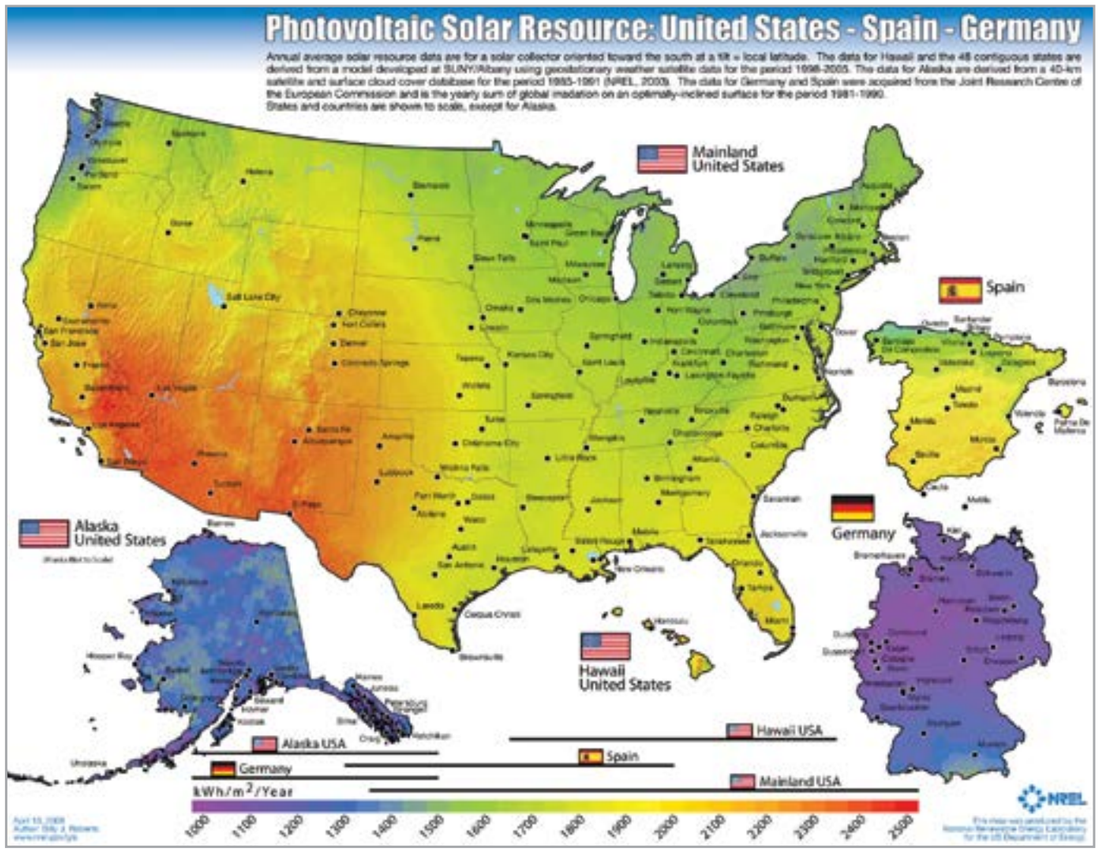
■ Verendrye Electric Cooperative of Velva has the largest PV solar program in the state with more than 235 solar-powered water pumps. The pumps provide water to pastures in remote areas where building power lines would be very costly.

■ In 2011, Bismarck State College installed an 8 kilowatt (kW) solar array for demonstration and educational purposes.

■ Whiting Petroleum uses PV systems at remote oil well sites for which electric services are not available.

Sources: National Renewable Energy Laboratory, Verendrye Electric Cooperative, Bismarck State College, Dr. Richard Alley – "Earth: The Operators Manual 2011," John Bagu, PhD

Solar radiation that strikes North Dakota is equal to or greater than that of Germany and Spain, which rank first and third in the world for the number of solar energy installations. This map was created by the National Renewable Energy Laboratory for the US Department of Energy.



A SOLAR HOUSE IN FARGO?

John and Robyn Bagu have 30 solar photovoltaic panels on the roof of their home in Fargo, with a combined rated generation capacity of 7.4 kW. In the first full year of operation (2013), the panels generated more electricity than the house used. So far in 2014, generation is ahead of last year. John and Robyn are able to sell their excess electricity to their utility company, Cass County Electric Cooperative, which makes the project more affordable for the homeowner.

A closer look at the Bagu home solar panels. Photo courtesy of Dr. John Bagu.

A look at the St. Anthony Heat Recovery Station. Photo courtesy of Basin Electric Power Cooperative.

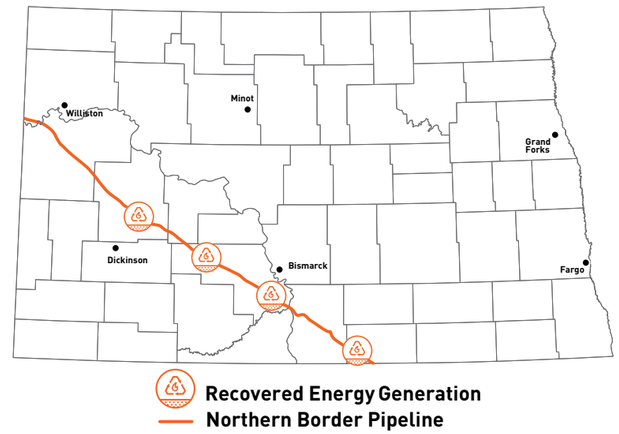
RECOVERED ENERGY

- Recovered energy is using waste energy to create electricity.

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

- Basin Electric Power Cooperative was the first company in the United States to use REG on a natural gas pipeline. In North Dakota, Basin Electric has three REG units, and Montana-Dakota Utilities has one REG unit attached to four different compressor stations on the Northern Border Pipeline. The compressor stations emit very hot exhaust gases ranging in temperature from 850 to 950 degrees Fahrenheit (454-510 degrees Celsius). This heat is captured to drive turbines. This technology was developed by a company called Ormat Technologies.

Recovered Energy in North Dakota



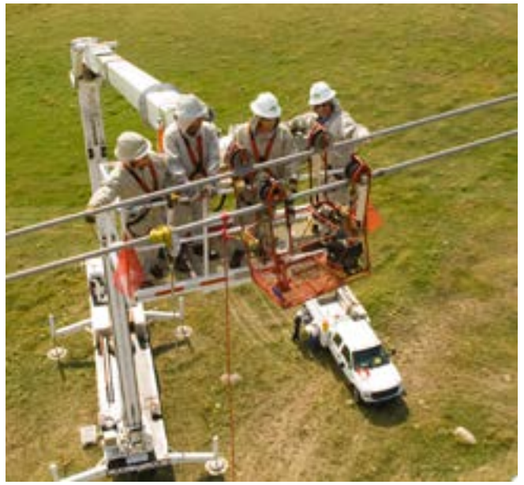
Sources: Basin Electric Power Cooperative, MDU Resources Group, Inc.

TRANSMISSION & DISTRIBUTION

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

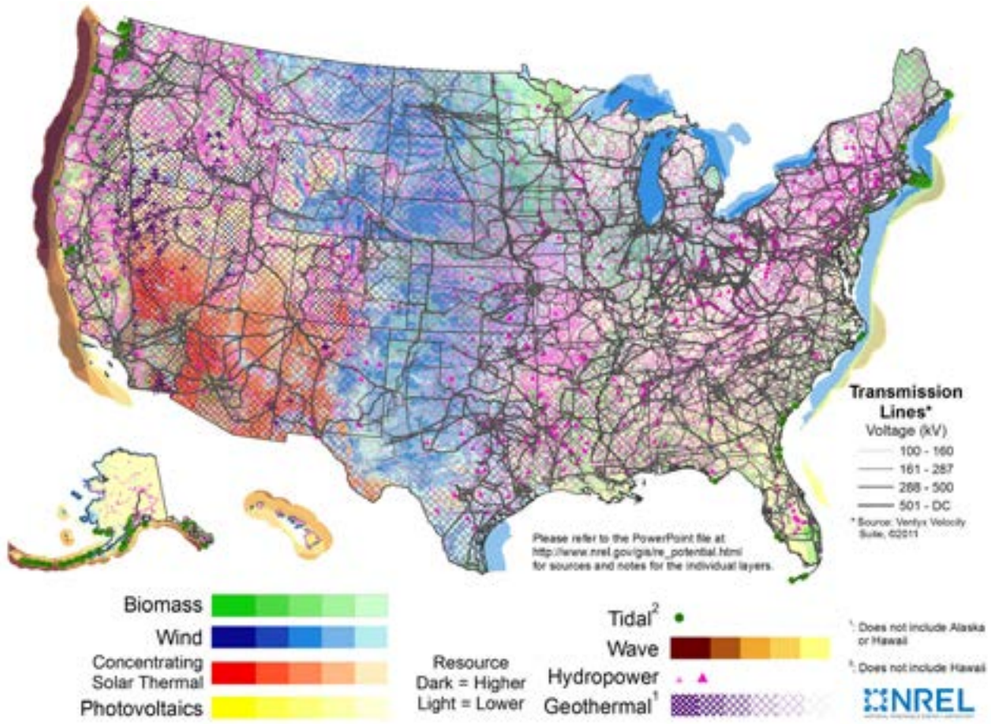
■ Because of increased wind energy development and other electrical generation development, there is an increasing need for more transmission facilities to move the electricity where it is needed.

■ Transmission costs vary depending on voltage, terrain, and many other factors. The average cost for a new 345 kV line can be between one and two million dollars per mile.

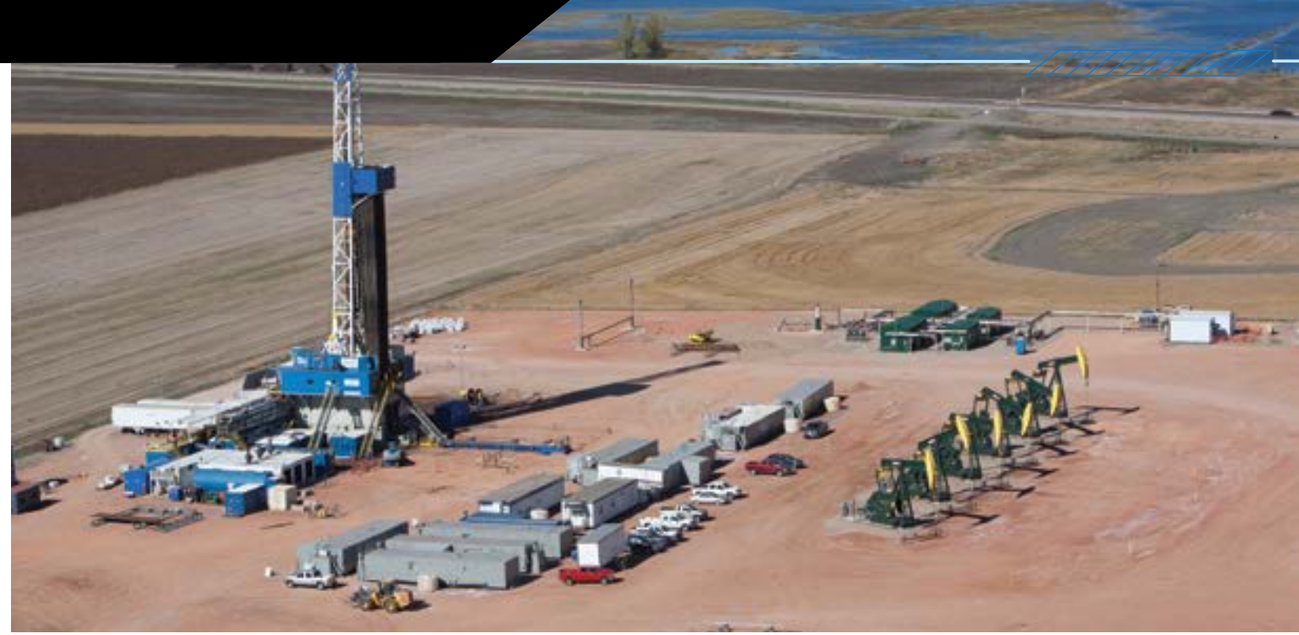


Basin Electric Transmission System Maintenance crew work on high-voltage power lines. Photo courtesy of Basin Electric Power Cooperative.

Source: North Dakota Transmission Authority



This map was created by the National Renewable Energy Laboratory for the US Department of Energy.



An aerial photograph shows a drilling pad with an oil rig and six producing wells. Photo courtesy of Vern Whitten Photography.

PETROLEUM PRODUCTION

■ In 2012, North Dakota surpassed both California and Alaska to become the second-largest oil producer in the nation, behind only Texas.

■ In April 2014, oil production surpassed 1 million barrels per day. (One barrel = 42 gallons).

■ The number of active drilling rigs in North Dakota has remained fairly steady over the past few years. In 2013, the average rig count was 185. More than 95 percent of the drilling takes place in the Bakken and Three Forks formations.

■ As of July 2014, there were 11,287 producing wells in the state. The North Dakota Department of Mineral Resources estimates that an additional 2,000 wells could be drilled every year for the next 20 years.

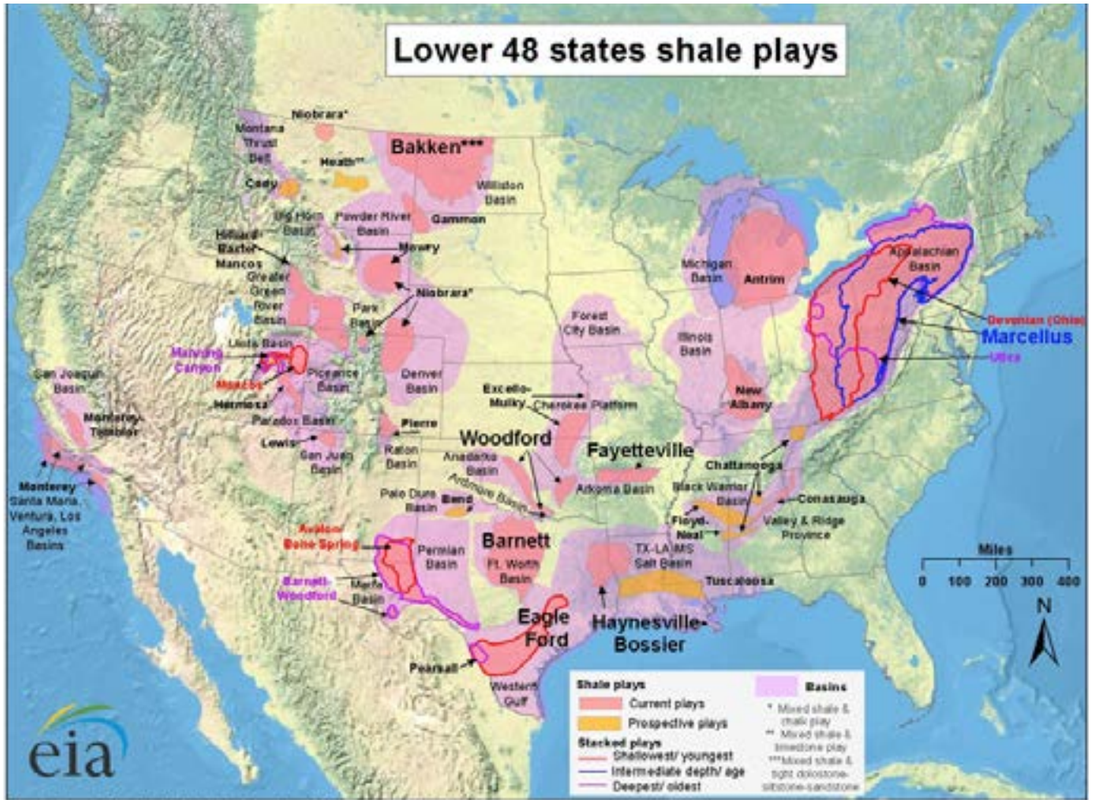
■ Oil companies are leaving less of a footprint than in the past because more wells can be added to existing sites, or pads, using extended reach horizontal drilling technology. As the above photo shows, six or more horizontally drilled wells can be placed on one existing pad and as many as 28 wells on some pads.

■ A typical 2013 North Dakota Bakken well will produce for 44 years. In those 44 years the average Bakken well will:

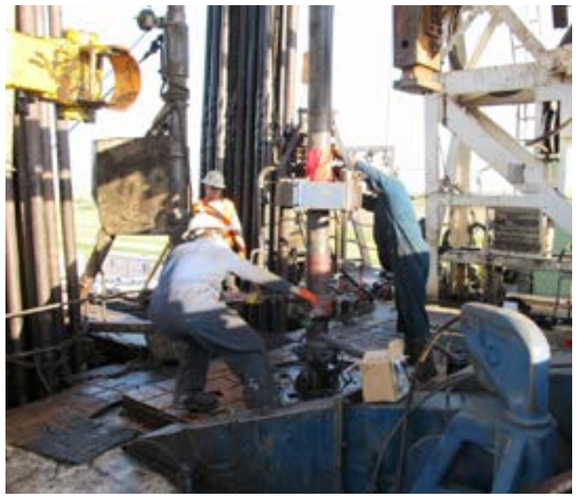
- ▹ Produce approximately 678,000 barrels of oil
- ▹ Generate about $20 million in net profit
- ▹ Pay approximately $5,339,000 in taxes
- ▹ Pay royalties of $7,845,000 to mineral owners
- ▹ Pay salaries and wages of $2,129,000
- ▹ Pay operating expenses of $2,602,000
- ▹ Cost $8,947,000 to drill and complete

■ North Dakota's first oil well began producing near Tioga in 1951. It was named Clarence Iverson #1 and produced more than 585,000 barrels of oil in 28 years.

Sources: ND Department of Mineral Resorces



Map courtesy of US Energy Information Administration.



Rig workers connect pieces of pipe for an 11,000-foot casing on an oil well (that is 2.1 miles!). "Casing" is a thick layer of steel pipe used to contain the oil or gas that is produced underground and brought to the surface. Bakken wells usually have three or four layers of casing. Photo courtesy of Wyoming Casing Service.

SHALE ENERGY TECHNOLOGIES

■ The Bakken shale was previously undeveloped because conventional drilling methods were not able to access the trapped oil and gas. Technological advances, including horizontal drilling and hydraulic fracturing (also called "fracking"), have made it possible for companies to economically drill for oil in the Bakken Formation.

■ Hydraulic fracturing is a process that has been used since the 1940s. It involves pumping a water-based fluid down the well under high pressure to create fissures in the dense shale rock.

■ The fluid carries with it some solids, usually clean quartz sand (and sometimes ceramic proppant) that props open the fissures allowing oil or gas to easily flow to the well. Some chemicals are also used to thicken the fluid to help suspend the shale, eliminate bacteria and build-up of scale, and protect the pipe and protective casing from corroding.

■ While hydraulic fracturing is important in the development of shale energy, it is horizontal drilling that has truly unlocked the Bakken.

■ Horizontal drilling is a highly advanced technology that allows companies to drill down two miles to the Bakken formation, turn at a 90-degree angle and drill horizontally for as far as four miles. In North Dakota, the typical horizontal leg is two miles.

■ Horizontal drilling allows operators to drill more wells from a single location, thereby accessing more of the energy resources in the Bakken using as much as 90 percent less surface area than traditional vertical drilling.

■ The development of a well will often take between three to five months, but a typical Bakken well will continue producing an average of 40 years, providing a valuable resource essential to energy needs as well as many products people use each day, including plastics, cosmetics, cleaning supplies, synthetic fibers for clothing, and more.

■ After a well has stopped producing, state law requires that the well be plugged with cement, the pipe cut off well below the surface and the land reclaimed to the way it was before.

Sources: North Dakota Petroleum Council

Graphic courtesy of North Dakota Petroleum Council, ND Department of Mineral Resources.

REFINING

■ Refining is the process of changing crude oil into useful products.

■ Tesoro Corporation's Mandan refinery was established in 1954 and employs 250 people in the Bismarck-Mandan area. The refinery has a crude oil processing capacity of 71,000 barrels per day. (1 barrel = 42 gallons)

■ The Tesoro Refinery refines oil into gasoline, diesel fuel, jet fuel, heavy fuel oils and liquefied petroleum gas.

■ The refined products are shipped by truck, rail, and pipeline to eastern North Dakota and Minnesota.

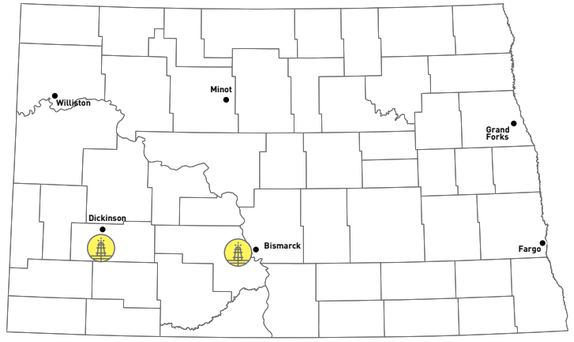
■ MDU Resources Group and Calumet Specialty Products Partners, LP, have built the first refinery in the United States since 1976. Dakota Prairie Refinery is located near Dickinson, ND, and will process up to 20,000 barrels per day of Bakken crude oil. The refinery will primarily produce diesel fuel and other specialty products.

■ Other, smaller refineries are under construction or are in the planning stages. These refineries will produce diesel fuel and other specialized products.

Sources: Tesoro Refinery, MHA Nation, MDU Resources Group, Inc., Dakota Oil Processing

A closer look at Tesoro's Mandan Refinery. Photo couresy of Tesoro Corporation.

Petroleum Refineries in North Dakota



NORTH DAKOTA TAXES

One of the benefits North Dakota is enjoying as a result of the oil boom comes from the increased revenue generated by taxes on the oil and gas industries within its borders. In 2013, the oil and gas production tax and the oil extraction tax totaled $2.9 billion, which was approximately 70 percent more than the prior year.

In 2010, North Dakota voters approved the creation of the "Legacy Fund," which receives 30 percent of the oil and gas production taxes. As of March 2014, the fund had $1.77 billion. Money from the Legacy Fund cannot be spent until 2017, and then only by a two-thirds majority vote of the legislature.

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

PIPELINES

■ The North Dakota Pipeline Authority was created in 2007 to assist in the development of pipeline facilities to transport energy-related commodities.

■ The United States has the largest network of pipelines in the world. There are close to 18,000 miles of these energy-related pipelines in North Dakota including:

- ▹13 crude oil pipelines
- ▹ 9 natural gas pipelines
- ▹ 4 products pipelines (gasoline, propane, and other refined products)
- ▹ 1 carbon dioxide pipeline

■ Additional pipeline projects to transport the increased oil and gas production in the state are in the planning stages.

Source: North Dakota Pipeline Authority

North Dakota Crude Oil Pipelines

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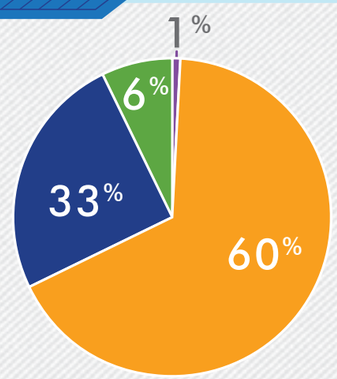
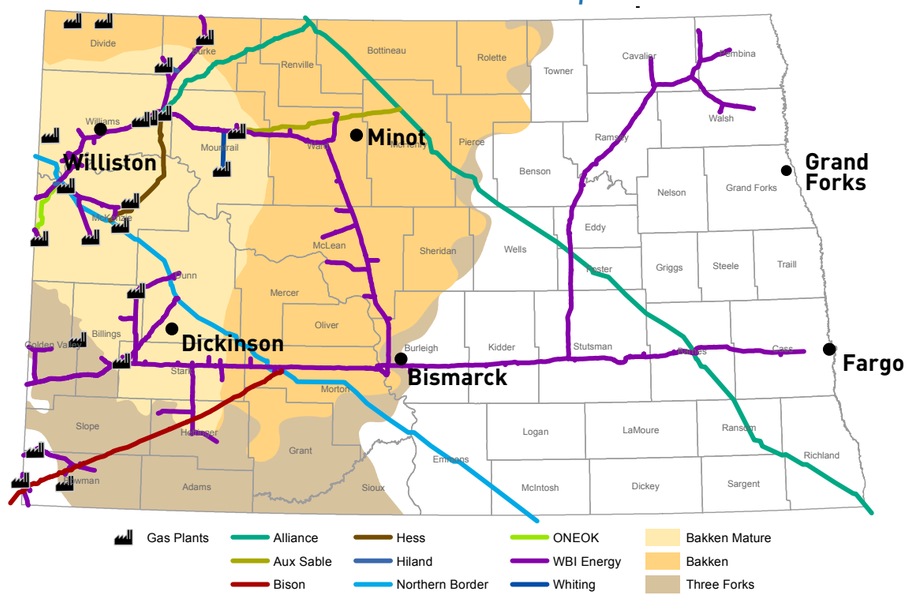


Transportation of Williston Basin Crude Oil

- Trucked to Canadian Pipelines
- Exported Out of State by Rail
- Exported Out of State by Pipeline
- Transported by Pipeline to Tesoro Refinery

As of July 2014. These percentages change rapidly depending on changes in regional oil prices.

North Dakota Natural Gas Pipelines



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SYNTHETIC NATURAL GAS

- The Great Plains Synfuels Plant, which is owned by the Dakota Gasification Company, is the only coal gasification plant in the United States that makes synthetic (artificial) natural gas from lignite coal.
- 160 million cubic feet of natural gas are produced daily.(A cubic foot is a cube that is one foot long, one foot high, and one foot wide.)
- The plant uses about 18,000 tons of lignite coal each day to produce the natural gas.
- The natural gas is shipped via pipeline to the eastern United States.
- Other products made at the Great Plains Synfuels plant are liquid nitrogen, anhydrous ammonia, and phenol. These products are sold throughout the United States as well as world wide.
- The Great Plains Synfuels Plant is the largest carbon sequestration project in the world.
- Carbon sequestration is the process of capturing carbon dioxide (CO_2), which is a by-product of burning fossil fuels. This captured CO_2 is then put into long-term storage. Carbon dioxide has been identified as a contributor to climate change. Sequestration has been proposed as a way to slow the accumulation of CO_2 in the atmosphere.

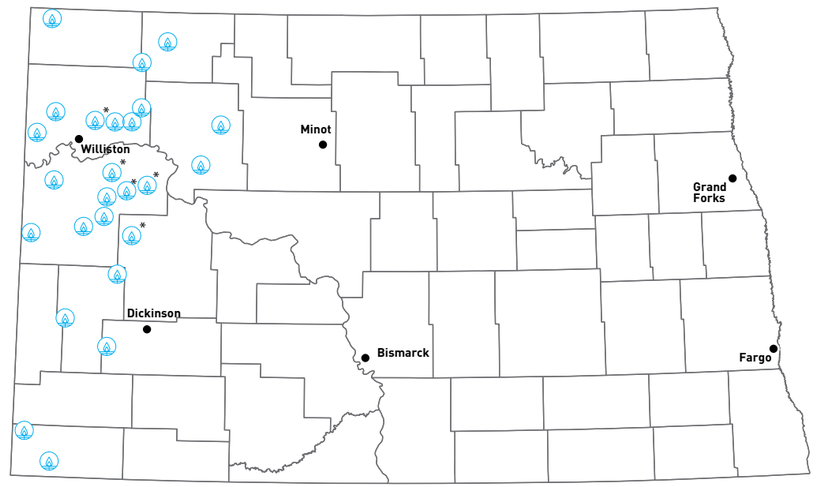
Source: Basin Electric Power Cooperative

NATURAL GAS PROCESSING

- A natural gas forecast estimates that North Dakota could be producing 2.0 to 2.4 billion cubic feet of natural gas each day by the late 2020s. In 2014, natural gas production was approximately 1.2 billion cubic feet per day.
- Most natural gas is found trapped deep underground along with petroleum deposits. When oil is removed from underground, natural gas also comes to the surface.
- Some of the natural gas is used to operate equipment at the well site, but most of the natural gas is transported to processing plants. At the plants, the natural gas is cleaned and separated into usable products such as propane or methane for heating, transportation fuels, and other uses. Natural gas is the cleanest burning fossil fuel.
- Not all of the natural gas can be captured and transported with current infrastructure. Extra gas that cannot be used will be flared, or burned, at the well site until sufficient infrastructure is built.
- The North Dakota Industrial Commission has set a series of goals to increase the amount of natural gas captured at a well site. Oil producers will be required to capture 90 percent of the gas by 2020.
- North Dakota currently has 22 natural gas processing plants operating in the western part of the state. More plants are in the planning stages of construction.
- Since 2010, the natural gas processing capacity in North Dakota has more than doubled.
- 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.
- Several new facilities that will add value to North Dakota's liquid rich natural gas are now being constructed. The processes will produce fertilizer for farmers, liquefied natural gas that can be used to replace or supplement diesel fuel, and potentially many other commodities in the future.

Sources: North Dakota Pipeline Authority, ND Department of Mineral Resources

Natural Gas Processing Plants in North Dakota



**Under Construction*

The ethanol plant near Hankinson uses approximately 46 million bushels of corn annually. Photo courtesy of Hankinson Renewable Energy.

ETHANOL

■ Ethanol is an alternative vehicle fuel made from grains such as corn, barley, or wheat. Ethanol is blended with regular gasoline to create a fuel that has lower emissions. It also reduces the need to import oil from other countries.

■ North Dakota has four operating ethanol plants and one under construction. Together they produce nearly 440 million gallons per year.

■ Approximately 160 million bushels of corn are used annually to produce the ethanol. Eighty percent of the corn is purchased from North Dakota farmers.

■ In a modern ethanol facility, one bushel of corn produces 2.8 gallons of ethanol, 18 pounds of livestock feed, and 18 pounds of carbon dioxide.

■ Approximately 9 percent of the ethanol produced in North Dakota is blended with gasoline and sold within the state. The remaining 91 percent is shipped to the East and West coasts.

■ The state's ethanol industry employs nearly 200 workers across the state. The average wage for ethanol workers is $64,000 a year.

■ Nearly all vehicles can use a fuel that is a blend of 10 percent ethanol and 90 percent regular gasoline. Vehicles made after 2001 can use a blend of 15 percent ethanol and 85 percent gasoline. There are also flex fuel vehicles that can use blends of up to 85 percent ethanol and 15 percent regular gas.

Source: North Dakota Ethanol Council

North Dakota has five ethanol production plants.

Plant	*Location*	*Employees*	*Ethanol Capacity (million gallons)*	*Corn Used (million bushels)*	*Animal Feed (tons)*
Blue Flint Ethanol	Underwood	40	65	23	190,000
Hankinson Renewable Energy, LLC	Hankinson	51	130	45	395,000
Red Trail Energy, LLC	Richardton	42	50	18	110,000
Tharaldson Ethanol	Casselton	54	130	50	395,000
Dakota Spirit AgEnergy*	Spiritwood	40	65	23	190,000
TOTAL:		227	440	159	1.28 million

**Under Construction*

Source: North Dakota Ethanol Council

BIOMASS/ BIOFUELS/ BIODIESEL

■ Biomass includes all plant and animal matter, including wood waste, energy crops (crops grown specifically for biomass use), crop residues, and other forms of organic waste. Corn used to produce ethanol is an example of using biomass for fuel production.

■ Research teams at North Dakota State University and the U.S. Department of Agriculture are exploring ways to use specialized sugar beets to produce biofuels. Just as livestock feed is also produced during ethanol production, other usable products could be created from this use of sugar beets.

■ Harvested biomass can be used to generate various forms of energy such as heat, electricity, and biofuels such as ethanol.

Oil from canola is used to produce biofuels.

■ Great River Energy is planning a biofuels plant near their ethanol facility in Spiritwood. This facility would use forms of biomass other than field corn to produce fuel.

■ Biodiesel is a fuel similar to petroleum diesel but with fewer emissions.

- Biodiesel can be blended with regular diesel and used in many different concentrations. The most common biodiesel blend is B20 (20 percent biodiesel, 80 percent petroleum diesel).

- Diesel and biodiesel fuels are used mainly in large vehicles and equipment including trucks, buses, and construction machinery.

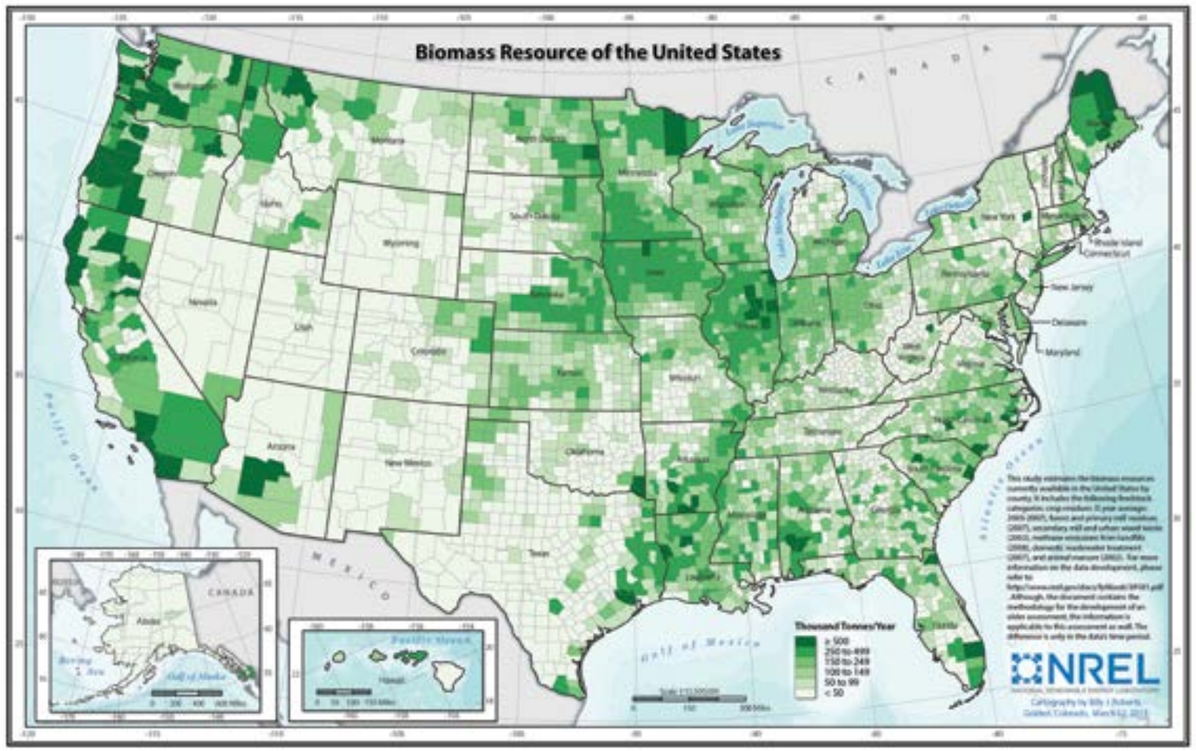
- North Dakota's only biodiesel production facility is located near Velva. The Archer Daniels Midland (ADM) plant has the capacity to produce 85 million gallons of biodiesel per year. The facility is currently producing biodiesel fuel made with canola oil. Most of this biodiesel fuel is exported to other states and to Canada.

- Other uses for biomass include:

  - Using sunflower shells, railroad ties, and other forms of biomass as boiler fuel and to generate a portion of the electricity needed at the ADM sunflower processing plant at Enderlin.

  - Using wood chips as heating fuel at the Bismarck State College Aquatic and Wellness Center and at the Bismarck City Household Hazardous Waste and Electronics Recycling building. The City of Bismarck operates a wood chipper at its landfill to process the wood waste it receives. These wood chips are provided to both buildings. Together the two buildings use approximately 1,500 tons of wood chips a year.

Sources: Great River Energy, ARS Northern Great Plains Research Laboratory, BeetsAll Biofuel, Clean Cities (DOE)



The darker color on the map indicates a greater amount of available biomass. This map was created by the National Renewable Energy Laboratory for the US Department of Energy.

Compact fluorescent bulbs last six to ten times longer than regular bulbs.

ENERGY EFFICIENCY

- The Alliance to Save Energy is a national organization that promotes energy efficiency programs and technology. This agency defines energy efficiency as allowing us to do more while using less energy. This organization states that "…without the energy-efficiency improvements that have taken place since 1973, we would need 55 percent more energy supplies than we use now."

- Examples of energy efficiency:

  - Insulating the walls and attic of a home will reduce the amount of heating and cooling needed to maintain a comfortable temperature.

  - Lighting with compact fluorescent light bulbs (CFLs), halogen incandescent bulbs, and light emitting diodes (LED) use less energy than a regular incandescent light bulb.

  - Because of energy efficiency improvements to vehicle engines, today's cars are able to drive much farther on the same amount of fuel that they were able to just a few years ago.

Insulating homes and buildings can make them much more energy efficient.

- The North Dakota Department of Commerce has an office of Renewable Energy and Efficiency that promotes efficiency activities within the state.

- North Dakota participates in the US Department of Energy (DOE) Weatherization Assistance programs, which provide energy efficiency improvements to homes occupied by income-eligible families.

- Homeowners participating in the North Dakota Weatherization Assistance Program achieve an average of 17 to 25 percent lower energy costs.

- Grants are available for energy efficiency projects in public buildings. Energy audits recommend improvements to reduce energy use and costs in these buildings.

- There are various national programs that recognize buildings for exceptional design and/or improvements in energy efficiency. One of these is the ENERGY STAR program, which is a joint program of the US Environmental Protection Agency and the US Department of Energy. The goal of the ENERGY STAR program is to save money and to protect the environment through the use of energy efficient products and practices.

  - In North Dakota, more than 700 buildings have been recognized as ENERGY STAR buildings. Many products, ranging from light bulbs to refrigerators and computers, also receive ENERGY STAR ratings.

Sources: North Dakota Department of Commerce, ENERGY STAR, Alliance to Save Energy

Students learning about the solar array on location at Bismarck State College National Energy Center of Excellence. Photo courtesy of Bismarck State College.

EDUCATION/WORKFORCE TRAINING

Many workers are needed for North Dakota's existing and growing energy industries, including oil and gas production, wind energy, lignite coal-fired power plants and mining operations, ethanol plants, and others. North Dakota colleges offer several excellent technical programs, four-year degrees and post-graduate degree programs related to employment with the state's energy industries.

- The North Dakota Department of Mineral Resources estimates that an average of 2,000 oil wells a year will be drilled for the next 20 years or so. One new well initially creates about three jobs, but over the life of the well, that number decreases to one job per well. North Dakota should see a high of about 70,000 oil-related jobs near 2030, with about 45,000 to 50,000 of those jobs being long-term.

- In June 2013, there were an estimated 30,692 workers in direct or support positions for the industries of oil and gas extraction, coal mining, utilities, and pipeline transportation. These jobs had an estimated yearly wage of approximately $95,000, which is well above the pay of many other jobs in the state. There are also additional jobs and wages for businesses that support these energy industries, including truck driving, construction, engineering, manufacturing and repair services.

- During 2013, North Dakota had an average of 20,155 job openings per month, many of them related to energy industries. The 17 oil and gas producing counties in western North Dakota accounted for slightly over one-third of the state's job openings.

- North Dakota colleges and universities have a variety of energy programs. A few of the colleges providing energy programs are summarized below:

  - Bismarck State College (BSC) is home to the National Energy Center of Excellence (NECE), which provides many nationally recognized energy industry education and training programs in fields such as power plant, process plant, instrumentation and control, electric power, lineworker, renewable energy generation, petroleum production, maintenance and more. The Great Plains Energy Corridor is also located at BSC.

  - The University of North Dakota in Grand Forks includes the Harold Hamm School of Geology and Geological Engineering and offers petroleum and other engineering programs.

  - A wind energy technician program is offered by Lake Region State College in Devils Lake. Students enrolled in the Lake Region program are able to train on a 1.6 MW wind turbine located near campus.

  - North Dakota State University in Fargo has a number of engineering programs and geology. NDSU also provides Extension Services and the Department of Agribusiness and Applied Economics, which includes biomass and biofuels.

EDUCATION/WORKFORCE TRAINING

North Dakota colleges provide opportunity for students to pursue great careers in the energy industry.

▹ The Energy & Environmental Research Center at the University of North Dakota in Grand Forks is a world-class research, development, demonstration and commercialization facility. Research programs include coal utilization technologies, hydrogen technology, renewable energy and biomass utilization, emission controls, carbon capture and storage, alternative fuels, and oil and gas.

▹ Minot State University offers a degree in energy economics and finance, which prepares graduates for careers such as business and financial analysts, energy economists, and more.

▹ Williston State College offers a variety of programs, including petroleum production, welding technology and diesel technology.

▹ North Dakota State College of Science offers diesel, welding and electrical programs.

▹ For more information on North Dakota colleges and energy programs, visit the "Careers in Energy" page in the *Energy: Powered by North Dakota* web curriculum at **www.ndstudies.gov.**

■ The Bismarck Public Schools Career Academy and the Missouri River Area Career and Technology Center offer dual credit and regular high school classes which introduce students to energy careers.

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