2006 Natural Gas Production in North Dakota

By Fred J. Anderson and Lynn D. Helms

Introduction

North Dakota produced nearly 63 billion cubic feet (bcf) of natural gas in 2006, which amounts to approximately 2.2% of total U.S. Production (fig. 1).

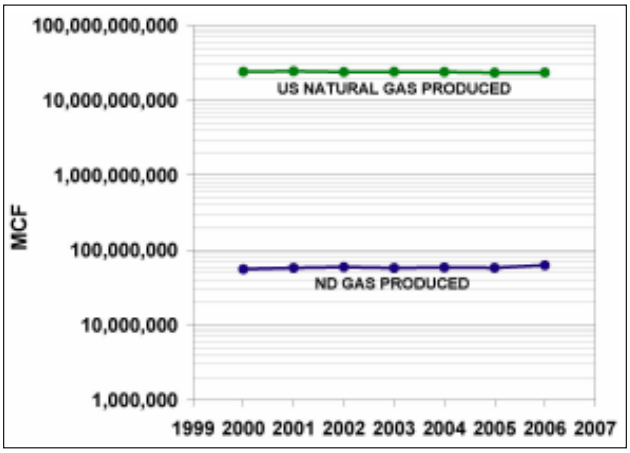

Figure 1. Historical U.S. and ND gas production from 2000 to 2006. Data from the EIA (2006) and ND Oil & Gas Division (2007).

Natural gas is currently being produced from 28 different formation (or equivalent) intervals in the North Dakota portions of the Williston Basin. These formation intervals range in age from the Cambrian to the Cretaceous, with the bulk of production, just over 41%, coming from Mississippian age units that are within the age range of 330 to 365 million years old (Ma) (Table 1).

2006 North Dakota Gas Production by Geologic Formation

Geologic Age (Period)	Formation	MCF Produced	Percent	MCF Sold	Percent	Wells
CRETACEOUS	PIERRE	3,723,407.00	5.93	3,723,407.00	6.93	163
	Subtotal	3,723,407.00				
TRIASSIC	SPEARFISH/CHARLES	44,743.00	0.07	-	0.00	91
	SPEARFISH/MADISON	61.00	0.00	-	0.00	3
	Subtotal	44,804.00				
PERMIAN/ PENNSYLVANIAN	MINNELUSA (NITROGEN)	52,396.00	0.08	52,396.00	0.10	1
	TYLER	38,957.00	0.06	-	0.00	26
	TYLER A	1,218.00	0.00	-	0.00	4
	Subtotal	92,571.00				
MISSISSIPPIAN	HEATH	44,165.00	0.07	26,169.00	0.05	25
	MADISON	24,518,390.00	39.05	22,878,169.00	42.58	1516
	MISSION CANYON	9,735.00	0.02	9,457.00	0.02	1
	LODGEPOLE	881,470.00	1.40	857,185.00	1.60	30
	RATCLIFFE	34,742.00	0.06	21,626.00	0.04	4
	MIDALE/NESSON	287,380.00	0.46	209,482.00	0.39	28
	Subtotal	25,775,882.00				
DEVONIAN	BAKKEN	3,124,126.00	4.98	2,445,217.00	4.55	271
	SANISH	189,078.00	0.30	188,302.00	0.35	11
	BIRDBEAR	1,629,646.00	2.60		2.45	105
	DEVONIAN	1,072,774.00	1.71	1,065,318.00	1.98	56
	DUPEROW	886,692.00	1.41	707,794.00	1.32	110
	DAWSON BAY	86,064.00	0.14	86,064.00	0.16	3
	WINNIPEGOSIS	219,073.00	0.35	200,630.00	0.37	17
	Subtotal	7,207,453.00				
SILURIAN	SILURIAN	3,213,677.00	5.12	3,198,395.00	5.95	53
	Subtotal	3,213,677.00				
ORDOVICIAN	STONEWALL	1,806,130.00	2.88	1,776,310.00	3.31	51
	GUNTON	2,685.00	0.00	-	0.00	1
	RED RIVER	7,971,894.00	12.70	6,138,231.00	11.42	196
	ORDOVICIAN	6,407,097.00	10.21	4,609,150.00	8.58	54
	RED RIVER B	4,768,551.00	7.60	2,409,380.00	4.48	266
	WINNIPEG	169.00	0.00	169.00	0.00	1
	Subtotal	20,956,526.00				
CAMBRIAN	CAMBRO/ORDOVICIAN	7,033.00	0.01	-	0.00	2
	WINNIPEG/DEADWOOD	1,761,846.00	2.81	1,811,846.00	3.37	5
	Subtotal	1,768,879.00				
	2006 ND Totals	123,797,519.00	100.00	52,414,697.00	100.00	3094

Gas Production by Geologic Formation

It is important to understand that 68% of the Natural gas produced in North Dakota is "associated gas", produced along with crude oil. The remaining 32% is "non-associated gas", gas that is produced entirely on its own (fig. 2).

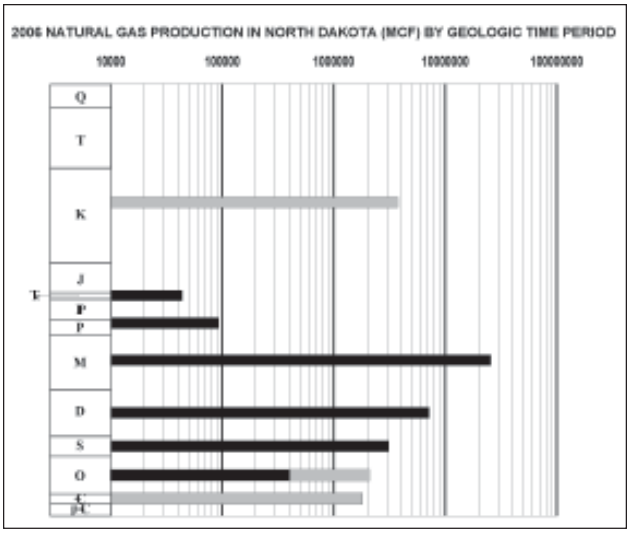

Figure 2. North Dakota natural gas production in 2006 by geologic time period. Gas production (MCF) plotted on a horizontal logarithmic scale in order to visually depict the relative and absolute contributions of the gas producing intervals in the state. Black bars show *associated gas* produced. Gray bars show *non-associated gas*.

Natural gas production in the state comes mostly from Paleozoic-age units in the Williston Basin. Mississippian age units have the greatest production - well over half of all production at 59%. Production from Devonian age units follows the Mississippian units at 16%. The remaining units, comprised of Cretaceous, Silurian, Ordovician, Cambrian, Permian/Pennsylvanian, and Triassic age units, listed in order of decreasing production, contribute the remaining 25% of gas production with all remaining units producing less than 10%, with production from the Permian/Pennsylvanian and Triassic units being well below one percent of total production.

Associated gas production comes from the Mississippian, Devonian, Silurian, Permian/

Table 1. Production figures for natural gas in North Dakota by geologic formation. Each of the formation intervals has been grouped according to its respective geologic age (i.e. geologic time period) for purposes of discussion.

Pennsylvanian, and Triassic age units. Non-associated gas is produced from Cretaceous, Ordovician (20% being associated gas) and Cambrian age units.

Gas Production and Price

Historically, gas production in North Dakota has followed a slightly decreasing trend since historic highs in 1985 of well over 6.5 million MCF to a low of just over 4 million MCF per month in the late 1990's. The price of natural gas has increased over time with the most dramatic increase occurring over the last six years from a low of around $2 per MCF to just over $7.50 per MCF in late 2006 (fig. 3). Generally speaking, the price of natural gas tends to mirror the price of oil over time, but can be influenced by acute demands, such as production losses from natural catastrophes like Hurricane Katrina, or atypical seasonal conditions (extremely cold winters of long duration, for example) that may occur in the northern and eastern states.

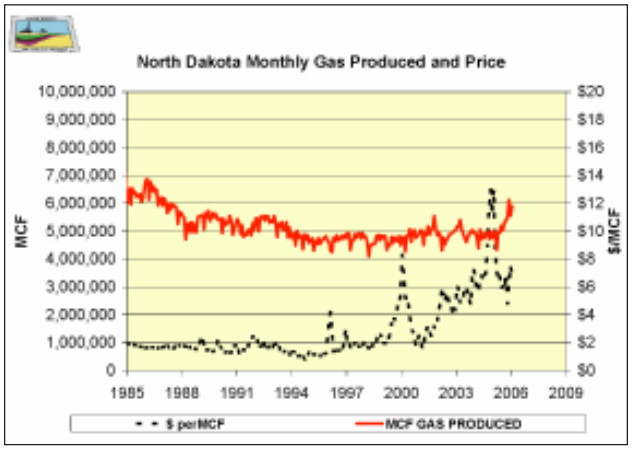

Figure 3. Gas production in North Dakota (MCF) vs the price of natural gas per MCF since 1985. Overall gas production in the state has shown a gradual decreasing trend from the "boom" years of the mid-1980's, but has recently shown an increase in production. Price per MCF of gas remained steady under $2 per MCF from 1985 to the late 1990's and began to climb, with several cost peaks occurring, to its present value near $8 per MCF (Data and graph from ND Oil & Gas Division, 2007).

County Gas Production

The majority of gas produced in North Dakota since 1990, nearly 73 %, is produced from wells in three counties in western North Dakota: McKenzie, Williams, and Billings counties, with production ranging from around 309 to 128 bcf (fig 4). The next five counties (listed in order of decreasing production): Bowman, Divide, Burke, Dunn, Stark, and Mountrail counties produce gas in the tens of millions of MCF from around 27 million MCF in Mountrail County to nearly 79 million MCF in Bowman County which make up around 25% of production. Gas production in the next five counties (listed again in order of decreasing production): Golden Valley, Renville, Bottineau, Slope, and McLean, produce gas in the range of 1.6 million MCF in McLean County to just over seven million MCF in Golden Valley County. Production from these counties accounts for around 1.8% of total gas production. The remaining gas producing counties of Ward, Renville, and Hettinger counties contribute less than one percent of the state's total gas production. Wells in Ward County, for example, have produced around 682 thousand MCF of gas.

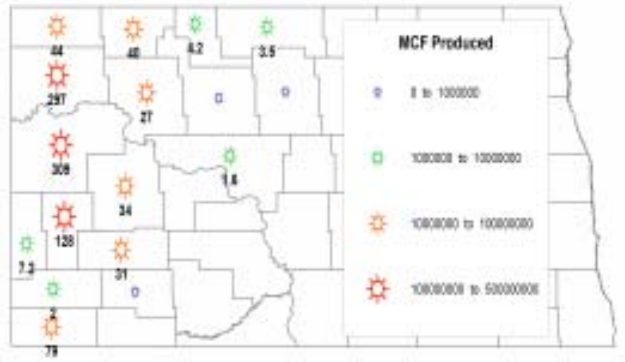

Figure 4. Map showing the amount of cumulative natural gas production by county since 1990. Values shown are reported as bcf.

Shallow Gas Production

Natural gas produced from formations of Cretaceous age and younger is defined as shallow gas production (fig. 5). In North Dakota, the term "shallow gas" is very specific and due to the configuration the Williston Basin, is precisely defined in the North Dakota Century Code.

Definition of Shallow Gas in North Dakota:

"Gas that is produced from a shallow gas zone, where shallow gas zone is defined as a strata or formation, including lignite or coal strata or seam, located above the depth of five thousand feet (1,524 meters) below the surface, or located more than five thousand feet (1,524 meters) below the surface but above the top of the Rierdon Formation, from which gas may be produced."

North Dakota Century Code

Currently, all shallow gas production in ND is from the more sandy permeable zones (Eagle Sand equivalent) of the Cretaceous Pierre Formation, coincident with the Cedar Creek Anticline, in southwestern North Dakota in Bowman County. Total shallow gas production, of around 3.7 million MCF, roughly 8% of total 2006 production, was from these Cretaceous age units.

It is likely that shallow gas production will continue to increase in North Dakota as more effective exploration techniques and technologies are developed in addition to alternative business models which help to drive natural gas exploration and production. Since 2002, shallow gas

production has been on the rise, increasing nearly 100% in each successive year, from a historic low of just over 25,000 MCF per month to nearly 350,000 MCF per month (fig. 6). Much of this increased production is related to the contemporaneous increase in the number of producing infill wells drilled in current shallow gas producing pools which have increased from 26 in 2002 to well over 150 in 2006. Shallow gas production from younger Cretaceous strata and ultra-shallow Quaternary-age sediments has yet to be realized but is currently being explored.

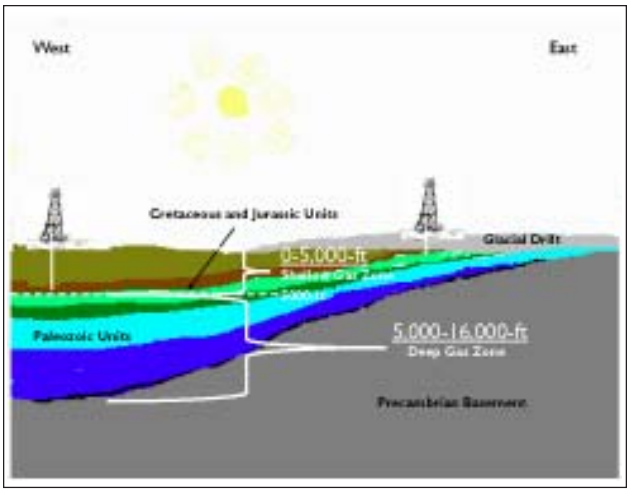

Figure 5. Generalized diagrammatic sketch of the architecture of geologic strata in the subsurface of North Dakota from west to east showing the relative relationship of shallow gas and deep gas producing zones and stratigraphic depths in the Williston Basin.

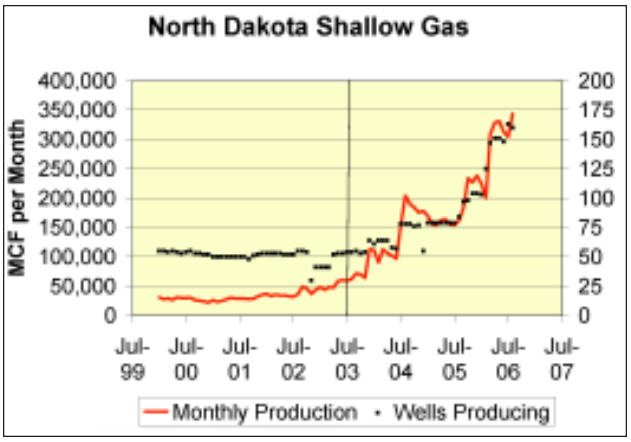

Figure 6. Graph of monthly shallow gas production (solid gray line) plotted with the number of wells producing (dotted black line) since the summer of 1999 in North Dakota. An increasing trend, beginning in 2002 can be seen (Data and Graph from ND Oil & Gas Division, 2007).

Common Units and Equivelancies of Natural Gas Measurement

Dekatherm = 1,000,000 Btu or the energy equivelant of 1,000 ft^3 of gas.

1 cubic foot (cf) = 1,027 Btu

100 cubic feet (1 ccf) = 1 therm (approximate)

1,000 cubic feet (1 Mcf) = 1,027,000 Btu (1 MMBtu)

1,000 cubic feet (1 Mcf) = 1 dekatherm (10 therms)

1 million (1,000,000) cubic feet (1 Mmcf) = 1,027,000,000 Btu

1 billion (1,000,000,000 cubic feet (1 bcf) = 1.027 trillion Btu

1 trillion (1,000,000,000,000) cubic feet (1Tcf) = 1.027 quadrillion Btu

1,000 cubic feet of natural gas meets the natural gas needs of an average home (space-heating, water-heating, cooking, etc.) for four days.

In 2004, the average American home consumed 77,900 cubic feet of natural gas (or 77.9 million Btu). On a daily basis, the average U.S. home used 213 cubic feet of natural gas

(American Gas Association, 2006)

Natural Gas Related Terms in Common Usage

Natural Gas – A mixture of hydrocarbons and varying quantities of nonhydrocarbons that exists either in the gaseous phase or in solution with crude oil in natural underground reservoirs. Natural gas is most commonly odorless, but may be associated with hydrogen sulfide (H_2S) in the natural environment or methyl mercaptan (CH_3SH), which is artificially added to commercial natural gas, to provide an easily recognizable odor.

Hydrocarbons – Chemical compounds consisting of carbon and hydrogen ranging in states from gas to solids that make up the consumable energy resource products of petroleum and natural gas.

Methane – The primary constituent of natural gas; colorless and odorless, chemically composed of one carbon and four hydrogen atoms (CH_4) that forms from either: the earth's mantle, the thermal maturation of organic matter, or the bacterial degradation of organic matter in the shallow subsurface.

Shallow Gas – Natural gas that is produced from shallow gas reservoirs and sediments typically of Cretaceous age and younger in North Dakota that range in depth from zero to 5,000 feet.

Biogenic Gas – Gas that is produced from biological processes, typically at shallow depths and lower temperatures, by the bacterial degradation of organic matter in the subsurface.

Thermogenic Gas – Gas that is produced from thermal maturation processes, typically at deeper depths and at higher relative temperatures.

Deep Gas – Natural gas that is produced from deeper gas reservoirs typically of Jurassic age or older in North Dakota that can range in depth from 5,000 to 16,000 feet.

Conventional Gas – Natural gas commonly produced during traditional oil and gas production from relatively deep reservoirs using common assessment, drilling, and production technologies.

Unconventional Gas – Natural gas generated within and produced from non-traditional systems, using non-traditional techniques and technologies for assessment, drilling, and production; includes, shale gas, coal-bed methane or coal gas, and biogenic gas, as well as gas produced from anthropogenic sources such as landfill gas or methane.

Coal Gas or Coal-Bed Methane – Natural gas consisting primarily of methane generated and produced from within buried coal seams by the destructive distillation of coal *in-situ*.

Associated Gas – Gas produced along with oil; can also be described as gas that is in contact with crude oil within a reservoir or as gas cap gas.

Non-Associated Gas – Gas produced from reservoirs that contain little oil.

Dry Gas – Gas composed nearly entirely of methane.

Wet Gas – Gas containing a condensate fraction of the simple hydrocarbon compounds (ethane, propane, and butane) of the alkane series.

Sweet Gas - Gas containing small relative amounts of hydrogen sulfide (H_2S).

Sour Gas – Gas containing large relative amounts of hydrogen sulfide (H_2S).

Dekatherm – Unit of natural gas measurement that measures the energy content of natural gas as related to residential consumption. Based on both the quantity and quality of natural gas used. Equal to 1,000,000 Btu or the energy equivalent of 1,000 cubic feet of gas.

Btu – British Thermal Unit; measure of the ability of a natural gas to produce heat; specifically defined as the amount of heat required to raise one pound of water one degree Fahrenheit.

Mcf – Thousand Cubic Feet of gas; Measure of gas volume in common usage in the U.S. as measured at standard conditions of temperature and pressure (60°F and 14.73 psi).

Bcf – Billion Cubic Feet of gas; Measure of gas volume in common usage in the U.S. and North America, typically used when communicating large producing volumes of natural gas resources of major producing regions or countries.

m^3 – Cubic Meters of gas. Measure of gas volume in common usage in the Canadian provinces and Europe.

Tcf – Trillion Cubic Feet of gas. Measure of gas volume commonly used to express extremely large volumes of gas produced or as assessed gas resources.

Selected References

AGA, 2006 Natural Gas Quick Facts, American Gas Association, www.aga.org

EIA, 2006, 2006 Natural Gas Production Statistics, Energy Information Administration Website, http://www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html

ND Oil & Gas Division, 2007, North Dakota Drilling and Production Statistics, North Dakota Oil & Gas Division Website, https://www.dmr.nd.gov/oilgas/stats/statisticsvw.asp

Shelley, R.C., 1998, Elements of Petroleum Geology, 2nd ed., Academic Press, 470p.