EXPLODING THE NATURAL GAS SUPPLY MYTH

COLD, HUNGRY AND IN THE DARK

BILL POWERS

FOREWORD BY ART BERMAN

Commonly Used Abbreviations

bbl	barrel
bbl/d	barrels per day
boe	barrels of oil equivalent
boe/d	barrels of oil equivalent per day
bop/d	barrels of oil per day
mboe	thousand barrels of oil equivalent
mcf	thousand cubic feet
mcf/d	thousand cubic feet per day
mmcf	million cubic feet
mmcf/d	million cubic feet per day
bcf	billion cubic feet
bcf/d	billion cubic feet per day
tcf	trillion cubic feet
6:1	boe conversion ratio of six mcf to one bbl

TABLE 1.01. Total curtailment volumes of interstate pipelines.

Year (April 1 to March 31)	Curtailment (tcf)	Approximate percentage of total consumption
1971–72	.48	2.18%
1972–73	.82	3.17%
1973–74	1.19	5.50%
1974–75	2.01	9.86%
1975–76	2.92*	14.79%

Source: Congressional Board, Office of Technology Assessment document, EIA.
* Projected.

Our country's gas supplies:

What the gas industry is doing to be sure your home has enough gas.

The gas supplies are there. The problem is getting at them. Today our country faces a growing need for all types of energy, including gas. Our continent has gas. Huge reserves of it. But much of it is deep down. Hard to get at. Some of it is under water. And there have been important new discoveries in the far-off Arctic. It's going to take time and money to make additional gas available.

There's no worry your home will run out of gas. In some areas, the amount of additional natural gas to large-scale industrial users is limited. But wherever there is any problem, gas companies are giving top priority to their residential customers. We've been serving you for a hundred years – and we don't intend to stop now.

The gas industry is drilling, piping, importing, researching to increase the gas supply. The gas industry and government are working together on an accelerated research program to convert coal into clean-burning gas. The gas industry is piping in gas from Canada and importing liquefied natural gas from overseas.

It will take higher prices to keep gas coming. For years gas prices at the wellhead have been kept artificially low – while drilling and other costs have skyrocketed. Recently more realistic price levels have been approved to get the huge job of exploration and drilling done. The higher costs incurred will mean somewhat higher prices to you, but gas will still remain more economical comparatively than other forms of energy. And it's worth more to keep this essential energy coming.

It make sense to save clean gas energy. Nowadays we all know we should use our natural resources wisely. There are many things we can do to save natural gas – like weatherproofing our homes and not wasting gas when we cook. Saving gas makes sense even after new supplies become available. Gas is clean energy – a pure, natural energy that doesn't foul the air we breathe. It's going to be important in giving us a cleaner world to live in. Natural gas is valuable. Use it wisely.

Gas, clean energy of the future

AMERICAN GAS ASSOCIATION

FIGURE 1.01. American Gas Association advertisement, *Life* magazine, October 22, 1971.

TABLE 1.02. Marketed US natural gas production and average wellhead price.[24]

Year	Marketed US natural gas production in tcf	Average wellhead price per mcf
1968	19.32	$.16
1969	20.69	$.17
1970	21.92	$.17
1971	22.49	$.18
1972	22.53	$.19
1973	22.64	$.22
1974	21.60	$.30
1975	20.10	$.44
1976	19.95	$.58
1977	20.02	$.79
1978	19.97	$.91

Source: eia.doe.gov/dnav/ng/hist/n9050us2a.htm, eia.gov/dnav/ng/hist/n9190us3A.htm.

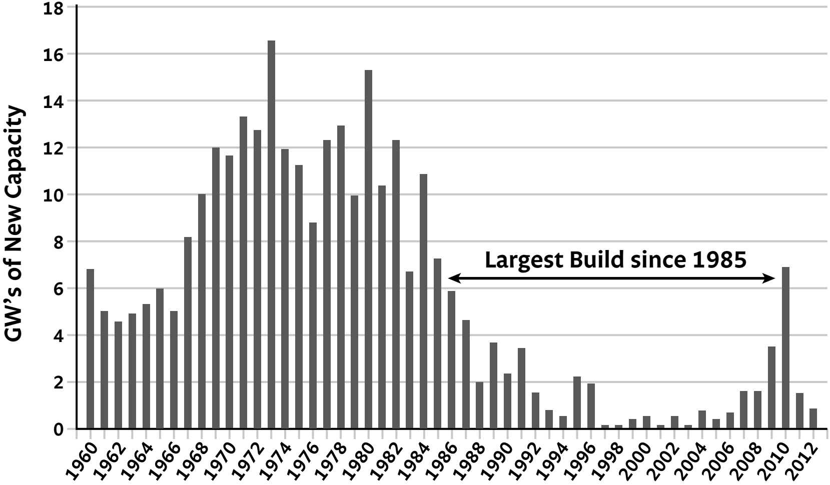


FIGURE 1.02. Last 50 years of new coal capacity

TABLE 1.03. 1970s Electricity Generation by Fuel Type in Billion Kilowatt Hours.

Year	Natural gas	Coal	Petroleum	Nuclear	All sources
1970	372.9	704.4	184.2	21.8	1,535.1
1971	374.0	713.1	220.2	38.1	1,615.9
1972	375.7	771.1	274.3	54.1	1,753.0
1973	340.9	847.7	314.3	83.5	1,864.1
1974	320.1	828.4	300.9	114.0	1,870.3
1975	299.8	852.8	289.1	172.5	1,920.8
1976	294.6	944.4	320.0	191.1	2,040.9
1977	305.5	985.2	358.2	250.9	2,127.4
1978	305.4	975.7	365.1	276.4	2,209.4
1979	329.5	1,075.0	303.5	255.2	2,250.7
1980	346.2	1,161.6	246.0	251.1	2,289.6

Source: EIA eia.doe.gov/emeu/aer/pdf/pages/sec8_8.pdf.

The Department of the TREASURY NEWS

BUREAU OF THE MINT WASH., D.C. 20220 · W04-5011

FOR IMMEDIATE RELEASE JANUARY 28, 1977

MINT FACILITIES TO CURTAIL USE OF NATURAL GAS

Deputy Director of the Mint Frank H. MacDonald announced today that in accordance with requests from the States of Pennsylvania and New York, the U. S. Mint at Philadelphia and the New York Assay Office will stop using natural gas in their production operations effective immediately.

The Mint facilities, like other industrial operations, have been asked to reduce consumption of natural gas to the lowest possible levels without causing irreparable damage to equipment. The curtailed usage will last for the duration of the natural gas crisis.

Affected operations will include die manufacturing and coin production in Philadelphia and all melting operations involving natural gas at the New York Assay Office. However, the two facilities will continue to work from inventories during the crisis period.

FIGURE 1.03: Letter from the US Mint.

TABLE 2.01. Average US Natural Gas Price and Annual Production 1979–1984.[1]

Year	Wellhead price of NG (mcf)	Marketed NG production (tcf)
1979	$1.18	20,471
1980	$1.59	20,179
1981	$1.98	19,955
1982	$2.46	18,711
1983	$2.59	16,884
1984	$2.66	18,304

Source: Energy Information Agency.

TABLE 2.02. Natural Gas Consumption in Decade after Passage of the NGPA (in tcf).[8]

Year	Residential	Commercial	Industrial	Elecricity generation	Total	GDP growth
1978	4,903	2,601	8,405	3,188	19,627	5.6%
1979	4,965	2,786	8,398	3,491	20,241	3.1%
1980	4,752	2,611	8,198	3,682	19,877	–0.3%
1981	4,546	2,520	8,055	3,640	19,404	2.5%
1982	4,633	2,606	6,941	3,226	18,001	–1.9%
1983	4,381	2,433	6,621	2,911	16,835	4.5%
1984	4,555	2,524	7,231	3,111	17,951	7.2%
1985	4,433	2,432	6,867	3,044	17,281	4.1%
1986	4,314	2,318	6,502	2,602	16,221	3.5%
1987	4,315	2,430	7,103	2,844	17,211	3.2%

Source: US EIA and US Department of Commerce/BEA.

TABLE 3.01. US Supply, Ave. Price, US Rig Counts and Active US Natural Gas Wells (1985–2000).[7]

Year	Marketed US production in Tcf	Canadian imports in Tcf	Average price per mcf in USD	Average US natural gas rig count	Active US natural gas wells
1985	17.27	.926	$2.51	NA	NA
1986	16.86	.749	$1.94	NA	NA
1987	17.43	.993	$1.67	NA	NA
1988	17.92	1.276	$1.69	354	NA
1989	18.10	1.339	$1.69	404	262,483
1990	18.59	1.448	$1.71	463	269,790
1991	18.53	1.710	$1.64	351	276,987
1992	18.71	2.094	$1.74	331	276,014
1993	18.98	2.267	$2.04	364	282,152
1994	19.71	2.566	$1.85	427	291,773
1995	19.51	2.816	$1.55	385	298,541
1996	19.81	2.883	$2.17	465	301,811
1997	19.87	2.899	$2.32	564	310,971
1998	19.96	3.052	$1.96	560	316,929
1999	19.80	3.368	$2.19	496	302,421
2000	20.20	3.544	$3.68	720	341,678

Source: EIA, Baker Hughes Inc.

TABLE 3.02. Natural Gas Consumed for Electricity Generation (TCF), 1990–2000.[12]

Year	Consumed for electricity generation (tcf)*
1990	3,245
1991	3,316
1992	3,448
1993	3,473
1994	3,903
1995	4,237
1996	3,807
1997	4,065
1998	4,588
1999	4,820
2000	5,206

* Includes combined-heat-and-power plants

Source: eia.doe.gov/emeu/aer/pdf/pages/sec6_13.pdf.

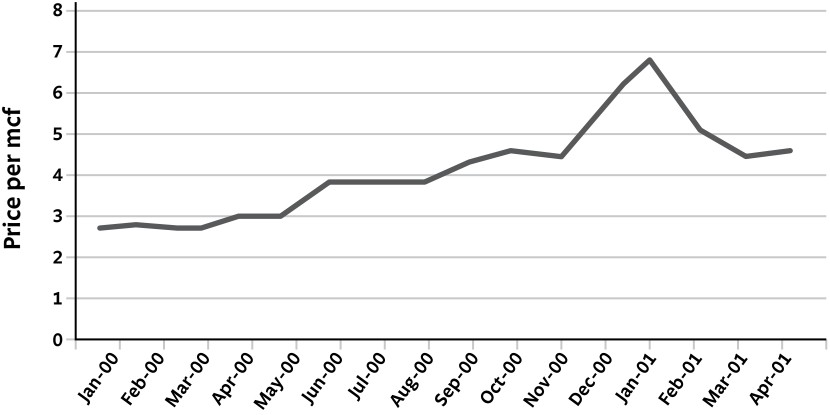


FIGURE 3.01. US Natural Gas Well Head Nominal Prices, January 2000–April 2001

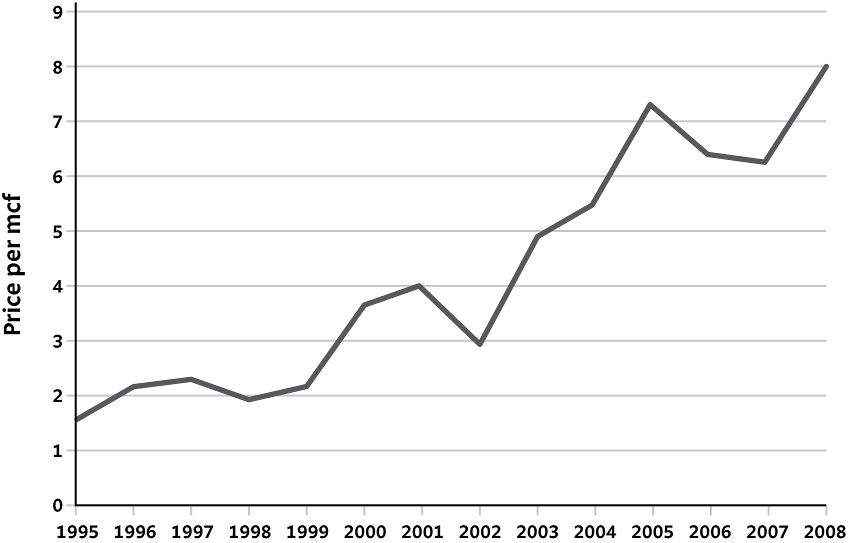


FIGURE 4.01. US Natural Gas Well Head Nominal Prices.[1]

TABLE 4.01. US NG Imports from Canada and US Marketed Production.[2,3,4,5]

Year	Canadian natural gas production (tcf)	Canadian natural gas rig count	Net US imports from canada (tcf)	US marketed production (tcf)
1990	3.49	NA	1.45	18.59
1991	3.72	NA	1.71	18.53
1992	4.11	NA	2.09	18.71
1993	4.55	NA	2.27	18.98
1994	4.90	NA	2.57	19.71
1995	5.23	NA	2.82	19.51
1996	5.42	NA	2.88	19.81
1997	5.51	NA	2.90	19.87
1998	5.66	NA	3.05	19.96
1999	5.73	179	3.37	19.80
2000	5.92	209	3.54	20.20
2001	6.05	231	3.73	20.57
2002	6.08	184	3.78	19.88

Source: EIA, Statistics Canada, Baker Hughes.

TABLE 4.02. Canadian NG Production, Canadian NG Count and US Net NG Imports from Canada.[8,9,10]

Year	Canadian natural gas production (tcf)	Canadian natural gas rig count	Net US imports from canada (tcf)
2003	5.88	271	3.43
2004	5.91	275	3.60
2005	6.03	355	3.70
2006	6.06	361	3.58
2007	5.83	215	3.78
2008	5.62	220	3.59
2009	5.21	122	3.27
2010	5.10	148	3.28

Source: EIA, Statistics Canada, Baker Hughes.

TABLE 4.03. US Natural Gas Production, Prices, NG Rig Count, Number of Producing Wells 2000–2008.[12,13,14,15]

Year	US marketed NG production (tcf)	Average US NG rig count	Average US NG price per mcf	Number of gas producing wells
2000	20.20	720	$3.68	341,678
2001	20.57	939	$4.00	373,304
2002	19.88	691	$2.95	387,772
2003	19.97	872	$4.88	393,327
2004	19.52	1,025	$5.46	406,147
2005	18.93	1,186	$7.33	425,887
2006	19.41	1,372	$6.39	440,516
2007	20.20	1,466	$6.25	452,945
2008	21.11	1,491	$7.97	476,652

Source: EIA, Baker Hughes Incorporated.

TABLE 4.04. US LNG Import 2001–2007.[22,23,24]

Year	LNG imports (bcf)	US natural gas wellhead prices	LNG imports as percent of total US consumption
2001	238	$4.00	1.07%
2002	229	$2.95	0.99%
2003	507	$4.88	2.27%
2004	652	$5.46	2.91%
2005	631	$7.33	2.87%
2006	584	$6.39	2.69%
2007	771	$6.25	3.33%
2008	352	$7.97	1.51%
2009	452	$3.67	1.98%
2010	431	$4.16	1.79%

Source: EIA.

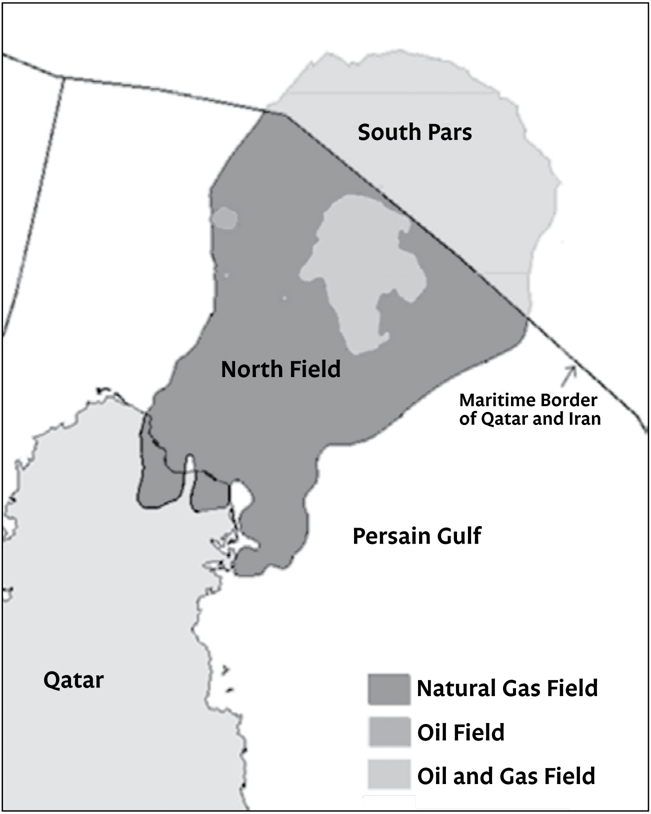


FIGURE 4.02. Map of Qatar's North Field.

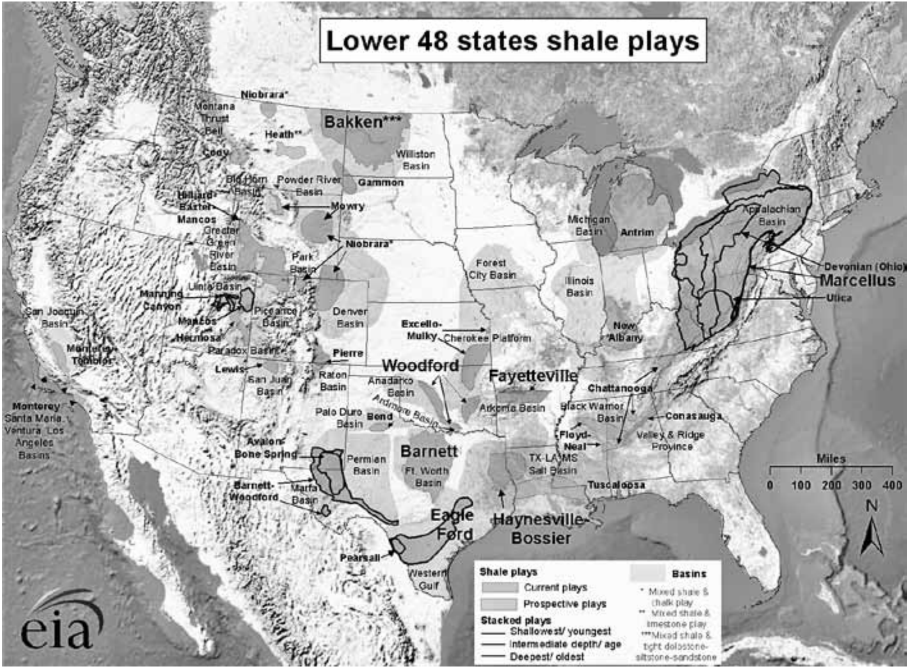


FIGURE 4.03. Shale Gas Plays, Lower 48 States.[45]

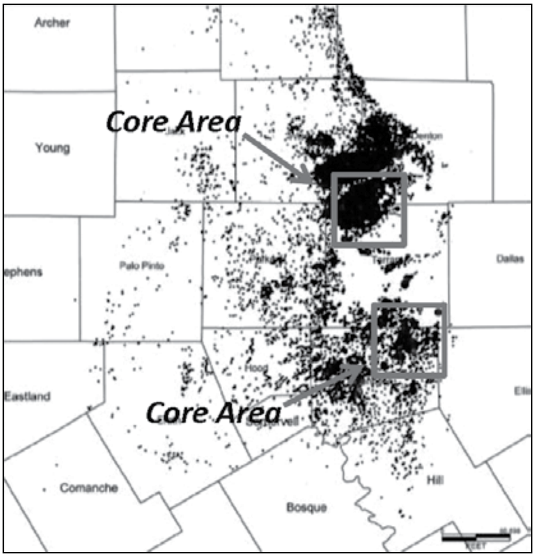


FIGURE 4.04. Barnett Shale Core Areas.[51]

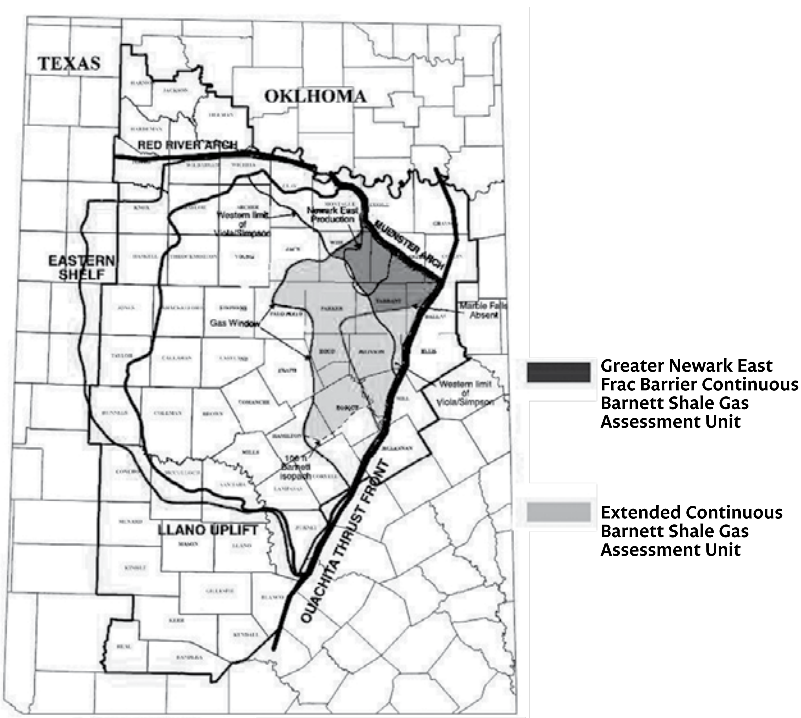


FIGURE 4.05. Important Geological Features of the Barnett Shale.[52]

TABLE 4.05. Devon Energy Barnett Shale Estimated Ultimate Recovery Examples.[54]

Index	Well vintage	EUR	Number of wells
1	DVN 2004	1,555,508	91
2	DVN 2005	1,172,450	160
3	DVN 2006	1,034,726	289
4	DVN 2007	1,139,035	459
5	DVN 2008	1,358,715	573
6	DVN 2009	1,156,912	287
7	DVN 2010	1,074,705	431
	DVN WTD Avg	1,189,856	2290

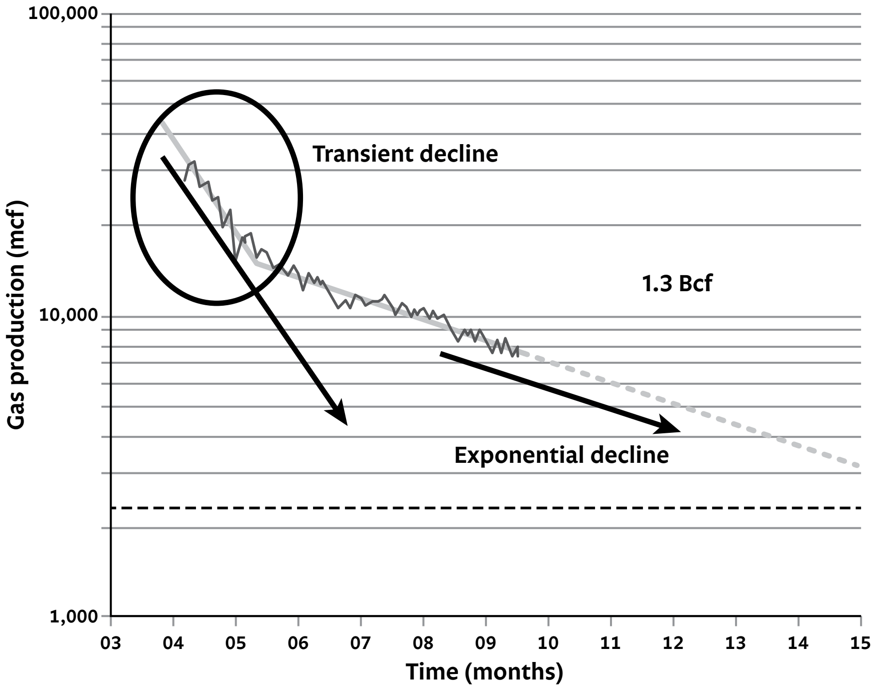


FIGURE 4.06. Barnett Well Decline Curves.[56]

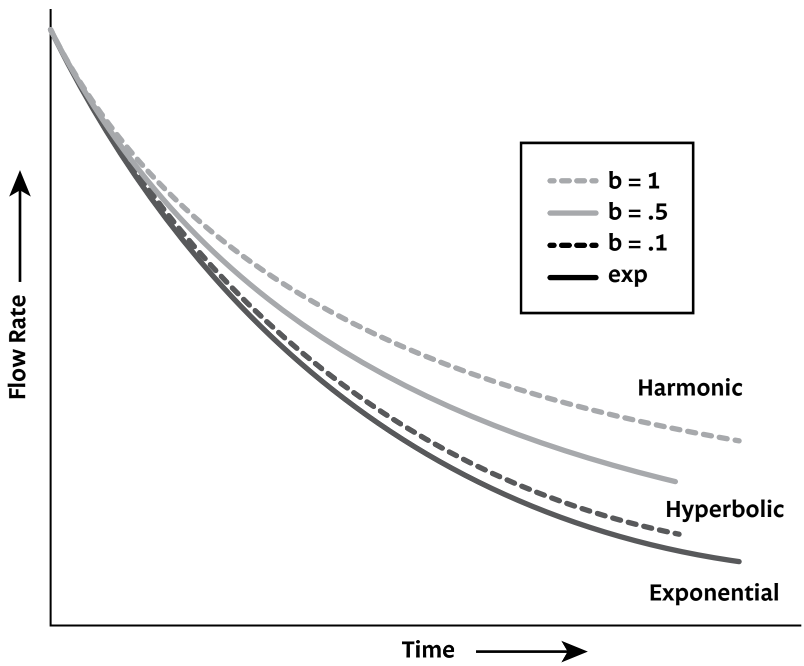
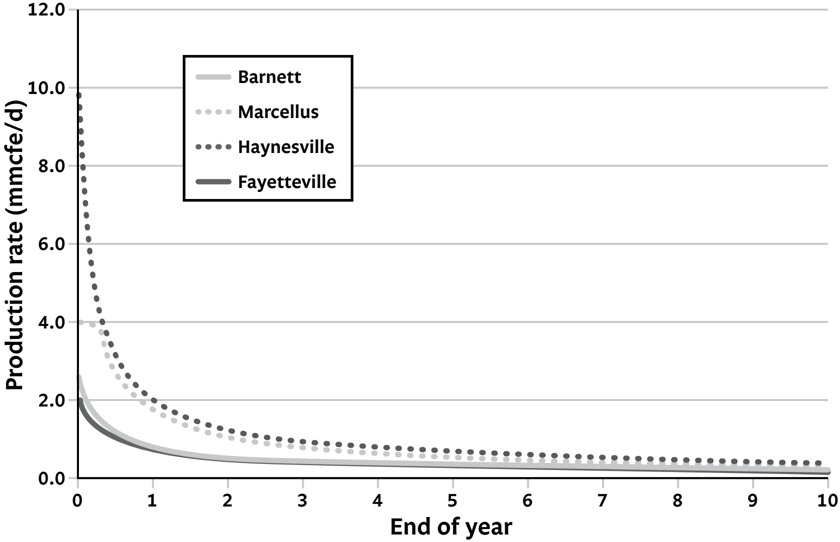


FIGURE 4.07. Exponential, Hyperbolic, Harmonic Declines.[57]



Pro forma	IP rate (mmcfe/d)	First month average production (mmcfe/d)	B-factor	Initial decline rate	Minimum decline rate	EUR (bcfe)
Haynesville	14.1	10.6	1.4	85%	5%	6.6
Marcellus	4.1	4.0	1.4	63%	5%	5.25
Barnett	3.1	2.7	1.6	74%	5%	3.0
Fayetteville	2.3	2.1	1.5	68%	5%	2.6

FIGURE 4.08. Natural Gas Shale Plays—Type Curves.

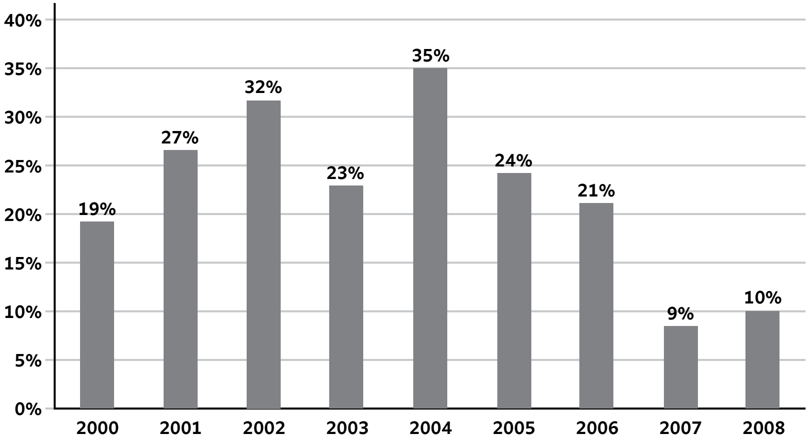


FIGURE 4.09. Barnett Wells Producing Less than 1 MMcf per Month or Dry.[65]

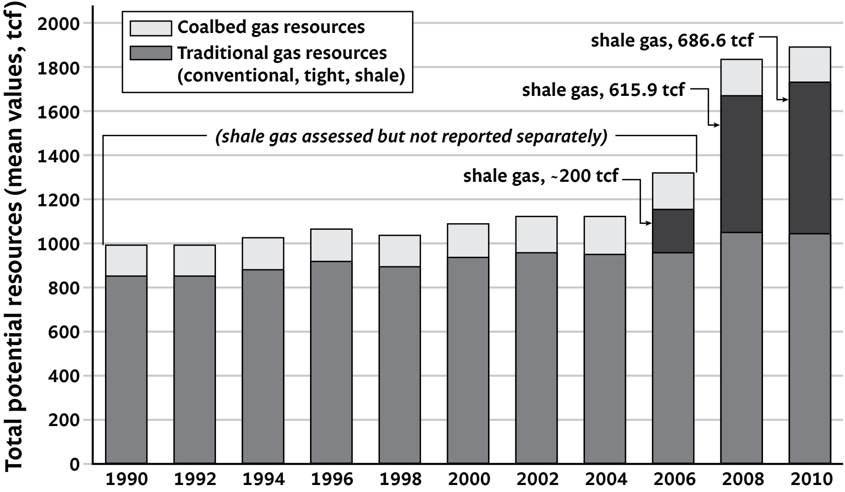


FIGURE 4.10. PGC Resource Assessment of the US, 1990–2010.[79]

TABLE 5.01. Pennsylvania Core Counties and Acreage.[30]

County	Acres
NE Core Counties	
Bradford	736,429
Clearfield	734,285
Potter	691,949
Tioga	725,587
Susquehanna	526,630
Lycoming	790,304
SW Core Counties	
Fayette	505,690
Greene	368,550
Washington	548,538
Westmoreland	656,307
Total Acres	6,284,269

Source: US Census.

TABLE 6.01. US Electricity Industry Consumption of NG from 1970–1985 and 1994–2011.[2]

Year	Electricity industry NG consumption in tcf	Total NG US consumption in tcf	Electricity as percentage of total NG consumption
1970	3.932	21.139	18.60%
1971	3.976	21.793	18.24%
1972	3.977	22.101	17.99%
1973	3.660	22.049	16.59%
1974	3.443	21.223	16.22%
1975	3.158	19.538	16.16%
1976	3.081	19.946	15.44%
1977	3.191	19.521	16.34%
1978	3.188	19.627	16.24%
1979	3.491	20.241	17.24%
1980	3.682	19.877	18.55%
1981	3.640	19.404	18.75%
1982	3.266	18.001	17.92%
1983	2.911	16.835	17.29%
1984	3.111	17.951	17.33%
1985	3.044	17.281	17.61%
1994	3.903	21.147	18.45%
1995	4.237	22.207	19.07%
1996	3.807	22.609	16.83%
1997	4.065	22.737	17.87%
1998	4.588	22.246	20.62%
1999	4.820	22.405	21.51%
2000	5.260	23.333	22.54%
2001	5.342	22.239	24.02%
2002	5.672	23.007	24.65%
2003	5.135	22.277	23.05%
2004	5.464	22.389	24.40%
2005	5.869	22.011	26.66%
2006	6.222	21.685	28.69%
2007	6.841	23.097	29.61%
2008	6.661	23.226	28.67%
2009	6.887	22.834	30.16%
2010	7.387	23.775	31.07%
2011	7.601	24.309	31.27%

*Includes combined-heat-and-power plants (which is between 15% and 20% depending on year).

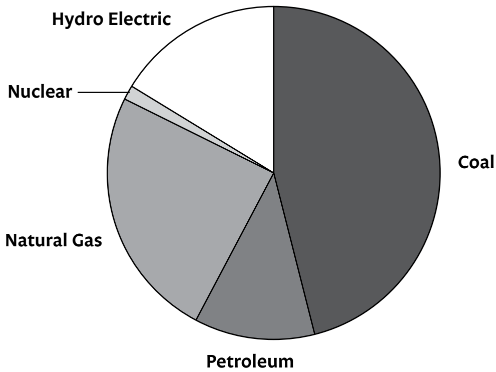


FIGURE 6.01. Electricity Generation Sources 1970.[5]

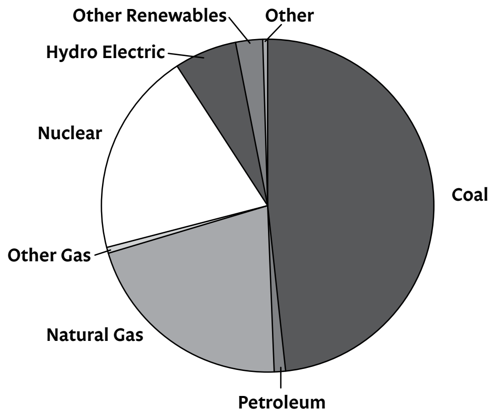


FIGURE 6.02. Electricity Generation Sources 2008.[6]

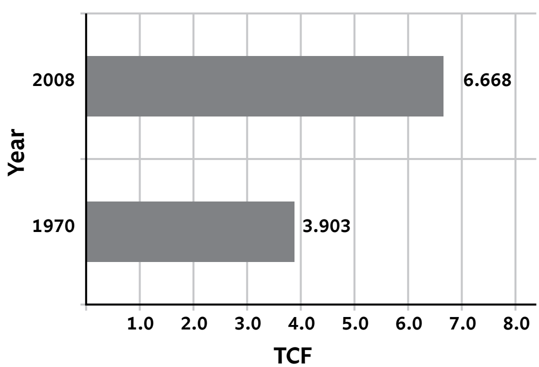


FIGURE 6.03. Natural Gas Consumption by Sector—Years 1970 and 2008 (tcf).[7]

TABLE 6.02. US Renewable Generation in Thousand Megawatt Hours.

Year	Hydroelectric generation	Other renewable generation*	Total renewable generation	Combined % of total generation
1996	347,162	75,796	422,958	12.28%
1997	356,453	77,183	433,606	12.41%
1998	323,336	77,088	400,424	11.06%
1999	319,536	79,423	398,959	10.79%
2000	275,573	80,906	356,479	9.37%
2001	216,961	70,769	287,730	7.70%
2002	264,329	79,109	343,438	8.90%
2003	275,806	79,487	355,293	8.94%
2004	268,417	83,067	351,484	8.85%
2005	270,321	87,329	357,650	8.81%
2006	289,246	96,525	385,771	9.49%
2007	247,510	105,238	352,748	8.48%
2008	254,831	126,212	381,043	9.24%
2009	273,445	144,279	417,724	10.57%
2010	260,203	167,173	427,375	10.36%
2011	325,074	194,993	520,067	12.67%

*Includes wind, solar photovoltaic, solar thermal, geothermal, wood, black liquor, other wood waste, biogenic municipal solid waste, landfill gas, sludge waste, agriculture byproducts and other biomass.[14]

TABLE 7.01. US Industrial Natural Gas Consumption 2000 to 2011.[1]

Year	Industrial consumption in tcf	Industrial consumption as % of total US consumption
2000	8,142	34.89%
2001	7,344	33.02%
2002	7,507	32.62%
2003	7,150	32.09%
2004	7,243	32.35%
2005	6,597	29.97%
2006	6,526	30.07%
2007	6,654	28.80%
2008	6,670	28.65%
2009	6,167	26.92%
2010	6,517	27.41%
2011	6,714	27.62%

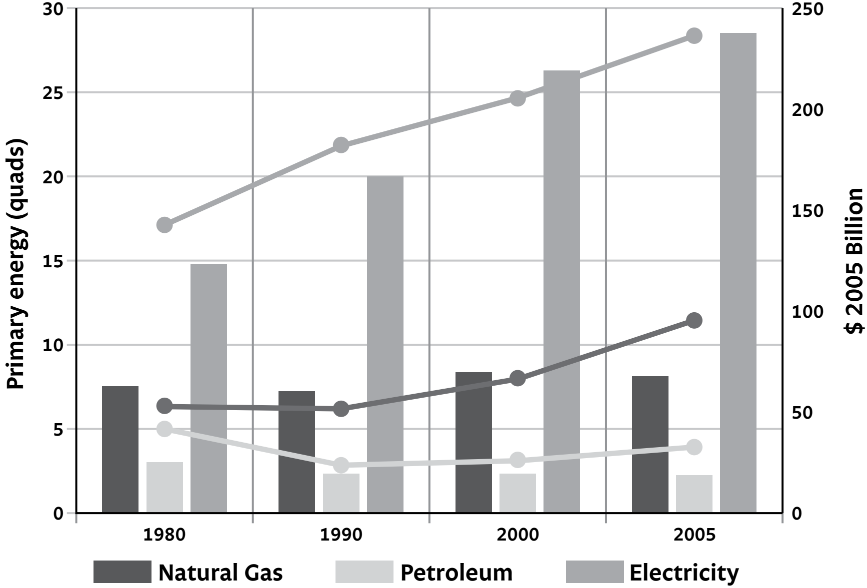


FIGURE 8.01. Predominance of Electricity as Buildings Energy Source.[2]

TABLE 8.01. US Heating and Cooling Demand.[6]

Year	Residential demand in tcf	Commercial demand in tcf	Total in tcf
1980	4.75	2.61	7.36
1985	4.43	2.43	6.86
1990	4.39	2.62	7.01
1995	4.85	3.03	7.88
2000	4.99	3.18	8.17
2005	4.82	2.99	7.81
2010	4.78	3.10	7.88

Source: EIA.

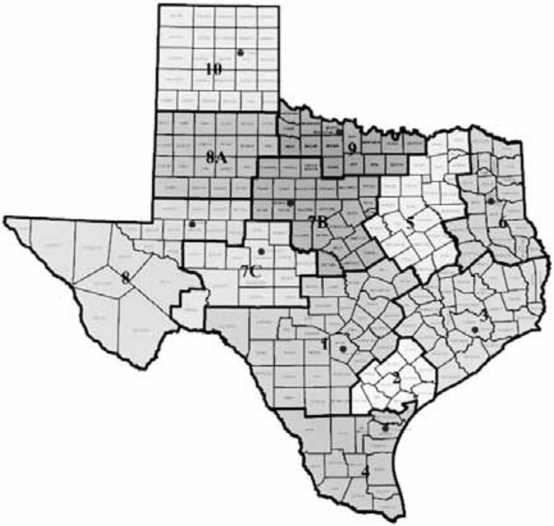
TABLE 9.01. NGV Demand 1997 to 2011.[8]

Year	US natural gas vehicle fuel consumption (mmcf)
1997	8,328
1998	9,341
1999	11,622
2000	12,752
2001	14,536
2002	14,950
2003	18,271
2004	20,514
2005	22,884
2006	23,739
2007	24,655
2008	25,982
2009	27,262
2010	30,670
2011	32,850

Source: EIA

TABLE 10.01. World's Largest NG Producers in 2011.[2]

Country	Production in tcf
US (includes TX)	22.99
Russia	21.43
Texas	7.60
Canada	5.67
Iran	5.36
Qatar	5.18
China	3.62
Norway	3.58
Saudi Arabia	3.50



District Office

1 & 2	**San Antonio**
3	**Houston**
4	**Corpus Christi**
5 & 6	**Kilgore**
7B	**Abilene**
7C	**San Angelo**
8 & 8A	**Midland**
9	**Wichita Falls**
10	**Pampa**

FIGURE 10.01. Railroad Commission of Texas—Oil and Gas Division District Boundaries.[3]

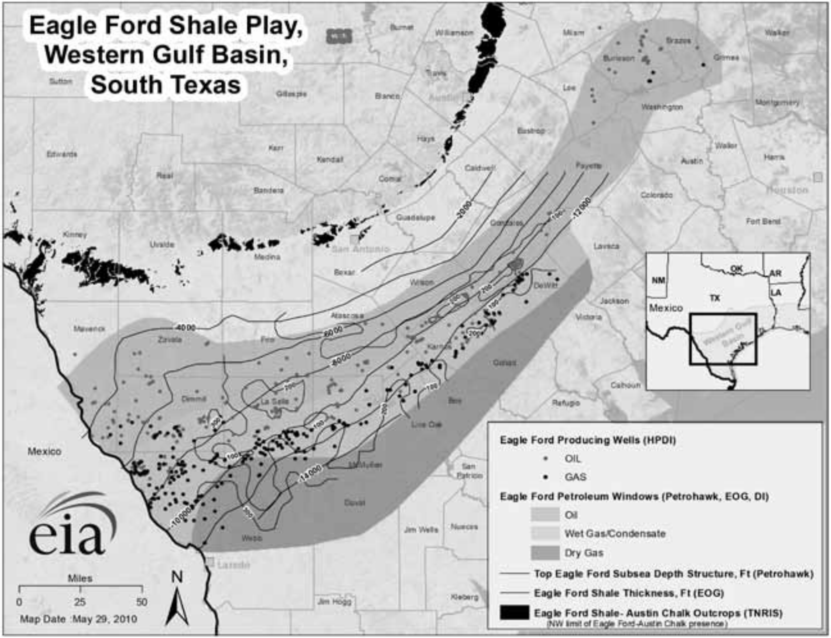


FIGURE 10.02. Eagle Ford Shale Play—Location, Wells and Petroleum Windows.[6]

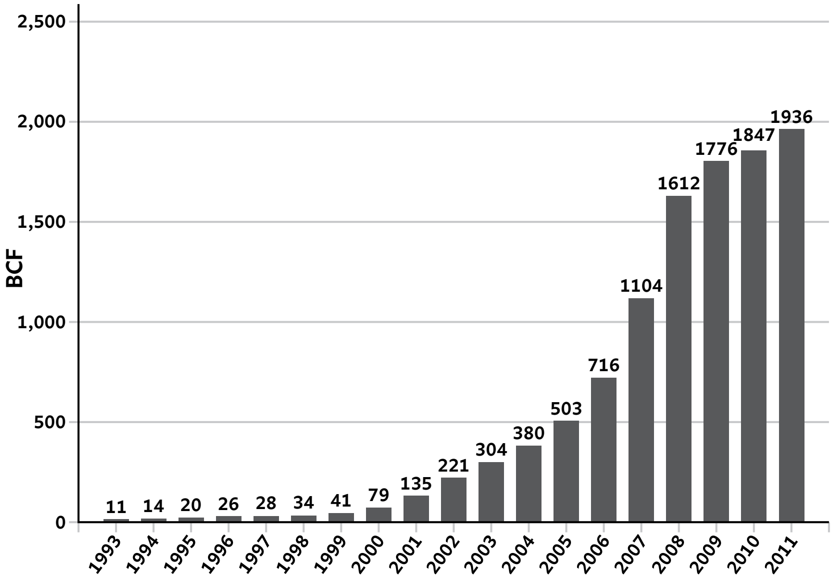


FIGURE 10.3. Newark East (Barnett Shale) Gas Well Gas Production (1993–2011).[22]

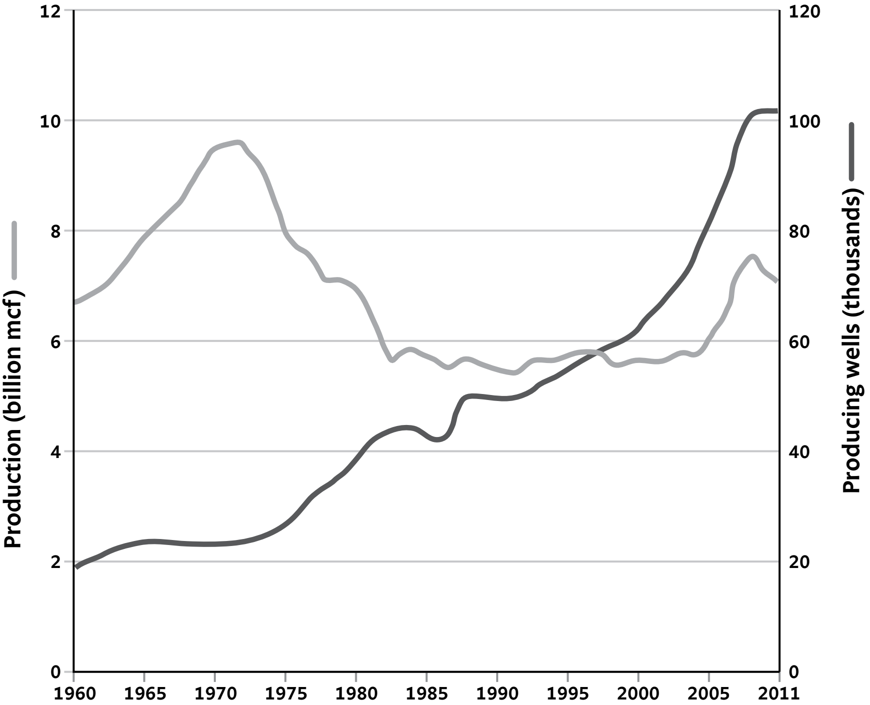


FIGURE 10.04. Texas Producing Wells and Production 1960–2011.[33]

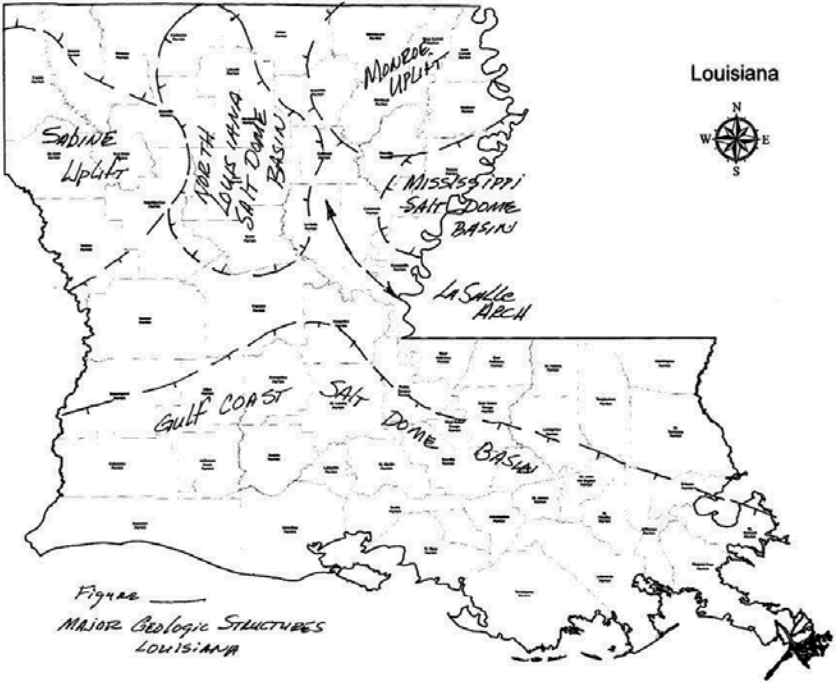
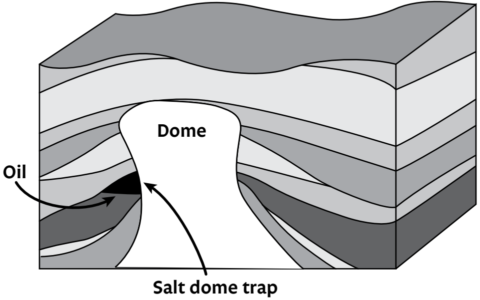


FIGURE 11.01. Map of the Salt Dome Basin.[9]

Salt is a peculiar substance. If you put enough heat and pressure on it,the salt will slowly flow, much like a glacier that slowly but continually moves downhill. Unlike glaciers, salt which is buried miles below the surface of the Earth can move upward until it breaks through to the Earth's surface, where it is then dissolved by ground- and rain-water. To get all the way to the Earth's surface, salt has to push aside and break through many layers of rock in its path. This is what ultimately will create the oil trap.



Here we see salt that has moved up through the Earth, punching through and bending rock along the way. Oil can come to rest right up against the salt, which makes salt an effective trap rock. However, many times, the salt chemically changes the rock next to it in such a way that oil will no longer seep into them. In a sense, it destroys the porosity of a reservoir rock.

FIGURE 11.02. Salt Dome Trap.[11]

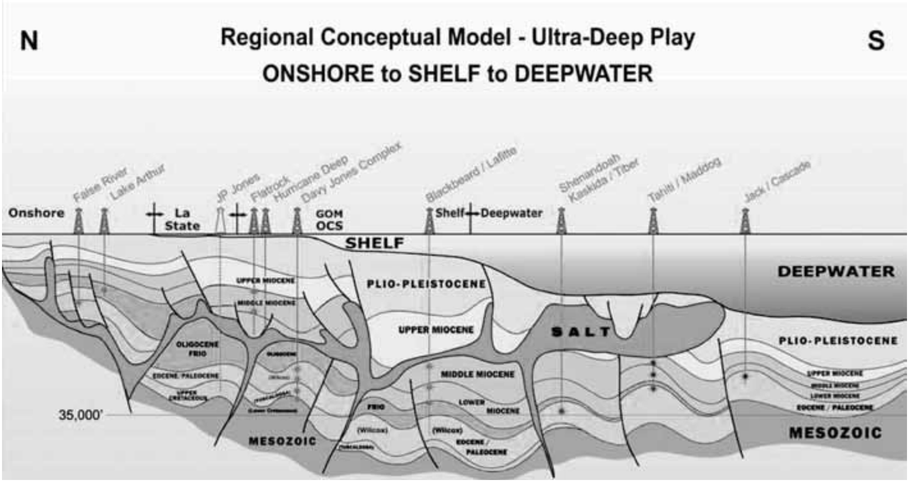


FIGURE 11.03. Regional Conceptual Model—Ultra-Deep Play.[12]

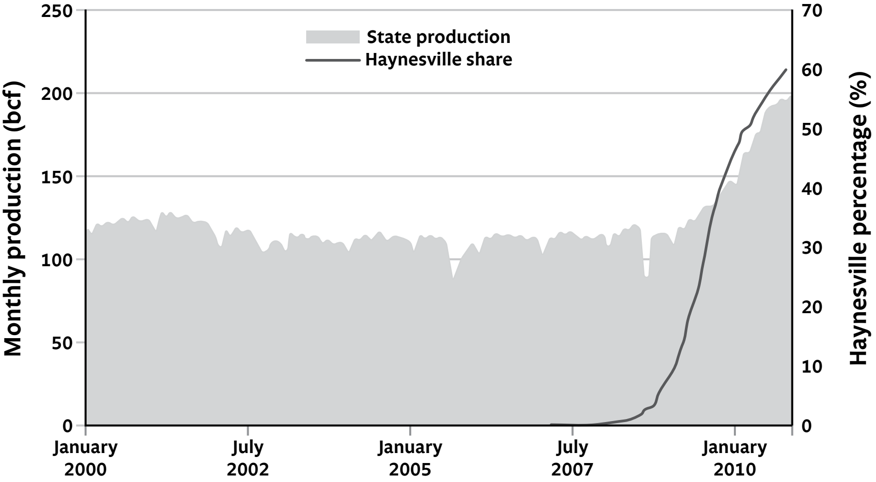
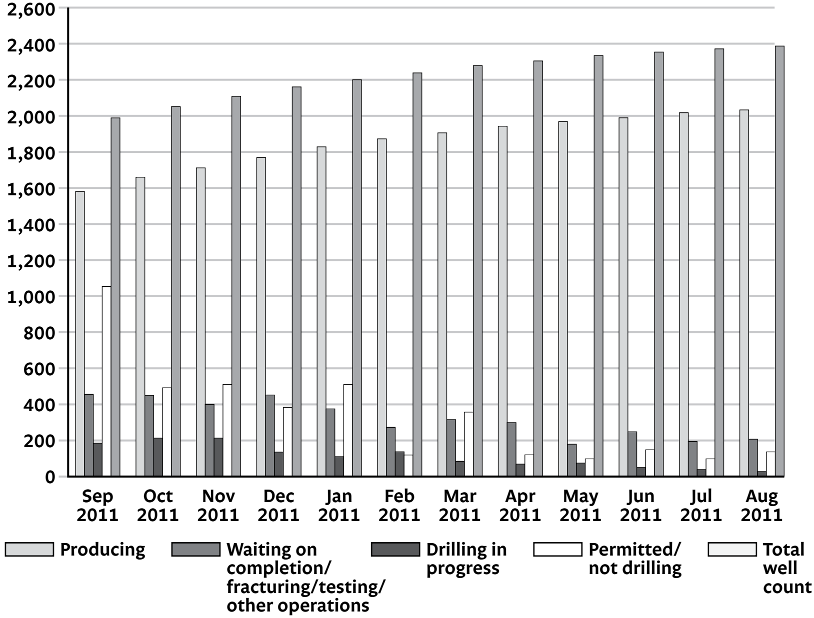


FIGURE 11.04. Haynesville Contribution to Louisiana Gas Production.[15]



	Month	Producing	Waiting on completion/ fracturing/testing/ other operations	Drilling in progress	Permitted/ not drilling	Total well count
1	Sep 2011	1,615	467	186	1,074	2,030
2	Oct 2011	1,691	464	214	500	2,093
3	Nov 2011	1,752	410	214	525	2,150
4	Dec 2011	1,811	460	140	390	2,202
5	Jan 2012	1,870	388	112	525	2,251
6	Feb 2012	1,910	285	140	122	2,286
7	Mar 2012	1,942	323	87	366	2,320
8	Apr 2012	1,977	304	69	122	2,349
9	May 2012	2,010	182	77	98	2,373
10	Jun 2012	2,036	258	46	146	2,397
11	Jul 2012	2,055	198	36	98	2,415
12	Aug 2012	2,071	205	26	134	2,432

FIGURE 11.05. Haynesville Shale Well Activities by Month.[20]

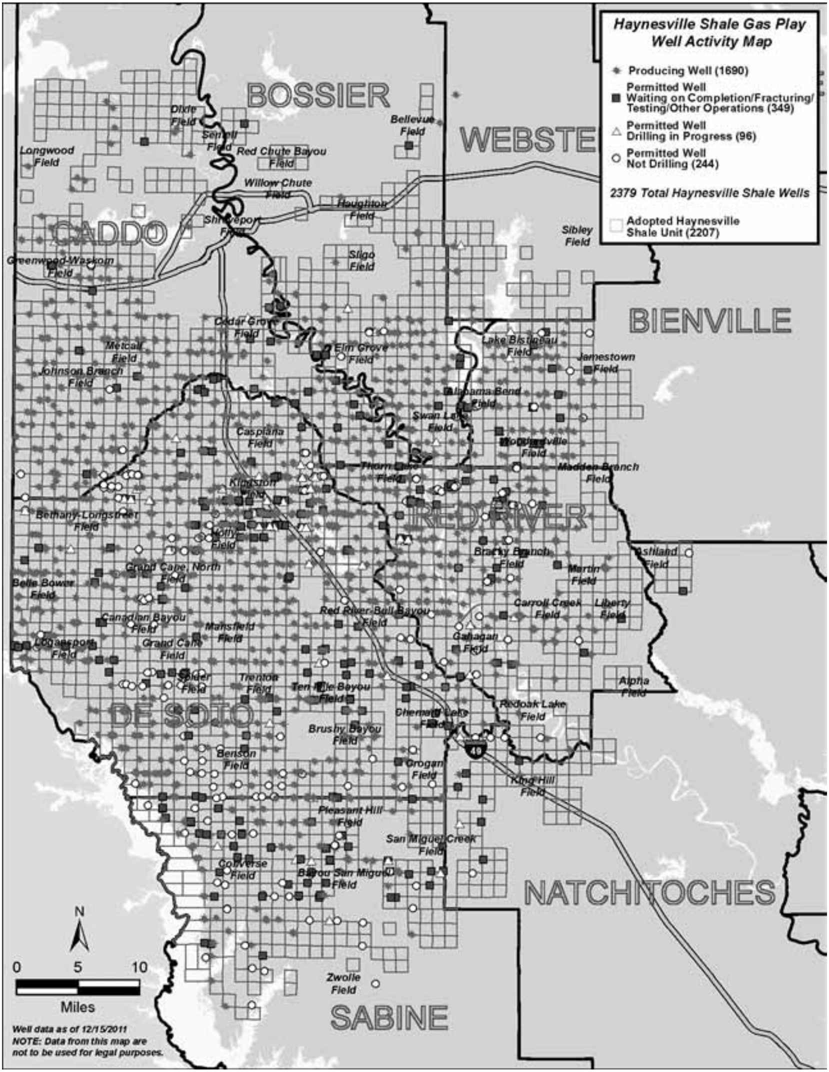


FIGURE 11.06. Haynesville Shale Gas Play Well Activity Map.[21]

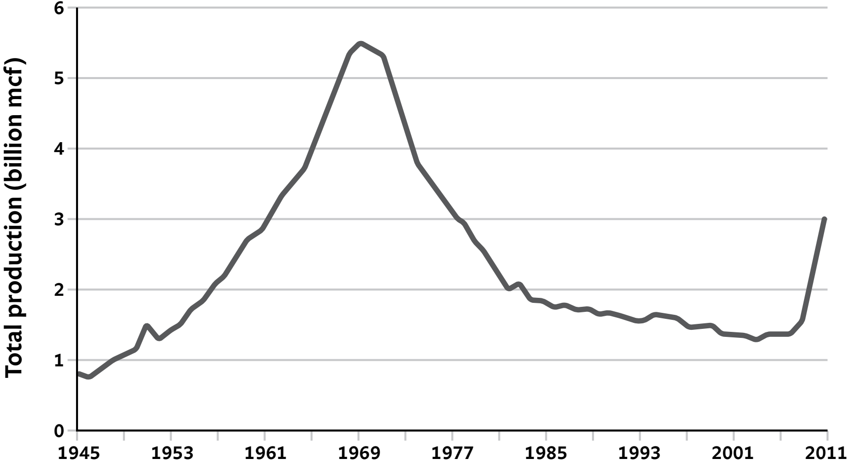


FIGURE 11.07. Louisiana Natural Gas Production 1945–2011.[22]

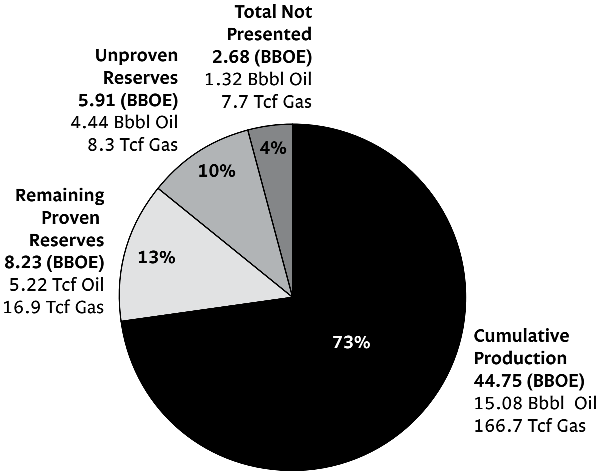


FIGURE 12.01. Gulf of Mexico Reserves and Resources.[3]

TABLE 12.01. Proven oil and gas reserves and cumulative production at end of year, 1975–2006 for Gulf of Mexico, Outer Continental Shelf and Slope.[5]

Year	Number of fields included	Proven reserves			Historical cumulative production			Remaining proven reserves		
		Oil	Gas	BOE	Oil	Gas	BOE	Oil	Gas	BOE
1975	255	6.61	59.9	17.27	3.82	27.2	8.66	2.79	32.7	8.61
1976	306	6.86	65.5	18.51	4.12	30.8	9.60	2.74	34.7	8.91
1977	334	7.18	69.2	19.49	4.47	35.0	10.70	2.71	34.2	8.80
1978	385	7.52	76.2	21.08	4.76	39.0	11.70	2.76	37.2	9.38
1979[1]	417	7.71	82.2	22.34	4.83	44.2	12.69	2.88	38.0	9.64
1980	435	8.04	88.9	23.86	4.99	48.7	13.66	3.05	40.2	10.20
1981	461	8.17	93.4	24.79	5.27	53.6	14.81	2.90	39.8	9.98
1982	484	8.56	98.1	26.02	5.58	58.3	15.95	2.98	39.8	10.06
1983	521	9.31	106.2	28.21	5.90	62.5	17.02	3.41	43.7	11.19
1984	551	9.91	111.6	29.77	6.24	67.1	18.18	3.67	44.5	11.59
1985	575	10.63	116.7	31.40	6.58	71.1	19.23	4.05	45.6	12.16
1986	645	10.81	121.0	32.34	6.93	75.2	20.31	3.88	45.8	12.03
1987	704	10.76	122.1	32.49	7.26	79.7	21.44	3.50	42.4	11.04
1988[2]	678	10.95	126.7	33.49	7.56	84.3	22.56	3.39	42.4	10.93
1989	739	10.87	129.1	33.84	7.84	88.9	23.66	3.03	40.2	10.18
1990	782	10.64	129.9	33.75	8.11	93.8	24.80	2.53	36.1	8.95
1991	819	10.74	130.5	33.96	8.41	98.5	25.94	2.33	32.0	8.02
1992	835	11.08	132.7	34.69	8.71	103.2	27.07	2.37	29.5	7.62
1993	849	11.15	136.8	35.49	9.01	107.7	28.17	2.14	29.1	7.32
1994	876	11.86	141.9	37.11	9.34	112.6	29.38	2.52	29.3	7.73
1995	899	12.01	144.9	37.79	9.68	117.4	30.57	2.33	27.5	7.22
1996	920	12.79	151.9	39.82	10.05	122.5	31.85	2.74	29.4	7.97
1997	957	13.67	158.4	41.86	10.46	127.6	33.17	3.21	30.8	8.69
1998	984	14.27	162.7	43.22	10.91	132.7	34.52	3.36	30.0	8.70
1999	1,003	14.38	161.3	43.08	11.40	137.7	35.90	2.98	23.6	7.18
2000	1,050	14.93	167.3	44.70	11.93	142.7	37.32	3.00	24.6	7.38
2001	1,086	16.51	172.0	47.11	12.48	147.7	38.77	4.03	24.3	8.35
2002	1,112	18.75	176.8	50.21	13.05	152.3	40.15	5.71	24.6	10.09
2003	1,141	18.48	178.2	50.19	13.61	156.7	41.49	4.87	21.5	8.70
2004	1,172	18.96	178.4	50.70	14.14	160.7	42.73	4.82	17.7	7.97
2005	1,196	19.80	181.8	52.15	14.61	163.9	43.77	5.19	17.9	8.38
2006	1,229	20.30	183.6	52.97	15.08	166.7	44.74	5.22	16.9	8.23

[1] Gas plant liquids dropped from system.

[2] Basis of reserves changed from demonstrated to SPE proved.

TABLE 12.02. Gulf of Mexico proven fields by rank order, based on probed barrels of oil equivalent reserves, top 50 fields.[6]

Rank	Field name	New field	Disc year	Water depth (ft.)	Field class	Field type	Field GOR (SCF/STB)	Proven reserves Oil (MMbbl)	Proven reserves Gas (Bcf)	Proven reserves BOE (MMbbl)	Cumulative production through 2006 Oil (MMbbl)	Cumulative production through 2006 Gas (Bcf)	Cumulative production through 2006 BOE (MMbbl)	Remaining proven reserves Oil (MMbbl)	Remaining proven reserves Gas (Bcf)	Remaining proven reserves BOE (MMbbl)
1	MC807		1989	3,393	PDP	O	1,444	1,208.2	1,745.2	1,518.7	734.7	959.6	905.4	473.5	785.6	613.3
2	EI330		1971	247	PDP	O	4,222	430.9	1,819.5	754.7	420.3	1,801.4	740.9	10.6	18.1	13.8
3	WD030		1949	48	PDP	O	1,617	573.7	927.7	738.7	561.8	867.8	716.2	11.9	59.9	22.6
4	MC778		1999	6,081	PU	O	776	642.7	498.4	731.4	0.0	0.0	0.0	642.6	498.4	731.3
5	GI043		1956	140	PDP	O	4,302	377.3	1,618.9	665.3	360.8	1,537.1	634.3	16.5	81.8	31.0
6	MC776	*	2000	5,662	PU	O	1,058	534.0	565.2	634.5	0.0	0.0	0.0	534.0	565.2	634.5
7	BM002		1949	50	PDP	O	1,037	530.3	549.9	628.1	522.5	536.5	618.0	7.7	13.4	10.1
8	GC743	*	1998	6,468	PDP	O	647	558.6	361.4	623.0	0.0	0.0	0.0	558.6	361.4	622.9
9	TS000		1958	13	PDP	G	83,526	38.3	3,201.4	608.0	37.5	3,155.0	598.8	0.9	46.4	9.1
10	VR014		1956	26	PDP	G	63,983	48.2	3,082.6	596.7	47.9	3,055.7	591.6	0.3	26.8	5.1
11	MP041		1956	42	PDP	O	5,715	263.0	1,503.1	530.5	252.1	1,448.2	509.8	10.9	55.0	20.7
12	VR039		1948	38	PDP	G	81,151	31.7	2,572.6	489.5	31.2	2,542.9	483.6	0.5	29.7	5.8
13	SS208		1960	102	PDP	O	6,217	220.3	1,369.5	464.0	216.0	1,338.5	454.2	4.3	30.9	9.8
14	GC640	*	2002	4,234	PDN	O	487	414.0	201.6	449.9	0.0	0.0	0.0	414.0	201.6	449.9
15	WD073		1962	178	PDP	O	2,458	265.2	651.7	381.1	259.3	632.0	371.7	5.9	19.7	9.4
16	GB426		1987	2,860	PDP	O	3,579	229.0	819.4	374.8	211.7	757.9	346.5	17.3	61.5	28.2
17	GI016		1948	53	PDP	O	1,271	303.4	385.5	372.0	299.2	377.9	366.4	4.2	7.6	5.6
18	SP061		1967	219	PDP	O	1,930	266.9	515.1	358.5	259.5	505.1	349.4	7.4	10.0	9.1
19	ST021		1957	46	PDP	O	1,729	272.7	471.5	356.6	246.0	396.5	316.6	26.7	74.9	40.0
20	EI238		1964	147	PDP	G	16,327	91.2	1,489.5	356.3	85.8	1,423.9	339.1	5.4	65.6	17.1
21	ST172		1962	98	PDP	G	136,478	14.0	1,907.2	353.3	11.5	1,831.9	337.4	2.5	75.4	15.9
22	SP089		1969	423	PDP	O	4,448	191.1	849.9	342.3	188.3	826.4	335.3	2.8	23.5	7.0
23	WC180		1961	48	PDP	G	141,655	12.9	1,821.4	336.9	12.7	1,779.5	329.3	0.2	41.9	7.6
24	AC857	*	2002	7,900	PU	O	1,205	272.5	328.3	330.9	0.0	0.0	0.0	272.5	328.3	330.9
25	ST176		1963	126	PDP	G	14,710	89.7	1,320.0	324.6	81.5	1,171.5	290.0	8.2	148.5	34.7
26	SS169		1960	63	PDP	O	5,411	163.2	883.3	320.4	154.3	825.1	301.2	8.9	58.1	19.2

27	SM048	1961	101	PDP	G	55,963	28.6	1,601.1	313.5	27.8	1,512.7	297.0	0.8	88.4	16.5
28	MC194	1975	1,022	PDP	O	4,175	178.8	746.4	311.6	176.5	738.0	307.8	2.3	8.4	3.8
29	EC064	1957	50	PDP	G	57,810	27.4	1,586.2	309.7	26.6	1,537.9	300.3	0.8	48.4	9.4
30	EI292	1964	212	PDP	G	84,604	19.1	1,617.4	306.9	18.3	1,609.4	304.7	0.8	7.9	2.2
31	EC271	1971	171	PDP	G	18,853	70.3	1,325.8	306.2	67.5	1,309.3	300.5	2.8	16.5	5.7
32	SS176	1956	100	PDP	G	19,836	65.3	1,294.6	295.6	62.9	1,261.7	287.4	2.3	32.9	8.2
33	SP027	1954	64	PDP	O	5,219	151.7	791.6	292.5	150.0	762.3	285.7	1.7	29.3	6.9
34	WC587	1971	211	PDP	G	110,142	14.1	1,554.0	290.6	12.8	1,528.5	284.8	1.3	25.5	5.8
35	ST135	1956	130	PDP	O	3,612	171.7	620.0	282.0	165.7	579.5	268.8	6.0	40.6	13.2
36	EI296	1971	214	PDP	G	69,965	20.3	1,421.6	273.3	20.3	1,413.6	271.8	0.0	8.0	1.5
37	WC192	1954	57	PDP	G	58,762	23.8	1,399.6	272.9	22.3	1,356.8	263.7	1.5	42.8	9.1
38	WD079	1966	124	PDP	O	3,800	162.7	618.3	272.7	160.5	609.1	268.9	2.2	9.2	3.8
39	MI623	1980	83	PDP	G	98,785	14.4	1,426.2	268.2	13.3	1,335.0	250.9	1.1	91.2	17.3
40	HI573A	1973	341	PDP	O	7,700	111.2	856.2	263.5	107.6	850.1	258.9	3.6	6.1	4.6
41	GC644	1999	4,340	PDP	O	1,234	209.6	258.7	255.6	28.0	29.4	33.3	181.5	229.3	222.3
42	GI047	1955	88	PDP	O	3,583	150.1	538.0	245.8	144.2	516.2	236.1	5.9	21.7	9.8
43	SP078	1972	203	PDP	G	11,544	77.6	896.3	237.1	72.9	881.3	229.8	4.7	15.0	7.4
44	SM023	1960	82	PDP	G	38,903	29.7	1,155.4	235.3	29.5	1,143.8	233.0	0.2	11.7	2.3
45	SM130	1973	214	PDP	O	1,341	187.4	251.3	232.1	182.8	246.0	226.6	4.5	5.3	5.5
46	PL020	1951	33	PDP	O	5,810	113.7	660.3	231.2	108.1	604.8	215.7	5.5	55.5	15.4
47	GC244	1994	2,762	PDP	O	2,005	170.3	341.5	231.0	160.0	318.8	216.7	10.3	22.7	14.3
48	VR076	1949	31	PDP	G	140,837	8.7	1,231.9	228.0	7.4	1,168.8	215.4	1.4	63.1	12.6
49	SM066	1963	124	PDP	G	255,946	4.9	1,250.3	227.4	4.8	1,218.0	221.5	0.1	32.3	5.9
50	VK956	1985	3,254	PDP	O	9,042	87.1	787.3	227.2	80.2	710.8	206.7	6.9	76.5	20.5

TABLE 12.03: GOM Natural Gas Rig Count, Daily Production and Prices 1992 thru 2011.[7]

Year	Average NG rigs in GOM	Avg. daily marketed GOM NG production in bcf/d	Average wellhead NG price
1992	NA	12.81	$1.74
1993	NA	12.83	$2.04
1994	61	13.45	$1.85
1995	63	13.30	$1.55
1996	91	14.12	$2.17
1997	99	14.26	$2.32
1998	91	13.91	$1.96
1999	80	13.78	$2.19
2000	117	13.52	$3.68
2001	118	13.77	$4.00
2002	95	12.36	$2.95
2003	98	12.07	$4.88
2004	90	10.88	$5.46
2005	75	8.58	$7.33
2006	81	7.95	$6.39
2007	68	7.67	$6.25
2008	61	6.34	$7.96
2009	38	6.65	$3.71
2010	16	6.15	$4.48
2011	18	4.98	$3.95

Source: Baker Hughes, EIA.

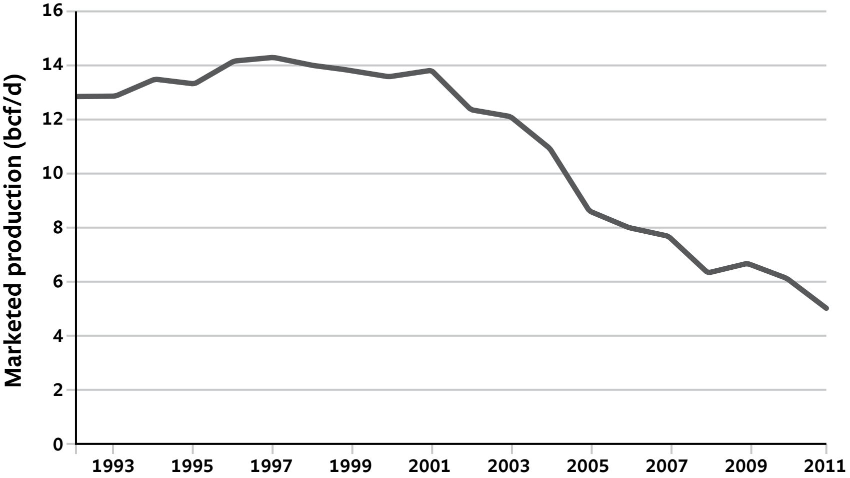


FIGURE 12.02. Natural Gas Supply from Federal GOM Waters.[8]

FIGURE 13.01. Pinedale and Jonah Field Locator Map.[9]

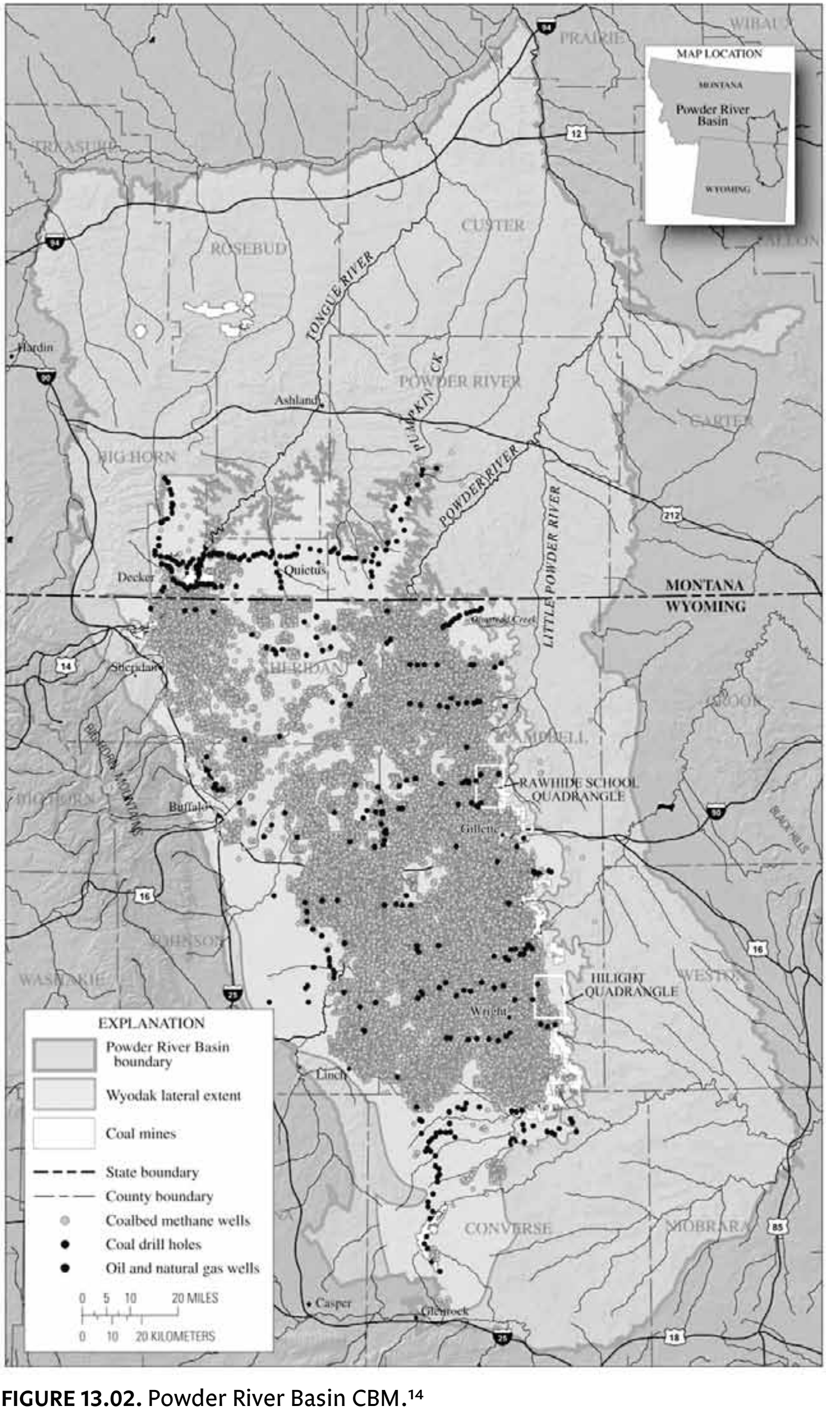


FIGURE 13.02. Powder River Basin CBM.[14]

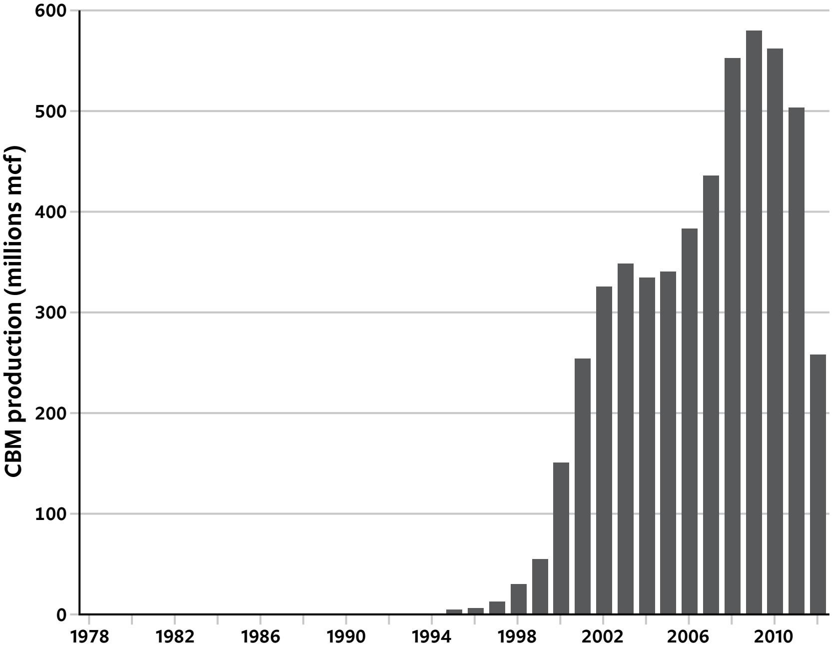


FIGURE 13.03. Wyoming Coalbed Methane Production (mcf).[17]

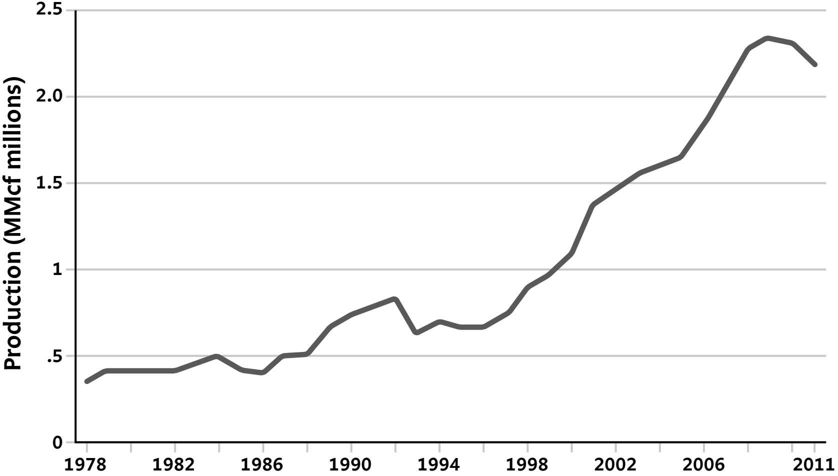


FIGURE 13.04. Wyoming State Wide Gas Production 1978–2011.[31]

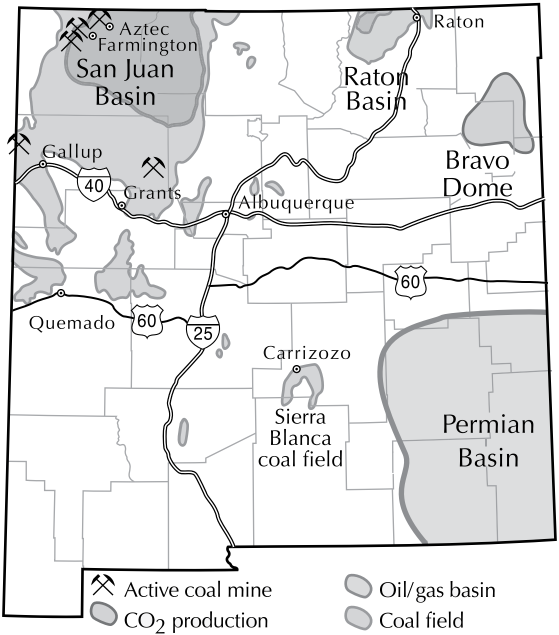


FIGURE 14.01. Major oil and natural gas production and coal resources in New Mexico.[2]

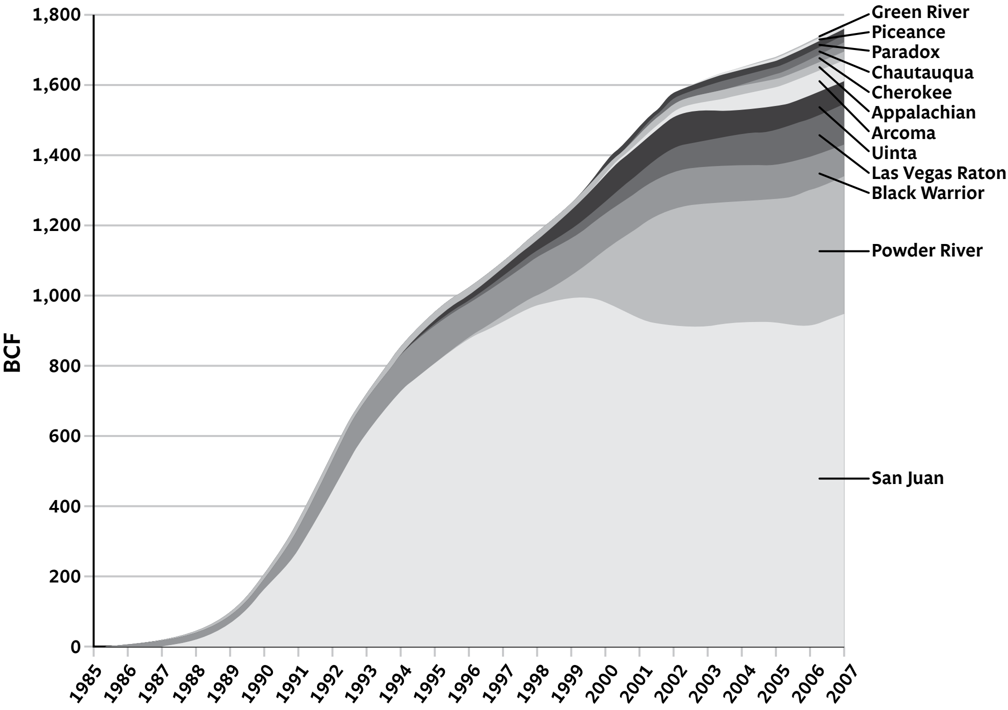


FIGURE 14.02. CBM Production History by Basin in the US.[8]

TABLE 14.01. New Mexico Coalbed Methane Gas Production.[10]

Year	NM San Juan CBM gas in bcf	Percentage change
1994	531	NA
1995	572	+7.7%
1996	603	+5.4%
1997	601	0.0%
1998	608	+1.1%
1999	612	+.6%
2000	584	−4.5%
2001	533	−8.7%
2002	486	−8.1%
2003	464	−4.5%
2004	485	+4.5%
2005	494	+1.8%
2006	498	+.8%
2007	482	−3.2%
2008	450	−6.6%
2009	424	−5.7%
2010	381	−10.1%
2011	353	−7.3%

Source: New Mexico Oil Conservation Division.

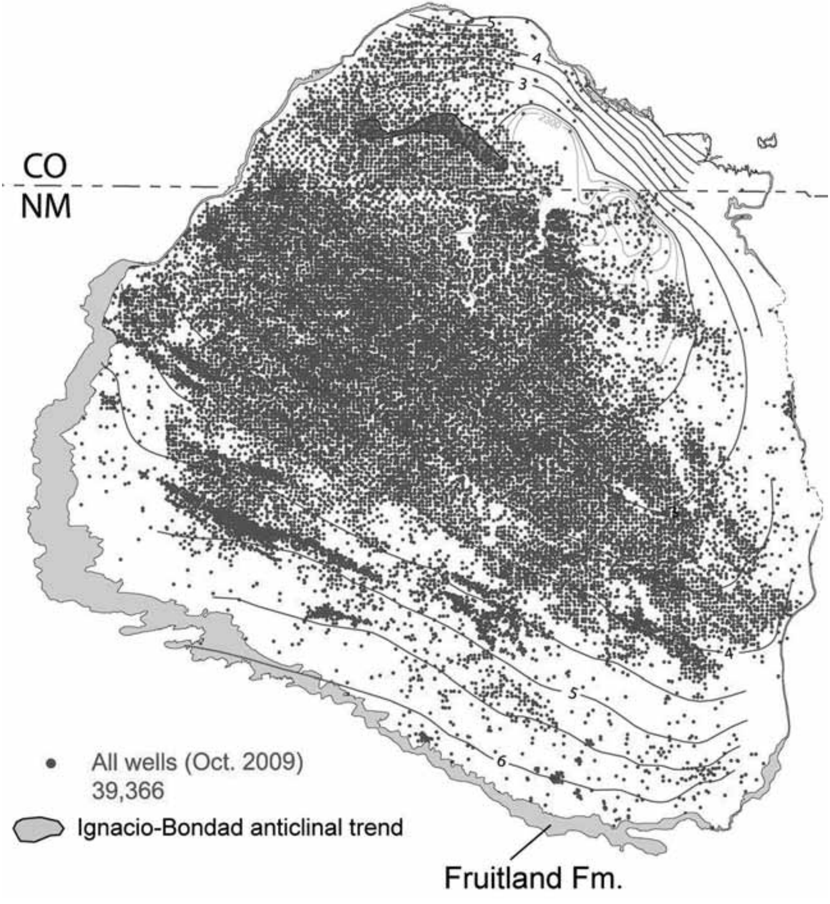


FIGURE 14.03. San Juan Basin Wells Drilled—October 2009.[12]

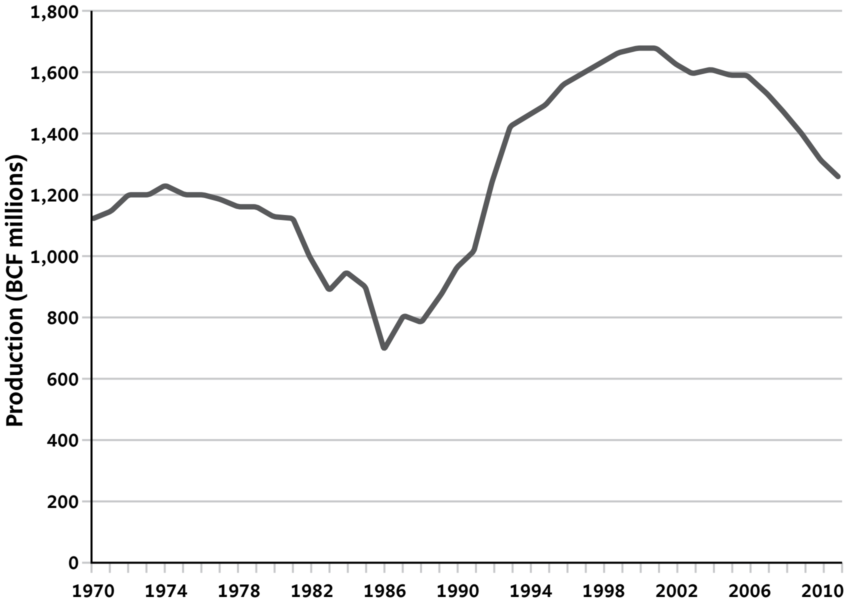


FIGURE 14.04. New Mexico Natural Gas Production 1970–2011.[15]

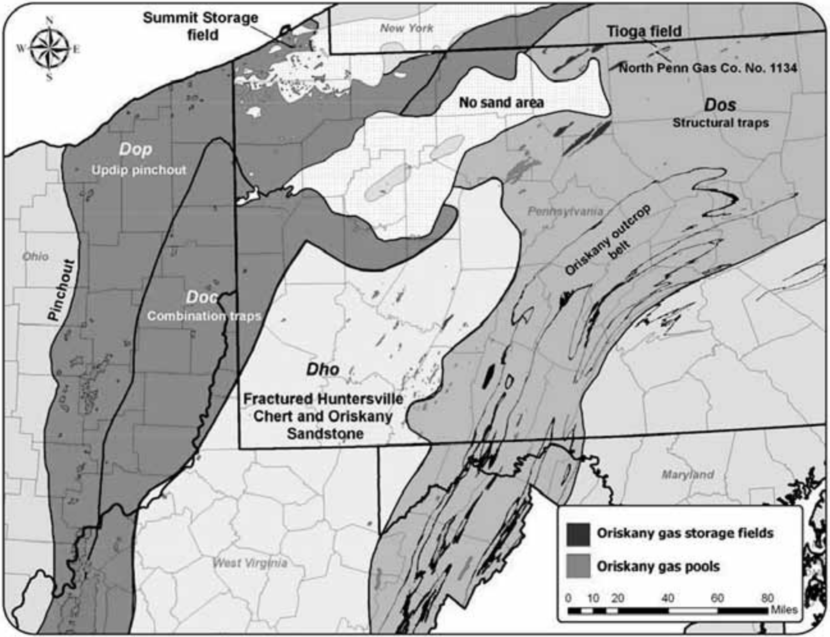


FIGURE 15.01. Map of the Oriskany Play.[7]

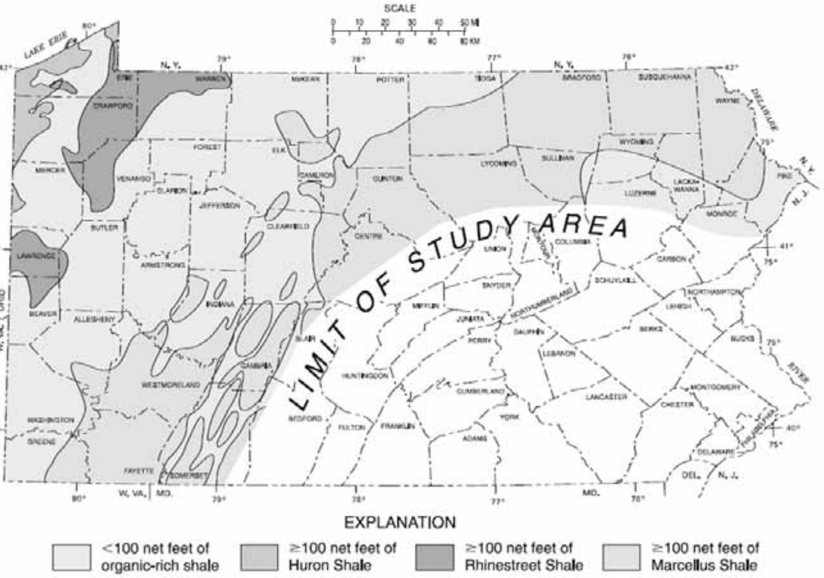


FIGURE 15.02. Distribution of Thickest Sequences of Shale.[9]

TABLE 15.01. Pennsylvania Annual Production 2000 thru mid-2012 in Billion Cubic Feet.[13]

Year	Conventional	Marcellus	Total
2000	NA	NA	150
2001	NA	NA	130
2002	NA	NA	157
2003	NA	NA	159
2004	NA	NA	197
2005	NA	NA	168
2006	NA	NA	175
2007	NA	NA	182
2008	NA	NA	185
2009	NA	NA	274
2010	NA	NA	573
2011	249	1,086	1,335
2012 (6 months)	NA	895	895

Source: EIA.

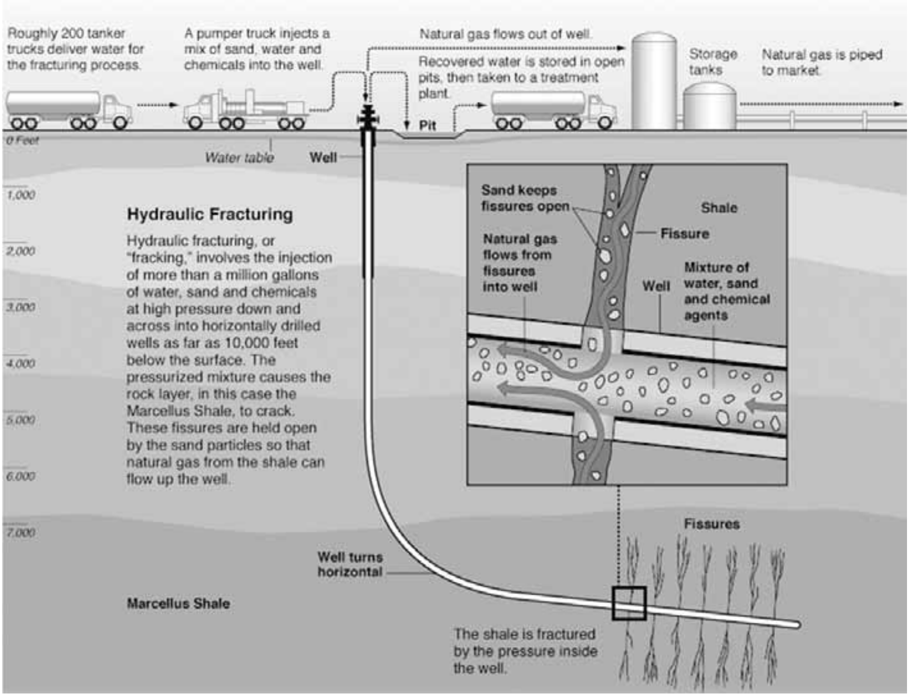


FIGURE 15.03. Hydraulic Fracturing Illustration.[17]

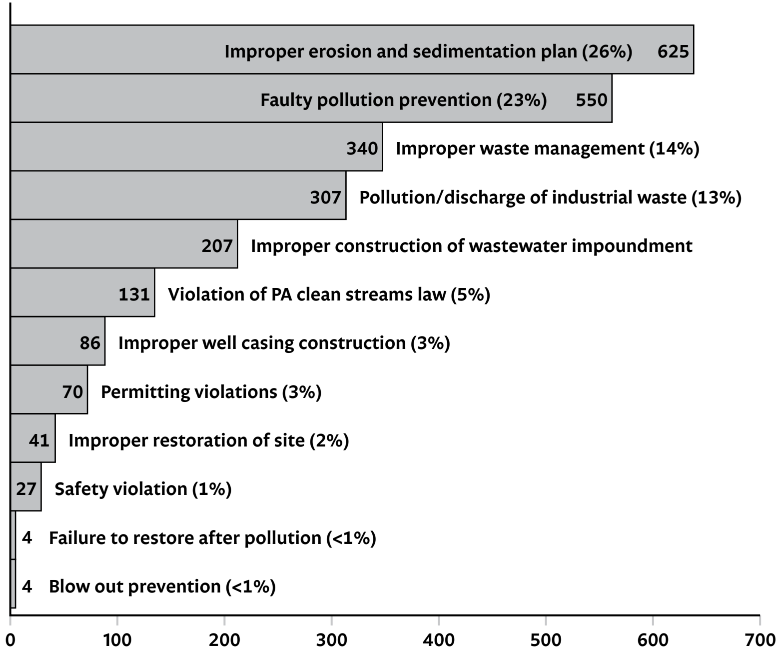


FIGURE 15.04. Environmental Violations by Category 2008–2011.[19]

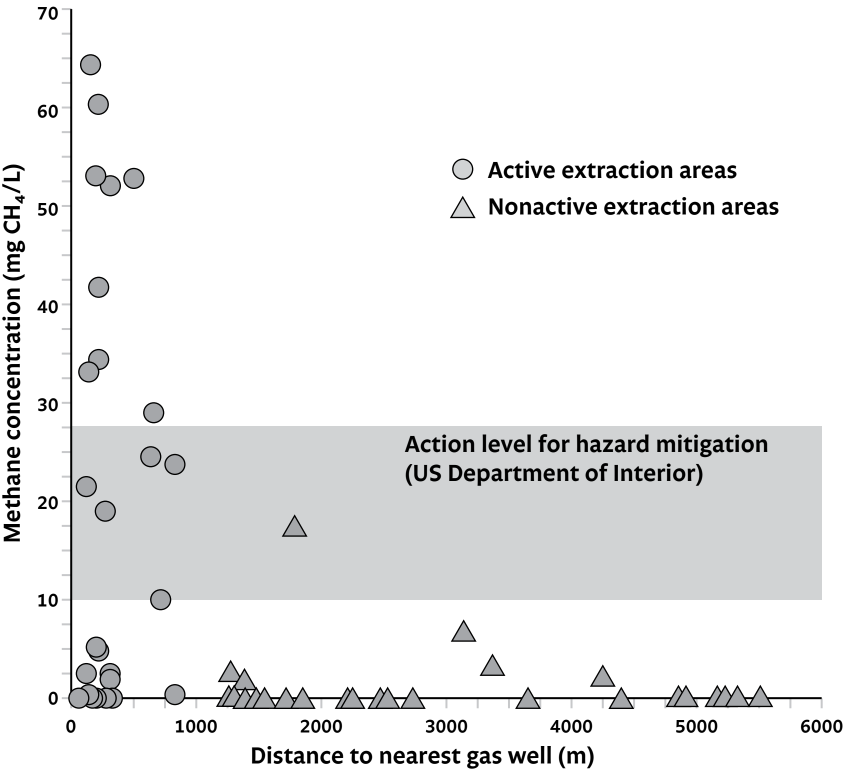


FIGURE 15.05. Methane Concentration Near Gas Wells.[26]

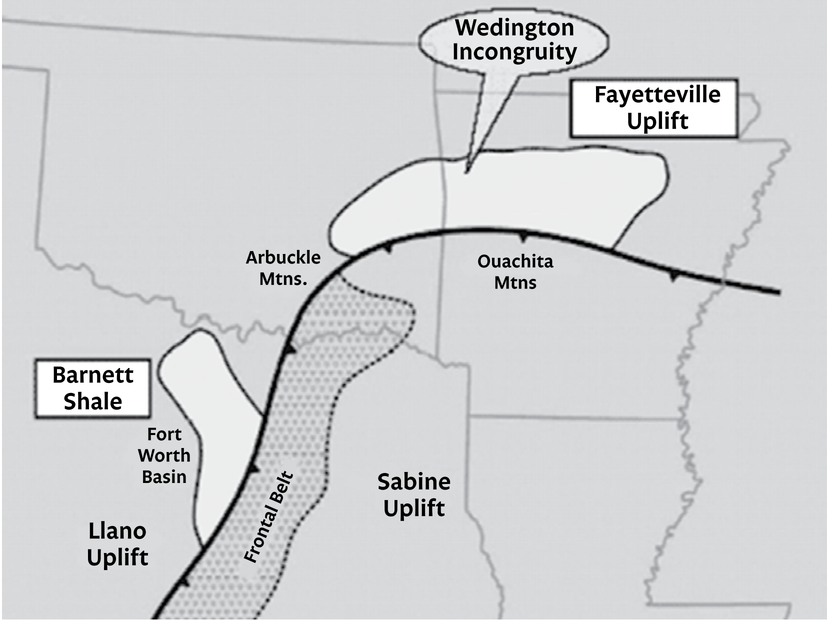


FIGURE 16.01. Map of the Weddington Incongruity.[3]

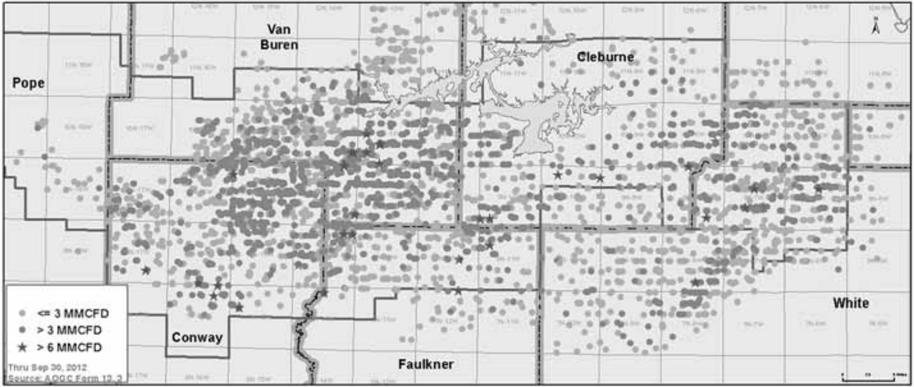


FIGURE 16.02. Southwestern Energy—Fayetteville Shale Focus Area.[6]

TABLE 16.01. Fayetteville Shale—Horizontal Well Performance.[13]

Time frame	Wells placed on production	Average IP rate (Mcf/d)	30th-day average rate (# of wells)	60th-day average rate (# of wells)	Average lateral length
1st Qtr 2007	58	1261	1066 (58)	958 (58)	2104
2nd Qtr 2007	46	1497	1254 (46)	1034 (46)	2512
3rd Qtr 2007	74	1769	1510 (72)	1334 (72)	2622
4th Qtr 2007	77	2027	1690 (77)	1481 (77)	3193
1st Qtr 2008	75	2343	2147 (75)	1943 (74)	3301
2nd Qtr 2008	83	2541	2155 (83)	1886 (83)	3562
3rd Qtr 2008	97	2882	2560 (97)	2349 (97)	3736
4th Qtr 2008[1]	74	3350[1]	2722 (74)	2386 (74)	3850
1st Qtr 2009[1]	120	2992[1]	2537 (120)	2293 (120)	3874
2nd Qtr 2009	111	3611	2833 (111)	2556 (111)	4123
3rd Qtr 2009	93	3604	2624 (93)	2255 (93)	4100
4th Qtr 2009	122	3727	2674 (122)	2360 (120)	4303
1st Qtr 2010[2]	106	3197[2]	2388 (106)	2123 (106)	4348
2nd Qtr 2010	143	3449	2554 (143)	2321 (142)	4532
3rd Qtr 2010	145	3281	2448 (145)	2202 (144)	4503
4th Qtr 2010	159	3472	2678 (159)	2294 (159)	4667
1st Qtr 2011	137	3231	2604 (137)	2238 (137)	4985
2nd Qtr 2011	149	3014	2328 (149)	1991 (149)	4839
3rd Qtr 2011	132	3441	2666 (132)	2372 (132)	4847
4th Qtr 2011	142	3646	2606 (142)	2243 (142)	4703
1st Qtr 2012	146	3319	2421 (146)	2131 (146)	4743
2nd Qtr 2012	131	3500	2454 (121)	2003 (77)	4840

Source: Southwestern Energy.

[1] The significant increase in the average initial production rate for the fourth quarter of 2008 and the subsequent decrease for the first quarter of 2009 primarily reflected the impact of the delay in the Boardwalk Pipeline.

[2] In the first quarter of 2010, the company's results were impacted by the shift of all wells to "green completions" and the mix of wells, as a large percentage of wells were placed on production in the shallower northern and far eastern borders of the company's acreage.

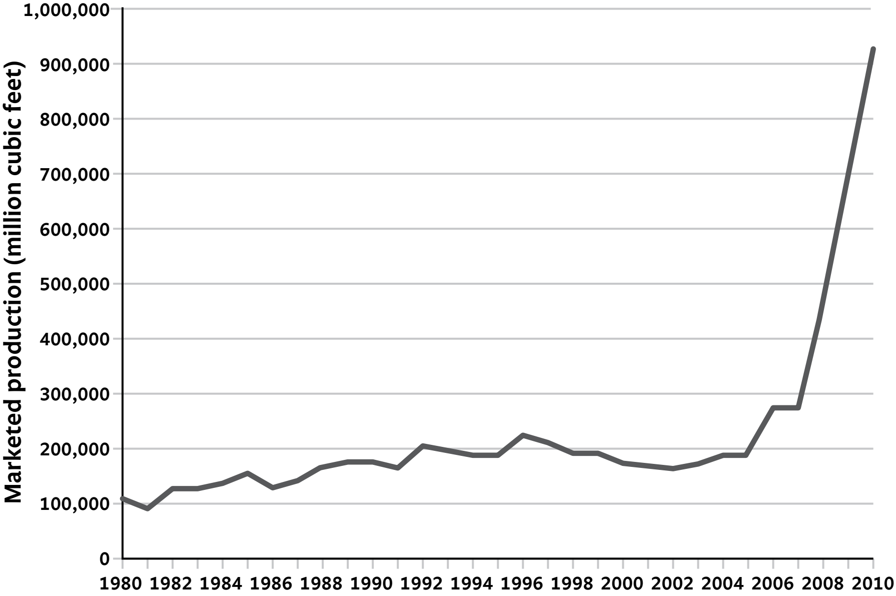


FIGURE 16.03. Arkansas Natural Gas Marketed Production (mmcf).[14]

TABLE 17.01. Canadian Daily NG Production 2001 to 2012.[3]

Year	Average daily production in bcf/d[1]	% Change from previous year
2001	16.56	NA
2002	16.69	+.01%
2003	16.12	–2.8%
2004	16.14	0%
2005	16.55	+2.5%
2006	16.60	0%
2007	16.17	–2.65%
2008	15.27	–5.6%
2009	14.22	–6.9%
2010	13.96	–1.8%
2011	14.05	+.01%
2012[2]	13.00	–7.5%

Source: Natural Resources Canada.

[1] Billion cubic feet per day.

[2] Author's estimate.

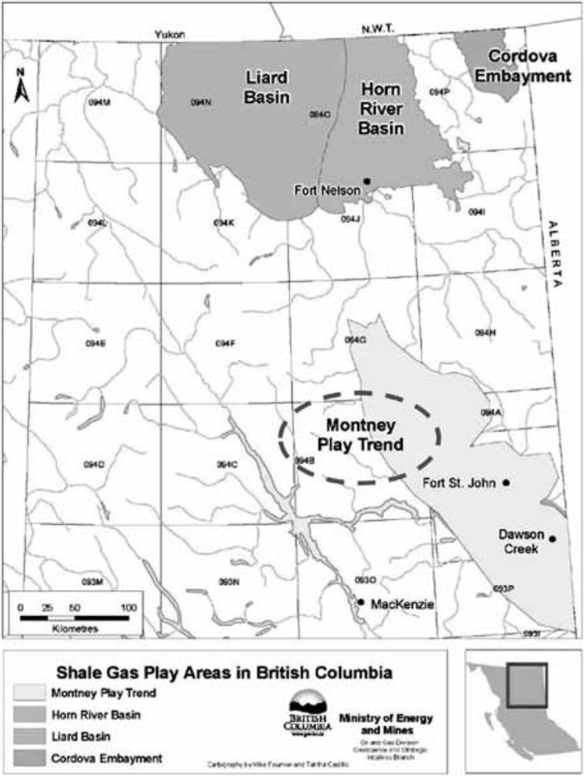
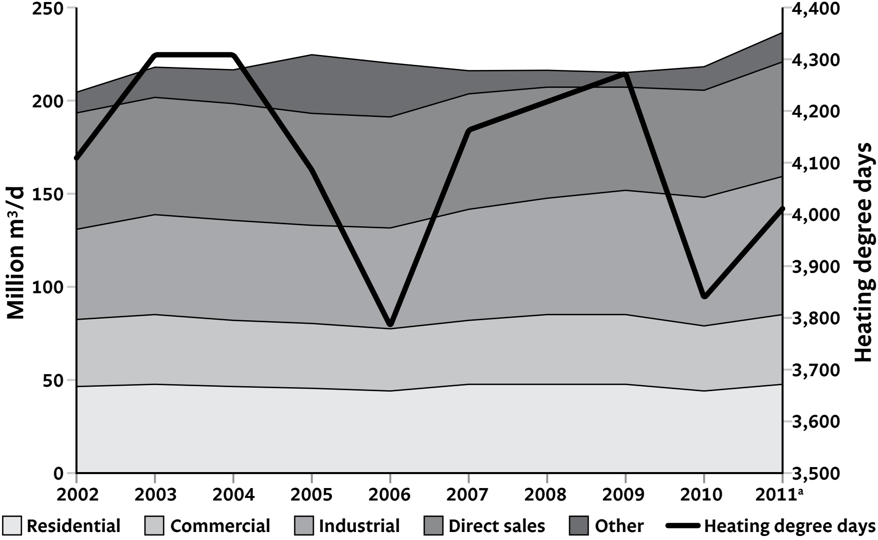


FIGURE 17.01. Map of Montney and the Horn River Basin.[4]



[a] Heating degree days (HDD) is an index calculated to reflect the demand for energy needed for heating homes, businesses, etc. HDD is the cumulative number of degrees in a year for which the mean temperature falls below 18.3 degrees C.

FIGURE 17.02. Canadian Natural Gas Demand by Sector.[7]

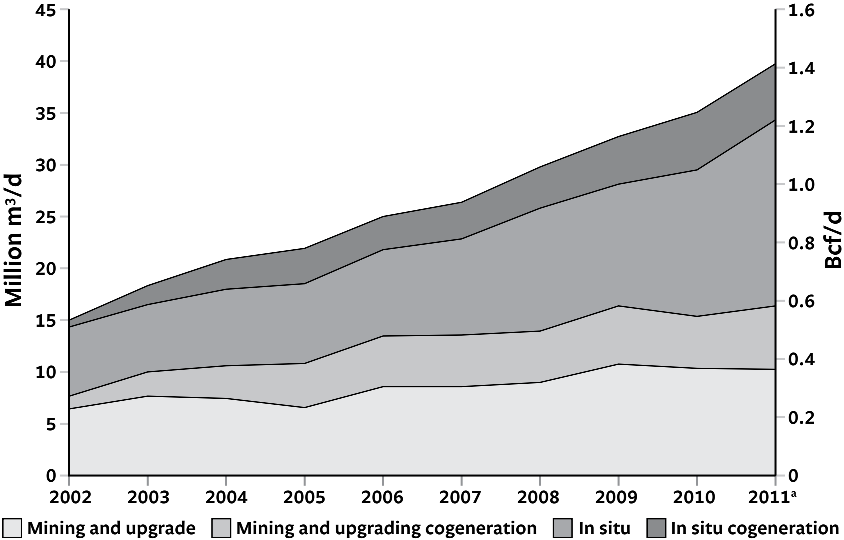


FIGURE 17.03. Average Annual Purchased Natural Gas Requirements for Oil Sands Operations.[10]

TABLE 17.02. Supply and Demand Flows 2012 and Projected 2015

	2012	**2015**
Supply		
Canadian production	13 bcf/d	11 bcf/d
Demand		
Oil sands	1.5 bcf/d	2 bcf/d
Rest of Canada demand	6.8 bcf/d	8 bcf/d
Net exports to US	4.7 bcf/d	0.3 bcf/d
LNG exports	0 bcf/d	0.7 bcf/d
Total	**13 bcf/d**	**11 bcf/d**

Source: Author's estimates.

TABLE 18.01. World's 10 Largest LNG Exporters in 2011.[7]

Country	LNG exports in tcf
Qatar	3.623
Malaysia	1.176
Indonesia	1.031
Australia	0.914
Nigeria	0.914
Trinidad and Tobago	0.667
Algeria	0.603
Russia	0.508
Oman	0.384
Brunei	0.331

Source: 2012 BP Statistical Review.

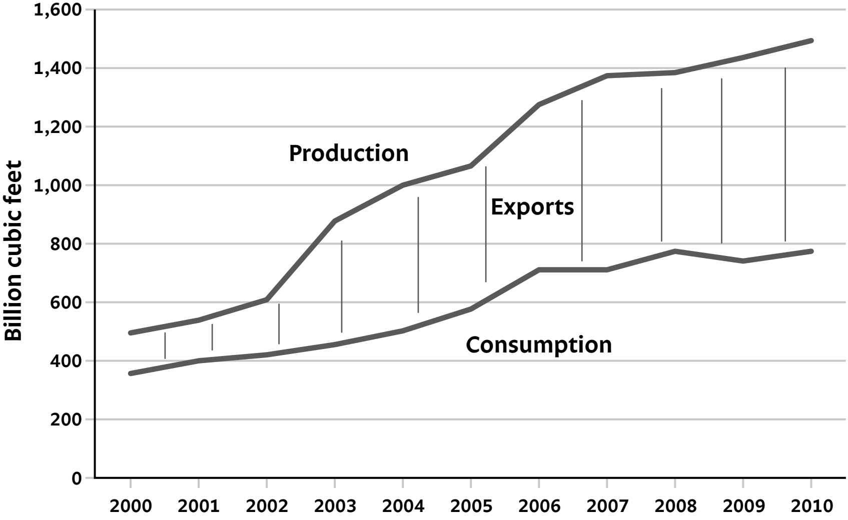


FIGURE 18.01. Natural Gas Production and Consumption Trinidad & Tobago, 2000–2010.[15]

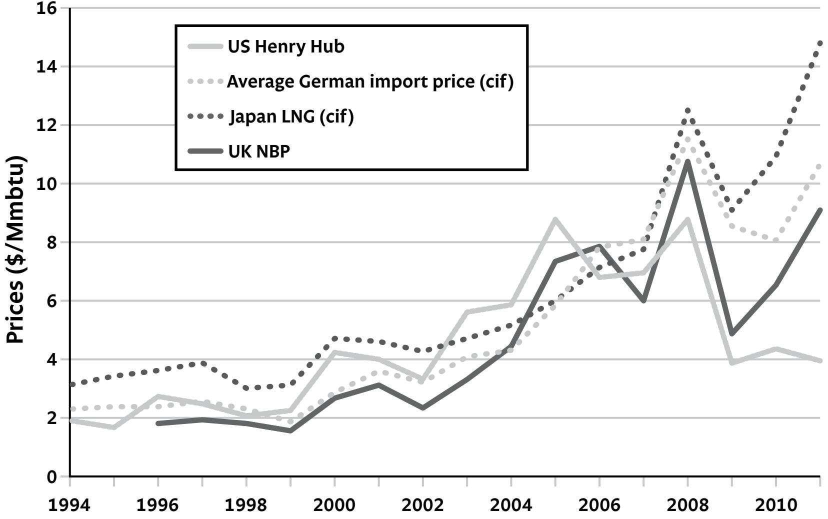


FIGURE 18.02. Natural Gas Prices $/Mmbtu.[26]

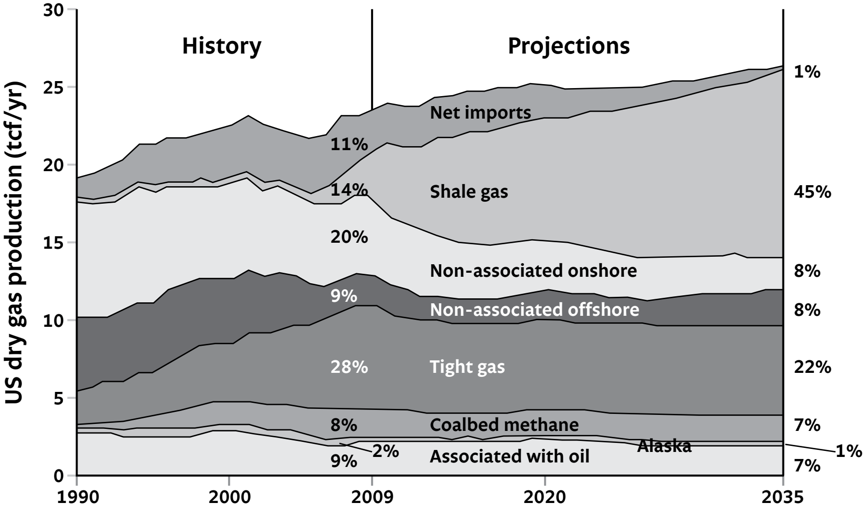


FIGURE 19.01. US Dry Gas Consumption by Production Type.[13]

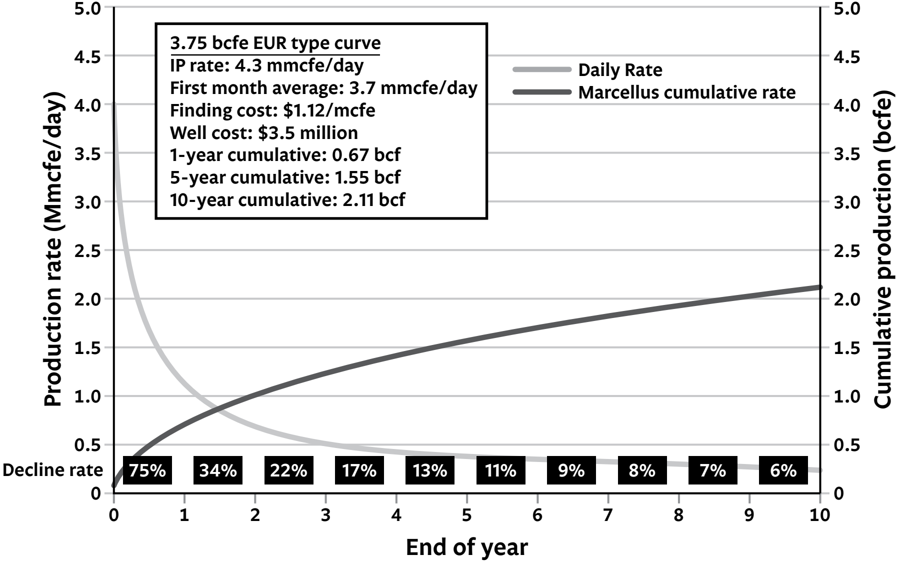


FIGURE 19.02. Marcellus Decline Curve and Estimated Ultimate Recoveries Example.[18]

TABLE 19.01. Intek Estimates of Underdeveloped Technically Recoverable Shale Gas and Shale Oil 1/1/2009.[19]

Onshore lower-48 oil and gas supply submodule region	Shale play	Shale gas resources (tcf)	Shale oil resources (bbls)
Northeast	Marcellus	410	–
	Antrim	20	–
	Devonian Low Thermal Maturity	14	–
	Great Siltstone	8	–
	Big Sandy	7	–
	Cincinnati Arch	1	–
Subtotal		472	–
Percent of total		63%	–
Gulf Coast	Haynesville	75	–
	Eagle Ford	21	3
	Floyd-Neal & Conasauga	4	–
Subtotal		100	3
Percent of total		13%	14%
Mid-Continent	Fayetteville	32	–
	Woodford	22	–
	Cana Woodford	6	–
Subtotal		60	–
Percent of total		8%	–
Southwest	Barnett	43	–
	Barnett-woodford	32	–
	Avalon & Bone Springs	–	2
Subtotal		76	2
Percent of total		10%	7%
Rocky Mountain	Mancos	21	–
	Lewis	12	–
	Williston-Shallow Niobraian	7	–
	Bakken	–	4
Subtotal		43	4
Percent of total		6%	15%
West Coast	Monterey/Santos	–	15
Subtotal		–	15
Percent of total		–	64%
Total onshore Lower-48 States		750	24

Note: From previous EIA estimates and thus not assessed in the INTEK shale report. Subtotals and total may not equal sum of components due to independent rounding.

TABLE 19.02. Marcellus Average EUR and Area.[29]

	Active	Undeveloped
Area (sq. miles)	10,622	84,271
EUR (Bcfe/well)	3.5	1.15
Well spacing (wells/sq. mile)	8	8
TRR (Tcf)	177.90	232.44

Gemasolar: how it works

1 Heliostats
Solar light is refl ected by the heliostats towards the receiver, located on top of the tower.

2 Tank 1
Molten salts, at 290ºC, are pumped from the cold molten salt tank to the receiver.

3 Tower
Inside the receiver, molten salts are heated up to 565ºC before being stored in the hot molten salt tank.

4 Tank 2
The hot molten salt tank keeps the energy accumulated in form of molten salts at very high temperature.

5 Steam Generator
The hot molten salts are delivered to the steam generation system, where they transfer their heat to the water, reducing their temperature.

6 Turbine
The heat transferred transforms the water into high pressure steam to move the turbine.

7 Electric Generator
The turbine powers the electric generator producing electrical energy.

8 Electrical Transformer
The electricity is delivered to a transformer to be injected into the distribution grid.

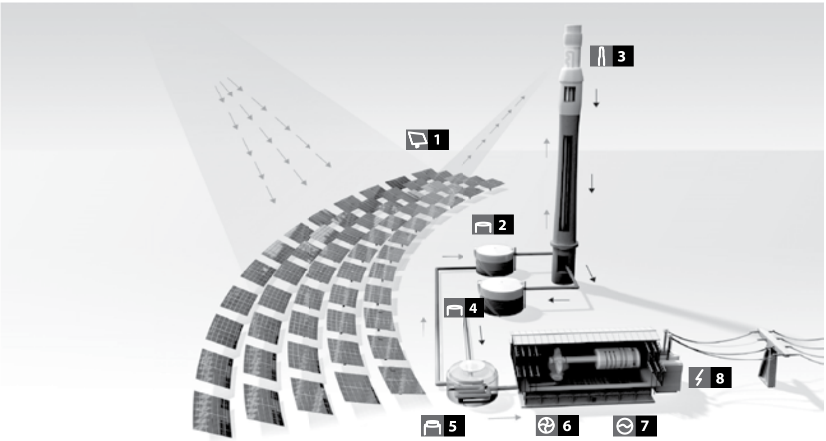


FIGURE 20.01. Gemasolar Technology Illustration.[11]

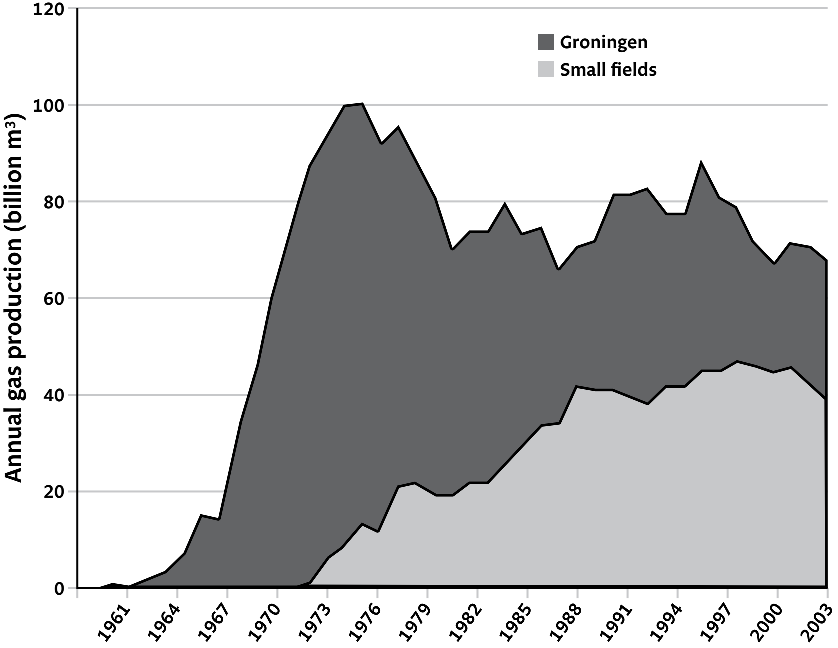


FIGURE 20.02. Annual Gas Production in the Netherlands in billion m^3.[24]

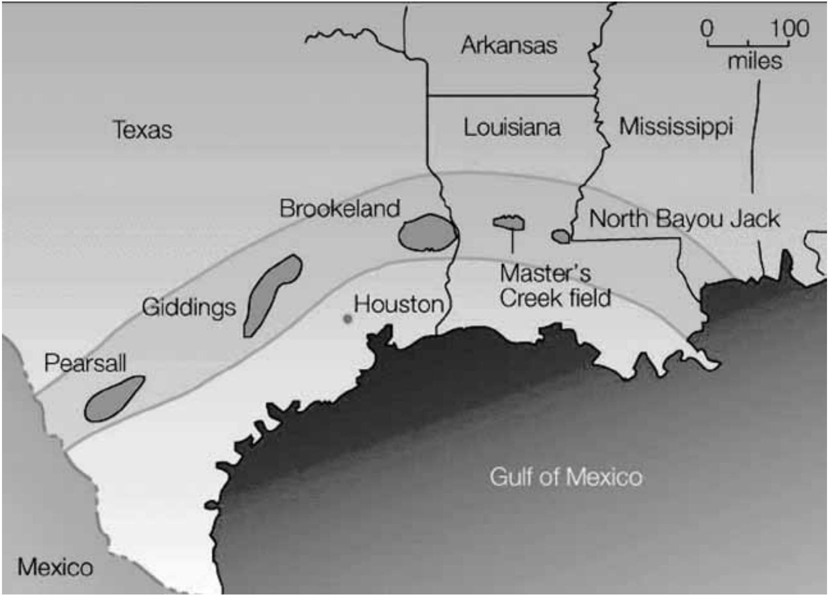


FIGURE 21.01. Map of Austin Chalk Play.[11]

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