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U.S. Energy Information Administration

Short-Term Energy Outlook Supplement: 2013 Outlook for Gulf of Mexico Hurricane-Related Production Outages

June 2013

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Highlights

- EIA's median estimates of storm-related production disruptions in U.S. Gulf of Mexico during the 2013 hurricane season are 19.3 million barrels (bbl) of crude oil and 46.4 billion cubic feet (Bcf) of natural gas. There is an equal chance that actual disruptions to production will prove to be higher or lower than these estimates. The mean estimates of disrupted volumes, 25.7 bbl for oil and 64.0 Bcf for natural gas take into account the relatively small probabilities of large disruptions.

- The EIA estimates are based on the National Oceanic and Atmospheric Administration's (NOAA) *Atlantic Hurricane Season Outlook*, which was released May 23. NOAA predicted that the Atlantic Basin likely will experience above-normal tropical weather during the 2013 hurricane season, which began June 1 and runs through November 30.

- NOAA estimated a 70-percent probability that 13 to 20 named storms will form within the Atlantic Basin over the next 6 months, including 7 to 11 hurricanes, of which 3 to 6 will be intense.[1] Tropical Storm Andrea, the first named storm of the season, appeared in early June, although typically the first storm develops in July.

- With the rapid growth in oil and natural gas production from onshore shale formations and other tight resources over the past several years, the share of total U.S. oil and natural gas production originating in the Gulf of Mexico has declined. The growing share of total production from inland areas has reduced the vulnerability of overall U.S. oil and natural gas supply to hurricanes.

- EIA's analysis shows a 58-percent probability of production shut-in volumes being equal to or larger than the production shut in during the 2012 hurricane season, which totaled 14.3 million bbl of crude oil and 32.1 Bcf of natural gas.

[1] A named storm generally refers to either a tropical storm or hurricane. An intense hurricane is one rated as Category 3, 4 or 5. A moderate hurricane is classified as either Category 1 or 2.

Expected Effects on Production in 2013

EIA's median estimates of storm-related production disruptions in U.S. Gulf of Mexico (GOM) during the 2013 hurricane season are 19.3 million barrels (bbl) of crude oil and 46.4 billion cubic feet (Bcf) of natural gas.

Forecasting storm damage is inherently difficult because a lot depends on how strong the storm is (categories 1-5) and the path it takes. Even a strong storm on the eastern seaboard likely won't disrupt GOM production, although it may wreak havoc for humans and businesses and temporarily reduce energy demand. On the other hand, a more moderate storm that barrels through the middle of the GOM and goes onshore along the Gulf Coast could cause significant harm to oil and natural gas production offshore as well as refineries, gas processing plants, and power generating stations onshore.

Also noteworthy is that the share of total U.S. oil and natural gas production originating in the GOM has declined sharply in recent years. As EIA recently reported, "in 1997, 26% of the nation's natural gas was produced in the federal Gulf of Mexico; in 2012, that number was 6%. The GOM share of crude oil production also has declined, from 26% in 2007-11 to 19% last year."[2]

Hurricane-related disruptions may usefully be considered in the context of overall demand and supply of hydrocarbons. EIA's median estimate of a potential shut-in of 19.3 million bbl of crude oil is about 25 percent more than just one day's crude oil input to refineries throughout the United States. For natural gas, the production shut-in of 46.4 Bcf in the Gulf would be 72 percent of one day's average production for the entire nation, and is less than half of the 111 Bcf that was injected into storage for the week ending May 31. Finally, the impact of any hurricane on energy markets can reflect its effects on demand, particularly if industrial operations and electrical systems are disrupted, as well as supply.

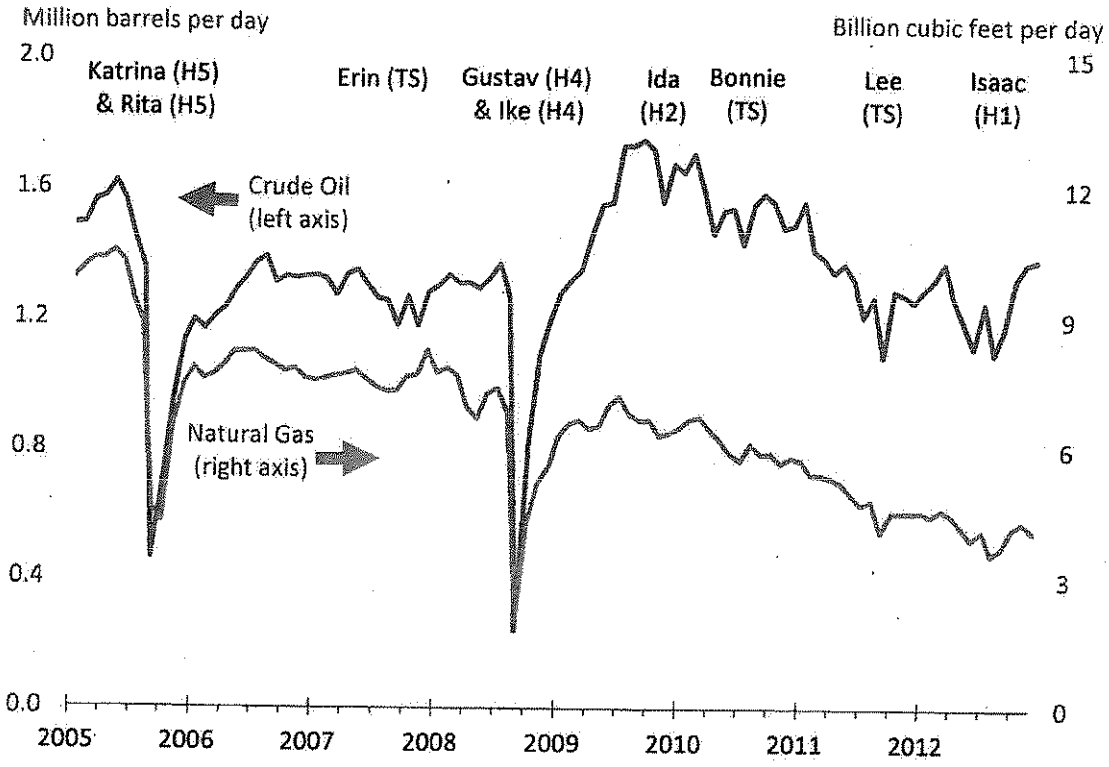
Lessons from the 2012 Hurricane Season

The Atlantic Basin experienced above-average hurricane activity during the 2012 hurricane season, consistent with NOAA's updated August 2012 *Outlook*. Nineteen named storms passed through the region, including 9 tropical storms and 10 hurricanes, of which 2 were classified as intense. NOAA's original projection in May 2012 had called for a near-normal hurricane season, but in August NOAA revised upwards its forecast to a likely range of 12 to 17 named storms, including 5 to 8 hurricanes.

Although 2012 hurricane activity in the entire Atlantic was above normal, storm activity in the GOM from June through November was relatively normal. Three tropical storms and two moderate hurricanes passed through the GOM. Two of these storms affected U.S. offshore Gulf energy production last year (Figure 1).

[2] EIA *Today in Energy*, May 31, 2013, "Hurricane effects on oil and natural gas production depend on storm trajectory, strength."

Figure 1. Crude oil and natural gas production in the Federal Offshore Gulf of Mexico and the impact of selected hurricanes and tropical storms, 2005-2012



Note: TS = Tropical Storm. Hn = Category n hurricane.
Source: U.S. Energy Information Administration and National Oceanic and Atmospheric Administration (NOAA).

The first, Tropical Storm Debby, began as a minor weather disturbance on the Yucatan Peninsula and eventually achieved tropical-storm status in middle of the Gulf in late June 2012. The storm headed northeastward, making landfall along the northwest coast of the Florida Peninsula. According to the Department of Interior's Bureau of Safety and Environmental Enforcement (BSEE), 1.3 million bbl of crude oil and 3.9 Bcf of natural gas were shut in by Debby, representing 2.7 percent of normal monthly Gulf crude oil and natural gas production.

The second storm affecting offshore production occurred in late August, when the disturbance that would eventually become Hurricane Isaac formed east of the Lesser Antilles. After traveling west-northwest for a week, it eventually passed directly over the Gulf production region and made landfall in Louisiana at the mouth of the Mississippi River. BSEE reported that 13 million bbl of crude oil production (33 percent of normal monthly production) and 28.2 Bcf of natural gas production (21 percent of normal) were shut in by Isaac.

The most destructive storm of the 2012 season was Hurricane Sandy. Although this storm did not shut in hydrocarbon production in the GOM, it caused significant disruptions to distribution of petroleum

products throughout the northeastern United States. In addition, electric power service was knocked out for more than eight million customers.

Methodology for Estimating Shut-in Production

EIA's projections for shut-in production during the 2013 hurricane season were derived using Monte Carlo simulation techniques. Based on information from the latest NOAA seasonal hurricane outlook and an analysis of the production impact from past tropical storms and hurricanes, EIA simulated the sampling distributions for seasonal shut-in crude oil and natural gas production.[3]

The Monte Carlo simulation used for this analysis consisted of two steps: first, EIA simulated the number of severe storms passing through the GOM, and, second, EIA developed a simulated estimate of shut-in production for each simulated storm. The numbers of tropical storms, moderate hurricanes, and intense hurricanes passing through the GOM were modeled using information contained in NOAA's *Atlantic Basin Hurricane Season Outlook*. The outlook's projected ranges for the entire Atlantic compare with a seasonal average of 11.8 named storms, 6.4 total hurricanes, and 2.7 intense hurricanes during NOAA's baseline period of 1981-2010. During the same period, the GOM had an average of 3.9 named storms, including an average of 1.9 hurricanes, with 0.7 considered intense.[4] EIA's simulation assumed that the likelihood of the number of each type of storm passing through the GOM could be modeled as a Poisson distribution. The assumed mean of each distribution was calculated by multiplying the average number of each type of Gulf storm by the ratio between the midpoints of NOAA's projected seasonal range for the number of each type of storm and the average number of storms in the Atlantic Basin.

The second step of the Monte Carlo simulation involved modeling the shut-in production caused by each simulated tropical storm or hurricane and aggregating the values to calculate a cumulative seasonal outage. EIA's model simulated the proportion of shut-in production compared with normal monthly production based on how tropical storms and hurricanes affected production in the past, where normal is defined as the average monthly production during the January to May period preceding each year's hurricane season. Simulated relative shut-in percentages were then multiplied by the average of EIA's estimates of monthly Gulf crude oil or natural gas production during January to May of 2013 to calculate a simulated level of cumulative shut-in production caused by each storm.

[3] In some cases EIA estimated the impact to offshore production of past hurricanes or tropical storms for which BSEE does not have historical shut-in reports. See *The 2007 Outlook for Hurricane Impacts on Gulf of Mexico Crude Oil & Natural Gas Production* for information about the outage estimation methodology.

[4] The mean number of storms was calculated by EIA using NOAA's HURDAT database. A storm was classified as a Gulf storm if it entered the area bounded by 18°N – 31° N latitude and 81° W – 98° W longitude.

Table 1. Shut-in production as a percentage of normal monthly production by type of weather system, 1995-2012

	Crude Oil		Natural Gas	
	Mean	Std Dev	Mean	Std Dev
Tropical Storm	1.38%	1.97	0.88%	1.19
Moderate Hurricane [a]	4.26%	7.26	2.68%	4.55
Intense Hurricane [b]	28.44%	39.36	25.00%	35.64

Notes: [a] Category 1 or 2. [b] Category 3, 4, or 5. Std Dev = standard deviation.
Source: U.S. Energy Information Administration calculations.

The simulated outage for each storm was assumed to be normally distributed, with a mean and standard deviation as shown in Table 1. These percentage outage statistics were calculated from EIA's estimates for the amount of production shut in by each storm over the period 1995-2012 (see Table A1 in the Appendix). The mean relative outages illustrate how weather-related production impacts increase dramatically with the severity of the storm. The mean value for intense hurricanes was skewed by the 100 million bbl of crude oil and 500 Bcf of natural gas cumulative production shut in by hurricanes Katrina and Rita during 2005. The large standard deviation values imply that extreme events such as Katrina and Rita are relatively rare. For this analysis, any negative simulated shut-in values were assumed to represent zero production impact.

EIA conducted 10,000 random draws of the Monte Carlo simulation to build sampling distributions of seasonal shut-in crude oil or natural gas production within the Gulf of Mexico. Crude oil outages and natural gas outages were simulated separately. Table 2 summarizes the expected levels of seasonal production outages derived from the sampling distributions along with the estimated probabilities of various shut-in production scenarios. The extreme asymmetry of the two sampling distributions is evident in the large difference between the mean and median values. The mean value of a sampling distribution represents the simple average of all possible outcomes. The median value is that outcome that has an equal probability, 50 percent, of either falling below or exceeding the outcome value.

Table 2. Simulated cumulative seasonal shut-in production

Crude Oil (million barrels)		Natural Gas (billion cubic feet)	
Mean 2013 seasonal outage	25.7	Mean 2013 seasonal outage	64.0
Median 2013 seasonal outage	19.3	Median 2013 seasonal outage	46.4
Median normal seasonal outage	7.4	Median normal seasonal outage	14.4

2013 Outage Scenario Probabilities		2013 Outage Scenario Probabilities	
P(No Shut-In)	0.0111	P(No Shut-In)	0.0105
P(> 15 MMbbl Shut-in)	0.5690	P(> 50 Bcf Shut-in)	0.4800
P(> 25 MMbbl Shut-in)	0.4160	P(> 100 Bcf Shut-in)	0.2390
P(> 50 MMbbl Shut-in)	0.1490	P(> 150 Bcf Shut-in)	0.0990

Notes: MMbbl = million barrels, Bcf = billion cubic feet. More complete scenario probability tables are shown in Tables A2 and A3 in the Appendix.
Source: U.S. Energy Information Administration calculations.

For crude oil, the median level of simulated cumulative shut-in production is 19.3 million bbl, in contrast to a mean of 25.7 million bbl. For natural gas, the median shut-in production level is 46.4 Bcf, in contrast to the mean of 64.0 Bcf. This skewness occurs because the simulation allows for the possibility of another season like 2005. Given that such outcomes represent outliers and the vast majority of simulated outages are comparatively low, the median statistic is a better representation of projected levels of shut-in production. Table 2 also shows the median outages for a simulated normal season in which the assumed mean values for Poisson distributions modeling the occurrence of each type of storm are equal to their average historical values over the period 1981-2010. EIA's projected median outages of 19.3 million bbl of crude oil and 46.4 Bcf of natural gas for the 2013 hurricane season are significantly higher than the simulated outages expected during a normal hurricane season.

The sampling distributions derived from the Monte Carlo simulation also allow analysis of other possible outage scenarios besides the median value. Table 2 lists some of the probabilities of exceeding certain levels of shut-in production during the 2013 season. More complete scenario probabilities are shown in Tables A2 and A3 in the Appendix, along with comparable probabilities during a normal season. During the 2012 season, Gulf of Mexico energy producers shut in a cumulative total of 14.3 million bbl of crude oil and 32.1 Bcf of natural gas, according to BSEE. The Monte Carlo simulation results indicate that the likelihood of experiencing similar disruptions as last year or worse during the 2013 season is 58 percent.

It is important to stress the high degree of uncertainty surrounding EIA's expected median level of shut-in production. The simulated cumulative probability distribution functions can be used to construct various likely ranges for production outages in the Gulf of Mexico. For example, there is a 70-percent probability that shut-in offshore production for the entire season will fall between 4 million and 50 million bbl of crude oil and between 8 and 127 Bcf of natural gas. Constructing intervals with a higher likelihood would widen the gap even further.

The seasonal outages simulated in this analysis are conditioned on NOAA's projections of the number of storms expected to form within the Atlantic Basin. The *Atlantic Hurricane Season Outlook* issued by NOAA at this time last year projected a near-normal number of hurricanes and tropical storms. As the season progressed, it became evident that hurricane activity was greater than expected, and NOAA revised its *Outlook* in August to an above-normal designation. Long-range forecasts of hurricane activity are difficult to project, especially with regard to particular oceanic regions. If hurricane activity over the next few weeks shows signs of a season that is even more active than NOAA initially projected, then the likelihood of the various levels of shut-in production would need to be revised upward.

Appendix

Table A 1. Shut-in production caused by selected Gulf of Mexico tropical storms and hurricanes, 1995-2012

			Reported and Estimated Shut-in Production [c]			
		Maximum	Crude Oil		Natural Gas	
Name	Date	Category [a]	(Mbbl)	% of Normal	(Bcf)	% of Normal
Allison	Jun 1995	1	624	2.2	0.33	0.1
Dean	Jul 1995	0	189	0.7	4.03	1.0
Erin	Aug 1995	1	1,529	5.4	15.45	3.9
Gabrielle	Aug 1995	0	490	1.7	4.94	1.2
Jerry	Aug 1995	0	67	0.2	0.68	0.2
Opal	Oct 1995	4	2,089	7.3	24.30	6.1
Roxanne	Oct 1995	3	1,459	5.2	17.39	4.3
Dolly	Aug 1996	1	0	0.0	0	0
Josephine	Oct 1996	0	821	2.7	7.76	1.9
Lili	Oct 1996	2	634	2.1	5.99	1.4
Marco	Nov 1996	0	0	0.0	1.75	0.4
Danny	Jul 1997	1	990	3.1	6.31	1.5
Charley	Aug 1998	0	0	0.0	0	0
Earl	Sep 1998	2	3,764	9.9	27.47	6.4
Frances	Sep 1998	0	787	2.1	5.74	1.3
Georges	Sep 1998	2	7,694	20.3	56.14	13.1
Hermine	Sep 1998	0	1,337	3.5	9.75	2.2
Mitch	Nov 1998	0	1,481	3.8	0.04	0.0
Bret	Aug 1999	4	1,723	4.4	5.67	1.3
Harvey	Sep 1999	0	764	1.9	5.17	1.2
Irene	Oct 1999	1	281	0.7	3.95	0.9
Beryl	Aug 2000	0	0	0.0	0.85	0.2
Gordon	Sep 2000	1	0	0.0	0.50	0.1
Helene	Sep 2000	0	0	0.0	0.35	0.1
Keith	Oct 2000	1	421	1.0	0	0
Allison	Jun 2001	0	991	2.2	7.15	1.7
Barry	Aug 2001	0	2,388	5.2	11.95	2.8
Chantal	Aug 2001	0	381	0.8	1.91	0.4
Gabrielle	Sep 2001	0	0	0.0	0	0
Michelle	Nov 2001	4	1,085	2.4	8.63	2.0

See notes at end of table.

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Table A 1. Shut-in production caused by selected Gulf of Mexico tropical storms and hurricanes, 1995-2012, continued.

			Reported and Estimated Shut-in Production			
		Maximum	Crude Oil		Natural Gas	
Name	Date	Category [a]	Mbbl	% of Normal [b]	Bcf	% of Normal [b]
Bertha	Aug 2002	0	0	0.0	0	0
Edouard	Sep 2002	0	5	0.0	0.03	0.0
Fay	Sep 2002	0	220	0.5	1.34	0.3
Hanna	Sep 2002	0	276	0.6	1.69	0.4
Isidore	Sep 2002	3	4,500	9.2	27.50	7.1
Lili	Oct 2002	4	9,900	20.2	61.50	16.0
Bill	Jul 2003	0	72	0.0	0.61	0.2
Claudette	Jul 2003	1	1,265	2.7	8.04	2.2
Erika	Aug 2003	1	10	0.0	0.33	0.1
Grace	Aug 2003	0	2	0.0	0.08	0.0
Henri	Sep 2003	0	392	0.8	1.88	0.5
Larry	Oct 2003	0	160	0.3	0	0
Bonnie	Aug 2004	0	699	1.5	4.10	1.2
Charley	Aug 2004	4	556	1.2	3.27	0.9
Frances	Sep 2004	0	62	0.1	0.12	0.0
Ivan	Sep 2004	5	38,005	82.8	150.71	42.3
Jeanne	Sep 2004	1	85	0.2	0.34	0.1
Matthew	Oct 2004	0	9	0.0	0.11	0.0
Arlene	Jun 2005	0	575	1.3	3.43	1.2
Bret	Jun 2005	0	33	0.1	0.20	0.1
Cindy	Jul 2005	1	312	0.7	1.68	0.6
Dennis	Jul 2005	4	5,297	11.7	23.25	7.6
Emily	Jul 2005	4	240	0.5	1.58	0.5
Gert	Jul 2005	0	17	0.0	0.09	0.0
Jose	Aug 2005	0	161	0.3	0.83	0.3
Katrina	Aug 2005	5	30,248	64.8	155.33	50.5
Rita	Sep 2005	5	70,476	150.5	361.91	116.2
Stan	Oct 2005	1	693	1.5	4.13	1.3
Tammy	Oct 2005	0	62	0.1	0.37	0.1
Wilma	Oct 2005	4	8,052	17.3	43.54	13.9
Alberto	Jun 2006	0	144	0.4	0.22	0.1
Barry	Jun 2007	0	85	0.2	0	0
Dean	Aug 2007	5	441	0.4	0.44	0.2
Erin	Aug 2007	0	3	0.0	0.02	0.0
Humberto	Sep 2007	1	1,353	5.9	2.47	1.0
Ten [c]	Sep 2007	[c]	2,831	7.1	7.81	3.3

See notes at end of table.

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Table A 1. Shut-in production caused by selected Gulf of Mexico tropical storms and hurricanes, 1995-2012, continued.

			Reported and Estimated Shut-in Production			
			Crude Oil		Natural Gas	
Name	Date	Maximum Category [a]	Mbbl	% of Normal [b]	Bcf	% of Normal [b]
Dolly	Jul 2008	2	137	0.4	1.42	0.6
Edouard	Aug 2008	0	127	0.3	11.23	4.8
Gustav	Sep 2008	4	38,938	97.7	219.92	95.5
Ike	Sep 2008	4	21,531	54.0	121.60	52.8
Claudette	Aug 2009	0	295	0.7	6.22	3.3
Ida	Nov 2009	2	1,375	2.9	4.60	2.2
Alex	Jun 2010	2	1,038	2.1	1.62	0.8
Bonnie	Jul 2010	0	3,261	6.8	6.32	3.2
Hermine	Sep 2010	0	0	0	0	0
Don	Jul 2011	0	530	1.2	1.01	0.6
Lee	Sep 2011	0	4,950	11.5	13.29	8.0
Debby	Jun 2012	0	1,324	2.7	3.9	2.8
Isaac	Aug 2012	1	13,016	33.1	28.16	20.5

Source: Storm information from NOAA. Shut-in production from BSEE shut-in statistics reports for available storms, otherwise EIA estimates of shut-in production (see *The 2007 Outlook for Hurricane Impacts on Gulf of Mexico Crude Oil & Natural Gas Production* for estimation methodology)

Notes: [a] 0 = Tropical storm. 1-5 = Category n hurricane. Mbbls = thousand barrels.

[b] Normal production is defined as average monthly production during the January to May period preceding the given hurricane season.

[c] Storm was classified as a tropical depression.

Table A 2. Simulated probabilities for exceeding various levels of seasonal shut-in Gulf of Mexico crude oil production

	Probability of Shut-in Production	
> Million Barrels	2013 Season	Normal Season
0.0	98.9%	94.3%
0.5	98.2%	91.5%
1.0	96.8%	87.7%
1.5	95.2%	83.4%
2.0	93.4%	79.4%
2.5	91.5%	75.5%
3.0	89.5%	71.8%
3.5	87.6%	68.3%
4.0	85.5%	65.4%
4.5	83.5%	62.7%
5	81.7%	59.9%
6	78.2%	55.3%
7	75.1%	51.7%
8	72.3%	48.3%
9	69.3%	45.3%
10	66.8%	42.6%
11	64.6%	40.4%
12	62.5%	38.5%
13	60.4%	36.8%
14	58.6%	35.2%
15	56.9%	33.9%
16	55.1%	32.6%
17	53.6%	31.0%
18	52.1%	29.6%
19	50.4%	28.4%
20	49.1%	27.3%
25	41.6%	21.8%
30	34.9%	17.1%
35	28.7%	12.9%
40	23.3%	9.4%
45	18.9%	6.8%
50	14.9%	4.9%
60	8.9%	2.7%
70	5.2%	1.4%
80	2.9%	0.6%
90	1.7%	0.3%
100	1.0%	0.1%

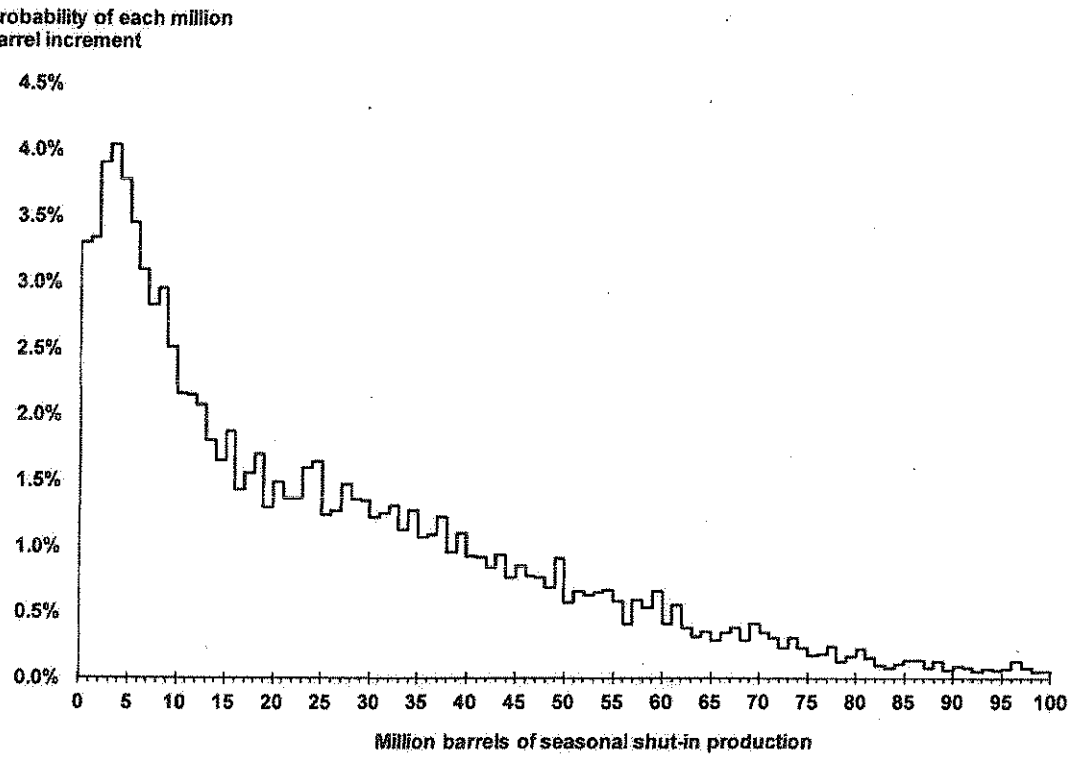
Source: U.S. Energy Information Administration calculations.

Table A 3. Simulated probabilities for exceeding various levels of seasonal shut-in Gulf of Mexico natural gas production

	Probability of Shut-in Production	
> Billion Cubic Feet	2013 Season	Normal Season
0	99.0%	94.1%
1	98.0%	91.5%
2	96.8%	87.4%
3	94.7%	83.2%
4	92.9%	78.9%
5	91.1%	74.9%
6	89.1%	71.3%
7	87.1%	68.0%
8	85.4%	64.6%
9	83.6%	61.6%
10	81.9%	59.1%
15	73.6%	49.1%
20	67.4%	43.3%
25	63.0%	39.1%
30	59.3%	36.3%
35	56.2%	34.0%
40	53.2%	31.8%
45	50.9%	29.6%
50	48.0%	27.6%
75	35.3%	17.6%
100	23.9%	10.2%
125	15.6%	5.9%
150	9.9%	3.3%
175	6.1%	1.7%
200	3.6%	1.0%
225	2.1%	0.6%
250	1.3%	0.3%
275	0.7%	0.2%
300	0.5%	0.1%
325	0.3%	0.1%
350	0.2%	0.1%
400	0.1%	0.1%

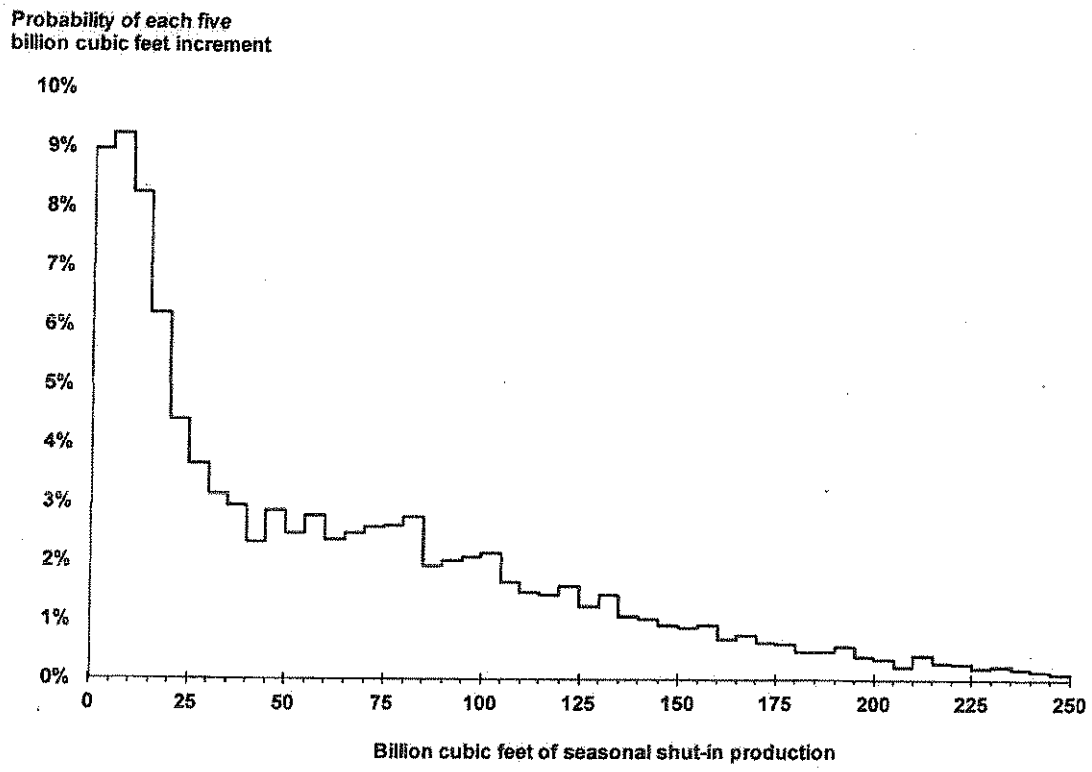
Source: U.S. Energy Information Administration calculations.

Figure A 1. Simulated probability distribution curve for seasonal Gulf of Mexico crude oil production outages



Source: U.S. Energy Information Administration calculations.
Note: Chart shows a histogram of the results of EIA's Monte Carlo simulation for shut-in crude oil production in the Gulf of Mexico. The probability of various ranges of shut-in production can be calculated by summing the probability values for each million-barrel increment within the range. The chart is not intended for projecting the probability of any single level of shut-in production, which is theoretically infinitesimal.

Figure A 2. Simulated probability distribution curve for seasonal Gulf of Mexico natural gas production outages



Source: U.S. Energy Information Administration calculations.
Note: Chart shows a histogram of the results of EIA's Monte Carlo simulation for shut-in natural gas production in the Gulf of Mexico. The probability of various ranges of shut-in production can be calculated by summing the probability values for each billion-cubic-feet increment within the range. The chart is not intended for projecting the probability of any single level of shut-in production, which is theoretically infinitesimal.