Independent Statistics & Analysis
U.S. Energy Information Administration

Short-Term Energy Outlook Supplement: 2014 Outlook for Gulf of Mexico Hurricane-Related Production Outages

June 2014

Independent Statistics & Analysis
www.eia.gov

U.S. Department of Energy
Washington, DC 20585

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Highlights

- EIA's mean estimate of storm-related production disruptions in the U.S. Gulf of Mexico during the 2014 hurricane season are 11.6 million barrels (bbl) of crude oil and 29.7 billion cubic feet (Bcf) of natural gas.

- The EIA estimates are based on the National Oceanic and Atmospheric Administration's (NOAA) *Atlantic Hurricane Season Outlook*, which was released May 22. NOAA predicted that the Atlantic Basin likely will experience near-normal or below-normal tropical weather during the 2014 hurricane season, which began June 1 and runs through November 30.

- NOAA expects that 8 to 13 named storms are likely to form within the Atlantic Basin[1] over the next 6 months, including 3 to 6 hurricanes, of which 1 to 2 will be intense.[2] Last season, the Atlantic Basin experienced 11 tropical storms and 2 hurricanes, neither of which was considered major. Four of the tropical storms and one of the hurricanes passed through the Gulf of Mexico. NOAA does not attempt to predict the location of any hurricane activity within the Atlantic Basin.

- The share of total U.S. oil and natural gas production originating in the federally-administered Gulf of Mexico has declined sharply. In 1997, 26% of the nation's natural gas was produced in the Gulf of Mexico; by 2013, that share had declined to 5%. The share of crude oil produced in the Gulf of Mexico also has declined in recent years, from 27% in 2003 to 17% last year. The declining share of total production from offshore areas has reduced the vulnerability of overall U.S. oil and natural gas supply to hurricanes.

- EIA's analysis estimates a 69% probability of production shut-in volumes being equal to or larger than the production shut in during the 2013 hurricane season, which totaled 3.1 million bbl of crude oil and 6.7 Bcf of natural gas.

[1] The Atlantic Basin includes the Atlantic Ocean in the northern hemisphere, the Caribbean Sea, and the Gulf of Mexico.

[2] A named storm generally refers to either a tropical storm or hurricane. A tropical storm has winds ranging from 39 to 73 miles per hour. Moderate hurricanes (classified as either Category 1 or 2) have winds ranging from 74 to 110 mph. An intense hurricane (classified as Category 3, 4 or 5) has winds in excess of 111 mph.

Expected Effects on Production in 2014

The mean estimates of EIA's simulated storm-related production disruptions in U.S. federally-administered Gulf of Mexico (GOM) during the 2014 hurricane season are 11.6 million bbl of crude oil and 29.7 billion cubic feet Bcf of natural gas.

Forecasting storm damage is inherently difficult because the overall impact during a hurricane season depends on the intensity of individual storms and the path that each one takes. Even a strong storm on the eastern seaboard likely won't disrupt GOM production, although it may wreak havoc for the region's population and temporarily reduce energy demand. On the other hand, a more moderate storm whose path leads right 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.

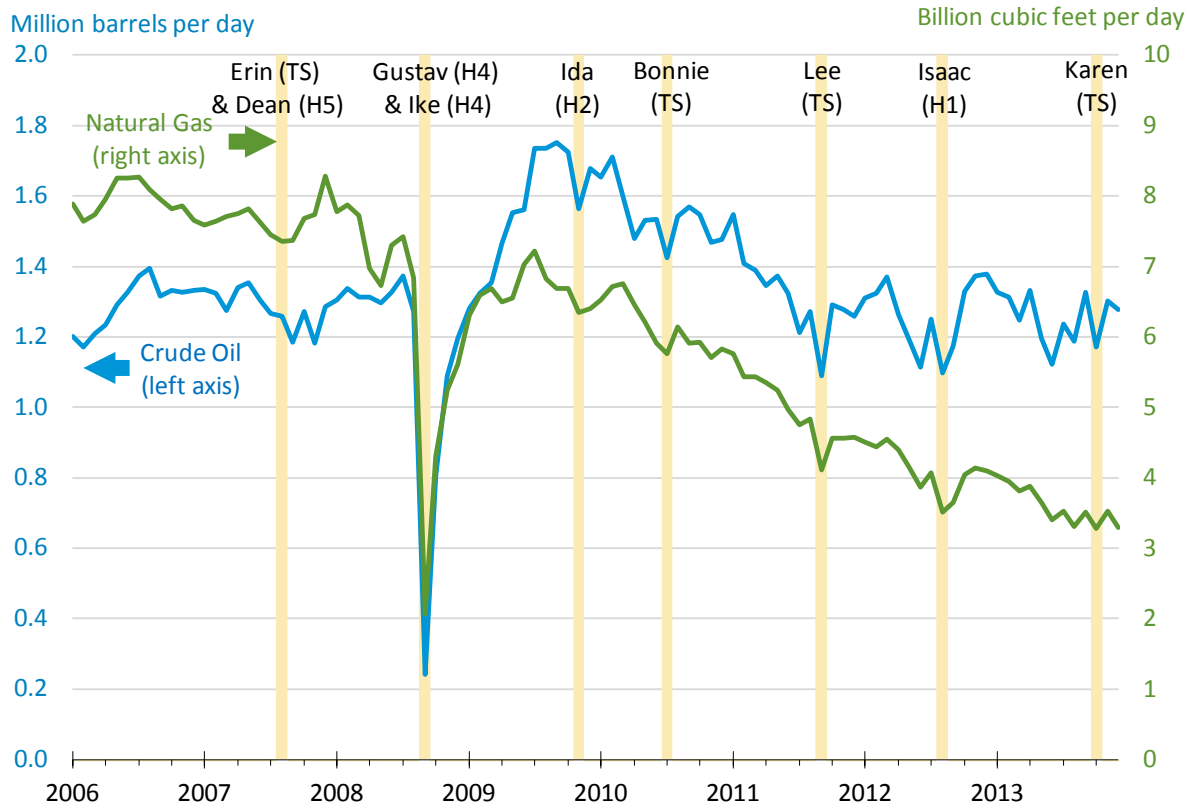
Lessons from Prior Hurricane Seasons

The Atlantic Basin experienced below-average hurricane activity during the 2013 hurricane season. Thirteen named storms passed through the region, of which 11 were tropical storms and 2 hurricanes. Neither of the Atlantic hurricanes was classified as intense. The actual level of hurricane activity last season was significantly overestimated by NOAA's initial projections. In May 2013 NOAA indicated a 70% chance for an above-normal hurricane season, with 13-20 named storms of which 7-11 were expected to become hurricanes. NOAA does not provide projections for individual regions within the Atlantic Basin, but the level of hurricane activity within the Gulf of Mexico last season was also below average. Four tropical storms and one moderate hurricane passed through the region. Only one of the tropical storms came close enough to the GOM producing region and affected U.S. offshore Gulf energy production (Figure 1).

The weather system named Karen achieved tropical storm status just off the Yucatan Peninsula on October 3, 2013, and over the next two days moved northwestward towards the Texas-Louisiana border. Eventually, the storm lost its status as a tropical storm before making landfall, but not before passing within 150 miles of the center of the GOM producing region. According to the Department of Interior's Bureau of Safety and Environmental Enforcement (BSEE), 3.1 million bbl of crude oil and 6.7 Bcf of natural gas were shut in by Karen, representing 7.5% of normal monthly GOM crude oil production and 3.4% of normal natural gas production.

Offshore energy production has experienced relatively minor disruptions because of tropical weather in recent years. However, a single strong storm can cause significant levels of shut-in production. During September of 2008, category-4 hurricanes Gustav and Ike at one point caused nearly 100% of production capacity to be shut in. EIA estimates that these two storms (along with a tropical storm in July) resulted in the loss of 25% of the GOM crude oil and natural gas that would have been produced during the 2008 hurricane season.

Figure 1. Crude oil and natural gas production in the federal offshore Gulf of Mexico and the impact of selected hurricanes and tropical storms, 2006-2013



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

Despite the potential for significant outages if a strong hurricane were to pass through the GOM producing region, the overall effect on U.S. supply would not be as severe as in past years because the share of total U.S. oil and natural gas production originating in the GOM has declined sharply. In 1997, 26% of the nation's natural gas was produced in the federal Gulf of Mexico; by 2013, that share had declined to 5%. The share of crude oil produced in the GOM also has declined in recent years, from 27% in 2003 to 17% last year.

Severe weather can have effects on other aspects of energy markets besides production from oil and gas wells. In the past, refinery operations have been disrupted because of strong winds and rain. In fact, a tornado in late May damaged the Garyville refinery in Louisiana, causing a partial shut-down. In addition, inventories of natural gas at the beginning of the 2014 hurricane season are far below normal levels. With the need to build natural gas inventories back to normal levels before the beginning of the winter heating season, a significant disruption in natural gas production could lead to price spikes. Finally, hurricanes also have the potential to affect energy demand, which could lead to volatility in

energy prices, particularly if industrial operations and electrical systems are disrupted. None of these impacts is specifically modeled in this report.

Methodology for Estimating Shut-in Production

EIA's projections for shut-in production during the 2014 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 2014 *Atlantic Hurricane Season Outlook* that was released May 22, 2014. 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, which is a type of statistical distribution for representing the probability of a certain number of events occurring within a given time period. The mean of each Poisson distribution was assumed to be equal to the product of the average number of each type of Gulf storm and 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 2014 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 (formerly the Minerals Management Service) 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, 1995-2013

	Crude Oil		Natural Gas	
	Mean	Std Dev	Mean	Std Dev
Tropical Storm	2.49%	0.0294	1.48%	0.0172
Moderate Hurricane [a]	7.94%	0.0959	5.02%	0.0600
Intense Hurricane [b]	34.43%	0.4132	30.33%	0.3748

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 the reported and estimated amounts of production shut in by each storm over the period 1995-2013 (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 and natural gas production within the Gulf of Mexico. Table 2 summarizes the simulated levels of 2014 seasonal production outages derived from the sampling distributions along with the estimated probabilities of various shut-in production scenarios. 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%, of either falling below or exceeding the outcome value. The table also illustrates the simulated mean outages during a hurricane season with a normal level of hurricane activity.

Table 2. Simulated cumulative seasonal shut-in production

Crude Oil (million barrels)		Natural Gas (billion cubic feet)	
Mean 2014 seasonal outage	11.6	Mean 2014 seasonal outage	29.7
Median 2014 seasonal outage	6.2	Median 2014 seasonal outage	13.1
Mean normal seasonal outage	18.0	Mean normal seasonal outage	48.4

Probabilities of 2014 Seasonal Crude Oil Outage Scenarios		Probabilities of 2014 Seasonal Natural Gas Outage Scenarios	
P(No Shut-In)	0.0756	P(No Shut-In)	0.0755
P(> 5 MMbbl Shut-in)	0.5700	P(> 10 Bcf Shut-in)	0.5790
P(> 20 MMbbl Shut-in)	0.1860	P(> 50 Bcf Shut-in)	0.1920
P(> 50 MMbbl Shut-in)	0.0290	P(> 100 Bcf Shut-in)	0.0810

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 expected (mean) level of simulated cumulative shut-in production is 11.6 million bbl, in contrast to a median of 6.2 million bbl. For natural gas, the mean shut-in production level is 29.7 Bcf, in contrast to the median of 13.1 Bcf. The extreme asymmetry of the two sampling distributions is evident in the large difference between the mean and median values. This skewness, with the mean much higher than the median, occurs because the simulation allows for the possibility of another season like 2005. Table 2 also shows the mean 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 expected outages for the 2014 hurricane season of 11.6 million bbl of crude oil and 29.7 Bcf of natural gas are about 40% lower than the simulated outages expected during a normal hurricane season.

EIA's *Short-Term Energy Outlook* (STEO) uses the expected seasonal outages to make adjustments to its projections for Gulf of Mexico crude oil and natural gas production. The seasonal outage estimates are distributed to the months of June through November 2014 based on each month's average level of hurricane activity in past years. The monthly outage estimates are then subtracted from the STEO baseline crude oil and natural gas production forecasts.

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 2014 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 2013 season, Gulf of Mexico energy producers shut in a cumulative total of 3.1 million bbl of crude oil and 6.7 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 2014 season is 69%.

It is important to stress the high degree of uncertainty surrounding EIA's expected 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% probability that shut-in offshore production for the entire season will fall between 1.2 million and 24 million bbl of crude oil and between 2.4 and 65 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 in May 2013 projected an above-normal number of hurricanes and tropical storms. However, the actual number of hurricanes and tropical storms last season fell below expectations. 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 more active than NOAA has 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 tropical storms and hurricanes passing through the Gulf of Mexico, 1995-2013

			Reported and Estimated Shut-in Production			
		Maximum	Crude Oil		Natural Gas	
Name	Date	Category [a]	(Mbbl)	% of Normal	(Bcf)	% of Normal
Dean	Jul 1995	0	189	0.7	4.03	1.0
Erin	Aug 1995	1	2,086	7.4	21.07	5.3
Opal	Oct 1995	4	2,089	7.3	24.30	6.1
Josephine	Oct 1996	0	1,455	4.8	13.75	3.3
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
Bret	Aug 1999	4	1,723	4.4	5.67	1.3
Harvey	Sep 1999	0	764	1.9	5.67	1.3
Helene	Sep 2000	0	0	0.0	0.85	0.2
Allison	Jun 2001	0	991	2.2	7.15	1.7
Barry	Aug 2001	0	2,388	5.2	11.95	2.8
Bertha	Aug 2002	0	0	0.0	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
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
Matthew	Oct 2004	0	9	0.0	0.11	0.0
Arlene	Jun 2005	0	575	1.3	3.43	1.2
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
Katrina	Aug 2005	5	30,248	64.8	155.33	50.5
Rita	Sep 2005	5	70,476	150.5	361.91	116.2
Wilma	Oct 2005	4	8,052	17.3	43.54	13.9

See notes at end of table.

Table continued on next page

Table A 1. Shut-in production caused by selected tropical storms and hurricanes passing through the Gulf of Mexico, 1995-2013 (continued)

			Reported and Estimated Shut-in Production			
		Maximum	Crude Oil		Natural Gas	
Name	Date	Category [a]	Mbbl	% of Normal [b]	Bcf	% of Normal [b]
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
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
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
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
Karen	Oct 2013	0	3,100	7.5	6.66	3.4

Source: Storm information from NOAA. Shut-in production from BSEE (formerly MMS) 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). Only storms passing within 300 miles of the center of the Gulf of Mexico producing area are shown.

Notes: [a] 0 = Tropical storm. 1-5 = category n hurricane. Mbbls = thousand barrels. Bcf = billion cubic feet.

[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	2014 Season	Normal Season
0.0	92.4%	95.1%
0.5	89.9%	93.3%
1.0	86.6%	91.1%
1.5	82.8%	88.4%
2.0	78.6%	85.8%
2.5	74.6%	82.7%
3.0	70.5%	80.1%
3.5	66.7%	77.7%
4.0	63.1%	75.3%
4.5	60.1%	73.0%
5	57.0%	70.6%
6	51.4%	66.8%
7	47.0%	63.0%
8	42.7%	59.5%
9	38.9%	56.1%
10	35.9%	53.1%
11	33.3%	50.4%
12	30.6%	47.9%
13	28.5%	46.0%
14	26.6%	43.9%
15	24.9%	41.6%
16	23.4%	39.7%
17	22.1%	38.0%
18	20.8%	36.4%
19	19.7%	35.0%
20	18.6%	33.7%
21	17.4%	32.2%
22	16.7%	30.8%
23	15.9%	29.6%
24	15.2%	28.5%
25	14.3%	27.3%
30	11.1%	22.0%
40	6.1%	12.8%
50	2.9%	7.1%
60	1.3%	4.1%
70	0.7%	2.2%
80	0.3%	1.1%

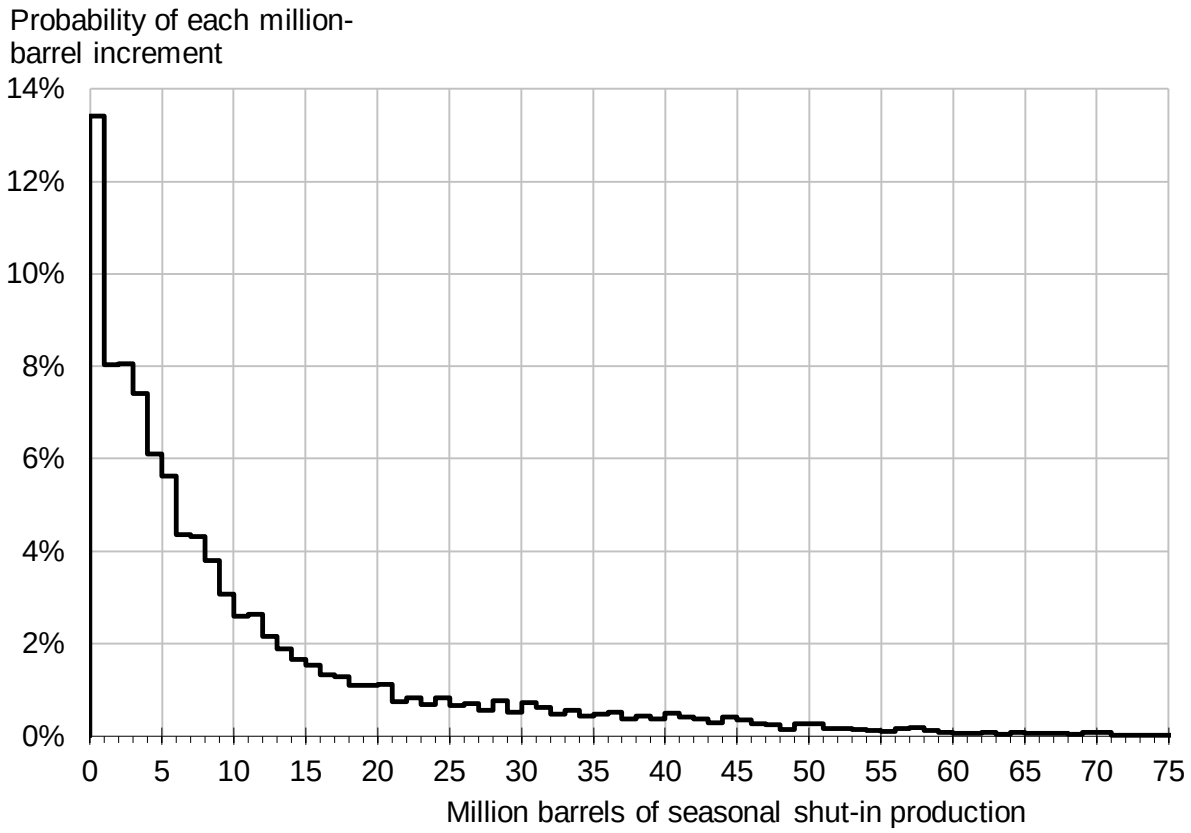
Source: U.S. Energy Information Administration calculations.

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	2014 Season	Normal Season
0	92.5%	95.1%
1	90.0%	93.5%
2	86.7%	91.3%
3	82.9%	88.8%
4	78.8%	86.3%
5	74.7%	83.8%
6	70.9%	80.8%
7	67.3%	78.4%
8	63.9%	76.3%
9	60.8%	74.3%
10	57.9%	72.2%
11	55.2%	70.2%
12	52.5%	68.3%
13	50.2%	66.4%
14	47.9%	64.8%
15	45.9%	63.2%
20	37.8%	55.5%
25	31.7%	49.7%
30	27.6%	45.1%
35	24.6%	41.3%
40	22.4%	38.5%
50	19.2%	33.9%
60	16.5%	29.8%
70	13.9%	26.1%
80	11.9%	22.5%
90	9.8%	19.4%
100	8.1%	16.4%
110	6.5%	13.6%
120	5.2%	11.3%
130	4.2%	9.3%
140	3.3%	7.8%
150	2.5%	6.3%
160	1.9%	5.2%
170	1.4%	4.3%
180	1.1%	3.5%
190	0.7%	2.8%
200	0.6%	2.3%

Source: U.S. Energy Information Administration calculations.

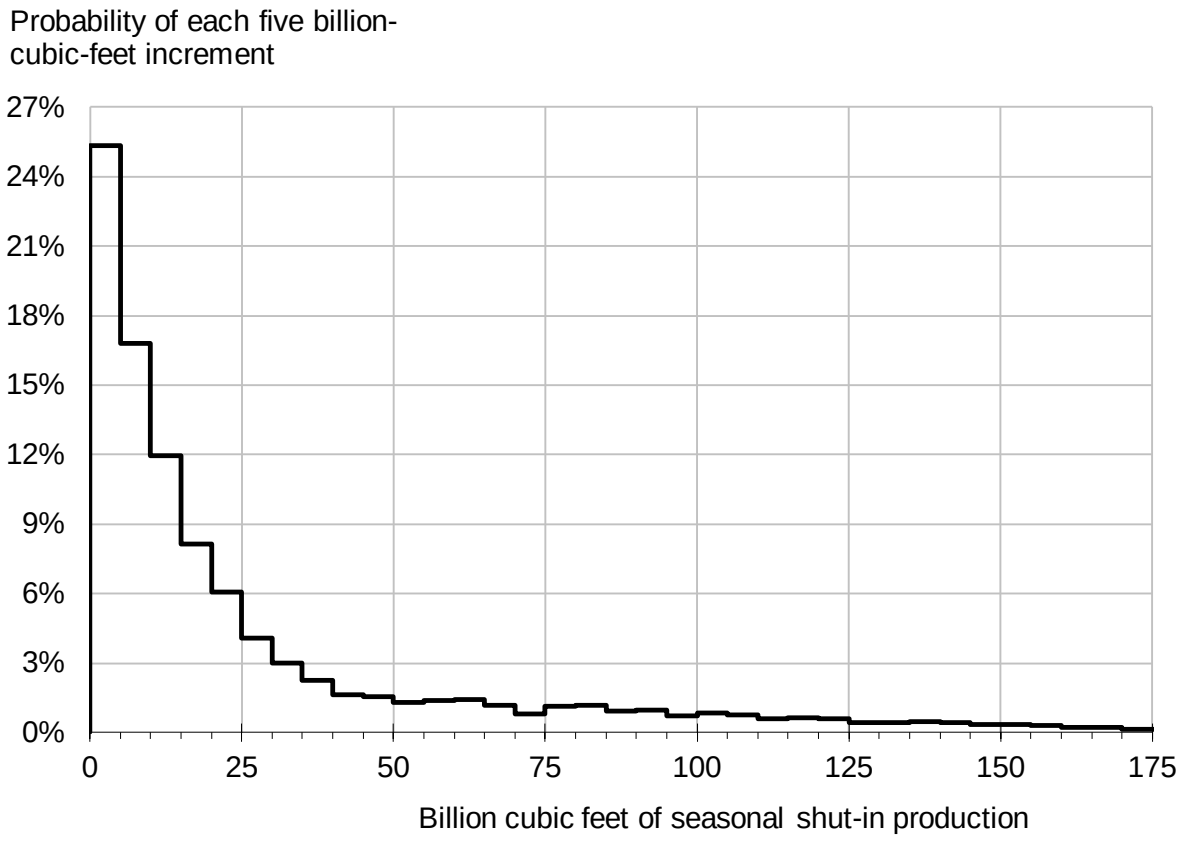
Figure A 1. Simulated probability distribution curve for seasonal Gulf of Mexico crude oil production outages



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.