Independent Statistics & Analysis
U.S. Energy Information Administration

June 2012

Short-Term Energy Outlook Supplement: 2012 Outlook for Hurricane-Related Production Outages in the Gulf of Mexico

Highlights

- The National Oceanic and Atmospheric Administration's (NOAA) *Atlantic Hurricane Season Outlook*, released on May 24, 2012, predicts that the Atlantic basin likely will experience near-normal tropical weather activity during the upcoming hurricane season (June 1 – November 30).[1] NOAA projects that 9 to 15 named storms will form within the Atlantic Basin over the next 6 months, including 4 to 8 hurricanes of which 1 to 3 will be intense.[2]

- Based on the results of a Monte Carlo hurricane outage simulation using the NOAA predictions for the level of hurricane activity, EIA estimates that median outcomes for shut-in production in the Federally-administered Gulf of Mexico as a result of disruptions during the 2012 hurricane season are 4.5 million barrels (bbls) of crude oil and 9.5 billion cubic feet (Bcf) of natural gas.

- EIA's simulation results indicate an approximately 40-percent probability of offshore crude oil or natural gas production experiencing outages during the upcoming hurricane season that are equal to or larger than the production shut in during the 2011 hurricane season (about 5.5 million bbls of crude oil and 14.3 Bcf of natural gas).

Effects of Recent Hurricanes on Crude Oil and Natural Gas Production

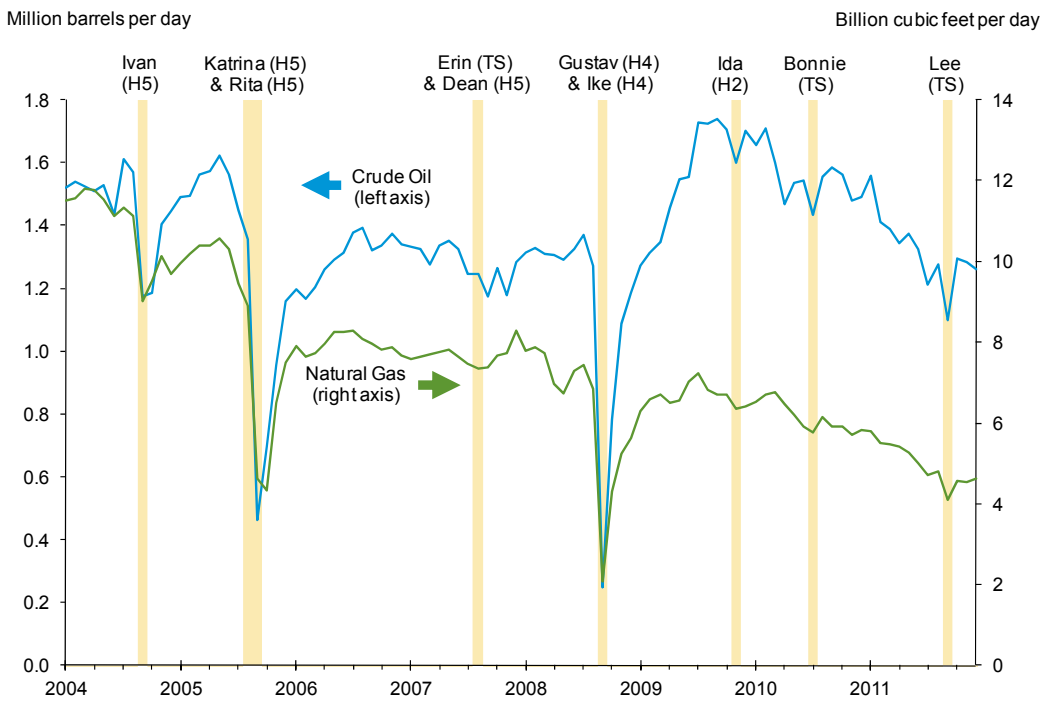
The Atlantic Basin experienced above-average hurricane activity during the 2011 hurricane season, consistent with NOAA's updated August 2011 Outlook. Nineteen named storms passed through the region, including 12 tropical storms and 7 hurricanes, of which 4 were classified as intense.[3] NOAA's original projections in its May 2011 Outlook also called for an above-normal level of hurricane activity. The projections were revised slightly upwards in August to a likely range of 14 to 19 named storms, including 7 to 10 hurricanes.

[1] http://www.cpc.noaa.gov/products/outlooks/hurricane.shtml, accessed June 7, 2012.
[2] 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.
[3] One short-lived weather system on September 1-2 was later reclassified as an unnamed tropical storm, but is included in the total of nineteen "named" storms for the 2011 season.

Although hurricane activity in the entire Atlantic was above normal, activity in the Gulf of Mexico during the 2011 hurricane season was relatively normal. Four tropical storms and 2 moderate hurricanes passed through the Gulf of Mexico, but only two storms threatened offshore energy production.[4]

Tropical Storm Don formed west of Cuba in late July 2011 and headed northwestward, eventually making landfall along the Padre Island National Seashore in south Texas. According to the Bureau of Ocean Energy Management (BOEM), a total of 530 thousand bbls of crude oil and 1.1 Bcf of natural gas were shut in by Tropical Storm Don, representing about 1.2 percent and 0.6 percent of normal monthly Gulf crude oil and natural gas production, respectively.[5] In early September, Tropical Storm Lee formed over the center of the Gulf of Mexico and made landfall just south of Lafayette, Louisiana. BOEM reports that 4.9 million bbls of crude oil production (12 percent of normal) and 13.3 Bcf of natural gas production (8 percent of normal) were shut in by Lee. Figure 1 highlights the effect of some past tropical storms and hurricanes on crude oil and natural gas production in the Gulf of Mexico.

Figure 1. Crude Oil and Natural Gas Production in the Federal Offshore Gulf of Mexico, 2004-2011



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

[4] The Gulf of Mexico is defined in this report as the area within the rectangle bounded by 18° N – 31° N latitude and 81° W – 98° W longitude.
[5] http://www.gomr.boemre.gov/homepg/whatsnew/hurricane/index.html, accessed June 7, 2012.

Shut-in Production Outlook for the 2012 Hurricane Season

NOAA's *Atlantic Basin Hurricane Season Outlook*, which was released May 24, 2012, calls for a 50-percent chance of near-normal hurricane activity this season, a 25-percent chance of above-normal activity, and a 25-percent chance of below-normal activity. Their *Outlook* indicates that 9 to 15 named storms likely will form within the Atlantic Basin, including 4 to 8 total hurricanes of which 1 to 3 will be intense. These projected ranges for different types of storms are incorporated into EIA's model of the likelihood for shut-in production in the Gulf of Mexico.

Seasonal hurricane-related disruptions to crude oil and natural gas production are difficult to forecast, primarily because of the uncertainty involved in predicting both the intensity of severe weather and the affected locations. Discussion of production outages in the face of such uncertainty requires analysis not just of the expected impact, but also the probabilities inherent in various scenarios. EIA's projections for shut-in production during the 2012 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. These sampling distributions can be used to summarize the expected level of shut-in production, but they also illustrate the uncertainty of the projections by outlining the probabilities of various outage scenarios.

The Monte Carlo simulation used for this analysis consisted of two steps: first, EIA simulated the number of severe storms passing through the Gulf of Mexico, and, second, a simulated estimate of shut-in production was developed for each simulated storm. The number of tropical storms, moderate hurricanes, and intense hurricanes passing through the Gulf of Mexico 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 12.1 named storms, 6.4 hurricanes, and 2.7 intense hurricanes during NOAA's baseline period of 1981-2010. During the same period, the Gulf of Mexico region experienced an average of 3.9 named storms including an average of 1.9 hurricanes of which 0.7 were intense.[6] EIA's simulation assumed that the likelihood of the number of each type of storm passing through the Gulf of Mexico 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 relative to 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. Simulating the relative level of shut-in production allowed the model to reflect the declining trend in Gulf natural gas production and the deepwater drilling

[6] The mean number of storms was calculated by EIA using NOAA's HURDAT database.

moratorium enacted last year, which has limited growth in offshore production. 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 2012 to calculate a simulated level of cumulative shut-in production caused by each storm.

Table 1. Shut-in Production as a Percentage of Normal Monthly Production by Type of Weather System, 1995-2011

	Crude Oil		Natural Gas	
	Mean	Std Dev	Mean	Std Dev
Tropical Storm	1.32%	1.97	0.82%	1.15
Moderate Hurricane [a]	3.15%	4.63	2.00%	2.98
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 relative 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 1995-2011 (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 bbls 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 skewness or 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 which has an equal probability, 50 percent, of either falling below or exceeding the outcome value.

For crude oil, the median level of simulated cumulative shut-in production is 4.5 million bbls, in contrast to a mean of 10.3 million bbls. For natural gas, the median shut-in production level is 9.5 Bcf, in contrast to the mean of about 28.4 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 4.5 million bbls of crude oil and 9.5 Bcf of natural gas for the 2012 hurricane season are slightly lower than the simulated outages expected during a normal hurricane season.

Table 2. Simulated Cumulative Seasonal Shut-in Production

Crude Oil (million barrels)		Natural Gas (billion cubic feet)	
Mean 2012 seasonal outage	10.4	Mean 2012 seasonal outage	28.4
Median 2012 seasonal outage	4.5	Median 2012 seasonal outage	9.5
Median normal seasonal outage	5.5	Median normal seasonal outage	11.8
2012 Outage Scenario Probabilities		2012 Outage Scenario Probabilities	
P(No Shut-In)	0.06	P(No Shut-In)	0.06
P(> 5 MMbbl Shut-in)	0.46	P(> 10 Bcf Shut-in)	0.48
P(> 15 MMbbl Shut-in)	0.23	P(> 50 Bcf Shut-in)	0.20
P(> 25 MMbbl Shut-in)	0.14	P(> 100 Bcf Shut-in)	0.08
P(> 50 MMbbl Shut-in)	0.02	P(> 150 Bcf Shut-in)	0.03

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.

The sampling distributions derived from the Monte Carlo simulation also allow an 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 upcoming season.[7] More complete scenario probabilities are shown in Tables A2 and A3 in the Appendix, along with comparable probabilities during a normal season.

Although the median simulated outages are slightly lower than would be expected during a normal season, the probability of the Gulf producing region experiencing some positive level of shut-in production (i.e., outages greater than zero) is still very high this year, about 95 percent. During the 2011 season, Gulf of Mexico energy producers shut in a cumulative total of 5.5 million bbls of crude oil and 14.3 Bcf of natural gas at some point, according to BOEM. The Monte Carlo simulation results indicate that the likelihoods of experiencing similar disruptions as last year or worse during the upcoming season are 43 percent for crude oil and 38 percent for natural gas.

It is important to stress the 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 2.8 and 7.2

[7] Probabilities are appropriate when discussing ranges of outcomes. The probability of any exact level of seasonal shut-in production, including the simulated mean or median value, is theoretically infinitesimal.

million bbls of crude oil and between 5.8 and 16.2 Bcf of natural gas. Constructing intervals with a higher likelihood would widen the gap even further.

The seasonal outage probability distributions simulated in this analysis are conditional upon 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 an above-normal number of hurricanes and tropical storms. Although this forecast was accurate for the entire Atlantic, hurricane activity in the Gulf of Mexico was less active than normal. Long-range forecasts of hurricane activity are difficult to project, especially with regards to particular oceanic regions. If hurricane activity over the next few weeks shows signs of a season that is more active than NOAA initially projected, then the likelihood of the various levels of shut-in production would need to be revised upwards.

Appendix

Table A1. Shut-in Production Caused by Gulf of Mexico Tropical Storms and Hurricanes, 1995-2011

			Reported and Estimated Shut-in Production [c]			
		Maximum	Crude Oil		Natural Gas	
Name	Date	Category [a]	(MMbbl)	% 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.

Table continued on next page

Table A1. Shut-in Production Caused by Gulf of Mexico Tropical Storms and Hurricanes, 1995-2011, continued.

			Reported and Estimated Shut-in Production			
		Maximum	Crude Oil		Natural Gas	
Name	Date	Category [a]	MMbbl	% 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.

Table continued on next page

Table A1. Shut-in Production Caused by Gulf of Mexico Tropical Storms and Hurricanes, 1995-2011, continued.

			Reported and Estimated Shut-in Production			
			Crude Oil		Natural Gas	
Name	Date	Maximum Category [a]	MMbbl	% 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

Source: Storm information from NOAA. Shut-in production from BOEM shut-in statistics reports for available storms, otherwise EIA estimates (see *The 2007 Outlook for Hurricane Impacts on Gulf of Mexico Crude Oil & Natural Gas Production* for estimation methodology <http://www.eia.gov/forecasts/steo/special/pdf/2007_hurricanes.pdf>)

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

[b] Normal production 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 A2. Simulated Probabilities for Exceeding Various Levels of Seasonal Shut-in Gulf of Mexico Crude Oil Production

	Probability of Shut-in Production	
> Million Barrels	2012 Season	Normal Season
0.0	94.3%	95.0%
0.5	90.4%	91.2%
1.0	85.6%	86.3%
1.5	80.0%	81.1%
2.0	73.9%	76.2%
2.5	68.4%	71.5%
3.0	63.3%	66.8%
3.5	58.2%	62.5%
4.0	53.7%	58.6%
4.5	49.7%	55.4%
5	46.3%	52.4%
6	40.6%	47.6%
7	36.1%	43.5%
8	32.8%	40.5%
9	30.3%	38.3%
10	28.6%	36.5%
11	27.4%	34.8%
12	26.3%	33.6%
13	25.0%	32.4%
14	23.8%	31.3%
15	23.0%	30.2%
16	22.1%	29.0%
17	21.1%	28.1%
18	20.2%	27.0%
19	19.3%	25.9%
20	18.3%	24.8%
25	14.2%	19.4%
30	10.6%	15.0%
35	7.6%	10.8%
40	5.4%	8.1%
45	3.5%	5.8%
50	2.4%	4.0%
60	1.1%	1.9%
70	0.5%	0.9%
80	0.2%	0.5%
90	0.1%	0.2%
100	0.1%	0.1%

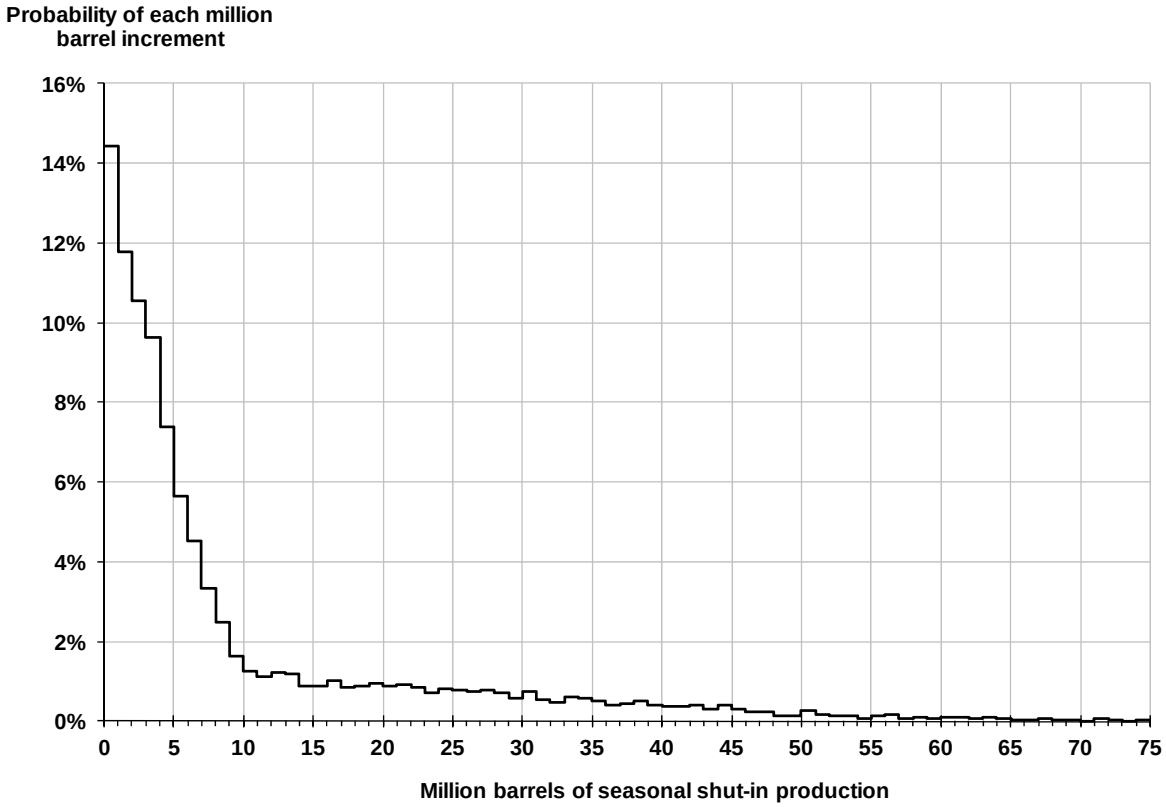
Source: U.S. Energy Information Administration calculations.

Table A3. Simulated Probabilities for Exceeding Various Levels of Seasonal Shut-in Gulf of Mexico Natural Gas Production

	Probability of Shut-in Production	
> Billion Cubic Feet	2012 Season	Normal Season
0	94.0%	94.7%
1	90.7%	91.3%
2	86.2%	87.0%
3	80.1%	81.8%
4	74.5%	77.1%
5	68.9%	72.4%
6	63.9%	68.3%
7	59.4%	64.3%
8	55.3%	60.9%
9	51.6%	57.4%
10	48.0%	54.4%
15	36.8%	44.4%
20	31.1%	39.6%
25	28.3%	36.8%
30	26.3%	35.0%
35	24.7%	33.3%
40	23.2%	31.7%
45	21.7%	29.7%
50	20.3%	28.0%
75	13.1%	19.1%
100	8.0%	11.6%
125	4.5%	6.8%
150	2.6%	4.0%
175	1.4%	2.1%
200	0.8%	1.2%
225	0.4%	0.7%
250	0.3%	0.3%
275	0.2%	0.2%
300	0.1%	0.1%

Source: U.S. Energy Information Administration calculations.

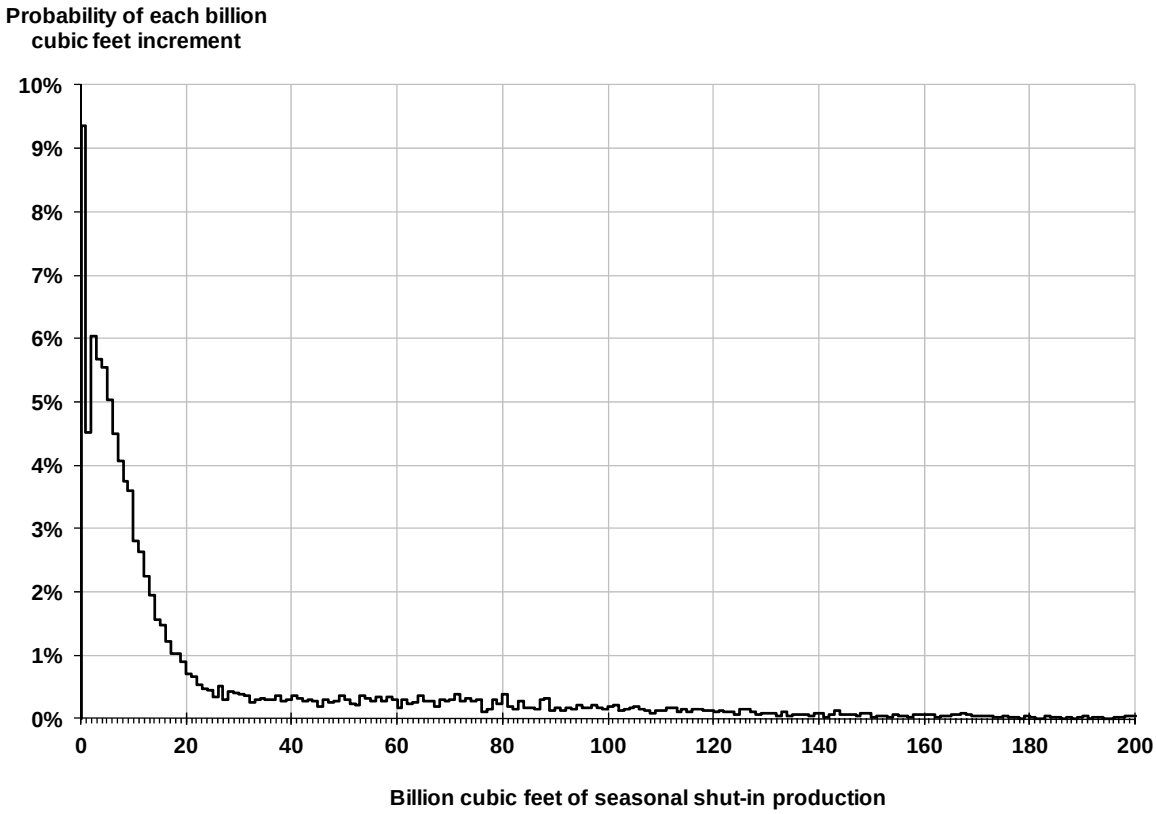
Figure A1. Simulated Probability Distribution Curve for Seasonal Gulf of Mexico Crude Oil Production Outages



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 A2. 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.