U.S. Energy Information Administration

June 2010

Short-Term Energy Outlook Supplement: 2010 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 27, 2010, predicted that the Atlantic basin will likely experience above-normal tropical weather activity during the upcoming hurricane season (June 1 – November 30).[1] NOAA projects that 14 to 23 named storms will form within the Atlantic Basin over the next 6 months, including 8 to 14 hurricanes of which 3 to 7 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 are 26 million barrels (bbl) of crude oil and 166 billion cubic feet (Bcf) of natural gas in the Federally administered Gulf of Mexico as a result of disruptions during the 2010 hurricane season. The actual level of shut-in production will depend on the number and severity of storms that threaten the producing region during the upcoming season.

- EIA's simulation results indicate a 17- to 20-percent probability of offshore crude oil or natural gas production experiencing outages during this season that are equal to or larger than the production shut in during the 2008 season when Hurricanes Gustav and Ike struck the Gulf Coast (about 65 million bbl of crude oil and 400 Bcf of natural gas).

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[1] http://www.cpc.noaa.gov/products/outlooks/hurricane.shtml

[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.

Gulf of Mexico Hurricanes and the Deepwater Horizon Incident

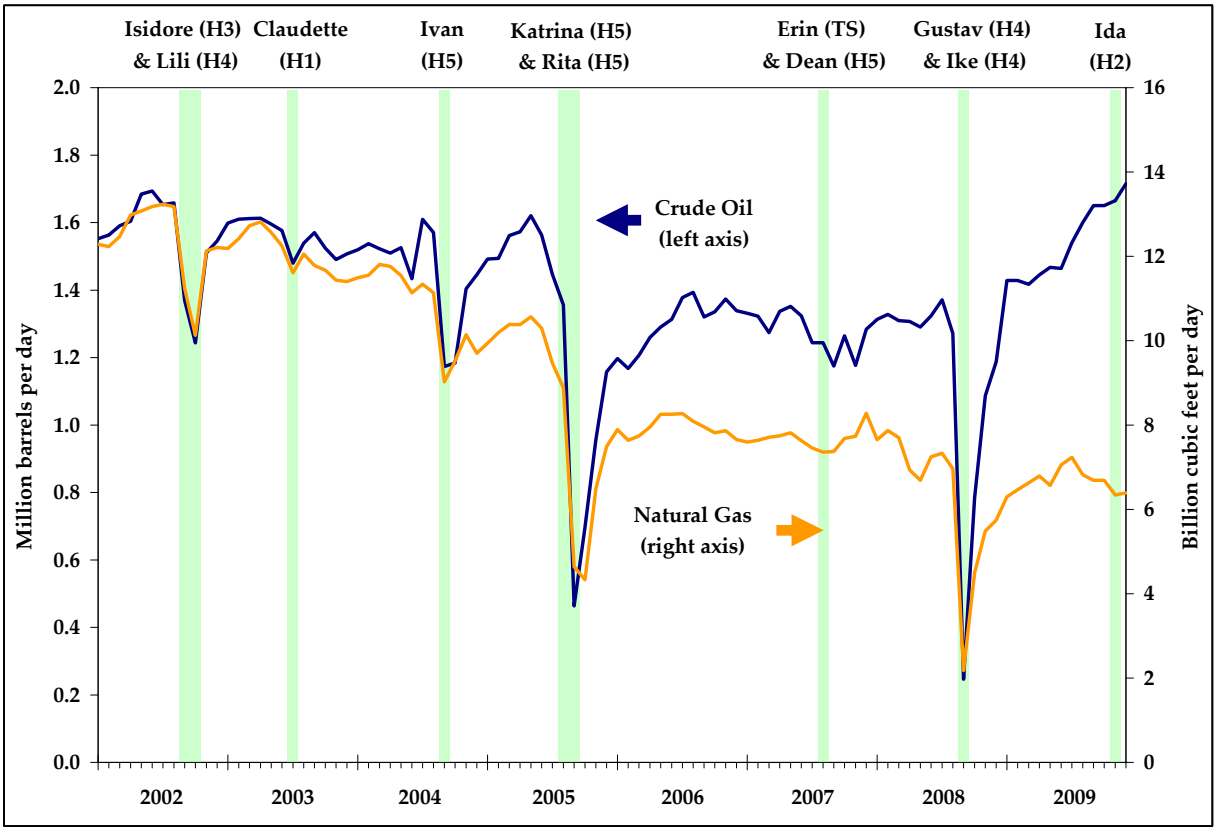
As the Gulf of Mexico hurricane season begins, most observers' attention is focused on the impacts of the release of crude oil caused by the destruction of the Deepwater Horizon offshore drilling rig. The occurrence of a hurricane or tropical storm passing through the Gulf producing region this summer could have environmental effects in addition to the likely impact on production activity. When severe weather threatens, offshore energy producers temporarily shut in production to protect facilities and employees. One reason for such measures is to prevent the potential release of crude oil and natural gas that might occur if infrastructure were to sustain major damage. If damage were to occur, production may be shut in for a longer period of time to repair facilities and mitigate any environmental damage.

This supplement to EIA's *Short-Term Energy Outlook* focuses on the likelihood of shut-in crude oil and natural gas production caused by tropical storms and hurricanes in the Gulf of Mexico during the upcoming hurricane season. To date, energy production, shipments, and prices have not been significantly affected by the release of crude oil from the Deepwater Horizon well. Although some offshore energy producers may be more sensitive to the potential for hurricane-caused damage because of the existing oil slick and possibly may be more likely to shut in production, this analysis assumes that the effects from such strategic decisions are minimal.

Effects of Recent Hurricanes on Crude Oil and Natural Gas Production

The 2008 and 2009 hurricane seasons illustrate a wide range of production impacts. Severe tropical weather during the late summer of 2008 caused significant disruptions to offshore Gulf of Mexico production. After weakening from a Category 4 storm, Hurricane Gustav made landfall along the coast of Louisiana on the first of September. At one point during this storm, 100 percent of Gulf crude oil production and 95 percent of the natural gas production was shut in. Production quickly resumed with almost 40 percent of production back online shortly after landfall. However, Gulf operators again needed to quickly shut in nearly all production as Hurricane Ike passed over the producing region, making landfall near Baytown, Texas, on September 13, 2008. The disruptions caused by these two hurricanes were extensive. Through the end of 2008, an estimated cumulative total of nearly 65 million bbl of crude oil and 400 Bcf of natural gas had been shut in (see Figure 1). The cumulative production outages during the 2008 hurricane season rank second to the outages experienced during 2005, when Hurricanes Katrina and Rita hit the Gulf Coast.

Figure 1. Crude Oil and Natural Gas Production
Federal Offshore Gulf of Mexico, 2002-2009

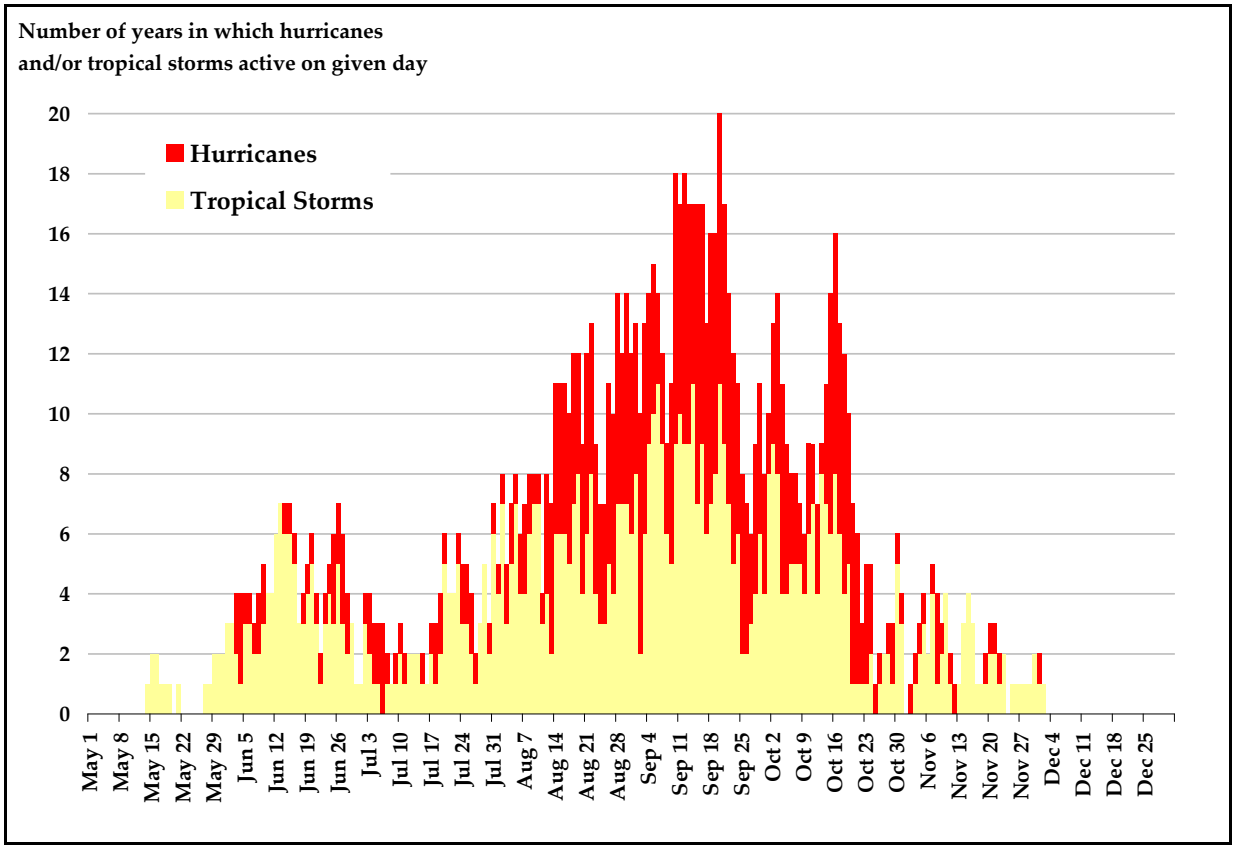


Note: TS = Tropical Storm. H*n* = Category *n* hurricane.
Source: U.S. EIA and National Oceanic and Atmospheric Administration (NOAA).

In contrast, only one tropical storm (Claudette) and one Category 2 hurricane (Ida) formed within the Gulf of Mexico during the 2009 hurricane season. Claudette passed well east of the producing region. Hurricane Ida passed directly over the region, but had weakened to a tropical storm by that time. Offshore energy producers reported only minor impacts from Ida, with estimated shut-in production of 2.5 million barrels of crude oil and 11.4 billion cubic feet of natural gas.

Over the past 100 years, tropical storms have formed within the Gulf of Mexico as early as May and as late as December (see Figure 2). Hurricanes, which usually cause the largest disruptions to offshore production, occur most frequently during the months of August and September.

Figure 2. Frequency of Gulf of Mexico Hurricanes and Tropical Storms, 1910-2009



Notes: The Gulf of Mexico is defined here as the area within the rectangle bounded by 18° N – 31° N latitude and 81° W – 98° W longitude.

Source: EIA calculations using NOAA's Hurdat database.

Shut-in Production Outlook for the 2010 Hurricane Season

In contrast to last year's quiet hurricane season, NOAA expects an 85-percent chance of above-average hurricane activity this season, as discussed in its *Atlantic Basin Hurricane Season Outlook* issued on May 27, 2010. They project 14 to 23 named storms will form within the Atlantic Basin, including 8 to 14 total hurricanes of which 3 to 7 will be intense. This higher level of severe tropical weather translates to a greater 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 an analysis not just of the expected impact but also the probabilities inherent in various scenarios. EIA's projections for shut-in production during the 2010 hurricane season are 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 consists 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 are modeled using information contained in NOAA's *Atlantic Basin Hurricane Season Outlook*. NOAA's projected ranges compare with a seasonal average of 10.4 named storms, 6.0 hurricanes, and 2.4 intense hurricanes during the years 1950-2009. During the same period, the Gulf of Mexico region has experienced an average of 3.3 named storms including an average of 1.7 hurricanes of which 0.8 are intense.[3] EIA's simulation assumes that the likelihood of the number of each type of storm passing through the Gulf of Mexico can be modeled as a Poisson distribution. The assumed mean of each distribution is calculated by multiplying the Gulf average of the number of each type of 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 involves modeling the shut-in production caused by each simulated tropical storm or hurricane and aggregating the values to calculate a cumulative seasonal outage. The simulated outage for each storm is assumed to be normally distributed, with a mean and standard deviation as shown in Table 1. These outage statistics are calculated from EIA's estimates for the amount of production shut-in by each storm over the period 1995-2009 (see Table A1 in the Appendix). The mean outages illustrate how weather-related production impacts increase dramatically with the severity of the storm. The mean value for intense hurricanes is especially skewed by the 100 million bbl of crude oil and 600 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 are assumed to represent zero production impact.

[3] The Gulf of Mexico is defined here as the area within the rectangle bounded by 18°N – 31° N latitude and 81° W – 98° W longitude. Average number of storms calculated by EIA using NOAA's HURDAT database.

Table 1. Estimated Shut-in Production by Type of Weather System, 1995-2009

	Crude Oil (thousand barrels)		Natural Gas (billion cubic feet)	
	Mean	Std Dev	Mean	Std Dev
Tropical Storm	503	636	4.12	6.73
Moderate Hurricane [a]	1,393	1,975	9.10	14.36
Intense Hurricane [b]	14,602	19,062	89.34	112.74

Notes: [a] Category 1 or 2. [b] Category 3, 4, or 5. Std Dev = standard deviation.
Source: EIA calculations.

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 26 million bbl, in contrast to a mean of 33 million bbl. For natural gas, the median shut-in production level is 166 Bcf, in contrast to the mean of about 206 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 expected 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 1950-2009. EIA's projected median outages of 26 million bbl of crude oil and 166 Bcf of natural gas for the 2010 hurricane season are about 4 times 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 2010 seasonal outage	33.0	Mean 2010 seasonal outage	206.4
Median 2010 seasonal outage	25.9	Median 2010 seasonal outage	165.9
Median normal seasonal outage	5.8	Median normal seasonal outage	39.5
2010 Outage Scenario Probabilities		2010 Outage Scenario Probabilities	
P(No Shut-In)	0.0051	P(No Shut-In)	0.0057
P(> 25 MMbbl Shut-in)	0.5140	P(> 150 Bcf Shut-in)	0.5300
P(> 50 MMbbl Shut-in)	0.2450	P(> 300 Bcf Shut-in)	0.2590
P(> 100 MMbbl Shut-in)	0.0340	P(> 600 Bcf Shut-in)	0.0390

Notes: MMbbl = million barrels, Bcf = billion cubic feet. More complete scenario probability tables are shown in Tables A2 and A3 in the Appendix.
Source: EIA 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 the probabilities of exceeding certain levels of shut-in production during the upcoming season. More complete scenario probabilities are shown in Tables A2 and A3 in the Appendix, along with comparable probabilities 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 very high this year, exceeding 99 percent. In contrast, the probability of experiencing outages greater than zero during a normal season is about 92 to 93 percent, still quite high but measurably lower than the projected probability during the 2010 hurricane season. In 2008, Gulf of Mexico energy producers shut in a cumulative total of 65 million bbl of crude oil and 400 Bcf of natural gas at some point during the season primarily as a result of Hurricanes Gustav and Ike. The Monte Carlo simulation results indicate that the likelihoods of experiencing similar disruptions or worse during the upcoming season are 17 percent for crude oil and 20 percent for natural gas, which are quite a bit higher than the probabilities expected during a normal season (5 to 6 percent).

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 4.5 and 63.5 million bbl of crude oil or between 35 and 392 Bcf of natural gas. Both of the ranges are wide, and 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 at this time last year projected a relatively normal number of hurricanes and tropical storms, and likewise, EIA's production outage projections for last year's hurricane season were quite a bit lower than those expected for the upcoming season. However, long-range forecasts of hurricane activity are difficult to project and in the past NOAA has made significant revisions to some of its initial seasonal projections. If hurricane activity over the next few weeks shows signs of a quieter-than-expected season, the likelihood of the various levels of shut-in production would need to be revised downwards.

Appendix

Table A1. Gulf of Mexico Tropical Storms and Hurricanes and Estimated Shut-in Production, 1995-2009

Name	Date	Maximum Category [a]	Closest Distance [b] (miles)	Estimated Outage [c] Crude Oil (MMbbl)	Natural Gas (Bcf)
Allison	Jun 1995	1	358	624	0.3
Dean	Jul 1995	0	136	189	4.0
Erin	Aug 1995	1	282	1,529	15.5
Gabrielle	Aug 1995	0	476	490	4.9
Jerry	Aug 1995	0	607	67	0.7
Opal	Oct 1995	4	230	2,951	25.3
Roxanne	Oct 1995	3	468	2,112	18.1
Dolly	Aug 1996	1	589	0	0
Josephine	Oct 1996	0	252	1,455	13.8
Danny	Jul 1997	1	50	990	6.3
Charley	Aug 1998	0	263	0	0
Earl	Sep 1998	2	125	3,765	27.5
Frances	Sep 1998	0	264	787	5.8
Georges	Sep 1998	2	195	7,695	56.3
Hermine	Sep 1998	0	54	1,337	9.8
Mitch	Nov 1998	0	509	1,482	0
Bret	Aug 1999	4	325	1,722	5.7
Harvey	Sep 1999	0	325	764	5.2
Irene	Oct 1999	1	692	281	3.9
Beryl	Aug 2000	0	438	0	0.9
Gordon	Sep 2000	1	465	0	0.5
Helene	Sep 2000	0	280	0	0.4
Keith	Oct 2000	1	580	421	0
Allison	Jun 2001	0	214	1,015	7.0
Barry	Aug 2001	0	291	2,747	13.3
Gabrielle	Sep 2001	0	493	0	0
Bertha	Aug 2002	0	134	0	0
Edouard	Sep 2002	0	652	11	0.1
Fay	Sep 2002	0	151	493	3.1
Hanna	Sep 2002	0	163	619	3.9
Isidore	Sep 2002	3	91	10,095	63.1
Lili	Oct 2002	4	27	6,075	46.9
Bill	Jul 2003	0	49	0	4.7
Claudette	Jul 2003	1	135	2,500	15.9
Erika	Aug 2003	1	208	226	0
Grace	Aug 2003	0	209	56	0
Henri	Sep 2003	0	416	375	2.7
Larry	Oct 2003	0	556	172	0

Table continued on next page

Table A1. Gulf of Mexico Tropical Storms and Hurricanes and Estimated Shut-in Production, 1995-2009, continued

Name	Date	Maximum Category [a]	Closest Distance [b] (miles)	Estimated Outage [c] Crude Oil (MMbbl)	Natural Gas (Bcf)
Bonnie	Aug 2004	0	220	748	0
Charley	Aug 2004	4	608	596	0
Frances	Sep 2004	0	454	93	0.4
Ivan	Sep 2004	5	25	27,294	118.1
Jeanne	Sep 2004	1	517	61	0.3
Matthew	Oct 2004	0	68	1,362	34.5
Arlene	Jun 2005	0	270	1,534	5.7
Bret	Jun 2005	0	657	91	0.3
Cindy	Jul 2005	1	95	946	6.7
Dennis	Jul 2005	4	302	1,653	11.6
Emily	Jul 2005	4	387	1,995	14.1
Gert	Jul 2005	0	598	52	0.4
Jose	Aug 2005	0	677	293	1.9
Katrina	Aug 2005	5	138	54,902	355.8
Rita	Sep 2005	5	77	48,351	255.6
Stan	Oct 2005	1	585	9	2.7
Tammy	Oct 2005	0	621	1	0.2
Wilma	Oct 2005	4	566	97	28.3
Alberto	Jun 2006	0	249	203	0.5
Barry	Jun 2007	0	516	144	0
Dean	Aug 2007	5	627	252	5.9
Erin	Aug 2007	0	256	23	0.5
Humberto	Sep 2007	1	144	2,394	7.0
Ten [d]	Sep 2007	[d]	274	197	0.6
Dolly	Jul 2008	2	365	0	0
Edouard	Aug 2008	0	30	1,396	15.3
Gustav	Sep 2008	4	64	40,377	247.4
Ike	Sep 2008	4	131	22,326	136.8
Claudette	Aug 2009	0	330	409	7.4
Ida	Nov 2009	2	187	2,576	11.4

Source: NOAA and EIA calculations.

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

[b] Closest distance that hurricane or tropical storm passed to the geographic center of all platforms within the offshore Outer Continental Shelf.

[c] EIA estimates, which may differ from those reported by MMS. See *The 2007 Outlook for Hurricane Impacts on Gulf of Mexico Crude Oil & Natural Gas Production* for estimation methodology <http://www.eia.doe.gov/emeu/steo/pub/pdf/2007_hurricanes.pdf>

[d] 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	2010 Season	Normal Season
0	99.5%	92.8%
0.5	99.0%	88.8%
1	97.9%	82.5%
1.5	96.3%	76.6%
2	94.4%	71.9%
2.5	92.4%	67.4%
3	90.6%	63.8%
3.5	88.7%	60.7%
4	86.9%	57.5%
4.5	85.1%	54.9%
5	83.2%	52.8%
6	79.7%	49.4%
7	76.5%	46.7%
8	74.1%	44.7%
9	72.1%	43.2%
10	70.2%	41.8%
11	68.4%	40.8%
12	66.9%	39.7%
13	65.7%	38.6%
14	64.2%	37.7%
15	63.0%	36.6%
16	61.8%	35.6%
17	60.6%	34.6%
18	59.6%	33.4%
19	58.4%	32.4%
20	57.4%	31.6%
25	51.4%	26.3%
30	45.3%	21.6%
35	39.1%	17.2%
40	33.9%	13.7%
45	28.9%	10.4%
50	24.5%	8.1%
60	17.3%	4.7%
70	11.9%	2.7%
80	8.3%	1.5%
90	5.6%	0.8%
100	3.4%	0.4%

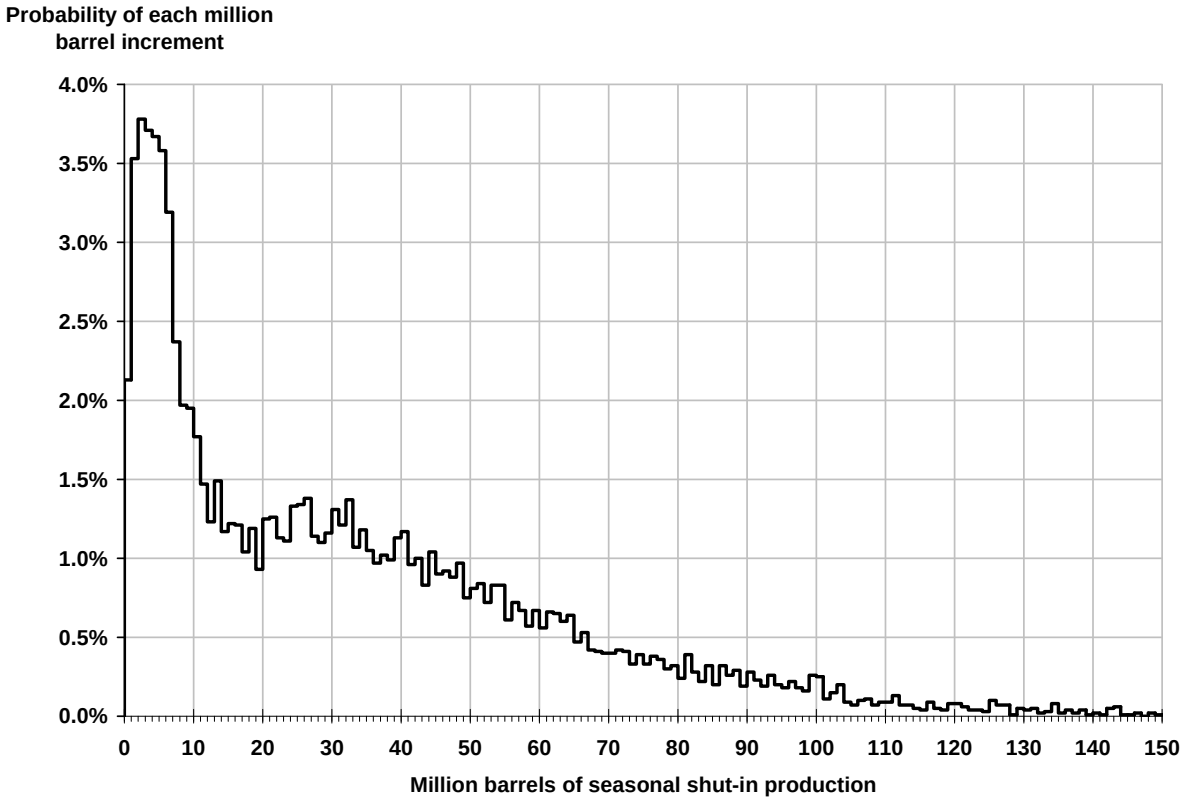
Source: EIA Monte Carlo simulation

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	2010 Season	Normal Season
0	99.4%	92.2%
1	99.4%	91.3%
2	99.3%	90.3%
3	99.1%	89.2%
4	98.8%	88.2%
5	98.6%	86.8%
6	98.4%	85.3%
7	98.1%	83.9%
8	97.9%	82.4%
9	97.5%	80.9%
10	97.2%	79.5%
15	95.4%	72.5%
20	93.3%	66.1%
25	90.2%	60.8%
30	87.8%	56.3%
35	85.1%	52.8%
40	82.6%	49.8%
45	80.0%	47.3%
50	77.6%	45.1%
75	69.0%	38.9%
100	63.1%	34.7%
125	58.2%	30.3%
150	53.0%	26.1%
175	48.2%	21.9%
200	43.1%	18.1%
225	38.1%	15.0%
250	33.8%	12.4%
275	29.7%	10.1%
300	25.9%	8.3%
325	22.4%	6.6%
350	19.5%	5.3%
400	14.3%	3.5%
450	10.4%	2.3%
500	7.3%	1.5%
550	5.2%	1.0%
600	3.9%	0.6%

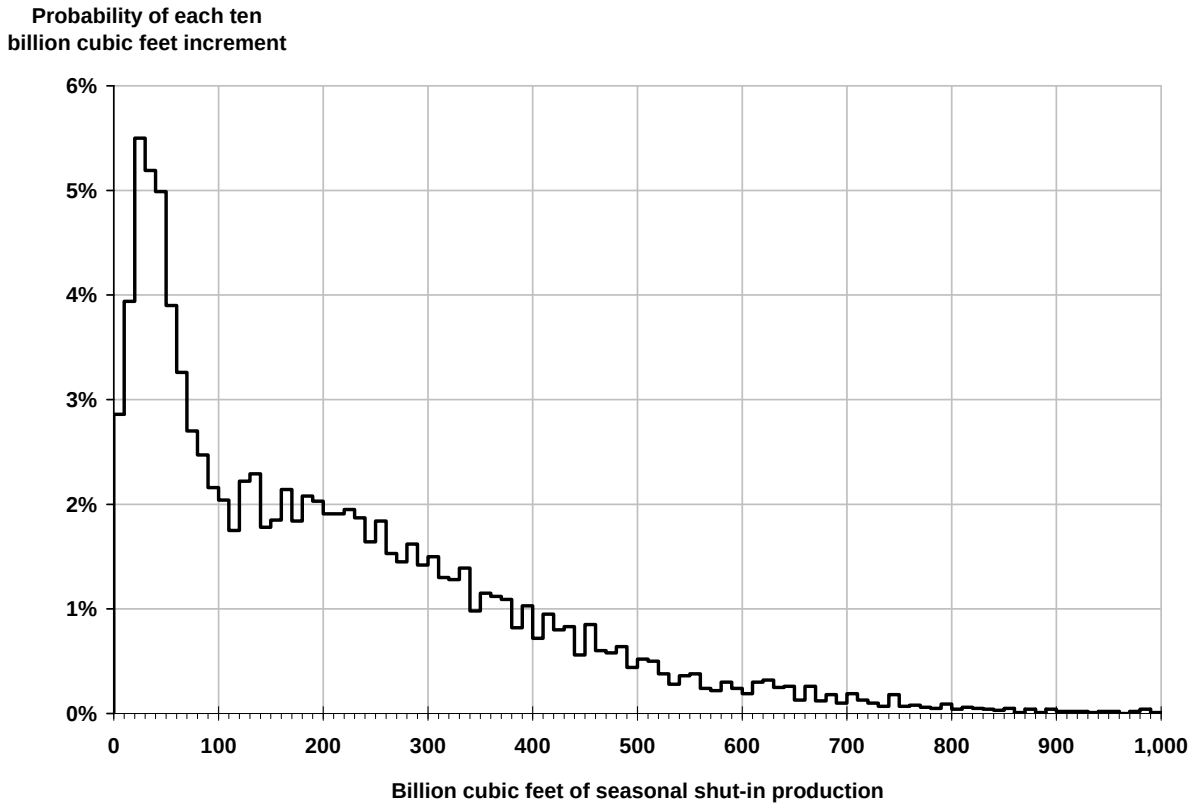
Source: EIA Monte Carlo simulation.

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



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



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 ten 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.