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Short-Term Energy Outlook Supplement: The 2009 Outlook for Hurricane Production Outages in the Gulf of Mexico

Highlights

- The National Oceanic and Atmospheric Administration (NOAA) predicted in its *Atlantic Hurricane Season Outlook* released on May 21, 2009 that the Atlantic basin will most likely experience near-normal activity during the upcoming hurricane season (June 1 – November 30).[1] NOAA projects 9 to 14 named storms will form within the Atlantic Basin over the next 6 months, including 4 to 7 hurricanes, of which 1 to 3 will be intense.[2]

- Based on the results of a Monte Carlo hurricane outage simulation using NOAA's most recent predictions for the level of hurricane activity, EIA expects a cumulative total of about 4.5 million barrels (bbl) of crude oil and 36 billion cubic feet (Bcf) of natural gas production in the Federally-administered Gulf of Mexico to be shut in as a result of disruptions during the 2009 hurricane season. However, given the uncertainty surrounding NOAA's climate predictions, the actual level of shut-in production will likely deviate from these expectations, depending on the number and severity of storms that threaten the producing region during the upcoming season.

- EIA's simulation results indicate a 3- to 4-percent probability of offshore crude oil or natural gas production experiencing outages the same as or larger than last season when Hurricanes Gustav and Ike struck the Gulf Coast, causing shut-in production of more than 60 million bbl of crude oil or 335 Bcf of natural gas. The likelihood that shut-in production will be greater than zero is estimated to be about 95 percent.

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

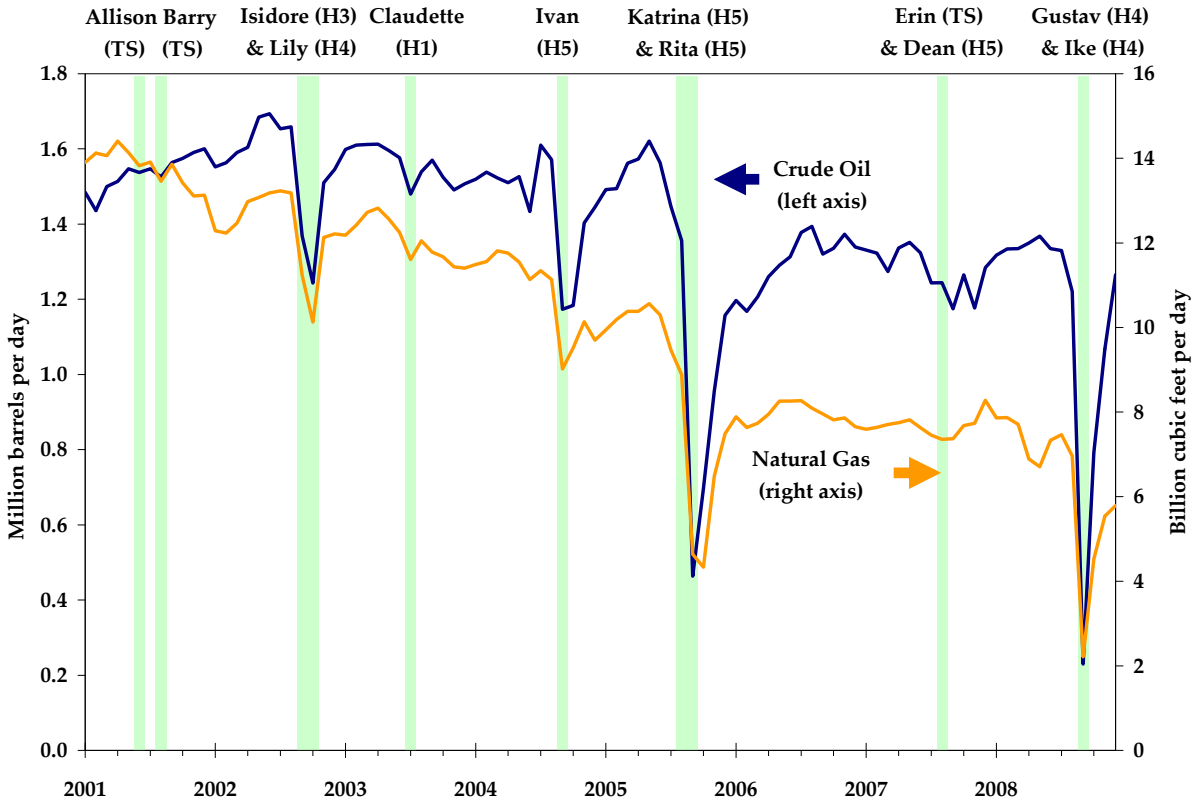
[2] A named storm generally refers to either a tropical storm or hurricane. An intense hurricane is one rated as category 3, 4 or 5. A moderate hurricane is classified as either category 1 or 2.

Past Effects of Hurricanes on Crude Oil and Natural Gas Production

The Gulf of Mexico region is an important source for U.S. crude oil and natural gas production. During the past 5 years, crude oil production from the Federally-administered offshore Gulf fields accounted for 25 percent of total U.S. oil production, and marketed production of Gulf of Mexico natural gas was about 15 percent of the U.S. total. In addition to production from Federal leases, Texas, Louisiana, Alabama, and Mississippi also contribute significant onshore and State-administered offshore production.

When severe weather threatens, offshore platform operators must evacuate personnel and temporarily shut in production to protect facilities. Generally, production can be restored within a few days after the storm passes. However, strong hurricanes passing directly through the production region can cause longer-lasting disruptions when production infrastructure is damaged. Figure 1 illustrates the effect of Gulf hurricanes on the regional production of crude oil and natural gas since 2001.

Figure 1. Crude Oil and Natural Gas Production
Federal Offshore Gulf of Mexico, 2001-2008



Note: TS = Tropical Storm. H*n* = Category *n* hurricane. Defined by maximum sustained wind speed while in the Gulf of Mexico region
Source: EIA and National Oceanic and Atmospheric Administration (NOAA).

Prior to 2005, even strong hurricanes such as Lily (2002) and Ivan (2004) usually caused only temporary losses in production, with the production rates of most operators returning to pre-storm levels within a month or two. However, in the late summer of that year hurricanes Katrina and Rita destroyed a total of 113 platforms and damaged another 52 platforms.[3] The cumulative impact of these two hurricanes was significant. The Minerals Management Service (MMS) reported in June 2006 that the cumulative shut-in production caused by those two hurricanes was 166 million bbl of crude oil (about 30 percent of annual Gulf production) and 804 Bcf of natural gas (22 percent of annual production).

After 2 years of relatively mild tropical weather in the Gulf of Mexico, the hurricane season of 2008 experienced a few tropical storms and hurricanes that again significantly impacted crude oil and natural gas production in the region. Hurricane Dolly threatened the Gulf Coast in late July, and then just a few days later, Tropical Storm Edouard passed directly over the producing area. Both storms led to temporary personnel evacuations from numerous platforms and rigs.

Tropical weather during September was especially disruptive to Gulf production. Hurricane Gustav made landfall as a Category 2 storm along the coast of Louisiana on the first of the month, causing 100 percent of the crude oil production and 95 percent of the natural gas production to be shut in. Over the next week, up to 40 percent of production slowly returned. Gulf operators needed to again quickly shut in nearly all production as Hurricane Ike passed over the producing region, making landfall near Baytown, Texas, on September 13. The disruptions caused by these two hurricanes were quite extensive. Through December 31, 2009, a cumulative total of nearly 60 million bbl of crude oil and 335 Bcf of natural gas had been shut in.

The 2008 hurricanes also affected midstream and downstream facilities in addition to the upstream impacts to Gulf production. As a result of Hurricanes Gustav and Ike, 28 of the pipelines operating in the Gulf declared *force majeure*,[4] and many of these pipelines were completely shut down.[5] In addition, nearly 3.9 million barrels per day of refinery capacity was offline at one point.[6] Yet, the damage to these facilities during last year's hurricane season was not as significant as that caused by Hurricanes Katrina and Rita in 2005.

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[3] Department of Energy, Office of Fossil Energy (2006). Impact of the 2005 Hurricanes on the Natural Gas Industry in the Gulf of Mexico Region. <http://www.fe.doe.gov/programs/oilgas/publications/index.html>

[4] *Force majeure* is defined as any occurrence that is beyond the control of a pipeline exercising due diligence.

[5] Energy Information Administration (2009). Impact of the 2008 Hurricanes on the Natural Gas Industry. <http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2009/nghurricanes08/nghurricanes08.pdf>

[6] Department of Energy, Office of Electricity Delivery and Energy Reliability (2008). Emergency Situation Reports, various dates.

Shut-in Production Outlook

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. Appropriate 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 some scenarios. The projections for shut-in production during the 2009 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 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, we simulate the number of severe storms passing through the Gulf of Mexico, and second, the shut-in production caused by each simulated storm. The number of tropical storms, moderate hurricanes, and intense hurricanes passing through the Gulf of Mexico are simulated using information contained in NOAA's *Atlantic Basin Hurricane Season Outlook*. The NOAA *Outlook* estimates a 70-percent probability that 9 to 14 named storms will form within the Atlantic Basin, including 4 to 7 total hurricanes of which 1 to 3 will be intense. These ranges compare with a seasonal average of 10.4 named storms, 6.1 hurricanes, and 2.4 intense hurricanes during the years 1950-2008. The Gulf of Mexico region has experienced an average of 3.4 named storms including an average of 1.7 hurricanes of which 0.8 are intense.[7] If we assume that projected weather conditions within the region relative to normal conditions will be similar to the relative conditions for the Atlantic Basin as a whole, then the Gulf of Mexico may be expected to experience:

- 3 – 5 named storms
- 1 – 2 total hurricanes
- 0 – 1 intense hurricanes.

The simulation assumes that the likelihood of the number of each type of storm occurring in the Gulf of Mexico can be modeled as a Poisson distribution with the mean of each distribution assumed to be the midpoints of the expected ranges listed above.

[7] 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, 1995-2008

	Crude Oil (thousand barrels)		Natural Gas (billion cubic feet)	
	Mean	Std Dev	Mean	Std Dev
Tropical Storm	505	645	4.02	6.80
Moderate Hurricane [a]	1,320	2,015	8.96	14.82
Intense Hurricane [b]	14,600	19,060	89.34	112.74

[a] Category 1 or 2.

[b] Category 3, 4, or 5.

Std Dev = standard deviation.

Source: EIA calculations.

The second step of the Monte Carlo simulation involves estimating 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 equal to the corresponding statistics for estimated shut-in production during 1995-2008 (Table 1). These outage statistics illustrate how weather-related production impacts increase dramatically with the severity of the storm. The mean outage 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. Crude oil outages and natural gas outages were simulated separately.

We conducted 10,000 random simulations of the number of tropical storms and hurricanes to form in the Gulf of Mexico during the upcoming season along with the aggregate seasonal shut-in production caused by these simulated storms. The simulated results can be used to build sampling distributions of seasonal shut-in crude oil or natural gas production within the Gulf of Mexico. The distributions describe both the expected levels of production outages and the probabilities of various possible shut-in quantities, some of which are shown in Table 2. More complete cumulative probability distribution tables for both crude oil and natural gas are shown in the Tables A2 and A3 in the Appendix.

Table 2. Simulated Cumulative Shut-in Production for 2009 Hurricane Season

Crude Oil (million barrels)		Natural Gas (billion cubic feet)	
Mean	12.9	Mean	85.6
50th Percentile (Median)	4.5	50th Percentile (Median)	36.4
90th Percentile	38.6	90th Percentile	241.7
95th Percentile	50.7	95th Percentile	318.4
Outage Scenario Probabilities		Outage Scenario Probabilities	
P(No Shut-In)	0.0409	P(No Shut-In)	0.0503
P(> 25 MMbbl Shut-in)	0.1930	P(> 150 Bcf Shut-in)	0.2110
P(> 50 MMbbl Shut-in)	0.0520	P(> 300 Bcf Shut-in)	0.0600
P(> 100 MMbbl Shut-in)	0.0030	P(> 600 Bcf Shut-in)	0.0030

MMbbl = million barrels.
Bcf = billion cubic feet.
Source: EIA calculations.

The extreme skewness of the two sampling distributions is evident in the large difference between the mean and median values.[8] For crude oil, the median level of simulated cumulative shut-in production is only 4.5 million bbl in contrast to a mean of 13 million bbl. For natural gas, the median shut-in production level is 36 Bcf in contrast to the mean of about 85 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.

The sampling distributions derived from the Monte Carlo simulation also allow an analysis of other possible outage scenarios. For example, the percentile statistics in Table 2 indicate a 10-percent probability (90th percentile) of losing more than about 40 million bbl of crude oil or 240 Bcf of natural gas during the hurricane season. Other possible scenarios can be examined using the cumulative probability distribution tables shown in the Appendix. For example, the sampling distributions indicate a relatively small 2.7-percent likelihood of experiencing disruptions similar to last year with cumulative outages exceeding 60 million bbl of crude oil or a 4-percent probability of more than 335 Bcf of shut-in natural gas. On the other hand, there is about a 95-percent chance that offshore crude oil or natural gas production will be at least somewhat impacted by hurricanes or tropical storms during 2009, i.e., shut-in production greater than zero.

[8] The mean value of a sampling distribution represents the simple average of all possible outcomes. The median value is that outcome with an equal probability, 50 percent, of either falling below or exceeding the value.

It is important to stress the uncertainty surrounding EIA's expected level of shut-in production. The 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 65 percent probability that shut-in offshore production for the entire season will fall between 1.2 and 27 million bbl of crude oil and between 10 and 175 Bcf of natural gas. Both of the ranges are wide, and constructing intervals with a higher likelihood would widen the gap even further.

The probability distributions simulated in this analysis are conditional upon NOAA's projections of the number of storms expected to form within the Atlantic Basin. NOAA's seasonal hurricane outlook at this time last year projected an above-average number of hurricanes and tropical storms, and likewise, EIA's production outage projections for the last year's hurricane season were higher than those expected for the upcoming season. The actual number of Atlantic hurricanes and tropical storms that did form last year fell towards the upper range of NOAA's early forecast, and at least four strong storms impacted or posed a significant threat to Gulf production. If the hurricane activity over the next few weeks shows signs of a stronger-than-expected season, the likelihood of the various levels of shut-in production would need to be revised upwards.

Appendix

Table A1. Gulf of Mexico Tropical Storms and Hurricanes and Estimated Shut-in Production, 1995-2008

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, 1995-2008, 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	0	0
Barry	Jun 2007	0	516	0	0
Dean	Aug 2007	5	627	9,850	4.9
Erin	Aug 2007	0	256	881	0.4
Humberto	Sep 2007	1	144	2,056	7.5
Ten [d]	Sep 2007	[d]	274	169	0.6
Dolly	Jul 2008	2	365	0	0
Edouard	Aug 2008	0	30	1,084	15.6
Gustav	Sep 2008	4	64	39,394	252.9
Ike	Sep 2008	4	131	21,782	139.8

Source: NOAA and EIA calculations.

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

[b] Closest distance that hurricane or tropical storm passed to geographic center of 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. Probabilities for Various Levels of 2009 Shut-in Gulf of Mexico Crude Oil Production

	Probability of Shut-in Production	
Million Barrels	More Than	Less Than
0	95.9%	4.1%
0.5	91.7%	8.3%
1	85.7%	14.3%
1.5	78.7%	21.3%
2	72.3%	27.7%
2.5	66.7%	33.3%
3	61.6%	38.4%
3.5	57.2%	42.8%
4	53.4%	46.6%
4.5	50.2%	49.8%
5	47.4%	52.6%
6	42.7%	57.3%
7	39.0%	61.0%
8	36.5%	63.5%
9	34.7%	65.3%
10	33.1%	66.9%
11	31.9%	68.1%
12	30.8%	69.2%
13	29.9%	70.1%
14	29.0%	71.0%
15	28.1%	71.9%
16	27.3%	72.7%
17	26.4%	73.6%
18	25.4%	74.6%
19	24.4%	75.6%
20	23.5%	76.5%
25	19.3%	80.7%
30	15.4%	84.6%
35	12.3%	87.7%
40	9.3%	90.7%
45	7.1%	92.9%
50	5.2%	94.8%
60	2.7%	97.3%
70	1.4%	98.6%
80	0.8%	99.2%
90	0.5%	99.5%
100	0.3%	99.7%

Source: EIA Monte Carlo simulation

Table A3. Probabilities for Various Levels of 2009 Shut-in Gulf of Mexico Natural Gas Production

	Probability of Shut-in Production	
Billion Cubic Feet	More Than	Less Than
0	95.0%	5.0%
1	94.2%	5.8%
2	93.3%	6.7%
3	92.0%	8.0%
4	91.0%	9.0%
5	89.5%	10.5%
6	88.3%	11.7%
7	87.0%	13.0%
8	85.5%	14.5%
9	84.1%	15.9%
10	82.6%	17.4%
15	74.7%	25.3%
20	67.3%	32.7%
25	60.9%	39.1%
30	55.7%	44.3%
35	51.1%	48.9%
40	46.9%	53.1%
45	43.9%	56.1%
50	41.1%	58.9%
75	32.7%	67.3%
100	28.4%	71.6%
125	24.6%	75.4%
150	21.1%	78.9%
175	17.9%	82.1%
200	14.8%	85.2%
225	12.0%	88.0%
250	9.4%	90.6%
275	7.7%	92.3%
300	6.0%	94.0%
325	4.7%	95.3%
350	3.7%	96.3%
400	2.4%	97.6%
450	1.3%	98.7%
500	0.7%	99.3%
550	0.5%	99.5%
600	0.3%	99.7%

Source: EIA Monte Carlo simulation.