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Energy Information Administration

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Short-Term Energy Outlook Supplement: The 2008 Outlook for Hurricane Production Outages in the Gulf of Mexico

Highlights

- The National Oceanic and Atmospheric Administration (NOAA) predicted above-normal hurricane activity in its *Atlantic Hurricane Season Outlook* released on May 22, 2008.[1] NOAA projects 12 to 16 named storms will form within the Atlantic Basin, including 6 to 9 hurricanes, of which 2 to 5 will be intense, during the upcoming hurricane season (June 1 – November 30).[2]

- Above-normal hurricane activity in the Atlantic is likely to correspond to increased impacts on offshore crude oil and natural gas producers in the Gulf of Mexico. However, the range of potential production outages is quite extensive, depending on the severity of the weather in the producing region.

- Based on the results of a Monte Carlo hurricane outage simulation, which is conditional on how NOAA's most recent predictions for the level of Atlantic basin hurricane activity compare to historical activity, EIA expects a total of about 11.3 million barrels (bbls) of crude oil and 78 billion cubic feet (Bcf) of natural gas to be shut in during the 2008 hurricane season.

- The simulation results indicate only a less-than-1-percent probability of experiencing seasonal outages similar to 2005 when Hurricanes Katrina and Rita struck the Gulf Coast, i.e., cumulative shut-in production of more than 100 million bbls of crude oil or 600 Bcf of natural gas. Conversely, EIA projects the chance that offshore production in the Federally-administered Gulf of Mexico will be impacted this year is 98 percent for both crude oil and natural gas.

Contact: Tyler Hodge (Tyler.Hodge@eia.doe.gov)

[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. In 2007, crude oil production from the Federally-administered offshore Gulf fields accounted for more than one quarter of total U.S. oil production, and marketed production of Gulf of Mexico natural gas was about 14 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.

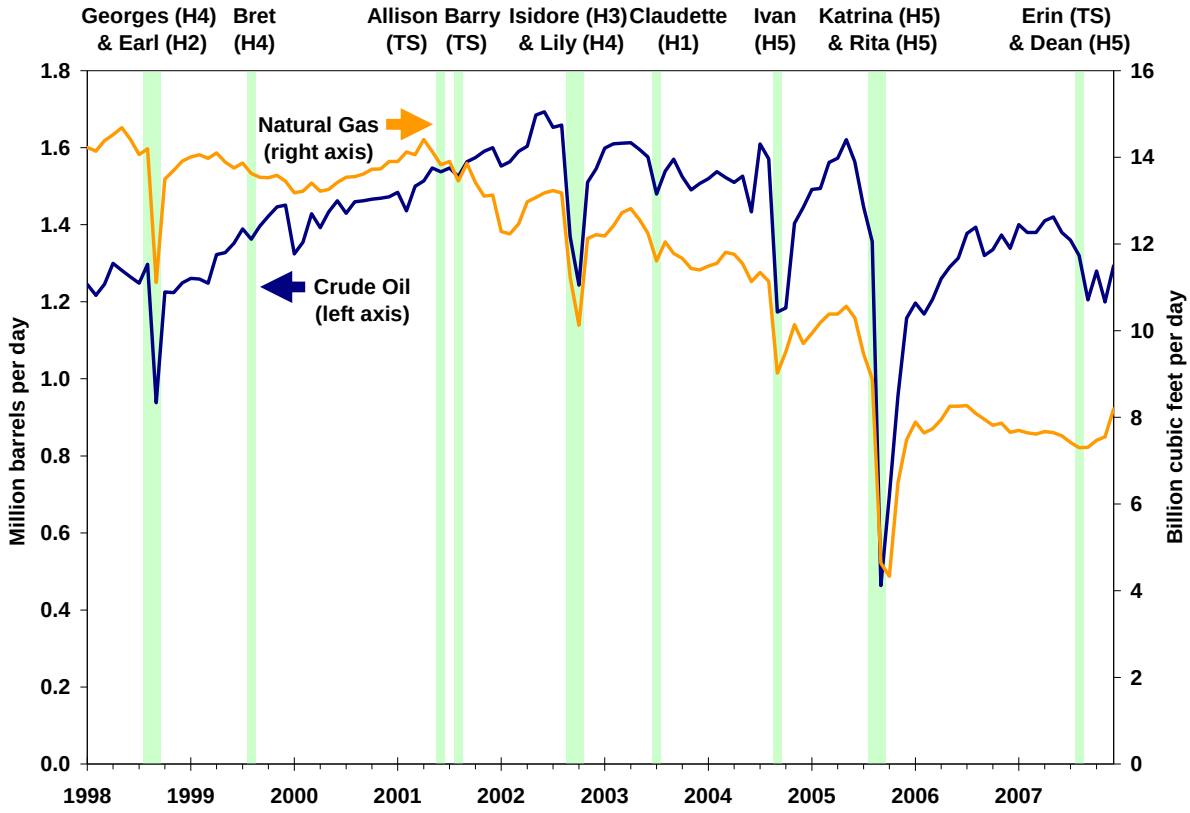
When severe weather threatens, offshore platform operators must evacuate personnel and temporarily shut in production to protect facilities. Hurricanes Katrina and Rita passed directly over the producing region, causing longer-lasting disruptions as a result of damage to production infrastructure. A total of 113 platforms were destroyed and 52 platforms suffered significant damage.[3] The vast majority of the destroyed platforms were older platforms that did not meet current design specifications mandated by the Minerals Management Service (MMS).

At one point just after the landfall of Hurricane Rita, 93 percent of Gulf platforms were evacuated. As much as 1.5 million bbls per day of crude oil (100 percent of normal daily production in the Federally-administered Gulf of Mexico) and 8.8 Bcf per day of natural gas (88 percent of normal daily production) were shut in while the two hurricanes passed over the producing region. The cumulative impacts of Katrina and Rita were just as extraordinary. Through the end of 2005, MMS reported that the cumulative loss as a result of the disruption from those two hurricanes was 109 million bbls of crude oil (about 20 percent of annual Gulf production) and 561 Bcf of natural gas (15.3 percent of annual production). MMS continued to collect Katrina and Rita shut-in production reports through June 19, 2006.

In addition to the upstream impacts to Gulf production, the 2005 hurricanes had significant impacts on midstream and downstream infrastructure. They damaged 457 underwater pipelines, and the Louisiana Offshore Oil Port had to temporarily stop accepting shipments during both hurricanes. A number of onshore crude oil refineries and natural gas processing facilities also suffered heavy damage. After Hurricane Katrina struck the Louisiana coast, nearly 2 million bbls per day of refinery capacity was shut down either because of direct damage or interruption of power supplies. A total of more than 4.9 million bbls per day of refinery capacity was shut down after Hurricane Rita hit the Texas coast.

[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>.

Figure 1. Crude Oil and Natural Gas Production
Federal Offshore Gulf of Mexico, 1998-2007



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

With the exception of the hurricanes during the summer of 2005, which affected Gulf crude oil and natural gas operations for many months, severe weather in the region historically impacts operations only for short periods of time. Figure 1 shows oil and natural gas production in the Gulf of Mexico for 1998 through 2007 with the effects of various tropical storms and hurricanes highlighted. The disruptions from severe weather often can be identified by temporary dips in production from normal levels. There have been five intense hurricanes during the past decade that have caused significant disruptions in crude oil and natural gas production: Georges (1998), Lili (2002), Ivan (2004), and Katrina and Rita (2005).

In response to the damaging effects of Hurricanes Katrina and Rita, MMS issued a final rule on April 15, 2008, incorporating design and assessment standards suggested by the American Petroleum Institute.[4] These standards should better protect offshore

[4] *Federal Register* 73, No. 73 (15 April 2008): 20166.

crude oil and natural gas infrastructure in the future and make sure these resources return more quickly to normal production rates after disruptions caused by severe tropical storms.

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 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 certain scenarios. The projections for shut-in production during the 2008 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 model used for this analysis consists of a two-step simulation: first, simulating the number of severe storms passing through the Gulf of Mexico, and second, the outage caused by each 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 May 22, 2008, NOAA *Outlook* estimates that 12 to 16 named storms will form within the Atlantic Basin, including 6 to 9 total hurricanes of which 2 to 5 will be intense. These ranges compare with a seasonal average of 10.3 named storms, 6.0 hurricanes, and 2.4 intense hurricanes during the years 1950-2007. 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.[5] If one assumes 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:

- 4.0 – 5.3 named storms
- 1.7 – 2.5 total hurricanes
- 0.6 – 1.5 intense hurricanes

[5] 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, 1995-2007

	Crude Oil (thousand barrels)		Natural Gas (billion cubic feet)	
	Mean	Std Dev	Mean	Std Dev
Tropical Storm	488	646	3.68	6.59
Moderate Hurricane [a]	1,407	2,054	9.56	15.14
Intense Hurricane [b]	12,142	19,023	72.88	109.98

[a] Category 1 or 2. [b] Category 3, 4, or 5

Source: Energy Information Administration calculations.

The Monte Carlo simulation assumes that the likelihood of the number of each type of Gulf storm occurring can be modeled as a Poisson distribution with the mean of each distribution calculated from the midpoints of the expected ranges for the Gulf of Mexico listed above.

The second step of the Monte Carlo simulation involves estimating the shut-in crude oil and natural gas production caused by each simulated tropical storm or hurricane and summing the aggregate 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 1995-2007 (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 skewed by the 100 million bbls 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.

The Monte Carlo simulation consists of 10,000 random scenarios simulating the number of moderate and intense hurricanes and tropical storms to occur during the upcoming season along with the simulated shut-in production caused by each of these storms. Any negative simulated shut-in values are assumed to represent zero production impact. The total seasonal shut-in production for each random scenario is calculated by aggregating the outages caused by each simulated tropical storm or hurricane. The resulting sampling distributions for seasonal shut-in crude oil and natural gas production within the Gulf of Mexico, which are conditioned on NOAA's prediction of the number of Atlantic named storms and hurricanes, describe both the expected levels of production outages and the probabilities of various possible shut-in quantities (Table 2). Complete cumulative probability distribution function charts for both crude oil and natural gas are shown in the Appendix.

Table 2. Simulated Cumulative Shut-in Production for 2008 Hurricane Season

Crude Oil (million barrels)		Natural Gas (billion cubic feet)	
Mean	21.0	Mean	129.4
50th Percent (Median)	11.3	50th Percent (Median)	78.4
90th Percentile	53.1	90th Percentile	319.6
95th Percentile	67.5	95th Percentile	392.4
Outage Scenario Probabilities		Outage Scenario Probabilities	
P(No Shut-In)	0.0167	P(No Shut-In)	0.0230
P(> 25 MMbbls Shut-in)	0.3370	P(> 150 Bcf Shut-in)	0.3430
P(> 50 MMbbls Shut-in)	0.1180	P(> 300 Bcf Shut-in)	0.1200
P(> 100 MMbbls Shut-in)	0.0090	P(> 600 Bcf Shut-in)	0.0086

Source: EIA calculations

The extreme skewness of the two distributions is evident in the large difference between the mean and median values.[6] For crude oil, the median level of cumulative shut-in production is 11 million bbls in contrast to a mean of 21 million bbls. For natural gas, the median shut-in production level is 78 Bcf in contrast to the mean of 129 Bcf. This skewness occurs because the simulation allows for the possibility of another season like 2005. Given that such outcomes represent extreme 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.

Although NOAA's seasonal hurricane outlook is similar to their forecast at this time last year, EIA's production outage projections are slightly lower. This change reflects the recent improvements in offshore production infrastructure. Only one tropical storm and one distant hurricane threatened production during the 2007 hurricane season, yet the shut-in production reported to MMS was smaller than the reported outages caused by similar storms in past years.

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 53 million bbls of crude oil and 320 Bcf of natural gas during the hurricane season. In addition, one can analyze the likelihood of a repetition of either the destructive 2005 season or the quiet 2006 season. The sampling distributions indicate a relatively small 0.9-percent likelihood of a repeat of a hurricane season similar to 2005 with cumulative outages exceeding 100 million bbls of crude oil and 600 Bcf of natural gas.

[6] 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.

On the other hand, there is a 98.3-percent chance that offshore crude oil production will be impacted by hurricanes or tropical storms during 2008 and a 97.7-percent chance that natural gas production will be affected, i.e., shut-in production greater than zero. During a season that experiences the average number of Gulf hurricanes, the probability of at least some level of shut-in production is approximately 92 percent. Other possible scenarios can be examined using the cumulative probability distribution curves shown in the Appendix.

It is important to stress the uncertainty of these expectations. The cumulative probability distribution curves 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 2 and 41 million bbls of crude oil and between 19 and 247 Bcf of natural gas. Both of the ranges are wide, and contructing intervals with a higher likelihood would widen the gap even further.

Appendix

Table A1. Gulf of Mexico Tropical Storms and Hurricanes and Estimated Shut-in Production, 1995-2007

Name	Date	Maximum Category [a]	Closest Distance [b] (miles)	Estimated Outage [c] Crude Oil (MMbbls)	Natural Gas (Bcf)
Allison	Jun 1995	1	358	624	0.33
Dean	Jul 1995	0	136	189	4.03
Erin	Aug 1995	1	282	1,529	15.45
Gabrielle	Aug 1995	0	476	490	4.94
Jerry	Aug 1995	0	607	67	0.68
Opal	Oct 1995	4	230	2,951	25.33
Roxanne	Oct 1995	3	468	2,112	18.13
Dolly	Aug 1996	1	589	0	0
Josephine	Oct 1996	0	252	1,455	13.75
Danny	Jul 1997	1	50	990	6.31
Charley	Aug 1998	0	263	0	0
Earl	Sep 1998	2	125	3,765	27.53
Frances	Sep 1998	0	264	787	5.76
Georges	Sep 1998	2	195	7,695	56.27
Hermine	Sep 1998	0	54	1,337	9.77
Mitch	Nov 1998	0	509	1,482	0.03
Bret	Aug 1999	4	325	1,722	5.68
Harvey	Sep 1999	0	325	764	5.18
Irene	Oct 1999	1	692	281	3.92
Beryl	Aug 2000	0	438	0	0.90
Gordon	Sep 2000	1	465	0	0.51
Helene	Sep 2000	0	280	0	0.36
Keith	Oct 2000	1	580	421	0
Allison	Jun 2001	0	214	1,015	7.04
Barry	Aug 2001	0	291	2,747	13.27
Gabrielle	Sep 2001	0	493	0	0
Bertha	Aug 2002	0	134	0	0
Edouard	Sep 2002	0	652	11	0.07
Fay	Sep 2002	0	151	493	3.08
Hanna	Sep 2002	0	163	619	3.87
Isidore	Sep 2002	3	91	10,095	63.06
Lili	Oct 2002	4	27	6,075	46.91
Bill	Jul 2003	0	49	0	4.66
Claudette	Jul 2003	1	135	2,500	15.90
Erika	Aug 2003	1	208	226	0
Grace	Aug 2003	0	209	56	0
Henri	Sep 2003	0	416	375	2.73
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, 1995-2007, continued

Name	Date	Maximum Category [a]	Closest Distance [b] (miles)	Estimated Outage [c] Crude Oil (MMbbls)	Natural Gas (Bcf)
Bonnie	Aug 2004	0	220	748	0
Charley	Aug 2004	4	608	596	0
Frances	Sep 2004	0	454	93	0.40
Ivan	Sep 2004	5	25	27,294	118.09
Jeanne	Sep 2004	1	517	61	0.26
Matthew	Oct 2004	0	68	1,362	34.51
Arlene	Jun 2005	0	270	1,534	5.73
Bret	Jun 2005	0	657	91	0.34
Cindy	Jul 2005	1	95	946	6.66
Dennis	Jul 2005	4	302	1,653	11.64
Emily	Jul 2005	4	387	1,995	14.05
Gert	Jul 2005	0	598	52	0.37
Jose	Aug 2005	0	677	293	1.90
Katrina	Aug 2005	5	138	54,902	355.77
Rita	Sep 2005	5	77	48,351	255.59
Stan	Oct 2005	1	585	9	2.69
Tammy	Oct 2005	0	621	1	0.24
Wilma	Oct 2005	4	566	97	28.30
Alberto	Jun 2006	0	249	0	0
Barry	Jun 2007	0	516	0	0
Dean	Aug 2007	5	627	9,850	4.87
Erin	Aug 2007	0	256	881	0.43
Humberto	Sep 2007	1	144	2,056	7.54
Ten [d]	Sep 2007	-	274	169	0.62

Source: NOAA and EIA calculations.

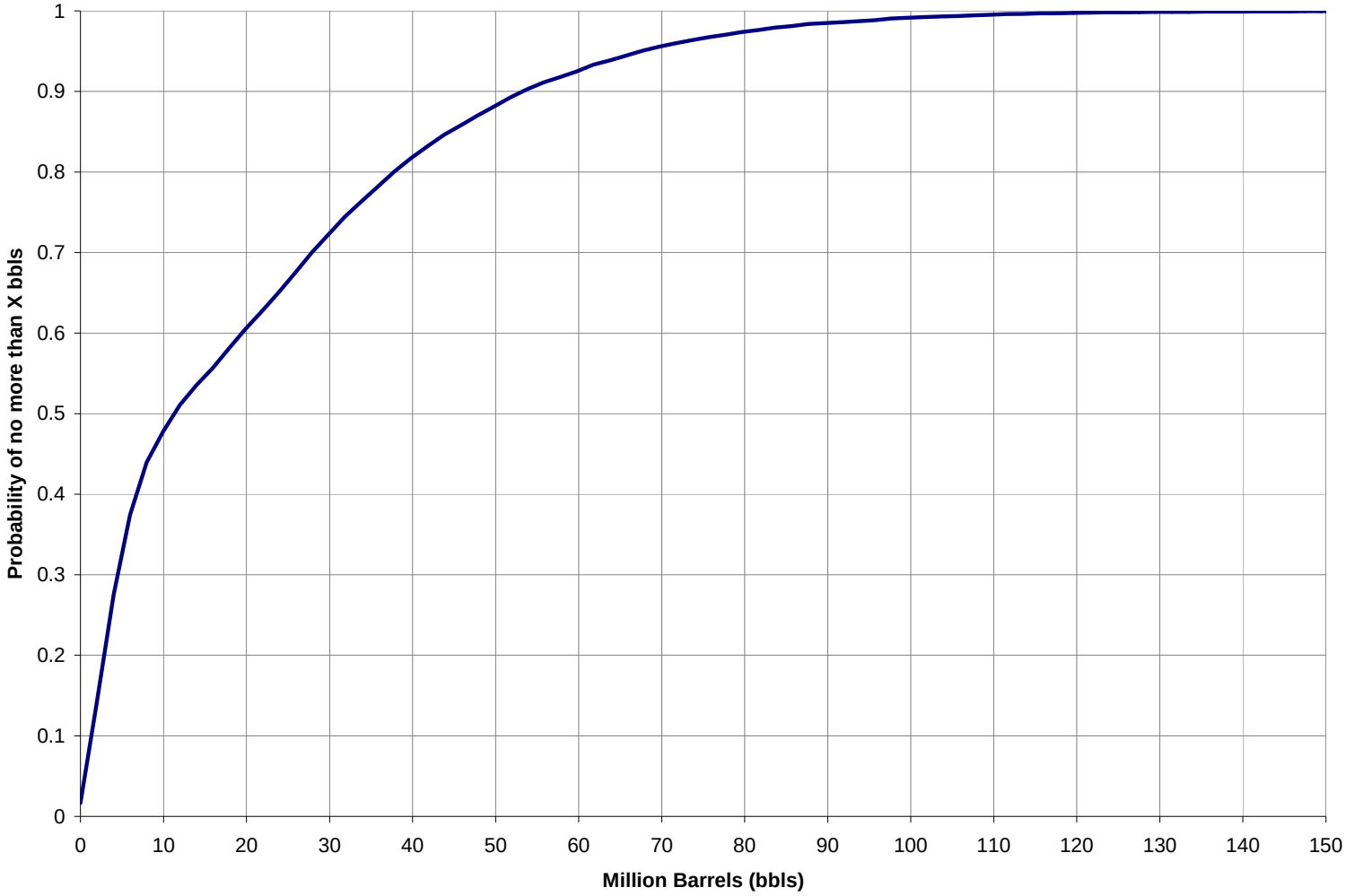
[a] 0 = Tropical storm. 1-5 = Category n hurricane.

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

[c] EIA estimates. 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)

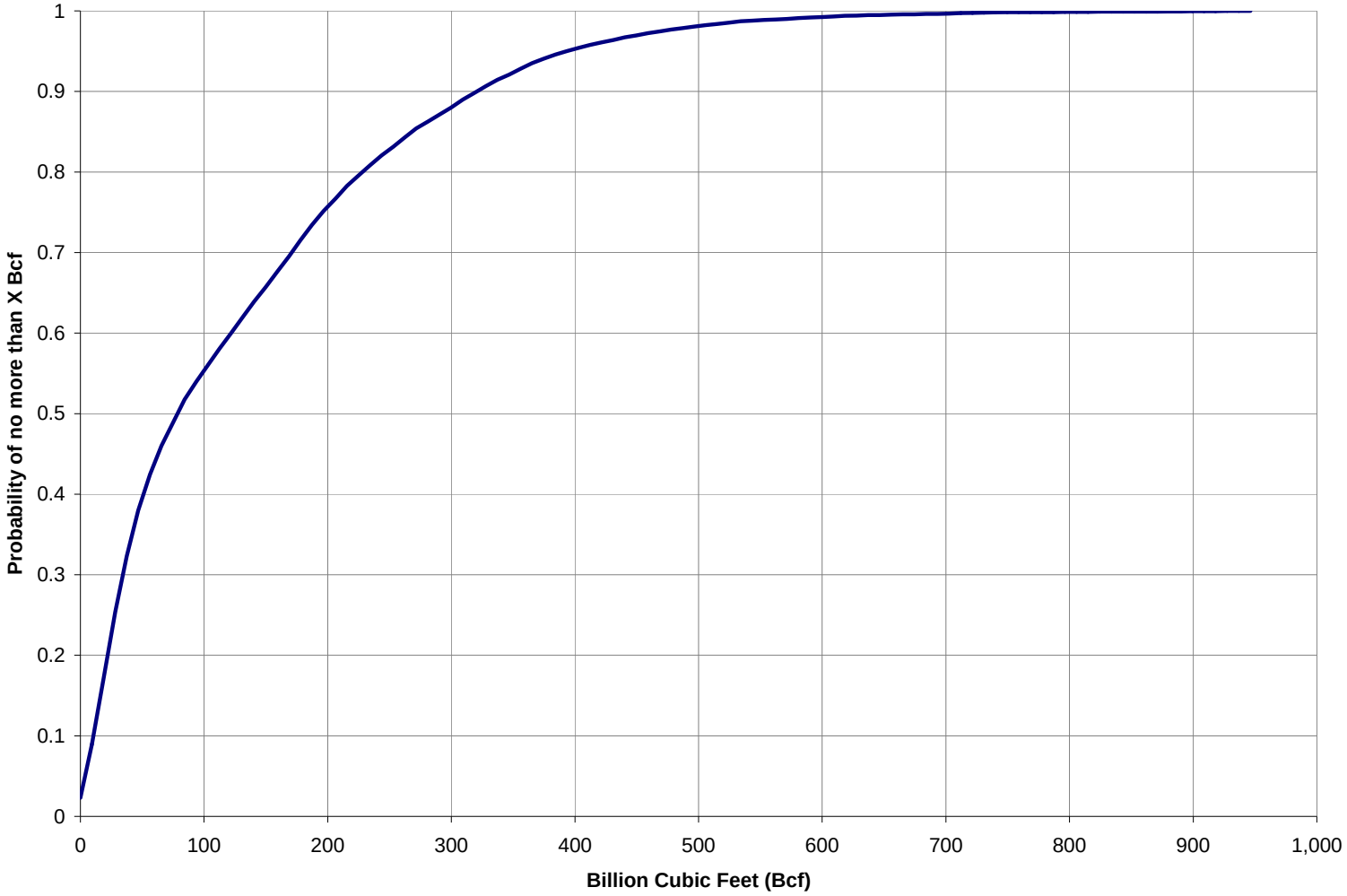
[d] Storm was classified as a tropical depression.

Figure A1. Cumulative Probability Distribution Curve for Shut-in Crude Oil Production



Source: EIA calculations.

Figure A2. Cumulative Probability Distribution Curve for Shut-in Natural Gas Production



Source: EIA calculations.