

Comparing the Impacts of the 2005 and 2008 Hurricanes on U.S. Energy Infrastructure

**Infrastructure Security and Energy Restoration
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For Further Information

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Cover: NASA image of Hurricane Katrina approaching Louisiana on August 28, 2005, <http://veimages.gsfc.nasa.gov/7938/Katrina.A2005240.1700.2km.jpg>.

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Executive Summary

Hurricanes Gustav and Ike struck the U.S. Gulf within two weeks of each other in September 2008, severely damaging energy infrastructure and disrupting oil and gas supplies throughout the United States. Millions of electricity customers lost power as the storms knocked down thousands of miles of transmission and distribution lines, and forced shut hundreds of substations. Two nuclear power plants were shut due to the storm. Extended electricity outages delayed the restoration of refineries, pipelines, gas processors, and other energy facilities that depend on grid-delivered power.

Oil and gas platform operators shuttered offshore production in the Gulf of Mexico as a precaution before both storms and damage caused by the storms kept a significant portion of that production offline several months after the storms passed. Some smaller platforms were completely destroyed and a small amount of Gulf of Mexico oil and gas production is likely to be permanently lost. Hurricanes Gustav and Ike also shut onshore natural gas processing plants and several gas pipelines, restricting the flow of gas throughout the United States for weeks. Despite the supply curtailment, natural gas prices remained stable both before and after the storms made landfall.

U.S. petroleum supply was also impacted by the hurricanes, which shut key petroleum infrastructure, including refineries, ports, waterways, and pipelines. More than a dozen refineries were shut as a precaution before each hurricane, but only a few remained offline for several weeks after Hurricane Ike due to lack of power supply. Port closures disrupted crude oil and petroleum product imports into the Gulf and once ports reopened, product imports were limited by stringent quality standards for gasoline and distillate fuel. Although stocks of petroleum products were sufficient in the Gulf, the closure of key product pipelines, ports, and waterways prevented many of these supplies from reaching consumer markets. Fuel supply problems were particularly acute in the Southeast, which is highly dependent on supply from two key petroleum products pipelines fed by Gulf refineries. A combination of supply shortages and panic buying occurred in the Southeast in the weeks following Gustav and Ike. Spot gasoline and diesel prices briefly spiked as Hurricane Ike approached and the market anticipated serious damage to Texas refineries but quickly returned to pre-storm levels after site assessments revealed only minor damage.

Table ES-1. Energy Impacts of 2005 Hurricanes vs. 2008 Hurricanes

Energy Type Impacted	2005			2008	
	Katrina 8/30/05	Rita 9/25/05	Wilma 10/25/05	Gustav 9/2/08	Ike 9/14/08
Electricity (Million Customers)	2.7	1.5	3.5	1.1	3.9
Natural Gas Production (Bcf/d)	8.8	8.1	0	7.1	7.3
Oil Production (MMBD)	1.4	1.5	0	1.3	1.3

Notes: Bcf/d = billion cubic feet per day; MMBD = million barrels per day.

Sources: OE/ISER Situation Reports, MMS

The energy infrastructure and supply disruptions caused by the 2008 hurricanes were similar but not as severe as those caused by Hurricanes Katrina, Rita and Wilma in 2005 (See Table ES-1.) Although worst-day outages between both hurricane seasons were comparable, Hurricanes

Katrina and Rita were more powerful and caused more lasting damage to energy infrastructure than Hurricanes Gustav and Ike. As a result, energy production and supply recovered more quickly in 2008 than in 2005.

Recovery in 2008 was hastened by the actions of the energy industry and Federal, State, and local government agencies, which were better prepared to mount extensive restoration efforts after the experience gained from 2005. Many Federal agencies helped with energy restoration, including the Department of Energy (DOE). The DOE Office of Electricity Delivery and Energy Reliability, Infrastructure Security and Energy Restoration division (OE/ISER) helped facilitate the restoration of damaged energy systems and components through a variety of actions. OE/ISER sent its Emergency Support Function #12 (ESF-12) responders to field offices in the Gulf to work with other Federal, State, and local officials and industry representatives to identify damaged infrastructure, prioritize restoration efforts, and recommend emergency actions. OE/ISER monitored and reported on damage assessment, restoration efforts and recovery estimates, and supported decision making by other government agencies responsible for granting waivers to help alleviate energy supply problems. DOE released crude oil from its Strategic Petroleum Reserve at the request of refiners experiencing supply problems in the wake of the hurricanes and monitored fuel prices to make certain that consumers were paying appropriate prices at the pump.

This report compares the impact of the major hurricanes of 2005 and 2008 on U.S. energy systems, including those that produce, process and transport oil, natural gas, and electricity. The magnitude and duration of hurricane-induced production and supply disruptions are compared, as well as the extent of damage to energy infrastructure. The effect of disruptions on energy prices and supply is analyzed. The report describes the actions taken by DOE and other Federal agencies to assist the energy industry in restoration.

The primary sources of 2005 and 2008 data provided in this report are the Emergency Situation Reports prepared by OE/ISER and available on the public web site, http://www.oe.netl.doe.gov/emergency_sit_rpt.aspx. The Energy Assurance Daily during the periods under study is used to provide supporting details and can be found at <http://www.oe.netl.doe.gov/ead.aspx>. Footnotes are provided where other sources are used in the report.

Storm Paths

The 2005 Atlantic hurricane season was the most active in recorded history, setting records for the number of named storms, the number of hurricanes, and the costliest hurricane (see Table 1). Of the storms that made U.S. landfall, three of the season's seven major hurricanes—Katrina, Rita, and Wilma—were responsible for most of the destruction.

Table 1. Seasonal Records of 2005 and 2008 Hurricanes

Seasonal Records ¹	2005	2008
Named storms	#1 – 27 named storms	#7 – 16 named storms
Hurricanes	#1 – 15 hurricanes	#25 – 8 hurricanes
Major hurricanes ²	#1 – 7 major hurricanes (4 reached Category 5 status)	#9 – 5 major hurricanes
Longest seasons ³	#2 – 126.5 days	#13 – 84.75 days
Costliest hurricanes	#1 – Katrina \$ 100 + billion	#4 – Ike \$ 16.2 billion
Deadliest hurricanes	#3 – Katrina 1,000 + dead	#26 – Ike 82 dead
Focus on 5 Storms Category, State, Date at Landfall	Katrina Cat. 1 FL 8/25/05 Cat 3 LA 8/29/05 Rita Cat 3 TX/LA 9/24/05 Wilma Cat 3 FL 10/24/05	Gustav Cat 2 LA 9/1/08 Ike Cat 2 TX 9/13/08

Notes: ¹ Since 1900, according to the National Hurricane Center.

² Category 3 or higher.

³ Number of named storm days in each year.

Sources: http://www.noaanews.noaa.gov/stories2008/20081126_hurricanesseason.html;
<http://www.ncdc.noaa.gov/oa/climate/research/2005/hurricanes05.html>;
<http://www.nhc.noaa.gov/HAW2/english/history.shtml>; http://www.nhc.noaa.gov/ms-word/TCR-AL122005_Katrina.doc; http://www.nhc.noaa.gov/archive/2008/tws/MIATWSAT_nov.shtml;
<http://www.wunderground.com/blog/JeffMasters/archive.html?year=2008&month=11>;
<http://www.wunderground.com/blog/JeffMasters/comment.html?entrynum=252&tstamp=200512>.

The most catastrophic effects of the season were felt on the U.S. Gulf Coast, where a 30-foot storm surge from Hurricane Katrina on August 29, 2005, caused devastating flooding that inundated New Orleans, Louisiana, and destroyed most structures on the Mississippi coastline. One month later, Hurricane Rita caused renewed flooding in New Orleans before making landfall on the Texas-Louisiana border, flooding the cities of Beaumont and Port Arthur, Texas. Hurricanes Dennis and Wilma both made landfall in Florida while Ophelia skirted the coast of North Carolina.

The 2008 Atlantic hurricane season was one of the most active on record but was not as severe as the 2005 season. Within a two-month period in 2008, three hurricanes and two tropical storms made landfall in the United States¹. Hurricanes Gustav and Ike, which made landfall on the Gulf Coast within two weeks of one another in 2008, were costly storms in terms of property damage and lives lost. Hurricane Gustav made landfall in Louisiana on September 1 as a strong Category

¹ Between July 23 and September 13, 2008, Hurricanes Dolly, Gustav, and Ike; and Tropical Storms Edouard and Hanna made landfall in the United States. Hurricane Dolly made landfall on the Texas-Mexico border and had only minor impacts to U.S. energy infrastructure.

2 hurricane – 1 mph below Category 3 level. Gustav made landfall to the west of where Hurricane Katrina hit in 2005, tearing through south central Louisiana and bringing significant flooding as far north as Baton Rouge. Hurricane Ike made landfall 13 days later as a Category 2 Hurricane. Ike, which made landfall at Galveston, Texas, to the west of where Rita made landfall as a Category 3 Hurricane in 2005, caused significant damage in the Houston area before racing across the eastern United States, impacting the Midwest and communities as far north as New York.

Of all the storms that made landfall in 2005 and 2008, this analysis is focused on Katrina, Rita, and Wilma (for electricity impacts only) in 2005 and Gustav and Ike in 2008. Figure 1 shows the paths of the three most powerful hurricanes in 2005 – Katrina (purple), Rita (orange), and Wilma (brown). The two most damaging hurricanes of 2008 – Gustav (green) and Ike (blue) – are layered on top to show the common paths.

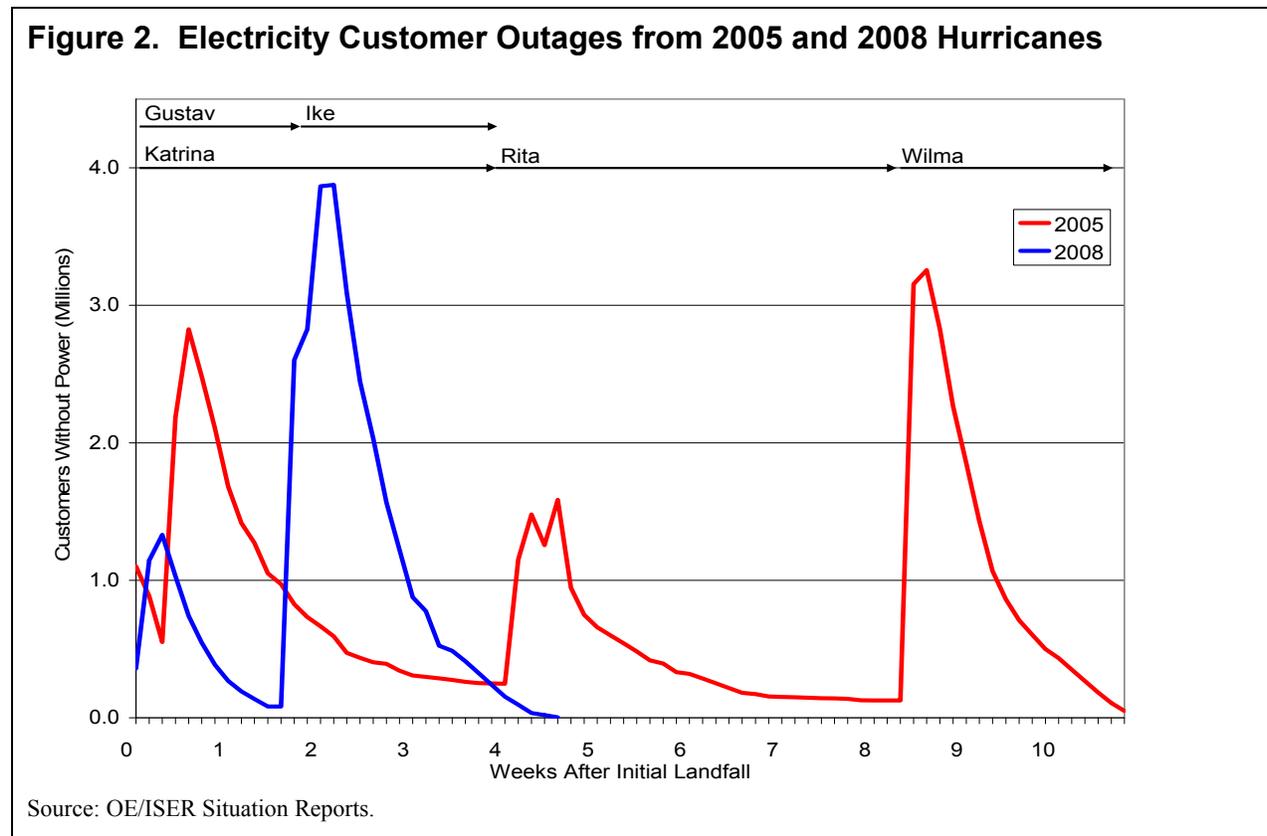


Both the 2005 and 2008 hurricane seasons caused severe damage and had lasting impacts on all types of energy infrastructure. However, the 2005 hurricane season was considerably more active in terms of the number of named storms, the number of storms that became hurricanes, and the intensity of the storms upon landfall. In 2008, a weaker hurricane season coupled with better preparations by the oil, gas and electricity industries resulted in less severe impacts on energy infrastructure than in 2005.

Electricity

Customer Outages

The hurricanes and tropical storms of 2005 and 2008 caused major power outages as high winds and heavy rains resulted in significant damage to electricity transmission and distribution networks. The magnitude of the power outages was determined by the intensity of the storm and the population density of the communities in the storm path. High density coastal communities with above ground power lines were most affected. In 2005, three major hurricanes made direct hits in the heavily populated areas of Miami, New Orleans, and Houston, impacting electricity assets owned and operated by Florida Power & Light, CenterPoint Energy, three Entergy operating companies (New Orleans, Gulf States, and Louisiana), and several other utilities operating in the Gulf.

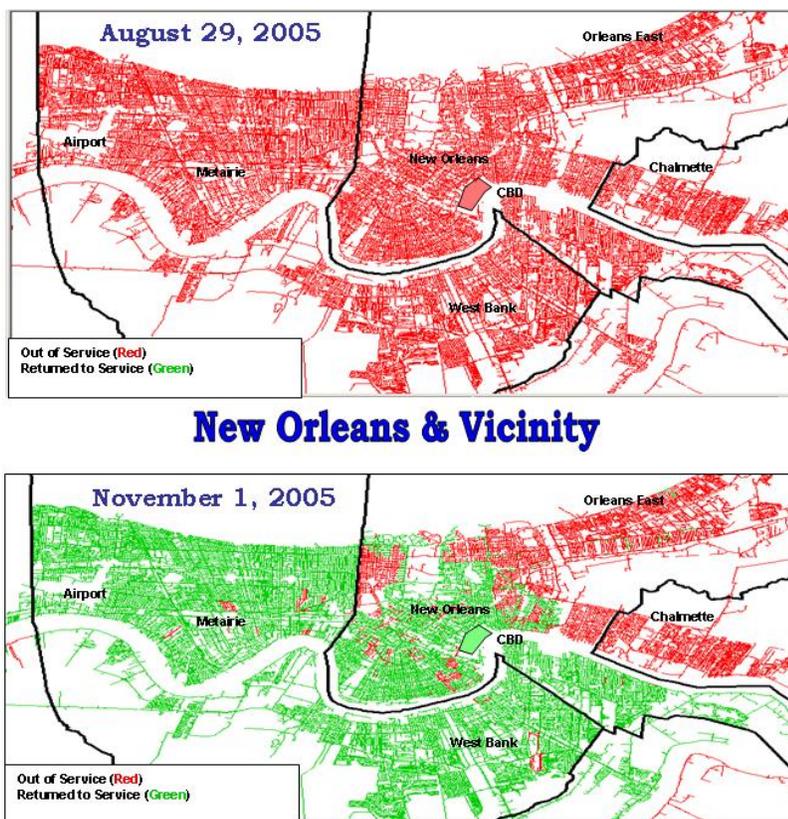


Electricity customer outages caused by Hurricane Katrina were greater in magnitude and duration than those caused by Hurricane Rita (see Figure 2 and State outages in Appendix Table A-1). Hurricane Katrina knocked out power to more than 1 million customers in Florida before crossing the Gulf of Mexico and making a second landfall in Louisiana. At its peak on August 30, 2005, an estimated 2.7 million customers were without power across four states. Two weeks after Katrina first made landfall in the United States, power had been fully restored to customers

in Alabama, Florida, and Mississippi, yet over 40 percent of the customers in the state of Louisiana remained without power.

The storm blacked out the city of New Orleans (see Figure 3). Restoration efforts were complicated by extensive flooding, particularly in the areas of New Orleans that were submerged when the levees on Lake Pontchartrain were breached. As a result, Entergy New Orleans was unable to fully restore power for several months. The investor-owned utility (IOU), facing estimated restoration costs in the range of \$260 to \$325 million and a loss of customer revenue estimated at \$147 million, filed for bankruptcy in late September 2005.² The utility did not emerge from Chapter 11 bankruptcy until May 2007.³

Figure 3. Entergy New Orleans Customer Outage Progression, 2005



Source: Entergy

Hurricane Rita, which made landfall along the Texas-Louisiana border on September 24, 2005, less than one month after Katrina, knocked out power to more than 1.3 million customers at its peak, bringing total customers without power from both storms to nearly 1.6 million. New outages from Rita were restored in less than three weeks. On October 21, 2005, eight weeks

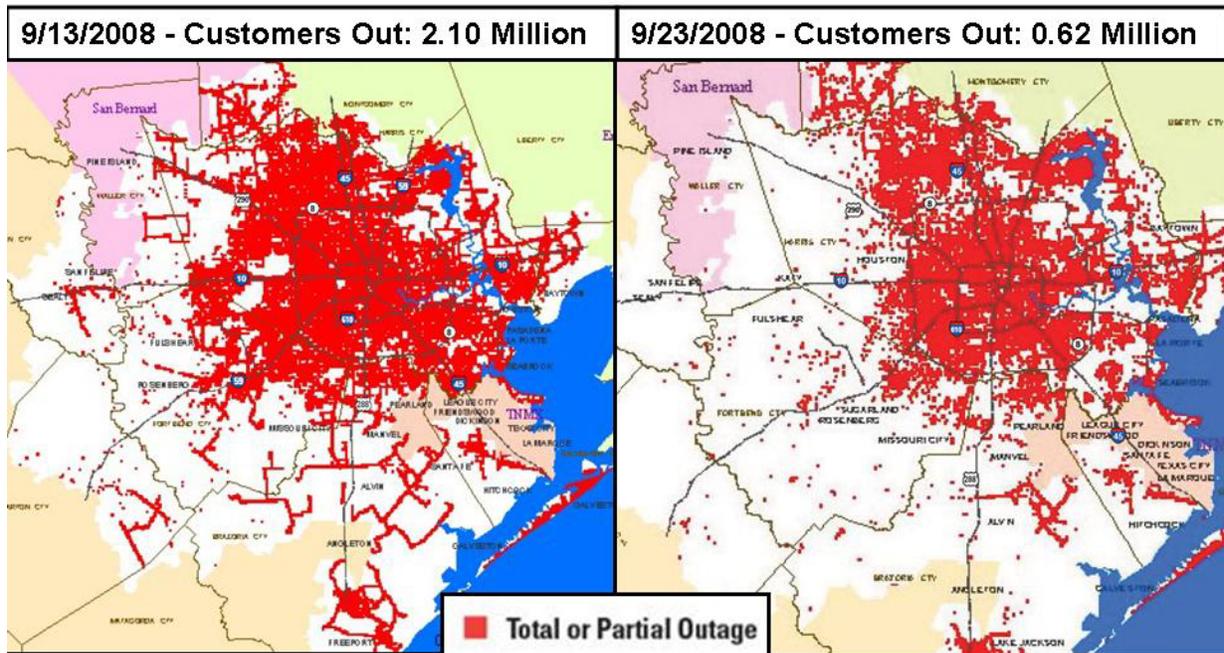
² <http://apps.shareholder.com/sec/viewerContent.aspx?companyid=ETR&docid=3925483> and <http://investor.shareholder.com/entergy/secfiling.cfm?filingID=65984-05-323>.

³ http://www.entergy.com/news_room/newsrelease.aspx?NR_ID=981.

after Katrina first made landfall in Florida, all but 120,000 customers had been restored from hurricanes Katrina and Rita. The remaining outages were customers of Entergy New Orleans whose residences were too damaged by Hurricane Katrina to permit electric service restoration.

The third storm of significance in 2005 was Hurricane Wilma, which was the 13th hurricane of the season. Wilma made landfall in Florida as a Category 3 hurricane, knocking out power to 3.5 million customers in the population-dense communities of southern Florida on October 24, 2005. Hurricane force winds cut a 180-mile swath across the state, blacking out 60 percent of Florida Power & Light’s 35-county territory. In Miami-Dade County, 98 percent of the IOU’s customers, including major airports, hospitals, and Port Everglades lost power. Restoration proceeded quickly with the help of 18,000 workers from 33 states and Canada and two weeks after Hurricane Wilma made landfall, only 100,000 customers remained without power (see Appendix Table A-2).

Figure 4. CenterPoint Energy (Houston) Customer Outage Progression, September 2008



Source: CenterPoint Energy

Power outages caused by Hurricanes Gustav and Ike in 2008 were comparable in magnitude but shorter in duration than those caused by Katrina and Rita in 2005. Hurricane Gustav’s outages, which peaked at more than 1.3 million customers on September 2, 2008, were concentrated primarily in Louisiana, Mississippi, and Arkansas. Gustav caused severe flooding in Baton Rouge, Louisiana, and raised water levels on the Mississippi River, shutting down locks and impacting waterborne deliveries of fuel to power plants and plant access to the river for cooling. The floods slowed the restoration efforts of Entergy and thousands of out of state workers who arrived to help restore power.

Power outages from Hurricane Ike, which made landfall on September 13, 2008, less than two weeks after Gustav, were greater in magnitude and covered a greater geographic region than Gustav. Ike ripped through major population centers in Galveston, Houston, and Port Arthur, Texas, knocking out power to virtually all customers in the service territories served by CenterPoint Energy and Entergy Texas. The hurricane continued to move northward, knocking out power to customers in Arkansas, Louisiana, Missouri, Kentucky, Indiana, Ohio, and New York. As reported in the Situation Report on September 14, 2008, Ike had blacked out a total of 3.9 million customers across nine states,⁴ making it the largest North American power outage since the great Northeast blackout of August 14, 2003. More than half of these outages affected customers in CenterPoint Energy’s Houston metropolitan service territory and much of the city remained without power for more than ten days after Ike struck(see Figure 4).

Transmission & Distribution

The prime cause of electricity outages during both the 2005 and 2008 hurricanes was damage to the electricity transmission and distribution systems along the Gulf Coast (see Table 2). The number of poles destroyed exceeded 72,000 for Hurricane Katrina. Both wooden and steel structures were damaged and key transmission lines were out of service for weeks. Entergy New Orleans did not report the number of poles destroyed, and as a result infrastructure impacts from Katrina are underestimated. Electric cooperatives in Mississippi reported that more than 50,000 utility distribution poles were destroyed by Hurricane Katrina. One Louisiana cooperative indicated that an estimated 3,500 miles of its power lines and poles were blown to the ground.⁵

Table 2. U.S. Gulf Electric Infrastructure Impacted by Hurricanes, 2005 vs. 2008

Infrastructure Impacted	2005			2008	
	Katrina	Rita	Wilma	Gustav	Ike
Utility Poles Destroyed	72,447	14,817	~14,000	11,478	10,300
Transformers Damaged	8,281	3,580	NA	4,349	2,900
Transmission Structures Damaged	1,515	3,550	NA	241	238
Substations Off-line	300	508	241	368	383

Based on damage to transmission and distribution structures reported by Entergy Louisiana, Entergy Gulf States, Centerpoint Energy, CLECO, Mississippi Power, Florida Power & Light, Sam Houston Electric Coop (Texas) and Mississippi cooperatives. Data is not comprehensive; excludes comparable data from Entergy New Orleans, and all cooperatives and municipal energy utilities throughout the Gulf.

Sources: ISER Situation Reports from 2005 and 2008; Entergy, CLECO, and Sam Houston news releases; SLEMCO Power.

Twice as many miles of lines were downed by Hurricane Katrina than Hurricane Rita. However, Rita had a greater impact on substations – taking over 500 off-line. Entergy's bulk transmission in east Texas sustained severe damage from Hurricane Rita, including 500-kV lines with damaged structures. Hurricane Wilma damaged more poles than the sum of those replaced after the 2004 Hurricanes Charley, Frances and Jeanne.

⁴ The peak outages from the storm, as monitored and reported in OE/ISER Energy Assurance Daily were closer to 7 million, but the timing did not coincide with the release of the Hurricane Ike Situation Reports.

⁵ <http://www.novec.com/documents/CoopLivingOct05.pdf>

The damage to the Entergy system from Hurricane Gustav was the worst ever in the Baton Rouge area. Gustav also impacted the electricity grid in southeastern Louisiana. Due to damage to several high-voltage transmission lines, a portion of Entergy’s transmission system south of Lake Pontchartrain, including the city of New Orleans, was “islanded,” meaning that the system was disconnected from the rest of the Entergy supply network. The islanded grid was reconnected to the Entergy system after two days by restoring East-West transmission line connections.⁶ In areas where the damage was the most extensive or where access was the most difficult, it took several weeks before necessary repairs were completed.

Hurricane Ike shut down over 30 transmission circuits and almost 1,000 distribution circuits in CenterPoint Energy’s service territory in Texas. Thousands of mutual assistance linemen from 31 states and Canada came to help the restoration efforts in Texas. In less than three weeks, Centerpoint reported it had restored electricity to all customers who could receive power in Texas.

Power Plants

The power outages experienced during the 2005 and 2008 hurricanes were not due to power plant closings. Nuclear power plant maintenance and refueling proceeded as scheduled during both hurricane seasons, according to the Nuclear Regulatory Commission. Three nuclear power plants lay within the area affected by Hurricane Katrina but none of the plants experienced any significant damage or flooding (see Table 3). Only one of the plants, the Waterford plant near New Orleans, shut in advance of Hurricane Katrina and remained shut for two weeks before restarting. The other two plants, River Bend and Grand Gulf, continued to produce electricity during and after the storm but operated at reduced capacity because of reduced electricity demand or damage to electricity delivery infrastructure that prevented integration of full output from the plants.⁷ No nuclear power plants were shut by the arrival of either Hurricane Rita or Wilma.

Table 3. Nuclear Power Plants Affected by Hurricanes, 2005 and 2008

Year	Unit	State	Company	Capacity (MW)	Impact	Impact Start Date	Restoration Date*
2005	Waterford 3	LA	Entergy	1,075	Shut Down	8/29/05	9/16/05
	River Bend 1	LA	Entergy	966	Reduced	8/30/05	9/5/05
	Grand Gulf 1	MS	Entergy	1,207	Reduced	8/30/05	9/6/05
2008	Waterford 3	LA	Entergy	1,075	Shut Down	8/31/08	9/12/08
	River Bend 1	LA	Entergy	966	Shut Down	9/2/08	9/29/08

Note: *Date of restoration to full capacity; not the same as restart date.

Source: Nuclear Regulatory Commission.

In anticipation of Hurricane Gustav, Entergy performed a controlled shut down of its Waterford 3 nuclear plant on August 31, 2008. Waterford 3 returned to full service within two weeks. Entergy also shut its River Bend nuclear plant for four weeks when it suffered exterior building damage from Hurricane Gustav’s winds. No nuclear plants were shut by Hurricane Ike.

⁶ <http://www.reuters.com/article/domesticNews/idUSN0350182220080903>.

⁷ <http://www.nei.org/keyissues/safetyandsecurity/factsheets/nuclearplantsstructuralstrengthkatrinapage2/>

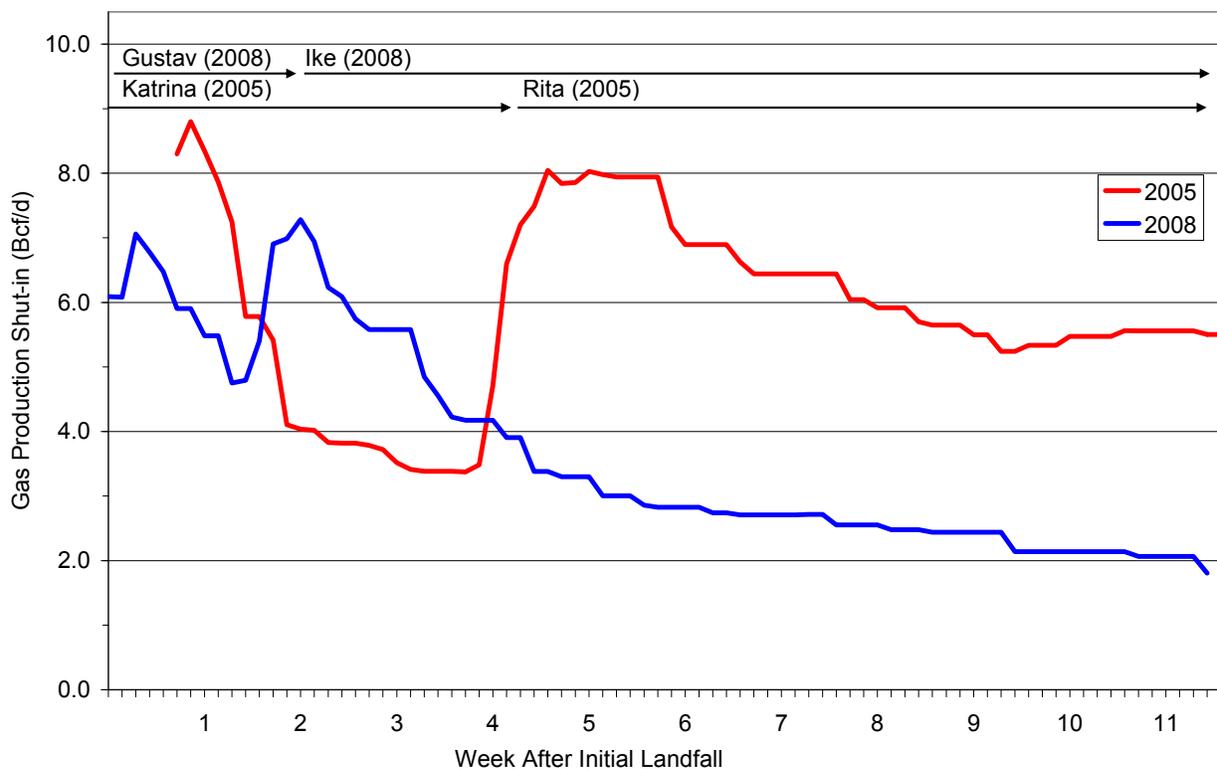
Energy infrastructure is highly interdependent. Electricity outages from hurricanes resulted in the closing of refineries, gas processors, pipelines, ports, and other facilities in both 2005 and 2008. Prolonged electricity outages delayed the restoration efforts at these facilities.

Natural Gas

Production

The hurricanes of 2005 and 2008 disrupted many facilities that extract, process, and transport natural gas. In 2005, the Minerals Management Service (MMS) estimated that 3,050 of the 4,000 platforms and 22,000 of the 33,000 miles of gathering pipelines in the Gulf of Mexico were in the direct path of either Hurricane Katrina or Rita.⁸ Before the 2005 hurricane season began, the offshore platforms in the Gulf of Mexico (Outer Continental Shelf, OCS) produced 10 billion cubic feet of gas per day (Bcf/d), or 20 percent of the natural gas produced in the United States. As Hurricane Katrina approached the Gulf in late August 2005, MMS reported that manned platforms and rigs in the potential storm path had been evacuated and 8.8 Bcf/d, or 88 percent of total Gulf production, was shut down as a precaution (see Figure 5 and Table A-3).

Figure 5. Gulf of Mexico OCS Natural Gas Production Shut In by 2005 and 2008 Hurricanes



Note: MMS data collection began August 29, 2005, days after Katrina made landfall in Florida, moving across the Gulf.
Source: MMS.

After Katrina passed, undamaged Gulf production facilities were quickly returned to service and one week after the storm hit, shut-in OCS production was reduced to about 4.0 Bcf/d.

⁸ MMS Press Release #3418, January 19, 2006, <http://www.mms.gov/ooc/press/2006/press0119.htm>.

Restoration at heavily damaged production facilities progressed more slowly and by September 20, 2005, shut-in production had been reduced to 3.4 Bcf/d before the approach of Hurricane Rita forced Gulf operators to again evacuate platforms and shut down production. As Rita approached, Gulf operators shut in an additional 4.7 Bcf/d as a precaution, bringing total offline Gulf production to 8.1 Bcf/d. Hurricane Rita, which veered farther west than Katrina, damaged many of the offshore facilities that had survived the passage of Katrina. About 8.0 Bcf/d of Gulf production remained shut in for one week after Rita and restoration proceeded slowly thereafter, with 5.6 Bcf/d of gas production still shut-in four weeks after Rita made landfall. Restoration proceeded slowly from November 2005 through March 2006, when DOE discontinued its active monitoring of restoration efforts.

In addition to the MMS-monitored production fields in the Gulf of Mexico OCS, Hurricane Katrina and Rita also disrupted Gulf offshore gas production within three miles of the Louisiana coastline. This production is monitored by the Louisiana Department of Natural Resources (DNR).⁹ At the start of the 2005 hurricane season, Louisiana offshore gas production averaged 2.2 Bcf/d. All of this production was shut down following Hurricanes Katrina and Rita. By December 27, 2005, three months after the passage of Rita, more than 0.6 Bcf/d remained shut-in.¹⁰ Most of this production was from smaller wells that operators deemed too small to restore and was lost permanently.

Restoration to Gulf OCS and Louisiana offshore facilities was slow due to the magnitude of the damage caused by the hurricanes (see Table 4). Industry assessments, investigations, and reports revealed a total of 457 pipelines damaged from the 2005 hurricanes. The number of larger diameter pipelines (10 inches or greater) that were damaged was 101.¹¹ Many of these pipelines were breached and large volumes of sea water had to be moved through the pipelines to shore where the lines could be dewatered and contaminants removed before returning to service.

Table 4. Natural Gas Operating Capacity in the Gulf of Mexico, 2005 and 2008

Source	2005 Capacity (Bcf/d)			2008 Capacity (Bcf/d)		
	Pre-Season	Season Low	Year-End	Pre-Season	Season Low	Year-End
Federal OCS	10.0	1.2	4.4	7.4	0.1	6.3
Louisiana DNR	2.2	0	1.6	1.6	0.3	1.1

Note: *Date of restoration to full capacity; not the same as restart date.

Source: MMS and Louisiana DNR, as reported in ISER Situation reports in 2005 and 2008.

In addition, restoration was hindered by complications caused by the depth of the water where the platforms and pipelines were most damaged, the limited number of crews able to make repairs in deep water, rough seas, and long lead times for delivery of parts and materials. Devastation to the offshore and onshore service industry supporting Gulf natural gas production also slowed recovery. The 2005 hurricanes significantly disrupted the network of work boats, crews, divers, supplies, and equipment needed to assess the damage and perform repairs to

⁹ Louisiana In-State Production Weekly Status Update, 1/5/09, <http://dnr.louisiana.gov/sec/execdiv/pubinfo/weekly-onshore-prod.ssi>. The parishes included in DNR survey are Acadia, Assumption, Calcasieu, Cameron, Iberia, Jefferson, Jefferson Davis, Lafayette, Lafourche, Orleans, Plaquemines, St. Bernard, St. Charles, St. Martin, St. Mary, Terrebonne, and Vermilion.

¹⁰ http://tonto.eia.doe.gov/oog/special/eia1_katrina.html.

¹¹ MMS Press Release #3486, May 1, 2006, <http://www.mms.gov/ooc/press/2006/press0501.htm>.

platforms and pipelines. Furthermore, docks and fleets were destroyed, electric power was lost on a wide-scale basis, and transportation fuels were not available for the boats, helicopters, and ground transportation vital to the recovery.¹²

Hurricanes Gustav and Ike in 2008 did not disrupt offshore gas production on the same scale as Katrina and Rita in 2005, despite following similar paths. Due to lasting effects from the 2005 hurricanes, there were almost 200 fewer operating production platforms in the Gulf of Mexico in August 2008, and the resulting capacity of Gulf of Mexico OCS production was reduced by more than 25 percent to 7.4 Bcf/d.

MMS estimated that approximately 2,127 of the 3,800 platforms in the Gulf of Mexico OCS were exposed to hurricane conditions in 2008, with winds greater than 74 miles per hour, from Hurricanes Gustav and Ike.¹³ As Gustav approached, operators evacuated offshore platforms and began shutting in offshore gas production in the path of the storm. On September 2, 2008, one day after Gustav made landfall in Louisiana, more than 95 percent of Gulf gas production was shut-in. After the passage of Gustav, operators quickly restored production from some undamaged facilities but were forced to shut production again due to the rapid approach of Hurricane Ike, which cut through the Gulf making landfall less than two weeks later. After Ike, operators completed flyovers and damage assessments of platforms in the hurricane path before bringing production back online. Recovery proceeded at a measured pace throughout the remainder of September, with 3.9 Bcf/d, or more than 50 percent of total Gulf gas production, remaining shut-in by the end of the month. By February 11, 2009, only 0.9 Bcf/d or 13 percent of total OCS natural gas production remained shut-in. MMS estimates that 60 platforms were destroyed in the Gulf that produced a total of 0.1 Bcf/d.¹⁴

Louisiana offshore production, which lost 27 percent of its 2.2 Bcf/d capacity, was recalibrated to 1.6 Bcf/d after the 2005 hurricanes. Hurricane Gustav pushed through the coastal Louisiana parishes, and by September 10, 2008, more than one week after Gustav's landfall, only 0.3 Bcf/d was known to be producing. By November 17, 2008, about one and half months after Gustav, wells were producing 1.1 Bcf/d, shut-in capacity was 0.3 Bcf/d and the status of 0.2 Bcf/d was unknown.¹⁵

In addition to damage to platforms and rigs, restoration of offshore Gulf of Mexico and offshore Louisiana gas production was hindered by damage to pipelines needed to bring offshore production to onshore processing facilities. Hurricane Ike generated towering waves that caused major impacts to eight gas transmission pipelines originating in the Gulf of Mexico. Nearly all the pipeline damage was caused by toppled platforms and in one case, a jack-up drilling rig. These shut-in pipelines, including TransCanada's Central Gulf, Panhandle Energy's Sea Robin, and Williams Transcontinental, stopped the flow of natural gas from connected platforms.¹⁶

¹² U.S. Department of Energy, "Impact of the 2005 Hurricanes on the Natural Gas Industry in the Gulf of Mexico Region," July 31, 2006,

http://www.fossil.energy.gov/programs/oilgas/publications/naturalgas_general/hurricane_report05.pdf.

¹³ MMS Press Release #3933, November 26, 2008, <http://www.mms.gov/ooc/press/2008/press1126a.htm>

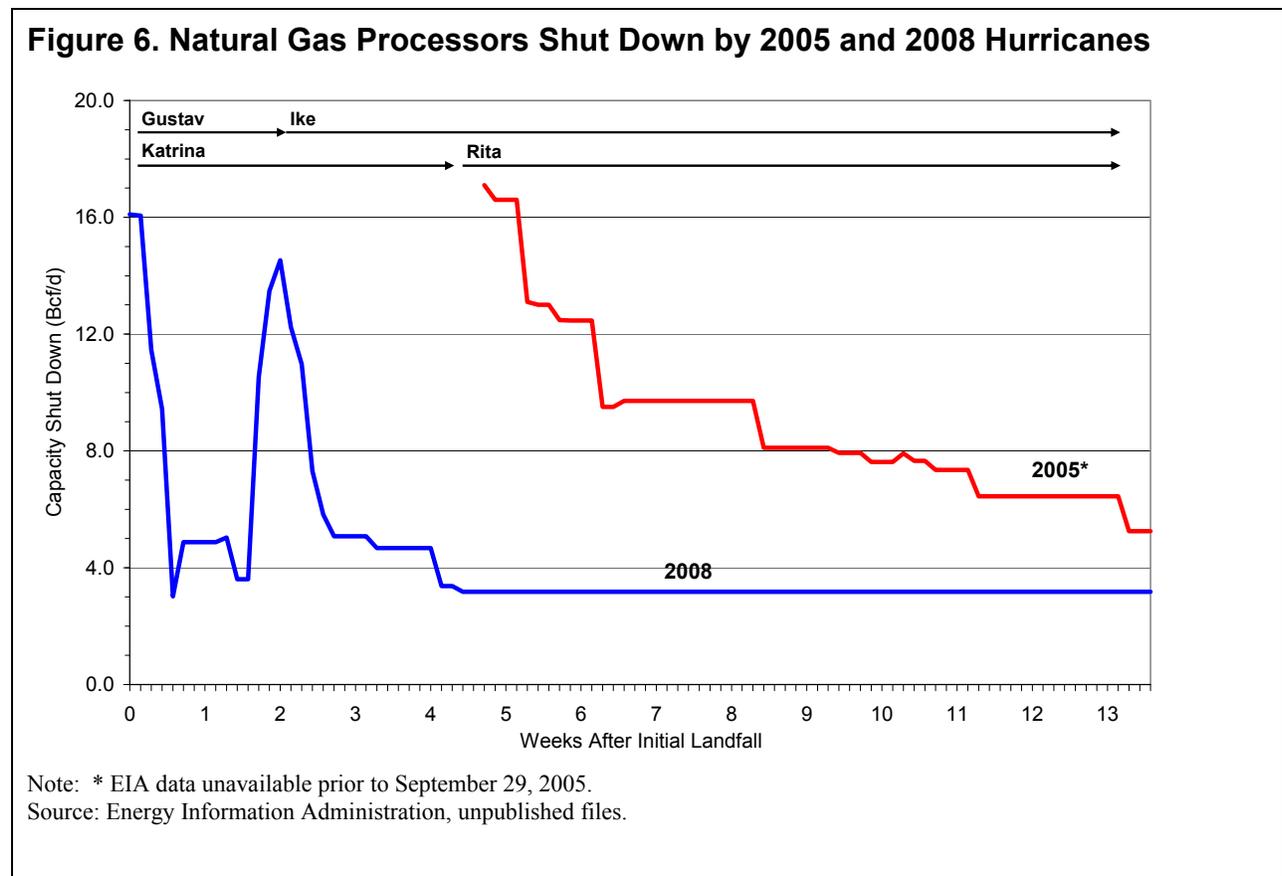
¹⁴ *Ibid* and MMS Press Release #3958, February 11, 2009, <http://www.mms.gov/ooc/press/2009/press0211.htm>.

¹⁵ Louisiana DNR has not issued any updates since November 17, 2008.

¹⁶ MMS Press Release #3902, October 7, 2008, <http://www.mms.gov/ooc/press/2008/press1007c.htm> and Bruce Nichols, "Post-Ike gas line fixes slow return of US Gulf oil," Reuters, December 11, 2008.

Processing

Onshore gas processing facilities were impacted by hurricanes in both 2005 and 2008. In 2005, there were at least 47 major gas processors in the Gulf Coast, mainly located in Louisiana, Texas, Mississippi and Alabama. Major processors have capacities of 0.15 Bcf/d or greater. These plants remove water, contaminants, and liquid hydrocarbons in order to prepare almost 23 Bcf/d of dry gas for end use. There were also 17 fractionators in the Gulf, the largest being the Mont Belvieu complex in southeast Texas, near the Louisiana border.¹⁷ A complete series of data on the operations of gas processors following Hurricane Katrina was not collected by EIA. As a result, it is not known precisely how many of these facilities were impacted and operable capacity data is not included in Figure 6 prior to September 30. This data is included in Appendix Tables A-3 and A-4 where appropriate.



Hurricane Katrina shut in at least eight major processors with a capacity of almost 7 Bcf/d. After Hurricane Rita made landfall, 27 natural gas processing plants, with a total capacity of 17 Bcf/d, were inactive in Texas, Louisiana, and Mississippi. The majority of processing plants cited external factors as the reason for the 2005 plant closures. External factors include the lack of

¹⁷ U.S. Department of Energy, "Impact of the 2005 Hurricanes on the Natural Gas Industry in the Gulf of Mexico Region," July 31, 2006, http://www.fossil.energy.gov/programs/oilgas/publications/naturalgas_general/hurricane_report05.pdf.

electric power experienced by many plants, lack of upstream supplies, inaccessibility to the plant because of road conditions, or lack of downstream capabilities.¹⁸ At least one plant was permanently decommissioned in late January 2006 as a result of the damage received.

By 2008, EIA acquired more complete data on gas processors through a new survey.¹⁹ A total of 97 gas processors in Texas, Louisiana, Mississippi and Alabama were in the region impacted by Hurricanes Gustav and/or Ike. Fifty-five of these 97 plants are major processors and represent 38 percent of the U.S. productive capacity (including both lower 48 and Alaska).²⁰ Operators shut down 25 of these plants in advance of Hurricane Gustav, reducing gas production capacity by more than 16 Bcf/d. Some of these gas processors were flooded, lacked power, or suffered damage due to Gustav and were still shut down when Ike made landfall two weeks later. After Ike made landfall, a combined total of 30 processors in Texas and Louisiana were closed by both storms. Several processors indicated that the unavailability of large fractionators, such as Mount Belvieu and Beaumont, and the shut-in of gathering pipelines from the Gulf of Mexico were the reasons for the processor outages. Restoration efforts were significant, with only five plants with 3.2 Bcf/d of capacity remaining shut down by the end of November 2008.²¹

Transportation

Natural gas pipeline companies operating in the U.S. Gulf, especially those moving gas from offshore production platforms to onshore processing plants, were impacted by Hurricanes Gustav and Ike in early September 2008. Twenty-eight pipelines declared *force majeure* or posted critical notices on their electronic bulletin boards. This list is not comprehensive: these are the significant pipelines tracked by the ISER Situation Reports. Fourteen of these were gathering pipelines, that shut-in their systems because of damage to the pipelines or damage to the OCS production platforms.²² The other 14 were interstate longhaul pipelines also impacted by the restriction of gas supply from the Gulf.²³ They posted notices informing shippers of reduced supply from offshore production, shutdown of processing plants and compressor stations along their systems. Some pipeline compressor stations were operated on emergency backup generators as commercial electric power was unavailable for days.

¹⁸ EIA, 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.

¹⁹ EIA-757, Schedule B, Natural Gas Processing Plant Survey, http://www.eia.doe.gov/pub/oil_gas/natural_gas/survey_forms/eia757bf.pdf.

²⁰ EIA, 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.

²¹ According to corporate press releases, three gas processors were due to come on line in December 2008 and the final two processors were to return to service by the end of second quarter 2009.

²² Black Marlin Pipeline, Chandeleur Pipeline, Dauphin Island Gathering, Destin Pipeline, Discovery Gas Transmission, Enbridge (UTOS), Garden Banks Gas Pipeline, High Island Offshore System, Manta Ray Offshore gathering, Mississippi Canyon Pipeline, Nautilus Pipeline, Sea Robin Pipeline, Stingray Pipeline, and Venice Gathering System are the 14 gathering lines.

²³ ANR Pipeline, Columbia Gulf Transmission, Gulf South Pipeline, Kinder Morgan Tejas Interstate, Kinder Morgan Texas Interstate, Natural Gas Pipeline Co. of America, Northern Natural Gas Pipeline, Sabine Pipeline (Henry Hub), Southern Natural Gas, Tennessee Gas Pipeline, Texas Eastern Transmission, Texas Gas Transmission, Transcontinental Gas Pipeline, and Trunkline Gas Pipeline are the 14 interstate pipelines.

.Eleven major interstate pipelines had their flow significantly restricted on the worst days of both storms (see Appendix Table A-4). All of these interstate longhaul pipelines resumed normal or close to normal operations within four weeks after Ike made landfall, using stock withdrawals to keep their lines full.

The liquefied natural gas (LNG) import terminals located in the Gulf Coast were shut as a precaution in 2008, but none reported any major damage upon personnel returning to the facilities.

Stocks & Prices

Natural gas prices during the hurricane season were far more volatile in 2005 than 2008. Supply disruptions caused by Hurricanes Katrina and Rita led to large spikes in the spot prices for natural gas in both the Gulf (Henry Hub) and at the New York City gate. New York spot prices have always trended above Henry Hub spot prices, but the premium became more pronounced following the arrival of Hurricane Katrina in 2005 (see Figure 7). Spot prices skyrocketed following the arrival of Rita.

Sabine Pipeline LLC's Henry Hub, located in south central Louisiana, is the largest centralized point for natural gas spot and futures trading in the United States. There was no trading at Henry Hub for three weeks in 2005 due to a *force majeure* related to lack of power and damaged pipelines at the Hub. As a result, there are disconnects in the 2005 price curves shown on Figure 7. After the Henry Hub resumed operations and trading restarted, spot prices began to fall.

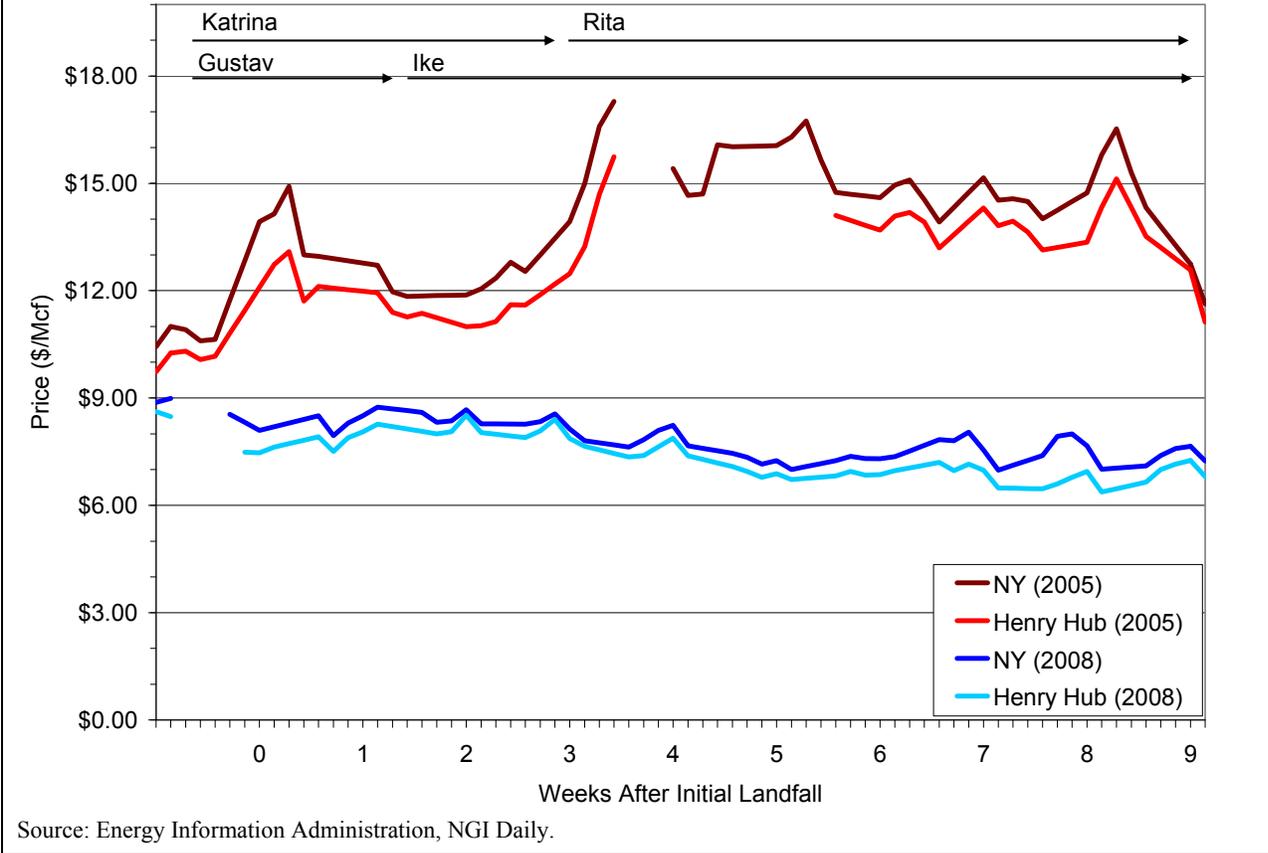
On August 31, 2008, the day before Gustav made landfall, Sabine Pipeline again declared a *force majeure* due to the mandatory evacuation of Vermilion Parish, which included all receipt and delivery points on the Sabine system and the Henry Hub operations. The shut down of the Hub is the cause of the disconnects in the 2008 price curves in Figure 7. In the weeks following the arrival of Hurricanes Gustav and Ike, there was very little movement in the spot price of natural gas, which finished out the year at levels well below 2005.

Working gas is the volume of natural gas stored in an underground reservoir that can be withdrawn (beyond the base or cushion gas that remains permanently in the reservoir). A network of depleted fields, salt caverns, and aquifers is controlled by 112 operators in the United States.²⁴ Storage maintains reliability of gas supplies during periods of high demand, supports load balancing for pipelines; and it provides arbitrage opportunities for owners of natural gas in storage. Natural gas consumption has a strong seasonal pattern due to its use as a heating fuel. As a result, natural gas is generally injected into storage during the nonheating season (April-October) and withdrawn from storage during the heating season (November-March). This pattern is evident in Figure 8 for the Eastern Consuming Region.²⁵

²⁴ EIA, U.S. Storage Drawdown Analysis Report, March 2008, http://www.eia.doe.gov/pub/oil_gas/natural_gas/feature_articles/2008/ngstordrawdown/ngstordrawdown.pdf.

²⁵ Eastern Consuming Regions includes all States east of the Mississippi River less Mississippi and Alabama, plus Iowa, Nebraska and Missouri.

Figure 7. Natural Gas Spot Prices during 2005 and 2008 Hurricanes



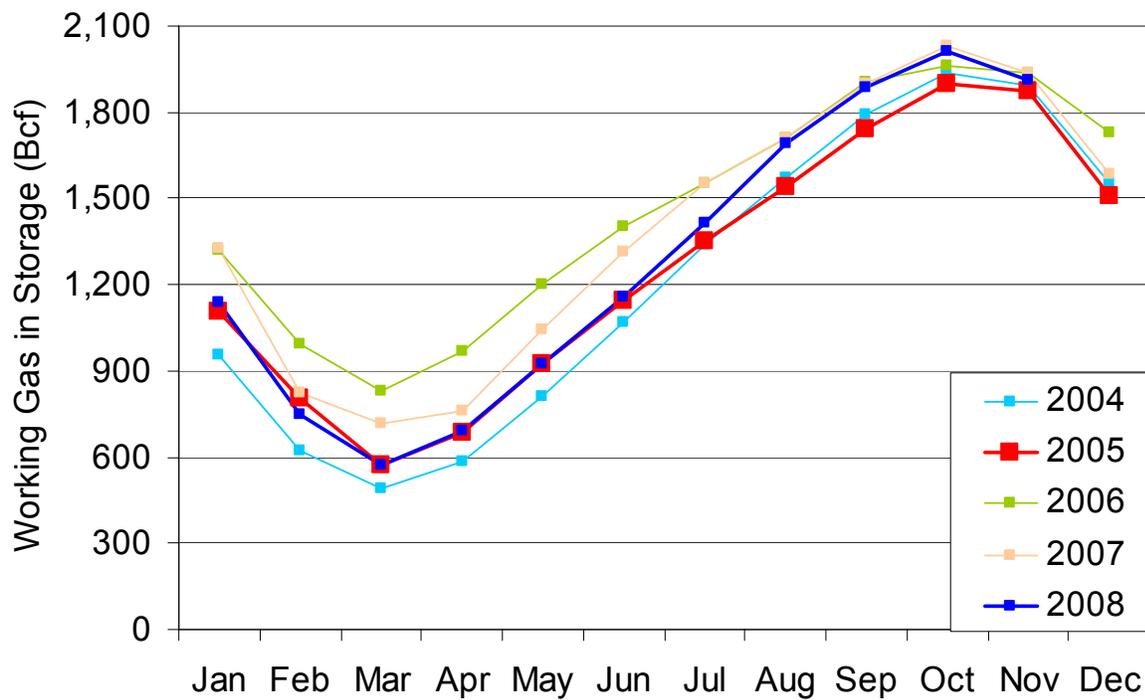
In August 2005, working gas was at its lowest levels in five years. Even though gas demand was low throughout the 2005 hurricane season, working gas storage was unable to recover. By contrast, working gas storage was high in August 2008, and remained healthy throughout the hurricane season. This may have helped dampen price volatility in 2008.

Other factors contributing to a limited price response in 2008 include:²⁶

- The 2008 hurricanes were not as powerful as the 2005 storms in terms of wind and storm surge
- Gas processors suffered more extensive damage in 2005 than in 2008, as is evident in the magnitude and duration of the outages
- Interrupted electricity, gas, and petroleum kept a lid on industrial demand for natural gas

²⁶ EIA, 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.

Figure 8. Working Gas in Eastern Consuming Region in 2005 and 2008



Notes: Eastern Consuming Regions includes all States east of the Mississippi River less Mississippi and Alabama, plus Iowa, Nebraska and Missouri.

Sources: <http://tonto.eia.doe.gov/dnav/ng/hist/n5020882m.htm> and <http://tonto.eia.doe.gov/dnav/ng/hist/n5020872m.htm>.

Petroleum

Production

Hurricanes Gustav and Ike in 2008, and Hurricanes Rita and Katrina in 2005 wreaked tremendous damage on Gulf oil production, refining, and transportation infrastructure, but the damage sustained in 2005 was greater than the damage sustained in 2008.

Prior to Hurricane Katrina in 2005, oil production in the federally-administered waters of the Gulf of Mexico stood at 1.5 million barrels/day (MMBD). Hurricane Katrina raced across Florida on August 25, before entering the Gulf of Mexico and causing the shut-in of OCS crude oil production due to evacuations of key personnel and other storm precautions. Katrina caused severe damage to many offshore oil facilities in the Gulf and although some undamaged platforms were quickly brought back online after the storm passed, about 0.8 MMBD, or more than 50 percent of total Gulf production, remained shut-in one month later as Hurricane Rita approached. Again, Gulf platforms were evacuated and 100 percent of oil production was shuttered in advance of Rita. Initial recovery from Hurricane Rita was tentative and nearly all production remained offline for about one week after the storm passed as companies completed flyovers and damage assessments. After one week, some production was brought back online, but restoration proceeded slowly; seven weeks after Hurricane Rita made landfall, 0.8 MMBD, or about 52 percent, of 2005 Gulf production remained shut in (see Figure 9 and Appendix Table A-5). The pace of restoration was delayed by damaged platforms and gathering pipelines, limited repair equipment and rigs, and the long duration of the 2005 hurricane season. In addition to MMS-monitored Gulf production, Hurricanes Katrina and Rita also forced the shut-in of 0.20 MMBD of oil production in the offshore region three miles off the Louisiana coast, which is monitored by the Louisiana Department of Natural Resources. Nearly one quarter of this production was permanently lost.

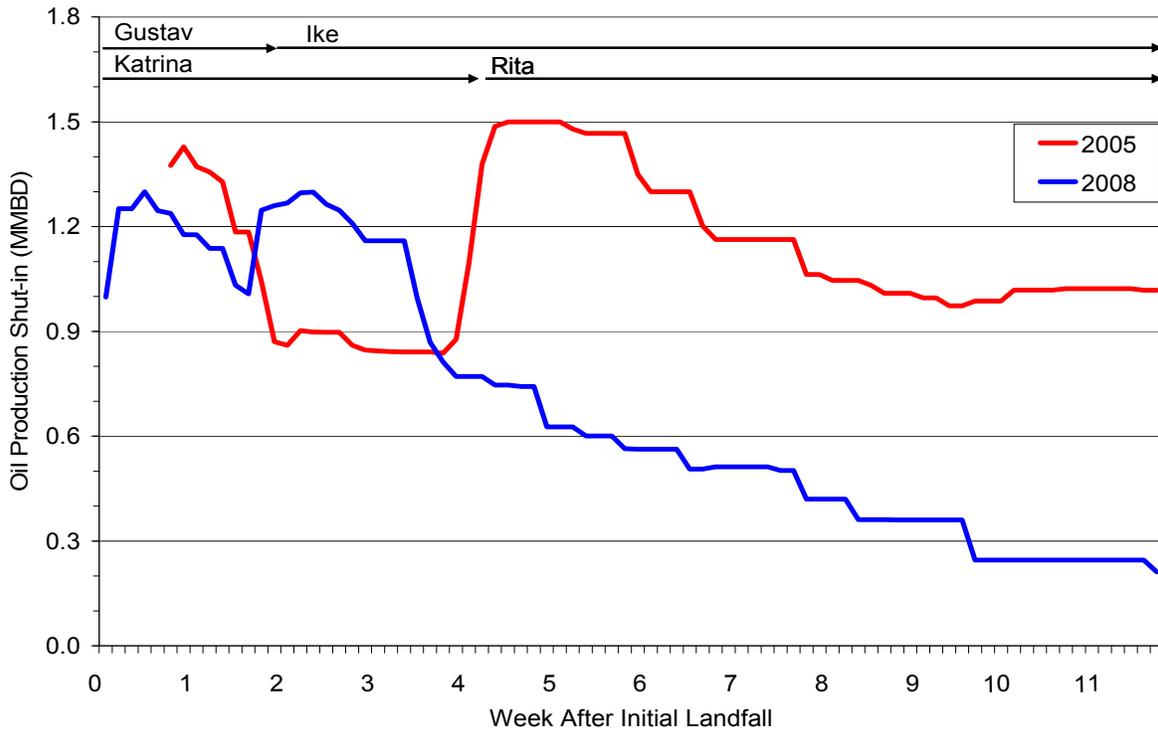
Gulf of Mexico crude oil production suffered significant long-lasting damage from the 2005 hurricanes. Before each storm, 80 percent of the Gulf's 819 platforms were evacuated and shut-in. Likewise, almost 70 percent of the Gulf's 134 operating rigs were shut-in before both hurricanes.²⁷ After the devastation of 2005, a number of platforms were sunk and significant crude oil production capacity was permanently lost, because restoration efforts for certain platforms were too costly. One such example was the Typhoon platform operated jointly by Chevron and BHP Billiton 165 miles south of New Orleans. Hurricane Rita severed the moorings to the platform, which capsized during the storm, and was found floating upside-down 80 miles from its original location. The \$250-million platform was donated to the MMS artificial reefing program.²⁸ Nineteen mobile offshore drilling units broke loose from their moorings and were set adrift; some causing damage to pipelines as anchors dragged along the ocean floor.²⁹ One drifted as far as the Mobile Bridge in Alabama.

²⁷ MMS Press Release #3418, January 19, 2006, <http://www.mms.gov/ooc/press/2006/press0119.htm>.

²⁸ "Chevron to Sink Typhoon Platform Damaged by Hurricane," May 9, 2006, <http://www.bloomberg.com/apps/news?pid=10000081&sid=a0J.TXumCtVQ&refer=australia>.

²⁹ Atkins, et.al., Pipeline Damage Assessment from Hurricanes Katrina and Rita in the Gulf of Mexico, prepared by Det Norske Veritas AS for MMS, Rpt # 448 14183, March 15, 2007.

Figure 9. Gulf of Mexico OCS Oil Production Shut In by 2005 and 2008 Hurricanes



Note: MMS data collection began August 29, 2005, days after Katrina made landfall in Florida, moving across the Gulf.
Source: MMS.

Hurricanes Gustav and Ike caused similar but less severe consequences to oil production infrastructure in the Gulf. Due to the lasting effects from the 2005 hurricanes and the natural decline of existing fields, average Gulf production in 2008 was 1.3 MMBD prior to Gustav, 0.2 MMBD below 2005 levels. The oil industry evacuated platforms and shut in 100 percent of offshore oil production in the Gulf of Mexico as a precaution in advance of Hurricane Gustav. Some of this production came back online after the storm but most of it remained shut-in as operators decided not to return staff to platforms due to the rapid approach of Hurricane Ike. Those platforms that had resumed production after Gustav were shut down again in advance of Ike, which passed well to the west of where Gustav struck before making landfall near Galveston, Texas. Restoration proceeded quickly at unscathed facilities after operators completed flyovers and damaged assessments but many heavily damaged platforms were unable to restart; seven weeks after Rita made landfall more than 0.4 MMBD, or almost one-third of Gulf production, remained shut in. By February 11, 2009, 0.1 MMBD or 9 percent of OCS crude production remained shut-in.³⁰ Hurricanes Gustav and Ike also shut down most of the 0.16 MMBD of Louisiana DNR-monitored offshore oil production within three miles of the Louisiana coast. By November 17, 2008, 0.12 MMBD of this production had resumed (see Table 5).³¹

³⁰ MMS Press Release #3958, February 11, 2009, <http://www.mms.gov/ooc/press/2009/press0211.htm>.

³¹ Louisiana In-State Production Weekly Status Update, January 5, 2009, <http://dnr.louisiana.gov/sec/execdiv/pubinfo/weekly-onshore-prod.ssi>. Louisiana DNR has not updated these values since November 17, 2008.

Table 5. Petroleum Operating Capacity in the Gulf of Mexico, 2005 and 2008

Source	2005 Capacity (MMBD)			2008 Capacity (MMBD)		
	Pre-Season	Season Low	Year-End	Pre-Season	Season Low	Year-End
Federal OCS	1.5	0	1.0	1.3	0	1.16
Louisiana DNR	0.2	0.2	0.16	0.16	0.02	0.12

Note: *Date of restoration to full capacity; not the same as restart date.

Source: MMS and Louisiana DNR, as reported in ISER Situation reports in 2005 and 2008.

Damage to oil production platforms and pipelines was the primary reason that oil production was slow to return after the hurricanes of 2005 and 2008. MMS reported that 113 platforms were destroyed and 52 were damaged out of the 3,050 platforms exposed to hurricane conditions in Gulf of Mexico in 2005. In 2008, by contrast, only 60 platforms were destroyed but 124 were damaged, out of the 2,217 platforms exposed to hurricane conditions. MMS also identified 457 pipelines damaged in 2005, 101 of which were larger diameter pipelines (10 inches or greater). As of early 2009, pipeline damage from Hurricanes Gustav and Ike was still being assessed (see Table 6).

Table 6. Gulf of Mexico OCS Infrastructure Impacted by 2005 and 2008 Hurricanes

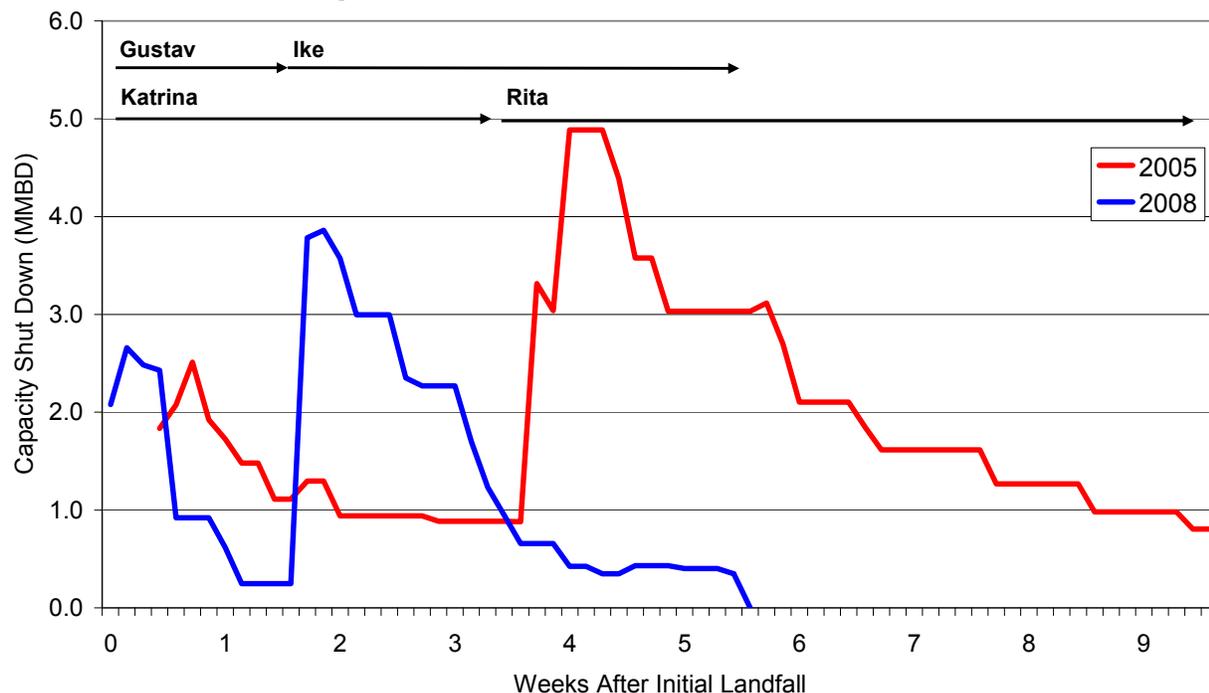
Impacted Infrastructure	2005	2008
Platforms Exposed to Hurricane Conditions	3,050	2,217
Platforms Destroyed	113	60
Platforms Damage	52	124
Pipelines Damaged	457	N/A

Sources: MMS Press Releases #3486 (May 1, 2006), "MMS Completes Assessment of Destroyed and Damaged Facilities from Hurricanes Gustav and Ike," (November 26, 2008).

Refining

In 2005 and 2008, numerous refineries in the Gulf were shut down due to hurricane-induced flooding, wind damage, and loss of electricity. By August 30, 2005, 11 refineries in Louisiana and Mississippi with a combined capacity of 2.5 MMBD were shut down as a precaution in advance of Hurricane Katrina (see Figure 10 and Appendix Table A-5). Hurricane Rita made landfall further west along the Gulf Coast, resulting in the precautionary shut down of 16 additional refineries in Houston, Galveston, Port Arthur and Lake Charles with a combined refining capacity of 4 MMBD. Due to severe damage and flooding, more than 2 MMBD of this capacity remained offline two weeks after Rita's landfall, and about 1 MMBD remained offline four weeks after landfall. In addition, a number of refineries operated at reduced rates for several weeks following the storms.

Figure 10. Duration of Refinery Shut Downs during 2005 and 2008 Hurricanes



Source: OE/ISER Situation Reports.

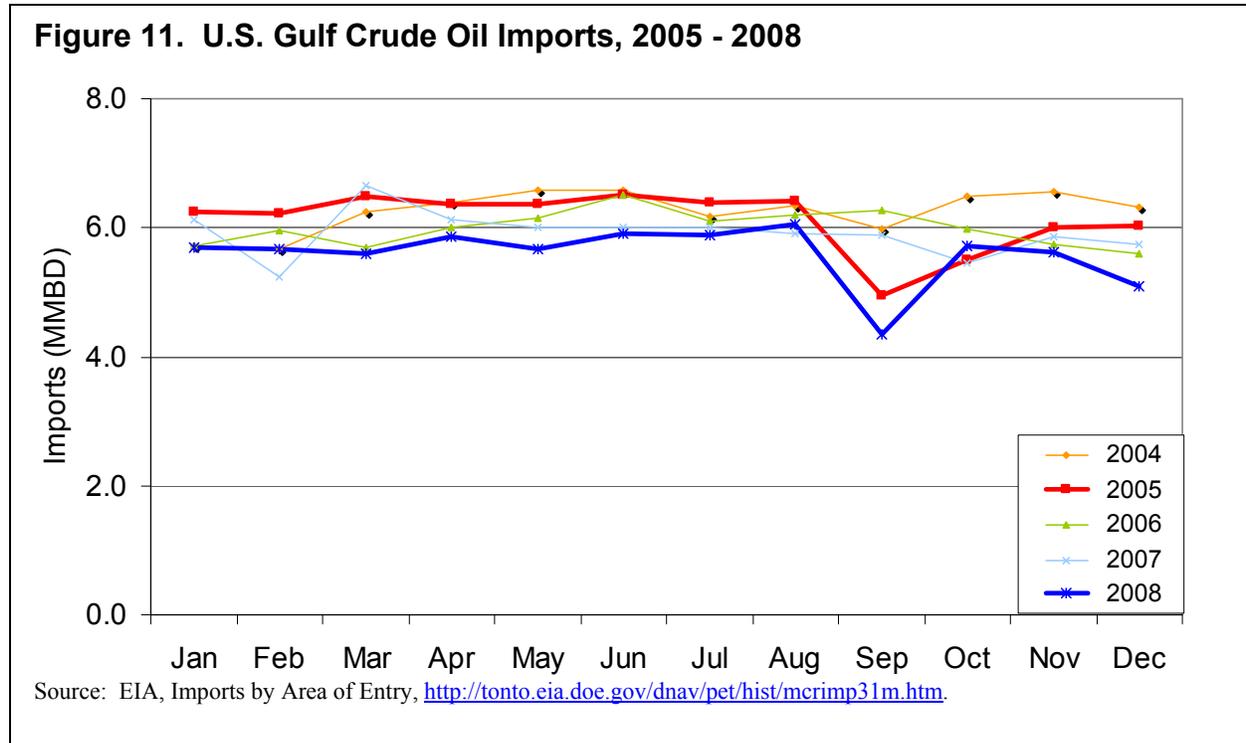
In 2008, Hurricanes Gustav and Ike did not hammer Gulf refineries as hard as Hurricanes Katrina and Rita did in 2005. Hurricane Gustav primarily impacted Louisiana refineries, shutting down 14 refineries with 2.7 MMBD of refining capacity along the Lower Mississippi River and in the Lake Charles region. Most of this capacity was shut as a precaution prior to the storm, and 10 days after Gustav all impacted refineries were completely restored to their pre-hurricane capacities. Hurricane Ike, which primarily impacted Texas refineries, shut in nearly 4 MMBD of refining capacity in Houston, Galveston, Port Arthur, and Corpus Christi. Again, much of this capacity was shut as a precaution prior to landfall. Three weeks later, only two refineries remained shutdown, one from complications during restart. Restoration proceeded more rapidly in 2008 because refineries did not experience nearly as much on-site damage. Although some refinery shutdowns lasted from two to three weeks, these outages were primarily caused by lack of electricity supply rather than on-site damage. The relative speed of refinery restoration following Gustav and Ike is apparent in Appendix Table A-7.

Imports & Ports

Hurricanes and tropical storms annually disrupt the imports of crude oil to the U.S. Gulf Coast. September is typically the month with the lowest volume of imports (see Figure 11).³² Crude oil imports in 2005 were greater than the five-year average in all months except September and October. Crude oil imports to the Gulf fell from 6.4 MMBD in August 2005 to 4.9 MMBD in

³² EIA, Imports by Area of Entry, <http://tonto.eia.doe.gov/dnav/pet/hist/mcrimp31m.htm>.

September 2005 and rose to 5.5 MMBD in October 2005. By contrast, in 2008, crude oil imports to the U.S. Gulf were below the levels of the prior four years in every month. Crude oil imports to the Gulf fell from 6.1 MMBD in August 2008 to 4.4 MMBD in September 2008. This 1.7 MMBD reduction was larger than the drop in 2005.



The U.S Coast Guard announces the closure of major ports and waterways as hurricanes enter the Gulf of Mexico. The Louisiana Offshore Oil Port (LOOP), which receives 1 MMBD of crude oil imports, is often shut first. In 2005, the LOOP was shut on August 28, 2005 before Hurricane Katrina made landfall and remained closed until September 3, 2005. Power was not fully restored to the LOOP until September 5, 2005, and imports remained at reduced rates until mid-September, when Port Fourchon became operational. By September 24, 2005, the LOOP was shut again in advance of Hurricane Rita, not to return to full operations until October 3, 2005.

Key waterways were closed starting on August 30, 2005, including the Mobile Ship Channel, Calcasieu Ship Channel, Gulf Intracoastal Waterway from Mobile to New Orleans, and the Mississippi River from the Gulf to Baton Rouge, Louisiana. Within a week, these waterways were back in service, but with draught restrictions and daylight only limitations. These closures and subsequent reduced operations resulted in long queues of crude oil tankers and adversely impacted imports and domestic movements of petroleum products.

When Hurricane Rita entered the Gulf of Mexico, U.S. Coast Guard again announced port closures affecting Houston, Freeport, Port Arthur, and Corpus Christi, Texas. The Port of Houston remained closed September 24 – 26, 2005, and after reopening, operated at reduced levels until September 29, 2005. Port Arthur was closed the longest from September 24-29, 2005, returning to full operations on October 17, 2005.

In 2008, the same ports and waterways were closed in advance of hurricanes Gustav and Ike. The LOOP was closed September 1, 2008 for five days. Tanker offloading resumed on September 5, 2008, only to stop again on September 11 as Ike approached. The LOOP resumed near normal rates on September 16, 2008. The Gulf Intracoastal Waterway was closed on August 31, 2008 from the Louisiana-Mississippi border east to St. Marks, Florida, and reopened on September 5, 2008. A week later, when Hurricane Ike arrived, the Intracoastal was again shut or under restrictions from New Orleans west to Corpus Christi, Texas. The Calcasieu Ship Channel was closed briefly before Gustav and Ike hit, and operated with draft restrictions for weeks. More than 200 miles of the Mississippi River were closed on August 31, 2008. The river reopened with draft restrictions on September 5, 2008. The Army Corps of Engineers closed three Lower Mississippi River locks on September 13, 2008, restricting traffic until September 19, 2008.

In October 2005, gasoline and distillate imports to the Gulf spiked at 6.2 MMB and 2.8 MMB respectively, a ten-fold increase over September 2005 and well beyond volumes seen in any other month.³³ Shutdown refineries with operable ports and connections to the Colonial and Plantation pipelines began importing gasoline and distillate volumes to maintain pipeline flow into the East Coast. State governments sought waivers to import gasoline meeting less stringent quality requirements.³⁴ Gasoline and distillate imports to the U.S. Gulf retreated back to average levels by November 2005.

The U.S. East Coast also compensated for the lack of pipeline movements from the Gulf by increasing petroleum product imports in 2005. Gasoline imports to the East Coast increased by 3.3 MMB to exceed 18.0 MMB in September 2005 and 20.1 MMB in October 2005. East Coast gasoline imports remained higher than normal through February 2006. The situation was the same for East Coast imports of distillate in 2005. Distillate imports spiked to 11.6 MMB in October 2005 and remained high through February 2006.³⁵

A sizeable portion of the additional gasoline and distillate imports in 2005 were due to the delivery of European product reserves from the International Energy Agency. The U.S. government did not request product reserves in 2008.

Gasoline imports to the U.S. Gulf in 2008 also spiked in September and October, but only to 2.5 MMB and 2.0 MMB, respectively.³⁶ U.S. Gulf distillate imports were almost nonexistent in September-October 2008, as foreign distillate fuel oil did not meet ultra low-sulfur standards required in the United States. East Coast gasoline and distillate imports remained flat from August 2008. Quality restrictions and the timing of the hurricane landfalls in early September 2008 limited the ability of imports to dampen market gyrations.

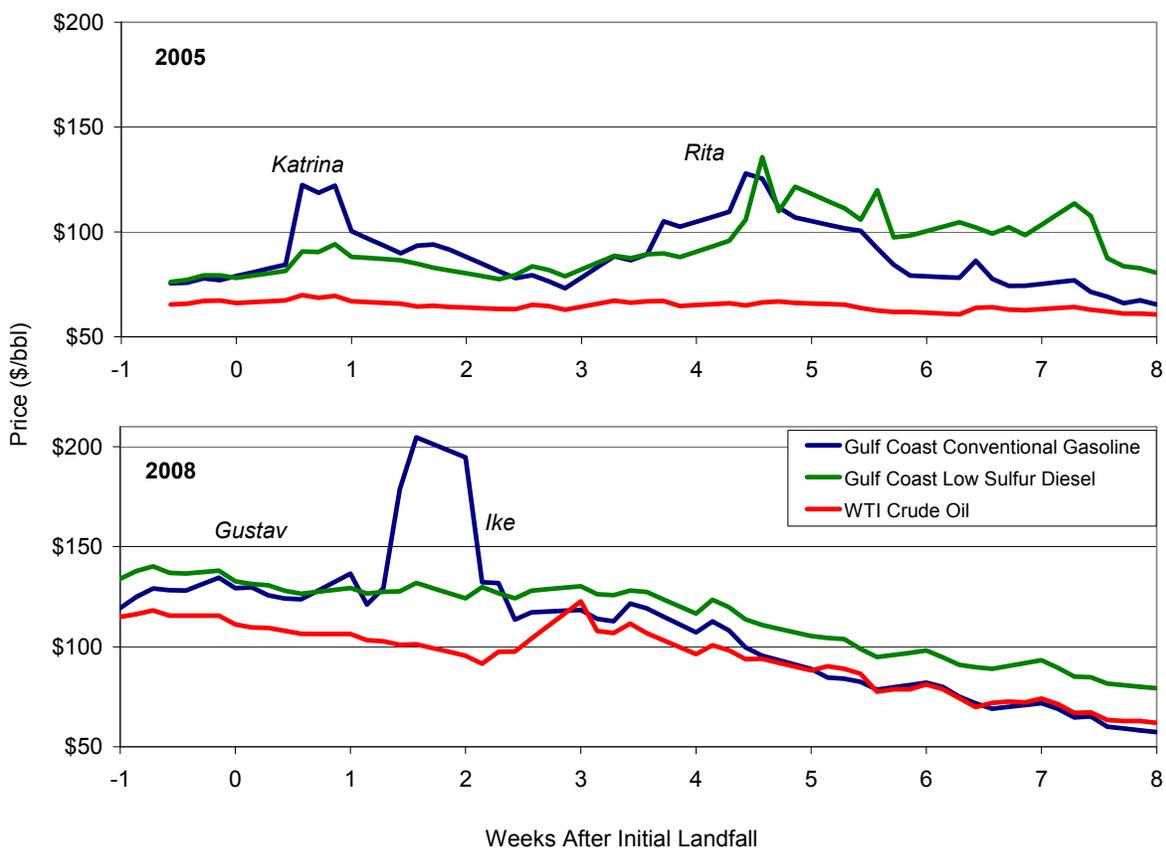
³³ *Ibid.*

³⁴ Reid Vapor Pressure (RVP) and sulfur requirements during summer driving season.

³⁵ *Ibid.*

³⁶ *Ibid.*

Figure 12. Selected Petroleum Spot Prices during 2005 and 2008 Hurricanes



Source: EIA Weekly Prices.

Prices & Stocks

Petroleum product prices reacted differently during the 2005 and 2008 hurricane seasons. In 2005, supply disruptions caused by outages at refineries, pipelines and ports, led to sharp spikes in petroleum product prices (see Figure 12). One week prior to Katrina, the price of West Texas Intermediate (WTI) stood at \$65 per barrel, the spot price of wholesale gasoline in the Gulf was \$75 per barrel, and the spot diesel price in Gulf was \$76 per barrel. Although the price of WTI crude oil did not increase significantly during Katrina and Rita, wholesale U.S. Gulf gasoline prices spiked to nearly \$125 per barrel (almost \$3 per gallon) after Katrina and more than \$125 per barrel after Rita. Wholesale U.S. Gulf diesel prices, which increased only slightly after Katrina, surged passed gasoline prices in the week after Rita, spiking to more than \$135 per barrel (more than \$3.20 per gallon)

The price environment for crude oil and petroleum products in 2008 was vastly different from that of 2005. In 2008 the price of WTI crude oil was about \$115 per barrel in the week prior to Gustav's landfall, almost double the price prior to Katrina's landfall in 2005. While crude oil prices were relatively stable in the summer and fall of 2005, oil prices in late summer and fall

2008 were quickly falling from record highs amid an increasingly pessimistic outlook for global economic growth and the weakening U.S. dollar. WTI prices continued to decline during and after Hurricane Gustav and Ike, falling to as low as \$91 in the trading week after Ike made landfall in Texas. On September 22, 2008, nine days after Ike's landfall, WTI spiked to close at more than \$122, but this price surge may have been attributed to financial investors who had been betting on falling oil prices rushing to cover their positions before the expiry of the October oil futures contract on NYMEX rather than to any production disruptions caused by Hurricanes Gustav and Ike.³⁷

Gasoline

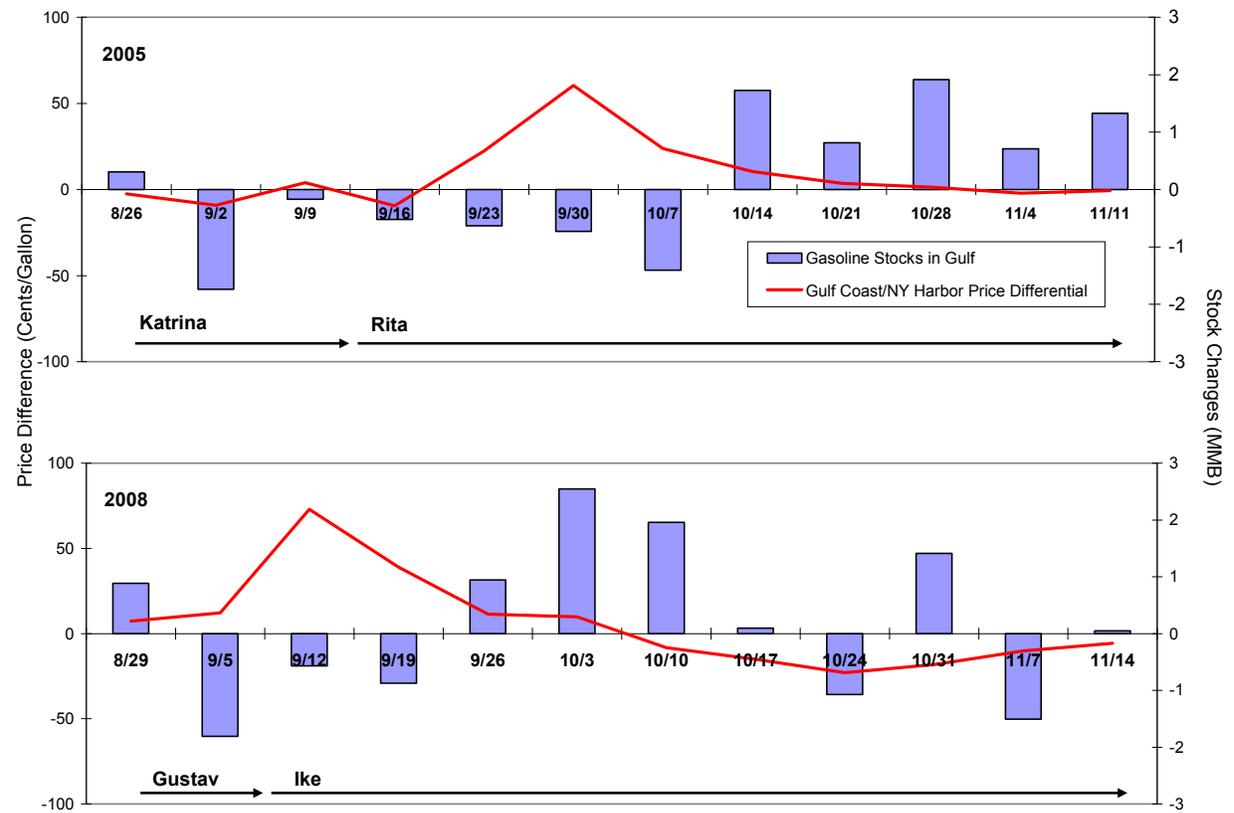
U.S. Gulf gasoline prices experienced a short-lived spike in 2008. One week before Gustav, the wholesale U.S. Gulf gasoline spot price was about \$120 per barrel (about \$2.85 per gallon). The spot price rose steadily to \$130 per barrel as Gustav approached but decreased after damage to Louisiana refineries proved to not be extensive. In the next week, as Ike approached major refining centers in Houston and Galveston, Texas, traders began to worry about potentially severe damage to refineries and pipelines in the region. In the days before Ike made landfall, U.S. Gulf spot gasoline price spiked sharply, reaching a peak of \$204 per barrel (about \$4.85 per gallon) on September 12, 2008, the day before Ike made landfall. This was an increase of about 70 percent over the price one week prior to Gustav. After Ike passed, prices remained high for two days as refiners completed assessments and began bringing units back online but then quickly returned to pre-hurricane levels.

The State of Florida used to have a month-long holiday from gasoline taxes. In August 2005, drivers topped off their tanks in advance of Hurricane Katrina's arrival and depleted gasoline stocks. Gasoline stock drawdowns were also experienced by the Gulf States in September and October 2005 as a result of refinery, pipeline and port disruptions caused by Hurricanes Katrina and Rita (see Figure 13). In the week after Hurricane Katrina made landfall, the week ending September 2, 2005, U.S. Gulf gasoline stocks fell by more than 1.7 million barrels to 32.6 MMB and stocks continued to decline for five weeks until mid-October as refinery disruptions from Hurricane Rita exacerbated the drawdown. Despite the initial drawdown after Katrina, wholesale gasoline prices on the Gulf Coast remained cheaper or about the same as the price of gasoline in New York Harbor. As Hurricane Rita approached in late September, however, the Gulf Coast gasoline price began to rise relative to the New York Harbor Price and in the week after Rita made landfall, Gulf Coast prices spiked to 60 cents more than the New York Harbor price. The premium on Gulf Coast gasoline did not disappear until the end of October 2005, after three weeks of large stock builds.

Stock draw downs were similar in 2008. After Gustav made landfall, gasoline production decreased in the Gulf Coast and the Colonial and Plantation pipelines, which serve the Southeast, had to run at reduced capacities and limit volumes on their spur lines. The 2008 hurricane season started with gasoline stocks at 31.2 MMB, 10 percent below 2005 stocks. The disruptions caused by Gustav resulted in a drawdown of 1.8 MMB.

³⁷ Javier Blas and Chris Flood, "Oil price jumps \$25 in a day," Financial Times, 9/22/08, <http://www.ft.com/cms/s/0/a42969f2-88e1-11dd-a179-0000779fd18c.html>.

Figure 13. U.S. Gulf Gasoline Stocks and Spot Prices during 2005 and 2008 Hurricanes



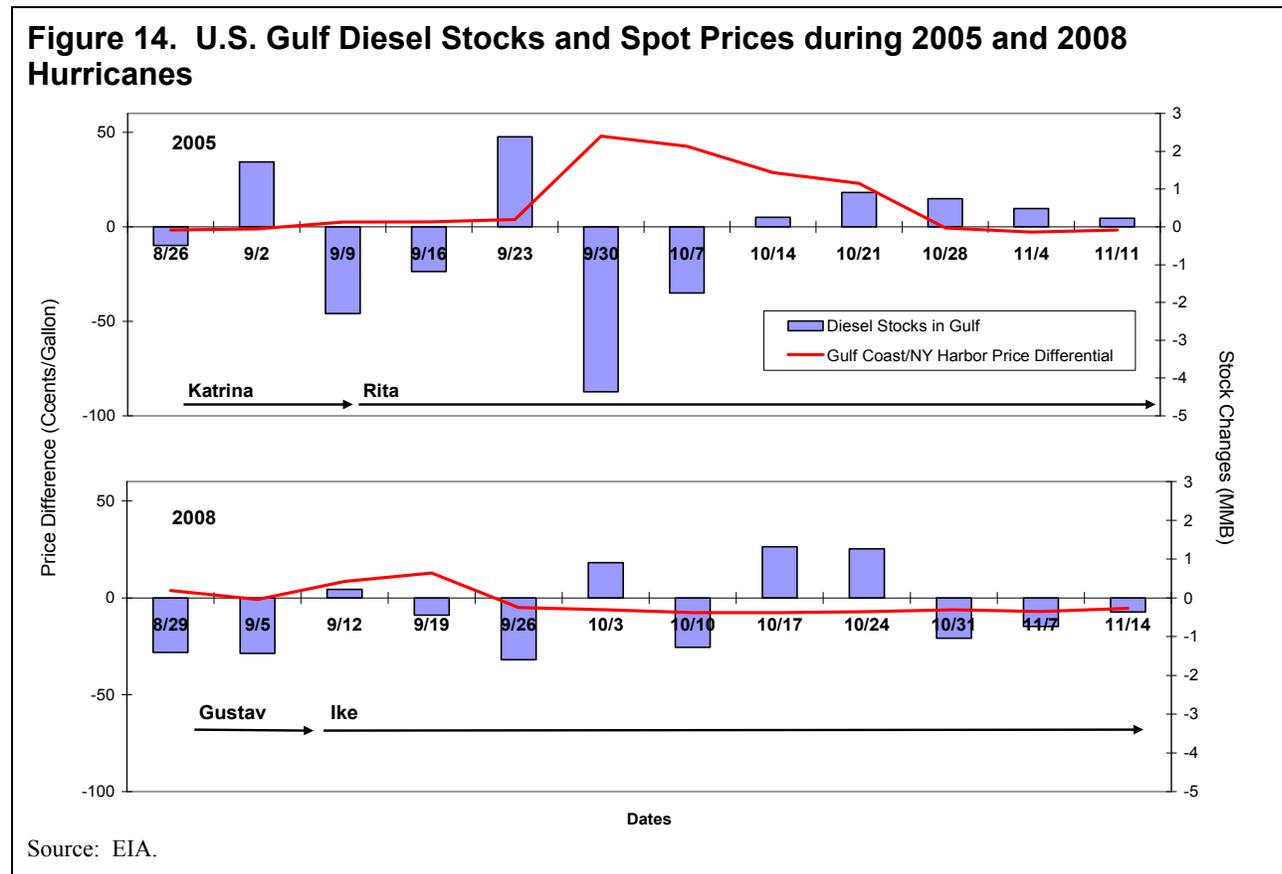
Source: EIA.

The effect of stock drawdowns on the Gulf gasoline market is apparent in the differentials that developed between gasoline prices in the Gulf and New York Harbor. U.S. Gulf wholesale gasoline was trading 2 cents below New York Harbor gasoline two weeks before Gustav hit. On August 29, 2008, two days before Gustav made landfall, a small premium of about 7 cents had developed in anticipation of the storm. In the week after Gustav, Gulf Coast gasoline prices shot up to a premium of more than 70 cent over the New York Harbor price. As Gulf gasoline stocks increased in late September and early October 2008, Gulf gasoline prices dropped below New York Harbor prices.

Diesel

In the week before Hurricane Katrina made landfall, diesel stocks in the Gulf Coast stood at just under 23 MMB. The 2005 hurricanes caused significant problems for the distribution of diesel fuel as far away as the Northeast, parts of which rely on supplies of diesel heating oil. U.S. Gulf diesel stocks rose by 2.4 MMB the week after Hurricane Katrina and Gulf wholesale diesel prices continued at parity with New York Harbor prices after the storm passed (see Figure 14). After Hurricane Rita, on the other hand, diesel stocks dropped by about 4.4 MMB, causing the

U.S. Gulf spot diesel premium to spike to 48 cents or about 22 percent above the New York Harbor price.



In 2008, movements in diesel stocks and prices were much tamer. In 2006, the U.S. completed a switch from low-sulfur diesel to ultra low-sulfur diesel (ULSD). In the week before Hurricane Gustav made landfall in 2008, Gulf Coast ULSD stocks stood at 24.4 MMB, about 1.4 MMB higher than where low-sulfur diesel stocks stood before Katrina in 2005. Despite a small drawdown in stocks after Gustav, ULSD prices in the Gulf and New York Harbor remained at parity immediately following the storm. Prior to the arrival of Ike, the Gulf ULSD price saw a 3 percent increase relative to the New York Harbor price, as traders anticipated refinery disruptions. The run up was not nearly as high as the spike seen in gasoline markets. In the week after Ike passed, the U.S. Gulf diesel premium reached as high as 12 cents or about 4 percent above the New York Harbor price. This is one fourth of the spike in diesel prices that occurred in 2005.

Transportation & Supply

Most of the crude oil and petroleum products moved through pipelines originate in the Gulf Coast. Production platforms, refineries, ports, and waterways are shut when hurricanes strike the Gulf, and inevitably impact the ability of petroleum pipelines to continue operating. In both 2005 and 2008, pipelines moving crude oil, petroleum products, and liquid petroleum gases were

shut entirely, shut partially, or operated at reduced rates for weeks (see Appendix Tables A-8 and A-9).

Hurricane Katrina's shut down and damage to the LOOP in 2005 resulted in the shut down of the Locap and Capline moving crude oil to refineries. These lines were shut for almost a week and operated at reduced rates for another week until electricity could be restored. While the operators deployed generators, they were unable to maintain normal flows on the pipelines with generators. Electricity loss to pump stations in Louisiana and Mississippi was the cause for the shut down of the Colonial, Dixie, and Plantation pipelines. Reduced refinery output kept the flow of products low on the Colonial and Plantation for a few more days.

Hurricane Rita made landfall further west in Texas, resulting in fewer pipeline shut downs. The Locap, Seaway, Longhorn, and Dixie pipelines shut down as a precaution but were quickly restarted. Almost all of the major product pipelines originating in the Gulf were operating at reduced rates from September 24, 2005 through early October. Reduced refinery output and electricity restoration delayed the return to normal operation.

Only a few major pipelines were shut down by Hurricane Gustav in 2008. The Capline and Locap shut down on September 1, 2008, returning to reduced service four days later. Centennial pipeline was shut on September 2, 2008 and remained down through Ike's landfall, restarting on September 21. Explorer pipeline was shut for one day as a precaution. Colonial, Plantation, and NuStar product pipelines reduced their flows on September 2, and continued in reduced operation through mid-September. Hurricane Ike's arrival resulted in the shut down of Seaway crude, Explorer, NuStar, and Enterprise LPG pipelines. Seaway was impacted by the closure of Freeport terminal. Lack of power at the LOOP kept flow rates low on the Locap and Capline pipelines for a week beginning on September 11, 2008. Reduced refinery operations limited product supply to pipelines for the last two weeks of September 2008. Almost all pipelines returned to normal operations by October 1, 2008.

Similar to 2005, supply shortages developed in some parts of the Southeast in 2008 due to transportation problems – waterborne, pipeline, and highway. Hurricanes Gustav and Ike prevented waterborne petroleum product deliveries from reaching many ports in southeast states and distributors began to truck supplies from nearby states. In some states, marketers with branded supply contracts were put on allocation and independent marketers experienced supply disruptions at stations and terminals.³⁸ Major oil companies prioritized gasoline supply delivery and generator installation at retail stations along evacuation routes. For example, Florida enacted a new law in 2007 requiring all owners of more than ten gas stations to maintain a generator than can be relocated to stations without power. Owners of more stations are required to have more generators on hand, e.g., 16 locations would require two generators, etc. All portable generators must be stored within the state or within 250 miles of the station, and must be available and in use within 24 hours after the disaster.³⁹

³⁸ Keith Reid, "Gustav and Ike Rattle Southeastern Supply," NPN web, 10/24/08, <http://www.npnweb.com/ME2/dirmod.asp?sid=3B7062773CE64BBC9CC064EED2542B6B&nm=Industry+Issues&type=MultiPublishing&mod=PublishingTitles&mid=8F3A7027421841978F18BE895F87F791&tier=4&id=748DCA5017FE4DAD97B6C96CBB65383A1>.

³⁹ http://www.fpma.org/upload_library/082106Generatorbill.pdf.

As a result, many fueling stations in storm affected areas were able to continue operating on temporary generators until electric power was restored. Supply and power problems at fueling stations were compounded by a surge in demand caused by panic buying as motorists rushed to top off their tanks fearing a repeat of the supply shortages that occurred in some areas following Katrina.⁴⁰ Long lines and spot outages of gasoline continued through October 1, 2008 at retail stations in the Georgia, Tennessee, North and South Carolina, and Alabama. According to AAA, Atlanta, Georgia and Charlotte, North Carolina were the cities most affected by the fuel shortages.

⁴⁰ *Ibid.*

Federal & State Actions

The Federal government and State governments coordinated their response to the energy emergencies in 2005 and 2008. Many Federal agencies were involved in the energy sector, including the Department of Energy (DOE), the Department of Homeland Security (DHS), the Department of Transportation (DOT), the Environmental Protection Agency (EPA), the Minerals Management Services (MMS) of the U.S Department of the Interior, U.S. Army Corps of Engineers (ACE), Federal Emergency Management Agency (FEMA), and the Federal Energy Regulatory Commission (FERC). Actions taken by these agencies are summarized below.

Monitoring Infrastructure

DOE is the lead agency for Emergency Support Function #12 (ESF-12), which is intended to facilitate the restoration of damaged energy systems and components when activated by the DHS Secretary for incidents requiring a coordinated Federal response. ESF-12 is an integral part of the larger DOE responsibility of maintaining continuous and reliable energy supplies for the United States through preventive measures and restoration and recovery actions.

ESF-12 collects, evaluates, and shares information on energy system damages and estimates on the impact of energy system outages within affected areas. Additionally, ESF-12 responders provide information concerning the energy restoration process such as projected schedules, percent restored, and geographic progression of restoration.

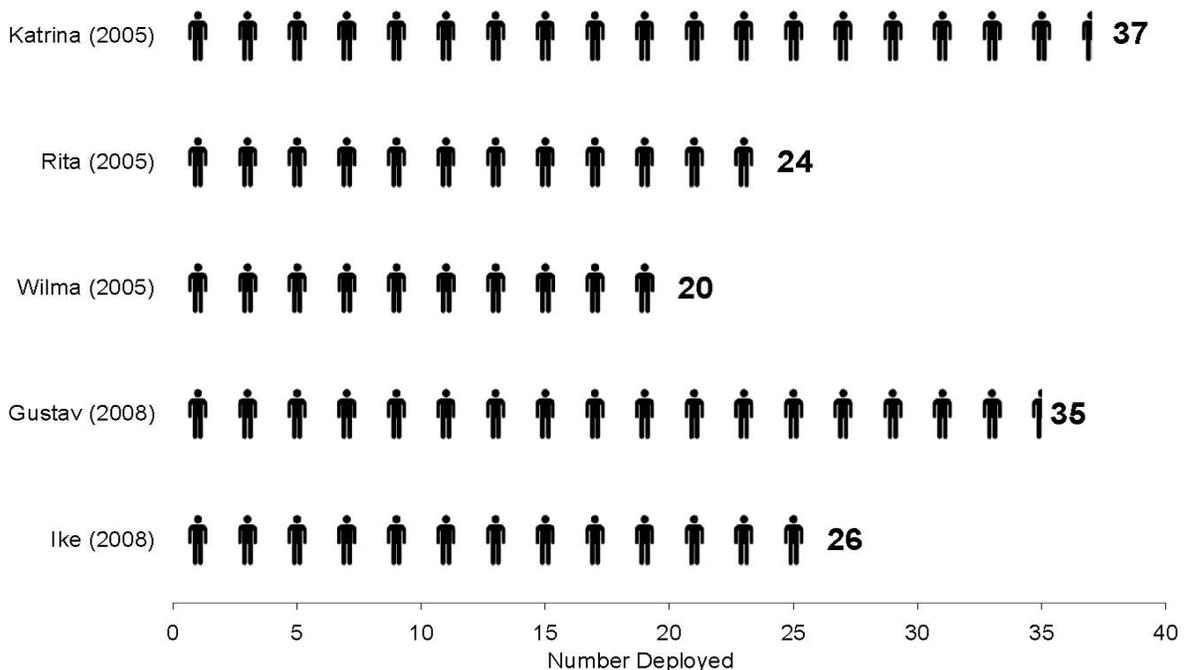
To achieve these objectives, DOE prepares Emergency Situation Reports, at times twice a day, to provide an official review of the status of energy infrastructure impacted by hurricanes and other natural events deemed to be of national significance. The Situation Reports are distributed widely and posted on the public web site (http://www.oe.netl.doe.gov/emergency_sit_rpt.aspx). In 2005, 93 Situation Reports were prepared; in 2008, 48 Situation Reports were prepared. DOE monitors developments in energy assurance when no emergencies are declared. The Energy Assurance Daily is a newsletter that summarizes the day's major developments and is posted on the public web site as well (<http://www.oe.netl.doe.gov/ead.aspx>).

Facilitating Restoration

DOE provides 24/7 coverage of the ESF-12 desk at regional FEMA headquarters when they are activated during an emergency. DOE has staff dedicated to serve as regional coordinators and has developed an extensive training program to prepare others to step in during emergencies. Staff are deployed at the National Response Coordination Center (NRCC) in Washington, DC, Regional Response Coordination Centers (RRCC) in each of the ten FEMA regions, state emergency operations centers, joint field offices, and other emergency facilities (see Figure 15).

ESF-12 facilitates the restoration of energy systems through legal authorities. ESF-12 engineers provide technical expertise to the utilities, conduct field assessments, and assist government and private-sector stakeholders to overcome challenges in restoring the energy system.

Figure 15. ESF-12 Deployments during Major Hurricanes in 2005 and 2008



Source: Volpentest HAMMER Training Center.

In response to Hurricane Katrina in 2005, staff began their deployment on August 27, 2005, and most ended by October 9, 2005 except for a joint field office that stayed operational through December 28, 2005. Staff were called up for Hurricane Rita as early as September 18, 2005 and at least one office did not stand down until November 21, 2005. When Hurricane Wilma appeared imminent, staff were again deployed from October 18 through November 29, 2005.

In 2008, ESF-12 deployments were more concentrated in terms of timing, but not geography. In 2008, FEMA Regions II & III (Mid-Atlantic), IV (Southeast), V (MidContinent) and VI (Gulf Coast) all requested ESF-12 support in their regions during a three week time period due to Gustav and Ike. ESF-12 staff remained in Texas months after Ike to assist with the electricity recovery efforts, especially related to temporary housing.

Prioritizing Power Restoration

DOE has the authority to invoke Section 202(c) of the Federal Power Act, which gives the Secretary of Energy the authority to determine that an "emergency" exists, and "to require by order such temporary connection of facilities and such generation, delivery, interchange, or transmission of electric energy as in [the Secretary's] judgment will best meet the emergency and serve the public interest." Section 202(c) was invoked both in 2005 and 2008 to provide an emergency interconnect to the Livingston Pumping Station which supplies Houston with water. CenterPoint provided the emergency connection to the facility normally supplied by Entergy. DOE issued a second 202(c) order in 2005 to authorize and direct TXU Electric Delivery to

temporarily connect and energize its existing Huntington to Etoile 138kV line for the purpose of delivering electricity to Deep East Texas Electric Cooperative, an area normally served by Entergy Gulf States, Inc. DOE also worked with pipeline, terminal, and power companies to coordinate restoration efforts by establishing Collins Tank Farm in Mississippi as a priority for power restoration. This tank farm is a significant location for Colonial and Plantation pipelines. Generators were brought instead and DOE worked with DOT to institute driver and weight limit waivers and to ensure that generators were delivered.

DOE also assisted an electricity pole producer in Alabama by facilitating delivery of distillate fuel on a priority basis to continue manufacturing poles needed for electricity recovery in the Gulf Coast region in 2005.

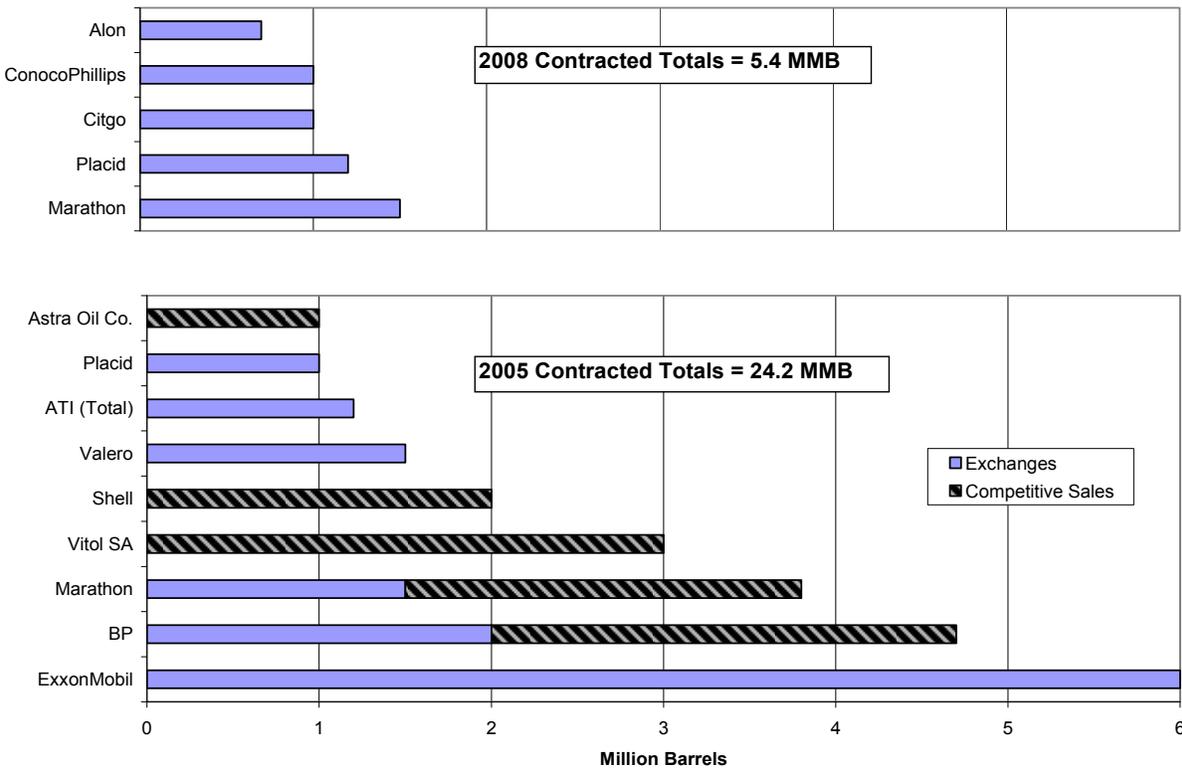
Strategic Petroleum Reserves

The Department of Energy's Strategic Petroleum Reserve (SPR) was fundamental in the Department's response to the 2005 and 2008 hurricanes. The SPR mission is to diminish the vulnerability of the United States to the harmful effects of petroleum supply disruptions, to meet U.S. obligations under the international energy program, and to maintain the ability to respond to an emergency. By virtue of their locations in Louisiana and Texas, SPR sites were impacted during both hurricane seasons. On August 28, 2005, SPR shut down operations in New Orleans, West Hackberry and Bayou Choctaw, Louisiana, primarily due to flooding.⁴¹ Shutdowns continued until the water receded and electricity was restored. SPR facilities at Bryan Mound and Big Hill, Texas were fully operational throughout Hurricane Katrina. West Hackberry and Big Hill were without power due to Hurricane Rita for about a week. Nonetheless, DOE activated the SPR when the facilities were restored, and invited companies to bid competitively on purchases and loans of available crude.

In 2005, nine Gulf Coast and Midwest refiners requested more than 24 MMB of crude oil from SPR (see Figure 16), equal to more than 16 days of full Gulf of Mexico oil production. Requests were made between August 29 and September 4, 2005. Deliveries of crude to refiners were completed by October 25, 2005. Over 13 MMB came in the form of exchanges in which the refiners were required to repay loans with physical barrels at a later date; all crude oil was returned to SPR by June 30, 2007. The remaining 11 MMB were disbursed through competitive auctions.

⁴¹ DOE "The Strategic Petroleum Reserve Reaction to Hurricanes Katrina And Rita" presentation at Petrostocks 2007, <http://www.petrostock.org/2007/Presentations/Gibson,%20Hoot/Hoot%20Presentation.pdf>.

Figure 16. Refiner Requests for U.S. Strategic Petroleum Reserves 2005 and 2008



Source: DOE Fossil Energy Techlines.

Three SPR sites were closed by the 2008 hurricanes: Bryan Mound, Texas; Big Hill, Texas; and West Hackberry, Louisiana; were impacted by storm surge and accessible only by boat for a week. In 2008, only 5.4 MMB were requested by five refiners who were impacted by Mississippi River and ship channel closures. All of these deliveries were made in the form of exchanges. Marathon and Placid were the only refiners to request oil in both 2005 and 2008.

In addition to domestic supplies of crude oil, the DOE can seek emergency release of petroleum product reserves in Europe. On September 2, 2005, the United States obtained 60 MMB of petroleum product stocks from the International Energy Agency (IEA), the first such release since the first Iraq war in 1991.⁴² IEA member countries hold about 4.1 billion barrels of public and industry oil stocks, of which, roughly 1.4 billion barrels are government controlled for emergency purposes. Unlike the SPR, which contains crude oil, the IEA reserves are all petroleum products. In September 2008, the United States coordinated with IEA but no formal request was made.

⁴²IEA Press Release, "IEA Announcement of Emergency Stock Release," 9/2/05, http://www.iea.org/Textbase/press/pressdetail.asp?PRESS_REL_ID=155.

Waivers

FERC Power Transaction Waivers

On September 4, 2008, the Federal Energy Regulatory Commission (FERC) granted Entergy two emergency waivers that allowed the company to manage their resources in the wake of Hurricane Gustav. FERC granted the company a waiver of the one-month minimum term for unit power sales and resales between the Entergy operating companies. FERC also allowed Entergy's operating companies to enter into transactions that include capacity from the Grand Gulf nuclear power plant without advance FERC approval. These waivers were in effect only where an Entergy operating company experienced a significant loss of load as a result of the hurricane, and only until the emergency conditions from the hurricane subsided.

Jones Act Waivers

DOE worked with DHS to provide due diligence, i.e., DOE collaborated with other Federal agencies to assess whether an energy emergency existed that would necessitate a temporary waiver. Following Hurricane Katrina, DHS waived the Merchant Marine Act of 1920 (the "Jones Act") for certain shipments of crude oil and petroleum products in the Gulf. The Jones Act prohibits foreign built, owned, or flagged vessels from carrying goods between U.S. ports. The waiver, which was effective from September 1 to 19, 2005, allowed large foreign flagged tankers to assist U.S. vessels in the transportation of crude oil and refined products from the Gulf Coast to other parts of the country to alleviate supply problems caused by the shutdown of Gulf refineries and pipelines.⁴³ On September 26, 2005, after the passage of Hurricane Rita, DHS issued another Jones Act Waiver, effective until October 24, 2005. No Jones Act waivers were requested during the 2008 hurricane season.

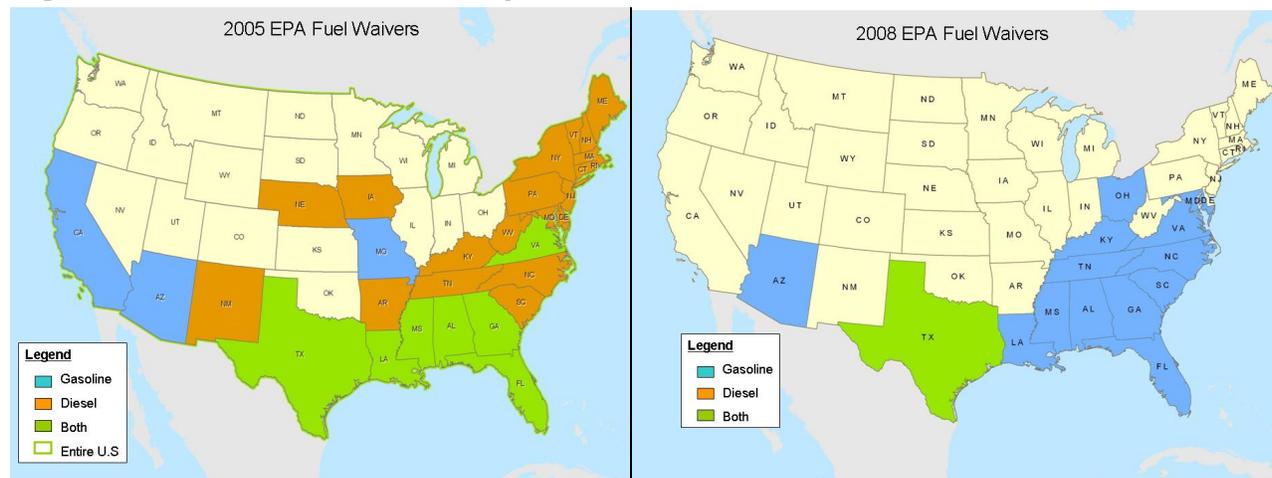
EPA Fuel Waivers

Following the hurricanes of 2005 and 2008, EPA waived certain fuel requirements in order to facilitate supply logistics and increase import flexibility. DOE worked closely with EPA to provide due diligence to facilitate decision-making regarding temporary waiver of certain fuel requirements. In 2005, EPA granted widespread fuel waivers to states impacted by supply disruptions caused by Hurricanes Katrina and Rita (see Figure 17). Thirty states and the District of Columbia, stretching from the east to west coasts and as far north as New England, requested and were granted waivers for gasoline, diesel fuel, or both by the EPA. Seven states - the five Gulf Coast states plus Georgia and Virginia – received fuel waivers for both gasoline and diesel. In addition, EPA issued a waiver for the entire United States covering the two weeks after Katrina's landfall of the requirement to sell summer gasoline and allowing the early use of higher volatility wintertime gasoline. Within the same waiver, the EPA also allowed the use of on-highway diesel fuel that exceeds 500 ppm sulfur content.

In 2008, by contrast, fuel waivers were limited primarily to the Gulf Coast and southeastern United States and were granted only for gasoline (with the exception of Texas which received waivers for both gasoline and diesel).

⁴³ http://npga.org/files/public/Jones_Act_Waver_9-05.pdf.

Figure 17. Fuel Waivers Issued by EPA to States in 2005 and 2008



Source: Environmental Protection Agency web site.

Driver Hour Waivers

DOE worked with the DOT Federal Motor Carrier Safety Administration (FMCSA) to approve a driver-hour waiver for motor carriers hauling emergency relief supplies, including emergency fuel supplies, in the Southern and Eastern regions of the country.⁴⁴ The waiver was issued on September 14, 2005 and expired on October 5, 2005. The waiver was extended nationwide through October 26, 2005. In addition, the governors of many states experiencing fuel shortages due to disruptions caused by Hurricanes Katrina and Rita declared states of emergency, triggering temporary suspension of certain Federal safety regulations, including driver hours for tanker trucks carrying fuel. On September 13, 2008, FMCSA issued a regional emergency declaration affecting six Southern states – Alabama, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina. The declaration and driver hour waiver for truckers delivering fuel-related supplies was extended through October 15, 2008.⁴⁵

Price Gouging

DOE monitors fuel prices to make certain that consumers pay appropriate prices at the pump. During emergencies, DOE opens its price gouging hotline (1-800-224-3301) and web site (www.gaswatch.energy.gov) for consumers. EIA monitors regional inventories and prices weekly, sharing data with the Federal Trade Commission and state energy offices.

At least 29 states plus the District of Columbia have laws that prohibit price gouging at fuel stations after a natural disaster, although the definition of “price gouging” varies from state to state. Maine and Michigan have declared price gouging illegal at all times within their states. Arkansas considers price gouging illegal following any disaster while Georgia and Texas tie these laws to a natural disaster or emergency declaration.

⁴⁴ <http://www.fmcsa.dot.gov/about/news/news-releases/2005/hosrelief.htm>.

⁴⁵ <http://www.fmcsa.dot.gov/emergency/SSC-Ruban-fuel-shortage-extension-dec-100708.pdf>.

Appendix Tables

Table A-1. 2005 Hurricane Electricity Impacts

Million Customers by State	Pre-Katrina 1/1/2005	Worst Day Outages		Outages 2 Weeks Later	Hurricane Wilma 10/25/05	Outages 6 Weeks Later
		Katrina 8/30/05	Rita 9/25/05	10/11/05		11/7/05
Alabama	2.4	0.8		-		
Arkansas	1.5	-	-	-		
Florida	9.2	0.2		-	3.5	0.1
Louisiana	2.2	0.8	0.7	0.1		
Mississippi	1.4	0.9	-	-		
Texas	10.4	-	0.8	<0.05		
Total	27.0	2.7	1.5	0.2	3.5	0.1

Sources: OE/ISER Situation Reports.

Table A-2. 2008 Hurricane Electricity Impacts

Million Customers by State	Pre-Gustav 1/1/08	Worst Day Outages		Outages 2 Weeks Later	Outages 4 Weeks Later	Outages 6 Weeks Later
		Gustav 9/2/08	Ike 9/14/08	9/29/08	10/14/08	10/28/08
Arkansas	1.5	-	0.2	-	-	-
Louisiana	2.1	1.1	0.2	-	-	-
Mississippi	1.4	0.1	-	-	-	-
Texas	10.7	-	2.5	0.2	<0.1	<0.1
Other States*	27.5	-	1.0	-	-	-
Total	43.3	1.1	3.9	0.2	<0.1	<0.1

* The storm quickly moved north impacting Missouri, Kentucky, Indiana, Illinois, Ohio, and New York through 9/15/08.

Source: OE/ISER Situation Reports.

Table A-3. 2005 Hurricane Natural Gas Impacts

Natural Gas Production, Processing & Pipelines	Pre-Katrina Production	Worst Day Outages		Outages 2 Weeks Later	Outages 4 Weeks Later	Outages 6 Weeks Later
		Katrina	Rita			
	8/24/2005	8/30/2005	9/25/2005	10/11/2005	10/25/2005	11/7/2005
Natural Gas Production						
Billion Cubic Feet per Day	10	8.8	8.1	6.0	5.6	4.5
% of Gulf Production	100%	88%	81%	60%	56%	45%
% of U.S. Production	19%	17%	15%	11%	11%	9%
Processing						
Gulf processors (number)	NA	NA	NA	NA	NA	NA
Billion Cubic Feet per Day	25.7	NA	17.1	9.5	8.1	7.9
% of Gulf Capacity	100%	NA	67%	37%	32%	31%
% of U.S. Capacity	33%	NA	22%	12%	11%	10%
Interstate Longhaul Pipelines						
Pipelines Shutdown	None					
Pipelines Reduced	None					

Sources: MMS and EIA.

Table A-4. 2008 Hurricane Natural Gas Impacts

Natural Gas Production, Processing & Pipelines	Pre-Gustav Production	Worst Day Outages		Outages 2 Weeks Later	Outages 4 Weeks Later	Outages 6 Weeks Later
		Gustav	Ike			
	8/28/2008	9/2/2008	9/14/2008	9/29/2008	10/14/2008	10/28/2008
Natural Gas Production						
Billion Cubic Feet per Day	7.4	7.1	7.3	3.9	2.7	2.5
% of Gulf Production	100%	95%	98%	53%	37%	33%
% of U.S. Production	14%	13%	14%	7%	5%	5%
Processing						
Gulf processors (number)	97	25	30	6	5	5
Billion Cubic Feet per Day	25.7	16.1	14.5	3.4	3.2	3.2
% of Gulf Capacity	100%	63%	57%	13%	12%	12%
% of U.S. Capacity	33%	21%	19%	4%	4%	4%
Interstate Longhaul Pipelines						
Pipelines Shutdown	None	None	None	None	None	None
Pipelines Reduced	None	ANR; Columbia Gulf; Gulf South; NGPL America; Northern NG; Southern NG; Tennessee Gas; Texas Eastern; Texas Gas; Transcontinental; Trunkline	ANR; Columbia Gulf; Gulf South; NGPL America; Northern NG; Southern NG; Tennessee Gas; Texas Eastern; Texas Gas; Transcontinental; Trunkline	ANR; Columbia Gulf; Southern NG; Texas Eastern; Texas Gas; Transcontinental; Trunkline	None	None

Sources: MMS, EIA, OE/ISER Situation Reports.

Table A-5. 2005 Hurricane Petroleum Impacts

Petroleum Production, Refining & Pipelines	Pre-Katrina Production	Worst Day Outages		Outages 2 Weeks Later	Outages 4 Weeks Later	Outages 6 Weeks Later
		Katrina	Rita			
	8/24/2005	8/30/2005	9/25/2005	9/29/2008	10/14/2008	10/28/2008
Crude Oil Production						
Million Barrels per Day	1.5	1.4	1.5	1.1	1.0	0.8
% of Gulf Production	100%	93%	100%	71%	69%	52%
% of U.S. Production	30%	28%	30%	21%	20%	15%
Refining						
Gulf refineries (number)	34	11	20	7	4	3
Million Barrels per Day	7.3	2.5	4.9	1.9	1.0	0.8
% of Gulf Capacity	100%	34%	67%	25%	14%	11%
% of U.S. Capacity	42%	14%	28%	11%	6%	5%
Petroleum Pipelines						
Crude Pipelines Shutdown	None	LOOP; Capline	LOOP; Sun; Seaway; TEPPCO	None	None	None
Crude Pipelines Reduced	None	None	Capline	Capline; Sun	None	None
Product Pipelines Shutdown	None	Colonial; Plantation; Dixie	Explorer; TEPPCO; Longhorn; Dixie	None	None	None
Product Pipelines Reduced	None	None	Colonial	Explorer; TEPPCO	None	None

Sources: MMS and OE/ISER Situation Reports.

Table A-6. 2008 Hurricane Petroleum Impacts

Petroleum Production, Refining & Pipelines	Pre-Gustav Production	Worst Day Outages		Outages 2 Weeks Later	Outages 4 Weeks Later	Outages 6 Weeks Later
		Gustav	Ike			
	8/28/2008	9/2/2008	9/14/2008	9/29/2008	10/14/2008	10/28/2008
Crude Oil Production						
Million Barrels per Day	1.3	1.3	1.3	0.7	0.5	0.4
% of Gulf Production	100%	100%	100%	57%	39%	28%
% of U.S. Production	26%	26%	26%	15%	10%	7%
Refining						
Gulf refineries (number)	33	14	15	2	0	0
Million Barrels per Day	7.5	2.7	3.9	0.4	0.0	0.0
% of Gulf Capacity	100%	35%	51%	6%	0%	0%
% of U.S. Capacity	43%	15%	22%	2%	0%	0%
Petroleum Pipelines						
Crude Pipelines Shutdown	None	LOOP; Capline; Marathon; Sunoco	Marathon; Sunoco; Genesis	Marathon; Genesis	None	None
Crude Pipelines Reduced	None		LOOP; Capline	None	None	None
Product Pipelines Shutdown	None	Centennial	Centennial; NuStar; Explorer; Longhorn; Seaway; Enterprise	None	None	None
Product Pipelines Reduced	None	Colonial; Plantation	Colonial; Plantation; Magellan; TEPPCO; Dixie	Centennial; CP; Explorer; Longhorn; Magellan; Plantation	None	None

Sources: MMS, AOPL, and OE/ISER Situation Reports.

Table A-7b. Progression of Refinery Shut Downs and Restoration During 2005 Hurricanes, 10/25/05–12/5/05

Company	Location	10/26/05	10/27/05	10/28/05	10/29/05	10/30/05	10/31/05	11/1/05	11/2/05	11/3/05	11/4/05	11/5/05	11/6/05	11/7/05	11/8/05	11/9/05	11/10/05	11/11/05	11/12/05	11/13/05	11/14/05	11/15/05	11/16/05	11/17/05	11/18/05	11/19/05	11/20/05	11/21/05	11/22/05	11/23/05	11/24/05	11/25/05	11/26/05	11/27/05	11/28/05	11/29/05	11/30/05	12/1/05	12/2/05	12/3/05	12/4/05	12/5/05											
Shell Chemical	Saraland, AL																																																				
ChevronTexaco	Pascagoula, MS																																																				
Valero	Krotz Springs, LA																																																				
Exxon	Chalmette, LA																																																				
ConocoPhillips	Belle Chasse, LA																																																				
Murphy	Meraux, LA																																																				
Exxon	Baton Rouge, LA																																																				
Marathon	Garyville, LA																																																				
Shell Chemical	St Rose, LA																																																				
Shell (Motiva)	Norco, LA																																																				
Valero	Norco, LA																																																				
Shell (Motiva)	Convent, LA																																																				
Placid Oil	Port Allen, LA																																																				
Calcasieu	Lake Charles, LA																																																				
Citgo	Lake Charles, LA																																																				
ConocoPhillips	West Lake, LA																																																				
ExxonMobil	Beaumont, TX																																																				
Shell (Motiva)	Port Arthur, TX																																																				
Total	Port Arthur, TX																																																				
Valero (Premcor)	Port Arthur, TX																																																				
BP	Texas City, TX																																																				
Marathon	Texas City, TX																																																				
Valero	Texas City, TX																																																				
ConocoPhillips	Sweeny, TX																																																				
Shell	Deer Park, TX																																																				
ExxonMobil	Baytown, TX																																																				
Lydonell Citgo	Houston, TX																																																				
Valero	Houston, TX																																																				
Astra Oil	Pasadena, TX																																																				
Citgo	Corpus Christi, TX																																																				
Flint Hills	Corpus Christi, TX																																																				
Koch	Corpus Christi, TX																																																				
Trigeant (asphalt)	Corpus Christi, TX																																																				
Valero	Corpus Christi, TX																																																				
Valero	Three Rivers, TX																																																				
ConocoPhillips	Wood River, IL																																																				
Marathon	Robinson, IL																																																				
BP	Whiting, IN																																																				
BP	Toledo, OH																																																				
Valero (Premcor)	Lima, OH																																																				
Marathon	Catlettsburg, KY																																																				
Valero (Premcor)	Memphis, TN																																																				
Notes:	Shut Down																																																				
	Restarting																																																				
	Reduced Runs																																																				
	Operating																																																				
Source:	OE/ISER Situation Reports																																																				

Table A-8. Progression of Refinery Shut Downs and Restoration During 2008 Hurricanes

Company	Location	9/1/08	9/2/08	9/3/08	9/4/08	9/5/08	9/8/08	9/9/08	9/12/08	9/13/08	9/14/08	9/15/08	9/16/08	9/17/08	9/18/08	9/19/08	9/20/08	9/23/08	9/24/08	9/25/08	9/26/08	9/29/08	10/1/08	10/3/08	10/6/08	10/9/08	10/16/08
Shell	Saraland, AL																										
Chevron	Pascagoula, MS																										
Alon (Formerly Valero)	Krotz Springs, LA																										
Chalmette Refining	Chalmette, LA																										
ConocoPhillips	Belle Chasse, LA																										
Murphy Oil	Meraux, LA																										
ExxonMobil	Baton Rouge, LA																										
Marathon	Garyville, LA																										
Motiva	Norco, LA																										
Valero	Norco, LA																										
Motiva	Convent, LA																										
Placid Refining	Port Allen, LA																										
Shell	Saint Rose, LA																										
Calcasieu	Lake Charles, LA																										
Citgo	Lake Charles, LA																										
ConocoPhillips	Westlake, LA																										
ExxonMobil	Beaumont, TX																										
Motiva	Port Arthur, TX																										
Total Petrochemicals	Port Arthur, TX																										
Valero (formerly Premcor)	Port Arthur, TX																										
BP	Texas City, TX																										
Marathon	Texas City, TX																										
Valero	Texas City, TX																										
ConocoPhillips	Sweeny, TX																										
Deer Park	Deer Park, TX																										
ExxonMobil	Baytown, TX																										
Houston Refining	Houston, TX																										
Valero	Houston, TX																										
Pasadena Refining	Pasadena, TX																										
Citgo	Corpus Christi, TX																										
Flint Hills Resources	Corpus Christi, TX																										
Valero	Corpus Christi, TX																										
Valero	Three Rivers, TX																										
Notes:	Shut Down																										
	Restarting																										
	Reduced Runs																										
	Operating																										

Source: ISER Situation Reports and company web sites.

