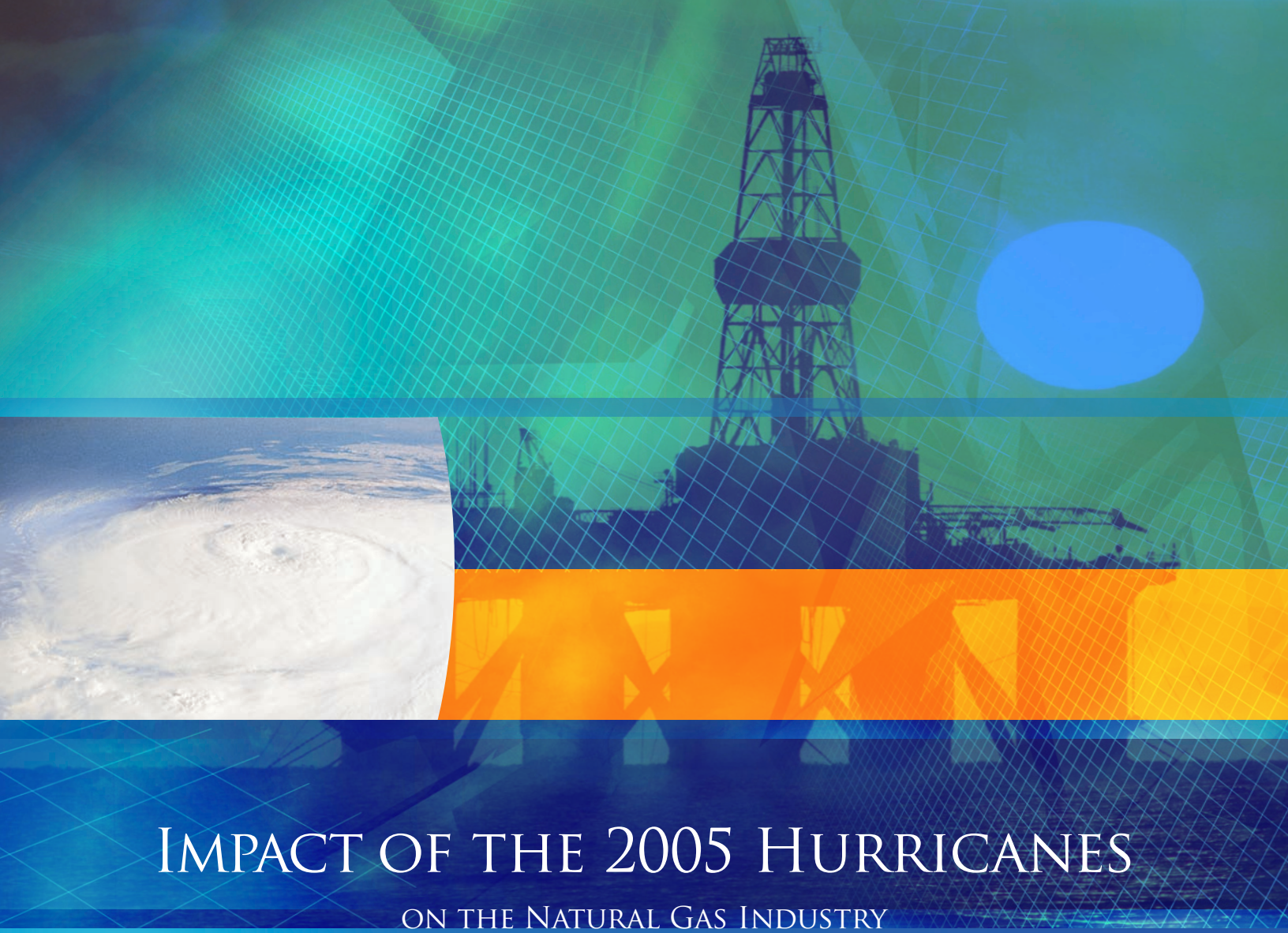
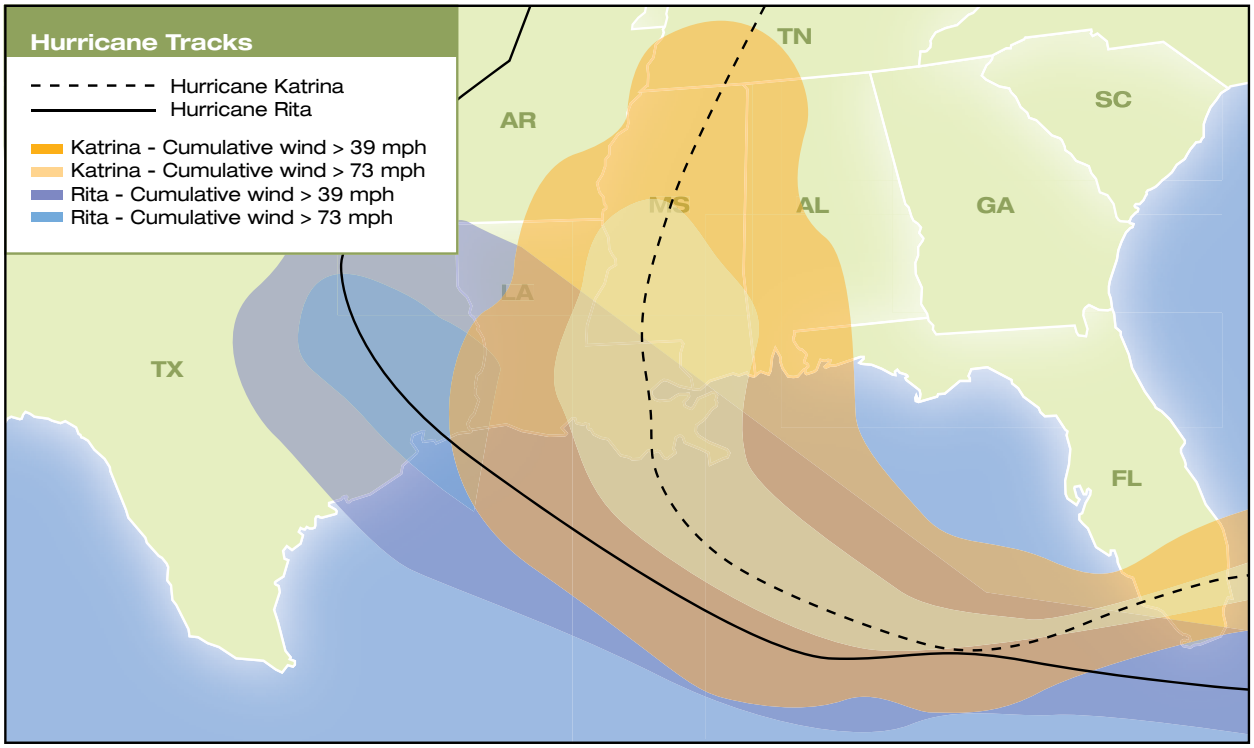


Impact of the 2005 Hurricanes

on the Natural Gas Industry in the Gulf of Mexico Region

Paths of Hurricane Katrina and Rita



About This Report

This report was prepared by the U.S. Department of Energy's Office of Fossil Energy with support from the Energy Information Administration's Office of Oil and Gas. The Office of Fossil Energy supports technology research and policy options to ensure clean, reliable and affordable supplies of oil and natural gas for American consumers working closely with the National Energy Technology Laboratory, which is the Department's lead center for the research and development of advanced fossil energy technologies. The Energy Information Administration (EIA) is the independent statistical and analytical agency within the Department of Energy.

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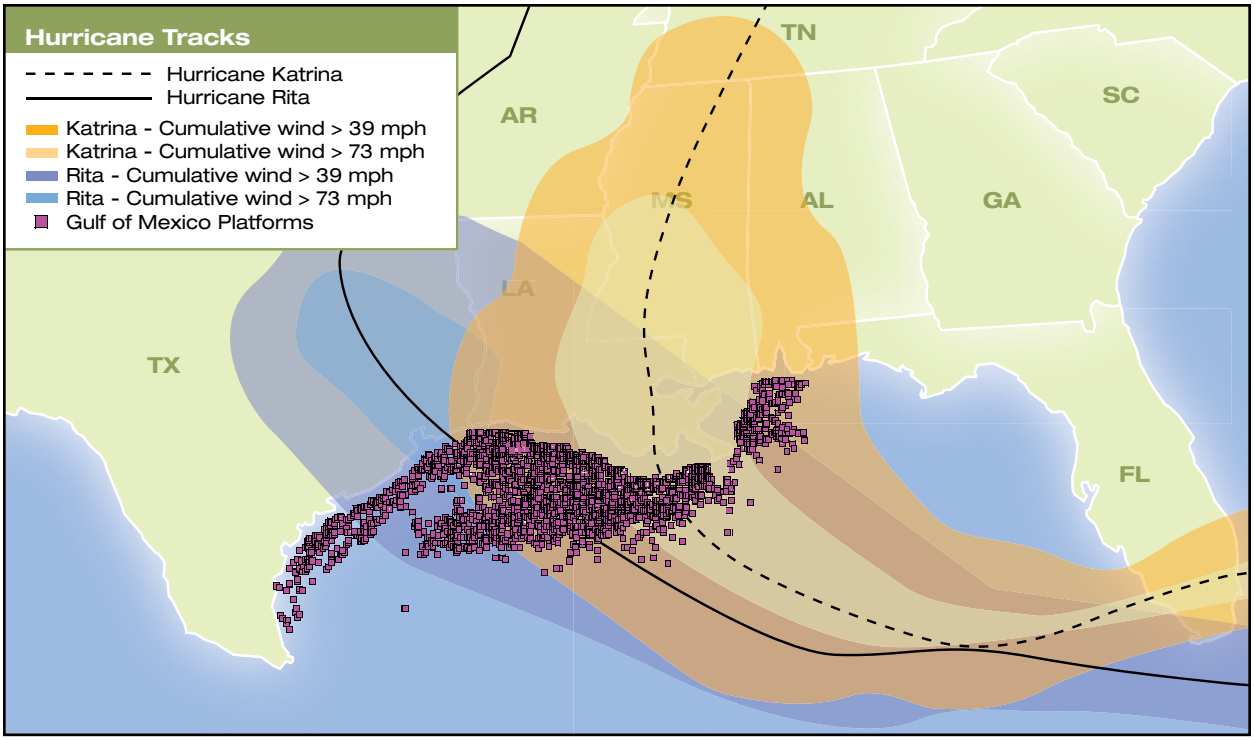
Executive Summary

This report summarizes the findings of the Department of Energy's (DOE) monitoring of the impact of hurricanes Katrina and Rita on the natural gas industry in the Gulf of Mexico region from late August 2005 through early March 2006. During that time, DOE coordinated with other Federal agencies and various natural gas industry personnel to track storm recovery efforts on a daily basis and identify disrupted natural gas flows and possible bypasses.

These monitoring efforts provided further insights into the complex supply delivery operation associated with offshore natural gas production. They also highlighted the importance of accurate, timely data and identified specific data elements that would be pertinent during other supply-related emergencies. Some of these lessons learned are particularly relevant as another hurricane season is underway.

Hurricanes and tropical storms are plentiful in the Gulf of Mexico, which is a major source of U.S. natural gas. The Federal Outer Continental Shelf (OCS) in the Gulf of Mexico provides about 10 billion cubic feet (Bcf) of gas per day or 20 percent of all the natural gas produced domestically. In a 4-week period in August and September 2005, hurricanes Katrina and Rita dealt a one-two punch to natural gas industry operations in the Gulf region. All aspects of the industry were affected, with the storms causing destruction and substantial damage to offshore production platforms and pipelines as well as onshore production wells, pipelines, processing plants, and other infrastructure supporting the Gulf production and delivery system.

The Minerals Management Service (MMS) estimated that 3,050 of the Gulf's 4,000 platforms and 22,000 of the 33,000 miles of Gulf pipelines were in the direct path of either Hurricane Katrina or Hurricane Rita. In addition, 47 major natural gas processing plants and 17 natural gas liquids fractionation sites located within the 70 counties and parishes along the Gulf Coast of Texas, Louisiana, Mississippi, and Alabama were threatened by the storms' approach. These facilities have the capacity to process 22.8 Bcf per day.



Gulf Platforms and Paths of Hurricanes Katrina and Rita

The damage from the two storms varied, but together caused the biggest disruption to operations that the industry has ever seen. Hurricane Katrina, which was a Category 5 storm (winds greater than 155 miles per hour) when it entered the Gulf in late August 2005, destroyed 44 platforms and damaged 20 others. It also damaged at least 100 pipelines in Federal waters (based on data as of March 8, 2006), 36 of which were large-diameter lines (10 inches or larger), and resulted in the shut-in of at least 8 natural gas processing plants.

Hurricane Rita, which was a Category 4 hurricane (winds between 131 and 155 miles per hour) when it entered the Gulf just a few weeks after Katrina, destroyed 69 platforms and damaged 32 others. It also damaged at least 83 offshore pipelines, 28 of which were large-diameter lines. As a consequence of both hurricanes, virtually all large natural gas processing plants in the area from Galveston Bay, Texas, through Mississippi were shut down. A total of 27 plants were affected, or nearly 75 percent of total processing capacity in the region, and operations were disrupted at several fractionators (natural gas liquids plants).

The offshore and onshore service industry supporting OCS natural gas production and deliveries was also devastated by the hurricanes. The network of workboats, crews, divers, supplies, and equipment needed to assess the damage and perform repairs to platforms and pipelines was shredded. In addition, 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. Even the basic necessities of food, water, and shelter were not available in large areas of the hurricanes' impact zones. This damage to the support service industry hindered the natural gas industry's ability to recover from the storms.

Two liquefied natural gas (LNG) import terminals (the Panhandle Energy/Trunkline LNG terminal in Lake Charles, Louisiana, and Excelerate Energy's offshore LNG operation, Gulf Gateway Energy Bridge) were also in the paths of hurricanes Katrina and Rita but suffered little or no damage. However, the navigation channel to the Lake Charles terminal was closed for several days after Rita because of debris in the shipping channel, and gas gathering pipelines serving Gulf Gateway Energy Bridge LNG operations were affected by the storms.

Storm recovery efforts have highlighted the complexity and inter-relatedness of the natural gas supply industry. Natural gas in the Gulf comes from wells as deep as 5 miles below the water's surface. Offshore production platforms are connected to downstream facilities by a series of gathering pipelines that transport the natural gas produced at these points to progressively larger diameter lines. The largest-diameter lines transport the consolidated natural gas stream to onshore compression stations, dehydration and separation facilities, processing plants, and eventually to transmission lines for delivery to end users.

Damage to any of these components affects the others. For example, reduced production flow meant that some operational processing plants were inactive because they had no gas to process. In other cases, production flow had to be redirected around damaged processing plants to other facilities or to other pipelines with access to processing capability. At times pipeline flow directions were reversed and temporary bypasses were utilized. Since all aspects of the Gulf natural gas delivery system – production, pipelines, and processing – are tied closely together, the recovery process for each of these three links is tied to the recovery of the other two links.

As of March 8, 2006, when DOE ended its active monitoring of storm recovery efforts, production had returned to about 9 Bcf per day, and flow rates of primary pipelines within the hurricane impact area were stabilizing within normal ranges. All but 2[1] of the 47 gas processing plants in the area were operating, although at reduced flow levels in aggregate. The remaining damage to production platforms, pipelines, and related infrastructure was expected to take several months to repair. In some cases, the decision to repair or how to repair had not been made, or the priority to proceed was low, based on economic considerations.

Damage assessments and information about recovery efforts throughout the whole process, from production to pipelines to processing plants, were often difficult to obtain by DOE staff. This was because of concerns about competitive advantage, limiting the responses to requests for company-specific information, as well as the lack of information about the extent and effects of the damages given the enormous impacts of the hurricanes.

The MMS released almost daily reports of evacuation and production shut-in statistics for the platforms in the Federal OCS from late August until mid December and then weekly reports through the end of February, followed by biweekly reports until May 3, 2006, and two additional reports on June 1 and June 21, 2006. DOE combined the MMS production data with data on pipeline and processing plant damages and repairs to provide daily reports on the status of the whole production and delivery process. These daily reports also included input from industry contacts and web-based pipeline informational postings.

It is noteworthy that as late as early May, when MMS issued its final damage assessment report, operators were still revising assessments and evaluating the economics of repair, abandonment, or expansion. On May 1, 2006, MMS reported that, based on additional industry investigations and reports, more than twice the number of pipelines were damaged than had been identified in January (457 vs. 183), and the number of damaged primary lines was revised from 64 to 101. MMS also reported that shut-in gas production was almost 1.3 Bcf per day as of May 3, 2006, or about 13 percent of daily gas production in the Federal waters of the Gulf.

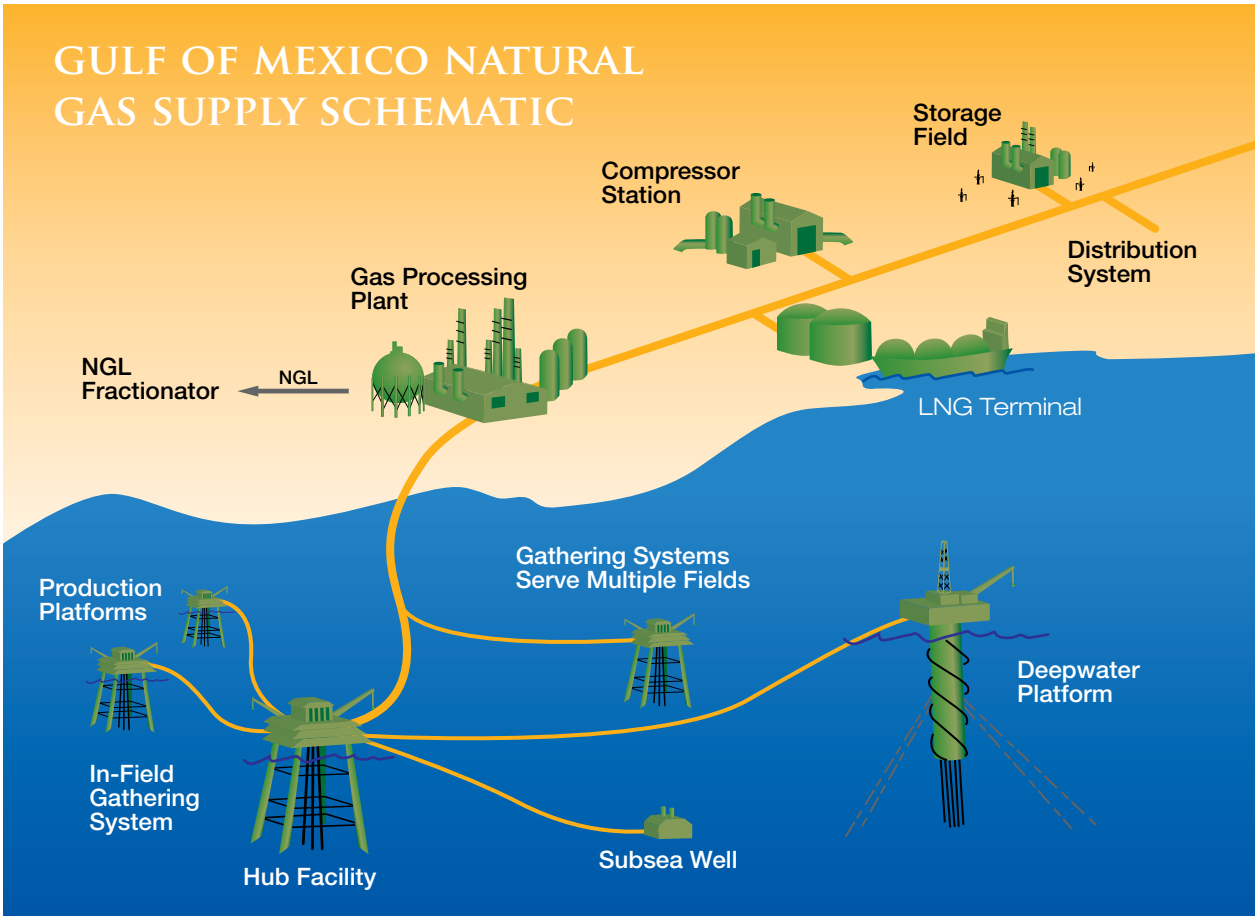
In its final shut-in statistics report on June 21, 2006, MMS estimated that about 9.4 percent of daily gas production remained shut in as of June 19, 2006. Cumulative shut-in gas production from August 26, 2005, through June 19, 2006, was 803.6 Bcf, which is equivalent to about 22 percent of yearly gas production in the Federal OCS in the Gulf.

I. The ABCs of Natural Gas Supply in the Gulf Region

Storm recovery efforts after hurricanes Katrina and Rita have highlighted the complexity and interrelatedness of the natural gas supply industry in the Gulf of Mexico region, as well as its flexibility. A highly complex infrastructure is required for producing natural gas offshore, gathering and moving the gas onshore, processing the gas and separating natural gas liquids, and delivering pipeline-quality gas to the long-distance transmission pipelines that transport natural gas to markets throughout the United States.

Compressor stations along the lines maintain the pressure to keep the gas flowing, and storage facilities feed and receive gas for system balancing and supply. The transmission lines serve a number of distribution company main lines that branch into yet smaller lines that serve residential, industrial and commercial customers. The Gulf of Mexico region also has two liquefied natural gas (LNG) import terminals, which play an important role in diversifying and expanding natural gas supplies. The LNG is transported by ship, stored at low temperatures and atmospheric pressure in super-insulated tanks, and then regasified and fed into the natural gas pipeline system.

Each element of this complex, integrated system is dependent upon adjacent elements, so damage to one



portion of the system can affect the entire chain. The system is generally capable of dealing with short-term interruptions or disturbances, but the major disruptions in the aftermath of hurricanes Katrina and Rita required extensive industry coordination, particularly since support services were overloaded. Producers, pipelines, and processors had to work together to optimize repair efforts and move as much natural gas to market as possible. Understanding the basics of the natural gas supply process can help put these recovery efforts in context.

Production: The Gulf of Mexico region produces about 20 percent of U.S. natural gas

Oil and natural gas in the Gulf come from wells as deep as 5 miles below the water's surface. These wells flow to production platforms where the primary separation of gas, oil, and water is completed. The type of production platform depends on the water depth of the producing area.

Platforms in shallow water (less than 1,000 feet) are generally fixed platforms, compliant towers, or tension-leg platforms that are attached to the seafloor.

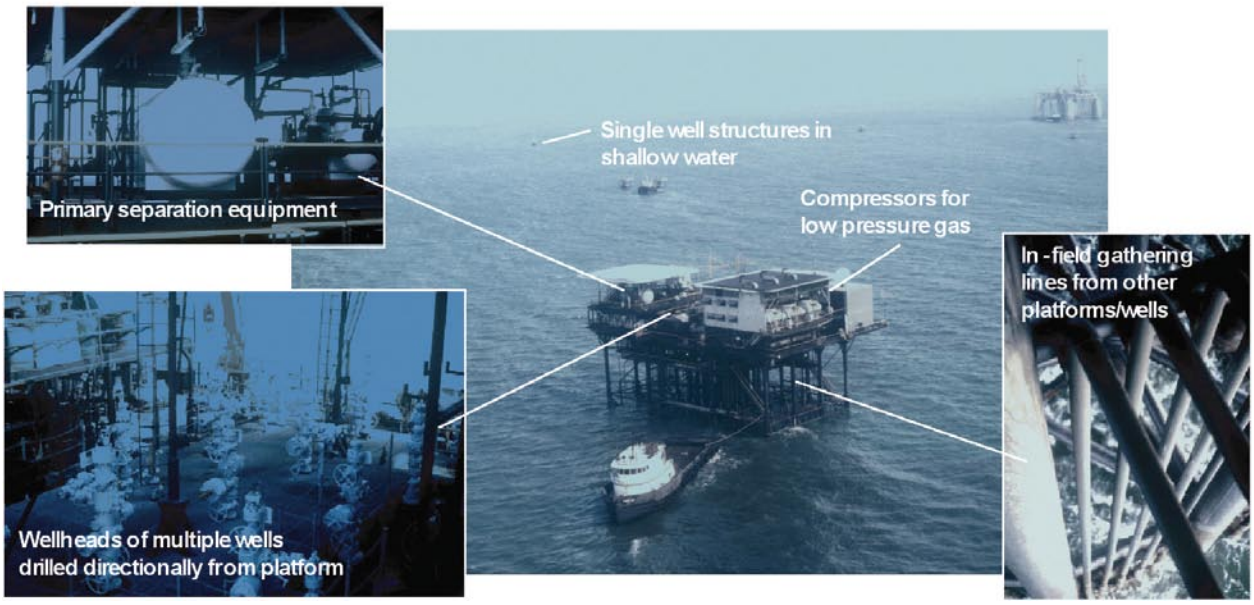
Platforms in deep water generally involve floating structures that can receive production from subsea wells. Deepwater platforms far offshore typically pipe gas and oil to a "hub platform" in shallower water before sending it to shore.

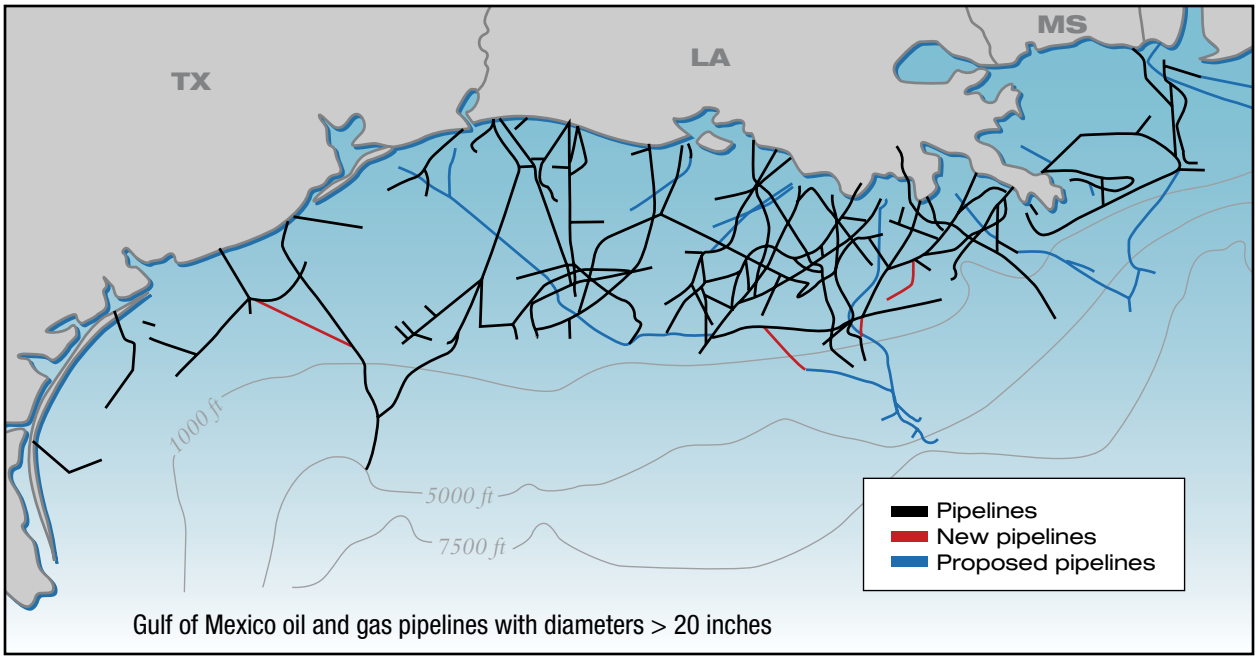
Typically 5 to 20 wells are drilled from production platforms, and there are about 4,000 platforms in the Gulf of Mexico. High-pressure gas (1,100 pounds per square inch) may go directly into a pipeline, while low-pressure gas must be compressed at a central platform.

Gathering: The Gulf Region has about 33,000 miles of gathering pipelines

A network of pipelines is used to collect the natural gas from multiple platforms in multiple fields and deliver it onshore through a process called gathering. The gathering system may include additional platforms, metering stations, compressors, and processing equipment. Gathering systems can serve multiple fields and multiple producers. A series of gathering pipelines transports the natural gas produced at the various points to progressively larger diameter lines.

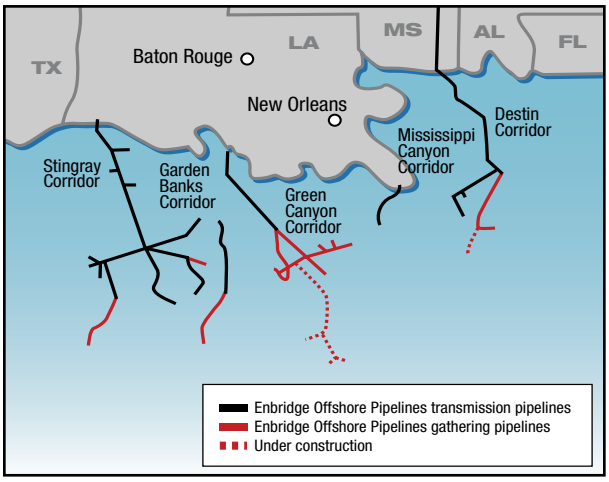
Components of Shallow Water Gas Production Platforms





Gathering Systems Collect Gas from Multiple Fields

The largest-diameter lines transport the consolidated natural gas stream to onshore compression stations, dehydration and separation facilities, processing plants, and eventually to transmission lines for delivery to end users.



Enbridge: One of Several Systems

The Federal Energy Regulatory Commission (FERC) has jurisdiction over interstate transmission lines but not over gathering lines. In some cases, however, gathering systems may connect to transmission pipelines while still offshore. These offshore transmission lines provide distinct corridors for moving gas from multiple gathering systems.

Processing: The Gulf Coast area has more than 45 major natural gas processing plants and 17 fractionators

The consolidated gas stream from the Gulf moves to natural gas processing plants located onshore in the Gulf of Mexico coastal region, mainly in Louisiana and Texas. These natural gas plants process the gas to remove water, contaminants, and hydrocarbon liquids for the primary purpose of preparing the gas and liquids for end use by the consumer.

Enterprise Natural Gas Processing Plant

Some plants process gas from wells in state waters, marshlands, and onshore gas fields, as well as the gas from offshore fields. Gas from multiple gas gathering systems is dehydrated, "sweetened" (removal of hydrogen sulfide gas and carbon dioxide), and processed to remove heavier hydrocarbons such as ethane, propane, butane, and pentanes. These "natural gas liquids" (NGLs) are sent to a fractionator (by pipeline or truck), and the clean dry gas, which is now mostly methane, is metered, compressed, and sent to a transmission line.

The fractionation facilities' products are shipped to regional petroleum and petrochemical industry customers by pipeline, truck, and barge. The petroleum refining process also produces NGLs, and refineries often have fractionators, which may also process NGLs from gas plants.

Promix Fractionation Plant

Transmission, Storage, and Distribution:

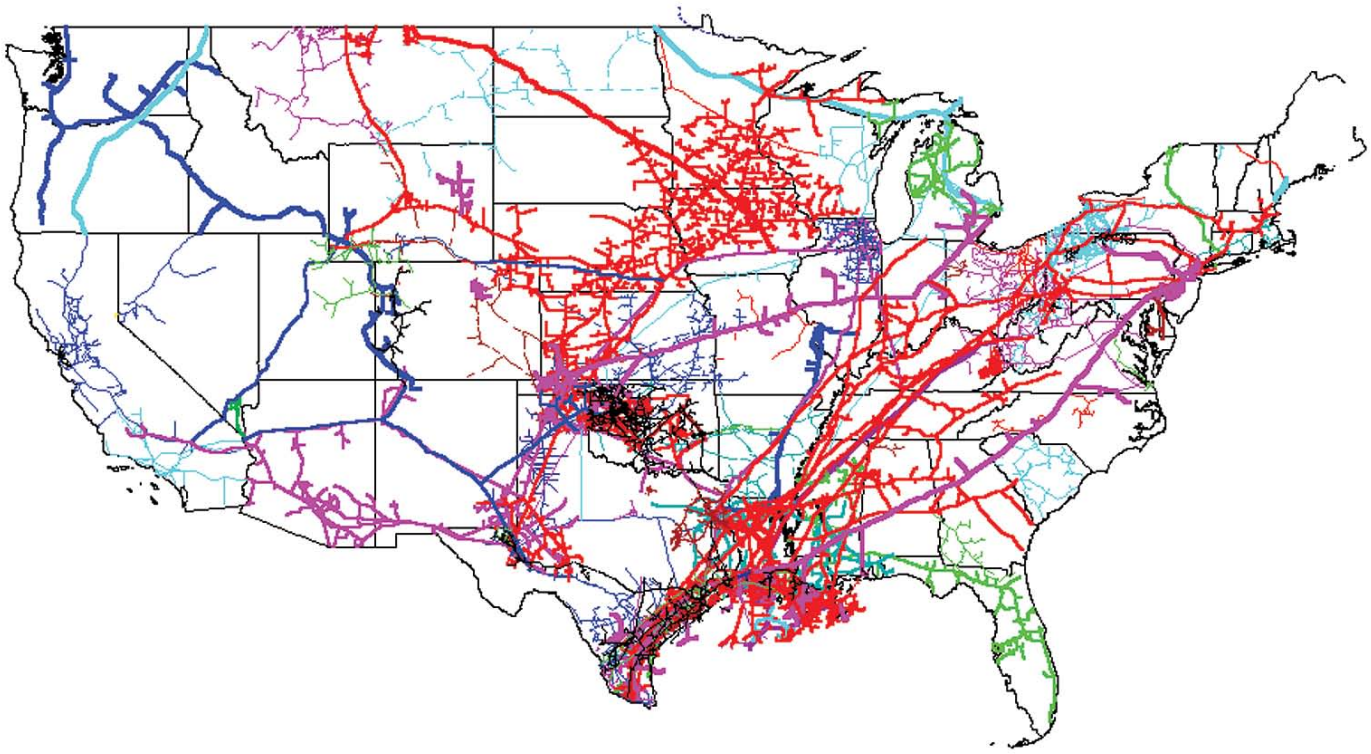
Major transmission lines link the Gulf Coast with points north and east and local distribution systems

Larger diameter pipelines are designed to transport volumes of natural gas from the Gulf of Mexico to markets in the Northeast, Midwest, and points in-between. A primary component of transmission lines are compressor stations that initially pressurize the gas feeding the lines and then recompress the gas at various points along the lines to maintain the line pressure and flow rate.

Gas storage facilities, found in both producing and consuming regions, feed the transmission system. Most storage in the Gulf region is in caverns formed in subsurface salt formations by dissolving with water. Market hubs have developed where multiple interstate pipelines meet, allowing for the efficient metering, storage, and trading of gas volumes among producers, pipelines, marketers, and customers.

The transmission lines also serve a number of distribution company main lines that branch into yet smaller lines which serve residential, industrial, and commercial customers. These distribution pipelines are regulated by state public utility commissions.

Major Interstate Gas Pipelines Connect the Gulf Coast to Northeast and Midwest Markets



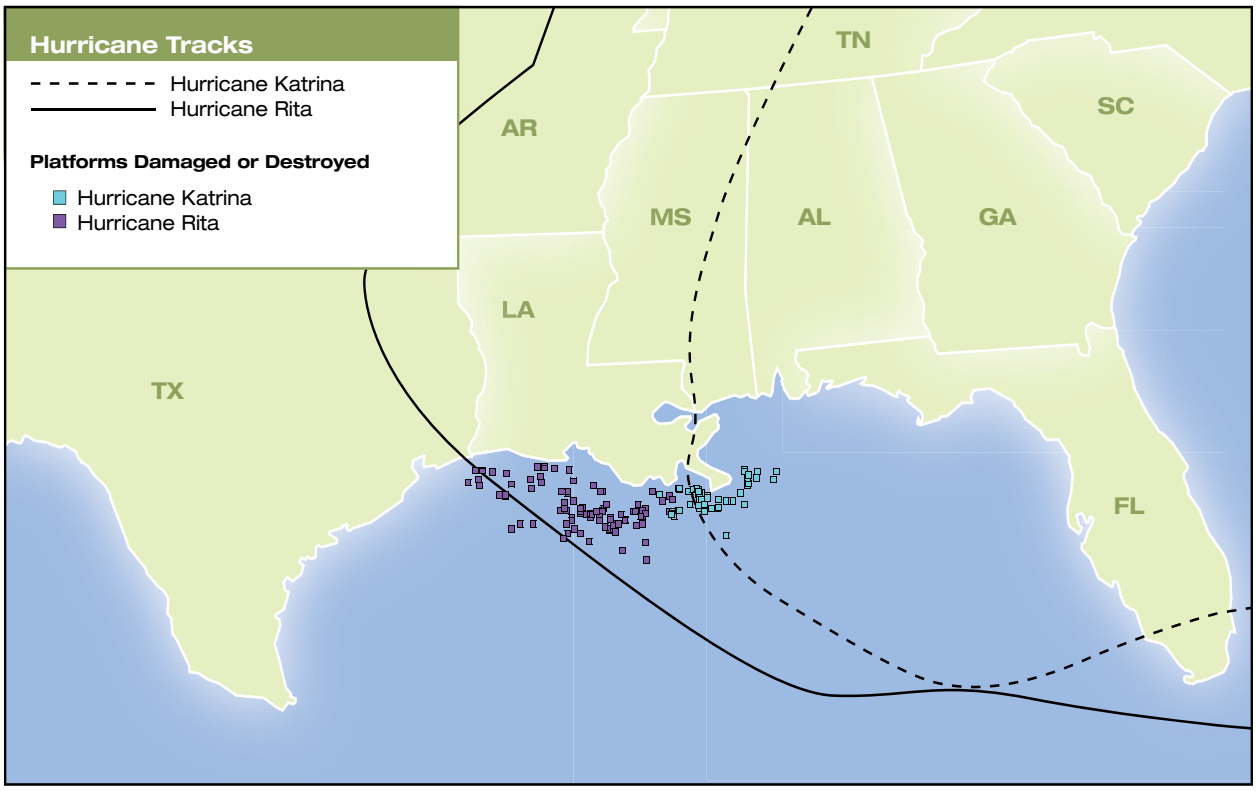


Figure 1. **Gulf Platforms Damaged or Destroyed by Hurricane Katrina or Hurricane Rita**

II. Production

The Gulf of Mexico (Gulf) region is an important source of U.S. energy supply.[2] Before hurricanes Katrina and Rita, the Federal Outer Continental Shelf (OCS) in the Gulf provided about 27 percent (1.5 million barrels per day) of all the oil and 20 percent (10 billion cubic feet (Bcf) per day) of all the natural gas produced domestically.

Hurricanes Katrina and Rita cut right through the major oil and natural gas production operations in the Gulf. As noted earlier, an estimated 3,050 of the Gulf's 4,000 platforms were in the direct path of either Hurricane Katrina or Hurricane Rita. Virtually all production was shut-in in anticipation of the storms, and employees were evacuated from platforms and working rigs. According to the Minerals Management Service (MMS), more than 90 percent of the manned platforms and 85 percent of the working rigs were evacuated at one time.[3]

Damage Assessment

Because of the large amount of infrastructure in the storms' paths, damages from each of the hurricanes were extensive. Combined, the damages from the two hurricanes were far worse than anything previously experienced by the petroleum industry in the Gulf of Mexico. Hurricane Katrina, which was a Category 5 hurricane when it entered the Gulf, destroyed 44 platforms and damaged 20 others, while Hurricane Rita, which was a Category 4 storm when it entered the Gulf, destroyed 69 platforms and damaged 32 others (Figure 1). In comparison, only 7 platforms were destroyed when Hurricane Ivan hit the Gulf in 2004 as a Category 4 storm, because Ivan's path bypassed the major production infrastructure.

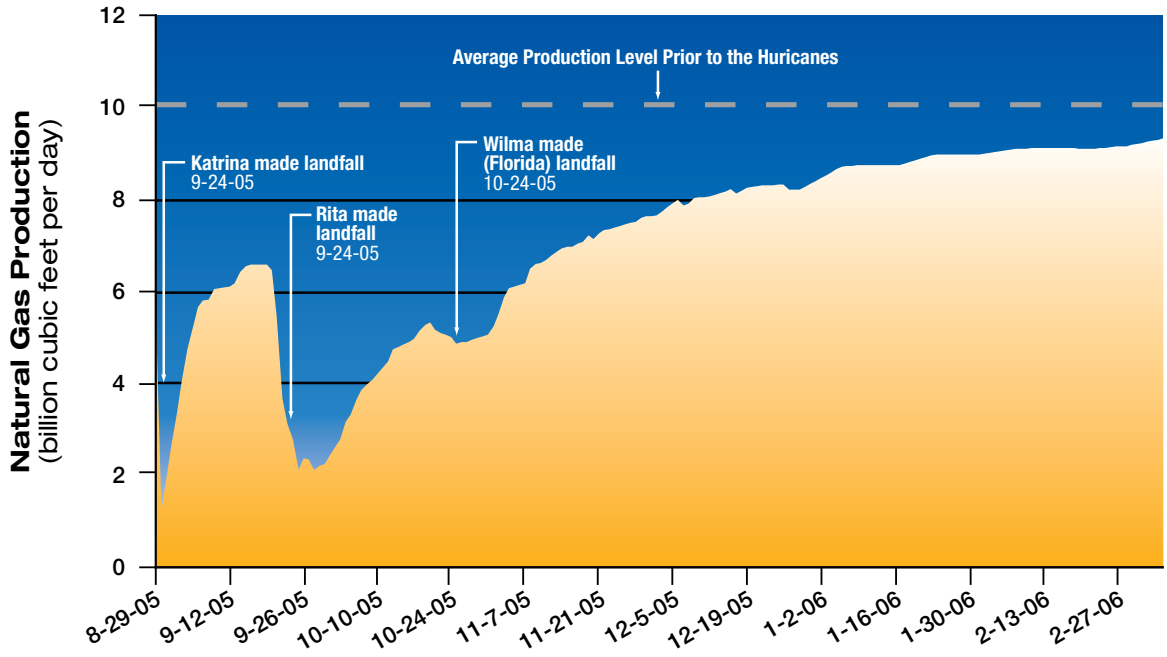


Figure 2. **Federal Offshore Gulf of Mecixo Natural Gas Production Recovery after the 2005 Hurricanes**

Almost 80 percent of the destroyed platforms were older "end of life" platforms not built to MMS 1988 design standards. MMS does not expect these platforms, which represented less than 1 percent of the Gulf' gas production, to be repaired.[4] Repairs on the remaining destroyed platforms were expected to be completed no earlier than the summer of 2006. The same schedule applies to the platforms that sustained structural damage or required engineering services before repairs could begin.

Recovery

Natural gas production in the Gulf declined from an average of approximately 10 Bcf per day to less than 2 Bcf per day after Katrina made landfall on August 29, 2005 (Figure 2). This low point in Gulf gas production was a result of shutting down all the production platforms threatened by Katrina. Repairs were undertaken as soon as possible after the storm, and gas production returned to approximately 6.5 Bcf per day by mid-September. Then Hurricane Rita hit on September 24, 2005, further damaging some of the platforms recovering from Katrina and causing new damage in other parts of the Gulf. After Rita struck, Gulf gas production was reduced to about 2 Bcf per day.

The industry's initial recovery after the second of the two hurricanes, Rita, was slower than what it experienced after Katrina. While with Katrina, Gulf gas production rebounded to 6.5 Bcf per day within 3 weeks, after Rita, Gulf gas production did not reach 6.5 Bcf per day for almost 2 months.

Gulf gas production returned to 8 Bcf per day by the end of December 2005, and had reached about 9 Bcf per day as of March 8, 2006, as more difficult repairs and longer-term solutions were required. The remaining damage to production platforms and infrastructure will likely take several months to repair. MMS reported on May 1, 2006, that it has approved four replacement platforms that were proposed by operators to take the place of eight destroyed platforms. MMS also reported that shut-in gas production was less than 1 Bcf per day as of June 19, 2006, which is equivalent to about 9 percent of daily gas production in the Gulf.

III. Pipeline Infrastructure

The pipeline system within the Gulf of Mexico (Gulf) comprises approximately 33,000 miles of pipelines that link the estimated 4,000 operating platforms to onshore elements. The hurricanes caused damage to and shut in most pipelines within more than 50 miles on either side of their respective paths. The pipeline system is composed of surface-level piping, valves, metering points, compressors, and dehydration and separation facilities, as well as sub-sea piping and valves, all working in harmony for the sole purpose of keeping natural gas flowing. Secondary lines (typically less than 20 inches) feed the larger diameter primary lines (20 to 36 inches in diameter) that transport the natural gas directly to points on shore.

Damage Assessment

The MMS estimated that 22,000 miles of pipeline were in the direct path of the two hurricanes. These pipelines transported approximately 67 percent of the natural gas produced in the Gulf. The path maps of Rita and Katrina indicate that the storms impacted the coast line at the west and east borders of Louisiana, respectively. If one were to draw a line 50 miles west of Rita's path and another 50 miles east of Katrina's path, the area bounded by these two lines would represent the area with the majority of the storm damage (Figure 3).

Approximately three dozen primary pipelines transport natural gas from the Gulf to the shorelines of Louisiana, Texas, Mississippi, and Alabama. Two-thirds of these primary lines enter Louisiana and thus were within the hurricane impact area. Most primary lines in the hurricane impact area experienced damage from the storms that either restricted or completely halted operations.

Most of the secondary lines were also located within the hurricane impact area and experienced similar levels of damage to those of the primary lines. At least two secondary lines in the Mobile Bay Area, located approximately 25 miles outside of the hurricane impact zone, experienced damage.

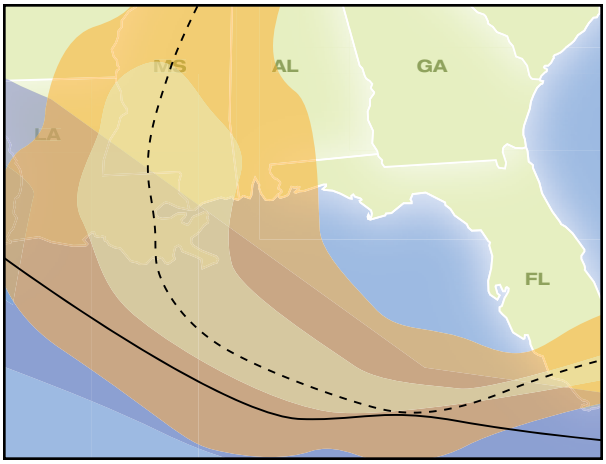


Figure 3. **Hurricane Impact Area**

The dozen or so primary lines located outside the hurricane impact area transport gas to Mississippi, Alabama, and Texas. Most of these pipelines had minimal damage from the storms and were fully operational when the platforms and processing plants in these areas resumed service.

The damage from the two storms to the pipelines varied in pattern, but there was a degree of similarity. In general, approximately half of the pipeline breaches occurred within an area that also experienced damaged or destroyed platforms.

All but a half dozen of the pipeline breaches occurred in the waters of the continental shelf (i.e., in water depths of 200 feet or less) with half of the continental shelf breaches located within 25 miles of the transition from deep water. As the continental shelf is closer to the shoreline in the eastern part of the hurricane impact area, approximately half of the breaches occurred within 25 miles of the shoreline in South Timberline and Main Pass areas or in the waters surrounding the Plaquemines Peninsula and Lafourche Parish.

Katrina caused almost double the number of natural gas pipeline breaches caused by Rita. Katrina's breaches, being in the eastern portion of the damage area, generally occurred closer to the shore, while the pipeline breaches caused by Rita were more randomly distributed along the path of the hurricane.

Recovery

Under normal conditions, primary and secondary pipelines flow at 50 to 60 percent of design capacity; however, the actual utilization of the line capacity can vary significantly, depending on circumstances. During the recovery period from the hurricanes, many lines operated at or beyond their design capacity, while others had low flow rates for periods lasting from several days to more than a week. Several lines had such low flow rates that they were shut down.

In spite of the operational problems, natural gas continued to flow because of the many interconnections that link the pipelines together. Companies used this interconnectivity to flow natural gas around non-operational damaged pipeline sections and pathways, to bypass non-operational plants or compressor stations, and to reroute flow to onshore operating facilities. This was accomplished through a great deal of teamwork and creativity such as reversing flow direction and utilizing bypasses. The interconnectivity of primary pipelines, which was the most important to maintaining gas flow, is greater onshore and declines as one moves away from shore. Onshore interconnects are typically less likely to suffer failure because of hurricane events, and repairs are not as difficult to make as those to offshore pipelines.

Even with the pipeline network flexibility and the cooperative efforts by operators, it was not physically possible or economical to reroute all available Gulf gas production. As a result, the damage sustained by the pipeline network materially reduced production from the Gulf.

Flow rates of primary lines located within the hurricane impact area were stabilizing within normal ranges by early March 2006. At that time, operators were still considering how or whether to repair the remaining damaged facilities. Most of the remaining damage was located near the outer fringes of the lines or at end segments that connect to platforms with low production volumes.

In some cases parties have decided, because of economics, not to repair shared assets (e.g., platforms) that were part of the pipeline infrastructure. This sometimes resulted in a work around, such as laying pipe on the sea floor, to avoid a more costly investment. The return on pipeline investment is recovered through gas flow rather than gas price. Therefore the depletion rates of producing areas are critical factors in the decision to repair, abandon, or expand facilities. Repairs to the secondary pipelines, which affect small portions of overall scheduled capacity for a pipeline, were prioritized based on the availability of work crews and economics (see box, "Factors Affecting Recovery Efforts").

In tracking recovery efforts on a line-by-line basis, DOE considered two events to be significant: (1) a pipeline's return to partial flow, and (2) when a pipeline reached and held a consistent flow rate. DOE also closely monitored a number of factors that could restrict the pipeline from operating at normal capacities and attempted to measure their effects.

Just after the hurricanes, the pipelines had the capability to transport approximately 4.5 Bcf per day, or enough flow capacity to handle all available production from the Gulf at that date. The capacity to flow was maintained by several pipelines, most of which were located outside of the hurricane impact area. Had there been more production available, the pipelines located within the hurricane impact area most likely would not have been able to handle the volume or reroute the flow to onshore facilities. The pipelines at this time were at least a partial constraint in the production and supply chain. By the end of October, many of the primary lines in the hurricane impact area were well on the way to recovery or fully operational. Recovery continued to progress through December, and by January, the recovery had reached a plateau.

As of March 8, 2006, when DOE discontinued its active monitoring of repair efforts, there were still several primary pipelines with damage to sections that cut off production. There was also damage remaining to some secondary pipelines and outlying laterals from both primary and secondary lines. Final repairs to these lines most likely will take several months to complete. Competition is extensive for the crews and equipment needed for making repairs and for extending lines to new producing areas.

Factors Affecting Recovery Efforts

Several factors have affected the return to service of various line segments. The depth of water in which the damage resides, the length of the effected zone, size of the pipeline, and the complexity of the zone (e.g., interconnects, sea valves) are all factors in determining the time, complexity, and costs required to repair or replace damaged areas. There are a limited number of crews that can make repairs in deep water. Initially after the hurricanes, many of these crews were under contract and committed to specific companies, thus affecting repair scheduling. Also, producers sometimes outbid pipeline operators for the services of these specialized crews. Other factors affecting repair schedules included those instances when damages turned out to be more extensive than original assessments revealed, which lengthened the time required to complete repairs. Rough seas at times also contributed to extending the required repair time.

Long lead times required for delivery of repair materials and components also hindered repair efforts. Many components such as valves and flanges must be custom-built or are in short supply. Destroyed or damaged platforms also presented major problems, as connections needed to be isolated and lines dewatered. Pipeline breaches create the need to dewater the line and remove contaminants before operation is restarted. The only facilities for treating large volumes of water from the pipeline are located onshore. This means that the sea water must be routed through the pipe to shore without damaging other sections of the pipeline during the transporting process.

As late as early May, pipeline operators were still revising assessments of damage to some outer-lying pipelines. These assessments, for the most part now complete, have revealed that several pipelines experienced more extensive damage than the original assessments indicated, and many more pipelines were damaged than first reported. On May 1, 2006, MMS reported that, based on additional industry investigations and reports, more than twice the number of pipelines were damaged than had been identified in January (457 vs. 183), and the number of damaged primary lines was upped from 64 to 101.[5] MMS reported that 32 of the damaged primary lines had returned to service.

IV. Natural Gas Processing

The natural gas product fed into the mainline gas transportation system in the United States must meet specific quality measures for the pipeline grid to operate properly. Consequently, natural gas produced at the wellhead, which in most cases contains contaminants[6] and natural gas liquids,[7] must be processed, i.e., cleaned, before it can be safely delivered to the high-pressure, long-distance pipelines that transport the product to the consuming public. Natural gas that is not within certain specific gravities, pressures, Btu content range, or water content levels will cause operational problems, pipeline deterioration, or can even cause pipeline rupture.

The processing of wellhead natural gas into pipeline-quality dry natural gas can be quite complex and usually involves several processes to remove: (1) oil; (2) water; (3) elements such as sulfur, helium, and carbon dioxide; and (4) natural gas liquids. In addition to those four processes, it is often necessary to install scrubbers and heaters at or near the wellhead. The scrubbers serve primarily to remove sand and other large-particle impurities. The heaters ensure that the temperature of the natural gas does not drop too low and form a hydrate with the water vapor content of the gas stream. These natural gas hydrates are crystalline ice-like solids or semi-solids that can impede the passage of natural gas through valves and pipes.

Within the 70 counties and parishes located along the Gulf Coast States of Texas, Louisiana, Mississippi, and Alabama, there were 47 major natural gas processing plants (each with a processing capability of 100 million cubic feet (MMcf) per day or greater) when the hurricanes struck. Total processing capacity for the major plants was 22,841 MMcf per day. Of the 47 plants,

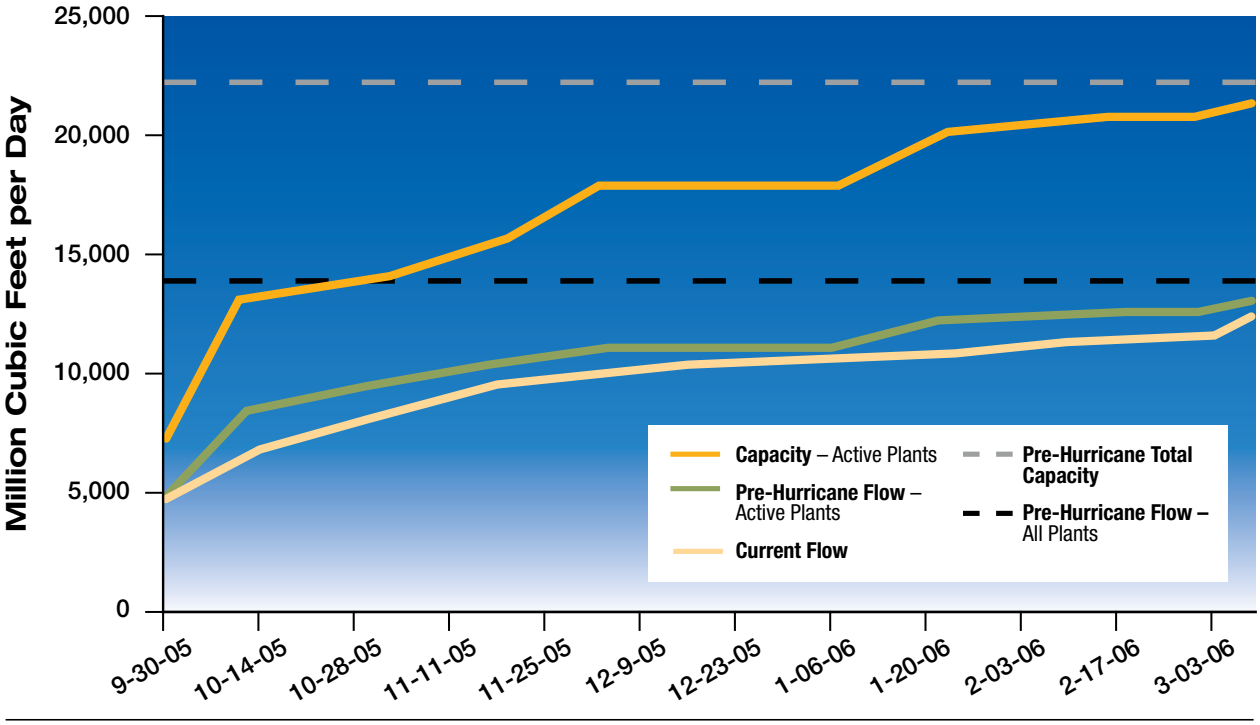


Figure 4. **Capacity and Flow Data for Major Gas Processing Plants in the Coastal Counties Adjacent to the Gulf of Mexico (End of September 2005—Early March 2006)**

9 also included on-site fractionation facilities, that is, they had the capability to extract individual natural gas liquid components including ethane, propane, butane, and pentane, which are sold as separate commodities.

The other 38 natural gas processing plants traditionally confine their operations primarily to extracting pipeline-quality natural gas (residue gas), and secondarily the production of a natural gas liquids mixture stream (often referred to as Y-grade) that is transported to a separate facility for fractionation via rail, truck, barge, or pipeline, mostly the latter.

In the area surveyed, there are at least 17 fractionation sites, the largest being the Mont Belvieu complex, located in southeast Texas about 60 miles from the Louisiana border. More than a dozen pipelines in the Texas-Louisiana area transport Y-grade liquids (a mixed heavy hydrocarbons liquid stream under pressure) to the Mont Belvieu area for fractionation. Conversely, multiple types of transportation infrastructure (pipeline, truck, rail, or barge) are available to move finished NGL products and refinery grade propylene to area markets as feedstock for chemical, refining, and industrial markets. Mont Belvieu and most of the other local fractionation facilities maintain, or have access to, salt cavern facilities which are used for storing unprocessed mixed liquids and individual extracted NGL products.

Natural Gas Processing Plants

Damage Assessment

Although the processing/treatment segment of the natural gas industry generally receives little public attention, its overall importance to the natural gas industry became readily apparent in the aftermath of hurricanes Katrina and Rita in August and September 2005. Damage caused by the hurricanes resulted in a number of shut-ins to gas processing plants.

Causes of the shut-ins varied—based on either internal or external conditions. Internal conditions refer to damage directly affecting the gas processing plants, including flooding, debris, and destruction of equipment. External conditions refer to closures caused by lack of electricity, inaccessibility of the plant site because of road damage or other problems, lack of upstream supplies to the processing plant caused by production shut-ins or pipeline problems, and downstream problems related to the disposal of natural gas liquids or Y-grade liquids.

Downstream conditions are critical to an operating gas processing plant whether the flow from the gas processing plant is raw gas for processing at a fractionator (i.e., the Y-grade liquids) or processed liquids that are ready to be marketed. If the typically large volumes of co-products cannot be properly disposed of, the gas processing plant cannot operate. The liquids problems were caused either by problems affecting the pipelines exiting the gas processing plant or at the downstream facility itself.

After Hurricane Katrina made landfall in late August, there were at least eight gas processing plants known to have been closed down.[8] These eight plants represented 6,615 MMcf per day of capacity that had a pre-hurricane flow of 4,158 MMcf per day. When Hurricane Rita struck the Gulf producing areas less than a month later, the cumulative damage from both storms was much greater.

At the end of September 2005, 27 gas processing plants with 16,796 MMcf per day of capacity were shut in, or almost 75 percent of total capacity for all major plants in the region (Figure 4).[9] The 27 shut-in gas processing plants included virtually all the large plants in the area from Galveston Bay, Texas, through Mississippi (Figure 5). Only 20 of the major plants, with a capacity of 6,045 MMcf per day, were active at the end of September.

Eleven of the twenty-seven plants were inactive because of internal factors, which forced the shut-in of 7,665 Bcf per day of capacity. Most of the facilities with internal

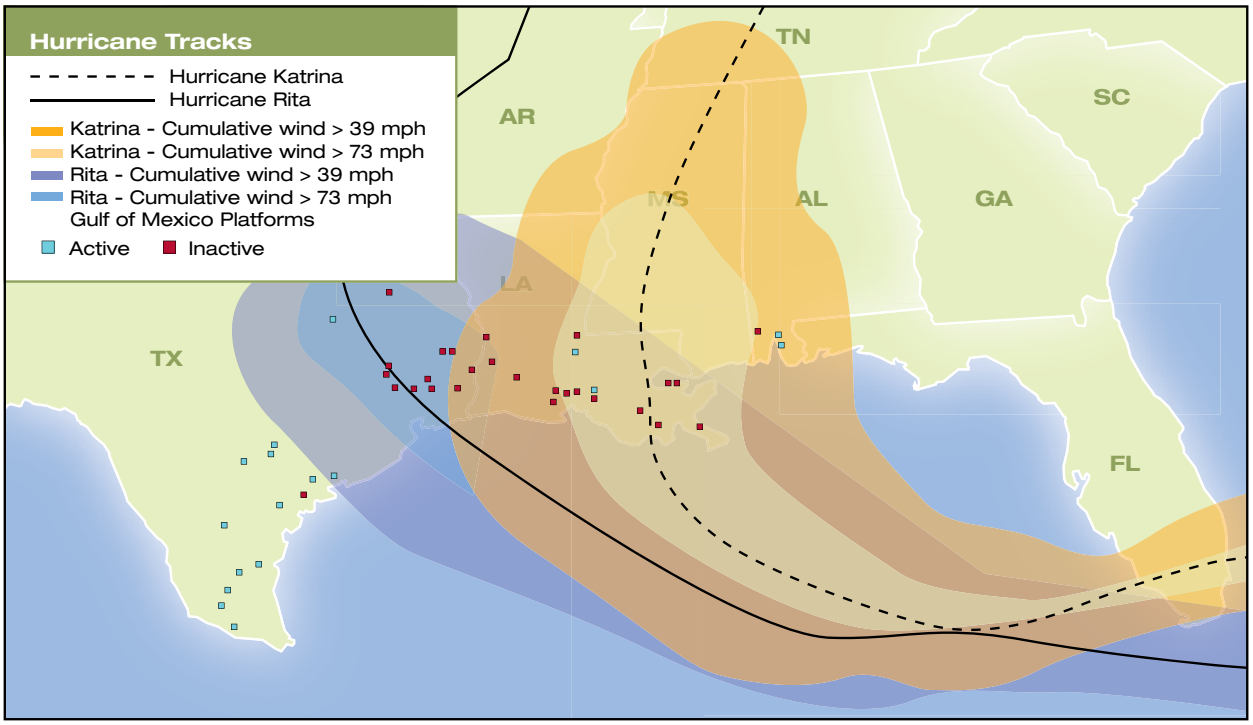


Figure 5. **Gulf Processing Plants Affected by Hurricane Katrina or Hurricane Rita**

problems appear to have endured some amount of flooding from either storm surge or rain penetration. The reports on water damage did not necessarily include a clear designation regarding the nature of the problem. A number of facilities were flooded so badly that inspections were not conducted or completed for weeks. The major internal problems were debris and damage to equipment, especially controls and electrical equipment. There were few reported problems involving damage to moving equipment or structures.

In addition to the shut-in capacity as a result of internal problems, an even larger amount of capacity was offline although the plants themselves were reported as operational. At the end of September 2005, there were 16 gas processing plants that were reported as operational but were not active because of problems outside the plant. Causes for these 16 shut-ins included: lack of power (6 plants), upstream supplies being unavailable (10 plants), problems with disposal of co-products downstream (6 plants), and one case of bypass because of market conditions.[10]

Recovery

As a group, the plants affected by external problems were reactivated most quickly, with roughly two-thirds of those being back on-line by the end of October 2005. The plants with internal problems required the longest recovery periods. Only one plant with internal problems became active again during October, and even at the end of December, 7 of the original 11 remained inactive.

Recovery during October 2005 was the most active of any month after the hurricanes in terms of the number of plants returned to service, as the number of inactive plants declined from 27 at the end of September to 15 by the end of October. At the end of October, 8,335 MMcf per day of capacity was inactive, with 14,506 MMcf per day active (Figure 4).

Almost half the remaining inactive gas processing plants returned to operation during November, as the count fell from 15 to 8 by the end of the month. Seven gas processing plants were inactive because of internal problems. By the end of November, there were 39 active plants with capacity of 17,366 MMcf per day and inactive capacity of 5,475 MMcf per day. The situation was unchanged at the end of the calendar year as no additional plants were activated during December, although flows through the active plants did increase. In January, four more plants with a capacity of 2,425 MMcf per day were restored back to active status. By the end of January, four gas processing plants were still inactive. Included in the group of four was BP's Grand Chenier plant with capacity of 950 MMcf per day, which was being decommissioned as announced in late January. As of March 8, 2006, 45 of the 47 plants were restored to active status. The final reactivation of a major processing plant occurred on April 2, 2006, when the Stingray plant resumed processing, bringing capacity of all major active plants to 21,891 MMcf per day.

Natural Gas Fractionators (Natural Gas Liquids Plants)

Damage Assessment and Recovery

Fractionators in Texas

While the path of Hurricane Katrina did not take it anywhere near the Mont Belvieu complex in east Texas, this area was within the edge of Hurricane Rita's path. Most of the fractionation, storage, and pipeline facilities in the area reported no sustainable major damage. However, the absence of water, which could not be pumped to three of the plants because the local electric power grid was down, did force temporary closures. (All plants in the Mont Belvieu area went into a planned shutdown mode prior to the expected hurricane landfall.)

One fractionator, which had its own on-site well water source, was able to return to operations within a day or so. The other three facilities at Mont Belvieu did not reopen for about 8 days. Some flows were directed to area storage facilities that were still operational. There was an indirect impact from the storm on parts of the area's pipeline network. Although a number of pipelines suffered no major damage themselves, a lack of electric utility service and/or damage to power facilities at pump stations along the pipeline system caused a temporary shutdown of operations.

Other fractionators are located in the Beaumont area of east Texas (Jefferson County), where certain facilities were significantly impacted by Hurricane Rita. Response to the damage to the fractionators varied. In mid-

October, Y-grade deliveries from some gas processing plants in the area were redirected to Mont Belvieu for fractionation or into temporary storage. In at least one case where both gas processing and refinery facilities were damaged, recovery of refinery operations was given priority. Consequently, the repairs to the fractionator facility were not completed until late November. Today all fractionation and refinery operations are back to normal.

Fractionators in Louisiana

The hurricanes caused numerous difficulties for several fractionators in southern Louisiana. A number of fractionators suspended operations at least temporarily because of up- or down-stream problems. Upstream problems included shut-in offshore production, pipeline damage, or loss of supply flow because of inactive gas processing plants.

Fractionators also are affected if the downstream pipelines or storage were unavailable or customers were unable to receive the NGLs. These difficulties then might result in other bottlenecks. For example, in the aftermath of the hurricanes, operations on certain pipelines were disrupted at least briefly, with the result that natural gas processing plants that used these lines for transportation of their raw NGL mixture had to cease gas processing operations because of a lack of liquids storage facilities.

V. LNG

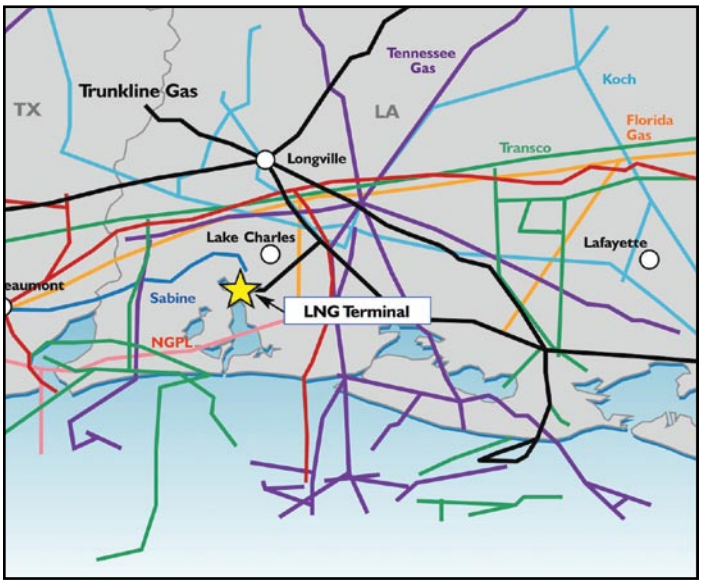
Liquefied natural gas (LNG) plays an important role in diversifying and expanding natural gas supplies. LNG arriving in the continental United States enters through one of five LNG receiving and regasification terminals located along the Atlantic and Gulf coasts. The United States currently has six LNG terminals that receive, store, and regasify LNG—four on the mainland, one in the offshore Gulf of Mexico, and one in Puerto Rico.

Damage Assessment

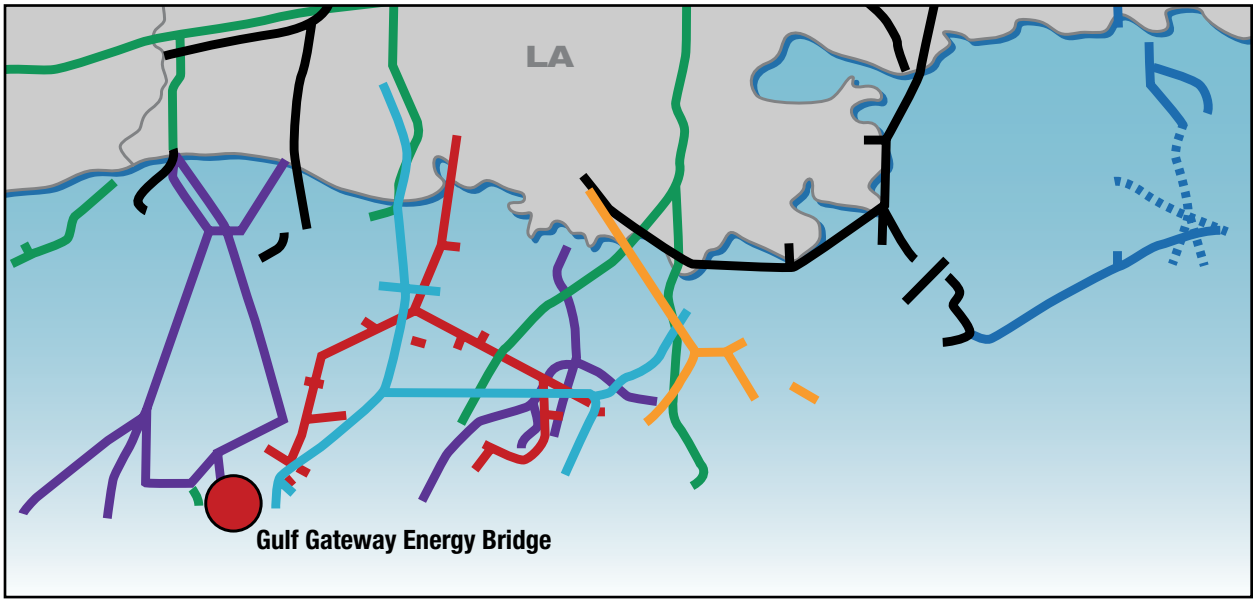
The Panhandle Energy/Trunkline LNG terminal in Lake Charles, Louisiana, and the Excelerate Energy sub-sea Gulf Gateway Energy Bridge 116 miles off the Louisiana coast were in the paths of hurricanes Katrina and Rita.

Assessments indicate the hurricanes had only minor impacts on these two LNG import terminals. The Lake Charles terminal has the capacity to import 1.5 billion cubic feet (Bcf) of gas per day and received 103.8 Bcf in 2005. The Gulf Gateway Energy Bridge facility has the capability to import 0.5 Bcf per day.

The Lake Charles terminal is connected to the Gulf of Mexico by a 48-mile (80 km) ship channel. The channel is dredged to a depth of 40 feet (12 m) and is 400 feet (120 m) wide with no overhead navigational obstructions. The facility is connected to the mainline transmission system of Trunkline Gas Company, LLC by 45 miles (72 km) of 30-inch diameter pipeline with a capacity of 1.2 Bcf per day (9.1 mmtpa).



From September 26 to October 3, 2005, the Lake Charles navigation channel and turning basin were closed because of debris in the waterway and dockage area that required removal. In addition there was limited operational capability to transfer LNG from tanker to storage because of the lack of commercial electric power.



On October 3, 2005, the navigational channel and turning basin reopened to deep draft marine traffic for daylight transits. However, the Trunkline LNG terminal was operating on backup generator power thereby limiting cargo transfers and regasification rates below normal operating inventories. The terminal's LNG inventory increased to 70 percent of capacity (4.4 Bcf) upon completion of cargo transfer from LNG tank ships. On October 5, 2005, the Trunkline LNG terminal at Lake Charles was operational at the pre-hurricane normal levels. Full commercial power was restored. Full regasification and send-out capability and LNG cargo transfers were completed in evening hours.

LNG operations at Excelerate Energy's Gulf Gateway Energy Bridge deepwater port were also affected by the paths of both Katrina and Rita. However, the initial diving assessment results indicated little or no damage was done to the facility. Gas gathering pipelines Sea Robin and Blue Water, which service the Gulf Gateway terminal, were impacted by the hurricanes and the pipelines were in-operative through mid-November. The Gulf Gateway facility is operational; however no shipments had been scheduled because of the unavailability of spot market cargos.

VI. Information Collection

Natural Gas Production Information Collection

The primary source of natural gas production data for the Federal Outer Continental Shelf (OCS) in the Gulf of Mexico is the Department of the Interior's Minerals Management Service (MMS),[11] which has oversight and regulatory responsibility for petroleum operations on the Federal OCS. As part of its normal operations, MMS collects monthly production information for all natural gas wells operating on platforms in the Federal OCS. This information is stored in MMS's Technical Information Management System (TIMS). It is made available to the public on a monthly basis on the MMS website, although data are only available 2 to 3 months after the month in question.

In response to the damage inflicted by the hurricanes, MMS conducted an emergency data collection effort to provide more detailed and real-time information on the impacts of the hurricanes on Federal OCS Gulf production. Here, MMS used TIMS data plus direct contact with operators of the natural gas wells and platforms to assess: numbers of platforms damaged or destroyed, shut-in production, pipeline segments that have facility measuring points (FMPs), and daily volumes at FMPs.[12] With this emergency data collection effort MMS was able to issue a daily report on how much natural gas production was shut in for the Gulf in aggregate.

Natural Gas Pipeline Information Collection

The Federal Energy Regulatory Commission (FERC) requires that natural gas interstate pipeline companies provide complete and timely information about available and released transportation capacity on user-friendly, Internet accessible informational listings that are accessible by all customers on an equal basis. These web-based electronic information profiles provide a wealth of information, including the Daily Scheduled Capacity and Available Capacity on a receipt and delivery point basis listed as Operationally Available by Segment or by Location. The listings also contain Total Design Capacity for each point.

Natural Gas Processing Plant Information Collection

Information on a limited number of data items is sufficient to represent the condition of the processing plant segment of the industry. There is no public source of information regarding plant status and operations that is available on a timely basis. After the hurricanes, information on the larger processing plants was provided by industry sources.

VII. Endnotes

1. Most of the information in this report is compiled through March 8, 2006, with few exceptions. A key exception concerns the final reactivation of gas processing plants which occurred with the startup of the Stingray plant on April 2, 2006, bringing the count of active plants to 46. As noted in the section on gas processing plants, the Grand Chenier plant was decommissioned so it will not be reactivated.

2. The Gulf of Mexico region in this section refers to the Federal Outer Continental Shelf (OCS) in the Gulf of Mexico, which is under the jurisdiction of the U.S. Department of the Interior, Minerals Management Service. The Federal Government administers the submerged lands, subsoil, and seabed, lying between the seaward extent of the States' jurisdiction and the seaward extent of Federal jurisdiction. State jurisdiction extends 3 nautical miles (3.3 miles) off the coastline, excepting Louisiana where it extends 3 imperial nautical miles (3.45 miles), and Texas and the west coast of Florida where jurisdiction extends 9 nautical miles.

   Federal jurisdiction is defined under accepted principles of international law. The seaward limit is defined as the farthest of 200 nautical miles seaward of the baseline from which the breadth of the territorial sea is measured or, if the continental shelf can be shown to exceed 200 nautical miles, a distance not greater than a line 100 nautical miles from the 2,500-meter isobath or a line 350 nautical miles from the baseline. Outer Continental Shelf limits greater than 200 nautical miles but less than either the 2,500 meter isobath plus 100 nautical miles or 350 nautical miles are defined by a line 60 nautical miles seaward of the foot of the continental slope or by a line seaward of the foot of the continental slope connecting points where the sediment thickness divided by the distance to the foot of the slope equals 0.01, whichever is farthest.

3. Minerals Management Service, Press Release: "Impact Assessment of Offshore Facilities from Hurricanes Katrina and Rita," January 19, 2006.

4. Minerals Management Service, Press Release: "Office of the Secretary, Interior Secretary Gale Norton Reports on Gulf of Mexico Energy Status," October 4, 2005.

5. Minerals Management Service, Press Release: "MMS Updates Hurricanes Katrina and Rita Damage," May 1, 2006.

6. Includes non-hydrocarbon gases such as water vapor, carbon dioxide, hydrogen sulfide, nitrogen, oxygen, and helium.

7. Ethane, propane, and butane are the primary heavy hydrocarbons (liquids) extracted at a natural gas processing plant, but other petroleum gases, such as isobutane, pentanes, and normal gasoline, also may be processed.

8. This information is as of September 19, 2005. It is based on reports by the Minerals Management Service, staff reports from the DOE Office of Fossil Energy, data compiled by the Energy Information Administration, and trade press reports.

9. Many of the gas processing plants ceased operations in advance of the hurricanes for safety reasons. Those plants that were unaffected by the storm opened promptly thereafter.

10. Some plants were confronted with more than one problem, so the sum of the plants exceeds the total.

11. Department of the Interior, Minerals Management Service (MMS), Minerals Revenue Management, Royalty-In-Kind Program, and Offshore Mineral Management, Production and Development, Structural & Technical Support, Surface Commingling & Production Measurement, and Pipeline Section.

12. When events occur in the Gulf of Mexico region, MMS Continuity of Operations Plan (COOP) requires natural gas companies to report evacuated rigs and platforms and shut-in oil (BOPD) and natural gas (MMcf/d) volumes. The data are required to be reported by 11:30 CST and a daily report, aggregated by districts, is posted on the MMS website (www.mms.gov) at 13:00 CST.

July 2006