Iowa State University

NSF-ECS

Data collection following Katrina: Interdependencies across time, space, and subsystems characterizing bulk energy transportation

Final Report

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Executive summary

The objective of this project report is to present data gathered to characterize the effects of hurricanes Katrina and Rita on the U.S. bulk energy transportation system, with the perspective of obtaining data for use in validating the simulation tools associated to our National Electric Energy System (NEES) model and to identify infrastructure weaknesses and interdependencies that can be better observed as a result of major system disturbances.

The data presented in this report covers the electric, natural gas, and coal bulk production and transportation sub-systems, since these are the main energy systems incorporated into the simulation tools associated to our NEES model. This data reflects the effects of the hurricanes in terms of changes in production, transportation, storage, and prices of the different energy forms. Where possible, data was gathered to reflect conditions given months or years before and for the months following the hurricanes. Information on restoration efforts in each subsystem was also included when available.

Even though the electric and the coal subsystems suffered disruptions in their infrastructures, the consequences of such disruptions remained local and affected a limited number of energy companies and consumers. On the other hand, the extensive damage to natural gas production and transportation facilities brought along consequences that could be observed nationwide. The data also presents evidence of interdependencies between different subsystems, and also suggests that coal storage plays an important role in the robustness of the system with respect to catastrophic events.

Acknowledgments

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1. Introduction

Catastrophic events like the 2005 hurricanes in the Gulf of Mexico area encompass not only dramatic cost in terms of human lives, but also a devastating effect in critical national infrastructure. The energy infrastructure located in the affected zones has fundamental importance in terms of the operation and performance of the National Electric Energy System (NEES), which comprises the production, transportation, storage, and conversion of electricity, coal, and natural gas, among others. The coal and natural gas production and transportation subsystems share with electricity the common characteristic that they can be moved in bulk quantities via a transportation network from the source of their production to the site of their use. These different transportation networks are highly coupled, and it is mainly through the electricity subsystem that these couplings take place. Data collection from energy industries operating in the affected zone is of extreme importance in order to obtain a better understanding of the impact of catastrophic events in the energy system, to appreciate how events propagate geographically and in time, and to study infrastructure interdependencies. Acquiring such knowledge can be also very helpful in order to help prevent the most harmful effects of catastrophic events, to raise awareness about infrastructure vulnerabilities, and to improve the government and industry reaction capacity in the aftermath of catastrophic events.

This report summarizes a data gathering effort performed following Hurricane Katrina to characterize the effects of the 2005 hurricanes on the U.S. bulk energy transportation system. Data was gathered for the electric, natural gas, and coal bulk production and transportation sub-systems, since these are the main energy systems incorporated into the simulation tools associated to our NEES model. The data reflects the hurricane's effects in terms of changes in production, transportation, storage, and prices of different energy forms. Where possible, data was gathered to reflect conditions given months or years before and for the months following the hurricanes. Data sources include daily situation reports by the Department of Energy's Office of Electricity Delivery and Energy Reliability (OE), Energy Information Administration (EIA),

Louisiana Public Services Commission, North America Electric Reliability Council (NERC), Mineral Management Service (MMS), Office of Pipeline Safety (OPS), Pipeline and Hazardous Materials Safety Administration (PHMSA), and on-site interviews, news releases, and financial releases offered by energy companies affected by the hurricanes, among others.

The main motivation behind this data collection effort is to obtain data for use in validating the simulation tools associated to our NEES model. It is also expected that this data will be useful in understanding the nation's bulk energy transportation systems during extreme events and that by making this data readily available to other researchers on power and energy systems further studies on this area will be stimulated. Data collected in this project is available at: http://home.eng.iastate.edu/~jdm/katrina/index.htm

This report is organized as follows: Chapter 2 provides data reflecting the damage caused by hurricanes Katrina and Rita's to electric generation, transmission, and distribution facilities, and the restoration efforts carried out by the affected electric power utilities. Chapter 3 provides data reflecting hurricanes Katrina and Rita's effects in terms of disruptions in natural gas production, transportation, and processing facilities. Chapter 4 provides data on coal production, transportation, storage, and consumption. In addition, each of the previous section also provides data on the evolution of prices of the respective commodity. Finally, Chapter 5 provides a summary and conclusions.

2. Electricity

Chapter 2 presents data reflecting hurricanes Katrina and Rita's effects in terms of damage to electric generation, transmission, and distribution facilities, and the restoration efforts carried out by the affected electric power utilities. It is also shown in this chapter the evolution of electricity prices in 4 different U.S. markets.

Section 2.1 reviews the widespread damage caused by hurricanes Katrina and Rita, and summarizes the impact in the power facilities and finances of the most affected companies. Sections 2.2 to 2.4 present data about the damage and restoration efforts in electric generation, transmission, and distribution respectively. Section 2.5 exhibits prices in the New England (NE-ISO), New York (NY-ISO), PJM, and MISO markets, in order to better understand to which extent the effects of the hurricanes propagated geographically in the electric power system.

Data for this section was gathered from many different sources, among others EIA's website, OE daily situation reports, Nuclear Regulatory Commission (NRC), Independent System Operator websites, NERC, Louisiana Public Services Commission, altogether with news and financial releases offered by the electric utilities which operations were affected by the hurricanes.

2.1. Overview

Tables 2.1.1, 2.1.2, and 2.1.3, extracted from Table B.1 in EIA's Electric Power Monthly, March 2006, summarize some of the effects of the hurricane season 2005 in the U.S. electric power system.

Major disturbances related to hurricanes during August 2005

Date	Utility/Power Pool (NERC Region)	Time	Area Affected	Type of Disturbance	Loss (MW)	Number of Customers Affected	Restoration Date/Time
August							
8/29/2005	Louisiana Generating, LLC (SPP)	1:10 a.m.	East and Southeast Louisiana	Hurricane Katrina	300	143,000	8/29/05, 12:42 p.m.
8/29/2005	Entergy Corporation (SPP)	6:00 a.m.	Buras, Louisiana	Hurricane Katrina	N/A	1.1 million and 100,000 gas customers	8/30/05, 6:00 a.m.
8/29/2005	Progress Energy Florida (FRCC)	7:10 a.m.	Counties of Alachua, Bay, Citrus, Columbia, Dixie, Franklin, Gilchrist, Gulf, Hamilton, Hardee, Hernando, Highlands, Jefferson, Lafayette, Lake, Levy, Madison, Marion, Orange, Osceola, Pasco, Pinellas, Polk, Seminole, Sumter, Suwannee, Taylor, Volusia and Wakulla	Hurricane Katrina disrupted fuel supply in the Gulf of Mexico. Public appeals for conservation were issued.	0	0	9/07/05, 3:00 p.m.
8/29/2005	Southern Company (SERC)	7:10 a.m.	Alabama, Florida, Mississippi	Hurricane Katrina	5,120	512,049	8/29/05, 10:00 p.m.
8/29/2005	Tennessee Valley Authority (SERC)	3:50 p.m.	Alabama, Mississippi, Tennessee	Hurricane Katrina	118.5	323,529	9/10/05, 12:00 p.m.
8/29/2005	City of Lakeland (FRCC)	5:00 p.m.	City of Lakeland, Florida	Hurricane Katrina disrupted normal gas allotment through natural gas pipelines (FGT & Gulf stream). Public appeals for conservation were issued.	0	0	9/08/05,12:01 a.m.
8/31/2005	Seminole Electric Cooperative (FRCC)	4:00 p.m.	Member Service Territory is located in the West coast of Florida from Tallahassee to Fort Myers	Hurricane Katrina disrupted normal gas supplies distribution. Public appeals for conservation were issued.	0	0	9/12/05, 8:00 a.m.

Source: Form EIA-417, "Electric Emergency Incident and Disturbance Report."

Table 2.1.1. Major disturbances related to hurricanes during August 2005.

Major disturbances related to hurricanes during September 2005

Date	Utility/Power Pool (NERC Region)	Time	Area Affected	Type of Disturbance	Loss (MW)	Number of Customers Affected	Restoration Date/Time
September							
9/14/2005	Progress Energy - Carolinas (SERC)	3:00 p.m.	Eastern North Carolina	Hurricane Ophelia	215	60,000	9/15/05, 3:00 p.m.
9/22/2005	Progress Energy Florida (FRCC)	12:00 p.m.	Counties of Alachua, Bay, Citrus, Columbia, Dixie, Franklin, Gilchrist, Gulf, Hamilton, Hardee, Hernando, Highlands, Jefferson, Lafayette, Lake, Levy, Madison, Marion, Orange, Osceola, Pasco, Pinellas, Polk, Seminole, Sumter, Suwannee, Taylor, Volusia and Wakulla	Hurricane Rita disrupted fuel supply in the Gulf of Mexico. Public Appeals for conservation were issued.	0	0	9/29/05, 12:00 p.m.
9/23/2005	City of Lakeland (FRCC)	7:00 a.m.	Lakeland, Florida	Hurricane Rita disrupted normal gas allotment through natural gas pipelines (FGT & Gulf stream). Public Appeals for conservation were issued.	0	0	9/28/05, 11:29 a.m.
9/23/2005	Louisiana Generating, LLC (SPP)	1:06 p.m.	West and Southwest Louisiana	Hurricane Rita	350	125,000	10/06/05, 2:30 p.m.
9/23/2005	CenterPoint Energy Houston Electric (ERCOT)	5:00 p.m.	Houston, Texas and the surrounding suburban areas	Hurricane Rita	1,950	715,000	9/24/05, 8:00 p.m.
9/23/2005	Entergy Corporation (SPP)	9:00 p.m.	Texas, Louisiana, Arkansas, and Mississippi	Hurricane Rita	N/A	766,000	9/25/05, 7:30 a.m.
9/24/2005	TXU Electric Delivery Company (ERCOT)	6:00 a.m.	Nacogdoches, Lufkin, Tyler, Jacksonville, Rusk, Paris, Commerce, Huntington	Hurricane Rita	260	200,000	10/02/05, 5:00 p.m.
9/24/2005	American Electric Power - CSWS (ECAR)	10:00 a.m.	Shreveport, Louisiana	Hurricane Rita	700	190,000	9/28/05, 6:00 p.m.

Source: Form EIA-417, "Electric Emergency Incident and Disturbance Report."

Table 2.1.2. Major disturbances related to hurricanes during September 2005.

Major disturbances related to hurricanes during October 2005

Date	Utility/Power Pool (NERC Region)	Time	Area Affected	Type of Disturbance	Loss (MW)	Number of Customers Affected	Restoration Date/Time
October							
10/23/2005	Florida Power and Light (FRCC)	8:00 p.m..	South Florida, Naples, Ft. Myers, Miami, Ft. Lauderdale, West Palm Beach and Martin county	Hurricane Wilma	10,000	3,241,437	10/24/05, 2:00 p.m.
10/24/2005	Seminole Electric Cooperative (FRCC)	4:00 a.m.	Florida counties of Collier, Charlotte and Lee	Hurricane Wilma	280	105,000	10/24/05, 4:00 p.m.
10/24/2005	Florida Municipal Power Agency (FRCC)	7:00 a.m.	South Florida - Cities of Key West, Clewiston, Lake Worth, and Ft. Pierce	Hurricane Wilma	148	84,900	11/10/05, 12:00 a.m.
10/24/2005	Allegheny Power (MAAC)	8:00 p.m.	Maryland, North Central West Virginia, Southwestern Pennsylvania, and Northern Pennsylvania	Hurricane Wilma	400	303,795	11/02/05, 4:30 p.m.

Source: Form EIA-417, "Electric Emergency Incident and Disturbance Report."

Table 2.1.3. Major disturbances related to hurricanes during October 2005.

Many electric power utilities were affected by widespread destruction of their generation, transmission, and distribution facilities caused by the hurricanes. Damages caused by Hurricane Katrina concentrated in Louisiana, Mississippi, and Alabama, while damages caused by Hurricane Rita concentrated in Texas and Louisiana. Two electric power companies especially affected by the catastrophic effects of the hurricanes were Entergy (in Louisiana, Texas, and Mississippi), and Mississippi Power (in Mississippi).

According to an Entergy financial release in Sep 20, 2005: "*Total restoration costs for the repair and/or replacement of Entergy's electric and gas facilities damaged by Hurricane Katrina and business continuity costs are estimated to be in the range of $750 million to $1.1 billion*". Restoration and business continuity cost estimates were disaggregated as indicated in Table 2.1.4.

Of the many subsidiaries of Entergy Corporation, Entergy New Orleans was the most dramatically affected. Both of Entergy New Orleans electric generating stations were damaged, 12 out of 23 substations were flooded, and thousands of poles and lines were down. The damage was so extended, that on 9/23/05 Entergy New Orleans filed for

bankruptcy protection. Entergy Corporation, Entergy New Orleans, the Louisiana Congressional delegation, the New Orleans City Council and the mayor of New Orleans worked in concert trying to get direct assistance from the federal government so that customers wouldn't have to pay for the new replacement facilities.

Company	**Estimated Costs (U.S. $ in millions)**
Entergy Gulf States –LA	25-45
Entergy Louisiana	275-400
Entergy Mississippi	75-100
Entergy New Orleans	325-475
Other	50-80
Total	**750-1,100**

Table 2.1.4. Entergy's estimated costs (damages by Hurricane Katrina)

In Mississippi, all of Mississippi Power's customers lost service immediately after Hurricane Katrina. From a news release in 9/7/05: *"The company lost all of its systems, including telecommunications, and suffered extensive facilities damage, including the use of all generating units at Plant Watson in Gulfport*."

According to an Entergy financial release in October 5, 2005: *"Total restoration costs for the repair and/or replacement of Entergy's electric facilities damaged by Hurricane Rita are estimated to be in the range of $400 million to $550 million."* Restoration costs estimates were disaggregated as indicated in Table 2.1.5:

Company	**Restoration Costs (U.S. $ in millions)**
Entergy Gulf States –LA	365-500
Entergy Louisiana	30-40
Other	5-10
Total	**750-1,100**

Table 2.1.5. Entergy's estimated costs (damages by Hurricane Rita)

In 10/14/05 the company released a new estimate, saying that that restoring the damage caused by Hurricane Rita in Texas would cost the company between $230 and $315 million.

	Hurricane Katrina	Hurricane Rita
Storm landfall and intensity	August 29th - Category 4	September 24 - Category 3
Jurisdictions affected	LA, MS, NO	AR, LA, MS, NO, TX
Electric customers affected	1.1 million	800,000
Percent of electric consumer base	41%	0
Gas customers impacted	145,000	-
Utility poles destroyed	17,389	11,503
Spans of wire replaced	34,587	18,585
Transformers destroyed	3,478	2,301
Fossil fuel units impacted	15	14
Nuclear units impacted	Waterford 3	none
Transmission lines out at peak	181	341
Substations out at peak	263	443
Transmissions structures damaged	1,000	700
Restoration workers	10,200	13,000
Restoration completed	42 days	21 days

Sources: Entergy news release (12/02/2005)
Utility Automation & Engineering T&D, January 2006

Table 2.1.5. Impact of hurricanes Katrina and Rita in Entergy's facilities.

Despite the magnitude of the damage and the adverse circumstances, there seems to be consensus that the affected companies performed a good job in the restoration process. By October 15th 2005, Entergy had restored power to all its clients able to

receive it. An article about Entergy restoration efforts can be found at *Utility Automation & Engineering T&D*, January 2006[1]. Mississippi Power restored power to all of its customers able to receive it by September 12th 2005, which made them recipients of the 2006 Edison award.

2.2. Electricity generation

Three nuclear power plants (Waterford, River Bend, and Grand Gulf), all of them owned by Entergy Nuclear, were being monitored in August 28, 2005 by the Nuclear Regulatory Commission (NRC) before the landfall of Hurricane Katrina. The Waterford nuclear power plant (with 1075 MW of capacity) is about 20 miles west of New Orleans, the River Bend plant is about 25 miles north-northwest of Baton Rouge, LA., and Grand Gulf is located 25 miles south of Vicksburg, MS. Waterford shut down and declared an "unusual event" (the lowest of four emergency action levels) because of the approach of the hurricane. The NRC had to authorize the restart of Waterford after it shut down. According to a NRC's news release, the Grand Gulf and River Bend power plants were both operating during the morning of August 30. The plants continued operating during the storm, but voluntarily reducing power generation in order to assist in restoring stability to the electrical grid, due to voltage fluctuations as a result of the loss of load by the utilities in the area affected by Hurricane Katrina. In September 9, Waterford was authorized to restart after a comprehensive review by NRC. Once operational, Waterford supplied electricity to support recovery of the regional infrastructure.

Also, as a result of Hurricane Katrina, by 9/14/05 eight of the seventeen Entergy generating units in the New Orleans area fueled by natural gas and/or oil were still out of service. These are peaker units, so most of them only operate a few days per year during peak periods.

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1 http://uaelp.pennnet.com/Articles/Article_Display.cfm?Section=ARTCL&ARTICLE_ID=245987&VERSION_NUM=2&p=22

According to Entergy press releases, the fact that the Waterford nuclear power plant and their peaker units in New Orleans were shut down did not cause any problems or concerns with regard to Entergy's ability to supply the load, informing that generation capacity was sufficient and that their fuel supplies were adequate. Of course, due to the loss of load because of the virtual destruction of Entergy New Orleans distribution system, the stress imposed on the still functioning generation facilities was not that severe.

Mississippi Power lost all of its systems, including telecommunications, and suffered extensive facilities damage, including the use of all generating units at Plant Watson in Gulfport. From a Mississippi Power press release, June 13, 2006: *"During the height of the storm, which cut a path straight through the company's service territory, more than 16 million gallons of water filled Plant Watson's power levels, reaching a depth of nearly 20 feet. While the facility's main components, such as the turbine generators and boilers, were not damaged, nearly all of the electronic controls and water pumps that operate the plant's five units were affected. Restoration efforts included inspecting, repairing and testing thousands of switches and electronic connections, hundreds of relaying and metering devices, 8000 cables, 370 AC/DC motors and 43 pumps. The plant's free standing combustion turbine also sustained damage and has been repaired. Company employees and outside contracting crews worked 24 hour days after the storm and restored Unit 4, a 250-megawatt coal-fired unit, to operational status within 46 days. Unit 5, a 500-megawatt coal-fired unit that comprises nearly half of the plant's output, was returned to service just before the end of the year. Repairs to the plant's three smaller units, used primarily to meet summer peaking demand, were completed May 31."*

As interesting as the direct effects of Hurricane Katrina in generation facilities is the effect of Hurricane Katrina in the generation of electricity elsewhere in the country. In the days following Hurricane Katrina, and according to OE daily situation reports, coal analysts estimated that "*Hurricane Katrina may have some impact in coal consumption in the Fall because coal-fired plants that typically ramp down following the peak summer*

months may be required to continue generating at high levels to make up for the gap caused by damage to gas production.". In the same context, multiple public appeals for conservation were issued by utilities in FRCC due to the disruption on the supply of natural gas from the Gulf of Mexico. The effects of Hurricane Katrina in the fuel supply chain will be analyzed in more detail in other sections of this report.

Hurricane Rita caused more damage to Entergy's generation facilities than Hurricane Katrina. Entergy owns and/or operates 14 fossil units in the area affected by Hurricane Rita). Some of Entergy's power plants sustained wind damage, but there was no flooding. The following citations relating the evolution of the damage to Entergy's generating facilities are extracted from DOE's Office of Electricity Delivery and Energy Reliability situation reports:

As of 9/30/05, Entergy reported that "*…of its 14 fossil units in the area affected by Hurricane Rita, two are online and 12 are currently offline. Of the 12 offline units: five units are available for restart once transmission and distribution issues related to the plants are resolved, two units are available once offsite power is restored, and five units remain offline until storm damage repairs are completed.*"

As of 10/04/05, Entergy reported that: *"Entergy is making progress in returning its fossil energy units to service. Of the 14 fossil units that Entergy owns and/or operates that were affected by Hurricane Rita, seven are now operational (both units at Lewis Creek, both units at Toledo Bend, and three units at Nelson) and seven are currently not operational. Of the seven units remaining impacted: two units are available once offsite power is restored (both at Sabine) and five units remain offline until storm damage repairs are completed (three at Sabine, two at Nelson).*"

As of 10/6/05, Entergy reported that "*… on 10/5 it had returned another generation unit to the grid, Sabine 3. Seven of the 14 generation units in the area severely impacted by Rita are now online. Lewis Creek (1 and 2), Nelson (1, 2 and 3) and Sabine (3 and 5). Five units (three at Sabine, two at Nelson) require repair of storm damage.*"

As of 10/7/05, Entergy reported that "*Of those 14, nine are operational (both units at Lewis Creek, both units at Toledo Bend, three units at Nelson and two units at Sabine) and five are currently not operational. The five unavailable units are awaiting*

storm damage repairs (three at Sabine, two at Nelson). Entergy reports that it has sufficient generation on-line to support current southeast Texas and southwest Louisiana requirements. Peak load in SE-TX/SW-LA on 10/5 was 2,859 MW, 72% of 2004 norm. Entergy's Nelson 6 generation unit has been repaired and will begin start-up on 10/7. The company reports that sufficient generation is on-line and in-reserve to support current southeast Louisiana requirements and return of additional load as restoration progresses. Peak load in southeast Louisiana on 10/5 was 4,155 MW, 84% of 2004 norm."

As of 10/11/05, Entergy reports that they continue making progress in bringing its power plants back into service, and "*now 12 of the 14 fossil units Entergy operating in the area affected by Hurricane Rita are operational (both units at Lewis Creek, both units at Toledo Bend, five units at Nelson and three units at Sabine). Two unavailable units at Sabine are awaiting storm damage repairs*."

A complete table detailing the Entergy generating units out of service can be found at the Appendix.

2.3. Electric transmission

NERC defines TLR as follows: "*Transmission load relief, TLR, is a series of actions taken while planning operations or during operations to prevent or correct security violations associated with the transmission system. The North American Electric Reliability Council, NERC, has created an Operating Manual, which outlines the TLR procedure. These procedures were created to help prevent or eliminate transmission loading problems. The first step in the TLR process is when NERC, or any other security coordinator, identifies a transmission facility has or is close to exceeding the operating security limit. Then TLR is invoked, either locally or through NERC. NERC TRL involves many levels*."

Figure 2.3.1 shows the total number of TLR in EES, the reliability coordinator corresponding to the area more affected by Katrina. There does not seem to be any special increase in the number of TLR during or after Katrina.

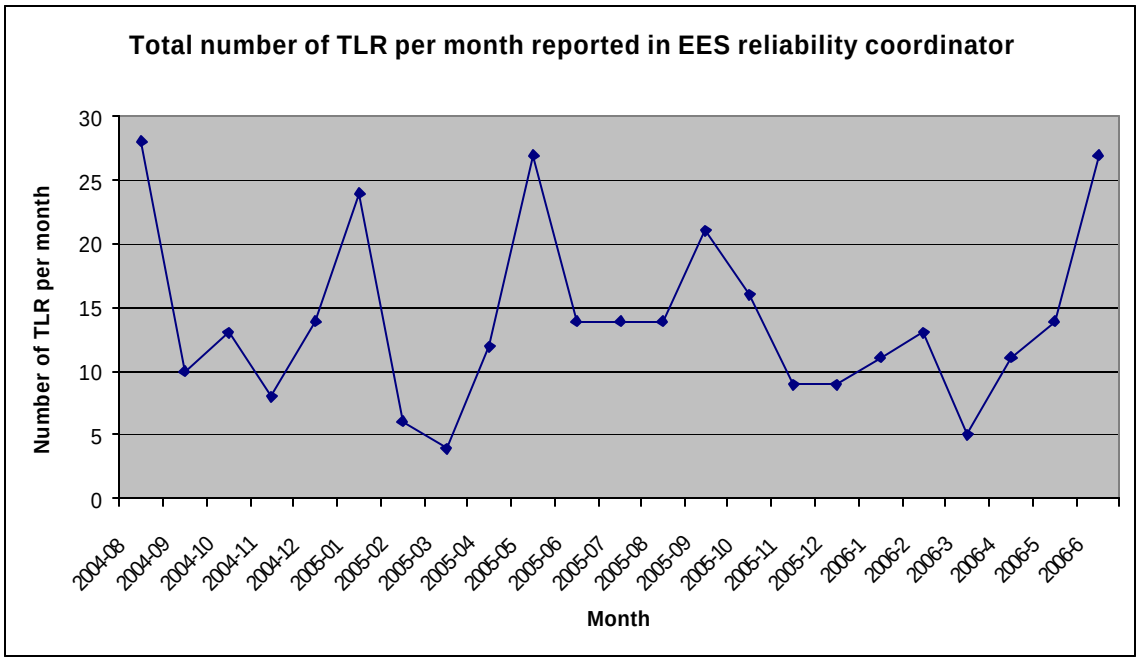

Figure 2.3.1. Total number of TLR per month reported in EES

A similar analysis was done week by week, and TLR by TLR, and there not seem to be any significant change in the TLR motivated by Katrina. This may due to the fact that, by their own definition, TLR are more concerned with transmission congestion than with transmission lines being out of service. As it will be discussed later in the report, since the electric demand decreased drastically due to the widespread damage in distribution facilities, it may be the case that the still-functioning transmission were not congested and therefore EES did not report any TLR.

However, this does not mean that transmission facilities were not damaged by the hurricanes. For example, Entergy had 181 transmission lines[2] and 263 substations out of service at Hurricane Katrina's peak, and 341 transmission lines and 443 substations at Hurricane Rita's peak. Table 2.3.1 and Figure 2.3.2 illustrate the evolution of Entergy's transmission equipment out of service.

[2] For electric transmission we understand all equipment 69kV and above. All equipment under 69 kV is considered electric distribution.

Entergy Transmission equipment out of service			
Date	Transmission lines	Substations	
29-Aug	181	263	
1-Sep	98	98	
6-Sep	46	36	
8-Sep	42	34	
13-Sep	32	25	
16-Sep	32	25	
18-Sep	28	23	
19-Sep	29	23	
20-Sep	29	23	
21-Sep	27	20	
22-Sep	25	19	
23-Sep	27	22	
25-Sep	153	120	*
25-Sep	341	443	*
25-Sep	279	284	*
26-Sep	288	283	
28-Sep	290	287	
29-Sep	264	259	
30-Sep	247	244	
3-Oct	191	219	
4-Oct	160	165	
5-Oct	138	128	
6-Oct	115	89	
7-Oct	105	63	
11-Oct	52	11	
12-Oct	45	4	
13-Oct	41	9	

Source: DOE's "Office of Electricity Delivery and Energy Reliability" situation reports

* In 9/25/05 there were 3 reports at 3 different times of the day

Table 2.3.1. Entergy transmission equipment out of service

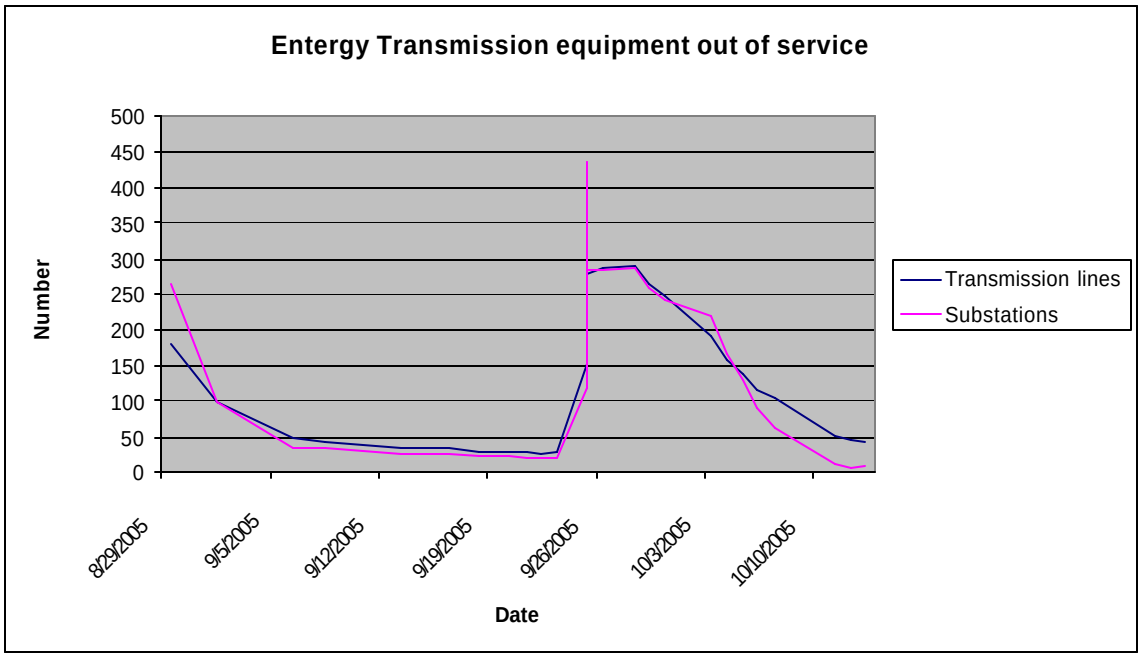

Figure 2.3.2. Entergy transmission equipment out of service

As another example, on 9/1/2006 Mississippi Power reported that about 70% of its 8000 miles of transmission and distribution lines would need to be replaced, and in 9/3/2006 reported that 750 miles of lines were on the ground, and nearly 5000 poles would need to be replaced, and thousands more repaired. The company lost all of its systems, including telecommunications. The Electric Power Associations of Mississippi (EPAOFMS) indicated that all of its 25 electric power associations suffered some loss of service during the storm. It was estimated that more than 50,000 utility poles were destroyed by the hurricane.

2.4. Electric distribution

Table 2.4.1 shows the number of customers without power by state, while Table 2.4.2 shows the number of customers without power by utility in Louisiana, and Table 2.4.3 documents the electricity restoration for Louisiana utilities from August 30 to September 15. Finally, Figure 2.4.1 illustrates the evolution of the electric service restoration process in Louisiana.

2005 Hurricane season - Number of customers without power by state

Date	Florida	Lousiana	Mississippi	Alabama	Georgia	Texas
26-Aug	1100875	.	.	.	.	.
27-Aug	746800	.	.	.	.	.
28-Aug	495200	.	.	.	.	.
29-Aug	382894	905075	.	193920	.	.
30-Aug	194856	890294	.	624427	12500	.
31-Aug	80705	863652	990425	310047	12500	.
1-Sep	<1%	780735	774244	235213	<1%	.
2-Sep	.	731758	635556	151598	.	.
3-Sep	.	668861	591548	74725	.	.
4-Sep	.	639392	550773	74002	.	.
5-Sep	.	586121	401011	<1%	.	.
6-Sep	.	529105	329653	.	.	.
7-Sep	.	488945	301102	.	.	.
8-Sep	.	459534	229651	.	.	.
9-Sep	.	445565	162090	.	.	.
10-Sep	.	427647	162090	.	.	.
11-Sep	.	384965	86584	.	.	.
12-Sep	.	344850	91116	.	.	.
13-Sep	.	319345	84327	.	.	.
14-Sep	.	311366	80530	.	.	.
15-Sep	.	283231	58704	.	.	.
16-Sep	.	272104	35000	.	.	.
19-Sep	.	243884	31547	.	.	.
20-Sep	.	239904	20643	.	.	.
21-Sep	.	232569	19443	.	.	.
22-Sep	.	230004	19443	.	.	.
23-Sep	.	227441	19443	.	.	.
24-Sep	.	258920	19443	.	.	861062
25-Sep	.	689519	13199	.	.	775298
26-Sep	.	539647	7383	.	.	707757
27-Sep	.	520990	2127	.	.	545470
28-Sep	.	448561	380	.	.	496497
29-Sep	.	368858	.	.	.	379100
30-Sep	.	341334	.	.	.	316044
3-Oct	.	258381	.	.	.	224343
4-Oct	.	229864	.	.	.	186988
5-Oct	.	224531	.	.	.	170379
6-Oct	.	205876	.	.	.	124760
7-Oct	.	194436	.	.	.	124760
11-Oct	.	143424	.	.	.	37866
12-Oct	.	136650	.	.	.	35872
13-Oct	.	135566	.	.	.	19000
14-Oct	.	132409	.	.	.	19301

Source: DOE's "Office of Electricity Delivery and Energy Reliability" situation reports

Table 2.4.1. Number of customers without power by state.

Number of customers without power by utility as of 1:00 PM on 8/29

Electric Utility	Customers w/o Power	Number of costumers (1)	% customers w/o Power
Entergy Louisiana Inc (ELI)	409,399	653,929	63%
Entergy Gulf States Inc (EGSI)	118,000	342,443	34%
Cleco Power LLC (CLECO)	70,014	257,299	27%
Entergy New Orleans Inc (ENOI)	215,163	NA	NA
Dixie Electric Membership Corp (DEMCO)	57,425	81,769	70%
Washington-St Tammany E C, Inc (WST)	20,000	41,304	48%
South Louisiana Elec Coop. Assn. (SLECA)	13,874	18,730	74%
Morgan City	1,200	6,316	19%
Total	**905,075**	**1,591,914**	**57%**

Source: Louisiana Public Service Commission
(1) Source: EIA Electric Sales and Revenues 2003

Table 2.4.2. Number of customers without power by utility during Katrina.

Number of customers without power by utility from 30-Aug to 15-Sep

Date		Utility							Total: All Utilities
		CLECO	DEMCO	EGSI	ELI	ENOI	SLECA	WST	
Tues	30-Aug	80,810	40,115	97,376	420,711	201,369	13,912	45,000	899,293
Wed	31-Aug	79,672	29,411	76,681	421,390	215,163	13,912	45,000	881,229
Thur	1-Sep	79,672	20,652	51,277	391,118	200,751	13,912	45,000	802,382
Fri	2-Sep	80,800	18,740	36,004	349,816	200,771	362	45,000	731,493
Sat	3-Sep	77,600	10,039	6,440	294,526	200,751	362	45,000	634,718
Sun	4-Sep	74,800	10,039	1,362	258,861	200,751	362	45,000	591,175
Mon	5-Sep	72,200	8,264	420	261,812	200,749	362	44,799	588,606
Tues	6-Sep	65,800	1,533	35	211,101	197,749	362	43,909	520,489
Wed	7-Sep	60,066	1,533	0	186,653	184,383	362	43,909	476,906
Thur	8-Sep	54,027	1,533	0	169,112	182,152	362	40,650	447,836
Fri	9-Sep	49,650	1,533	0	157,354	181,645	362	40,650	431,194
Sat	10-Sep	41,894	1,533	858	136,670	179,522	362	36,050	396,889
Sun	11-Sep	31,897	1,533	502	110,291	176,644	362	31,650	352,879
Mon	12-Sep	27,058	0	273	93,757	176,124	362	28,669	326,243
Tues	13-Sep	27,058	0	93	93,379	173,605	362	26,019	320,516
Wed	14-Sep	24,770	0	3	69,628	166,932	362	21,539	283,231
% Back in Service		69%	100%	100%	85%	19%	97%	52%	74%

Source: Hurricane Katrina Situation Report #36, September 15, 2005

Table 2.4.3. Number of customers without power by utility after Katrina

As of October 10th, 2005, there remained 120,000 customers in Orleans, Plaquemites, and St. Bernard parishes who were unable to accept service due to significant repair or reconstruction requirements.

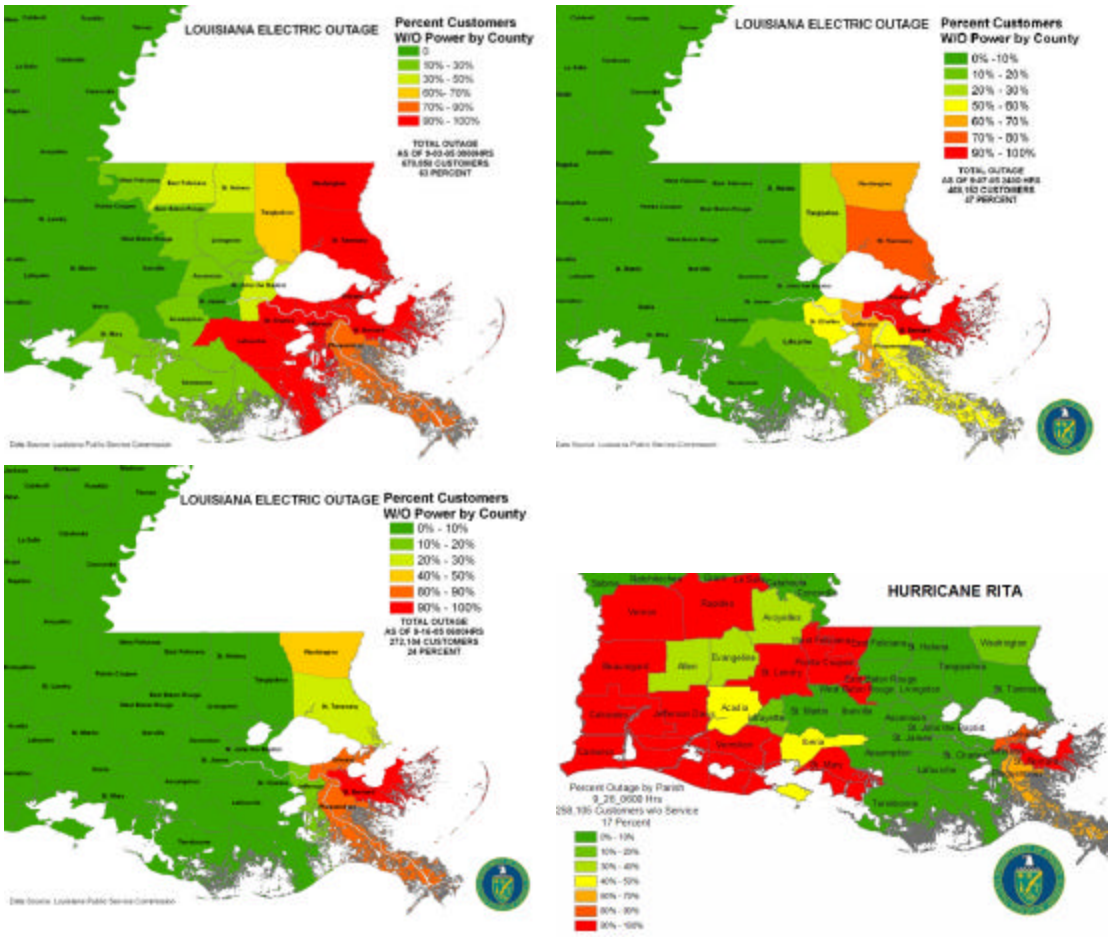

Figure 2.4.1. Evolution of the electric service restoration process in Louisiana.

2.5. Electricity prices

Figures 2.5.1 to 2.5.4 present nodal prices in reference buses at PJM, ISO-NE, NY-ISO, and MISO, respectively. Even though there are noticeable peaks in all of them the day of the hurricanes, the effect on the electricity prices on the long term trend seems to be inconclusive. However, there is a noticeable increase in the variability of the daily prices in the period immediately following Katrina.

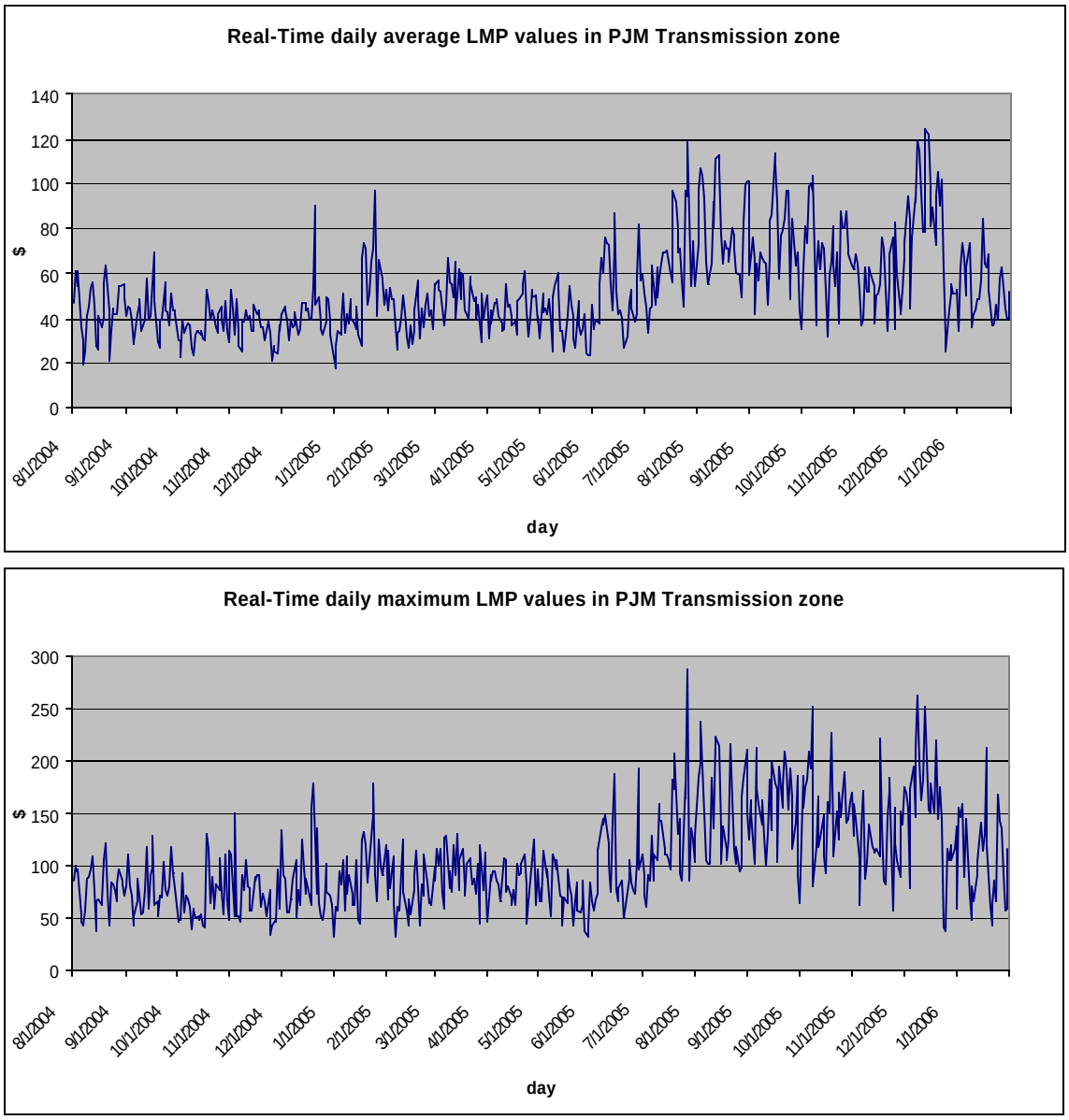

Figure 2.5.1. Daily LMP values at PJM.

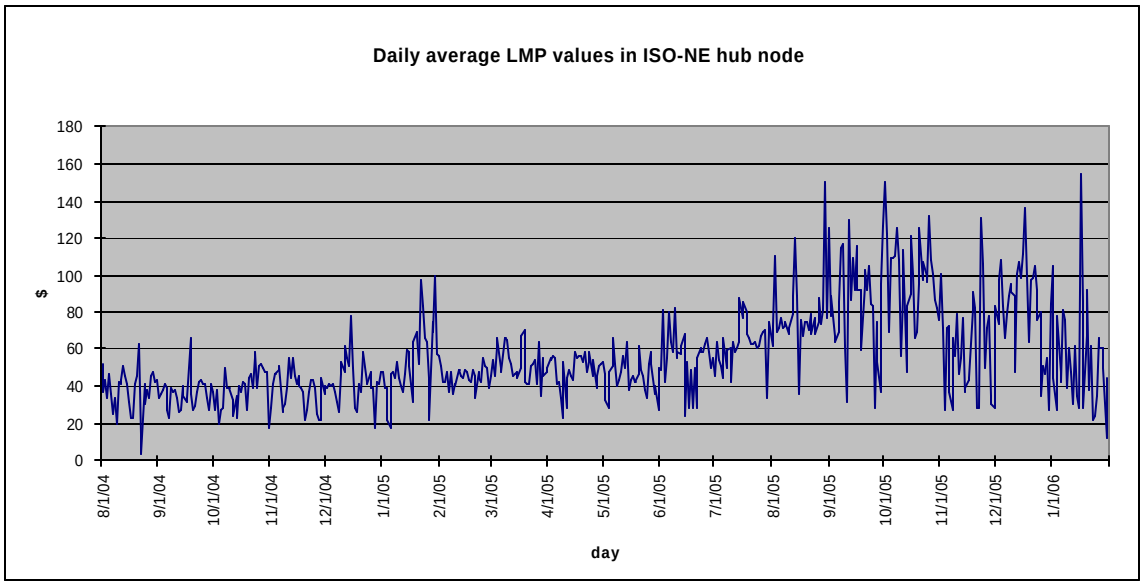

Figure 2.5.2. Daily LMP values at NE-ISO.

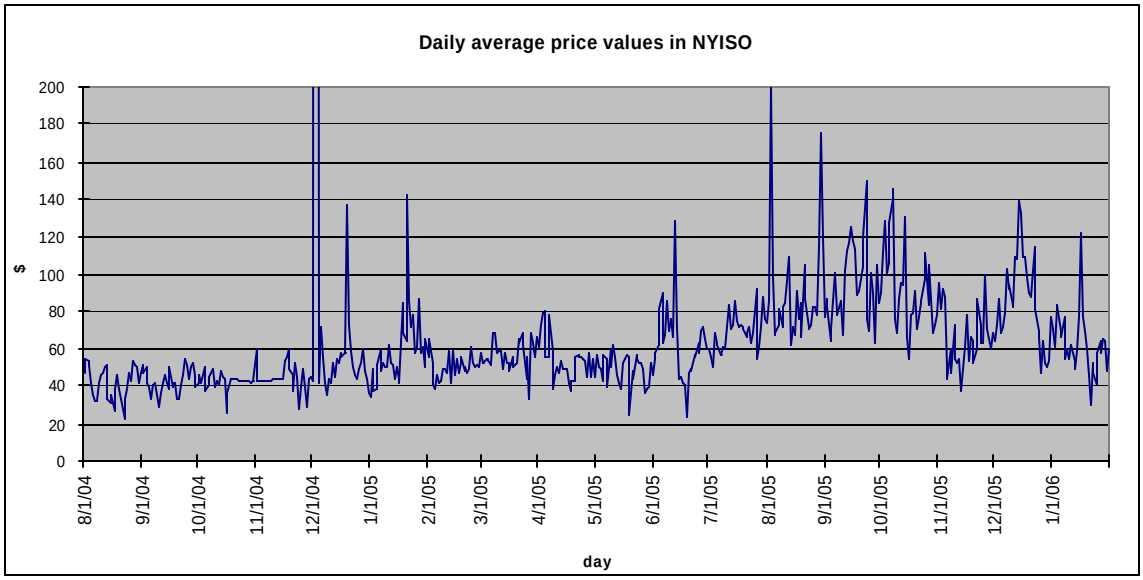

Figure 2.5.3. Daily LMP values at NY-ISO.

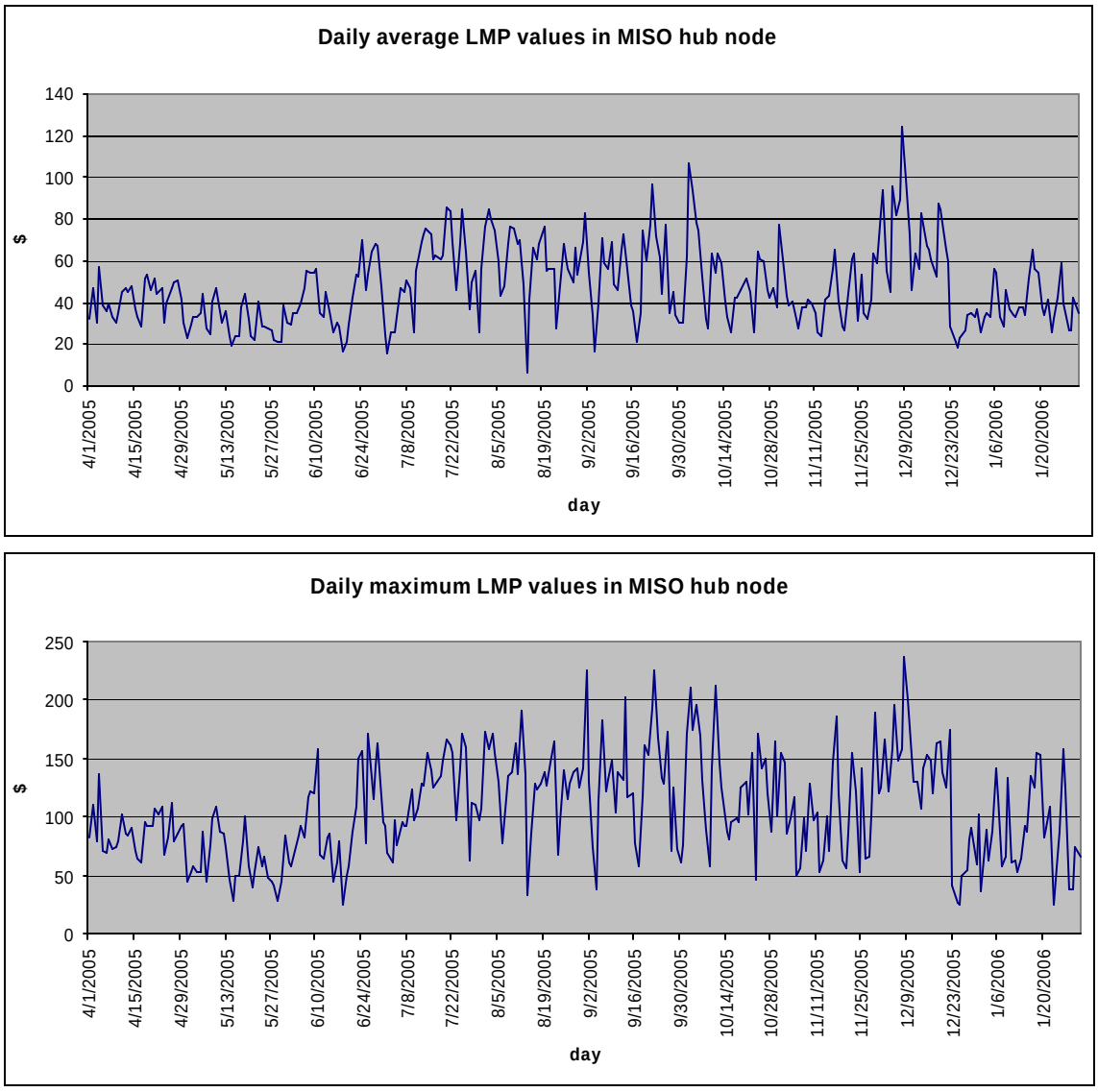

Figure 2.5.4. Daily LMP values at MISO.

2.6. Summary

It is interesting to notice that even though some electric generating facilities were affected by the hurricanes, the forced decrease in electric load (as a result of the widespread damage to transmission and distribution systems) motivated the affected companies to declare that there was no generation shortage. A lesson that we may draw from this is that, by their own nature, electric transmission and distribution facilities are more exposed to the elements than electric generation facilities. Therefore, catastrophic natural event like hurricanes will more likely cause a forced reduction of load due to the

damage in distribution equipment altogether with problems of transmission congestion than generation shortages.

The previous observation is interesting in regards to our modeling of catastrophic events affecting the NEES. From the evidence collected to this point, the most appropriate way to model the impact of the hurricanes in the electricity component of the NEES structural model is by reducing the electrical demand in the transshipment nodes corresponding to the affected areas. In particular, it is pertinent to adjust the electrical demand in the EES and ERCOT nodes.

Also, some minor adjustment may also be necessary to adjust the capacity of the arcs representing generation, but this adjustment does not seem at this point to be critical, given the small size of most of the units out of service and the short period that the larger units remained off-line (in particular Waterford). Adjustments on the capacity of the arcs representing transmission capability between different regions (transshipment nodes) does not seem to be necessary since no effect on the TLR could be perceived.

Finally, electric prices can be used as a good indicator of how the destructive effects of hurricane Katrina in other subsystems (specially the natural gas production and transportation system) affected the electric system nationwide, and to better understand interdependencies between different subsystems. In the same lines, electricity prices in Section 2.5 can be compared to nodal prices obtained by simulation in the NEES network model for the sake of validation of the model.

3. Natural Gas

Chapter 3 presents data reflecting hurricanes Katrina and Rita's effects in terms of damage to natural gas production, transportation, and processing facilities. Also included are data about the restoration efforts carried out by the natural gas companies affected by the event, and information about the evolution of natural gas prices and natural gas storage levels in the aftermath of the hurricanes.

This chapter is organized as follows: Sections 3.2 and 3.4 present data about the damage caused by the hurricanes and restoration efforts in natural gas production and transportation respectively. Section 3.5 will show natural gas prices for different types of users and their evolution in the US.

Data for this section was gathered from many different sources, among others EIA's website, OE daily situation reports, Mineral Management Service (MMS) shut-in reports, Office of Pipeline Safety (OPS), Pipeline and Hazardous Materials Safety Administration (PHMSA), and news and financial releases by the companies affected by the hurricanes.

3.1. Natural gas production and storage

The MMS manages the mineral resources on 1.76 billion acres of the Outer Continental Shelf (OCS), including the Gulf coast area where about 21% of the US domestic natural gas and 30% of domestic oil is produced. Daily gas production in the Gulf of Mexico is currently approximately 10,000 million cubic feet per day. The MMS website provides information on the impact of hurricanes in the production of natural gas in the Gulf of Mexico. Complete Hurricane Katrina/Hurricane Rita/Hurricane Wilma evacuation and production shut-in statistics reports can be found in http://www.gomr.mms.gov/homepg/whatsnew/hurricane/index.html. MMS's damage assessment press releases and shut-in press releases for the period going from August 26, 2005 to June 19, 2006 can also be found in that location.

According to the MMS, at the peak of the Hurricane Katrina, a recorded 88% of daily gas production was shut-in. The shut-in of gas is a standard safety procedure in the industry, and once each facility is inspected it then can be brought back on line. In the aftermath of the hurricane, a portion of natural gas was released. On September 24, Hurricane Rita made landfall causing gas that had been released to be shut-in once again. Approximately 80% of the natural gas was shut-in after Rita. After hurricane Rita had passed, more gas was released. On October 24, Hurricane Wilma made landfall; causing a slight raise of gas shut-in. After Wilma, the natural gas was again being released. The following production areas were affected by the hurricanes: Lake Jackson, Lake Charles, Lafayette, Houma, and New Orleans. As of June 1, 2006, about 11% of the natural gas is still shut-in. MMS has commissioned a research project called "*Assessment of Fixed Offshore Platform Performance in Hurricanes Hurricane Katrina and Rita*" to be completed on March 2007.

Figure 3.1.1 shows the total daily natural gas production shut-in caused by the hurricanes Hurricane Katrina, Rita, and Wilma in the Gulf of Mexico area, in million cubic feet per day.

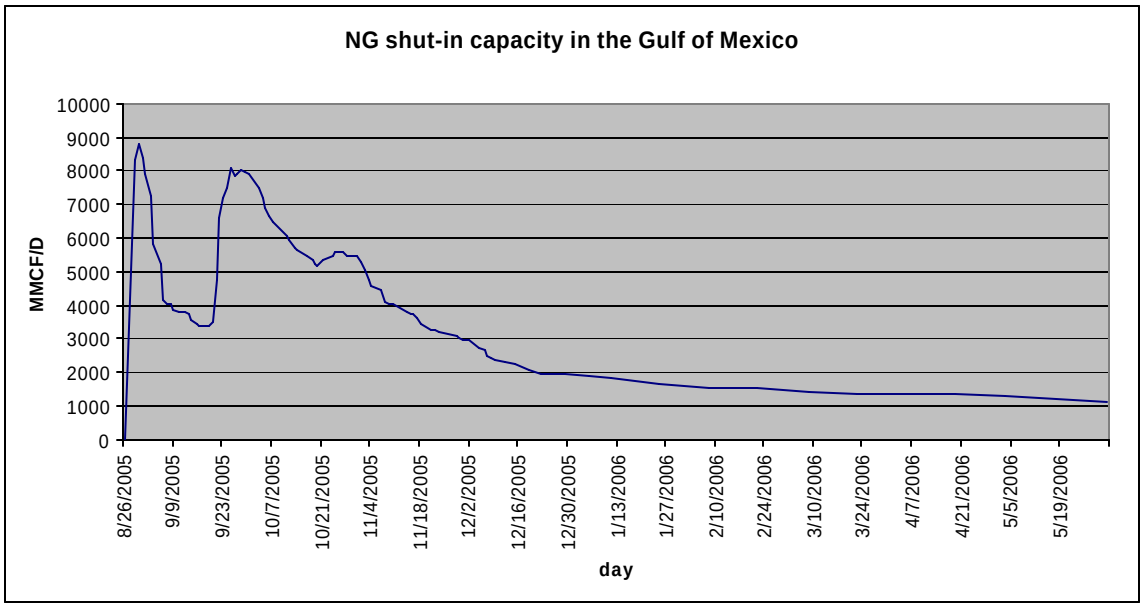

Figure 3.1.1. Natural gas shut-in capacity in the GOM

According to the MMS, after the hurricanes 13 rigs went adrift and 9 others reported damage, with some of them dragging anchor chain and other below-water components along the sea floor, damaging pipelines and gather systems. Approximately 2900 platforms were in the path of Katrina and Rita, of which 35 were destroyed and 16 reported extensive damage.

On October 12, 2005, one industry analyst noted: *"At last week's Independent Petroleum Association of America investor conference in San Francisco, most Gulf exploration companies suggested they are beginning to return workers to production platforms, and they're finding the majority of platforms fared pretty well in the storms. However, what didn't fare as well were wellheads, pipelines, gathering systems and coastal processing facilities. The infrastructure that helps bring oil and gas from the sea to shore is just as critical as the anchored hunk of steel from which energy is produced. Without pipelines and processing facilities, there is nowhere for oil and natural gas to flow. And, with flood and wind damage to such key areas as Venice, La., and the Sabine Pass area -- which straddles the Louisiana-Texas border -- it could be months before the Gulf infrastructure can handle pre-Katrina and Rita levels of oil and natural gas production… Production will come back only as fast as pipelines and processing facilities return to service."*[3] According to the same analyst, the recovery efforts in the Gulf of Mexico were somehow slowed down because it was very difficult to get access to work boats and helicopters.

EIA provides information on natural gas production, but only marketed natural gas production information is provided for 2005. Marketed Production corresponds to Gross withdrawals less gas used for re-pressuring, quantities vented and flared, and non-hydrocarbon gases removed in treating or processing operations. It includes all quantities of gas used in field and processing plant operations. Figures 3.1.2 to 3.1.4 show the marketed production for the US and for each state. There is a noticeable drop in the production due to the effect of hurricanes Katrina and Rita.

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[3] *Gulf Repair Job Tougher Than Expected*, by Christopher Edmonds. Thestreet.com, October 12, 2005.

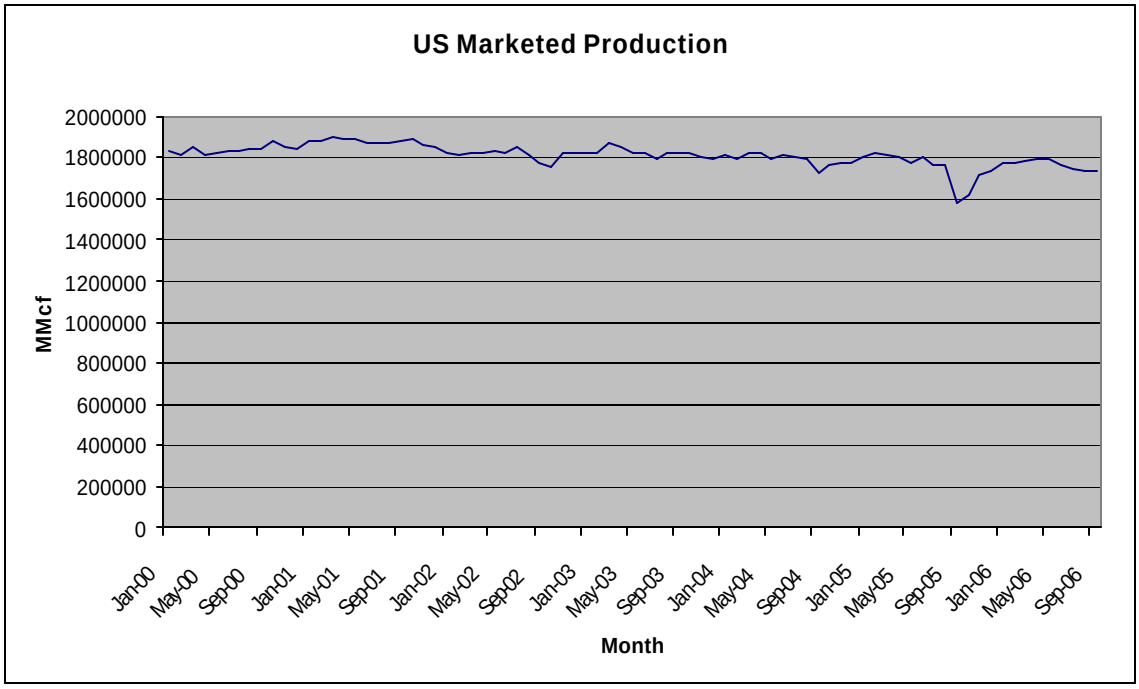

Figure 3.1.2. US natural gas marketed production

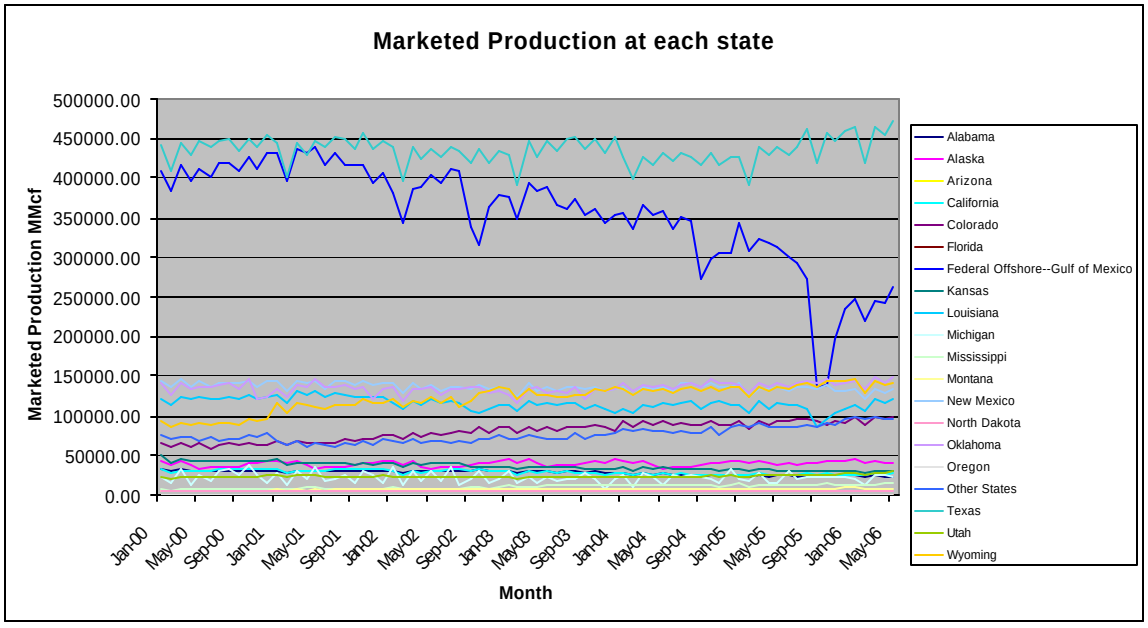

Figure 3.1.3. Natural gas marketed production by state

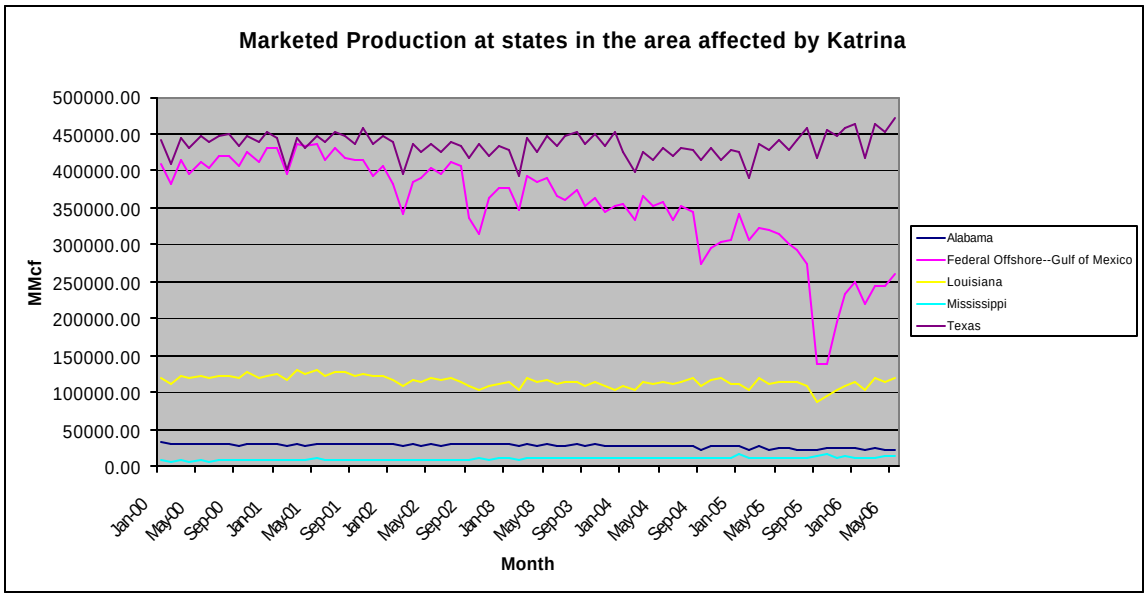

Figure 3.1.4. Natural gas marketed production in the state affected by hurricane Katrina

The situation of natural gas storage at the national level is depicted in Figure 3.1.5 and Figure 3.1.6.

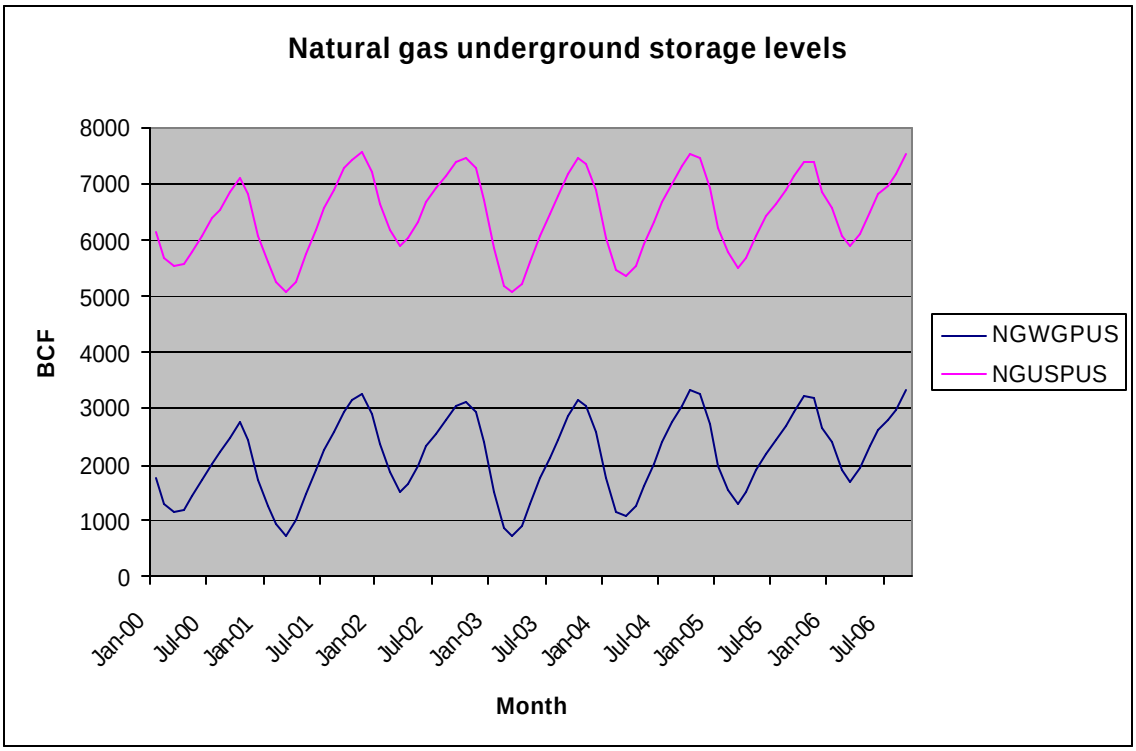

Figure 3.1.5. Natural gas underground storage levels

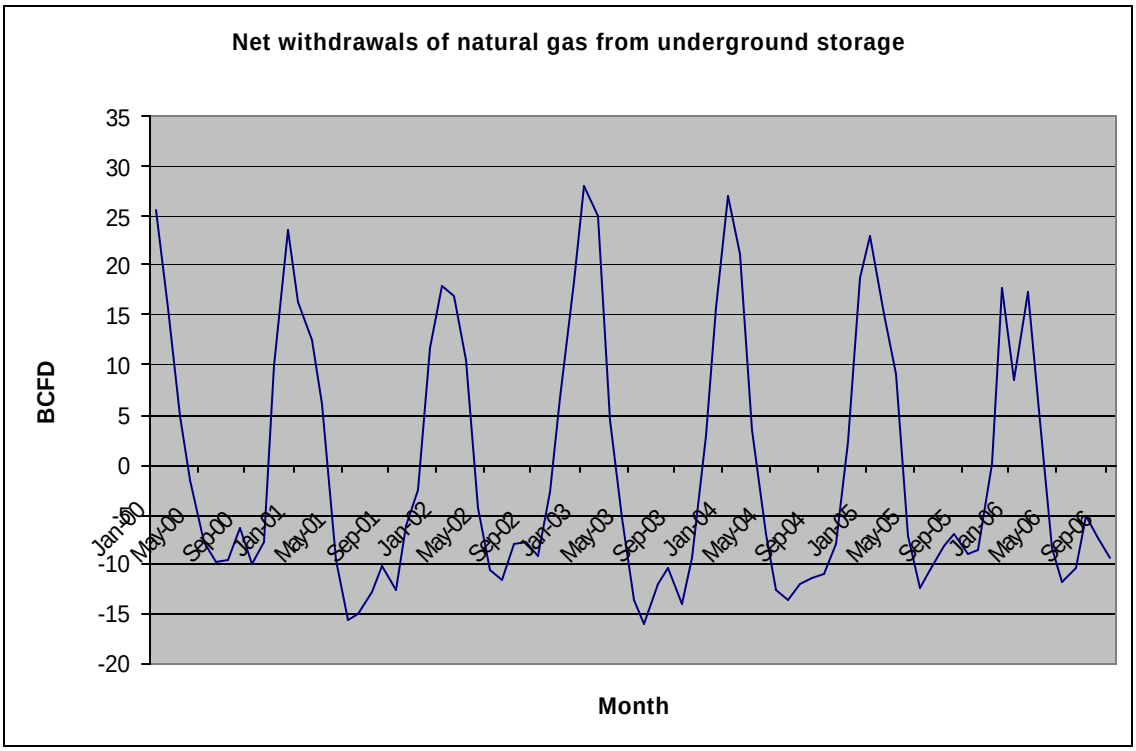

Figure 3.1.6. Natural gas underground storage levels

The situation of natural gas storage in the days following Hurricane Katrina is described in a CRS report[4]: *"Despite reduced production output of natural gas, gas was still being placed in storage; the additions during the week ending October 14 were 75 billion cubic feet (bcf). The amount of gas already in storage was equivalent to the five-year average, although it was slightly below year-earlier levels. Gas sold from storage is used to balance seasonal demand swings, and not to replace a catastrophic loss of production. Given that the current amount of shut-in OCS and Louisiana state lands gas is the equivalent of half the most recent week's storage addition, the perception of a robust injection to storage should be adjusted accordingly. Despite the fact that supplies continue to flow, wellhead prices have doubled since last summer. Issues for the onset of cold weather include timing and severity, as with oil, as well as "demand destruction" resulting from higher prices. But if Gulf of Mexico production does not recover, there is no import safety-valve, and supplies could become tight and prices could spike… Storage*

[4] *CRS Report for Congress: Oil and Gas Disruption from Hurricanes Katrina and Rita*. Congressional Research Service, October 21, 2005.

peaks at about 3.25 trillion cubic feet (tcf) in late fall, and declines to about 0.75 tcf at the end of the heating season, typically during April. Current inventory is about 3.0 tcf — about the average stock level during the past five years. During the most recent week, 75 bcf were added to storage (slightly under the five-year average figure for this week), suggesting that gas is available and flowing in the nation's pipeline system. To what extent this will be the case after the onset of cold weather remains to be seen, but it is likely that prices will keep demand in check, and allocate supply where needed."

3.2. Natural gas transmission

Hurricanes Katrina and Rita affected the operation in many natural gas pipelines. In Tables 3.2.1 and 3.2.2 is presented a complete list of incidents related to the hurricanes Katrina and Rita in 2005. The incident related data presented in those tables was obtained from the OPS website (http://ops.dot.gov/stats/IA98.htm). Table 3.2.3 presents statistics related to natural gas pipeline transmission incidents by year (illustrated in Figure 3.2.1), while table 3.2.4 presents statistics related to natural gas pipeline transmission incidents due to heavy rains/flood by year. Figure 3.2.2 shows the number of natural gas pipelines disruptions by month in 2005. From the data presented, it seems pretty obvious the significant effect of the hurricanes in the normal operation of the pipelines.

According to an American Gas Association (AGA) report: *"MMS has revised its estimate of pipeline damage associated with the 2005 hurricane season. MMS now says that 457 pipelines suffered damage compared to the 183 identified in their January 2006 assessment. The agency also notes that 101 pipelines 10 inches in diameter or greater were among those damaged. That compares to an estimate of 64 for the so-called "larger" pipelines made in January. In addition, the number of Gulf of Mexico platforms destroyed by Katrina and Rita was revised downward to 113."*[5] MMS has commissioned a research project called "*Pipeline Damage Assessment from Hurricane Katrina/Rita*", to be completed in February 2007.

[5] *Gulf of Mexico Natural Gas Production Shut-In Report: Residual Production Impacts from Hurricanes Katrina, Rita and Wilma, Final report,* American Gas Association, May 3, 2006.

List of Natural Gas pipeline incidents related to hurricane Katrina

Date of incident	Company Name	Location				Receiving -- Delivering (From:) Pipeline	Average Operating Pressure (PSIA)	Bi-directional Line?	Capacity (MMcf/d)		Average Daily Flow in 2004 (MMcf/d)	Incident						Time I area
		State From	State To	County From	County To				as of end of 2005	as of end of 2004		City of incident	County of incident	State	Type of Failure	Type of Failure - Other description	Cause of damage	hours
8/28/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Lafourche	Tennessee Gas Pipeline Co	980	N	66	66	16.329				LEAK		HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
8/29/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	UNDER INVESTIGATION	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
8/29/2005	TRUNKLINE GAS COMPANY	GM	LA	Gulf Of Mexico	Terrebonne	Trunkline Gas Co	1158	N	1327	1327	303.304				RUPTURE		HEAVY RAINS/FLOODS - HURRICANE KATRINA	24
8/30/2005	GULF SOUTH PIPELINE COMPANY, LP	GM	LA	Gulf Of Mexico	St. Mary	Gulf South Pipeline Co	0	N	250	250	61.851	CHALMETTE	ST BERNARD	LA	OTHER	TAP	HEAVY RAINS/FLOODS	28
8/30/2005	GULF SOUTH PIPELINE, LP	GM	LA	Gulf Of Mexico	Lafourche	Gulf South Pipeline Co	0	N	80	80	19.792	POINTE A LA HACHE	PLAQUEMINES	LA	OTHER	TAP	HEAVY RAINS/FLOODS	532
8/30/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127	PORT SULPHUR	PLAQUEMINES	LA	OTHER	UNDER INVESTIGATION	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
8/30/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Lafourche	Tennessee Gas Pipeline Co	980	N	66	66	16.329				OTHER	TWO RISERS MISSING	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
8/30/2005	WILLIAMS GAS PIPELINES (TRANSCONTINENTAL GAS P L Co)	GM	LA	Gulf Of Mexico	Terrebonne	Transcontinental Gas P L Co	0	N	800	800	144.643				RUPTURE		HIGH WINDS	1
8/31/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127		PLAQUEMINES	LA	OTHER	1-INCH NIPPLE AND VALVE DAMAGED	HEAVY RAINS/FLOODS - HURRICANE KATRINA	2
8/31/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	18-INCH RISER&PIPELINE DAMAGED AT THE NOBLE PLAT	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
8/31/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Tennessee Gas Pipeline Co	980	N	238	238	58.882				OTHER	8 INCH RISER MISSING	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
9/1/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	12-INCH FLANGE ON RISER LEAKED	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
9/3/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127		PLAQUEMINES	LA	OTHER	LEAK NEAR EXISTING SIDE VALVE	HEAVY RAINS/FLOODS - HURRICANE KATRINA	0
9/4/2005	GULF SOUTH PIPELINE COMPANY, LP	GM	LA	Gulf Of Mexico	St. Mary	Gulf South Pipeline Co	0	N	250	250	61.851	ALGIERS	ORLEANS	LA	OTHER	TAP	HIGH WINDS	175
9/4/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Tennessee Gas Pipeline Co	980	N	238	238	58.882				OTHER	CONTROL LINE ON PLATFORM FOUND LEAKING	HEAVY RAINS/FLOODS - HURRICANE KATRINA	3
9/4/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127		PLAQUEMINES	LA	OTHER	1/2-INCH VALVE DAMAGED AT VALVE 526A-601	HEAVY RAINS/FLOODS - HURRICANE KATRINA	2
9/5/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	20-INCH & 14-INCH RISERS DAMAGED AT PLATFORM	HEAVY RAINS/FLOODS - HURRICANE KATRINA	4
9/5/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				RUPTURE		HEAVY RAINS/FLOODS - HURRICANE KATRINA	
9/5/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Lafourche	Tennessee Gas Pipeline Co	980	N	66	66	16.329				OTHER	UNDER INVESTIGATION	HEAVY RAINS/FLOODS - HURRICANE KATRINA	4
9/8/2005	ENTERPRISE PRODUCTS OPERATING L.P.														OTHER	TO BE DETERMINED UPON INSPECTION	EARTH MOVEMENT - HURRICANE KATRINA	2
9/8/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	12-INCH RISER DAMAGED	HEAVY RAINS/FLOODS - HURRICANE KATRINA	
9/8/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	6-INCH RISER DAMGED	HEAVY RAINS/FLOODS - HURRICANE KATRINA	
9/11/2005	TENNESSEE GAS PIPELINE COPMANY	GM	LA	Gulf Of Mexico	Lafourche	Tennessee Gas Pipeline Co	980	N	66	66	16.329				OTHER	UNDER INVESTIGATION	HEAVY RAINS/FLOODS - HURRICANE KATRINA	
9/17/2005	SOUTHERN NATURAL GAS	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127		PLAQUEMINES	LA	OTHER	LEAK ON 1-IN. BYPASS AT METER STATION	HEAVY RAINS/FLOODS - HURRICANE KATRINA	

Table 3.2.1. List of natural gas pipeline incidents related to Hurricane Katrina

List of Natural Gas pipeline incidents related to hurricane Rita

Date of incident	Company Name	Location				Receiving -- Delivering (From:) Pipeline	Average Operating Pressure (PSIA)	Bi-directional Line?	Capacity (MMcf/d)		Average Daily Flow in 2004 (MMcf/d)	Incident						Time lapsed until area made safe	
		State From	State To	County From	County To				as of end of 2005	as of end of 2004		City of incident	County of incident	State	Type of Failure	Type of Failure - Other description	Cause of damage	hours	minutes over hours
9/24/2005	ENBRIDGE OFFSHORE (GAS GATHERING) L.L.C.	GM	LA	Gulf Of Mexico	Cameron	ANR Pipeline Co	1050	N	750	750	185.552				RUPTURE		HEAVY RAINS/FLOODS - HURRICANE RITA	0	1
9/24/2005	ENBRIDGE OFFSHORE (GAS TRANSMISSION) L.L.C.	MS	LA	Wilkinson	West Feliciana	Enbridge Pipelines (Midla)	0	N	70	70	16.923		CAMERON	LA	OTHER	BROKEN FITTING	HEAVY RAINS/FLOODS - FLOTATION	0	0
9/24/2005	GULF SOUTH PIPELINE COMPANY, LP	GM	LA	Gulf Of Mexico	Cameron	Gulf South Pipeline Co	0	N	1061	1061	247.494	CAMERON	CAMERON	LA	OTHER	"1/2"" FITTING KNOCKED OFF SEPARATOR"	HIGH WINDS		
9/24/2005	SEA ROBIN PIPELINE COMPANY	GM	LA	Gulf Of Mexico	Vermilion	Sea Robin Pipeline Co	1200	N	1595	1595	817.492						HEAVY RAINS/FLOODS - HURRICANE RITA		
9/24/2005	SEA ROBIN PIPELINE COMPANY	GM	LA	Gulf Of Mexico	Vermilion	Sea Robin Pipeline Co	1200	N	1595	1595	817.492						HEAVY RAINS/FLOODS - HURRICANE RITA	0	20
9/24/2005	SEA ROBIN PIPELINE COMPANY	GM	LA	Gulf Of Mexico	Vermilion	Sea Robin Pipeline Co	1200	N	1595	1595	817.492				RUPTURE		HEAVY RAINS/FLOODS - HURRICANE RITA	0	5
9/24/2005	TARGA MIDSTREAM SERVICES LP.														RUPTURE		HEAVY RAINS/FLOODS - STORM SURGE		
9/24/2005	TRUNKLINE GAS COMPANY	GM	LA	Gulf Of Mexico	Terrebonne	Trunkline Gas Co	1158	N	1327	1327	303.304						HEAVY RAINS/FLOODS - HURRICANE RITA		
9/24/2005	TRUNKLINE GAS COMPANY	GM	LA	Gulf Of Mexico	Vermillion	Trunkline Gas Co	1050	N	399	399	98.714	ABBEVILLE	VERMILLION	LA	OTHER	BROKEN INSTRUMENT TUBING	HEAVY RAINS/FLOODS - FLOOD MOVEMENT	192	0
9/25/2005	ANR PIPELINE COMPANY	GM	LA	Gulf Of Mexico	Cameron	ANR Pipeline Co	1050	N	750	750	185.552				OTHER	UNKNOWN AT THIS TIME	HEAVY RAINS/FLOODS - STORM SURGE		
9/25/2005	ANR PIPELINE COMPANY	GM	LA	Gulf Of Mexico	St. Mary	ANR Pipeline Co	1008	N	1630	1630	403.267				OTHER	UNKNOWN- DAMAGE BEING ASSESSED	HEAVY RAINS/FLOODS - HURRICANE RITA		
9/25/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Plaquemines	Southern Natural Gas Co	1100	N	336	336	83.127				OTHER	RISER AND CONNECTING PIPING DAMAGED	HEAVY RAINS/FLOODS - HURRICANE RITA		
9/26/2005	NATURAL GAS PIPELINE CO. OF AMERICA	LA	TX	Cameron	Jefferson	Nat Gas P L Co Of America	1100	Y	140	140	0	BEAUMONT	LIBERTY	TX	OTHER	RELIEF VALVE	HIGH WINDS		
9/26/2005		TX	LA	Jefferson	Cameron	Nat Gas P L Co Of America	1100	Y	796	796	555.537								
9/26/2005	NATURAL GAS PIPELINE CO. OF AMERICA	LA	TX	Cameron	Jefferson	Nat Gas P L Co Of America	1100	Y	140	140	0	CAMERON	CAMERON	LA	LEAK		HEAVY RAINS/FLOODS - HURRICANE RITA	20	
9/26/2005		LA	TX	Cameron	Jefferson	Nat Gas P L Co Of America	1100	Y	140	140	0								
9/26/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Vermilion	Tennessee Gas Pipeline Co	950	N	975	975	216.218				OTHER	UNKNOWN- DAMAGE BEING ASSESSED	HEAVY RAINS/FLOODS - HURRICANE RITA		
9/27/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Cameron	Tennessee Gas Pipeline Co	950	N	12	12	2.969				OTHER	FITTINGS ON PIG RECEIVER LEAKING	HEAVY RAINS/FLOODS - HURRICANE RITA		
9/27/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Vermilion	Tennessee Gas Pipeline Co	950	N	975	975	216.218				OTHER	UNDER INVESTIGATION	HEAVY RAINS/FLOODS - HURRICANE RITA		
9/27/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Cameron	Tennessee Gas Pipeline Co	950	N	12	12	2.969		CAMERON	LA	OTHER	1/2-INCH VALVE BROKEN	HEAVY RAINS/FLOODS - HURRICANE RITA		
9/27/2005	TEXAS EASTERN TRANSMISSION, LP	GM	LA	Gulf Of Mexico	Cameron	Texas Eastern Trans Corp	1200	N	800	800	172.922				OTHER	SEE F7 & G	HIGH WINDS	24	0
9/27/2005	WILLIAMS GAS WILLIAMS (TRANSCONTINENTAL GAS P L Co)	GM	LA	Gulf Of Mexico	Terrebonne	Transcontinental Gas P L Co	0	N	800	800	144.643				RUPTURE		HIGH WINDS	77	5
9/28/2005	ENTERPRISE PRODUCTS OPERATING L.P.														RUPTURE		EARTH MOVEMENT - HURRICANE RITA	2	0
9/28/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Vermilion	Tennessee Gas Pipeline Co	950	N	975	975	216.218				OTHER	6-INCH RISER DAMGED WITH PRODUCER PLATFORM	HEAVY RAINS/FLOODS - HURRICANE RITA		
10/2/2005	SHELL PIPELINE COMPANY LP														OTHER	HURRICANE RITA - SEPARATED LINE	HIGH WINDS		
10/3/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Cameron	Tennessee Gas Pipeline Co	950	N	12	12	2.969				OTHER	LEAK ON PRODUCER PLATFORM METER TUBE	HEAVY RAINS/FLOODS - HURRICANE RITA		
10/5/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Vermilion	Tennessee Gas Pipeline Co	950	N	975	975	216.218				OTHER	16-IN. RISER TOPPLED WITH PRODUCER PLATFORM	HEAVY RAINS/FLOODS - HURRICANE RITA		
10/5/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Vermilion	Tennessee Gas Pipeline Co	950	N	975	975	216.218				OTHER	8-IN. RISER TOPPLED ALONG WITH PRODUCER'S PLATFORM	HEAVY RAINS/FLOODS - HURRICANE RITA		
10/11/2005	ENTERPRISE PRODUCTS OPERATING L.P.														RUPTURE		EARTH MOVEMENT - HURRICANE RITA	2	0
10/14/2005	ANR PIPELINE COMPANY	GM	LA	Gulf Of Mexico	Cameron	ANR Pipeline Co	1050	N	750	750	185.552				OTHER	PIPE SEPARATED SUB-SEA	HEAVY RAINS/FLOODS		
10/29/2005	SEA ROBIN PIPELINE COMPANY	GM	LA	Gulf Of Mexico	Vermilion	Sea Robin Pipeline Co	1200	N	1595	1595	817.492				OTHER	PARTIAL CIRCUMFERENTIAL TEAR	HIGH WINDS	0	0
11/2/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Vermilion	Tennessee Gas Pipeline Co	950	N	975	975	216.218				OTHER	UNKNOWN- DAMAGE BEING ASSESSED	HEAVY RAINS/FLOODS - HURRICANE RITA		
11/14/2005	TENNESSEE GAS PIPELINE	GM	LA	Gulf Of Mexico	Lafourche	Tennessee Gas Pipeline Co	980	N	66	66	16.329				RUPTURE		HEAVY RAINS/FLOODS - HURRICANE RITA		

Table 3.2.2. List of natural gas pipeline incidents related to Hurricane Rita

Natural gas pipeline transmission operators
Incident summary statistics by year (1/1/1986 - 08/31/2006)

Year	No. of Incidents	Fatalities	Injuries	Property Damage
1986	83	6	20	$11,166,262
1987	70	0	15	$4,720,466
1988	89	2	11	$9,316,078
1989	103	22	28	$20,458,939
1990	89	0	17	$11,302,316
1991	71	0	12	$11,931,238
1992	74	3	15	$24,578,165
1993	95	1	17	$23,035,268
1994	81	0	22	$45,170,293
1995	64	2	10	$9.957.750
1996	77	1	5	$13,078,474
1997	73	1	5	$12,078,117
1998	99	1	11	$44,487,310
1999	54	2	8	$17,695,937
2000	80	15	18	$17,868,261
2001	87	2	5	$23,674,225
2002	82	1	5	$26,713,069
2003	98	1	8	$52,940,561
2004	123	0	3	$68,179,092
2005	182	0	7	$269,307,752
2006	100	1	3	$41,217,116
Totals	**1874**	**61**	**245**	**$758,876,689**

Note: FY 2006 data continues to be updated as the reports are obtained by PHMSA Pipeline Safety.

Table 3.2.3. Natural gas pipeline transmission incidents by year

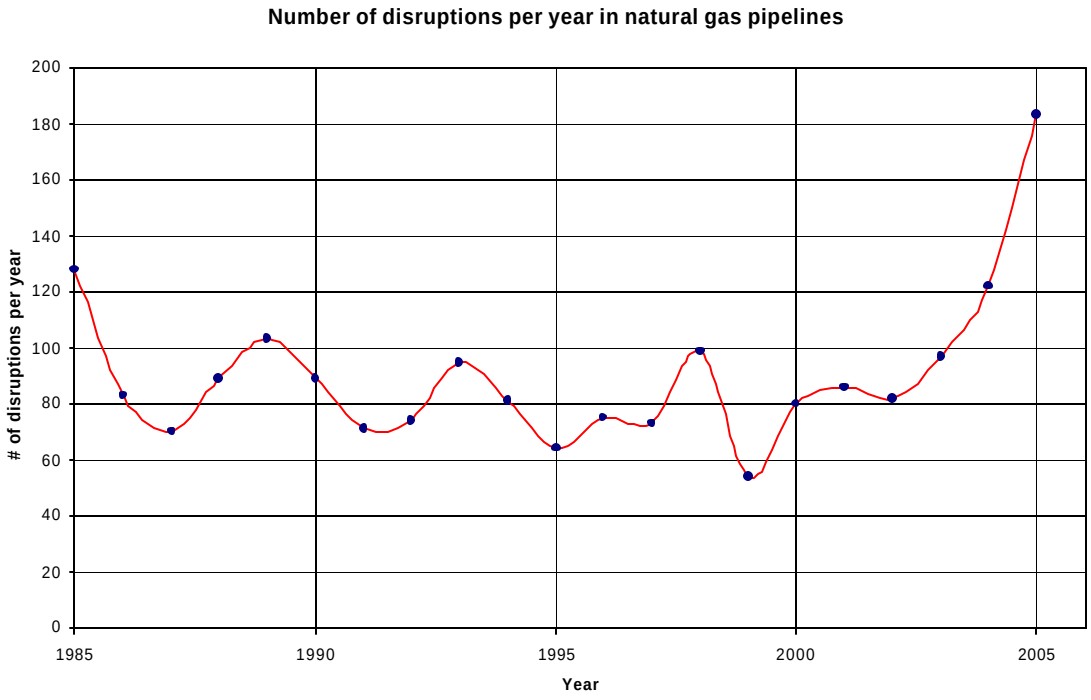

Figure 3.2.4. Number of natural gas pipelines disruptions per year

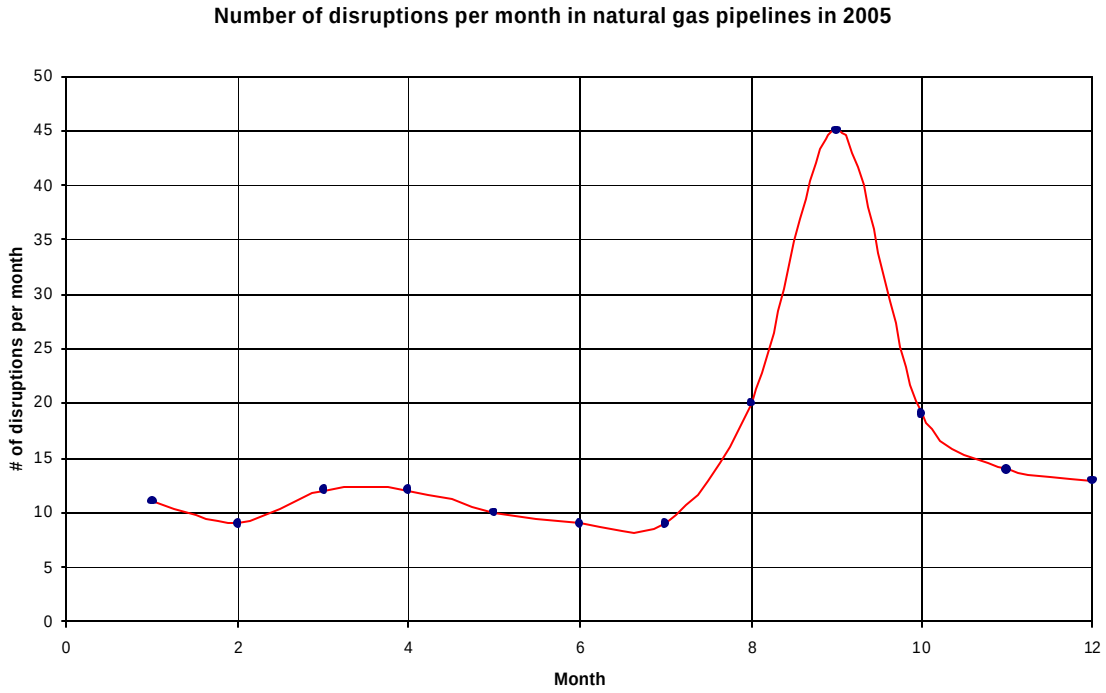

Figure 3.2.5. Number of natural gas pipelines disruptions per month in 2005

Incidents due to heavy rains/floods per year

Year	Number of Incidents	% of total incidents	Property damages	% of total damages	Fatalities	Injuries
2001	0	0	$0	0	0	0
2002	5	6.1	$4,359,000	16.3	0	0
2003	0	0	$0	0	0	0
2004	8	6.5	$17,270,840	25.3	0	0
2005	46	25.3	$57,483,338	21.3	0	0

Table 3.2.6. Natural gas pipeline transmission incidents due to heavy rains/flood by year

Natural gas processing plants treat gas, upgrading its quality and making it suitable for transport in a pipeline. As of 9/9/2005, OE informed in their daily situation report that a total of 15 natural gas processing plants in Alabama, Mississippi, and Louisiana were impacted due to flooding, damage to equipment, or power failure. In 9/23/2005, they reported that over 60 natural gas plants and processing facilities (not counting pipelines and compression stations) from New Mexico to Alabama were shut down as a precaution prior to the landfall of Hurricane Rita. As of 10/3/2005, 21 natural gas processing plants in Texas, Louisiana, and Mississippi remained offline: 11 of the

plants with a capacity of 7.7 BCFD because to damage to their facilities and 10 of the plants with a total capacity of 5.4 BCFD due to external factors like lack of electric or gas supply. As of October 13, 2005, OE informed that 15 gas processing plants with aggregate capacity of 9.5 billion cubic feet or greater were offline in Louisiana. These plants had a pre-Katrina throughput of 5.3 BCFPD.

Tables 3.2.7 to 3.2.10 report the status at different times of natural gas pipelines and natural gas processing plants located on the Gulf Coast, as reported in OE situation reports.

Natural Gas Processing Plant Status 9/8/05 2:00PM

Natural Gas Processing Plant	Capacity/Throughput (2004 avg) (MMcfd)*	Pipeline Feed	Current Status
Duke Energy – Mobile Bay, AL	600/172	Dolphin Is, Transco, Gulfsteam	Available for service but waiting on pipeline outlet for liquids.
BP – Pascagoula, MS	1000/768	Destin	Minor damage, Waiting on power
Dynegy – Venice, LA	1300/997	Southern NG, Gulf South, Columbia	Seawater damage. Could take 3-6 months to repair.
Dynegy – Yscloskey, LA	1850/1343	Tennessee	Seawater damage. Could take 3-6 months to repair.
Enterprise Prod. – Toca, LA	1100/468.4	Gulf South	Assessment ongoing.
ExxonMobil – Garden City, LA	630/NA	LA Intrastate, Cypress	Waiting on power
ExxonMobil – Grand Isle, LA	115/72	Tennessee	Waiting on power
Marathon – Burns Point, LA	200/60	Nautilus, Southern NG	Waiting on power

* Average throughput based on average of 12 months for 2004 (Data from Worldwide Gas Processing Survey, Oil and Gas Journal, June 27, 2005 issue)

Table 3.2.7. Natural gas processing plant status (9/8/2005)

Natural Gas Processing Plant Status (9/13/05)

Processing Plant	State	Capacity as of Jan 1, 2005 (MMcfd)*	2004 Average Throughput (MMcfd)**	Current Status
Dynegy - Yscloskey	LA	1,850	1,343	Seawater damage. Could take 3-6 months to repair.
Dynegy – Venice	LA	1,300	997	Seawater damage. Could take 3-6 months to repair.
Enterprise Products – Toca	LA	1.100	468	Assessment ongoing.
BP - Pascagoula	MS	1,000	768	Power restored. Waiting for pipelines to deliver gas.
Exxon Mobil – Garden City	LA	630	NA	Waiting on power
Duke Energy – Mobile Bay	AL	600	172	Available for service but waiting on pipeline outlet for liquids.
Marathon – Burns Point	LA	200	60	Waiting on power
ExxonMobil – Grand Isle	LA	115	72	Waiting on power

Table 3.2.8. Natural gas processing plant status (9/13/2005)

Natural Gas Transmission Pipeline Status (9/13/05)

Pipeline	Primary Markets	Capacity (MMcfd)	Impacts
ANR Pipeline	Midwest	6.414	None reported
Florida Gas Transmission	Florida	2,150	10% overage limit (9/13/2005)
Gulf South	Gulf States	2,750	Allocations in categories other than Primary Firm service
Southern Natural Gas	Southeast	3,296	550 mmcfd production shut in
Tennessee Gas	Northeast	6,937	700 mmcfd production shut in
Texas Eastern Transmission	Northeast	5,939	Deliveries allowed only for confirmed receipts
Trunkline Gas Midwest,	East Coast	1,500	Deliveries allowed only for confirmed receipts
Transco	Northeast	8.100	None Reported
Gulfstream	Florida	1,100	Deliveries allowed only for confirmed receipts

Table 3.2.9. Natural gas transmission pipeline status (9/13/2005)

There is plenty of information made available by OE on pipeline and processing plant status. However, no information is provided about how much natural gas is actually flowing through interstate pipelines. The following was commented in the CRS report for Congress: *"Henry Hub is a nodal point on the Sabine Pipeline, which connects with nine interstate and four intrastate pipelines. When fully operational, it has the capacity to move 1.8 bcfpd. Because of these attributes, it is the point at which NYMEX contracts for physical delivery are settled. Trading in Henry Hub futures is an extremely important benchmark for establishing natural gas prices nationwide. The Sabine Pipeline went out of service after Rita, and force majeure was ultimately declared on the NYMEX contracts, resulting in postponement of trades and physical deliveries. Trading was suspended on September 22; it resumed on October 7, when Sabine partially reopened. How much gas can be transported given limited availability of pipeline compression is unclear, as is how this limited pumping ability might affect trading in futures and physical deliveries for traditional customers of deferred gas. The absence of definitive reports on the condition of the gas delivery infrastructure has caused uncertainty that has become reflected in spot gas prices".*

On-Shore and Off-Shore Pipelines with Reported Supply Issues

Pipeline	Status 9/25/2006	Status 9/26/2006	Status 9/27/2006
ANR	20 percent of capacity with reduced supply	20 percent of capacity with reduced supply	20 percent of capacity with reduced supply
Chevron	Western LA facilities shut-in	Western LA facilities shut-in	Western LA facilities shut-in
Columbia Gulf Transmission	Loss of supply	Loss of supply	Loss of supply
Comstock Offshore	Shut-in since Sept 20	Shut-in since Sept 20	Shut-in since Sept 20
Duke Energy Field Services including CIPCO, Seabreeze and Black Lake	Shut-in (Note that most of company's natural gas assets are in Oklahoma and West TX and are not adversely affected.)	Shut-in (Note that most of company's natural gas assets are in Oklahoma and West TX and are not adversely affected.)	CIPCO has minor damage and Black Lake remains shut-in due to lack of supplies; (Note that most of company's natural gas assets are in Oklahoma and West TX and are not adversely affected.)
Duke Energy Gas Transmission	9 compressor stations shut-in. The Texas Eastern pipeline is in balance and holding pressure. The Gulfstream natural gas system is operational.	5 compressor stations shut-in, 3 others have minimal damage. The Texas Eastern pipeline is in balance and holding pressure. The Gulfstream natural gas system is operational.	The Texas Eastern pipeline is in balance and holding pressure. Most compressor stations and storage facilities affected by Rita are back on-line. The Gulfstream natural gas system is operational.
Enbridge Inc.'s Offshore System, which includes Garden Banks, Manta Ray, Nautilus, Stingray, and MS Canyon	No nominations until further notice	No nominations until further notice	No nominations until further notice
Gulf South –Lake Charles	Loss of supply	Loss of supply	Loss of supply
Kinder Morgan	Loss of supply & damage at Johnson Bayou compressor station –no gas moving downstream from that station; Force Majeure on pipelines in affected areas of TX/LA continues today.	Loss of supply & damage at Johnson Bayou compressor station –no gas moving downstream from that station; Force Majeure on pipelines in affected areas of TX/LA continues today.	Force Majeure continues on Border, Texas, North Texas, and Tejas pipelines; Natural Gas Pipeline Company of America operating although one compressor station out.
Sabine	Loss of supply	Loss of supply	Loss of supply
Southern Union's Trunkline Gas	Limited Flow in TX due to loss of supply	Limited Flow in TX due to loss of supply	Trunkline's Terrebonne System is accepting nominations for gas on starting today Sept 27. Some receipt and delivery points are not available. Trunkline LNG, in Lake Charles, LA, remains shut down Sea Robin is not accepting nominations
Tennessee Gas	20 percent of capacity with reduced supply	20 percent of capacity with reduced supply	20 percent of capacity with reduced supply
Transcontinental Gas	Loss of supply in LA	Loss of supply in LA	Loss of supply in LA
Williams –station # 44 Johnson Bayou	Unable to get to facility	Unable to get to facility	Unable to get to facility
Florida Gas Transmission	Some compressor stations down- no impact on operations	Some compressor stations down- no impact on operations	Some compressor stations down- no impact on operations

(Source: Platt's, Company web sites, and DOT)

On-Shore and Off-Shore Pipelines with Reported Supply Issues

Pipeline	Status 9/28/2006	Status 9/29/2006
ANR	20 percent of capacity with reduced supply. Still on Force Majeure.	20 percent of capacity with reduced supply. Still on Force Majeure; approximately 1.3 Bcf shut-in.
BP/Enbridge Destin pipeline	OK - Force Majeure ended Sept 27	OK, Force Majeure ended Sept 27
Chevron	Western LA facilities shut-in	Western LA facilities shut-in
Columbia Gulf Transmission	Loss of supply	Force Majeure, effective immediately for meters upstream of and including the Egan Measurement Stations due to high water at and around the Pecan Island compressor and Separation Station resulting from Hurricane Rita. CGT requires all operators and producers located upstream of this facility to keep physical flow and scheduled volumes at zero until further notice.
Comstock Offshore	Shut-in since Sept 20	Shut-in since Sept 20
Duke Energy Field Services including CIPCO, Seabreeze and Black Lake	CIPCO has minor damage and Black Lake remains shut-in due to lack of supplies; (Note that most of company's natural gas assets are in Oklahoma and West TX and are not adversely affected.)	CIPCO has minor damage and Black Lake remains shut-in due to lack of supplies; note that most of company's natural gas assets are in Oklahoma and West TX and are not adversely affected.
Duke Energy Gas Transmission	The Texas Eastern pipeline is in balance and holding pressure. Most compressor stations and storage facilities affected by Rita are back on-line. The Gulfstream natural gas system is operational.	The Texas Eastern pipeline is in balance and holding pressure. Most compressor stations and storage facilities affected by Rita are back on-line. The Gulfstream natural gas system is operational.
Enbridge Inc.'s Offshore System, which includes Garden Banks, Manta Ray, Nautilus, Stingray, and MS Canyon	No nominations until further notice. Stingray has flooding and wind damage to onshore facilities; Sea Robin delivery point damaged.	No nominations until further notice; Stingray has flooding and wind damage to onshore facilities; Sea Robin delivery point damaged.
Enterprise Product Partners GulfTerra Texas Pipeline		Shut-in after completion of Schedule Day Cycle 1, September 23, 2005 (Flow Day beginning September 24, 2005) until further notice.
Gulf South –Lake Charles	Loss of supply	May be required to schedule only primary firm capacity and implement scheduling reductions for the September 29 Gas Day and Nomination Cycle.
Kinder Morgan	Force Majeure continues on Border, Texas, North Texas, and Tejas pipelines; Natural Gas Pipeline Company of America declared Force Majeure on parts of Segment 16 (Arkoma), 23 (TGT Lowry), 24 (Col Erath, Equitable, GS Erath, and LRC) , and 26 (Sabine).	Force Majeure continues on Border, Texas, North Texas, and Tejas pipelines; Natural Gas Pipeline Company of America declared Force Majeure on parts of Segment 16 (Arkoma), 23 (TGT Lowry), 24 (Col Erath, Equitable, GS Erath, and LRC) , and 26 (Sabine). Sabine Force Majeure continues in effect at all points on the Sabine system. Power remains out in most areas of the system. Efforts are underway to remove standing water from Sabine's Henry facilities.
Southern Union's (Panhandle Energy) Trunkline and Sea Robin	Trunkline's Terrebonne System is accepting nominations for gas on starting today Sept 27. Some receipt and delivery points are not available. 28 receipt points are now cleared for flow, up from 17.Trunkline LNG, in Lake Charles, LA, remains shut down. Florida Gas Transmission fully operational. Sea Robin has damage at its delivery point.	Trunkline's Terrebonne System is accepting nominations for gas on starting today Sept 27. Some receipt and delivery points are not available. 28 receipt points are now cleared for flow, up from 17. Trunkline LNG, in Lake Charles, LA, remains shut down. Florida Gas Transmission fully operational. Sea Robin has damage at its delivery point; it is not accepting nominations.
Tennessee Gas	20 percent of capacity with reduced supply	Tennessee is lifting the system wide OFO Balancing Alert effective immediately. However, Tennessee reminds customers to flow scheduled volumes to avoid the necessity of issuing ar Operational Flow Order in accordance with tariff provisions. Tennessee has identified several leaks and instances of flooding that will limit the operational flexibility of its system. There are also several points that remain shut in due to Force Majeure declarations on other pipelines.
Transcontinental Gas	Loss of supply in LA	
Williams –station # 44 Johnson Bayou	Unable to get to facility	Most Williams facilities are returning toservice. The Transco and Gulfstream natural gas pipeline systems have remained operational throughout hurricanes Rita and Katrina, although volumes were reduced on both systems because of producers' storm related supply shut-ins. Transco is experiencing continued power outages and other storm related logistics in Louisiana, specifically in the Lake Charles and Eunice areas. Nominations will not be accepted on the Southeast Louisiana Lateral due to damage to Transco and 3rd party facilities as a result of Hurricane Rita. The pre-hurricane volume from these locations that will be impacted is approximately 80 MMcf/d. Black Marlin offshore pipeline is now operational and ready for gas as of Sept 26; The only report of significant damage so far is at the company's Cameron Meadows natural gas processing plant near Johnson Bayou, LA.
Florida Gas Transmission	Some compressor stations down- no impact on operations	

Sources: Company web sites, and DOT.)

3.3. Natural gas prices

Figure 3.3.1 shows monthly U.S. natural gas prices for different types of consumers, obtained from EIA's Short-Term Energy Outlook Query System (http://tonto.eia.doe.gov/STEO_Query/app/). Figures 3.3.2 to 3.3.4 display monthly natural gas prices, by region, for different types of consumers. Figure 3.3.5 shows monthly natural gas cost for electric utilities.

The price peak after Hurricane Katrina was especially noticeable in the cost of natural gas to electric utilities and in the natural gas prices in the Northeast.

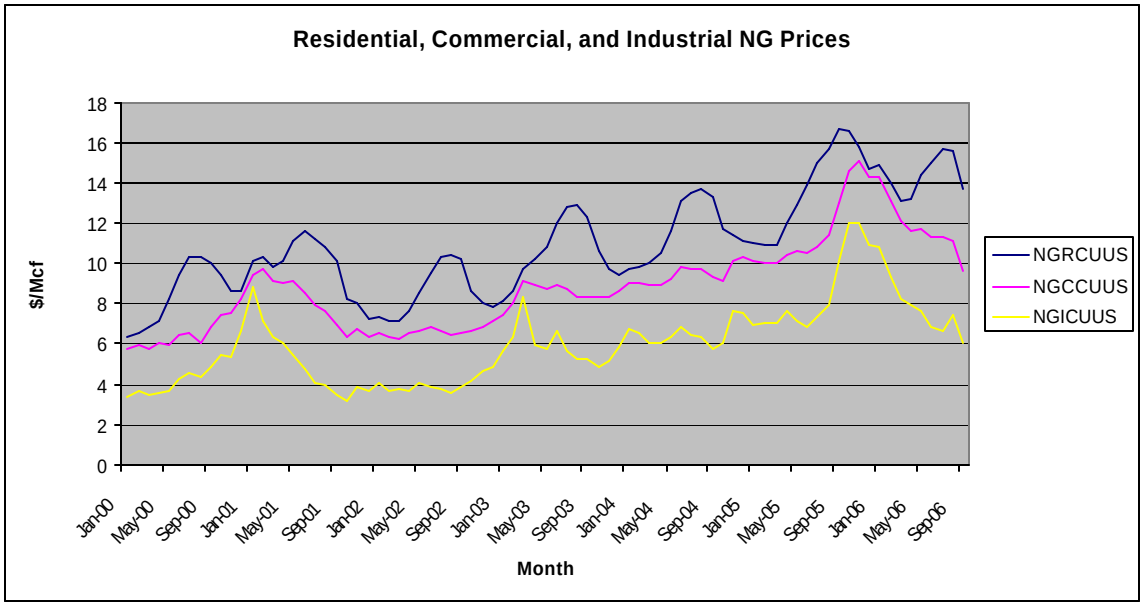

Figure 3.3.1. Residential, commercial, and industrial monthly natural gas prices.

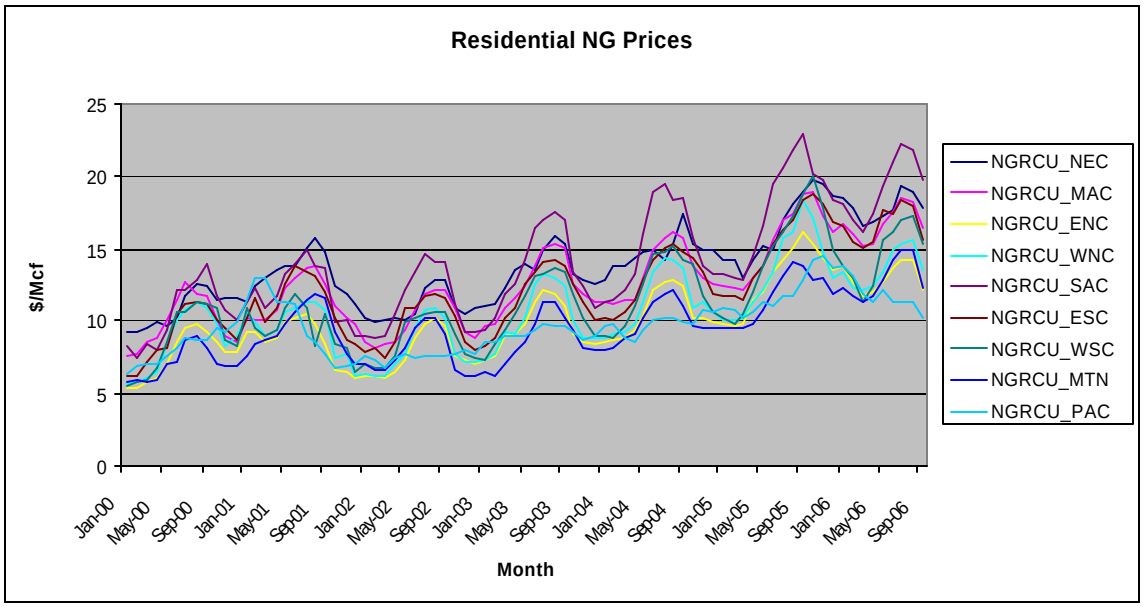

Figure 3.3.2. Residential monthly natural gas prices.

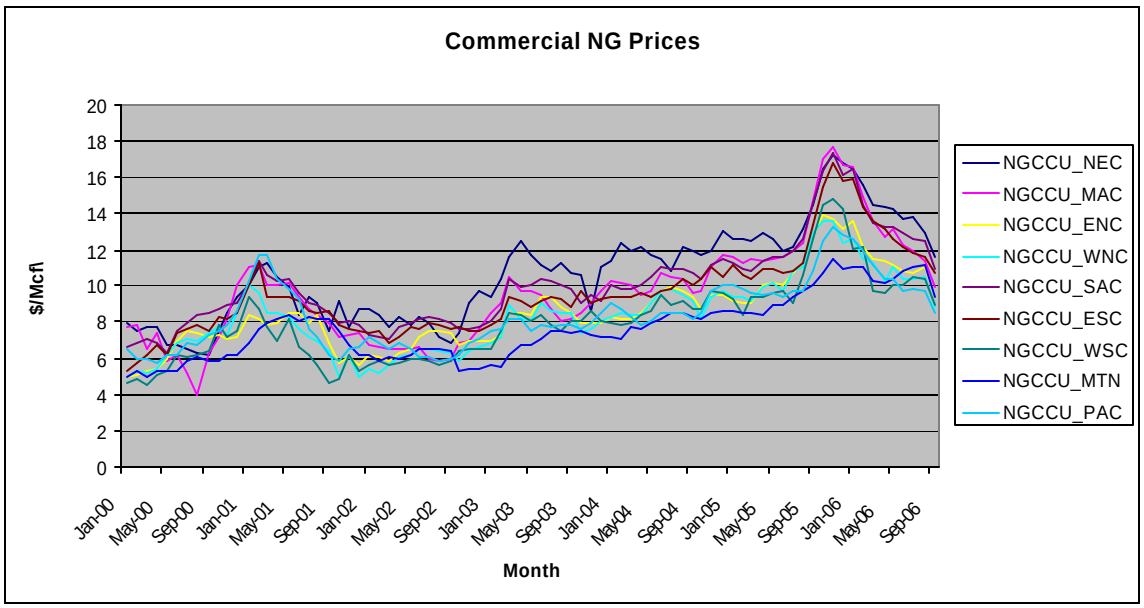

Figure 3.3.3. Commercial monthly natural gas prices.

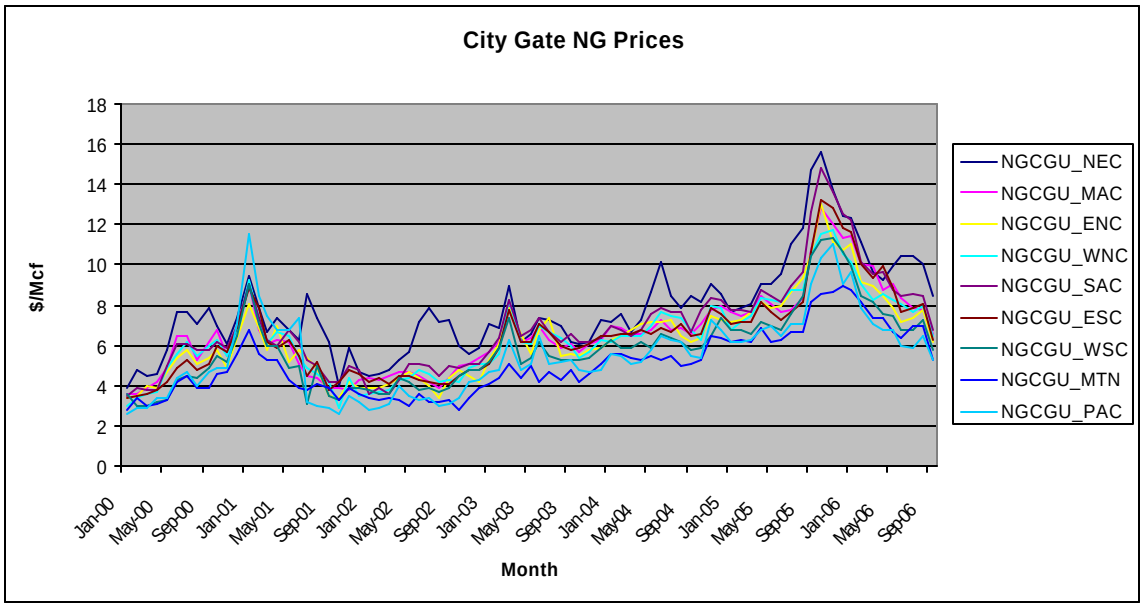

Figure 3.3.4. City gate monthly natural gas prices.

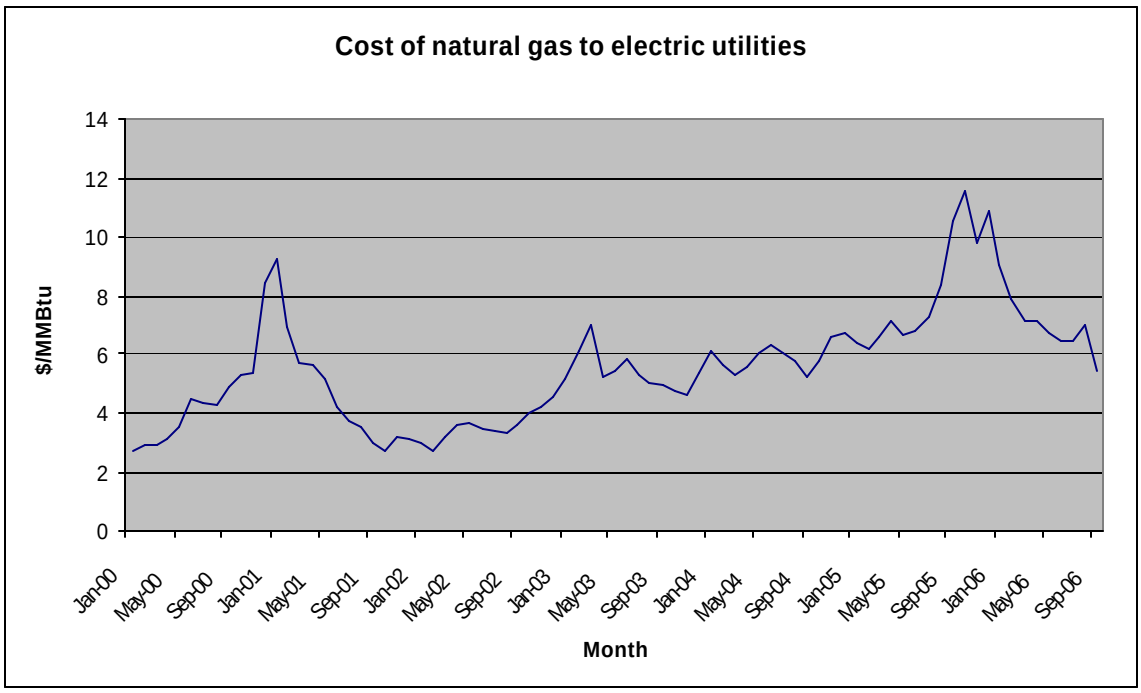

Figure 3.3.5. Monthly natural gas cost to electric utilities.

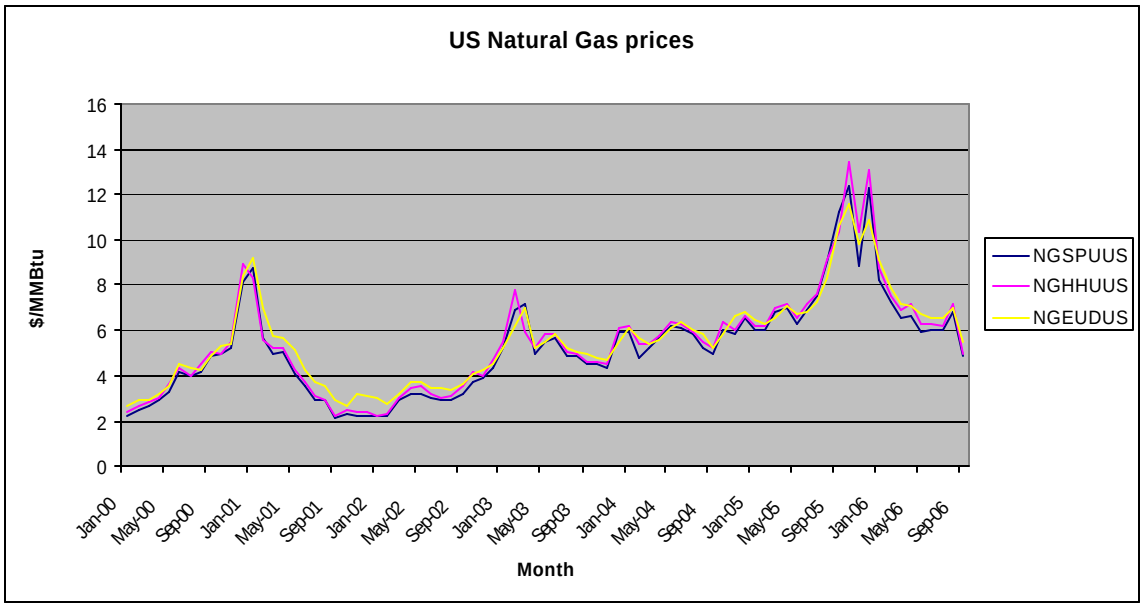

Figure 3.3.6. US natural gas prices.

3.4. Summary

Natural gas production in the Gulf of Mexico and Texas corresponds approximately to 50% of the total US production. Therefore, due to the relative importance of natural gas production in the areas more hardly hit by the hurricanes in terms of the total national production, it is not a surprise that a spike in prices of natural gas could be observed nationwide, and that these effects of this price increase permeated to the coal and electricity subsystems as well.

At the peak of the Hurricane Katrina, a recorded 88% of daily gas production in the Gulf of Mexico was shut-in., and approximately 80% of the natural gas was shut-in after Rita. The recovery was not fast: at the end of 2005 approximately 2000 MMcf/D remained shut-in. But not only natural gas production was affected; natural gas transportation was hit hardly too. The number of disruptions in natural gas pipelines increased dramatically due to the hurricanes with respect to other periods, especially due to heavy rains and floods. These changes in natural gas production and transportation capacity are of extreme importance for an adequate modeling of the event in the NEES network model.

Particularly, the capacity of the arcs representing natural gas production in the Gulf of Mexico, in Louisiana and Arkansas, and in Texas needs to be adjusted accordingly for the months after the hurricanes. All of these arcs go to the natural gas transshipment node corresponding to the region (Southwest node). The capacity of the arc representing natural gas production in Mississippi and Alabama (connecting to the Southeast transshipment node) also needs to be adjusted.

Furthermore, in order to appropriately model the impact of hurricanes Katrina and Rita to natural gas pipelines, capacity of the arcs representing natural gas transmission between different transmission areas (arcs connecting 2 different natural gas transshipment nodes) needs to be adjusted. In particular, the transmission arcs in the NEES model aggregating pipelines which operation was affected by the hurricanes are: Southwest-Central, Southwest-Western, and Southwest-Southeast. The most important of these is the Southwest-Southeast arc, in view of the fact that according to previous simulations performed using the NEES network model this arcs operates at maximum capacity. Operation at maximum capacity (a binding upper bound) is associated to congestion in the natural gas transmission system going from Southwest to Southeast. Therefore, any reduction of the capacity of this arc will lead to an increase in the marginal prices in other nodes of the system. This assertion is further confirmed by analyzing the natural gas price spike in different parts of the system following the hurricanes.

An interesting situation can be observed in the natural gas storage. Due to the shortage in natural gas production and the transportation problems, it was expected to see some depletion of the natural gas in underground storage. However, it seems that the natural gas demand decreased due to the high prices, and therefore at the end of the winter the storage levels were even higher than in previous years. This observation suggests us to consider an elastic natural gas demand in our model.

Finally, we can say that natural gas marginal prices at different nodes can be used as an indicator of how the effects of the hurricanes propagated through the system. Also, natural gas prices in Section 3.3 can be compared to nodal prices obtained by simulation in the NEES network model for the sake of validation of the model.

4. Coal

Over 50% of the total electricity produced in the U.S. uses coal as its primary energy source. Chapter 4 presents data reflecting hurricanes Katrina and Rita's effects in coal production, transportation, storage levels, and price. Even tough there were no major damages of the hurricanes to coal facilities (coal mines in the area are not close to the coast), there was a suspicion that the patterns of coal production and transportation may have been somehow altered as a result of coal being a substitute fuel for natural gas in what refers to electricity generation.

This chapter is organized as follows: Section 4.2 presents data about coal production, storage, and consumption, Section 4.3 presents data on coal transportation, and Section 4.4 presents data on coal prices.

Data for this section was gathered from many different sources, among others EIA's website, OE daily situation reports, news releases, and on-site interviews.

4.1. Coal production, storage, and consumption

The area directly affected by the hurricanes is not a major producer of coal. As shown in Figure 4.1.1, coal production at the national level seems to remain unaffected by the event. The data was obtained from obtained from EIA's Short-Term Energy Outlook Query System (http://tonto.eia.doe.gov/STEO_Query/app/).

In Figure 4.1.2 can be observed the coal stock levels of the electric power sector. Coal stock levels over the years follow a seasonal behavior: the level decreases during the months of more electric energy consumption (in the Winter and Summer), and increases during the months of less consumption (in the Fall and Spring). From the data presented in Figure 4.1.2, it seems that during the Fall season following Katrina, the coal stocks did not recover as usual, probably because the high natural gas prices at the time motivated a shift to cheaper coal-fired generation, and therefore coal reserve levels could not recover

as usual. However, due to the fact that the large amount of coal in storage by the electric sector serves as a buffer, the impact was apparently not poured out to coal production.

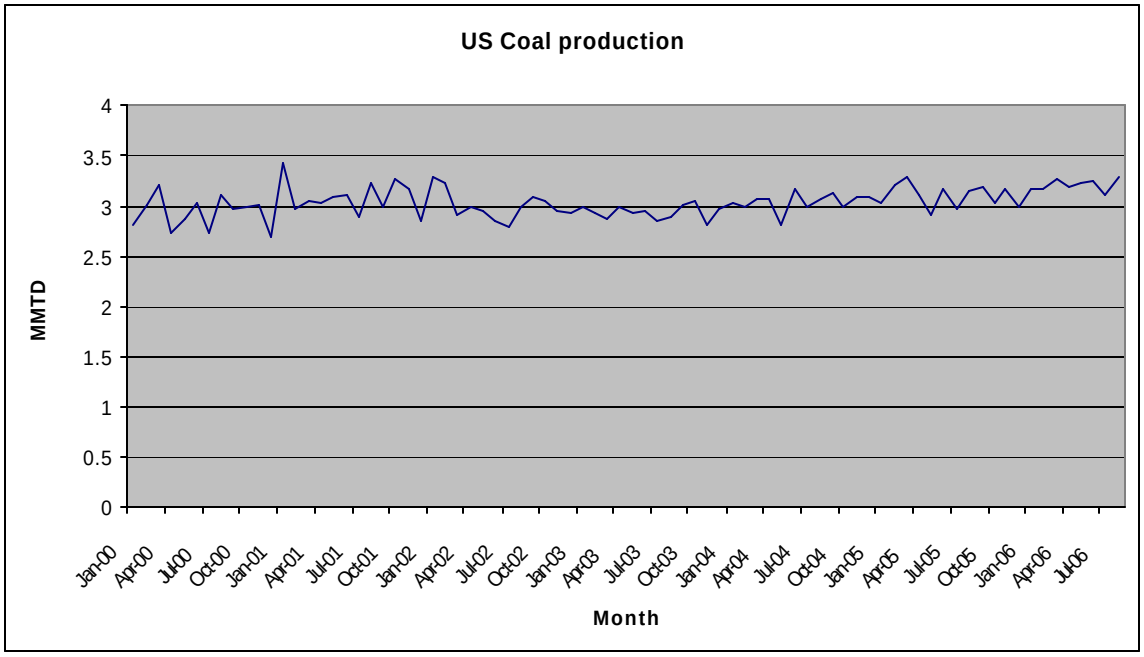

Figure 4.1.1. U.S. coal production

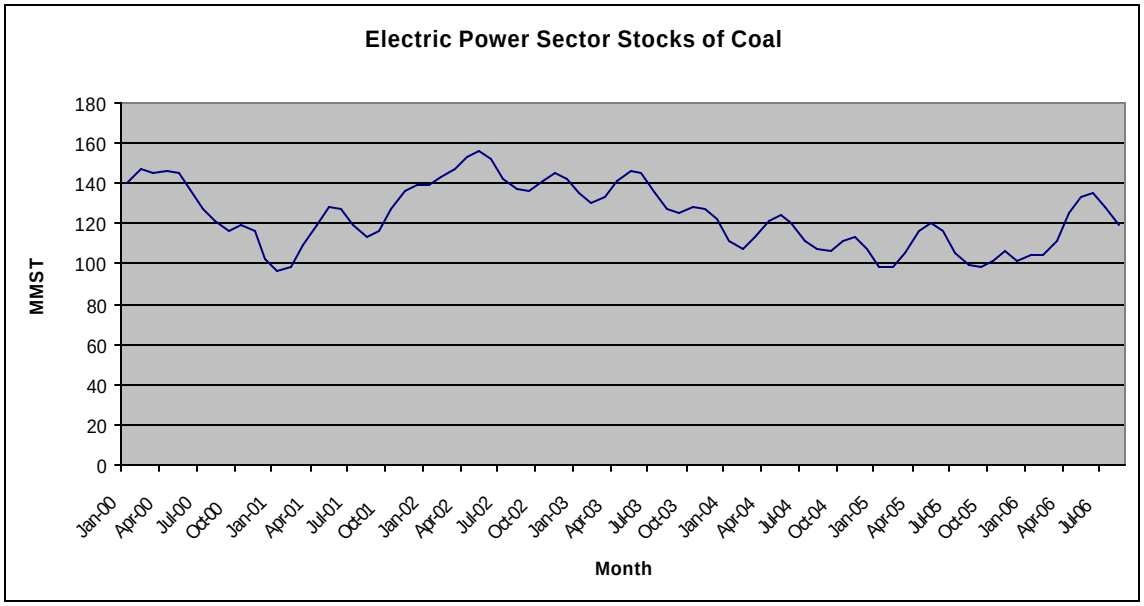

Figure 4.1.2. Electric sector coal storage.

According to a OE situation report on 9/9/05, in the aftermath of Katrina: "*Coal analysts estimated that Hurricane Katrina may impact coal consumption this fall because coal-fired plants that typically ramp down following the peak summer months may be required to continue generating at high levels to make up for the gap caused by damage to gas production*". Even though Figure 4.1.3 seems to somehow support this prediction, the effect was not that obvious, at least at the national level. If data were available, maybe the predicted effect of Katrina may be perceived better at the regional level.

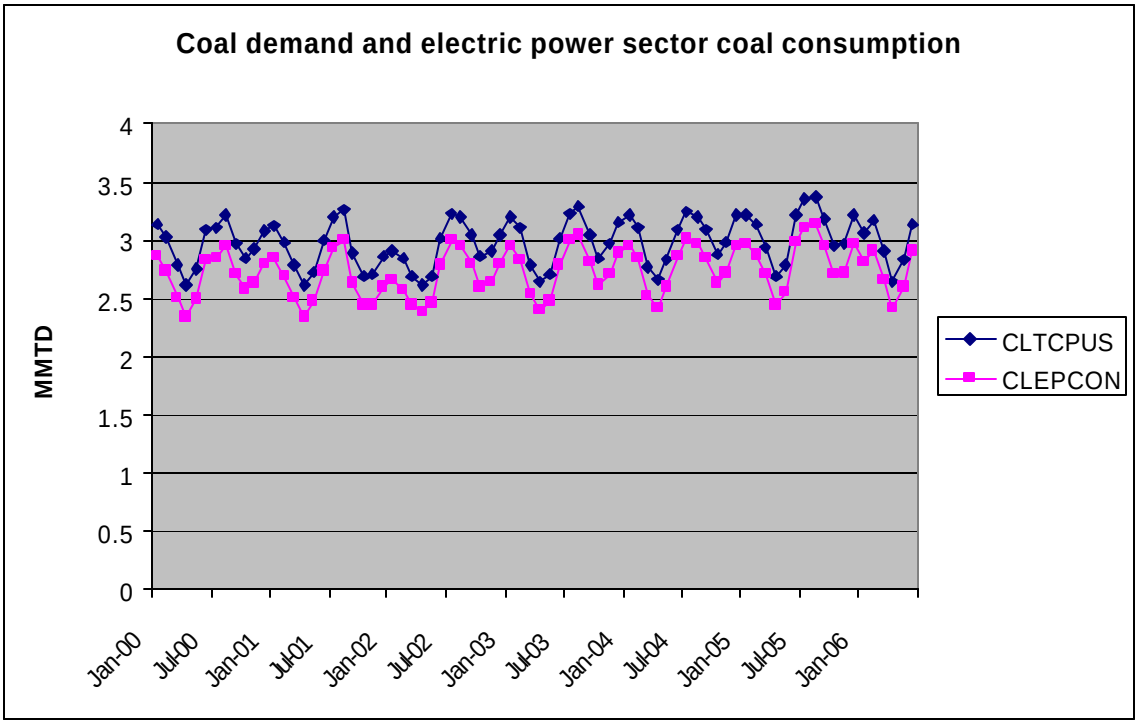

Figure 4.1.3. Coal demand.

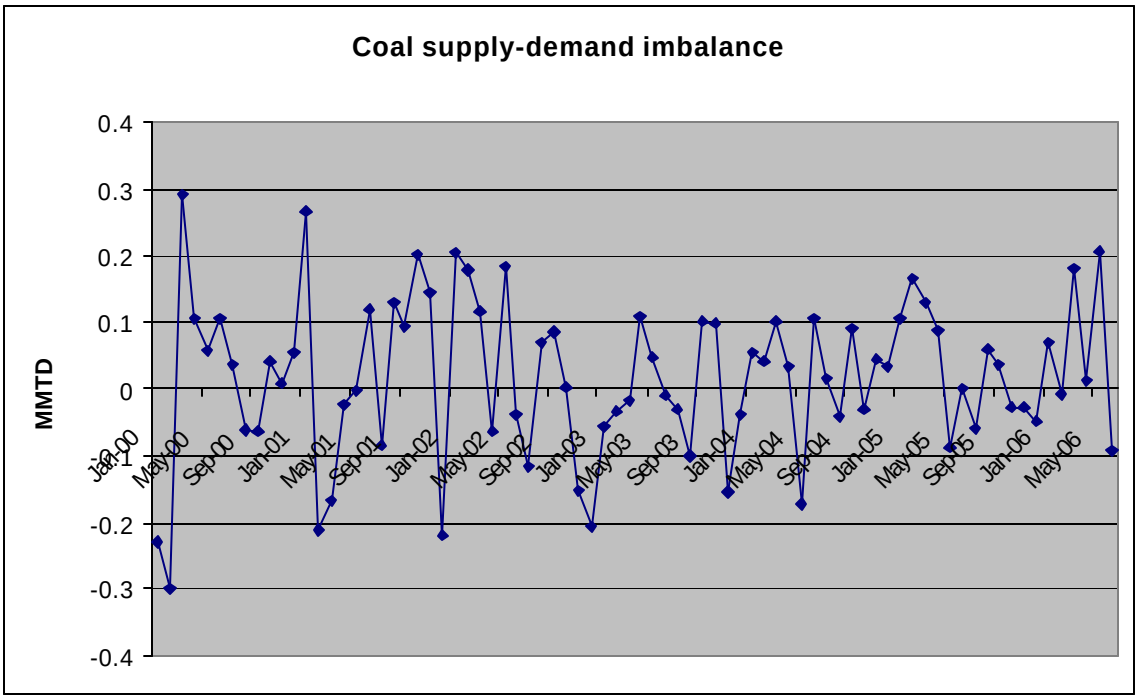

Figure 4.1.4. Coal supply-demand imbalance.

4.2. Coal transportation

Barge transportation

The Mississippi river is heavily used for barge transportation of coal. Barge transportation was interrupted in the southern part of the river for several weeks following hurricane Katrina. There is not information readily available for coal movements in the southern part of the river, but the U.S. Army Corps of Engineers website provides tonnage information for different commodities moved trough the locks system located north of St. Louis (see figure 4.2.1).

Figure 4.2.1. Locks on Mississippi and Illinois Rivers (source: U.S. Army Corps of Engineers website)

Figure 4.2.2 shows weekly movements of coal through a few selected locks. 200-2005 data for the month of September is presented for the sake of detecting any possible effect that coal movements may have suffered north of Saint Louis as a consequence of hurricane Katrina. From the data, there does not seem to be any significant effect of Katrina in coal barge transportation north of Saint Louis.

Even though readily available data on coal movements south of Saint Louis is limited, from on-site interviews to coal-handling companies in the New Orleans area, the researchers could learn some of the effects of Katrina in coal barge transportation in the Southern part of the Mississippi river. Except for TECO's bulk terminal in Davant, Louisiana, hurricane Katrina didn't cause major damages in other coal-handling terminals. Nevertheless, the traffic in the river was totally interrupted for nearly 1 week from mile 125 to the south. Then, the river was reopened with limited capacity (in terms of the deep of the vessels). But the main problem was the limited number of pilots (Pilot City at mile 0 was affected), to the point that there were 2 week delays in some vessels.

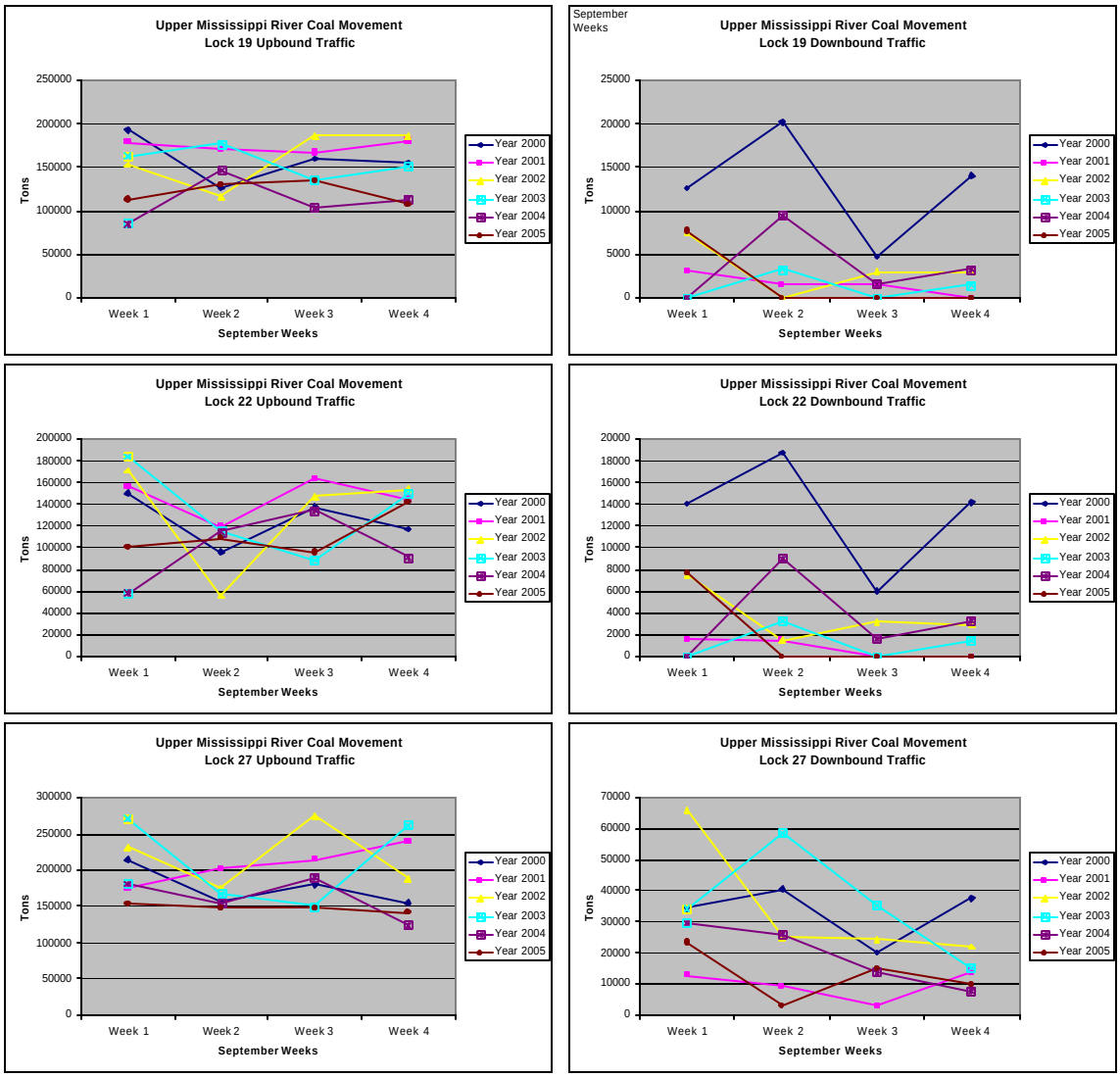

Figure 4.2.2. Coal movements for the month of September in the Upper Mississippi River

As mentioned, TECO's bulk terminal in Davant suffered extensive damage. TECO Energy has 4400MW of coal-fired power plants in Florida, and the coal they use is extracted mainly from the Illinois Basin, then transported by barge to TECO bulk terminal in Davant, where it is sometimes blended with imported coal, and finally shipped by ocean vessels to be used in their coal-fired power plants in Florida. Katrina wiped out TECO's Davant facilities, which were completely flooded. Half of their 165 employees lost everything. Infrastructure was already operational in November, but they didn't have the employees to operate full capacity. As of March 2006, they were

operating in a 7 days on – 7 days off schedule because of their employee's situation. At that point they were being able to handle all their coal business, but the transportation of other commodities was somewhat interrupted. Katrina altered all the logistics chain of the company. For example, their barges already on the river were not able to unload, and at the beginning the interruption in the supply chain was temporarily solved by shipping coal directly by rail to the power plants in Florida[6].

Rail transportation

In October 5, 2005, Norfolk Southern news release indicated that: *"Norfolk Southern reopened its intermodal terminal in New Orleans October 3. The facility had been closed since Hurricane Katrina struck the Gulf Coast Aug. 29. The terminal is now accepting inbound and outbound shipments at the gate. Due to local curfews, the terminal will operate from 8 a.m. to 4 p.m., Monday through Friday.*
NS also reopened its Oliver Yard Terminal in New Orleans, which serves local industrial customers and interchanges freight with the New Orleans Public Belt Railroad."

According to a CSX news release in January 18, 2006, *"CSX Transportation is resuming local freight rail service on its Gulf Coast line, a vital transportation artery to New Orleans. Service through the entire area is expected to be restored beginning in early February..... Over the past five months, the company has been working to restore six major bridges, more than 40 miles of track, and its major rail yard in New Orleans. The largest engineering challenge was the nearly two-mile bridge at Bay St. Louis, Miss. More than 300 CSXT employees in the Gulf region were affected by Hurricane Katrina, and many took advantage of assistance offered by the company that included disaster relief payments and temporary jobs in other regions. Many transferred employees will be returning to the area as operations resume."*

4.3. Coal prices

Figure 4.3.1 shows the cost of coal for electric power plants.

[6] To provide some reference, each barge can hold approximately 1600 tons, in contrast to trains which can hold approximately 100 tons/unit train.

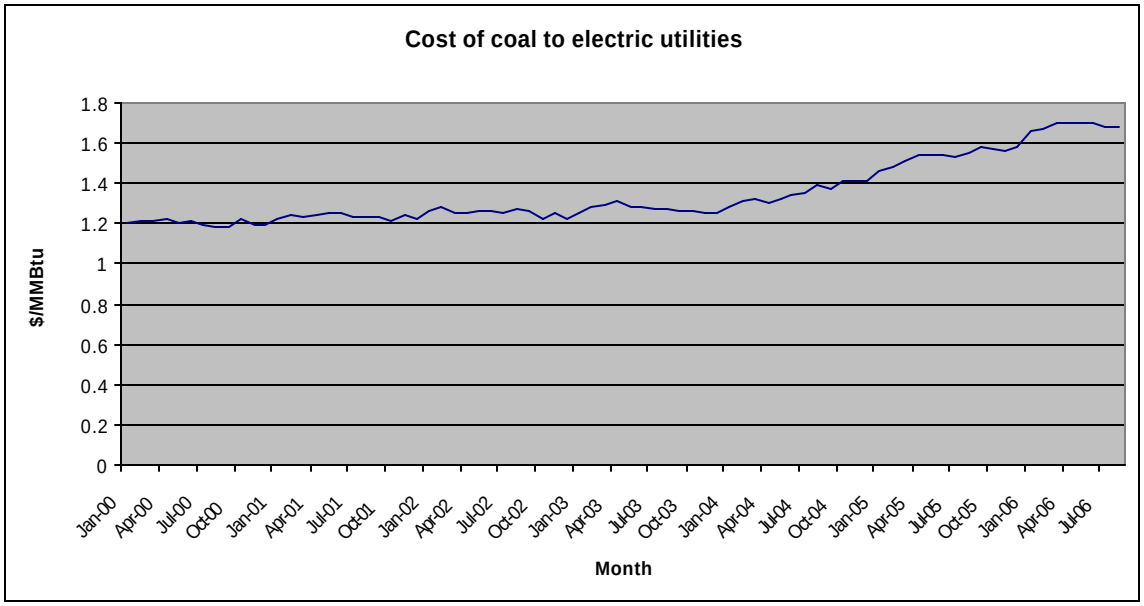

Figure 4.3.1. Cost of coal to electric utilities.

Coal prices only increased after January, maybe because coal storage levels in the electric sector had reached a low threshold after the not recovery of the storage levels in the Fall and subsequent higher consumption during the Winter months. The attempt by the electric power companies to maintain their coal storage at a reasonable size may have motivated a price jump in January

4.4. Summary

From the coal data collected, we can say that no significant coal production facilities were affected by the hurricanes. We also consider that the effects in coal transportation facilities were short-lived and somehow dampened by the coal storage stocks and by the use of alternative transportation paths. Therefore, at this point no changes in the capacities of the arcs of the coal component of the NEES network model seem to be necessary.

It seems that during the fall months following Katrina, the coal stocks did not recover as usual, probably because the high natural gas prices motivated a shift to cheaper coal-fired generation, and therefore coal reserve levels could not recover as

usual. However, due to the fact that the large amount of coal in storage by the electric sector serves as a buffer, the impact was apparently not poured out to coal production. Coal prices only increased after January, maybe because coal storage levels in the electric sector had reached a low threshold after the not recovery of the storage levels in the Fall and subsequent higher consumption during the Winter months. The attempt by the electric power companies to maintain their coal storage at a reasonable size may have motivated a minor price jump in January. The data collected about coal price and storage levels will be useful to be compared with simulation results of the NEES network model for validation purposes.

5. Conclusions

This report presented energy-related data before, during, and following hurricanes Katrina and Rita, with the aim of better understand the effects of catastrophic events on the bulk energy transportation system in the U.S. The data reflects the hurricanes effects in terms of changes in production, transportation, storage, and prices of different energy forms. Where possible, data was gathered to reflect conditions for the months or years before and for the months following the hurricane.

Electric system

Detailed data on disruptions in electric generation, transmission, and distribution, as well as electric energy prices and information on restoration efforts were presented in Section 2 of this report.

Transmission and distribution facilities in areas affected by the hurricanes sustained heavy damage. Since in general electric transmission and distribution facilities are very exposed to the elements, natural event like hurricanes will likely cause a temporary electric load reduction because of the damage in transmission and distribution equipment. As a consequence, even though some electric generating facilities were affected by the hurricanes, the damage in transmission equipment and the virtual destruction of the distribution systems in the area affected by Hurricane Katrina caused a forced reduction of electric load, and therefore no generation shortage could be perceived.

Electric energy prices in different power markets were also collected, as they can be a useful indicator of how the destructive effects of the hurricanes propagated geographically, as well as to recognize interdependencies between different subsystems.

Natural gas system

Data on natural gas production shut-in, pipelines disruptions, natural gas prices, and restoration efforts was presented in Section 3 of this report. Of all the energy subsystems included in our NEES model, the natural gas production and transportation system was the most affected.

Natural gas production in the Gulf of Mexico and Texas corresponds approximately to 50% of the total US production. Therefore, due to the relative importance of natural gas production in the area in terms of the total national production, it is not a surprise that a spike in prices of natural gas could be observed nationwide, and that these effects of this price increase permeated to the coal and electricity subsystems as well.

At the peak of the Hurricane Katrina, a recorded 88% of daily gas production in the GOM was shut-in., and approximately 80% of the natural gas was shut-in after Rita. By the end of 2005 approximately 2000 MMcf/D of the natural gas production capacity in the GOM remained shut-in. Several natural gas pipelines and processing plants in the area suffered disruptions or limitations on their normal operations, mainly due to heavy rains and floods caused by the hurricanes. With respect to other periods, a dramatic increase in the number of disruptions could be observed after the hurricanes.

A significant increase in natural gas prices could be observed after Hurricane Katrina. From the storage data, we can also say that the spike in natural gas prices after the hurricanes caused a reduction of its demand, as the natural gas storage level at the end of the following winter, which was higher than in previous years, seems to confirm.

Coal system

Section 4 of this report presented data on coal production, transportation, storage, consumption, and prices.

No significant coal production facilities were affected by the hurricanes. Despite the fact that some coal transportation facilities sustained heavy damage as a consequence of Hurricane Katrina, it seems that overall the effects in the coal subsystem were short-lived and almost negligible, if any. This robustness of the coal subsystem is probably due to the leverage offered by the large coal storage stocks and by the possibility of using alternative transportation paths.

Inter-dependencies between energy subsystems

The most noticeable interdependency between energy subsystems was the impact of high natural gas prices as a consequence of the hurricanes on the coal and electric

subsystems. Through price and availability of natural gas the effects of the disruptions permeated and propagated to the coal and electric subsystems.

During the fall months following Katrina, the coal stocks did not recover as usual. Probably because of the high natural gas prices and the coal being a substitute of natural gas in what regards to electric energy generation, cheaper coal-fired generation may have replaced natural gas generation and therefore coal reserve levels could not recover as usual. However, due to the fact that the large amount of coal in storage by the electric sector serves as a buffer, the impact was apparently not poured out to coal production. Coal prices only increased after January, maybe because coal storage levels in the electric sector had reached a low threshold after the not recovery of the storage levels in the Fall and subsequent higher consumption during the Winter months. It seems likely that the attempt by the electric power companies to maintain their coal storage at a reasonable level may have increased the demand for coal and motivated a minor price jump in January.

Use of the data in the NEES model

The most appropriate way to model the impact of the hurricanes in the electricity component of the NEES structural model is by reducing the electrical demand in the EES and ERCOT transshipment nodes. Also, some minor adjustment may also be necessary to adjust the capacity of the arcs representing generation, but this adjustment does not seem at this point to be critical, given the small size of most of the units out of service and the short period that the larger units remained off-line (in particular Waterford). Adjustments on the capacity of the arcs representing transmission capability between different regions (transshipment nodes) do not seem to be necessary.

Due to the magnitude of the disruption and to their relative weight at the national level, changes in natural gas production and transportation capacity caused by Katrina seem to be of the utmost importance for an adequate modeling of the event in the NEES network model. Particularly, the capacity of the arcs representing natural gas production in the Gulf of Mexico, in Louisiana and Arkansas, and in Texas needs to be adjusted accordingly for the months after the hurricanes. All of these arcs go to the natural gas transshipment node corresponding to the region (Southwest node). The capacity of the

arc representing natural gas production in Mississippi and Alabama (connecting to the Southeast transshipment node) also needs to be adjusted. Moreover, in order to appropriately model the impact of hurricanes Katrina and Rita to natural gas pipelines, capacity of the arcs connecting 2 different natural gas transshipment nodes needs to be adjusted. In particular, the transmission arcs in the NEES model which consider pipelines which operation was affected by the hurricanes are: Southwest-Central, Southwest-Western, and Southwest-Southeast. The most important of these is the Southwest-Southeast arc, in view of the fact that according to previous simulations performed using the NEES network model this arcs operates at maximum capacity. Operation at maximum capacity (a binding upper bound) is associated to congestion in the natural gas transmission system going from Southwest to Southeast. Therefore, any reduction of the capacity of this arc will lead to an increase in the marginal prices in other nodes of the system. This assertion is further confirmed by analyzing the natural gas price spike in different parts of the system following the hurricanes. Also, the natural gas storage data suggests us to consider an elastic natural gas demand in our model.

At this point, no changes in the capacities of the arcs of the coal component of the NEES network model seem to be necessary. The data collected about coal price and storage levels will prove to be useful when compared with simulation results of the NEES network model for validation purposes.

Finally, we can say that natural gas marginal prices at different nodes can be used as an indicator of how the effects of the hurricanes propagated through the system. In the same lines, electric energy, natural gas, and coal prices can be compared to nodal prices obtained by simulation in the NEES network model for the sake of validation of the model.

As a final remark, from the observation of the data collected we believe that, despite the magnitude of the event, the bulk energy behaved within reasonable limits. From a reliability standpoint, the bulk energy system seems to be pretty robust, and able to tolerate large and multiple disruptions. An important factor helping with this robustness

is coal storage, that can dampen the negative effects caused by disruptions in infrastructure of the U.S. energy system.

Appendix

Entergy's transmission system has 15,500 miles of lines between 69kV and 500kV spread over 4 states (Texas, Louisiana, Mississippi, and Arkansas).

Extracted from Entergy financial release, September 20, 2005.

Appendix A provides Hurricane Katrina Outage Restoration Statistics.

Table 1: Outage Restoration Status – Retail Customer Outages
Current Status vs Storm Peak

Number of Retail Customer Outages	Electric			Gas		
	Total as of 9/19/2005	Extended Restoration	Total as of Storm Peak	Total as of 9/19/2005	Extended Restoration	Total as of Storm Peak
(in thousands)						
Entergy Gulf States – LA	-	-	107	-	-	-
Entergy Louisiana	45	35 - 40	507	NA	NA	NA
Entergy Mississippi	-	-	302	NA	NA	NA
Entergy New Orleans	173	115 - 130	172	95	95	96
Total Customer Outages	218	150 - 170	1,088	95	95	96

Table 2: Outage Restoration Status – Transmission Line & Substation Outages
Current Status vs Storm Peak

Transmission Lines	Total as of 9/19/2005	Total as of Storm Peak	Substations	Total as of 9/19/2005	Total as of Storm Peak
(count: #)			(count; #)		
Entergy Gulf States – LA	1	32	Entergy Gulf States – LA	-	36
Entergy Louisiana	-	90	Entergy Louisiana	11	86
Entergy Mississippi	16	41	Entergy Mississippi	-	117
Entergy New Orleans	12	19	Entergy New Orleans	12	24
Total Transmission Line Outages	29	182	Total Substation Outages	23	263

Table 3: Outage Restoration Status – Fossil Fleet Impacted by Hurricane Katrina
Current Status vs Storm Peak

Plant	Unit	Owned Capability (a)	Fuel Type	Purpose	As of 9/19/2005	As of Storm Peak
Entergy Louisiana						
Buras	8	12	Gas/Oil	Peaking	Extensive Flooding (EF)	Outage
Little Gypsy	1	238	Gas/Oil	Intermediate	Returned to Svc (RTS)	Outage
Little Gypsy	2	415	Gas/Oil	Intermediate	RTS	Outage
Little Gypsy	3	545	Gas/Oil	Intermediate	RTS	Outage
Ninemile Point	1	50	Gas/Oil	Peaking	RTS	Outage
Ninemile Point	2	60	Gas/Oil	Peaking	RTS	Outage
Ninemile Point	3	125	Gas/Oil	Intermediate	RTS	Outage
Ninemile Point	4	730	Gas/Oil	Intermediate	RTS	Outage
Ninemile Point	5	740	Gas/Oil	Intermediate	RTS	Outage
Waterford	1	411	Gas/Oil	Intermediate	RTS	Outage
Waterford	2	411	Gas/Oil	Intermediate	RTS	Outage
Entergy New Orleans						
A. B. Paterson	3	50	Gas/Oil	Peaking	EF	Outage
A. B. Paterson	4	-	Gas/Oil	Peaking	EF	Outage
A. B. Paterson	5	11	Oil	Peaking	EF	Outage
Michoud	1	65	Gas/Oil	Peaking	EF	Outage
Michoud	2	244	Gas/Oil	Intermediate	EF	Outage
Michoud	3	545	Gas/Oil	Intermediate	EF	Outage

(a) Owned Capability is the dependable load carrying capability as demonstrated under actual operating conditions based on the primary fuel (assuming no curtailments) that each unit was designed to utilize.

Extracted from Entergy financial release, October 5, 2005.

Appendix A provides Hurricane Rita & Katrina Outage Restoration Statistics.

Table 1: Outage Restoration Status – Retail Customer Outages
Current Status vs. Storm Peak

Number of Retail Customer Outages	Electric			
	Total (a) as of 10/4/2005 @ 3:00 p.m.	Katrina Extended Restoration	Rita (b) Total as of Storm Peak	Katrina Total as of Storm Peak
(in thousands)				
Entergy Arkansas	-	-	62	-
Entergy Gulf States - LA	32	-	188	107
Entergy Gulf States - TX	131	-	287	-
Entergy Louisiana	3	34	149	507
Entergy Mississippi	-	-	30	302
Entergy New Orleans	14	122	50	172
Total Customer Outages	180	156	766	1,088

(a) Katrina extended restoration customer count has been removed from total as of 10/4/05
(b) Rita count includes Entergy Louisiana and Entergy New Orleans customers impacted by Hurricane Katrina who remained out of power during Hurricane Rita

Table 2: Outage Restoration Status – Transmission Line & Substation Outages
Current Status vs Storm Peak

Number of Outages	Transmission Lines			Substations		
	Total as of 10/4/2005 @3:00 p.m.	Rita Total as of Storm Peak	Katrina Total as of Storm Peak	Total as of 10/4/2005 @3:00 p.m.	Rita Total as of Storm Peak	Katrina Total as of Storm Peak
Entergy Arkansas	2	4	-	-	6	-
Entergy Gulf States - LA	39	139	32	25	167	36
Entergy Gulf States - TX	97	179	-	103	231	-
Entergy Louisiana	11	17	90	3	8	86
Entergy Mississippi	-	5	41	-	24	117
Entergy New Orleans	10	-	19	11	-	24
Total Outages	159	344	182	142	436	263

Table 3: Outage Restoration Status – Utility Fossil-Fueled Fleet Affected by Hurricanes Rita & Katrina
Current Status vs Storm Peak

Plant	Unit	Capability (c)	Fuel Type	Purpose	As of 10/4/05	As of Storm Peak
Hurricane Rita						
Entergy Gulf States						
Lewis Creek	1	226	Gas/Oil	Intermediate	Online	Online
Lewis Creek	2	230	Gas/Oil	Intermediate	Online	Online
Toledo Bend (d)	1	40	Hydro	Peaking	Available for Restart with T/D resolution (AFR – T/D)	Outage
Toledo Bend (d)	2	40	Hydro	Peaking	AFR – T/D	Outage
Roy S. Nelson (d)	1	110	Gas/Oil	NISCO Unit	Returned to Service (RTS)	Outage
Roy S. Nelson (d)	2	105	Gas/Oil	NISCO Unit	RTS	Outage
Roy S. Nelson	3	153	Gas/Oil	Intermediate	RTS	Operating but Disconnected
Roy S. Nelson	4	500	Gas/Oil	Intermediate	Outage	Outage
Roy S. Nelson (e)	6	385	Coal	Base	Outage	Outage
Sabine	1	212	Gas/Oil	Intermediate	Outage	Outage
Sabine	2	212	Gas/Oil	Intermediate	Outage	Outage
Sabine	3	390	Gas/Oil	Intermediate	Start-up Mode	Outage
Sabine	4	525	Gas/Oil	Intermediate	Outage	Outage
Sabine	5	470	Gas/Oil	Intermediate	RTS	Outage

Nomenclature

AFR-T/D	Available for Restart with Transmission & Distribution Resolution
AGA	American Gas Association
AK	Arkansas
AL	Alabama
BCFD	Billion Cubic Feet per Day
CLECO	Cleco Power LLC
CLEPCON	Electric Power Sector Coal Consumption
CLTCPUS	Total coal demand
CRS	Congressional Research Service
DEMCO	Dixie Electric Membership Corp
DOE	Department of Energy
DOT	Department of Transportation
ECAR	East Central Area Reliability Council
EES	Entergy Electric System
EF	Extensive Flooding
EGSI	Entergy Gulf States Inc
EIA	Energy Information Administration
ELI	Entergy Louisiana Inc
ENOI	Entergy New Orleans Inc
EPAOFMS	Electric Power Associations of Mississippi
ERCOT	Electric Reliability Council of Texas, Inc
FERC	Federal Electric Regulatory Commission
FL	Florida
FRCC	Florida Reliability Coordinating Council
GOM	Gulf of Mexico
INGAA	
ISO	Independent System Operator
LA	Louisiana
MAAC	Mid-Atlantic Area Council
MISO	Midwest Independent System Operator

MMBtu	Million Btu
MMcf or Mcf	Million Cubic Feet
MMcfd	Million Cubic Feet per Day
MMS	Mineral Management Service
MMST	Million Short-Tons
MMTD	Million Short-Tons per Day
MS	Mississippi
MW	Megawatt
NA	Not Available
NE-ISO	New England Independent System Operator
NEES	National Electric Energy System
NERC	North America Electric Reliability Council
NGCCUUS	Price of natural gas, commercial sector
NGCCU_NEC	Natural Gas, Commercial Delivered Price, New England Census Region
NGCCU_MAC	Natural Gas, Commercial Delivered Price, Mid Atlantic Census Region
NGCCU_ENC	Natural Gas, Commercial Delivered Price, East North Central Census Region
NGCCU_WNC	Natural Gas, Commercial Delivered Price, West North Central Census Region
NGCCU_SAC	Natural Gas, Commercial Delivered Price, South Atlantic Census Region
NGCCU_ESC	Natural Gas, Commercial Delivered Price, East South Central Census Region
NGCCU_WSC	Natural Gas, Commercial Delivered Price, West South Central Census Region
NGCCU_MTN	Natural Gas, Commercial Delivered Price, Mountain Census Region
NGCCU_PAC	Natural Gas, Commercial Delivered Price, Pacific Census Region
NGCGU_NEC	Natural gas citygate price, New England Census Region
NGCGU_MAC	Natural gas citygate price, Middle Atlantic Census Region
NGCGU_ENC	Natural gas citygate price, East North Central Census Region
NGCGU_WNC	Natural gas citygate price, West North Central Census Region
NGCGU_SAC	Natural gas citygate price, South Atlantic Census Region

NGCGU_ESC	Natural gas citygate price, East South Central Census Region
NGCGU_WSC	Natural gas citygate price, West South Central Census Region
NGCGU_MTN	Natural gas citygate price, Mountain Census Region
NGCGU_PAC	Natural gas citygate price, Pacific Census Region
NGHHUUS	Henry Hub Spot natural gas price
NGHHMCF	Henry Hub Spot natural gas price
NGSPUUS	Spot natural gas wellhead price
NGEUDUS	Cost of natural gas to electric utilities
NGRCUUS	Residential natural gas price
NGICUUS	Price of natural gas, industrial sector
NGRCU_NEC	Natural Gas, Residential Delivered Price, New England Census Region
NGRCU_MAC	Natural Gas, Residential Delivered Price, Mid Atlantic Census Region
NGRCU_ENC	Natural Gas, Residential Delivered Price, East North Central Census Region
NGRCU_WNC	Natural Gas, Residential Delivered Price, West North Central Census Region
NGRCU_SAC	Natural Gas, Residential Delivered Price, South Atlantic Census Region
NGRCU_ESC	Natural Gas, Residential Delivered Price, East South Central Census Region
NGRCU_WSC	Natural Gas, Residential Delivered Price, West South Central Census Region
NGRCU_MTN	Natural Gas, Residential Delivered Price, Mountain Census Region
NGRCU_PAC	Natural Gas, Residential Delivered Price, Pacific Census Region
NGUSPUS	Natural gas storage: U.S. total underground storage
NGWGPUS	Natural Gas Storage: working gas in underground storage
NRC	Nuclear Regulatory Commission
NY-ISO	New York Independent System Operator
NYMEX	New York Mercantile Exchange
OCS	Outer Continental Shelf
OE	Office of Electricity Delivery and Energy Reliability
OPS	Office of Pipeline Safety
PHMSA	Pipeline and Hazardous Materials Safety Administration

RTS	Returned to Service
SERC	SERC Reliability Corporation
SLECA	South Louisiana Electric Cooperatives Association
SPP	Southwest Power Pool, Inc
T/D	Transmission and Distribution
TECO	Tampa Electric Company
TLR	Transmission Load Relief
TX	Texas
WST	Washington-St Tammany E C, Inc.