Interdependence of Critical Energy Infrastructure Systems


Washington, D.C.
October 12-13, 2006

David E. Dismukes
Center for Energy Studies
Louisiana State University
• Concentration of infrastructure along the Gulf of Mexico ("GOM") is an asset not liability.

• While many areas of the Gulf South will take years to be rehabilitated from the 2004 AND 2005 tropical activity, the energy sector has been able to take rebound in a matter of months from the most comprehensively destructive set of storms in its history.

• Despite concentration of assets, the overwhelming majority of all energy infrastructure was rehabilitated in less than 45 days after the events of 2005 – there is probably no place in the world where that kind of restoration activity could have been done in that amount of time.

• Emphasis should be on developing policies that help insure infrastructure and quickly rehabilitate infrastructure in concentrated areas. -- “Bend don’t break”
How Concentrated is Activity on the GOM?

The Gulf of Mexico:

- Supports 30 percent total domestic crude oil production and 20 percent total natural gas production.
- Provides over $6 billion in federal royalties and fees.
- Supports 45 percent of total U.S. refining capacity (62 percent east of the Rockies)
- Home to the last greenfield refinery in U.S. (Garyville, LA, 1975)
- Supports 60 percent of total crude imports (LOOP supports 15 percent alone).
- Home to 43 percent of the SPR storage capability.
- A large share of the refining, pipeline and petrochemical industry in the U.S.
- Most of the pipeline capacity in U.S. originates in the GOM (25,000 miles in LA alone)
- Home to the Henry Hub.
- The largest natural gas users in the world (LA’s industrial and power generation use as large as China)
Hurricanes and Energy Production, Processing, and Transportation
Summary on Impacts of Hurricanes

- Clearly drove home what a natural disaster-created event could do to the energy sector – real world “worst case event” -- happened in the worst possible area (GOM) at the worst possible time (summer).

- Hurricanes were incredibly destructive to energy business. Catastrophic destruction experienced in all sectors (infrastructure categories) in the region. Hard to believe that a man-made event could be as broad.

- Hurricanes clearly showed the interrelationship of all types of energy infrastructure in the Gulf – the “4 Ps” – production, processing, pipes, and power.

- Hurricanes impacts were felt nationally and internationally – drives home importance of Gulf coast and critical energy infrastructure.
As of June 2006, there was some 936 MMcf/d and 179 MBbl/d of shut in gas and oil production. In total some 800 Bcf of gas shut in and 165 MMBbls of oil shut in from the hurricanes.

Note: Shut-in statistics for Ivan were no longer reported after 150 days. The last shut-in statistics for Katrina and Rita were published on June 21, 2006 (the 296th day after Katrina made landfall).

Source: Minerals Management Service
Total Immediate Refinery Impact

**Hurricane Katrina**

- LA/MS/AL Gulf Coast Refiners (reduced runs and shutdowns)
  - 2,528 mbbl/day
  - 15% of US operating capacity
- Port Arthur/Lake Charles (reduced runs and supply loss)
  - 775 mbbl/day
  - 5% of US operating capacity
- Midwest (reduced runs – supplied by Capline Pipeline)
  - 1,628 mbbl/day
  - 10% of US operating capacity
- Remaining US Operating Capacity
  - 12,075 mbbl/day
  - 70% of US operating capacity

**Total Refinery Impact**
- 4,931 mbbl/day
- 30% of US operating capacity

**Hurricane Rita**

- Port Arthur/Lake Charles (shutdowns and damaged facilities)
  - 1,715 mbbl/day
  - 10% of US operating capacity
- Houston/Texas City (shutdowns and damaged facilities)
  - 2,292 mbbl/day
  - 13.5% of US operating capacity
- Corpus Christi (shutdown and reduced runs)
  - 706 mbbl/day
  - 4% of US operating capacity
- Midwest (reduced runs from supply loss)
  - 338 mbbl/day
  - 2% of US operating capacity
- Remaining US Operating Capacity
  - 11,954 mbbl/day
  - 70% of US operating capacity

**Total Refinery Impact**
- 5,052 mbbl/day
- 30% of US operating capacity

Source: Energy Information Administration, Department of Energy
Critical Electricity Transmission Lines Impacted by Katrina

Map showing the impact of Katrina on critical electricity transmission lines, with areas marked in green, yellow, and orange indicating varying levels of impact. Locations such as Capline, LOCAP, St. James, Houma, and Clovelly (LOOP) are highlighted on the map.
Critical Terminals and the Power-Pipeline Infrastructure
Gasoline Price Increases
August 30, 2005 to September 6, 2005

Regional Changes in Gasoline Prices (cents per gallon)

Source: American Petroleum Institute

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Outages at gas processing facilities throughout all of south Louisiana was one of the more unique aspects of the combined hurricanes.

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<thead>
<tr>
<th>State/Company</th>
<th>Facility</th>
<th>Gas Capacity (MMcf/d)</th>
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<tbody>
<tr>
<td>Alabama</td>
<td>Duke Energy Field Services</td>
<td>Mobile Bay</td>
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<td>Shell Western E P Inc</td>
<td>Yellowhammer</td>
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<td>Louisiana</td>
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<td>East Louisiana Plants</td>
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<td>Gulf Terra Energy Partners LP</td>
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<td>Central Louisiana Plants</td>
<td>Amerada Hess Corp</td>
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<td>Burns Point</td>
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<td>Mississippi</td>
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<td>TOTAL</td>
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<td>TOTAL GOM CAPACITY</td>
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<td>PERCENT OF TOTAL GOM</td>
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Source: Oil and Gas Journal; Energy Information Administration, Department of Energy
Damage to power infrastructure (transmission) extensive. Restoration was monumental and impressive, but still created “nervous” moments for other energy infrastructure.

**Graph Details:**
- Katrina Landfall: Day 14
- Rita Landfall: Day 38
- 85% Restored: Day 47
- Oct. 15

**Legend:**
- Return to Service Customers
- Extended Outage Customers

Source: Entergy Corp.
Refining capacity restoration closely follows power system restoration, which in turn have direct impacts on refined product markets.

Source: Assumes 95 percent capacity factor; assumes 4 week recovery for facilities damaged by Rita.
Proven System Resiliency

- All refineries seriously impacted by the hurricane are operational.
- Most gas pipelines have been repaired or alternative routes/service has been secured for most shippers.
- All petrochemical facilities are operational.
- All service basis and ports are operational. Some in MS at 70-80 percent capacity.
- Electricity restored to all homes that can take service within 2 weeks (some 2.7 million without power Day 1 after Hurricane Katrina)
- To date, all but one gas processing facility is back on line.
- Most all crude oil production and natural gas production is back on line in GOM
  -- Crude oil shut-in: 179 MBbls/d (12 percent).  
  -- Natural gas shut-in: 936 MMcf/d (9 percent).
Potential Ongoing Threats to Critical Energy Infrastructure Development
Coastal Land Loss in Louisiana

Coastal Lands

- Red: Historical Land Loss (1932-2000)
- Yellow: Projected Land Loss (2000-2050)
- Blue: Louisiana Swamps and Marshes
What are the Likely Impacts of Coastal Erosion

- Gradual coastal erosion will increase the cost of operating in coastal areas. This will require higher O&M costs, faster depreciation (corrosion/exposure), and capital costs (upgrade and new investments). A more gradual, longer term, and hidden cost to American consumers.

- Economic impacts of catastrophic events are larger than otherwise given the greater flooding and storm surge intrusion. A much larger and recognizable (although debatable) impact. Richardson/Scott approach well suited for this type of impact (provided the incremental impacts are determined).
Louisiana Land Loss and Critical Energy Infrastructure

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<tr>
<th>All At-Risk Energy Infrastructure</th>
<th>Land Types</th>
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<tr>
<td>Refineries / Swamp and Marsh</td>
<td>Historical Land Loss (1932-2000)</td>
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<td>Petrochemicals / Projected Land Loss (0.5 miles)</td>
<td>Projected Land Loss (2000-2050)</td>
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<td>Petrochemicals / Swamp and Marsh</td>
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<td>Gas Processing / Swamp and Marsh</td>
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<td>Pipeline / Swamp and Marsh</td>
<td>Louisiana Swamps and Marshes</td>
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Land Types:
- Historical Land Loss (1932-2000)
- Projected Land Loss (2000-2050)
- Louisiana Swamps and Marshes
Conclusions

- GOM region has played an important historic role in the development of energy infrastructure. Not likely to change despite hurricane activity.

- Hurricanes proved that the region, its workforce, and the underlying assets are resilient and can be restored quickly, even in the face of two natural disasters.

- Some concerns about “diversifying” energy infrastructure in the region. Given current economic challenges concern is that diversity in some infrastructure areas could “diversify” to other parts of the world, which actually increase US vulnerability, not decrease it.

- Man-made incidents and catastrophic incidents should not be taken lightly -- but the “stochastic” nature of these events requires a more probabilistic approach to mitigation – more than likely a resiliency as opposed to “hardening” solution.

- Should the real threat mitigation resources be directed towards the slower, less noticeable, but cumulatively more important threats to this critical infrastructure (i.e., coastal erosions) – which in turn, can aggravate the catastrophic events many are placing their attention upon.
Questions, Comments, & Discussion

dismukes@lsu.edu

www.enrg.lsu.edu