Energy Risk Predictions for the 2015 Hurricane Season

DOE-NASEO Webinar on Forecasting Energy Infrastructure Risk for the 2015 Hurricane Season

June 23, 2015

Office of Electricity Delivery and Energy Reliability
US Department of Energy

Argonne NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

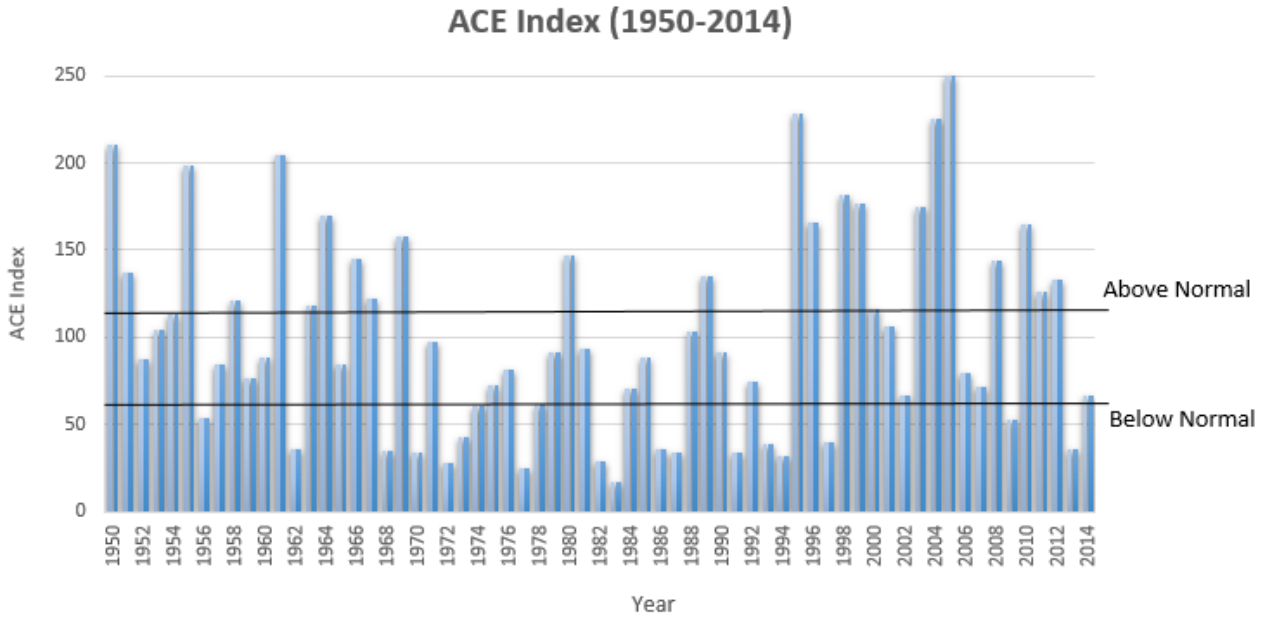
What is a normal Hurricane Season ?

- NOAA defines a season as above-normal, near-normal or below-normal by a combination of the number of named storms, the number reaching hurricane strength, the number reaching major hurricane strength, and the Accumulated Cyclone Energy (ACE) index.

The North Atlantic hurricane season officially runs from June 1 to November 30.

The vast majority of tropical storm and hurricane activity occurs during peak season from August-October.

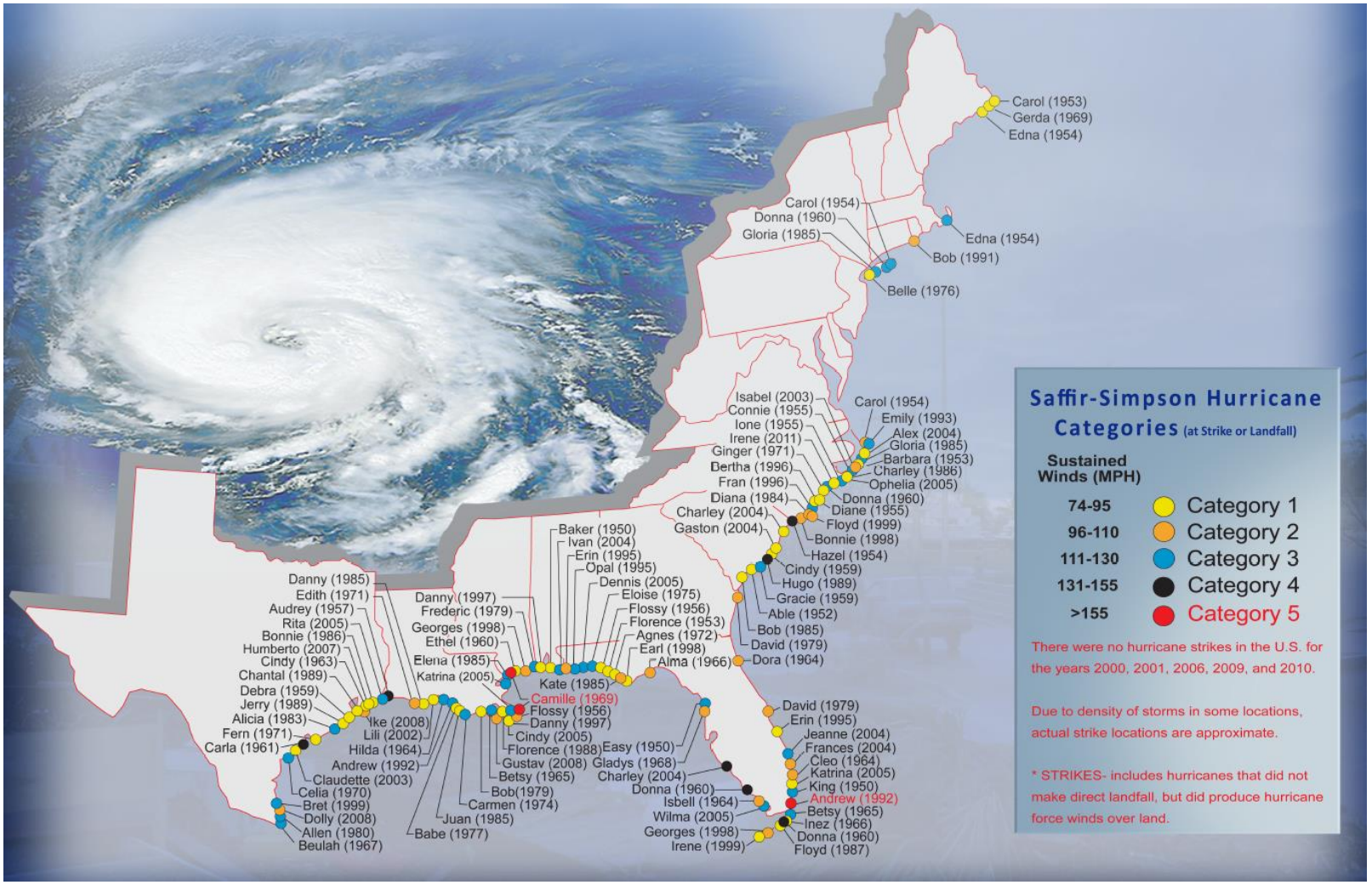
- NOAA classifies 13 of the 20 seasons since 1995 as above normal, with eight being very active (i.e., hyperactive defined by ACE > 165% of median).
  - Only three seasons since 1995 were below normal (1997, 2009, and 2013).
  - The 2005 Season had 28 named storms, 15 hurricanes, and 7 major hurricanes.



**Note that "named storms" refer to all tropical storms, hurricanes, and subtropical storms.*

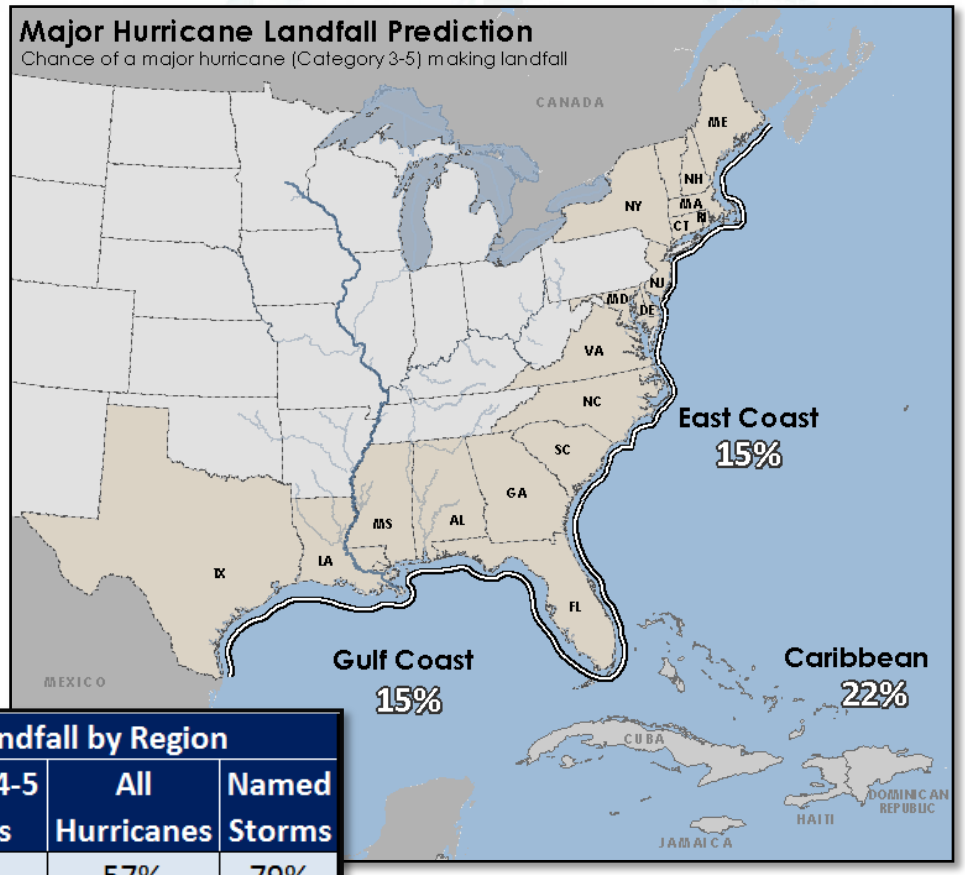
Historical U.S. Landfall Hurricanes

Hurricane Strikes 1950-2011



Predictions for 2015 Hurricane Season - CSU

- Forecasters at Colorado State University are predicting a below-average probability for major hurricanes making landfall for 2015.
  - 7 named storms, 3 hurricanes, 1 major hurricanes
- Official NHC 1981-2010 seasonal averages
  - 12.1 named storms, 6.4 hurricanes, and 2.7 major hurricanes



2015 Climatological Probability of Storm Making Landfall by Region					
Region	Tropical Storms	Category 1-2 Hurricanes	Category 3-4-5 Hurricanes	All Hurricanes	Named Storms
Entire U.S.	51%	40%	28%	57%	79%
Gulf Coast	33%	22%	15%	34%	55%
Florida plus East Coast	27%	23%	15%	35%	52%
Caribbean	54%	32%	22%	46%	75%

Source: Colorado State University, issued 9 April 2015.

Extended Range Forecast of Atlantic Seasonal Hurricane Activity and Landfall Strike Probability for 2015
April 9, 2015 Update [http://hurricane.atmos.colostate.edu/Forecasts/]

Other Prediction Sources for 2015 Hurricane Season

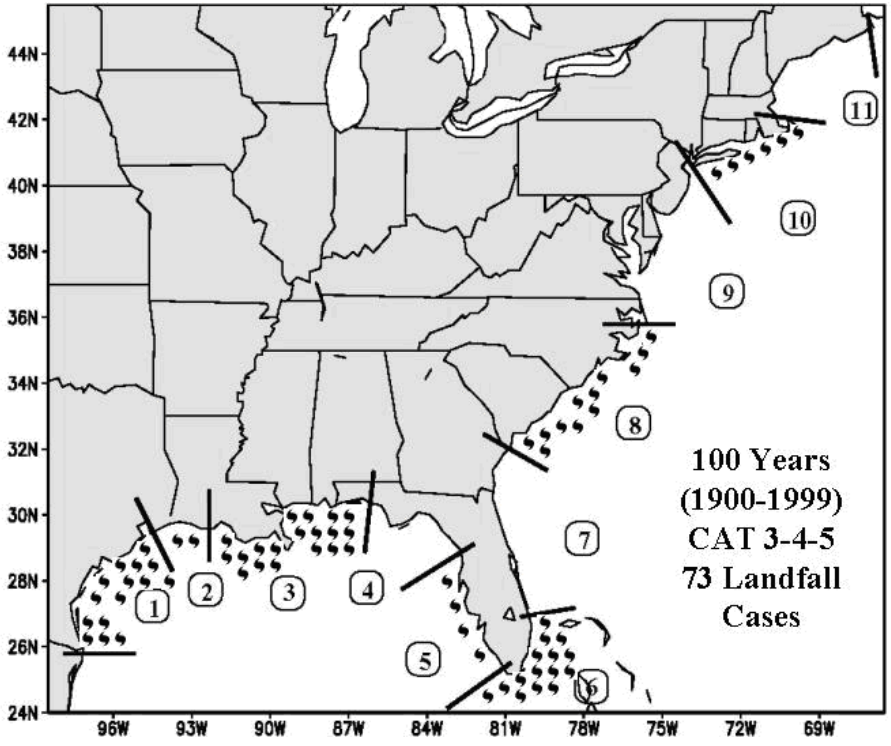
- Various extended range forecasts for Atlantic hurricane activity in 2015 anticipate a below-normal season:
  - Range of 4 to 11 named storms.
  - Between 1 to 5 hurricanes.
  - Between 1 to 2 major hurricanes.
- Most likely number of named storms (winds of at least 39 mph) predicted to occur during the June to November period is 8 for 2015:
  - Most-likely prediction for 2015 is 4 hurricanes and 1 major hurricane.
- All sources predict 2015 hurricane intensity to be lower than 1981-2010 seasonal averages:
  - Expected to be below-normal in terms of number of storms, number of storm days, and ACE index.

Tropical Storm Forecasts for 2015			
Source	Named Storms	Hurricanes	Major Hurricanes
Colorado State University (CSU)	7	3	1
North Carolina State University (NCSU)	4-6	1-3	1
The Weather Channel (TWC)	9	5	1
Tropical Storm Risk (TSR)	11	5	2
UK Met Office	8	5	1
Weather Services International (WSI)	9	5	1
2015 Forecast Avg	**8**	**4**	**1**
30-Year Average	**12.1**	**6.5**	**2**

Probabilities of Hurricanes making Landfall by State

State Risk of Hurricane Landfall

- Climatological probability of each state along the United States coastline being impacted by a hurricane and major hurricane.



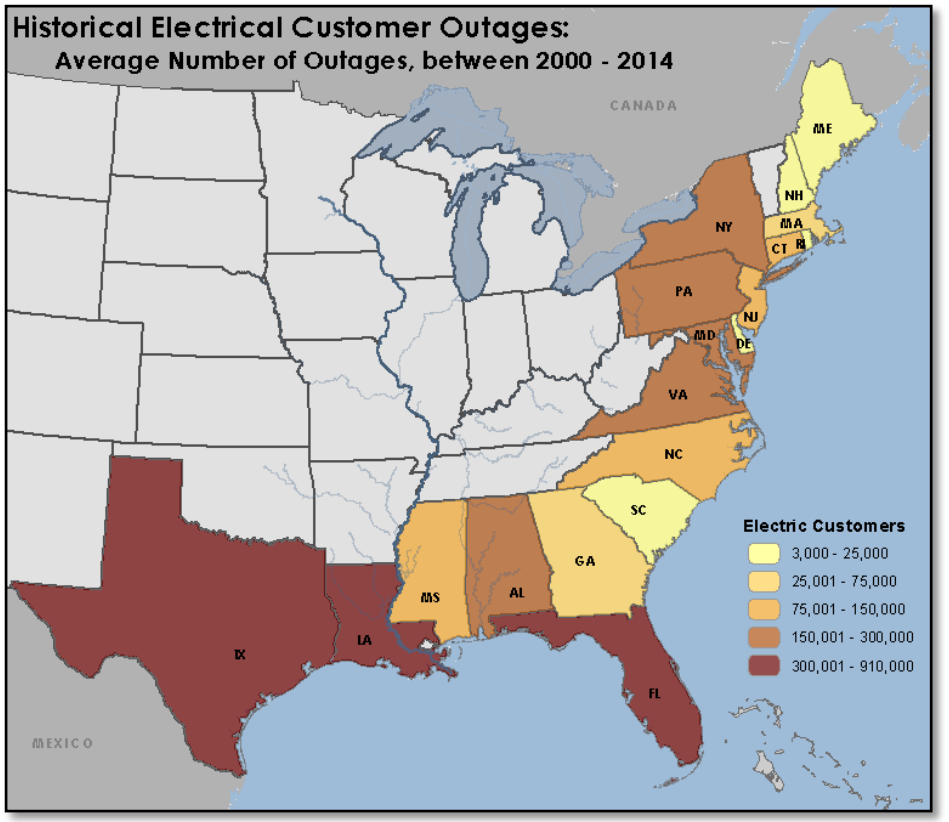
2015 Climatological Probability		
State	Hurricane	Major Hurricane
Texas	16%	5%
Louisiana	15%	5%
Mississippi	5%	2%
Alabama	7%	1%
Florida	27%	10%
Georgia	5%	1%
South Carolina	8%	2%
North Carolina	14%	3%
Virginia	3%	<1%
Maryland	1%	<1%
Delaware	1%	<1%
New Jersey	1%	<1%
New York	3%	1%
Connecticut	3%	1%
Rhode Island	3%	1%
Massachusetts	3%	1%
New Hampshire	1%	<1%
Maine	2%	<1%

Source: United Stated Landfalling Hurricane Probability Project

Landfall Probability Region Map http://www.e-transit.org/hurricane

Historical: Electric Impacts by State

- Hurricanes cause widespread damage to electric power transmission and distribution networks:
  - Magnitude of power outages determined by storm intensity and population density of the communities in the storm path
- Historical number of outaged customers highest in Florida:
  - Texas has second-highest number of customer outages, followed by Louisiana.
- Generally number of outaged electric customers increases with hurricane category:
  - Apparent anomaly for Category 1-2 storms along Atlantic Coast due to Superstorm Sandy.



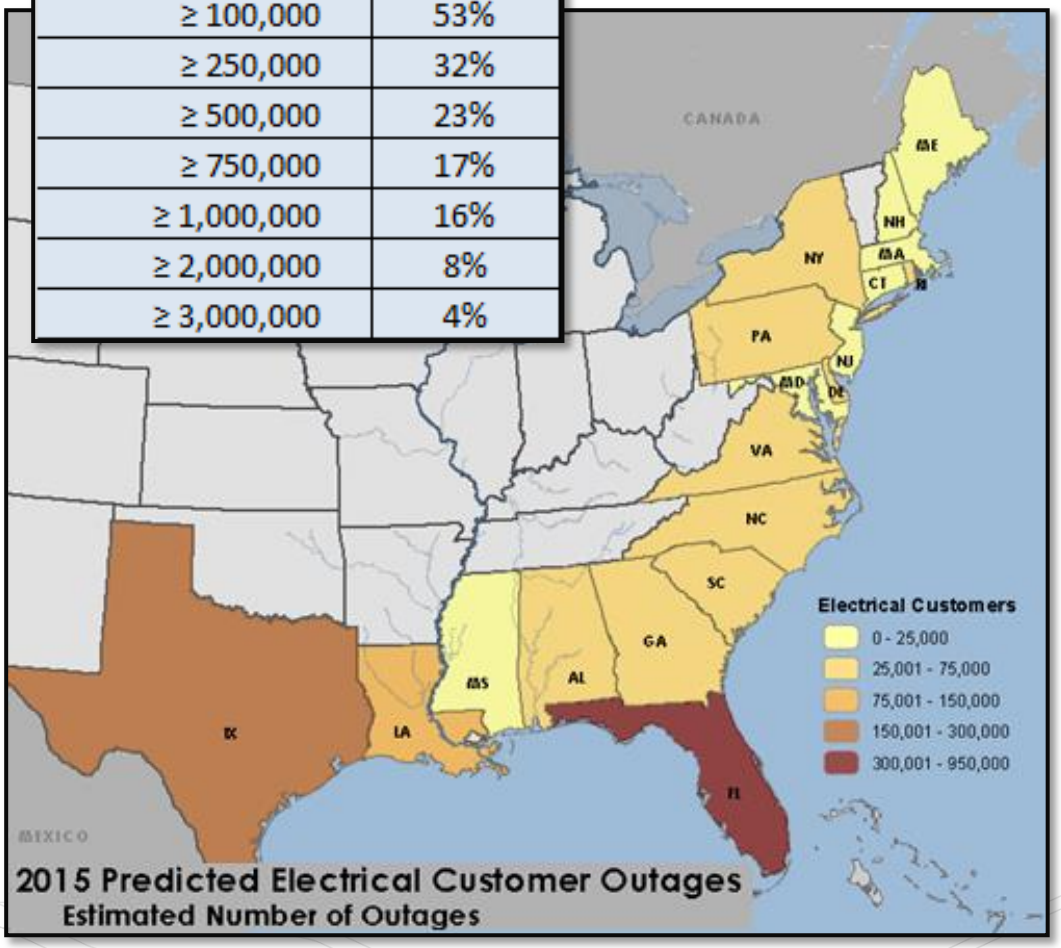
Average Number of Outaged Electric Customers by Region			
Region	Tropical Storm	Category 1-2 Hurricanes	Category 3-4-5 Hurricanes
Gulf Coast	129,000	1,500,000	2,500,000
Atlantic Coast*	113,000	3,037,000	2,361,000
* Atlantic Coast also includes Florida			

Predictions: Electric Impacts by State

- Lower customer impacts predicted for 2015:
  - Projected total of ~1.8 million customers for 2015.
  - Historic value of ~3.4 million customers (average from 2000 to 2014 hurricane seasons).

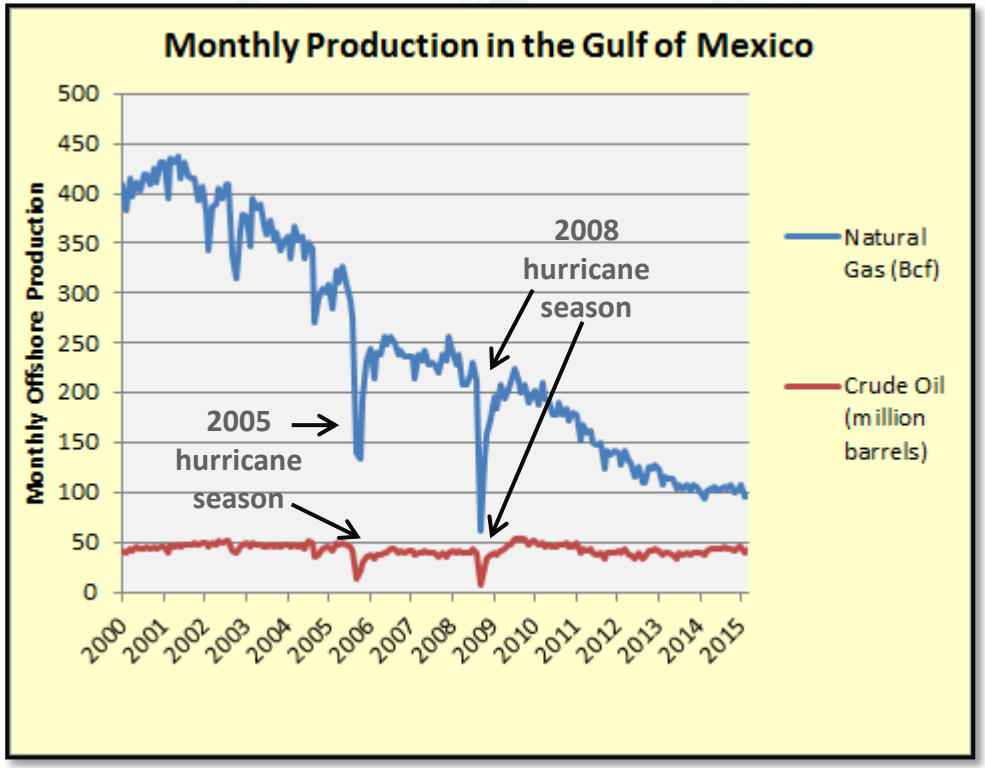
- Probability curve indicates that large customer outages will be unlikely:
  - ~4% probability of ≥ 3 million electric customer outages.
  - ~1% probability of ≥ 4 million electric customer outages.

2015 Projections	
Number of Electric Customer Outages	Probability
≥ 100,000	53%
≥ 250,000	32%
≥ 500,000	23%
≥ 750,000	17%
≥ 1,000,000	16%
≥ 2,000,000	8%
≥ 3,000,000	4%



Hurricane Effects on Oil and Natural Gas Production

- Crude oil and natural gas production in the Gulf of Mexico has historically been impacted by storms:
  - Major disruptions during 2005 and 2008 hurricane seasons.
- Shut-in production averages estimated as a function of storm intensity:
  - Based on 54 tropical storms / hurricanes from 1995 to 2013.
  - Shut-in production values increase with storm intensity.
- Predicted mean-estimate of storm-induced production disruptions in the Gulf of Mexico during 2015 hurricane season:
  - 5.3 million barrels of crude oil
  - 26 billion cubic feet of natural gas

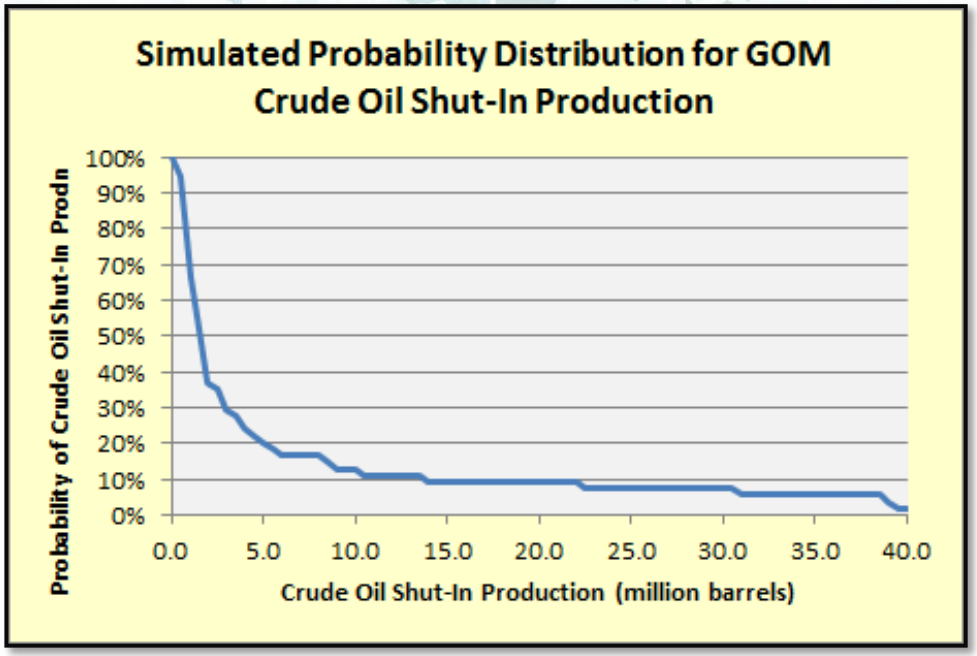


Mean Estimate of Storm-Related GOM Production Disruptions			
Storm Category	Projected No. for 2015	Projected Shut-In	
		Crude Oil (MB)	Natural Gas (Bcf)
Tropical storm	4	1,318	6.1
Cat 1-2 hurricane	3	1,817	8.8
Cat 3-5 hurricane	1	2,184	11.5
Projected for 2015	**8**	**5,300**	**26**

Predicted: Crude Oil Shut-In Production

- Probability curve indicates that large crude oil losses will be unlikely:
  - ~13% probability of ≥ 10 million barrels shut-in (U.S. average daily demand is 15 million barrels).
  - ~2% probability of ≥ 40 million barrels shut-in.

- Lower-than-normal crude oil production losses predicted for 2015:
  - During 2013 hurricane season, 3.1 million barrels of crude shut-in.
  - Likelihood of experiencing similar or greater disruptions is ~30%.

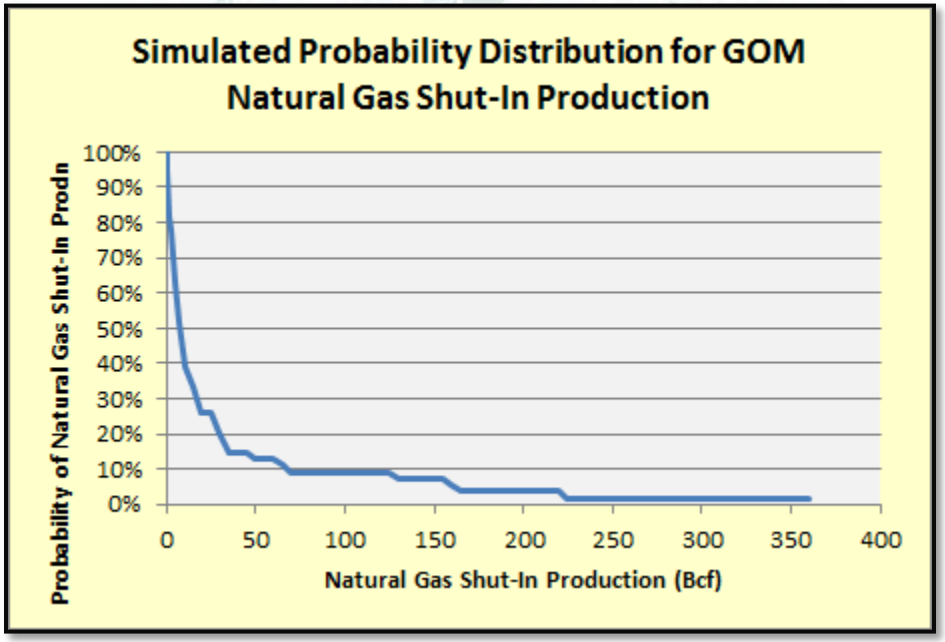


2015 Projections		
Crude Oil Shut-In Production (million barrel)	Probability	Percent 2014 U.S. Daily Demand
≥ 1	67%	6.3%
≥ 5	20%	32%
≥ 10	13%	63%
≥ 20	9.3%	126%
≥ 40	1.9%	252%

Predicted: Natural Gas Shut-In Production

- Probability curve indicates that large natural gas losses will be unlikely:
  - ~13% probability of ≥ 50 Bcf shut-in (US average daily demand is 68 Bcf).
  - ~4% probability of ≥ 200 Bcf shut-in of natural gas.

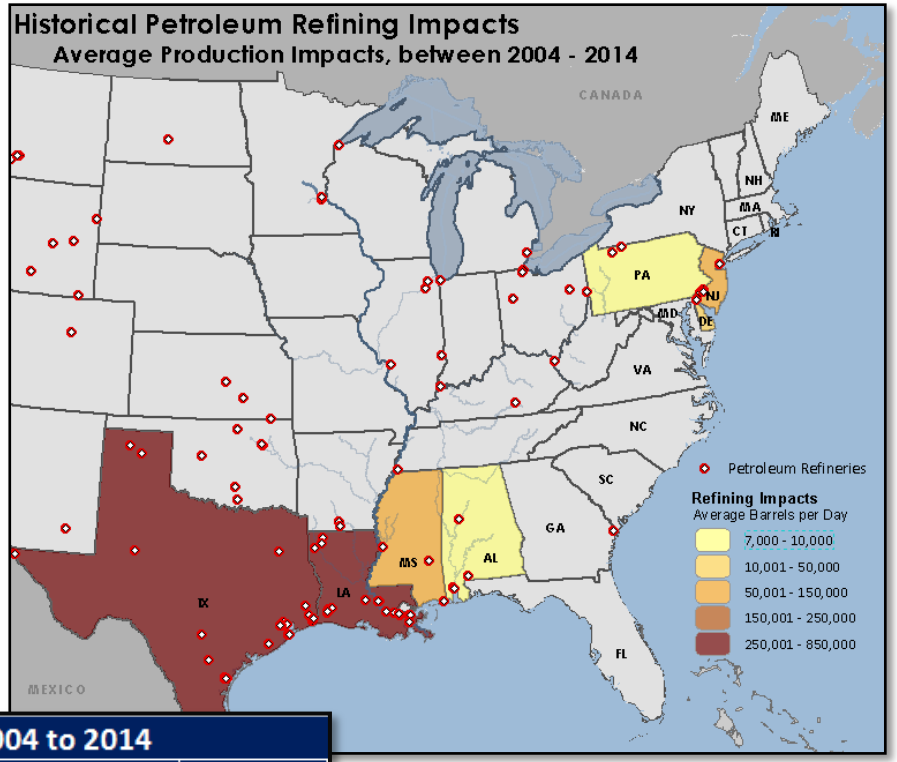
- Lower-than-normal natural gas production losses predicted for 2015:
  - During 2013 hurricane season, 6.7 Bcf of natural gas shut-in.
  - Likelihood of experiencing similar or greater disruptions is ~30%.



2015 Projections		
Naural Gas Shut-In Production (Bcf)	Probability	Percent 2014 U.S. Daily Demand
≥ 1	81%	1.4%
≥ 5	63%	6.8%
≥ 10	39%	14%
≥ 50	13%	68%
≥ 100	9.3%	136%
≥ 200	3.7%	272%

Historical: Petroleum Refining Impacts

- Average production impacts from petroleum refinery disruptions developed from historic incident data:
  - Potential damage to petroleum refinery production varies significantly based on the severity of the storm.
- Annual average impacts greatest for Gulf Coast states:
  - Many refineries in Louisiana and Texas located along the coast at-risk from tropical storms and hurricanes.



Hurricane and Tropical Storm Statistics for Years 2004 to 2014									
State	StateID	Location	Tropical Storms		Category 1-2 Hurricanes		Category 3-4-5 Hurricanes		Average per Year (2004 to 2014)
			Number	Avg Barrels per day	Number	Avg Barrels per day	Number	Avg Barrels per day	
Alabama	AL	Gulf	0	0	0	0	1	80,000	7,000
Delaware	DE	Atlantic	0	0	2	95,000	0	0	17,000
Louisiana	LA	Gulf	2	95,000	3	1,096,000	3	1,885,000	830,000
Mississippi	MS	Gulf	0	0	2	25,000	3	325,000	93,000
New Jersey	NJ	Atlantic	0	0	2	658,000	0	0	120,000
Pennsylvania	PA	Atlantic	0	0	2	48,000	0	0	9,000
Texas	TX	Gulf	2	198,000	4	1,259,000	3	799,000	712,000

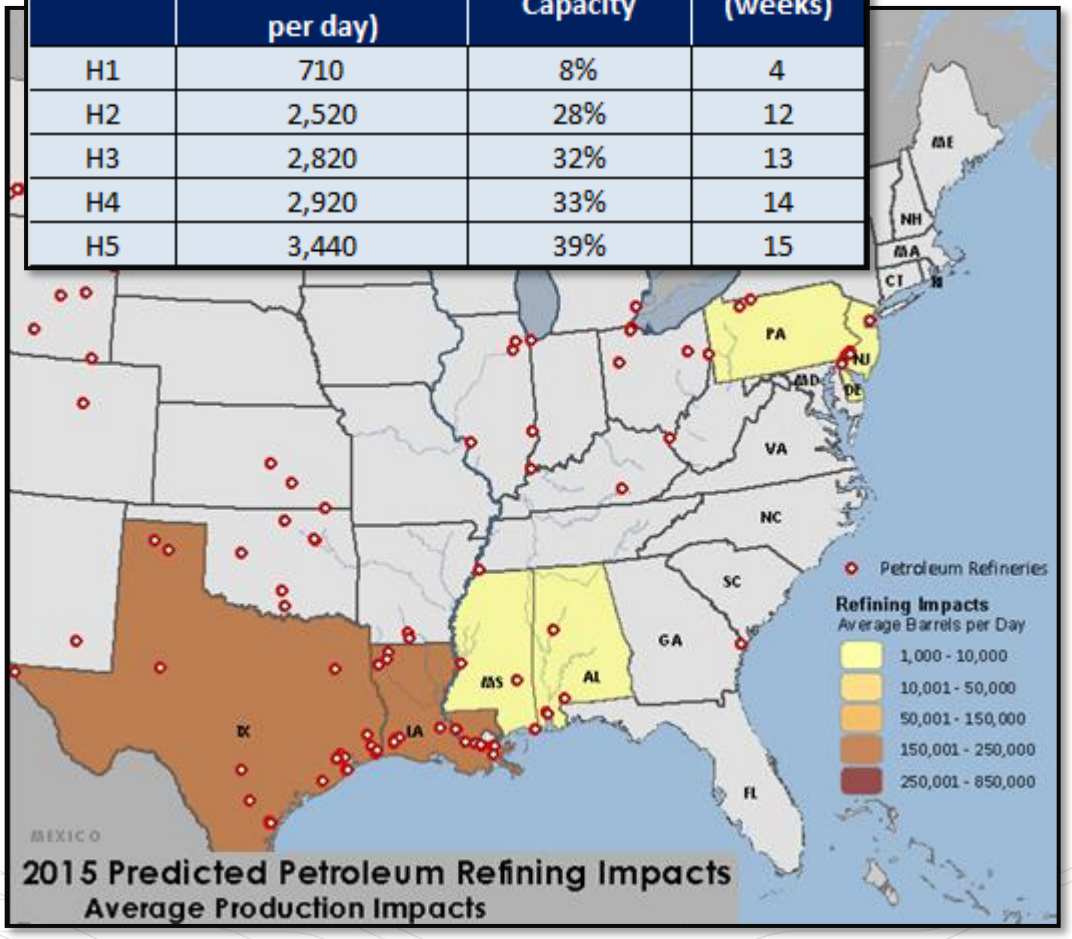
Predicted: Petroleum Refining Impacts

- Impact of hurricanes on Gulf Coast refining operations is largely a function of:
  - The distance the refinery is from the hurricane's landfall.
  - The strength of the hurricane (i.e. Category 1-5).

- Projected 2015 impacts lower for U.S. refining industry:
  - Projected production shortfall of ~513,000 barrels per day for 2015.
  - Historic shortfall of ~1.8 million barrels per day.

Impact of Hurricanes on Gulf Coast Refining

Hurricane Category	Maximum Refinery Production Shortfall (thousand barrels per day)	Percent of Gulf Coast Refining Capacity	Restoration Duration (weeks)
H1	710	8%	4
H2	2,520	28%	12
H3	2,820	32%	13
H4	2,920	33%	14
H5	3,440	39%	15



Petroleum Pipeline Impacts

- Petroleum pipelines may encounter difficulties from hurricanes from:
  - Loss of commercial power.
  - Damage to pumps and motors.
- Two pipelines historically vulnerable to hurricane outages:
  - Colonial Pipeline (2.6 MMBD).
  - Plantation Pipe Line (0.7 MMBD).
  - Both pipelines account for a large percentage of gasoline and distillate supply along the Atlantic Coast.
- Percent reduction in pipeline shipments based on projected 2015 probability of landfall for the Gulf Coast:
  - Estimated percent loss of 18%.
  - Projected pipeline shut down period of less than 2 days.

2014 FERC Data on Pipeline Deliveries

Pipeline	Used Capacity (MMBD)	Motor Gasoline (%)	Jet Fuel (%)	Distillate Fuel Oil (%)
Colonial Pipeline	2.51	54%	13%	33%
Plantation Pipe Line	0.63	71%	11%	18%
Total	**3.14**	**57%**	**12%**	**30%**

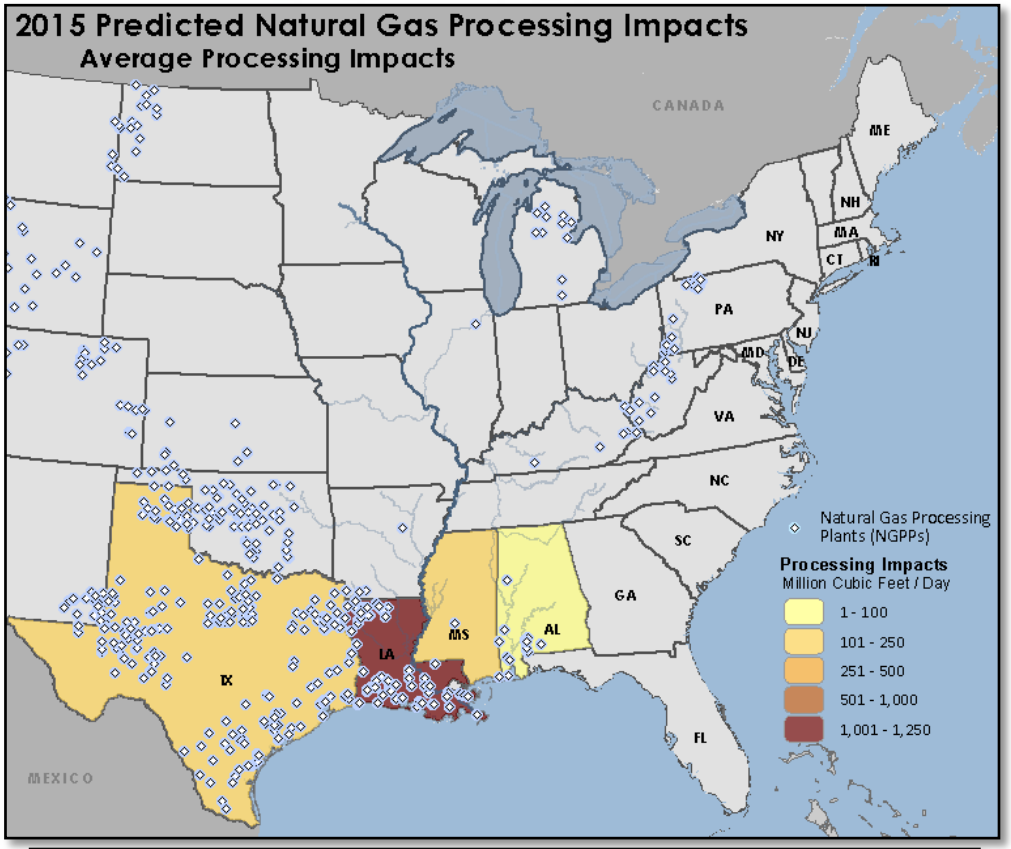
Percent Reduction in Colonial and Plantation Pipeline Shipments due to a Gulf Coast Hurricane

Hurricane Category	Days Shut Down	Percent Loss
H1	0	0%
H2	2	20%
H3	4	40%
H4	7	50%

NOTE: does not account for any loss of product shipments due to refinery outages or outages of terminals feeding pipelines.

Predicted: Natural Gas Processing Plant Impacts

- Gulf Coast is home to about 30% of total U.S. natural gas processing plant (NGPP) capacity.
- Major hurricanes such as Gustav and Ike (2008) restricted the flow of natural gas throughout the U.S. for weeks.
- Average production impacts from natural gas processing plant (NGPP) disruptions for 2015 hurricane season:
  - Based on estimated probability of landfall along the Gulf and Atlantic Coasts.
- Estimated average 2015 impacts on the order of 1.5 Bcf per day:
  - Equates to ~3% of average NGPP daily production rate in 2013.



Mean Estimate of Storm-Related NPGG Production Disruptions for 2015						
Storm Category	Projected for 2015	Projected NGPP Production Impact (MMcfd)				
		Total	Alabama	Louisiana	Mississippi	Texas
Tropical Storm	4	400	0	200	100	200
Cat 1-2 hurricane	3	1,400	100	1,100	100	100
Cat 3-5 hurricane	1	5,700	200	5,600	500	100
Projected for 2015	**8**	**1,500**	**100**	**1,200**	**200**	**200**

Conclusions

- This year predicted to be quietest hurricane season in decades:
  - Seven named storms predicted versus the 30-year average of 12.
  - Last time only 7 storms were named was 1997 and that year included an unnamed subtropical storm.
- Projected total of ~1.8 million electric customer outages for 2015 hurricane season:
  - Annual average value of ~3.4 million customer outages for 2000 to 2014.
- Predicted mean-estimate of storm-induced production disruptions in the Gulf of Mexico during 2015 hurricane season:
  - 5.3 million barrels of crude oil.
  - 26 billion cubic feet of natural gas.
  - ~30% likelihood of disruptions greater than 2013 hurricane season.

- Projected refinery production shortfall of ~513 MBD for 2015:
  - Historic shortfall of ~1.8 MMBD.
- Estimated avg. 2015 NGPP impacts on the order of 1.5 Bcf per day:
  - Equates to ~3% of average NGPP daily production rate in 2013.
- A quiet hurricane season could mean lower energy prices:
  - However, it only takes one major hurricane making landfall to make it an active season.

Thank you very much!

We look forward to your questions and comments!