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**Real Time Information** — Currency of the New Decade

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# Entergy Using PI to Build a Foundation for Grid Monitoring with Phasor Technology

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# Agenda

- Entergy Company Overview
- Islanding Caused by Hurricane Gustav
- Successfully Monitoring, Protecting and Managing Islanding Event
- Lessons Learned
- SGIG (Smart Grid Investment Grant) Award
- PI Expansion to Build a Robust Foundation for Grid Monitoring

# Acknowledgment and Disclaimer

- Acknowledgment: This material is based upon work supported by the Department of Energy under Award Number(s) DE-OE0000375
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# The Entergy System

- Over 15,500 miles of transmission lines in four states
- 1,450 transmission substations
- 2.4 million customers
- 40,400 MW of interconnected generating plant capability
- 22,000 MW of Entergy native load
- Entergy is the second-largest nuclear operator in the nation
- Entergy is one of the cleanest utility generator in the US and the first U.S. utility to voluntarily stabilize greenhouse gas emissions





**Tropical Wave off African Coast  
8/13/2008**

**Depression formed on 8/25/08  
in the Netherland Antilles  
Hurricane Gustav by 8/26/08**

**Haiti**

**Dominican Republic**

**Jamaica**

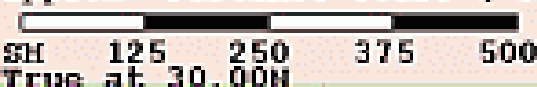
**The Cayman Islands**

**Cuba 8/29/08,  
8/30/08 Gulf**

**153 Deaths in US & Caribbean**



Approx. Distance Scale ( Statute Miles )



# Hurricane Gustav August 29, 2008 5 PM EDT Friday

NWS TPC/National Hurricane Center  
Advisory 20

Current Center Location 19.2 N 79.7 W

Max Sustained Wind 75 mph

Current Movement NW at 12 mph

● Current Center Location

● Forecast Center Positions

H Sustained wind > 73 mph

S Sustained wind 39-73 mph

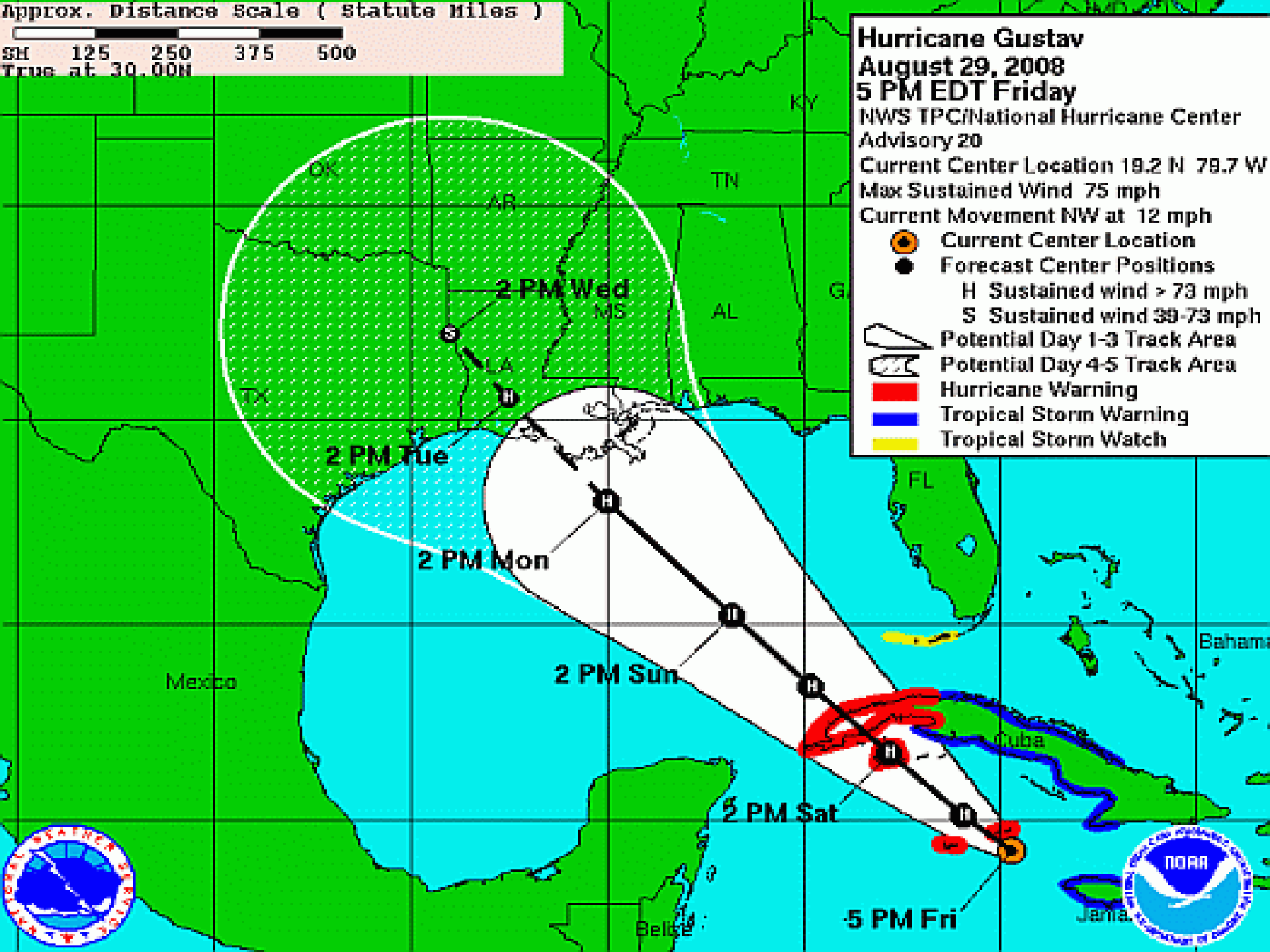
▨ Potential Day 1-3 Track Area

▨ Potential Day 4-5 Track Area

■ Hurricane Warning

■ Tropical Storm Warning

■ Tropical Storm Watch



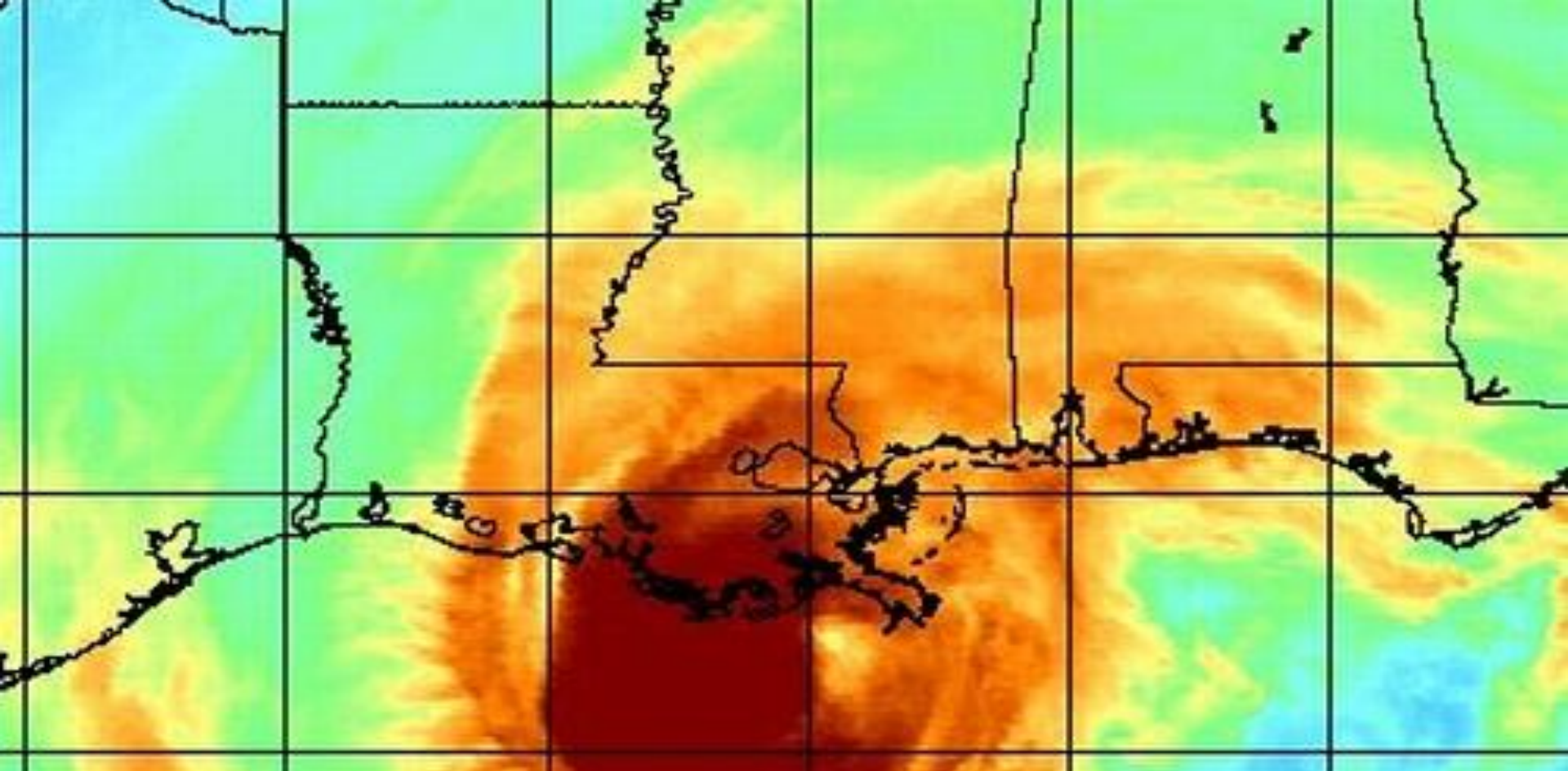




**Largest Evacuation in US History-  
Over 3 Million People,  
Estimated damage in Louisiana \$4.1 B**

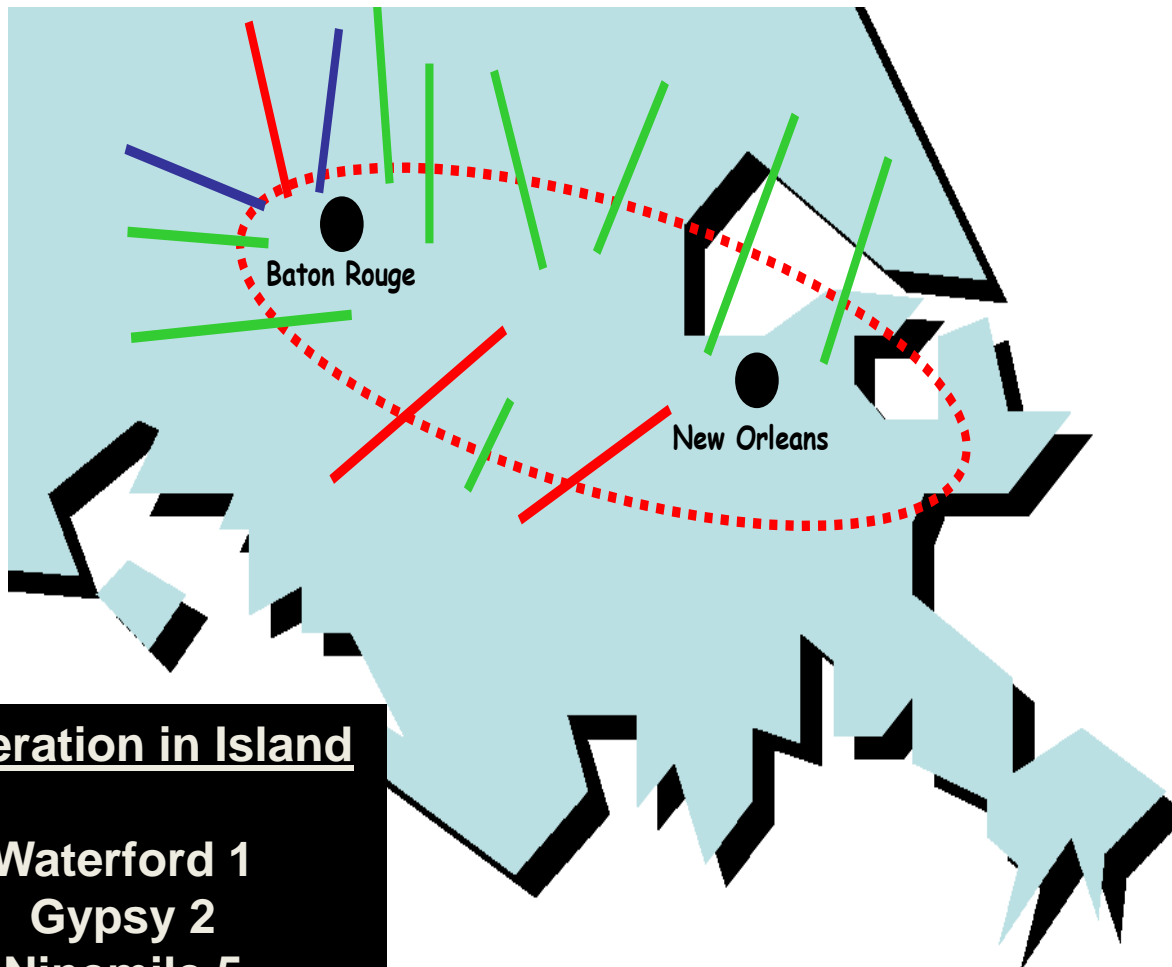






Hurricane Gustav made landfall on September 1, 2008 at 9:30 am at Concodrie, Louisiana as a Category 2 hurricane – 115 PMH winds. In comparison, Hurricanes Katrina and Rita both made landfall as category 3 Hurricanes.

# Island Formation



**2 - 500 kV Lines**  
**9 - 230 kV Lines**  
**3 - 115 kV Lines**

**~100 miles across**  
**~200-250K Customers**  
**~300 MW Load**

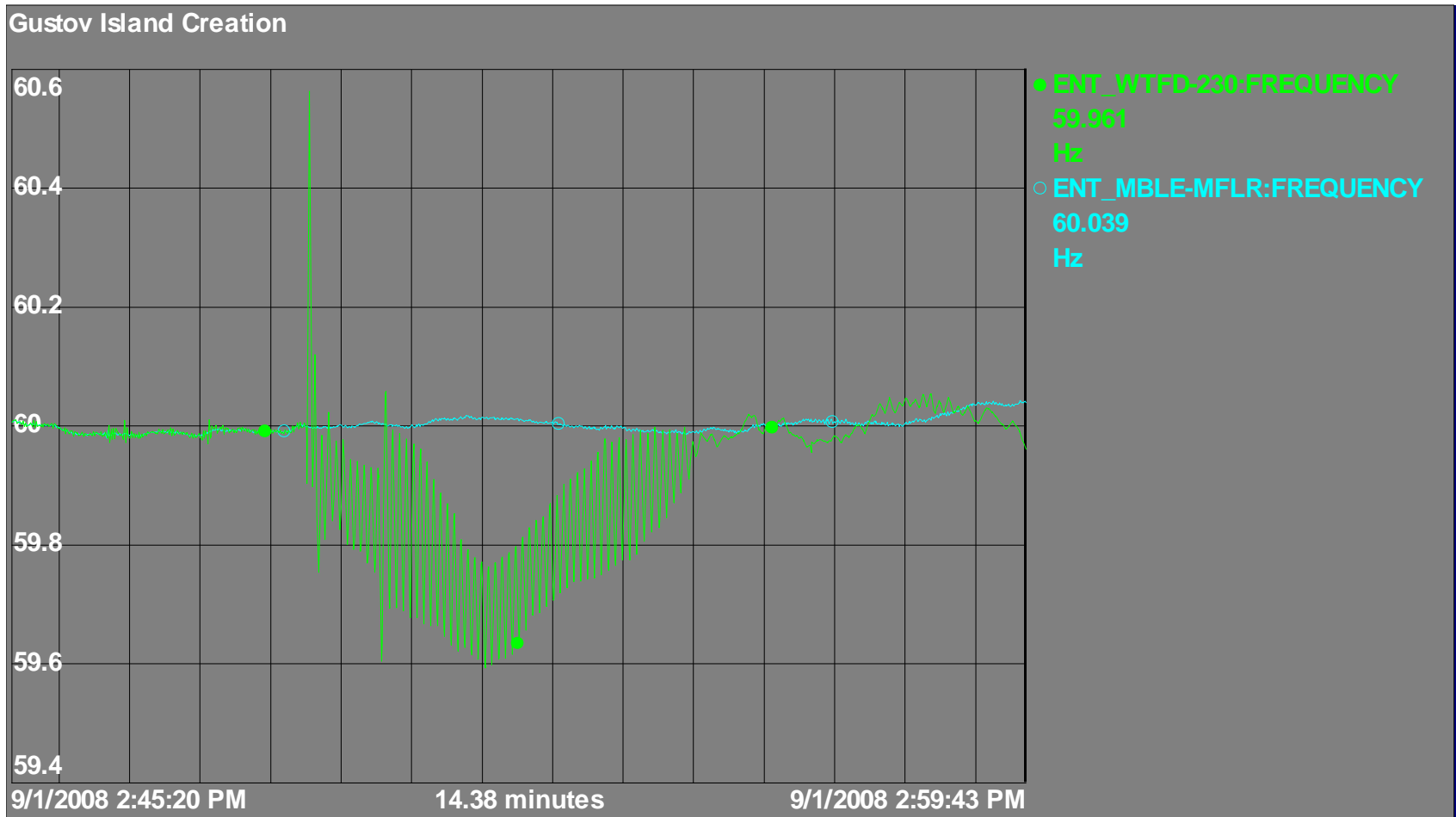
**Island formed:**

**September 1, 2008**  
**2:49 PM**

## Generation in Island

**Waterford 1**  
**Gypsy 2**  
**Ninemile 5**

# Creation of Gustav Island at 2:49 PM on 9/1/2008





# Monitoring the Island

Customer outage restoration within the island was suspended

1. Reduces the risk of inadvertently adding more load than available generation.
2. Helps to maintain voltage and frequency control

# Monitoring the Island

PMU frequency measurements were monitored during the life of the island to identify frequency oscillations within the island.

## 1. Cause of Frequency Oscillations

- Electrical strength of the island was much less than when connected to the grid.
- Generators within the island automatically attempting to respond to demand changes at the same time

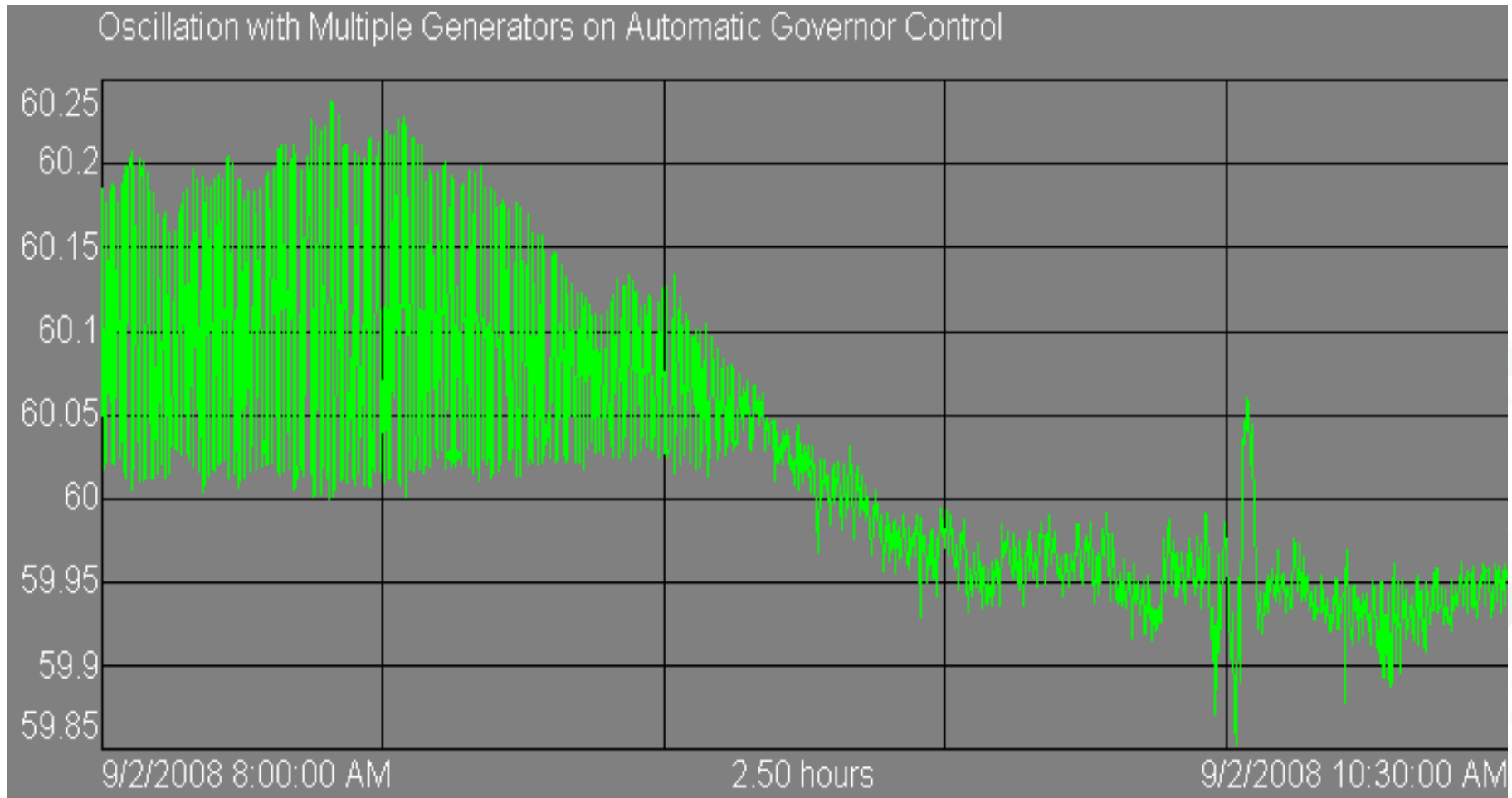
# Monitoring the Island

Action taken to prevent frequency oscillations.

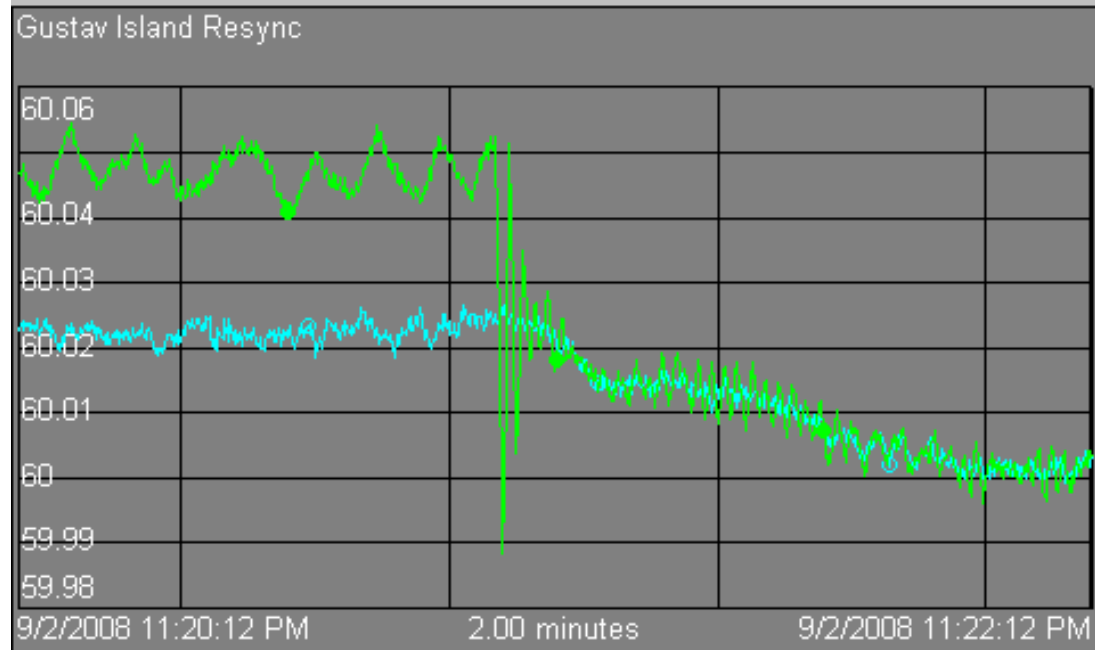
- Placed two of the three generators within the island on manual boiler control mode and left the third generator on automatic boiler control mode.



# Frequency Oscillations Observed



# Gustav Island Successfully Resynchronized



September 2, 2008 at 11:21 PM  
(33 Hours in Island)

# Hurricane Gustav: By the Numbers

- 241 transmission lines and 354 substations outaged
- 4,349 Distribution transformers damaged or destroyed
- 2500 circuit miles affected
- 964,000 customer outages, second only to the 1.1 million customer outages in 2005 during Hurricane Katrina.



# Lessons Learned

1. For this islanding event, PMUs were essential in detecting monitoring, and maintaining the island.
2. A widely dispersed monitoring system is critical.
3. Prior to the islanding event, Phase Angle Difference Calculations did not show a large or growing phase angle difference. We believe this may be caused in part to Entergy having sufficient generation in the area to support the load  
(Note: Reference angle for this calculation changed to outside of hurricane path)

# Lessons Learned cont...

4. Our customers understand that hurricanes causes outages. They do not, however, understand that hurricanes can also cause islands.
5. Entergy now has one of the richest data archives for an islanding event. We will use this data to perform studies that will enhance Entergy's understanding of its grid during these types of events.

# Lessons Learned cont...

- It is estimated that approximately 200,000-250,000 customers, and 50 transmission substations were kept in service by virtue of the island being maintained
- Projected Savings for this islanding event is approximately 2-3 million dollars by maintaining the island. Additional societal benefits would also have been realized.



# PI Infrastructure Enabling Entergy Smart Grid DOE Synchrophasor Project

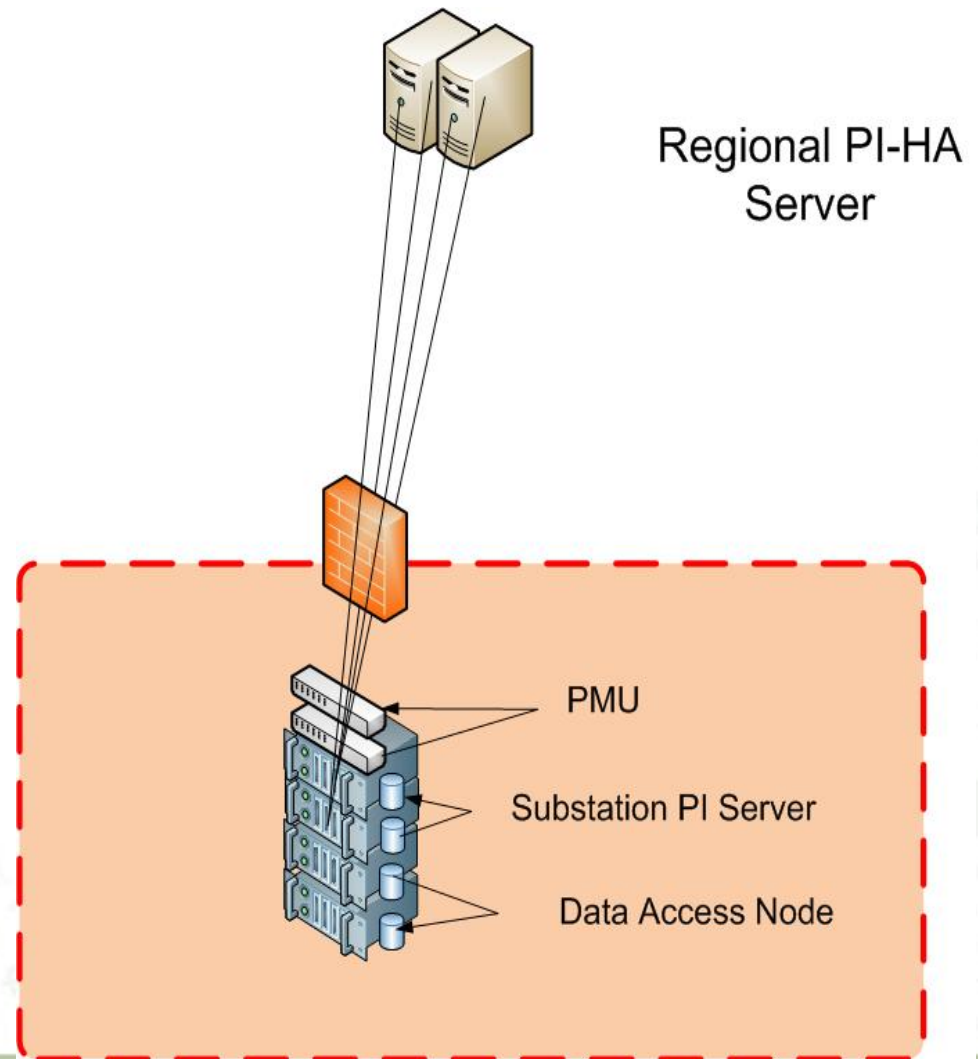
# PMUs at Entergy



- 2004
  - 11 Arbiter 1133a PMUs 20Hz
  - PI IEEE 1344 interface
- 2006
  - 22 Arbiter 1133a PMUs 30Hz
  - PI IEEE 1344 interface
  - PI IEEE C37.118 interface
- 2010 - 2013
  - 41 Arbiter/Other PMUs
  - 20 Cyber-Secure PI Phasor Platforms

# Cyber-Secure Phasor Platform

- Redundant PMUs
- Redundant DAN (Data Access Node)
- Automatic failover
- Buffering to HA PI Servers
- Local PI Archiving
- Local Client Access



# Support Provided by OSIsoft to Entergy for SGIG Award

- OSIsoft PI System
- Review of Entergy Phasor Infrastructure and OSIsoft Product Efficiencies
- Provide Options to Conceptual Phasor Data Collectors / Phasor Gateways
- Provide Product Awareness of Alternative Solutions being proposed/used in other countries
- Provide OSIsoft product integration solutions for the many aspects of the Entergy SGIG Award





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**Thank you**

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