Transmission ITP

Load Forecasting and Weather

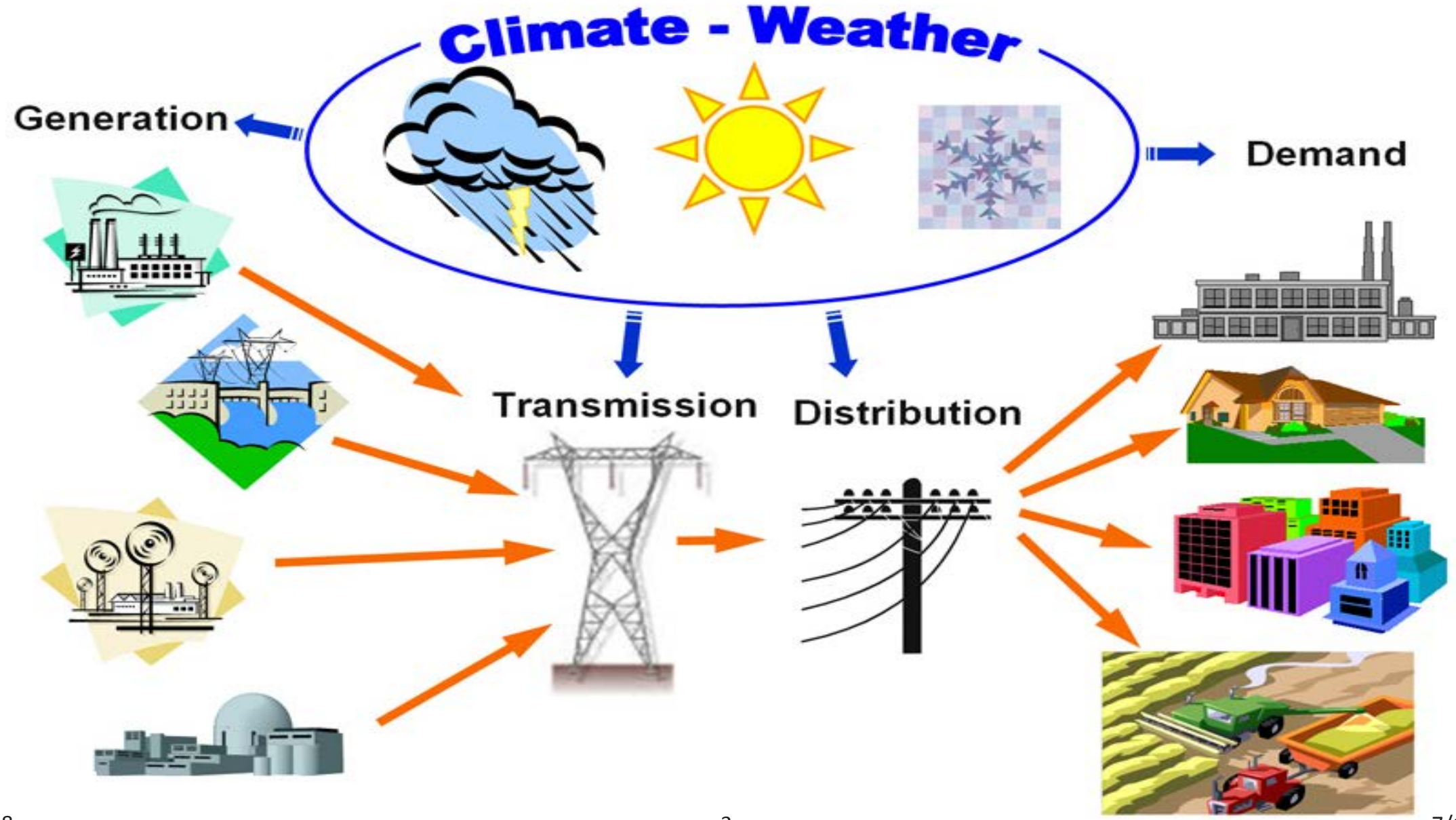
PJM State & Member Training Dept.

Objectives

At the conclusion of this presentation, the student will be able to:

- Identify the relationship between load and weather
- Describe the load pattern impacts based on the duration of the weather conditions
- Identify possible effects of human behavior on the load

Weather and Load



Weather and Load

- Weather conditions interact to affect the loading and performance of the transmission system
- Some of the most impacting conditions include:
  - Temperature: Minimum/maximum
  - Humidity: Temperature Humidity Index (THI)
  - Wind: Direction/Speed/Wind Chill Index (WCI)
  - Storms: Lightning/Precipitation
  - Cloud cover
- During hot weather, temperature and humidity have greatest impacts
- During cold weather, temperature and wind speed have greatest impacts

Temperature

- Temperature:
  - Exceedingly hot or cold temperatures will cause the efficiency of system to decrease at or near maximum capacity
  - Significant temperature swings will increase system loading
  - Overloads on the transmission system
  - Unavailability or tripping of transmission facilities

Humidity

- Percentage of water vapor present in a given quantity of air compared to the amount it can hold at its temperature
  - Does not change the temperature
  - Does change how much energy is available for cooling
- Temperature Humidity Index (THI) reflects outdoor atmospheric conditions of temperature and humidity as a measure of comfort or discomfort during the warm season of the year
  - Effects of heat and moisture in the air

Temperature Humidity Index (THI)

Temperature (Fahrenheit)	Relative Humidity									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
80°	69	70	72	73	74	75	76	78	79	80
81°	70	71	72	73	75	76	77	78	80	81
82°	70	72	73	74	75	77	78	79	81	82
83°	71	72	73	75	76	78	79	80	82	83
84°	71	73	74	75	77	78	79	81	83	84
85°	72	73	75	76	78	79	80	82	84	85
86°	72	74	75	77	78	80	81	83	84	86
87°	73	74	76	77	79	81	82	84	85	87
88°	73	75	76	78	80	81	83	85	86	88
89°	74	75	77	79	81	82	84	86	87	89
90°	74	76	77	79	81	83	85	87	88	90
91°	75	76	78	80	82	84	85	87	89	91
92°	75	77	79	81	83	85	86	88	90	92
93°	76	78	80	81	83	85	87	89	91	93
94°	73	78	80	82	84	86	88	90	92	94
95°	77	79	81	83	85	87	89	91	93	95
96°	77	79	81	84	86	88	90	92	94	96
97°	78	80	82	84	86	88	91	93	95	
98°	78	80	83	85	87	89	91	94	96	
99°	79	81	83	85	88	90	92	95		
100°	79	82	84	86	89	91	93	95		
101°	80	82	84	87	89	91	94	96		
102°	80	83	85	88	90	92	95			
103°	81	83	86	88	91	93	96			
104°	81	84	86	89	91	94	96			
105°	82	84	87	90	92	95				
106°	82	85	87	90	93	96				
107°	83	85	88	91	94	96				
108°	83	86	89	92	95					
109°	84	87	89	92	95					
110°	84	87	90	93	96					

- Developed by National Weather Service
- Provides a single numerical value reflecting outdoor atmospheric conditions of temperature and humidity as a measure of comfort or discomfort during warm weather
- Electricity use increases as a heat wave lingers

Warning Zone

Danger Zone

THI $\leq$ 70 Relatively few people uncomfortable
THI @ 75 Half will be uncomfortable
THI @ 79 Almost all are uncomfortable

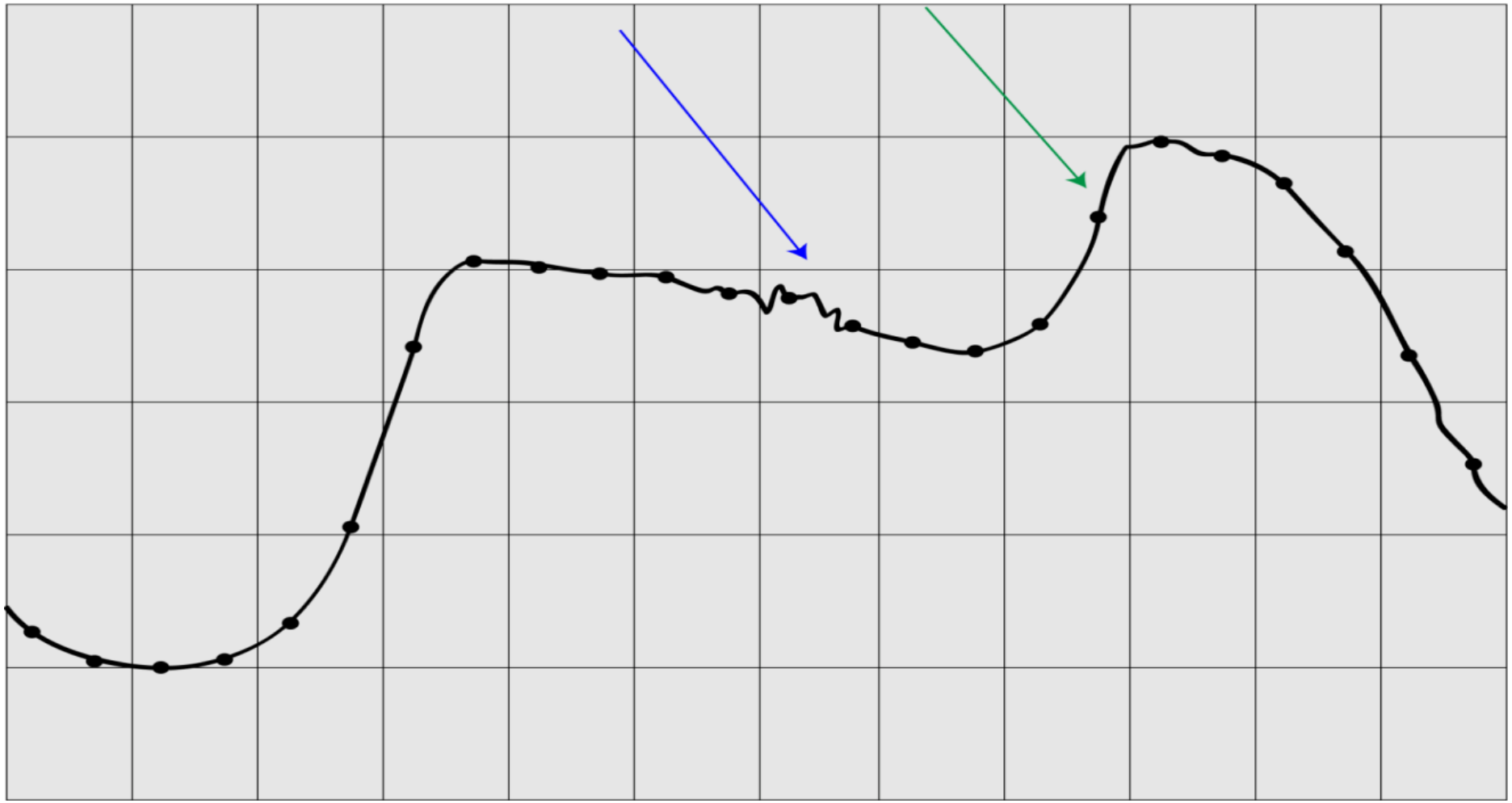
Wind

- Caused as temperature/pressure from one weather system replaces the temperature/pressure of another weather system
  - Commonly associated with fronts and storms
  - Cool air is dense and heavy, circulating strongly over the earth's surface (Northern wind)
  - Warm air is lighter, rising above cooler air
- Can flatten afternoon valleys or increase peak loading
- Wind Chill Index (WCI) reflects the "felt" air temperature on exposed skin due to the wind

Wind

Effects of wind & dropping temperatures:
Limited drop off in valley
Large Evening Pick-up

PJM EAST LOAD FORECAST



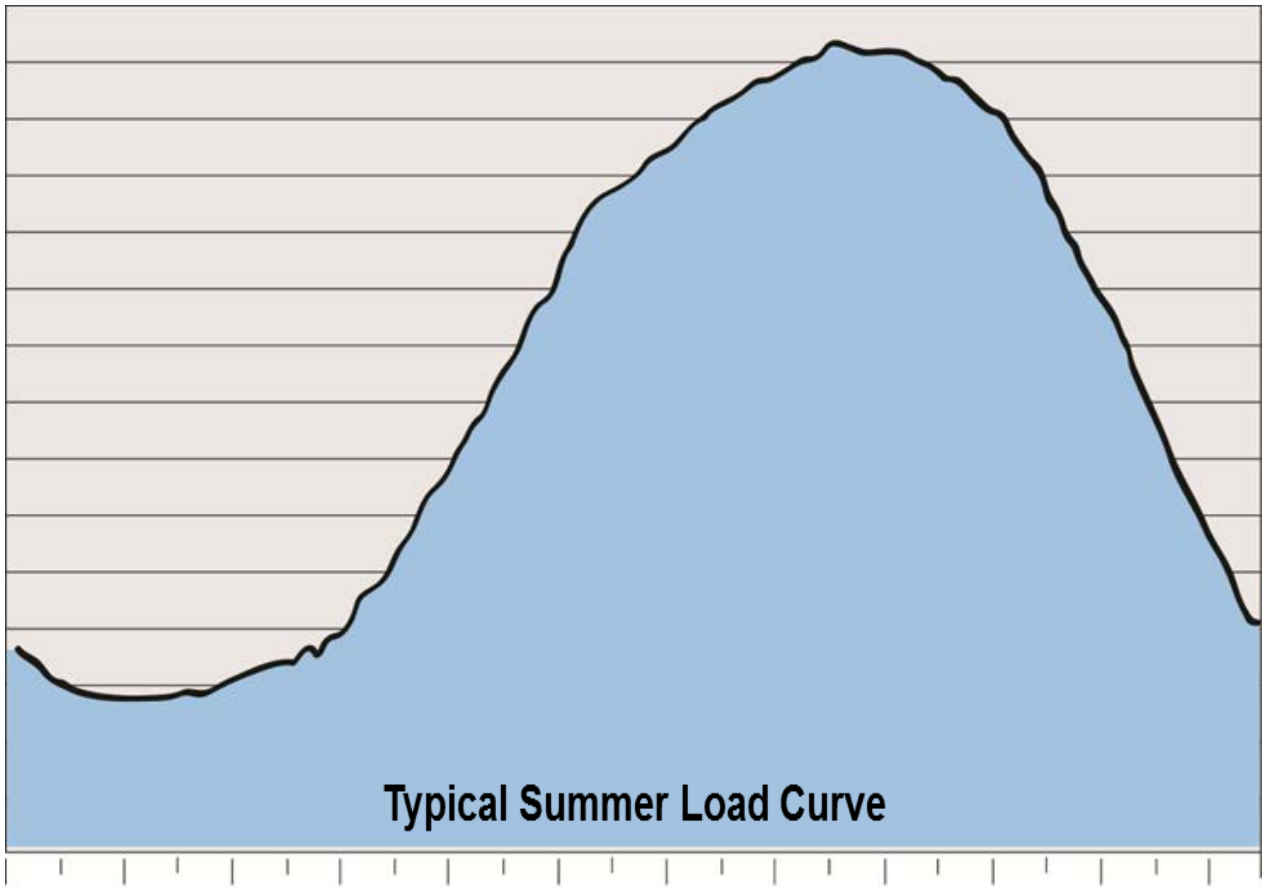
Storms

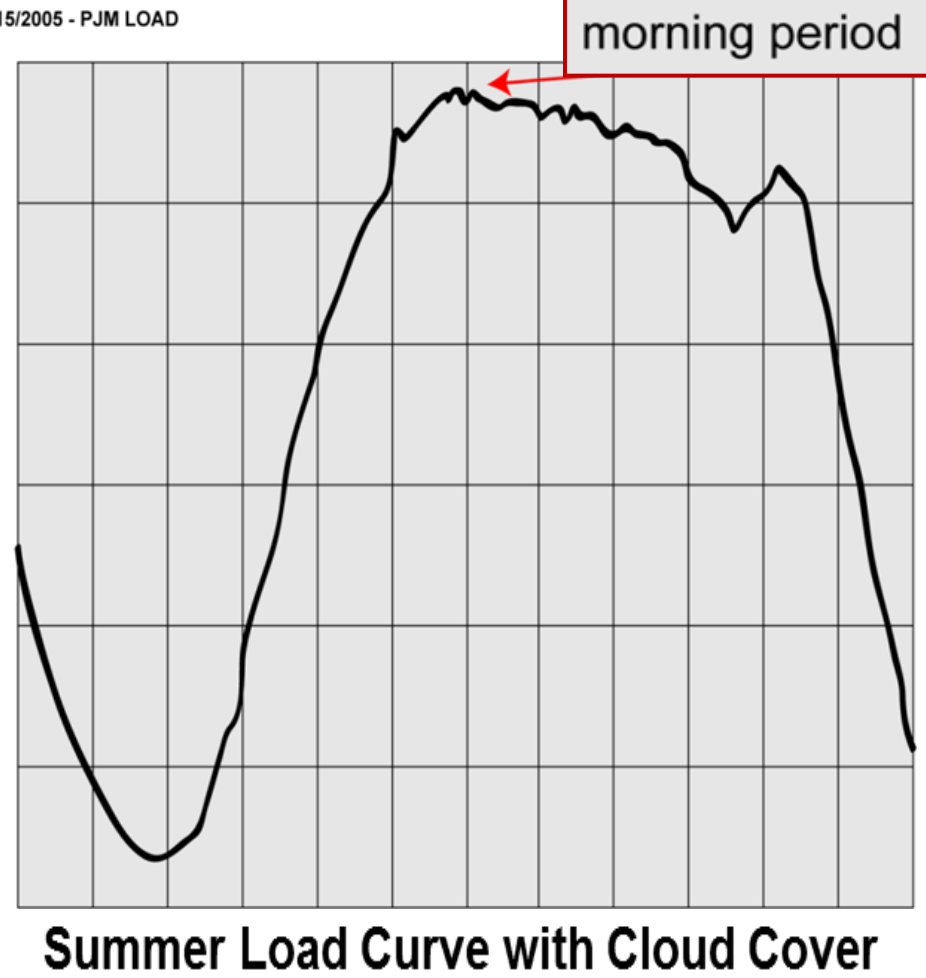
- Power outages and loss of customer demand
  - Thunderstorms cause wind and lightning damage
  - Lightning-related outages cause the nation's utility industry over $100 million annually in materials and labor costs
- Precipitation can decrease temperatures
  - Snow can decrease loading due to facility closings
  - Blizzards can increase loading on weekends

Cloud Cover

- Associated with fronts and storms
- Can flatten load curves
- Can cause afternoon valleys to be shallow or non-existent
- Increase “lighting” load during the day or afternoon

Cloud Cover


Typical Summer Load Curve


8/15/2005 - PJM LOAD
Flattened Peak resulting from heavy cloud cover in PHIL & DCA area in morning period
Summer Load Curve with Cloud Cover

Other Weather Effects

- Duration of Weather Conditions:
  - If a hot spell extends to 2-3 days or more:
    - Nighttime temperatures do not cool down
    - Thermal mass in homes and buildings retain the heat from the previous days
    - Causes air conditioners to turn on earlier and stay on later in the day
  - During cold weather, portable heaters and strip heaters are among the highest sources of electrical demand

Human Effects on Load

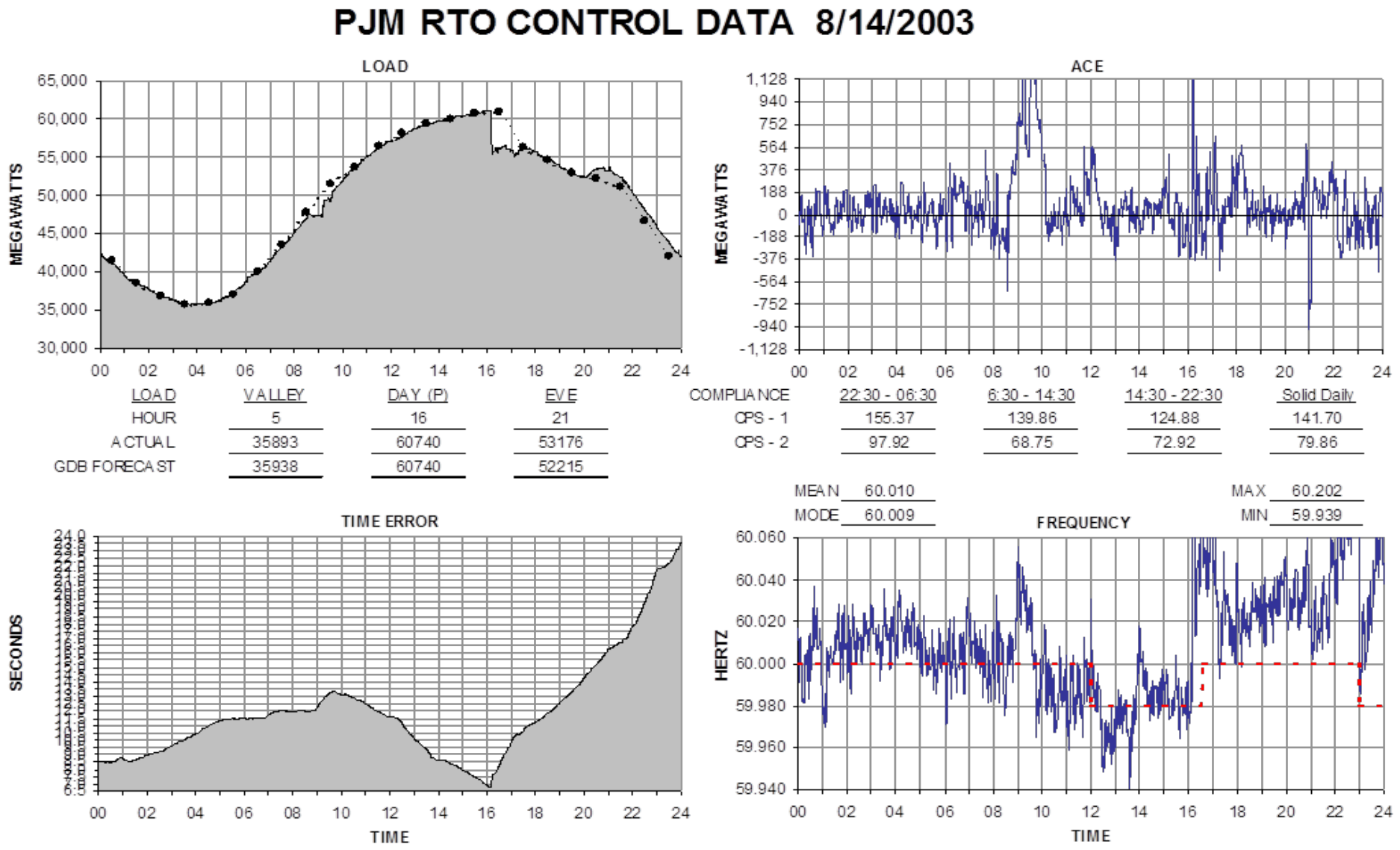
- Holidays
  - Holidays have decreased load demand based on the duration and length
    - More difficult to forecast due to infrequent occurrence
- Day of the week
  - Load differences between weekends and weekdays
  - Load on different weekdays
    - Monday and Fridays are adjacent to weekends and have structurally different loads than Tuesday, Wednesday, and Thursday
  - Sundays have the lowest demand followed by Saturday
    - The rest of the weekdays have small load variations

Human Effects on Load

- Hour of the day
  - Load pattern follows the activities of the consumers
  - Demand steadily increases from 9 am to 12 noon with a small decrease during midday picking up again until 4 pm in the afternoon
  - Demand steadily decreases from 4 pm to 7 pm increasing again around 8 pm to 9 pm
  - After 9 pm, demand decreases gradually to the lowest load demand in the early morning
- Events
  - Depending on the event, it can have either an increasing or decreasing effect on the overall load demand

Human Effects on Load

August 14, 2003

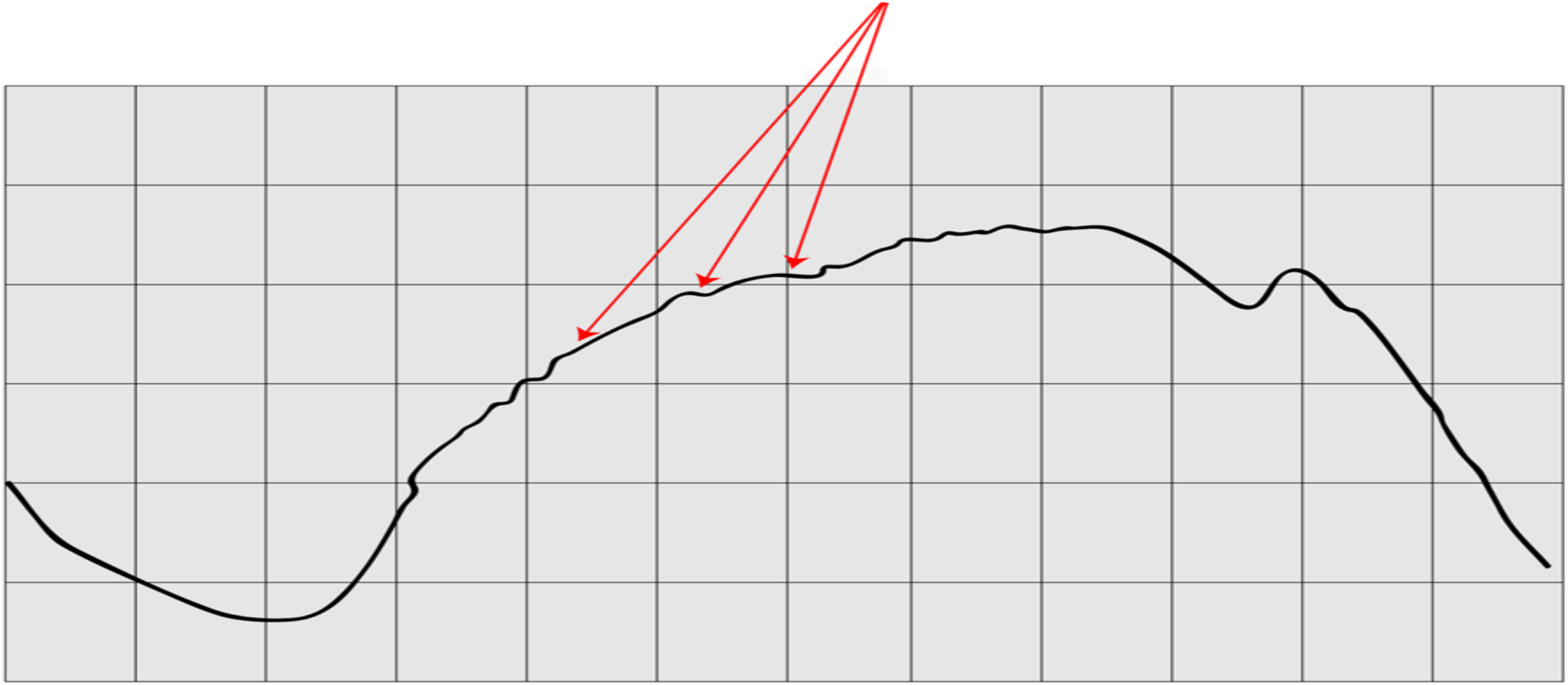


Human Effects on Load – O.J. Simpson's Verdict

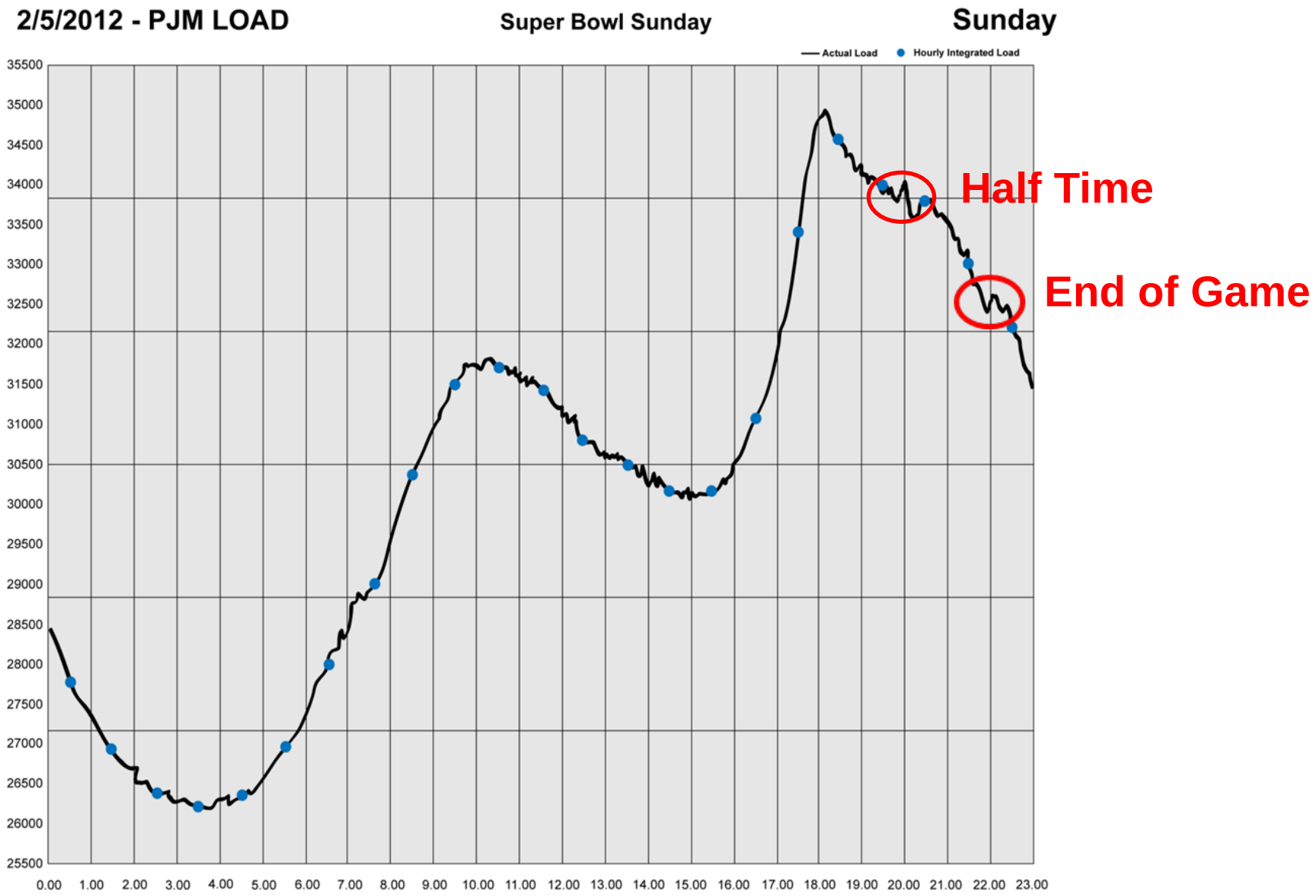
- Example of erratic / unusual load shape during and after the televised announcement of the verdict in trial of O.J. Simpson – October 3, 1995

Human Effects on Load – 9/11

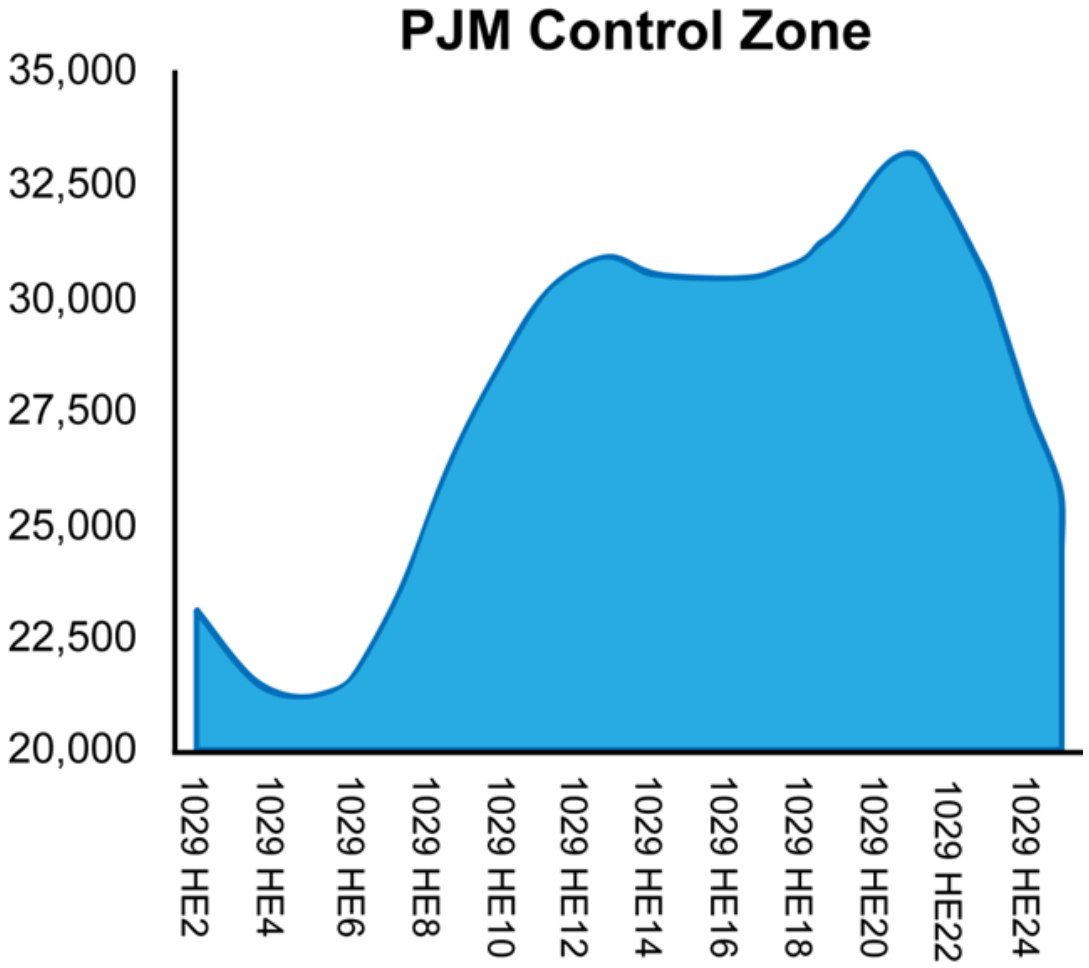
- Effects of the attacks on the World Trade Center and Pentagon 9/11/01

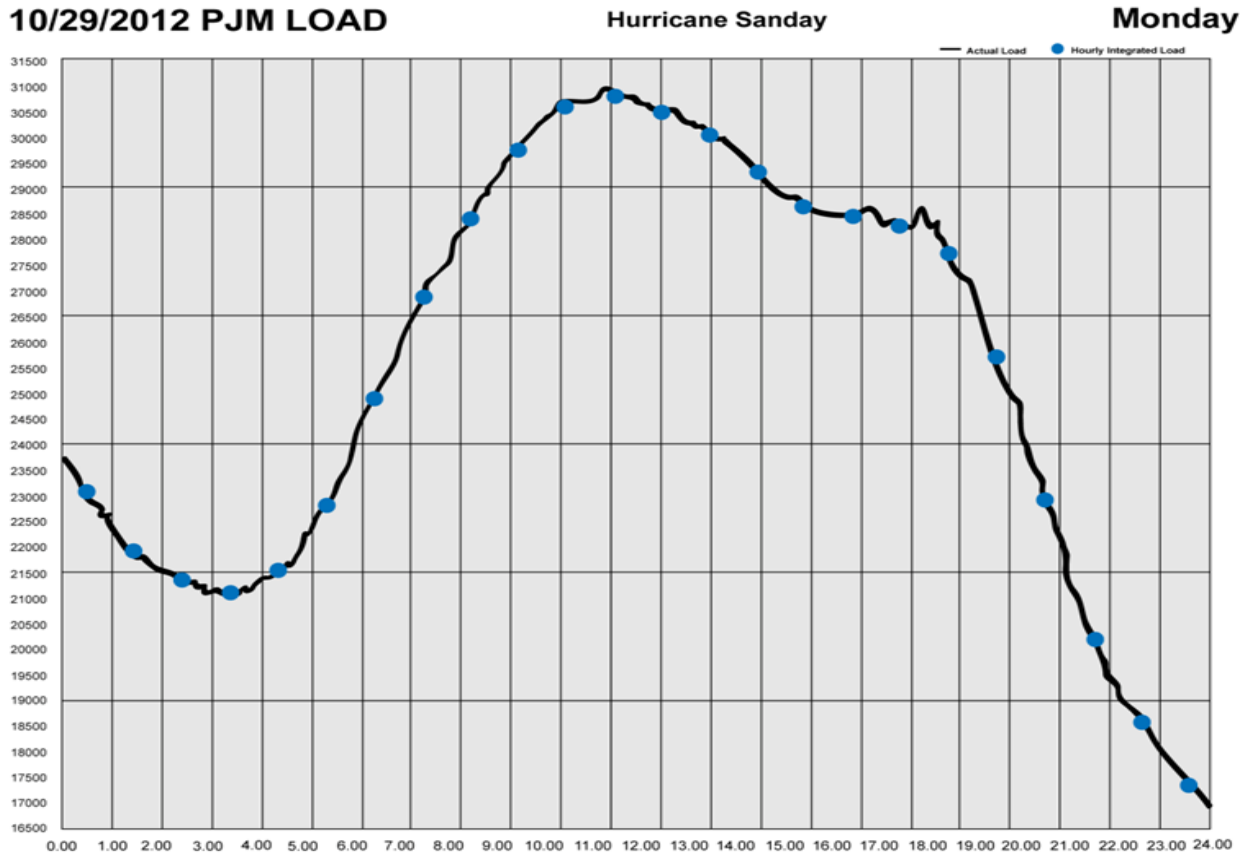


Human Effects on Load – 2012 Superbowl



Human Effects on Load – Hurricane Sandy, 2012





Summary

- Weather brings a variety of changes to load demand
  - Direct weather impacts (wind, lightning, etc.)
  - Human reactions to weather changes (or lack of weather changes)
- Hot Weather
  - Temperature
  - Humidity
- Cold Weather
  - Temperature
  - Wind
- Storms & Cloud Coverage

Contact Information

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Website: www.pjm.com

The Member Community is PJM's self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services

Resources and References

- “Climate Change Impacts on the Electric Power System in the Western United States,” Decision and Information Sciences, www.dis.anl.gov/index.html
- “The Estimated Impact of Weather on Daily Electric Utility Operations,” Ronald N. Keener, Jr., sciencepolicy.colorado.edu/socasp/weather1/keener.html
- “Load Forecasting,” Eugene A. Feinberg, Eugene.Feinberg@sunysb.edu