Analytics2011
CONFERENCE SERIES

# On the Holiday Effect of Electricity Demand

Dr. Tao Hong, SAS

# Outline

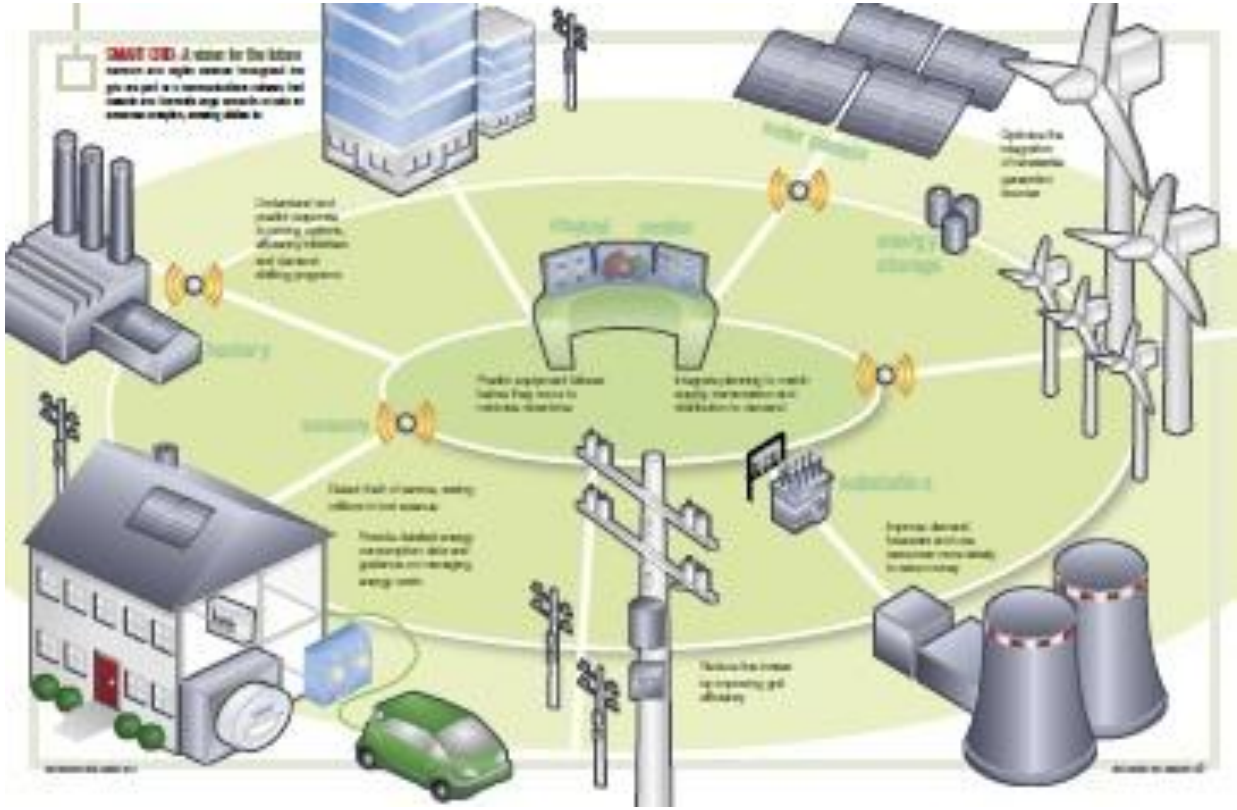
- Introduction
- Background
- Holiday effect
- Case studies
- Beyond this talk

# Outline

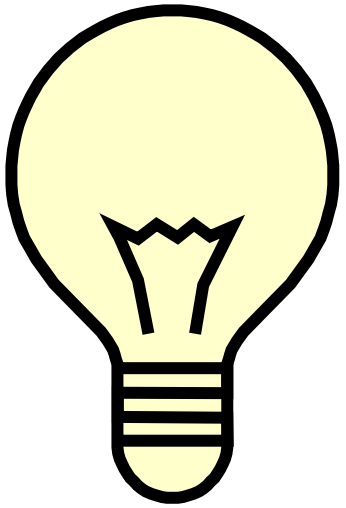
- **Introduction**
  - Electricity
  - Demand
  - Holiday
  - Motivation
  - Challenges
- Background
- Holiday effect
- Case studies
- Beyond this talk

# Electricity

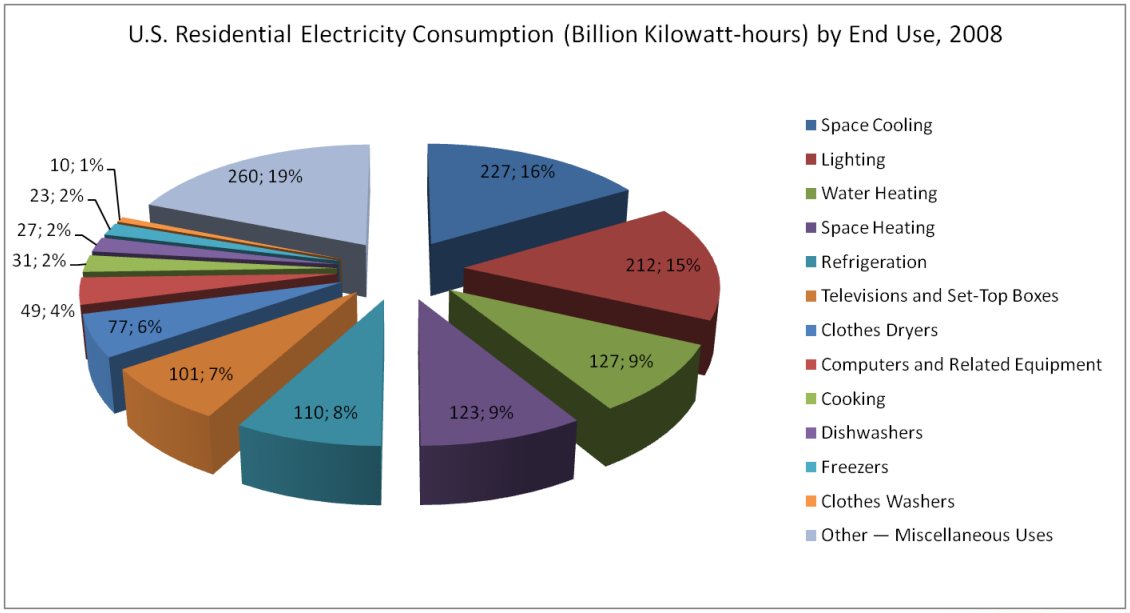
- Necessity
- Commodity
- Grid (smart?)
- Utility



# Demand



- Ampere
- Watt
- Watt-hour



# Holiday

- US Public Holidays Established by Federal Law

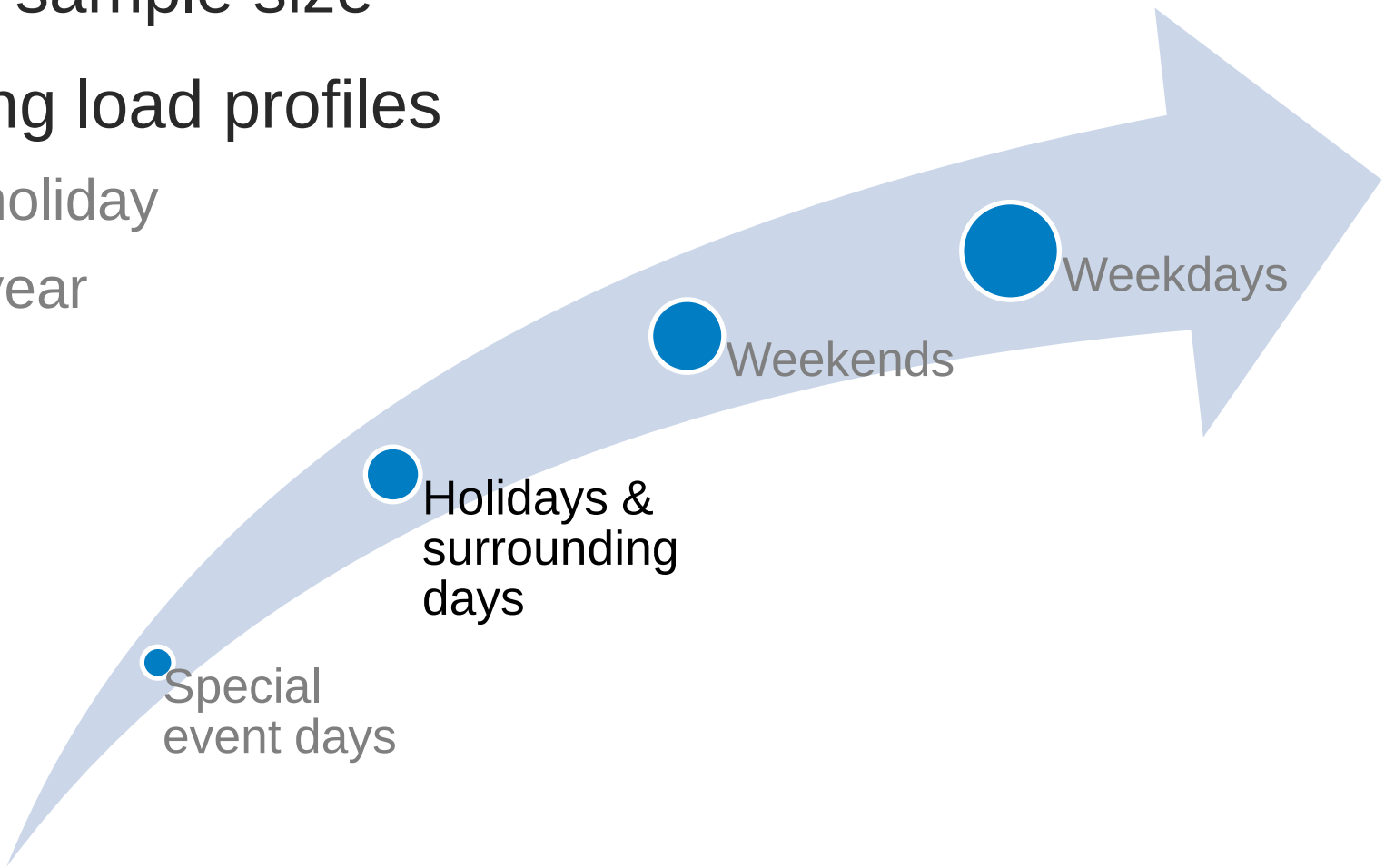
| | Date | Official Name |
|---|---|---|
| 1 | Jan 1 | New Year's Day |
| 2 | 3rd Mon in Jan | Birthday of Martin Luther King Jr. |
| 3 | 3rd Mon in Feb | Washington's Birthday |
| 4 | Last Mon in May | Memorial Day |
| 5 | July 4 | Independence Day |
| 6 | 1st Mon in Sep | Labor Day |
| 7 | 2nd Mon in Oct | Columbus Day |
| 8 | Nov 11 | Veterans Day |
| 9 | 4th Thu in Nov | Thanksgiving Day |
| 10 | Dec 25 | Christmas Day |

# Motivation

- Better load forecasting
  - Energy trading
  - Operations
  - Planning
    - » Weather normalization
- Better understanding of customer behavior
  - Demand side management

# Challenges

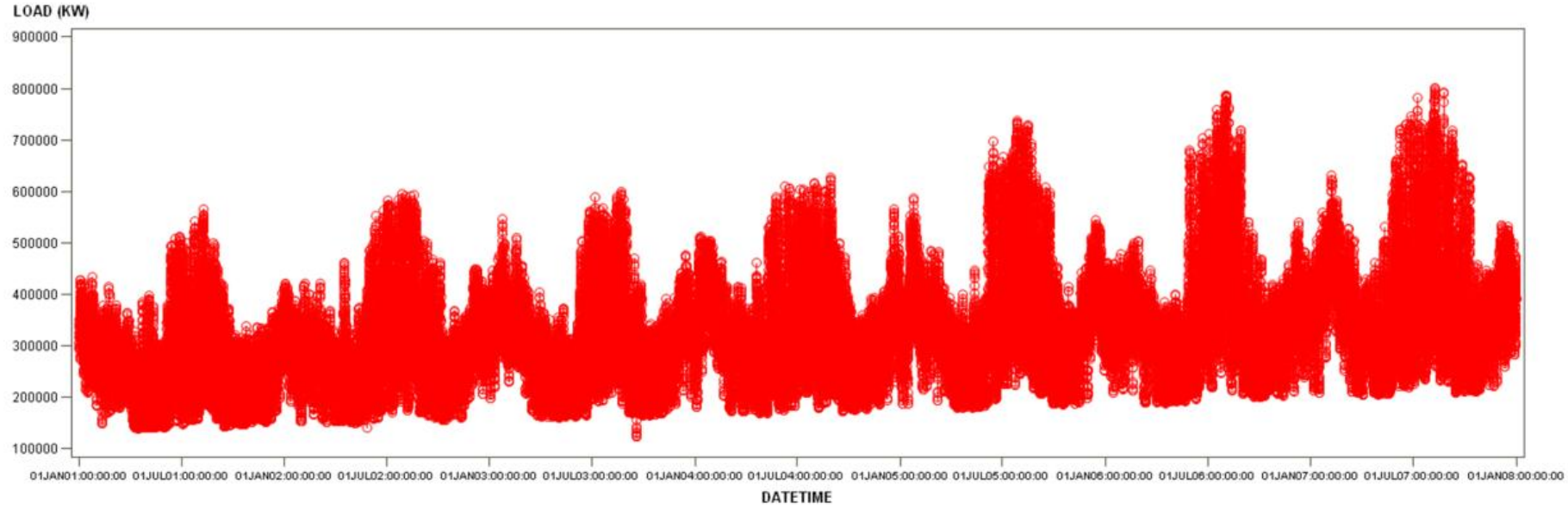
- Small sample size
- Varying load profiles
  - By holiday
  - By year

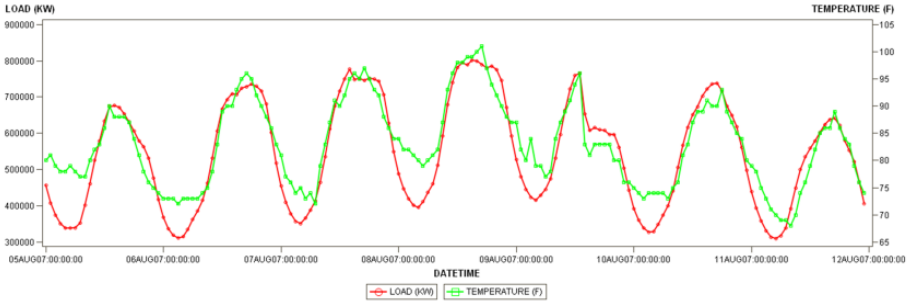


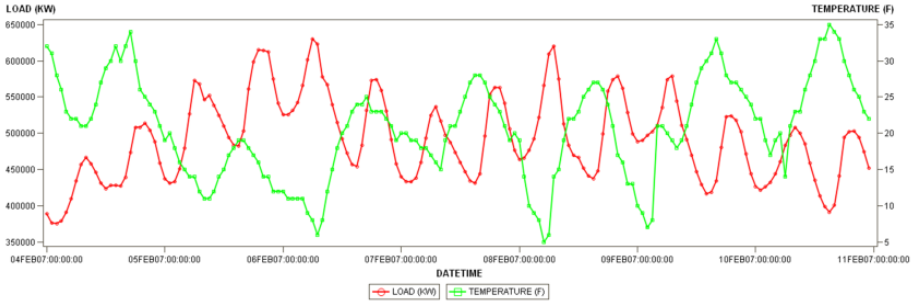
# Outline

- Introduction
- **Background**
  - Electric load forecasting
  - Day ahead forecasting
  - General linear models
  - Naïve MLR benchmark
  - Recency effect
- Holiday effect
- Case studies
- Beyond this talk

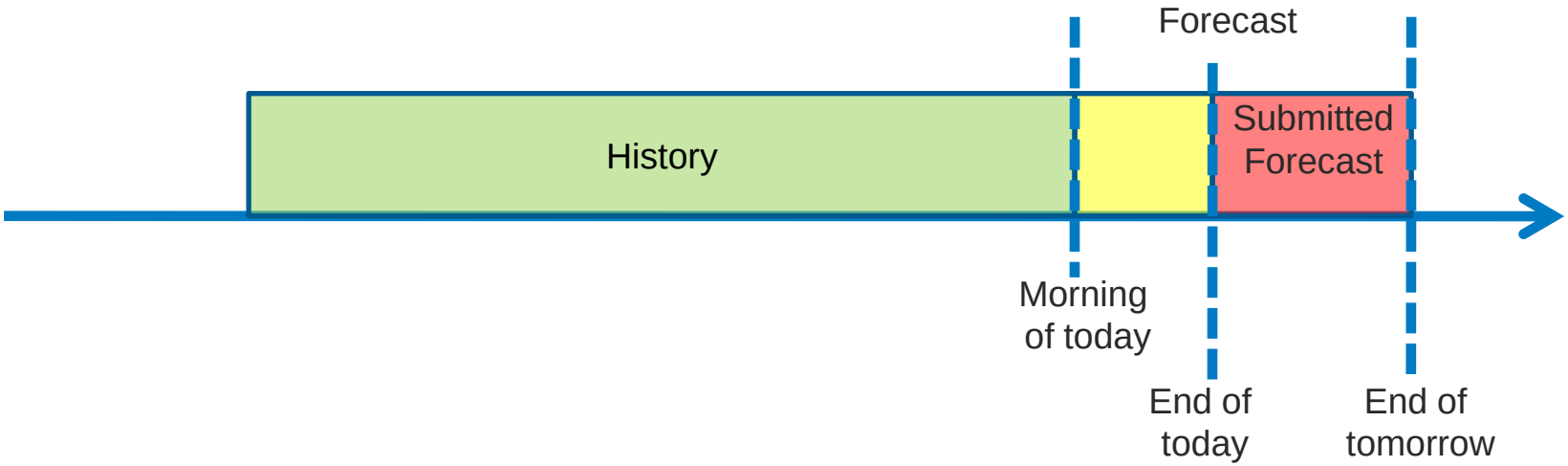
# Electric Load Forecasting

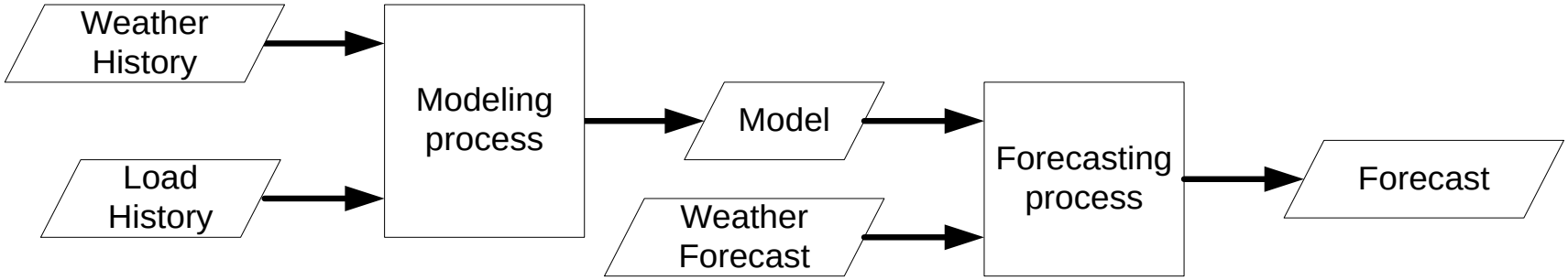


# Day Ahead Load Forecasting



# General Linear Models

- SAS/STAT PROC GLM
- Simple linear regression
- Multiple linear regression
- Polynomial regression
- Interaction regression
- Lagged regression
- Dynamic regression

# Naïve MLR Benchmark

$$E(Load) = \beta_0 + \beta_1 * Trend + \beta_2 * Day * Hour + \beta_3 * Month$$
$$+ \beta_4 * Month * T + \beta_5 * Month * T^2 + \beta_6 * Month * T^3$$
$$+ \beta_7 * Hour * T + \beta_8 * Hour * T^2 + \beta_9 * Hour * T^3$$

Tao Hong, et. al., "*A Naive Multiple Linear Regression Benchmark for Short Term Load Forecasting*", 2011 IEEE PES General Meeting, Detroit, Jul 24-29, 2011

# Recency Effect

- The most recently presented items or experiences will most likely be remembered best. If you hear a long list of words, it is more likely that you will remember the words you heard last (at the end of the list) than words that occurred in the middle
- Load = f(T, T(t-1), T(t-2), …)
  - Load refers to Load(t), T refers to T(t)
  - i.e., Load = f(trend, calendar variables, T, T(t-1))

# Outline

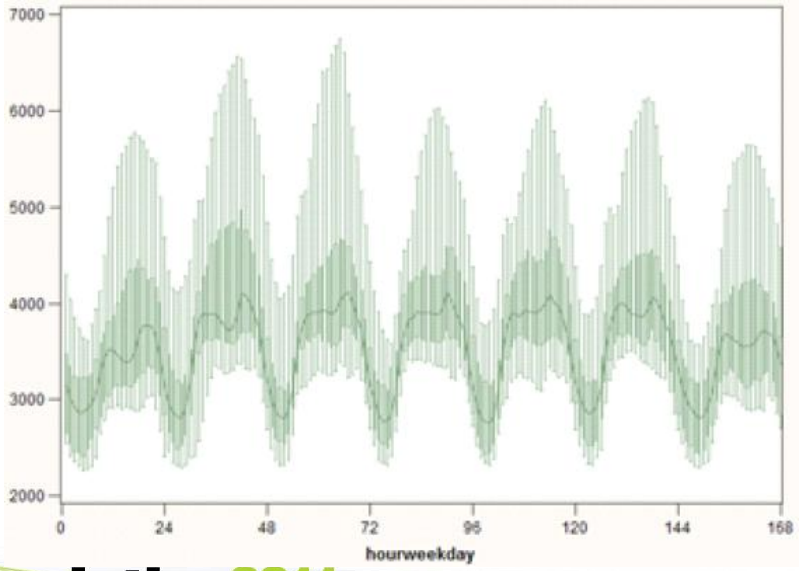
- Introduction
- Background
- **Holiday effect**
  - Methodology
  - Weekend effect
  - Significant holidays
  - Surrounding days
  - Example
- Case studies
- Beyond this talk

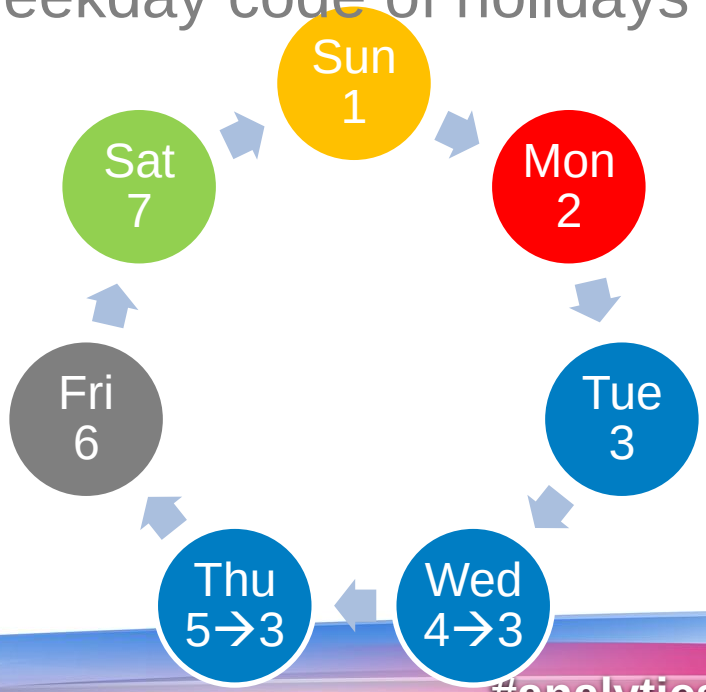
# Methodology

- Principles
  - Parsimony, keep it simple & stupid (KISS)
  - Use weekends to model holidays
  - Use weekdays/weekends to model surrounding days
- Steps
  - Weekend effect
  - Identify and model significant holidays
  - Model surrounding days of significant holidays

# Weekend Effect

- Group similar days of week together
  - Reduce the levels of the class variable *Weekday*
  - Maintain the same or better forecasting accuracy
  - More samples for each levels
  - Less alternatives for the weekday code of holidays



# Significant Holidays

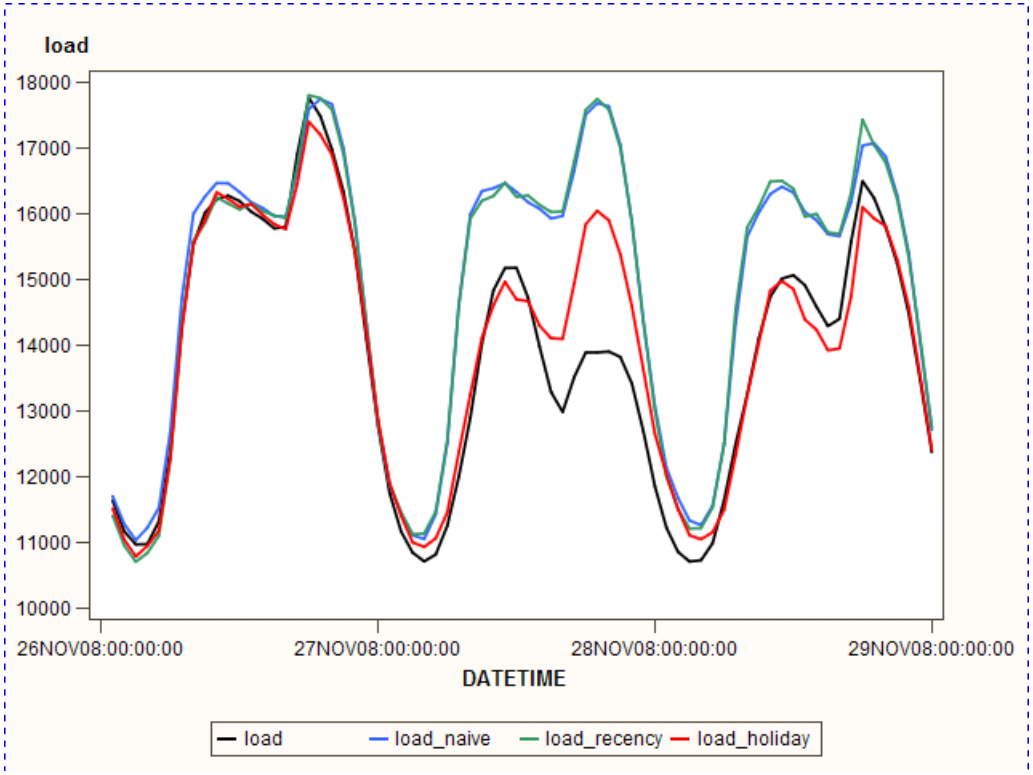
- Significant
  - When alternating the weekday code to weekend, the forecasting accuracy can be improved
- Memorial Day – last Monday in May
  - May behave more like a Sunday than Monday
  - If so, significant
- Columbus Day – 2nd Monday in October
  - A Monday holiday
  - May *not* be different than regular Monday's

# Surrounding Days

- Assumption
  - Only significant holidays impact the surrounding days
- Memorial Day – last Monday in May
  - When behave more like a Sunday than Monday
  - The day after Memorial day may behave more like a Monday than Tuesday
- Thanksgiving Day – 4$^{th}$ Thursday in November
  - Black Friday may behave more like a weekend day than Friday

# Example
## Thanksgiving Day of 2008, NEISO

- The day before
  - Wed → Fri
- Thanksgiving
  - Thu → Sat
- The day after
  - Fri → Sat




| DATE | MAPE_naive | MAPE_recency | MAPE_holiday |
|---|---|---|---|
| 11/26/2008 | 1.7% | 1.3% | **0.8%** |
| 11/27/2008 | 14.6% | 14.7% | **5.4%** |
| 11/28/2008 | 7.8% | 8.0% | **2.1%** |

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- Holiday effect
- **Case studies**
  - Sample utilities
  - Forecasting accuracy
  - Holidays and surroundings
  - PEPCO vs. BG&E
  - Take aways
- Beyond this talk

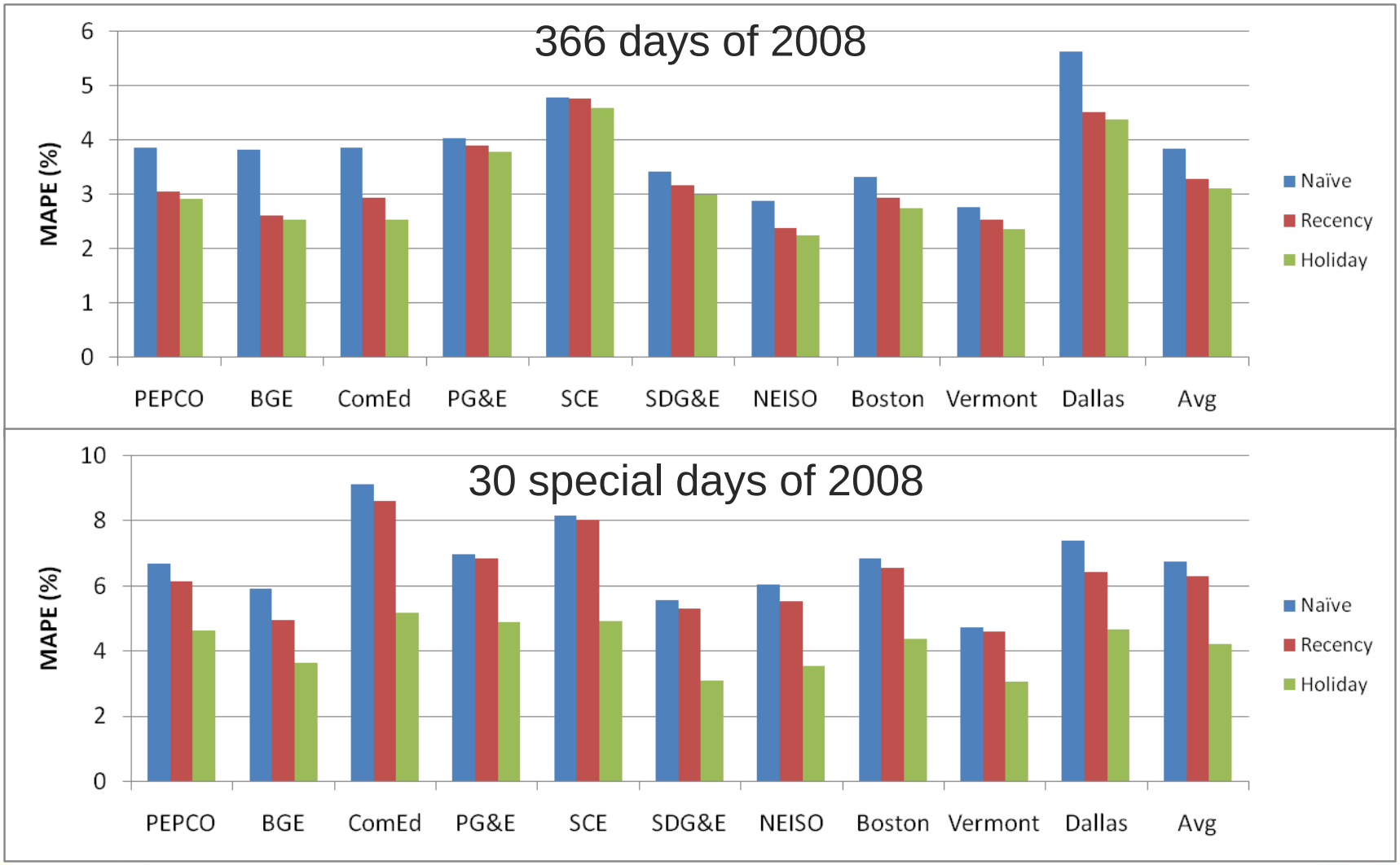
# Sample Utilities

- PEPCO – KDCA
- BG&E – KBWI
- ComEd – KMDW
- PG&E – KSFO
- SCE – KLAX
- SDG&E – KSAN

- NEISO
  - Great Boston
  - Vermont
- ERCOT
  - North Central – KSFW (Dallas/Fort Worth)

Tao Hong, et. al., "*Cost of Temperature History Data Uncertainties in Short Term Electric Load Forecasting*", 2010 IEEE 11th International Conference on Probabilistic Methods Applied to Power Systems (PMAPS), Singapore, Jul 24-29, 2010

# Forecasting Accuracy



# Holidays and Surroundings

| | Date | Official Name | Holiday | Before | After |
|---|---|---|---|---|---|
| 1 | Jan 1 | New Year's Day | **10** | 9 | 8 |
| 2 | 3rd Mon in Jan | Birthday of MLK Jr. | 1 | 0 | 0 |
| 3 | 3rd Mon in Feb | Washington's Birthday | 3 | 0 | 2 |
| 4 | Last Mon in May | Memorial Day | **10** | 0 | 7 |
| 5 | July 4 | Independence Day | **10** | 8 | 7 |
| 6 | 1st Mon in Sep | Labor Day | 8 | 0 | 5 |
| 7 | 2nd Mon in Oct | Columbus Day | 0 | 0 | 0 |
| 8 | Nov 11 | Veterans Day | 0 | 0 | 0 |
| 9 | 4th Thu in Nov | Thanksgiving Day | **10** | 7 | **10** |
| 10 | Dec 25 | Christmas Day | **10** | **10** | 9 |
| Total | | | **62** | **34** | **48** |

# PEPCO vs. BGE

| Official Name | PEPCO | | | BGE | | |
|---|---|---|---|---|---|---|
| | Holiday | Before | After | Holiday | Before | After |
| New Year's Day | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Birthday of MLK Jr. | ✓ | | | | | |
| Washington's Birthday | ✓ | | | | | |
| Memorial Day | ✓ | | | ✓ | | ✓ |
| Independence Day | ✓ | ✓ | | ✓ | ✓ | |
| Labor Day | ✓ | | | ✓ | | ✓ |
| Columbus Day | | | | | | |
| Veterans Day | | | | | | |
| Thanksgiving Day | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Christmas Day | ✓ | ✓ | ✓ | ✓ | ✓ | |

# Take Aways

- Some holidays can be modeled as weekends
- Day code of the surroundings days of holidays can be altered
- Different utilities or zones may have different holiday effects
  - One reason for multi-region forecasting
- Results based on the 10 sample utilities/zones
  - By altering nearly half of the 30 special days
  - Forecasting accuracy of the special days can be improved by 30% to 44% comparing to Naïve MLR

# Outline

- Introduction
- Background
- Holiday effect
- Case studies
- **Beyond this talk**
  - BKS course
    - *Electric Load Forecasting*
  - IEEE Working Group on Energy Forecasting

# BKS Course: Electric Load Forecasting

- SAS Business Knowledge Series course
- 2 days, 4 half-day sessions
- Intermediate level
- Prerequisite
  - Familiar with SAS Enterprise Guide
  - Basic statistics preferred

# BKS Course: Electric Load Forecasting

- Session 1
  - Introduction to electric load forecasting
  - Salient features of electric load series
  - Multiple linear regression
  - Practice
- Session 2
  - A naïve benchmark for short term load forecasting
  - Customizing the benchmarking model
  - Practice

# BKS Course: Electric Load Forecasting

- Session 3
  - Very short term load forecasting with autoregressive terms
  - Medium/long term probabilistic load forecasting with macroeconomic information
  - Practice
- Session 4
  - A review of load forecasting techniques
  - Frequently made mistakes
  - Practice

# IEEE WG on Energy Forecasting

- FAQ from utility engineers / managers

  (Most scientific papers could not answer the following)

  - What data do we need?
  - How is our data quality?
  - Which weather station(s) shall we use?
  - Which software package or services shall we buy?
  - What skill sets shall we stuff?
  - Is my forecast accurate enough?
  - How does my forecast comparing to others?
  - Shall we spend more men/hours to improve our forecast?
  - How can we explain the forecasts to regulators / commissioners / executives?
  - What if our load forecaster changes job?

# IEEE WG on Energy Forecasting

- Scope of work
  - Utility application oriented energy forecasting
  - Focus on practical needs of utilities
  - Data: outlier detection, data cleansing, selection of weather station(s)
  - Inputs: temperature forecast, wind forecast, solar forecast, EV load forecast, customer behavior, demand response activities, loss evaluation
  - Modeling: hierarchical (system-substation-feeder) forecasting, multi-region forecasting
  - Applications (outputs): price forecasting, demand response analysis, planning of demand side management, risk management, weather normalization, loss evaluation

# IEEE WG on Energy Forecasting

- Activities in PESGM 2011, Detroit, MI
  - Practical aspects of electric load forecasting
    - » 6 panelists
    - » 4 countries
    - » 3 utilities, 2 universities, 1 consultant
    - » Around 30 attendees

# IEEE WG on Energy Forecasting

- Activities in PESGM 2012, San Diego, CA
  - Demand response: analytics, practice, and challenges in smart grid environment
    - » 5 to 6 panelists
  - Load forecasting and its applications in operations and planning
    - » 5 to 6 panelists

# IEEE WG on Energy Forecasting

- On-going project: benchmark of forecasting accuracy
  - Utilities have been wondering about the satisfaction level of load forecasting accuracy. This project will establish accuracy statistics for load forecasting, and use data from over 20 utilities to benchmark the forecasting accuracy in the industry.
  - As the project moves on, we hope to attract more data entries from more utilities in the next a few years.

http://sites.ieee.org/pes-pspic/about-pspi/subcommittees/energy-forecasting/

# Thank You!

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