

Day Ahead Hourly Load Forecasting

An Introduction

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THE
POWER
TO KNOW®

Outline

- Introduction
- What, Why and How?
- General Linear Models
- A Naïve MLR Based Benchmarking Model
- Demonstration

Introduction

Tao Hong

- Appointment
 - Industry Consultant, Utilities Practice, SAS
 - Instructor, Business Knowledge Series, SAS
 - Chair, IEEE Working Group on Energy Forecasting
- Experience
 - Energy forecasting
 - T&D planning, reliability planning
 - Renewable integration
 - Risk management
 - Retail forecasting
 - Revenue management

Introduction

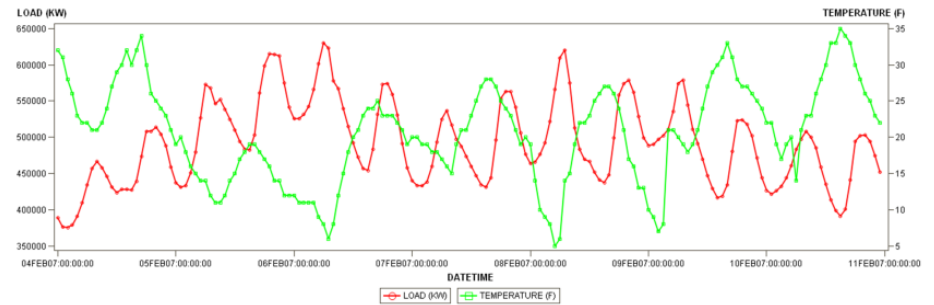
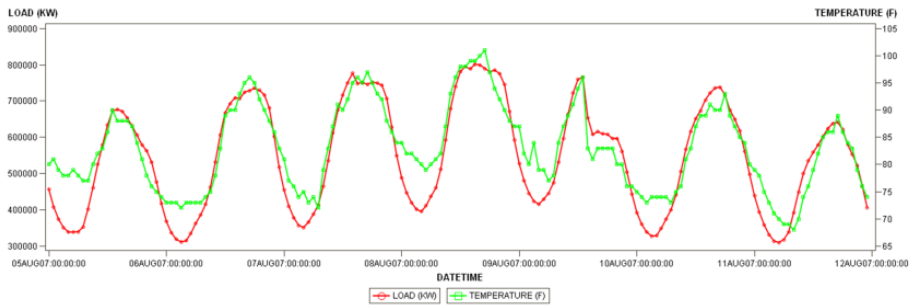
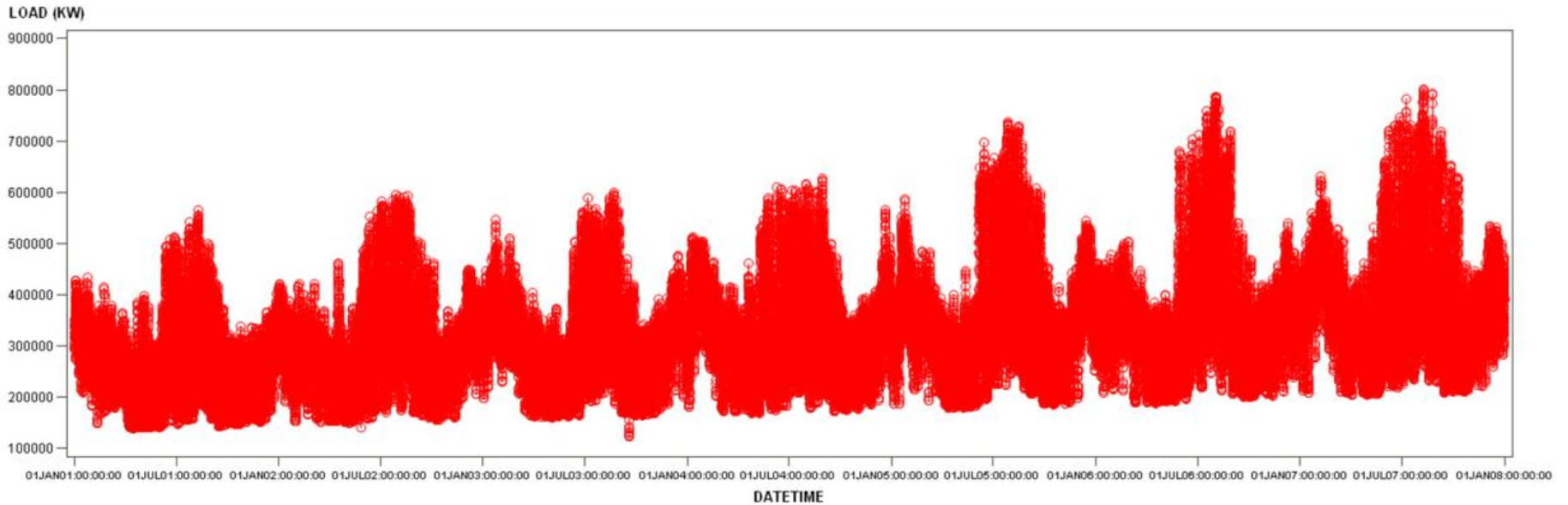
This Lecture

- Taste the flavor of load forecasting
- Understand basic concepts of short term load forecasting
- Learn how to
 - discover salient features of electric load series using graphic methods
 - capture the salient features using regression models
 - build regression models using SAS Enterprise Guide
 - develop a naïve model for one day ahead hourly load forecasting

Notes, data, and reading materials can be downloaded from the lecture webpage:
<http://courses.drhongtao.com/dahlf>

What?

Electric Load Forecasting



What? Classification



Why?

A Job Description

- BSE is currently seeking a Senior Load Forecasting Specialist. The ideal candidate is prepared to meet the following expectations:
 - This position directs the processes necessary to produce the forecast of the total demand for electricity within the BSE balancing area along with forecasts of the sale of electricity by BSE and others and BSE's transmission demand requirements as part of BSE's overall Integrated Planning Process.
 - The incumbent serves as an expert in the methodologies used in the in load forecasting and is responsible for directing from beginning to end the one or more of the forecasting processes. The incumbent plans and insures that the appropriate research and design is completed to assure that BSE has load forecasting procedures and methodology which are equal to or exceed current standard forecasting processes when compared to other major electric utilities.
 - Accurate forecasts are essential to decisions impacting BSE's operating practices and the type/timing of resource acquisitions such as decisions to build, lease, or sell generation and transmission assets and the decisions to purchase or sell wholesale power.

Why?

Industry Jobs

- Load Forecasting Specialist
- Load Research Analyst
- Rate analyst
- Planner
- Business analyst
- Quantitative analyst
- Risk analyst
- Price forecaster
- Energy trader
- And their management chain...

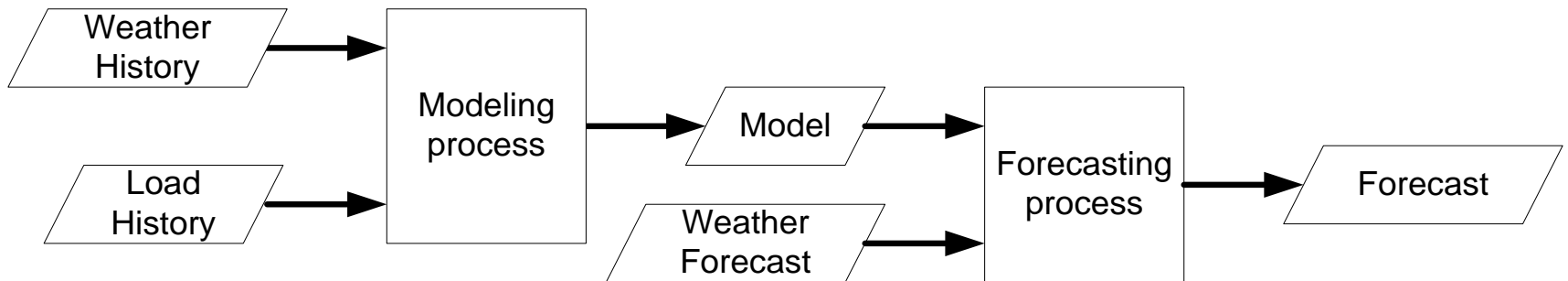
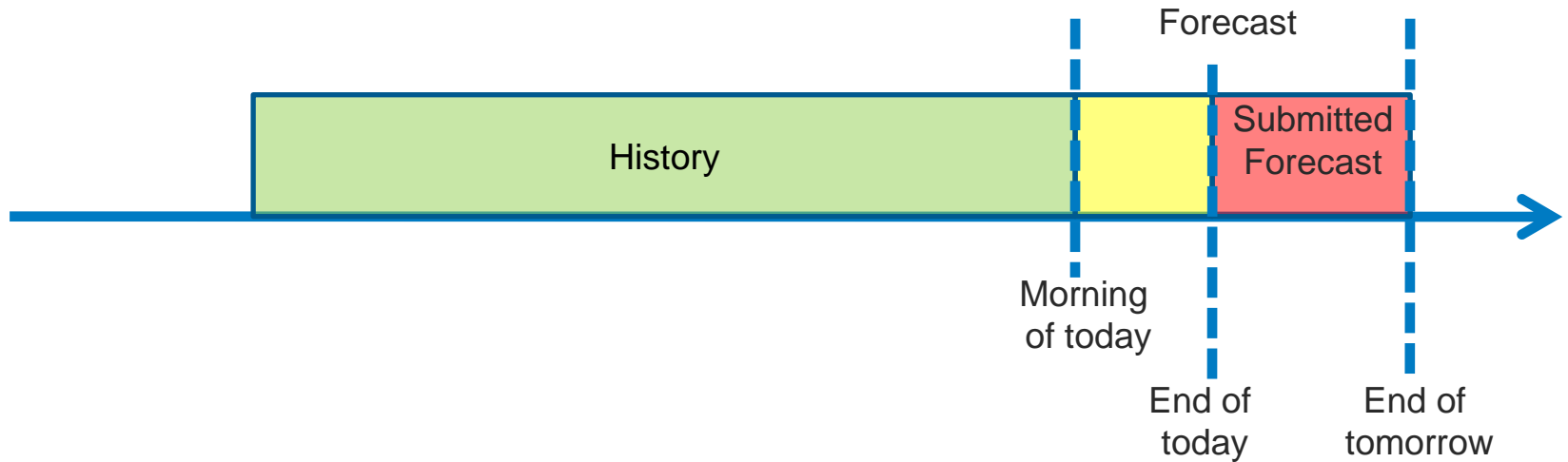
Why?

Business Needs

- Generation
- Transmission
- Distribution
- Retail
- Planning
- Operations & Maintenance
- Market

How?

Day Ahead Hourly Load Forecasting



How?

Regression Analysis

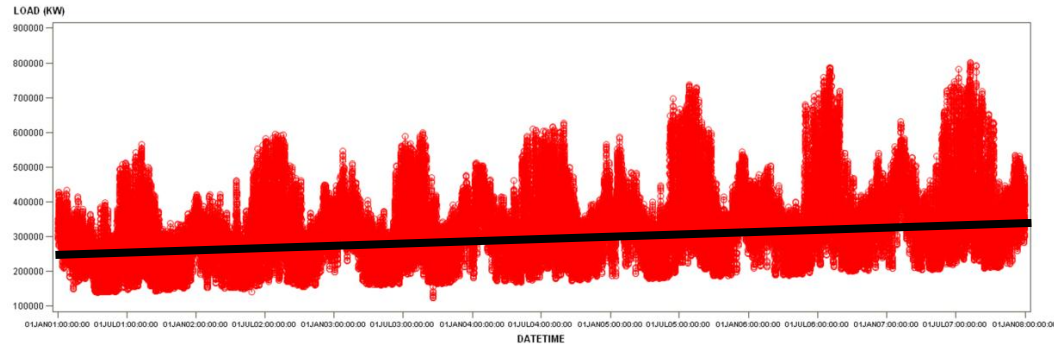
- Plot the data
- Select variables
 - Dependent variables
 - Independent variables
- Build the model
- Evaluate the model
 - Statistical tests
 - Goodness-of-fit
 - Forecasting accuracy
 - Intuition
- Document
 - Model
 - Procedure
 - Results
 - Reasoning
 - Any judgmental changes
 - Limitations
- Report
 - Written report
 - Oral presentation

Ex Ante Forecasting vs. Ex Post Forecasting

General Linear Models

Simple Linear Regression

- Elements
 - Intercept
 - Slope
 - Random error term
- Formal assumptions
 - Linearity
 - Constant variance
 - Independent
 - Normally distributed
- Parameter estimation

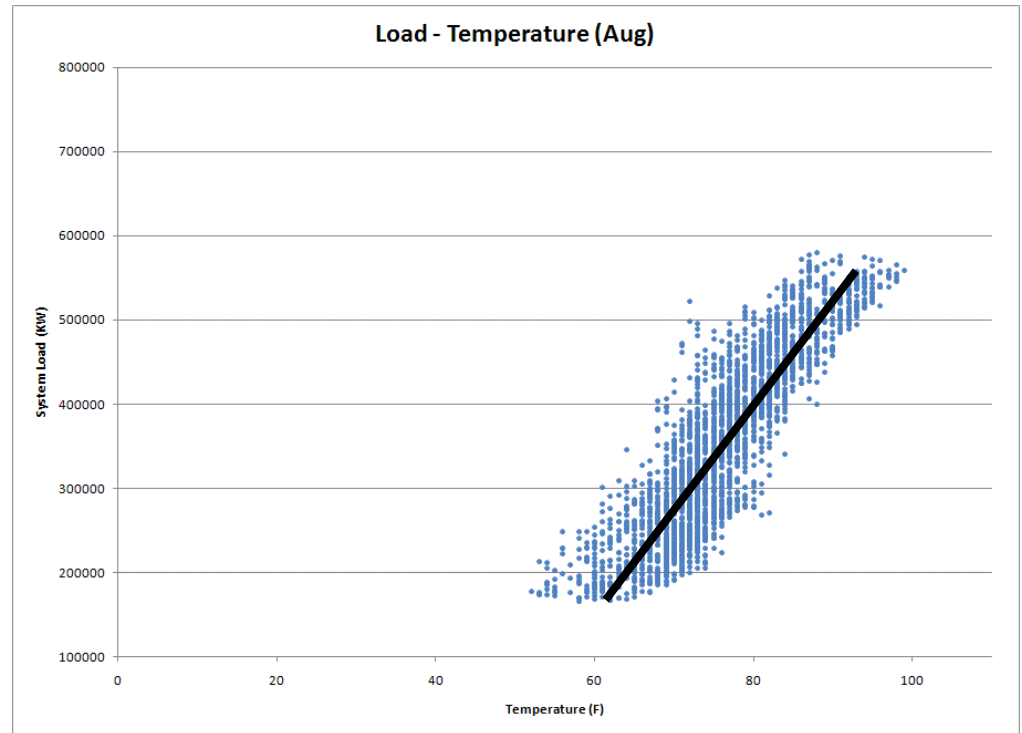


$$\text{Load} = \beta_0 + \beta_1 \text{Trend}$$

General Linear Models

Multiple Linear Regression

- Quantitative variables
 - Trend
 - Temperature

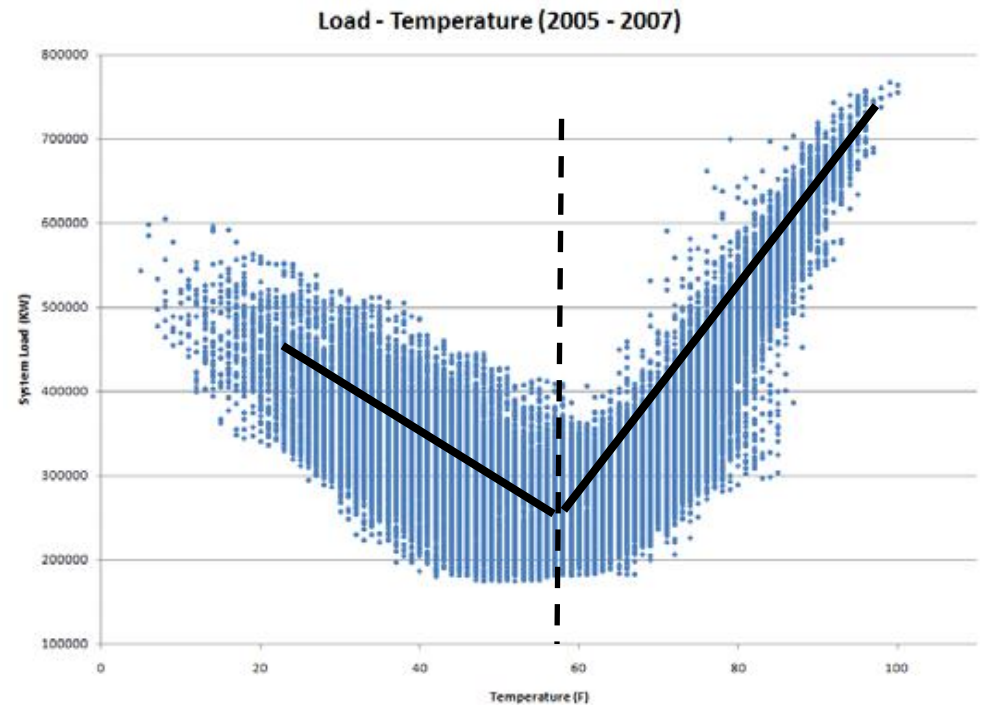


$$\text{Load} = \beta_0 + \beta_1 \text{Trend} + \beta_2 T$$

General Linear Models

Multiple Linear Regression

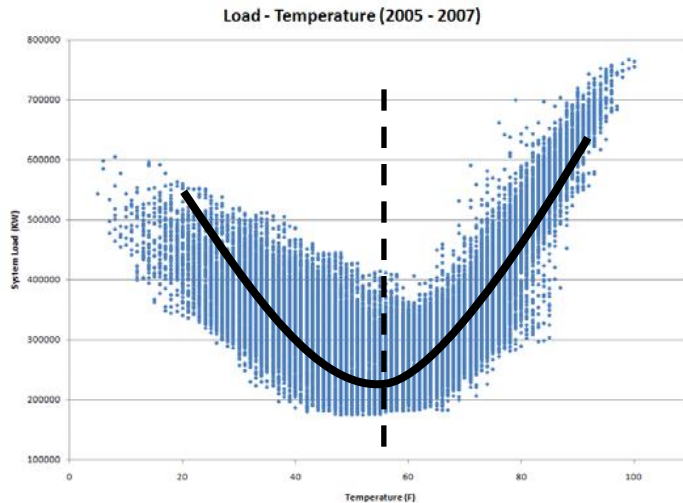
- Qualitative variables
 - 0-1 indicator
 - » Piecewise linear regression
 - Calendar variables
 - » Months of a year
 - » Days of a week
 - » Hours of a day



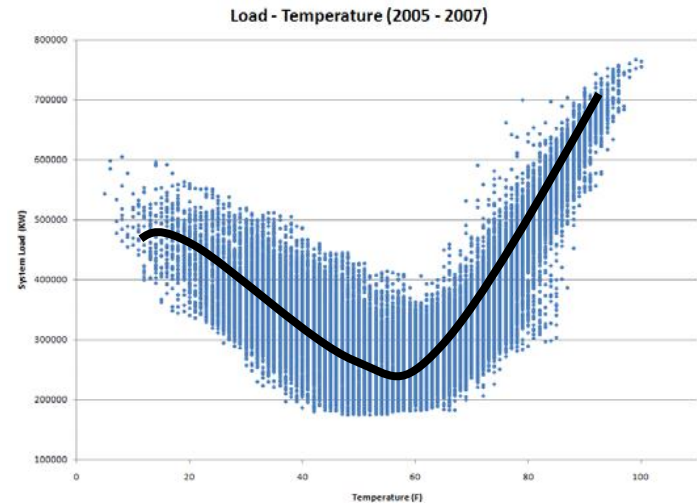
General Linear Models

Polynomial Regression

- Polynomials of independent variable(s)
 - Temperature



2nd order – symmetric



3rd order – asymmetric

General Linear Models

Interaction Regression

- Interactions between/among
 - Quantitative variables
 - » A new quantitative variable (*not covered*)
 - Quantitative variables and qualitative variables
 - » Month and temperature (plots)
 - » Hour and temperature (plots)
 - Qualitative variables
 - » Weekday and hour

A Naïve MLR Benchmarking Model

Benchmark

- Simple
 - Easy to implement
- Creditable
 - Fairly accurate and theoretically sound
- Widely applicable
 - Can be used by a wide range of utilities
- Interpretable
 - Can be understood by average electrical engineers, managers, etc.
- Reproducible
 - Can be reproduced based on documented procedures

A Naïve MLR Benchmark Model

- Main Effects
 - Trend
 - Month, Day, Hour
- Cross Effects

$$\begin{aligned} E(\text{Load}) = & \beta_0 + \beta_1 \times \text{Trend} + \beta_2 \times \text{Day} \times \text{Hour} + \beta_3 \times \text{Month} \\ & + \beta_4 \times \text{Month} \times T + \beta_5 \times \text{Month} \times T^2 + \beta_6 \times \text{Month} \times T^3 \\ & + \beta_7 \times \text{Hour} \times T + \beta_8 \times \text{Hour} \times T^2 + \beta_9 \times \text{Hour} \times T^3 \end{aligned}$$



Demonstration

SAS Enterprise Guide

Readings

- Tao Hong, Pu Wang and H. Lee Willis, “*A Naïve Multiple Linear Regression Benchmark for Short Term Load Forecasting*”, 2011 IEEE PES General Meeting
- Ott and Longnecker, “*An Introduction to Statistical Methods and Data Analysis 5ed*”



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