CALIFORNIA ISO

California Independent
System Operator

Managing Reliability and the Markets with PI

PI System Users Conference

OSI Software, Inc.

April 2-5, 2000

Jim Detmers
Director, Engineering and Maintenance
California Independent System Operator

CALIFORNIA ISO

California Independent System Operator

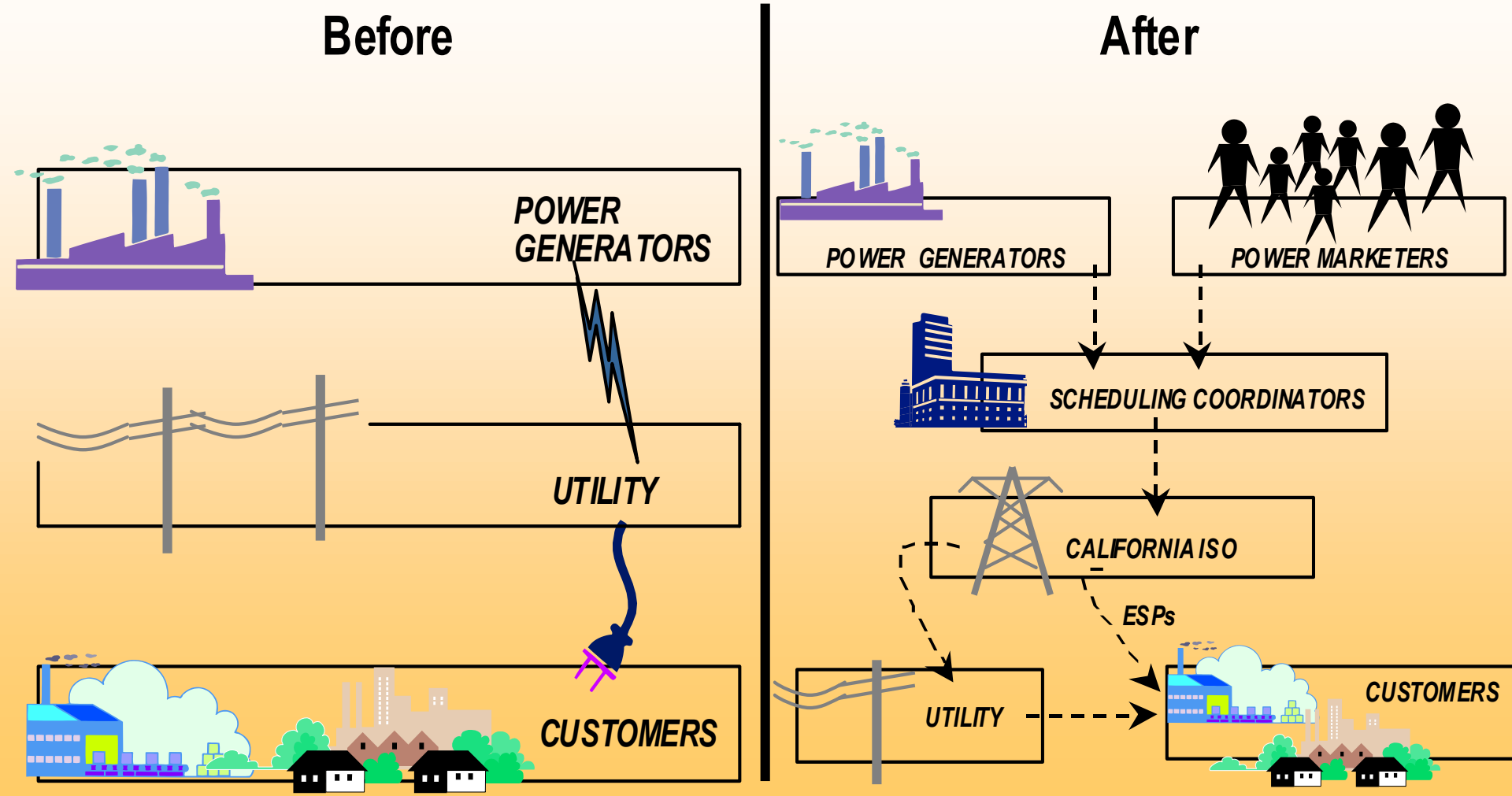
Some Facts About the California ISO

- Consists of PG&E, SCE, and SDG&E Service Territories.
- Covers 124,000 square miles.
- 21,000 Circuit Miles of Transmission
- Approximately 600+ Generators
- 45,000 Megawatt Summer Peak Load
- 164 Billion KWh of Energy Delivered to 27 Million Californians.
- Consumers Use Over $23 Billion of Energy Annually.

CALIFORNIA ISO

California Independent System Operator

De-Regulating the Electric Industry in California



CALIFORNIA ISO

California Independent
System Operator

How the California ISO was Formed

Sept. '96

AB 1890 signed

Dec. '96

ISO Restructuring Trust established

$191 million credit facility for ISO start-up and development costs

Jan. '97

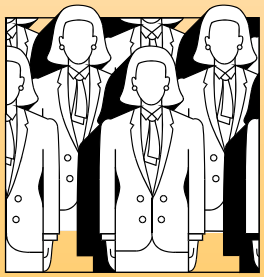
AB 1890 goes into effect

Mar.'97

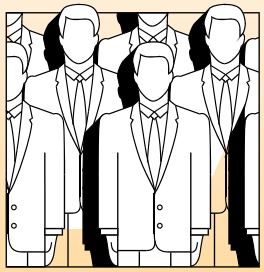
Vendor Contracts Signed

May '97

First Staff is Hired



July.-Oct. '97



ISO staff & Executives hired

Initial Applications & infrastructure delivered

Oct.'97-Mar.'98

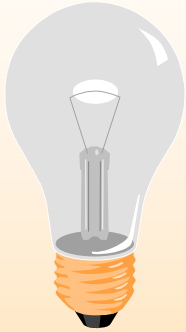
Operational Dry Run

Staff Training

Mar. '98

The ISO's Basic Functions

- Assure that the Transmission Grid is Reliable.

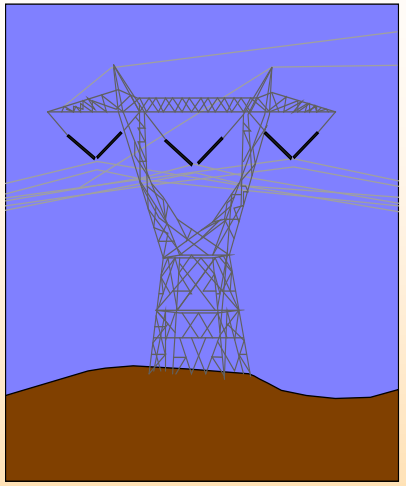


- Access to the Transmission Grid is Open and Non-discriminatory.

- Electricity Markets Function Efficiently and Effectively.

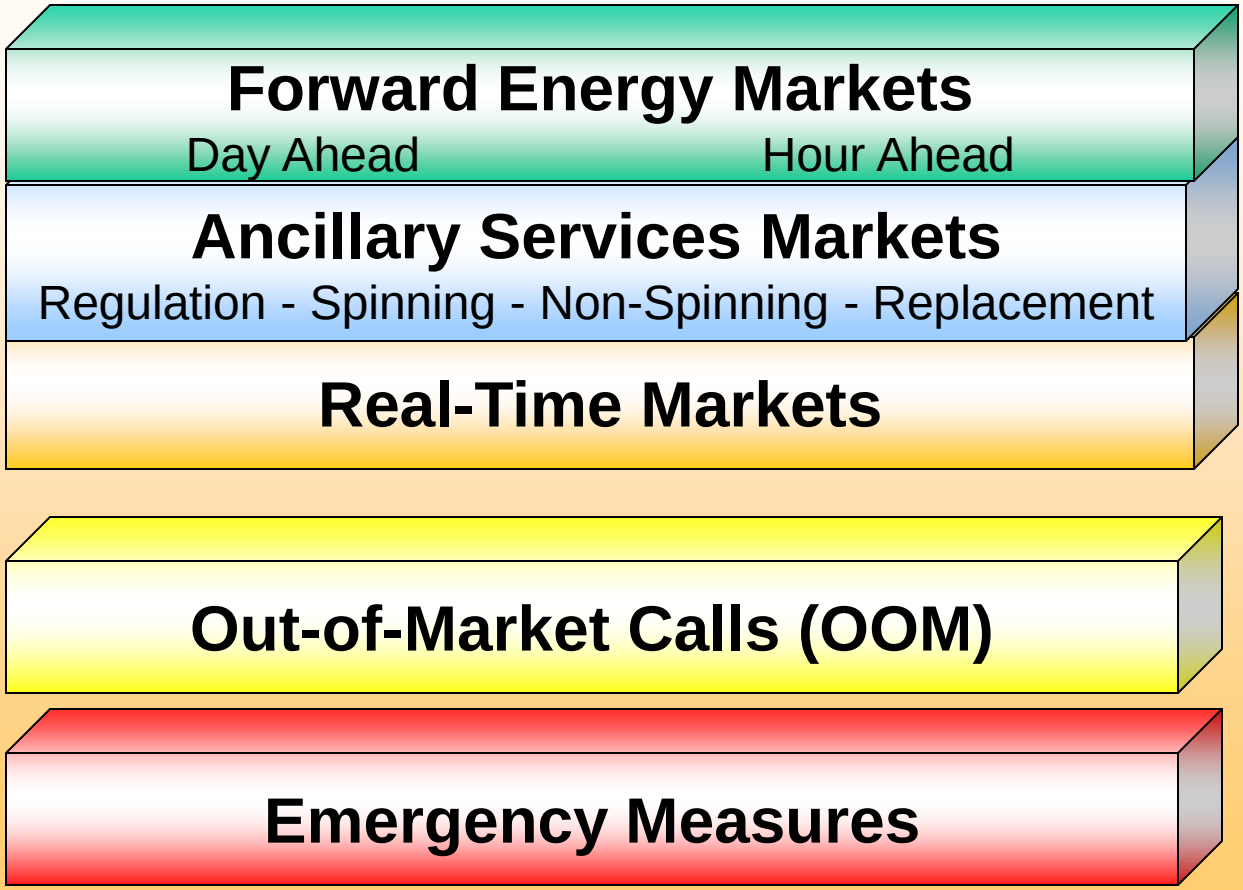
The ISO Reliability Requirements

- Maintain National and Regional Reliability Standards.
  - Operating Reserve
  - Frequency Response and Bias
  - Control Performance
  - Control Surveys
  - Backup Power Supply
  - Automatic Generation Control
  - Time Control
  - Inadvertent Interchange
  - Control and Monitoring Equipment

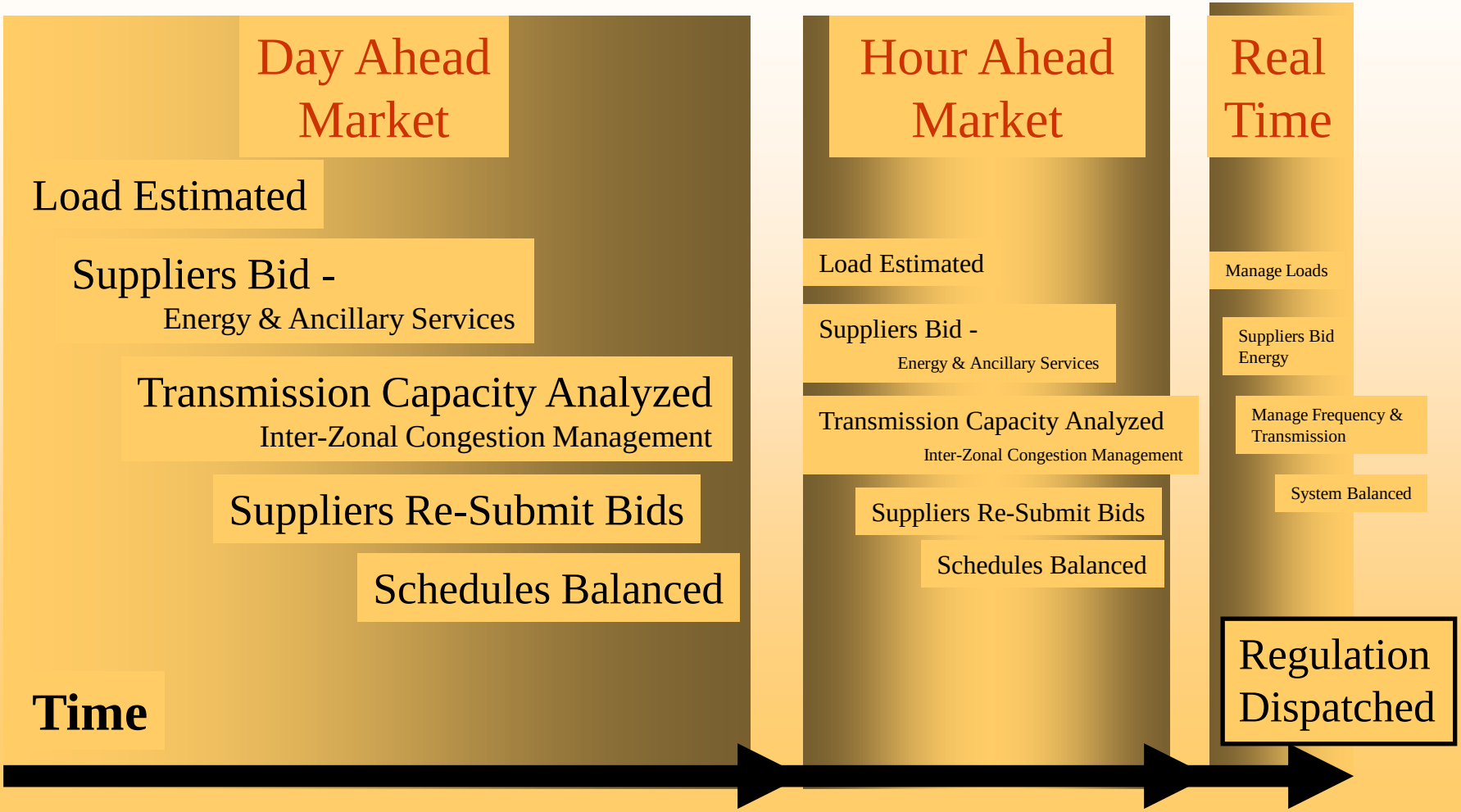


- Maintain Operating Transfer Capability (OTC) between other Control Areas
- Maintain Operating Limits in the Local Area Transmission System.

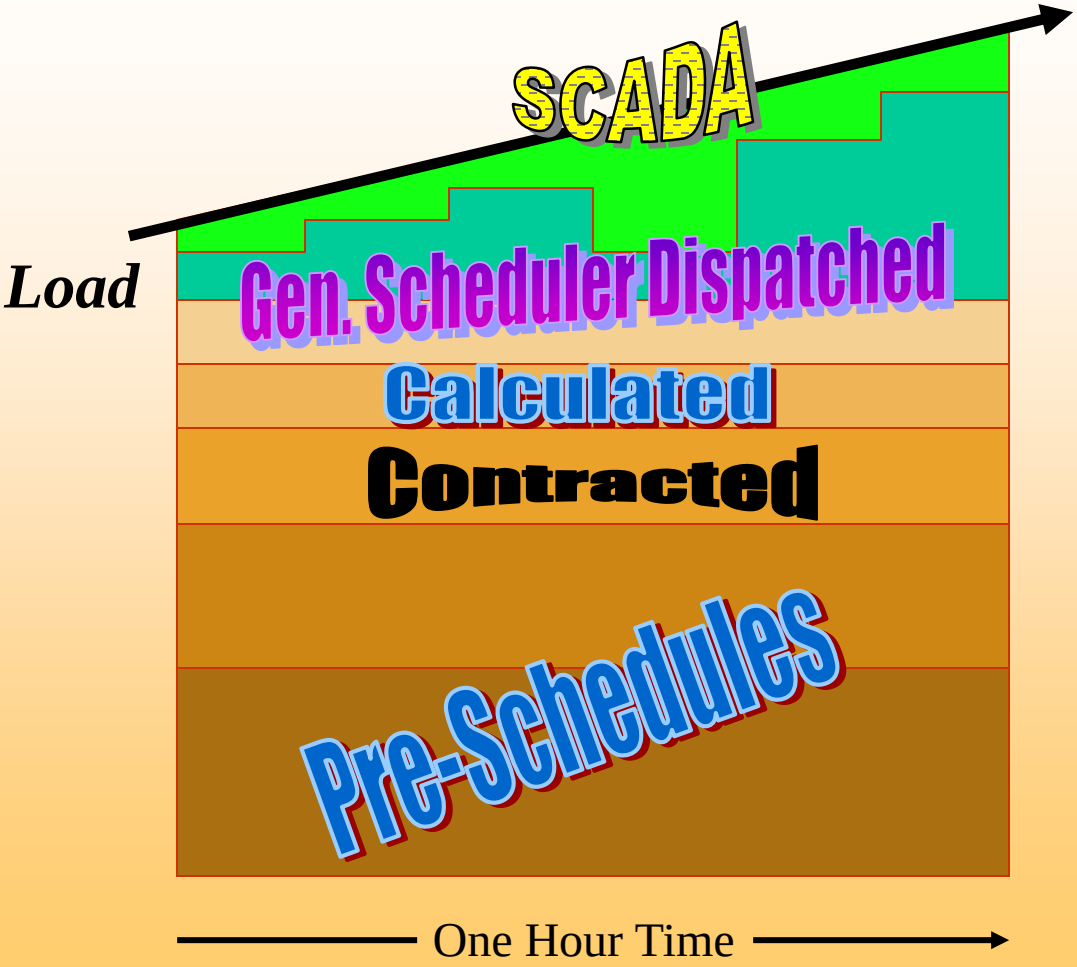
"Reliability through Markets"



From Schedule to Reality



One Hour in the Market



Regulation (AGC)

10 Minute Market

Balancing Energy

Balancing Energy Ties

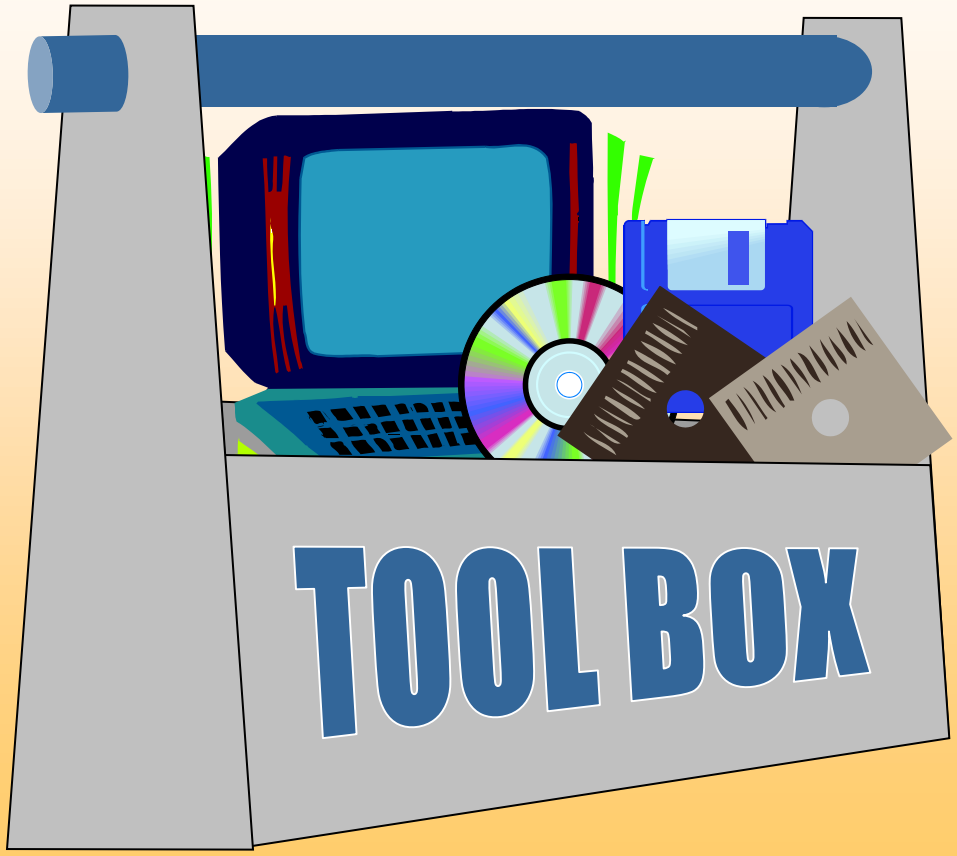
Uninstructed Deviation

Reliability Must Run

Hour Ahead Energy Market

Day Ahead Energy Market

The Tools That Make It Work



- **INITIAL ISO COMPUTER SYSTEMS:**
- Scheduling Infrastructure (SI)
- Scheduling Applications (SA)
- Energy Management System (EMS)
- Meter Data Acquisition System (MDAS)
- Balance of Business System (BBS)

- **ADDITIONAL COMPUTER SYSTEMS:**
- Plant Information System (PI)
- Generator Communications Project (GCP)

Why Use PI?

- Historical Operational Data.
- Reliability and System Security
- Compliance with Market Bids
- Market Analysis

Examples of Using PI

Real-time

- Regulation Response.
- Trend System Loads.
- Monitor Critical Transmission System Components.

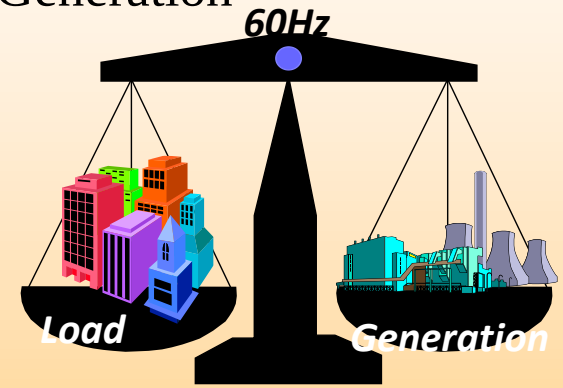
After the Fact

- Retrieve Operational Data.
- Analyze Transmission System Disturbances.
- Reliability Management System (RMS) reporting.

"Real-Time" Example: ISO Regulation

The Dynamics of Regulation

- Provides Real-Time Difference Between Load and Generation
- Maintains Frequency and Interchange Schedules.
- Unique Ancillary Services Market.



- A Regulation Set-Point Signal is Calculated Every 4 Seconds.
- Regulation Market Bids are Dispatched Directly from the ISO.

"Real-Time" Example: ISO Regulation

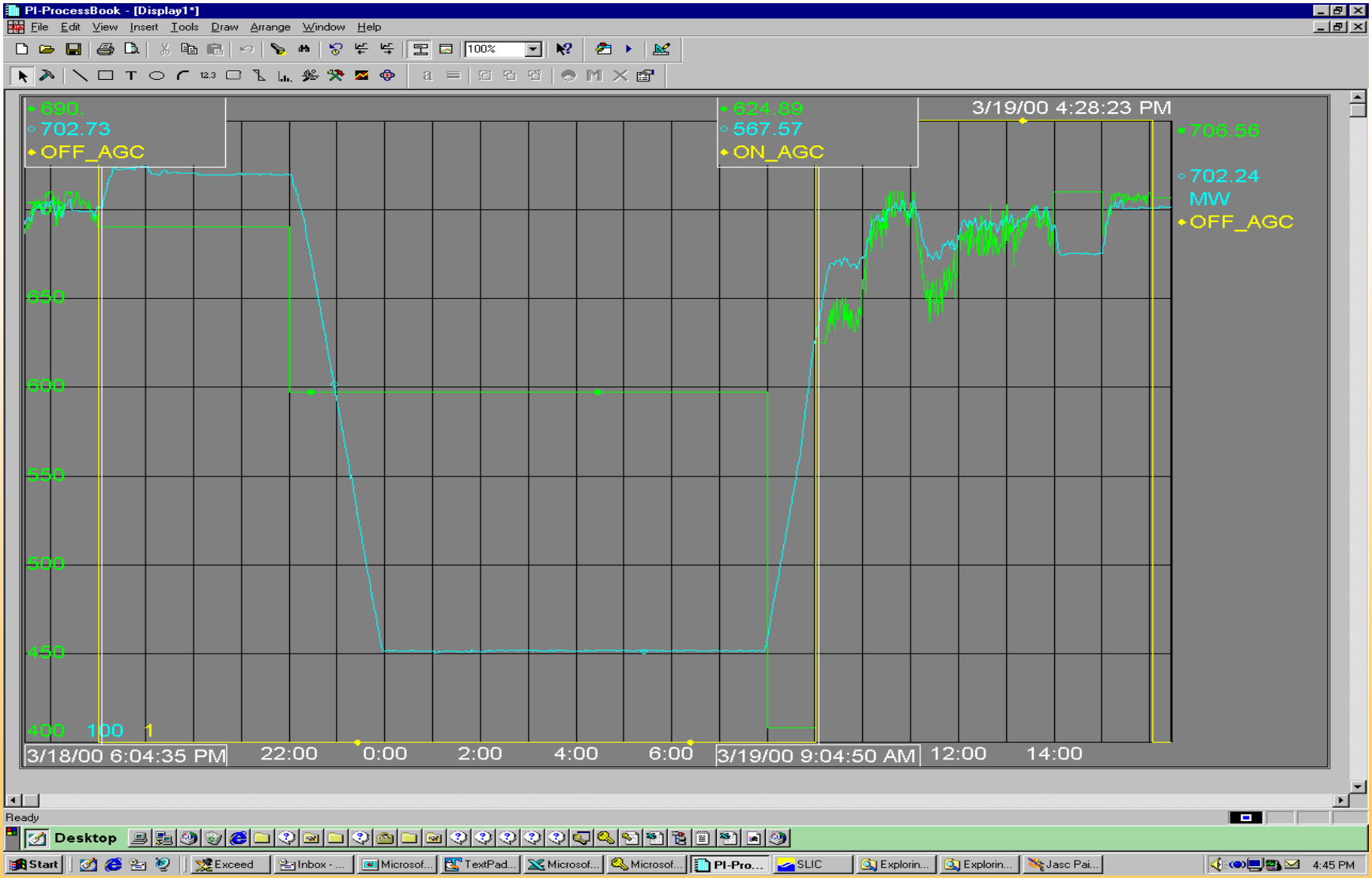
The Problem with Regulation

- New Market Environment Greatly Increased Regulation Requirements.
- Regulation Costs California Consumers up to $1,000,000 Each Day.
- Regulation is Complex and Difficult to Analyze.
  - Multiple Generation Suppliers Bid to Provide Service
  - Market Determines Which Units Will Provide Regulation Each Hour
  - Dynamic Load Determines Regulation Need

CALIFORNIA ISO

California Independent
System Operator

Regulation is Bid in Market



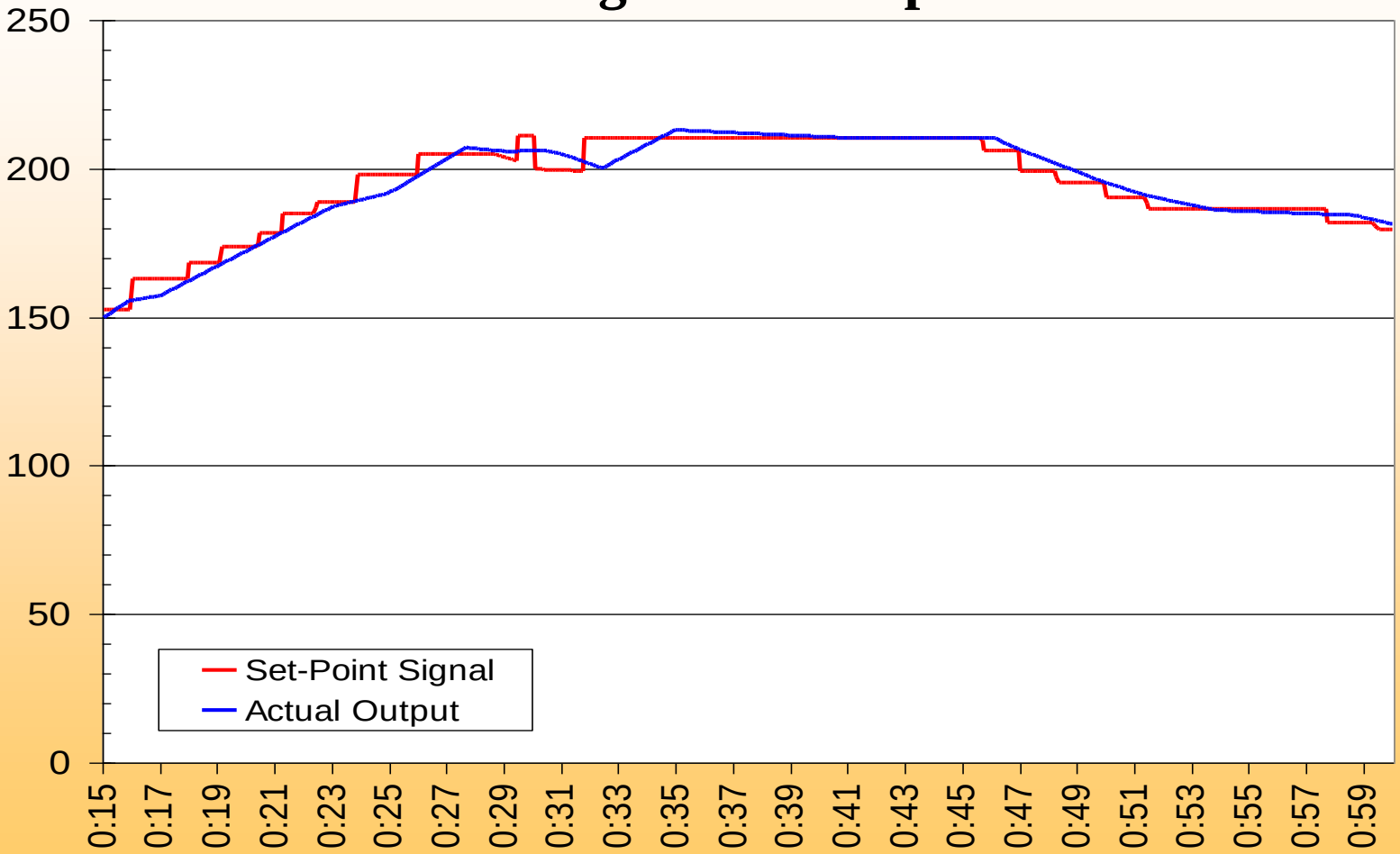
"Real-Time" Example: ISO Regulation

Using PI to Find the Regulation Problem

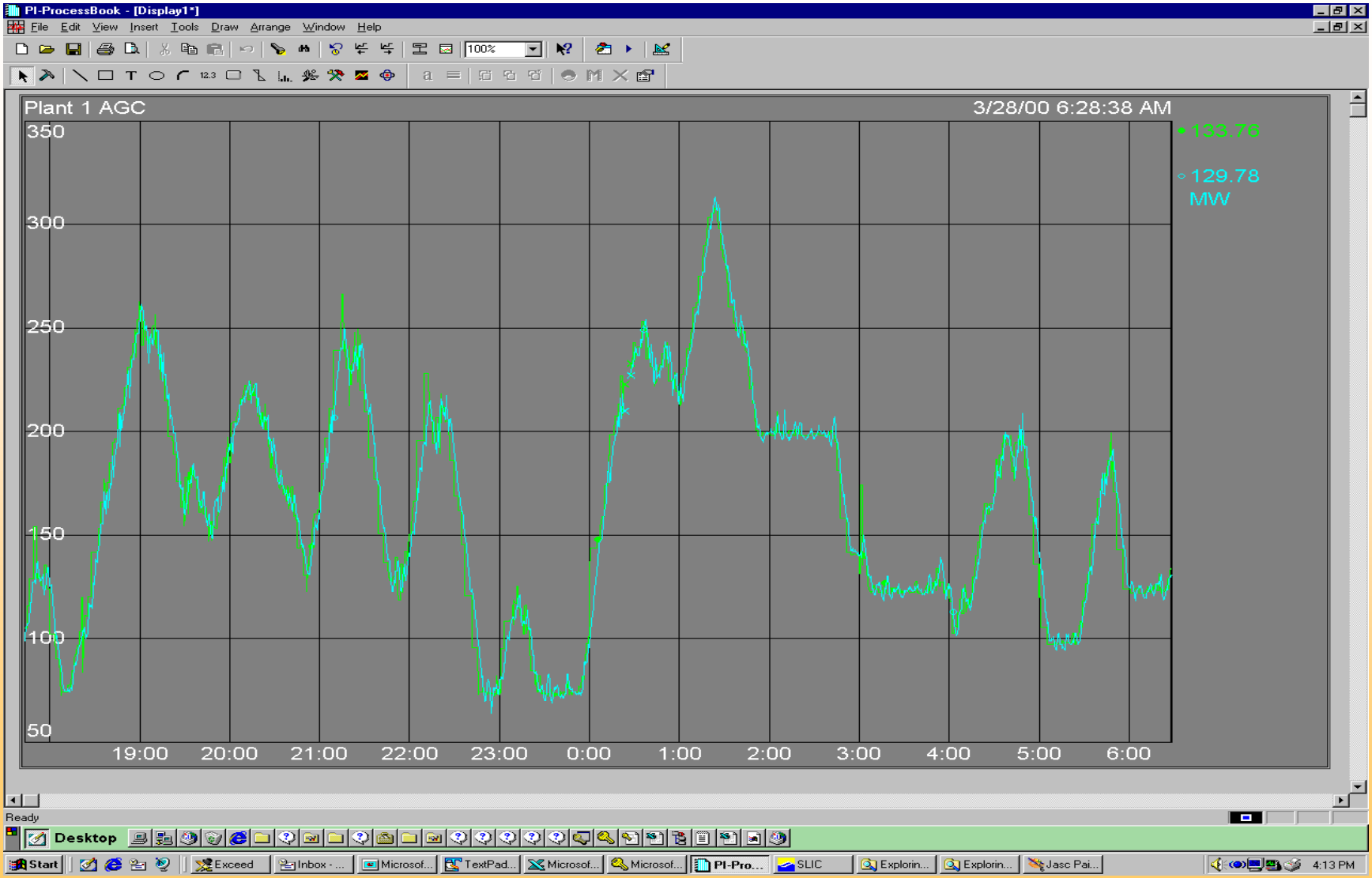
- Process Book Trends of Each Generator on Regulation
- Hourly Deviations Between Set-Points and Actual MW Output
- List of Generators Based on their Ability to Deliver Regulation
- Real-Time Updates of Generators Selected by the Market
- Net Regulation Trend Display.

"Real-Time" Example: ISO Regulation

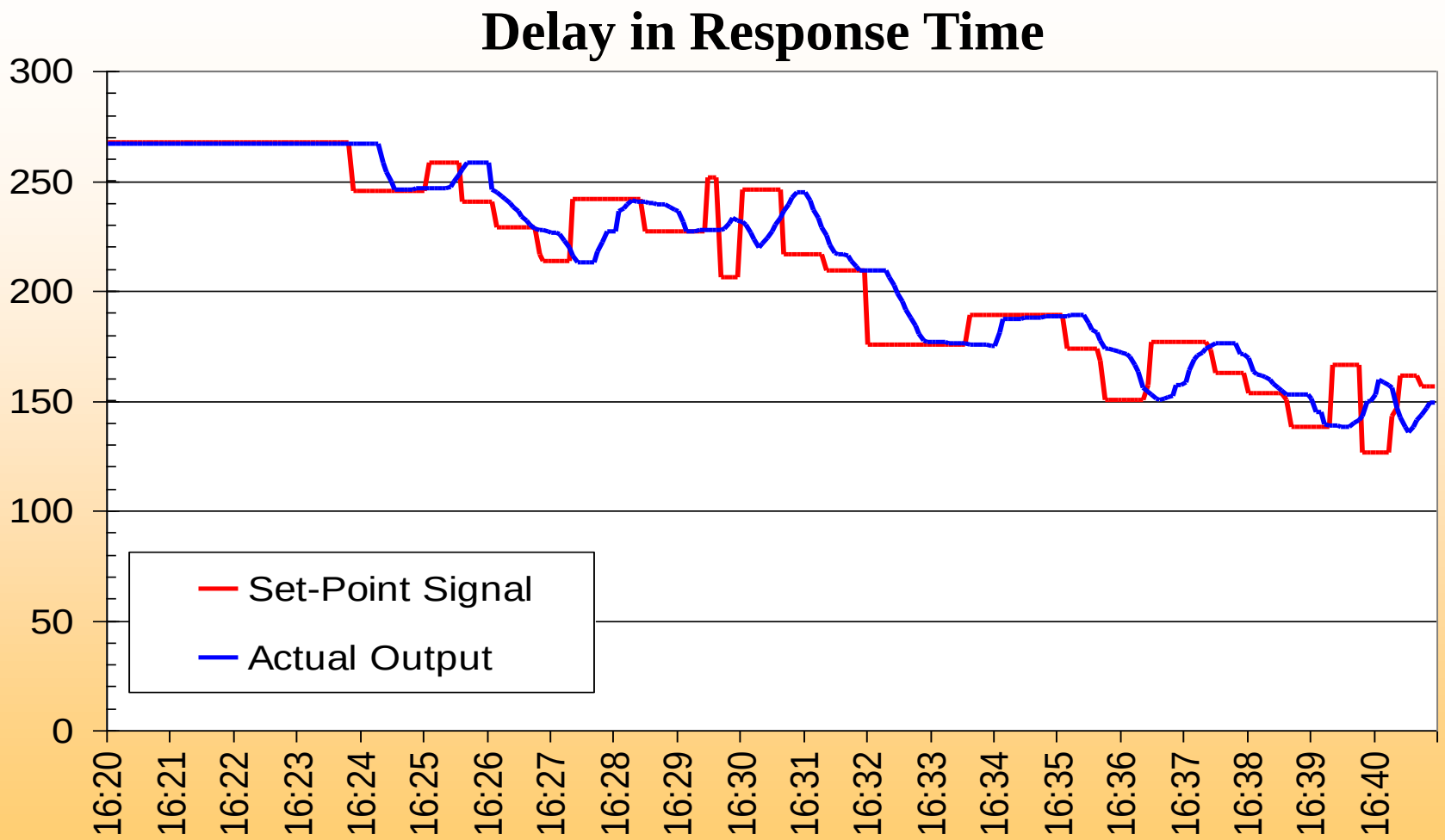
Good Regulation Response



PI Trend - Good Regulation Response

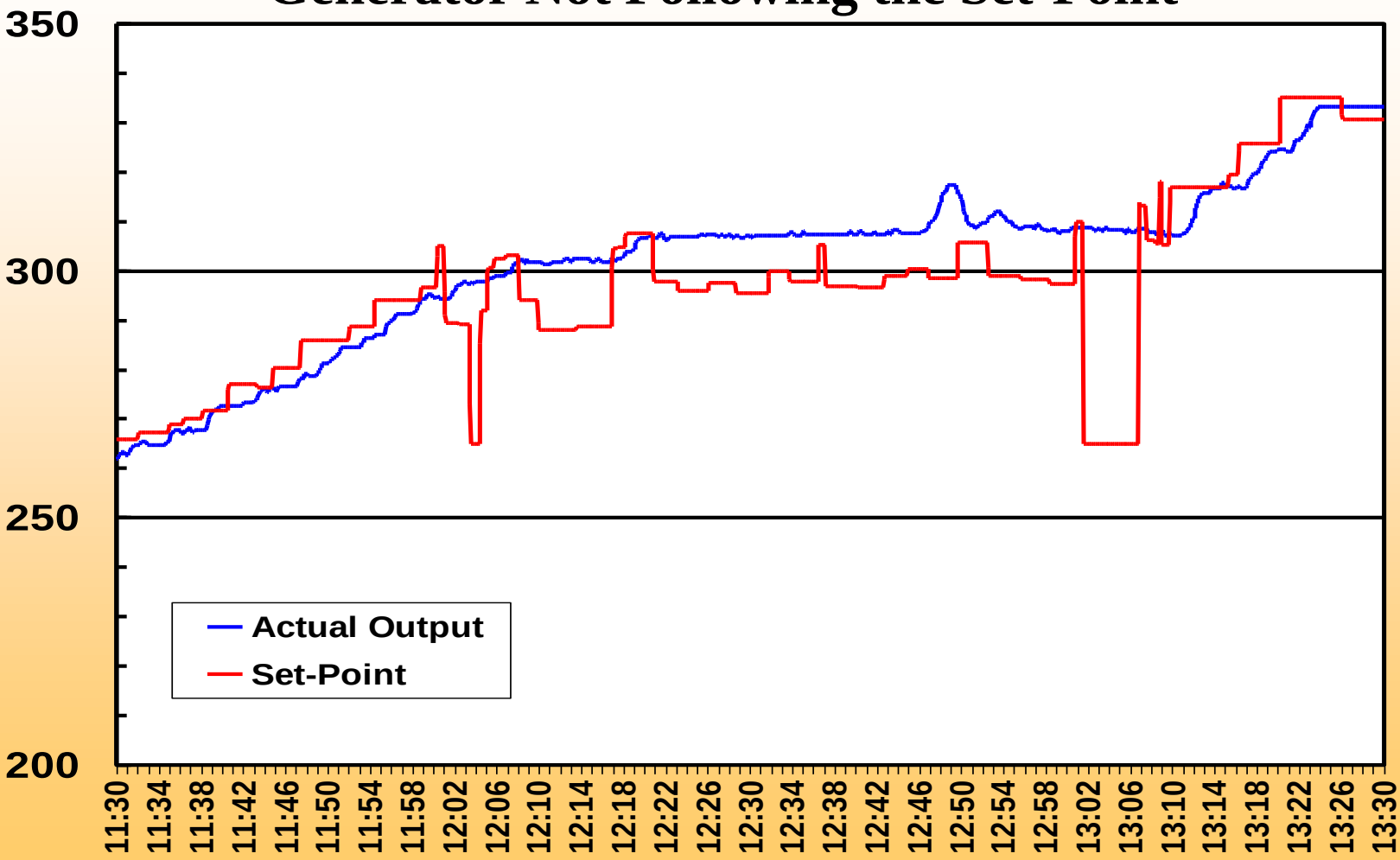


"Real-Time" Example: ISO Regulation



"Real-Time" Example: ISO Regulation

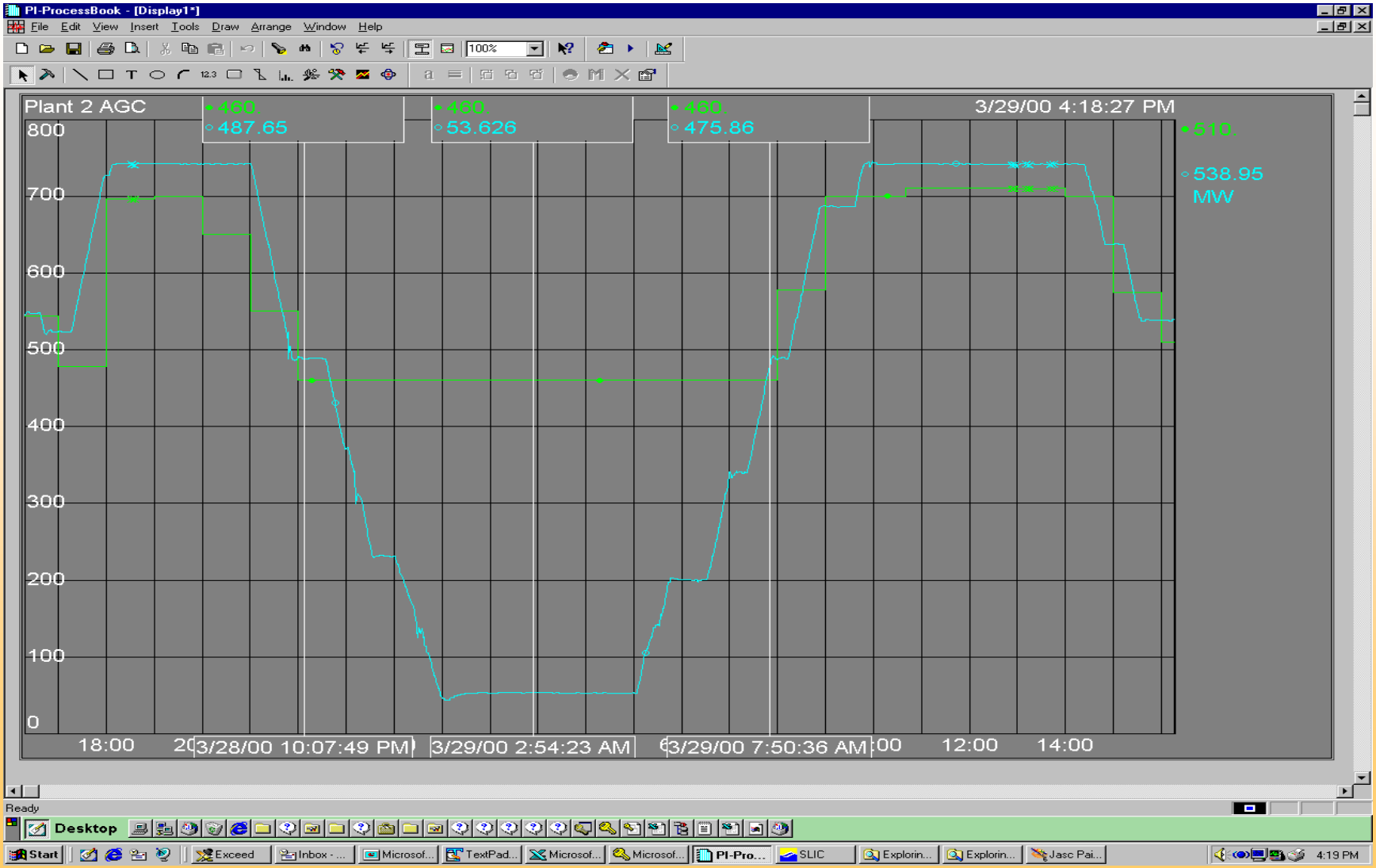
Generator Not Following the Set-Point



CALIFORNIA ISO

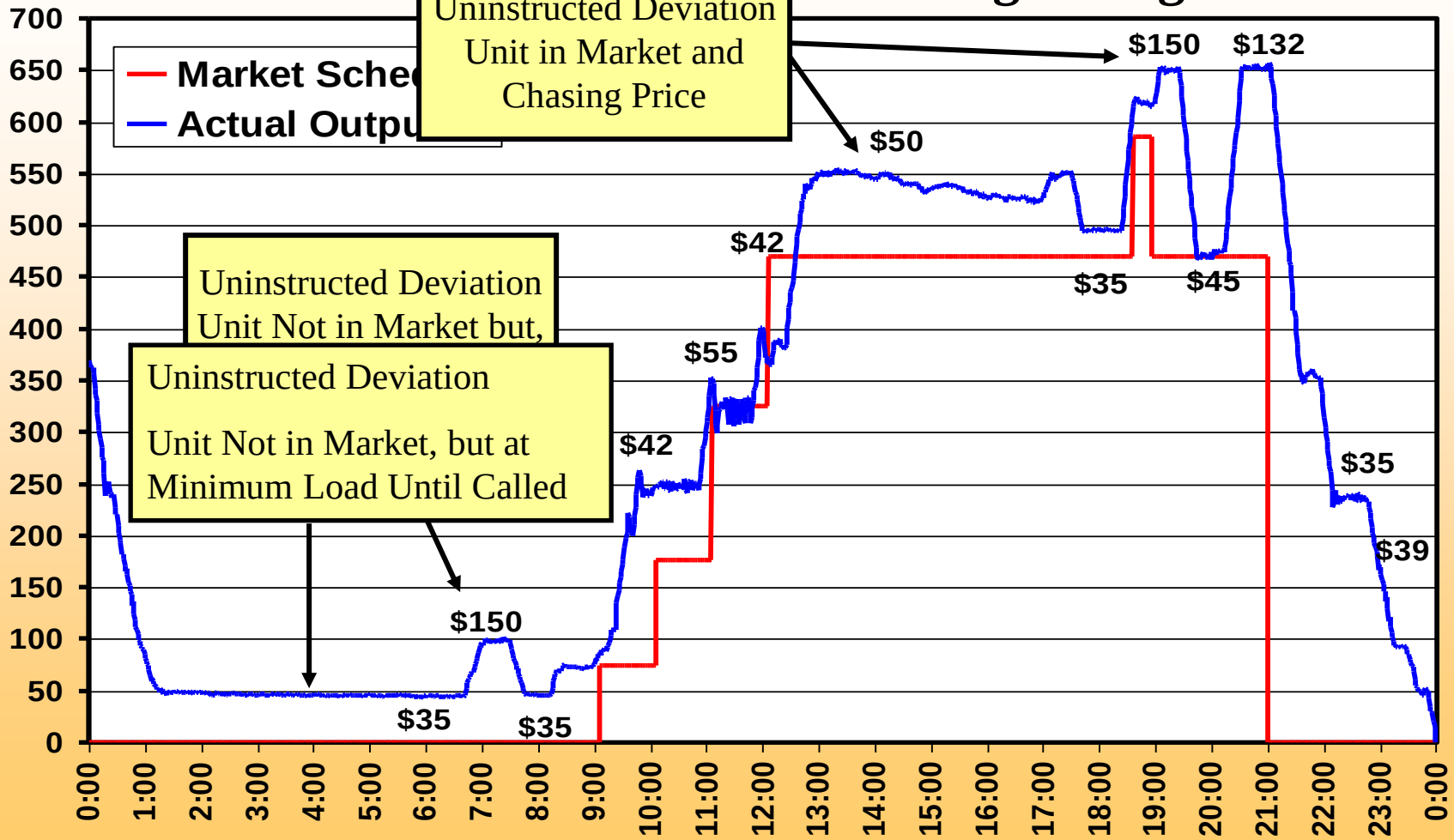
California Independent
System Operator

Improper Regulation Response



"Real-Time" Example: ISO Regulation

Uninstruct… a Non-regulating Unit



"Real-Time" Example: ISO Regulation

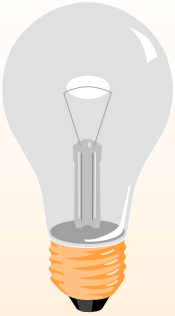
Solving the Regulation Problem

The Regulation Problem was Caused by Generators Not Responding to Control Signals. To Solve This Problem, the ISO is:

- Establishing Direct Communications with the Generators
- Correcting Improper Conversions for the AGC Set-Point Signal.
- Penalizing Units Deviating from Schedules because of Spot Prices.

"Real-Time" Example: ISO Regulation

Results of Solving the Regulation Problem



- Correcting Regulation Problems Improves System Reliability.
- Reducing Regulation Requirements Enhances Market Competition.
- Reduced Requirements Result in Savings up to $300,000 a Day.
- The PI System Easily Paid for Itself After a Few Weeks of Operation.

"After the Fact" Example: Disturbance Analysis

On September 30, 1999, under-frequency was experienced in the Western United States for about two hours.

It appeared that the California transmission system was the cause of the event because:

- Higher than Expected Loads.
- Overloads on a Major Intertie Between Oregon and California.
- Shortage of Operating Reserves.
- Interruptible Load Shedding in California was Implemented.

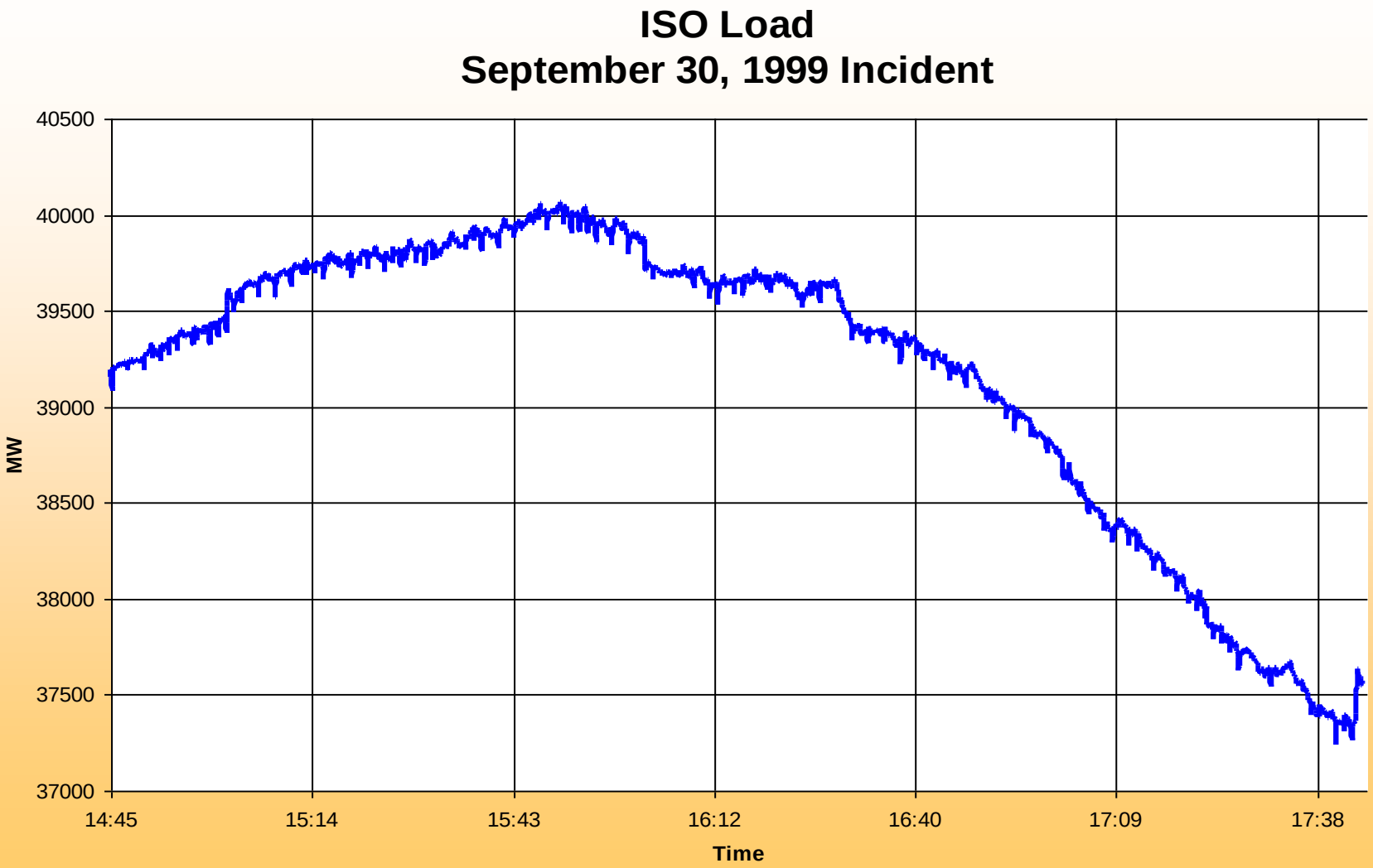
"After the Fact" Example: Disturbance Analysis

Using PI to Analyze the Disturbance

Develop Trends For:

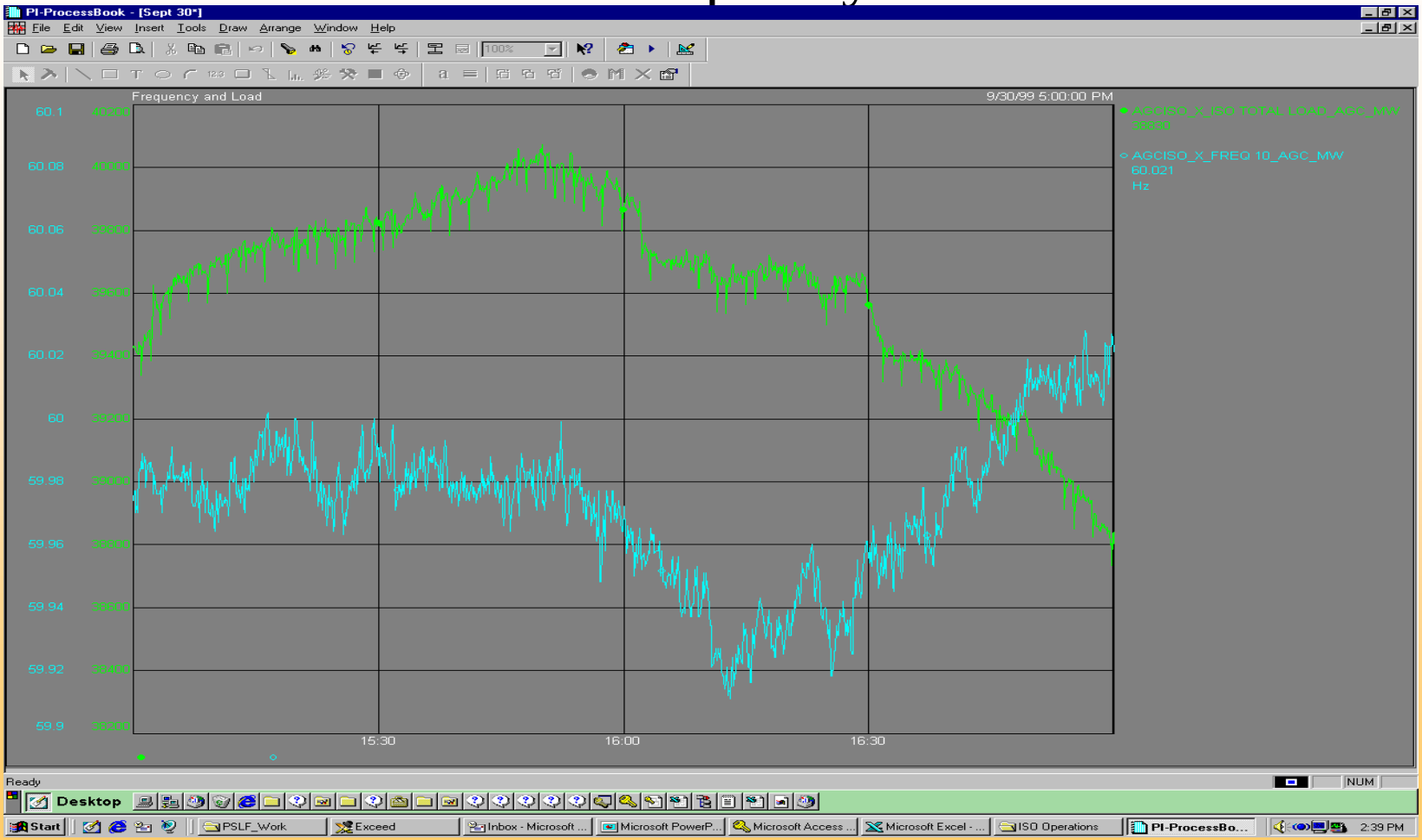
- Load
- Frequency
- Area Control Error (ACE)
- Flows on the Overloaded Transmission Lines
- Regulation Reserves.

"After the Fact" Example: Disturbance Analysis



"After the Fact" Example: Disturbance Analysis

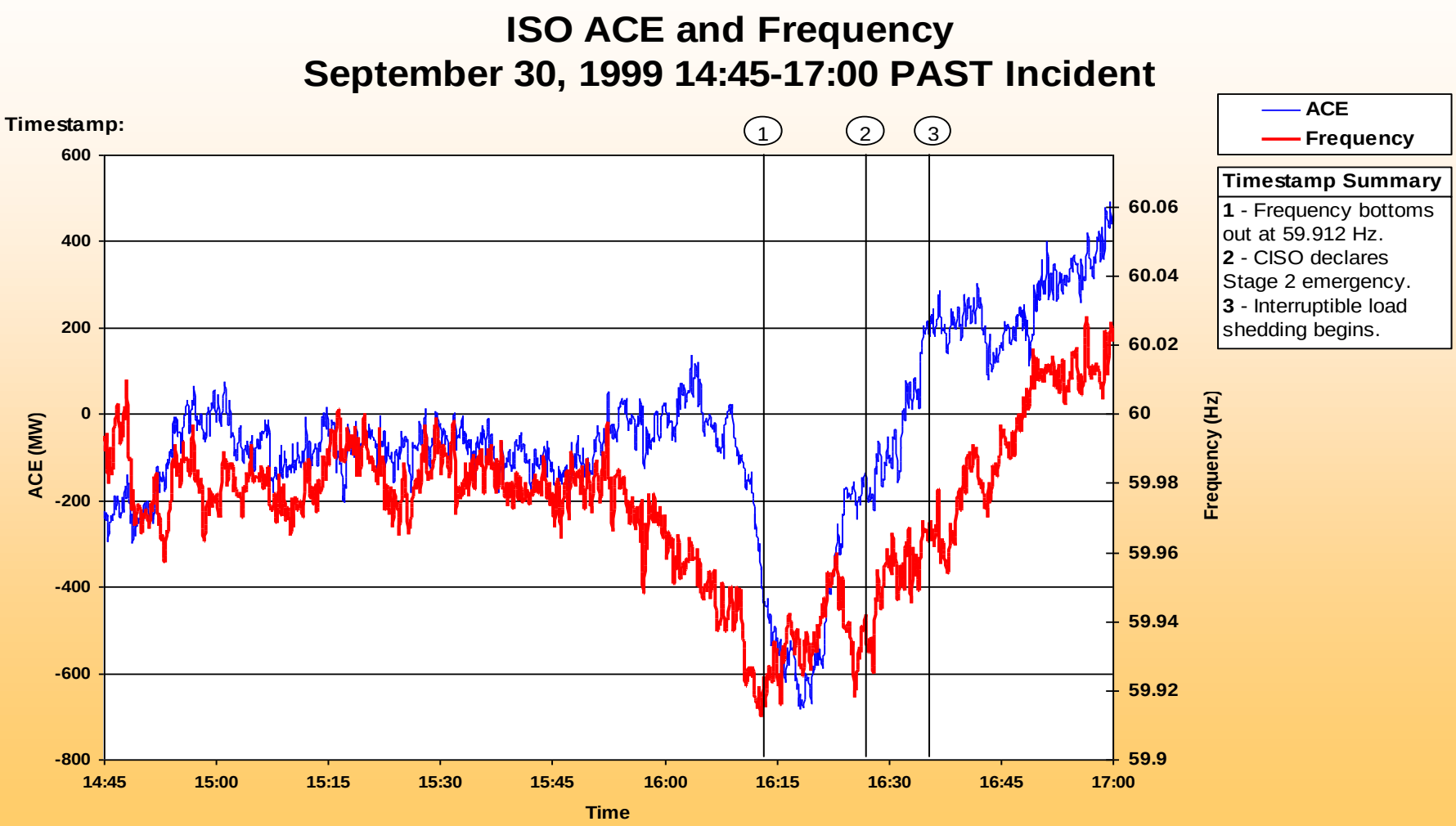
PI Trend of Frequency and Load



CALIFORNIA ISO

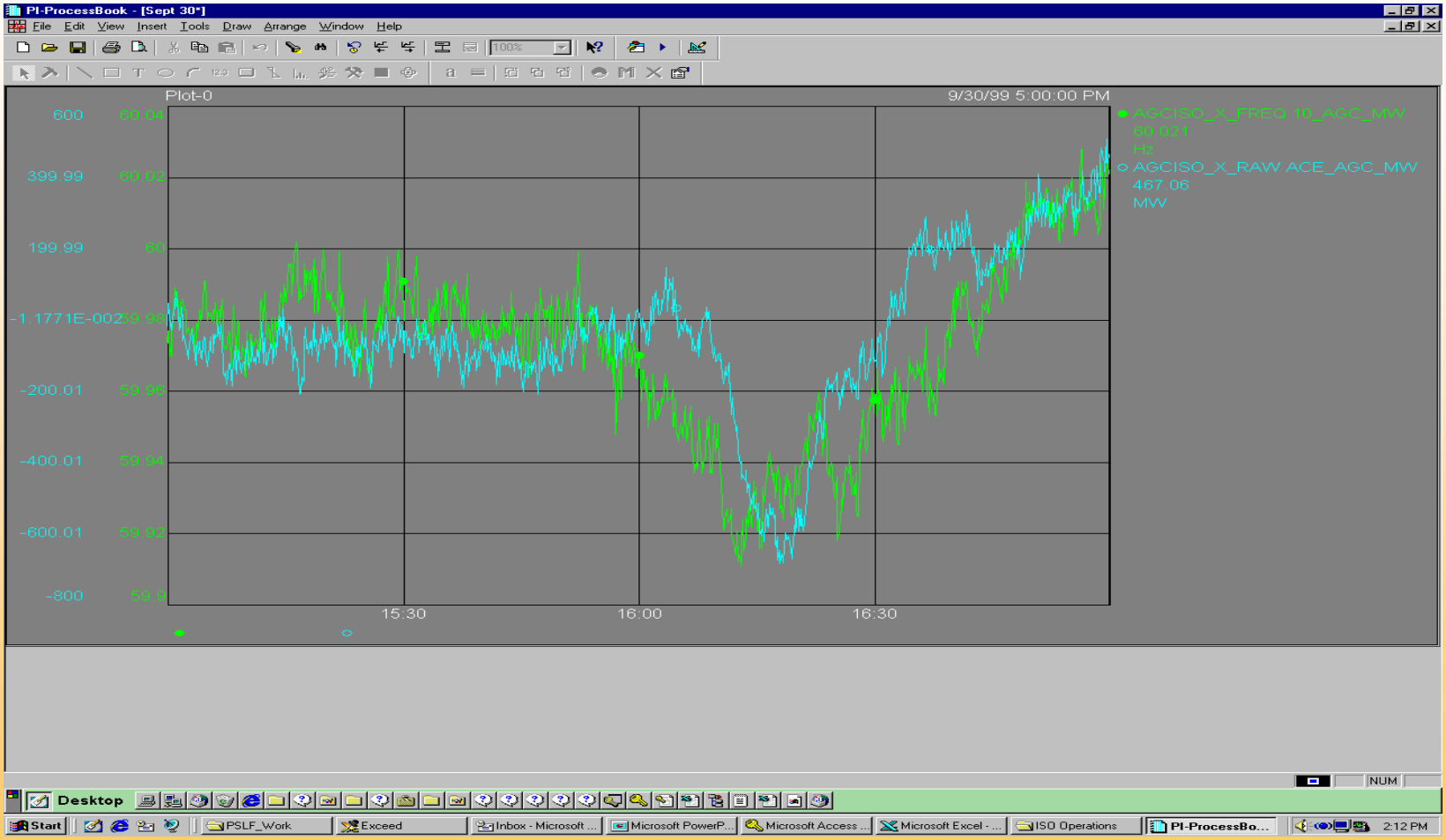
California Independent System Operator

"After the Fact" Example: Disturbance Analysis



"After the Fact" Example: Disturbance Analysis

PI Trend of Frequency and ACE



"After the Fact" Example: Disturbance Analysis

Results of the Analysis

PI is a Valuable Tool for Determining the Causes of System Disturbances and Teaching Us How to Prevent Them from Occurring Again.

- Losses of Generation Outside of the California System Initiated the Event.

Conclusions

- PI can Be Used to Improve the Efficiency of the Markets and Reduce Costs to Consumers.
- PI can Be Used to Determine the Cause of Problems and Help to Improve System Reliability.
- PI has helped the ISO Realize its Mission Statement of “Reliability Through Markets” and to Meet ISO Corporate Goals.