Big Data
How Will It Be Used ?

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Overview

- Sources
  - System Measurements - PMUs
  - Wholesale Market Quantities
  - Interval Metering
- Uses
  - Reliability Analysis
  - Market Design & Pricing
- Caveats
  - Analysis Tools and Methods
  - Assumptions

Sources & Timing

Old

- Events Only
  - 10 Samples / second
- EMS/SCADA
  - 2 – 20 seconds / Interval
- Market Data
  - Market Interval
- Interval Metering
  - 60, 30 & 15 minutes on selected large customers

New

- PMU Continuous
  - 30 Samples / second
- EMS/Scada w / PMUs
  - 30 Samples / second
- Market Data
  - Market Interval
- Interval Metering
  - 60, 30, 15, 5 & ? minutes on agreeable customers

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New Uses

- **Continuous PMU Wide Area Analysis**
  - Time Stamps enable Wide Area Analysis
  - High Resolution enables more accurate analysis
  - High Resolution enables faster and better EMS & SCADA control
- **Interval Metering**
  - Interval Pricing
  - New Market Design and Pricing Methods

PMU Wide Area Analysis

- New Analysis Tools and Methods
  - Sampling, Aliasing & Filtering
  - Fourier Analysis & Wavelet Analysis
  - Probability Theory & Bayes Theorem
  - Statistical Methods & Hypothesis Testing
  - Stochastic & Econometric Analysis
  - ANOVA & Error Evaluation
  - Data Mining & Neural Networks
  - Data Bases & SQL

Interval Metering Analysis

- **Interval Metering Requires Spot Pricing (i.e. Schweppe Pricing)**
  - "A key assumption of spot pricing and economic dispatch is that the power system is in quasi-steady state; i.e. power system dynamics involving frequency, voltage, etc. are ignored, and only Kirchoff's laws for network are considered."
  - When Pricing is attempted for intervals shorter than 15 minutes, the assumption upon which the pricing is based is no longer valid.
  - We need new market design and pricing models before we can effectively use interval metering with intervals less than 15 minutes.

Economic Market Design

- Economic Energy Price with separate Ancillary Services (A/S) managing Risk
  - Optimal price solutions without uncertainty
  - Assumes economics considered first and reliability second in all time frames up to Real Time
  - Risk managed externally with A/S Market
  - Assumes Energy Price is appropriate for energy components associated with A/S Market

What Really Happens

- System Operators consider Economic Energy Prices first and reliability second as the decision drivers when planning dispatch
- System Operators consider Reliability first and Economic Energy Prices second as the decision drivers in Real Time

Risk Based Market Design

- Economic Market Design used for intervals greater than 15 minutes
  - As Real Time approaches, the market transitions from Economic to Risk Based
- Risk Based Market Design used for intervals less than 15 minutes from Real Time
  - The Risk Based Market Design recognizes that the primary decision driver becomes risk management, not economics

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Three Part Market Design(1)

- **Part One - Base Energy (BE)**
  - Use "Schweppe Assumption" and current pricing methods to set a Base Price for later adjustment
    - Price is similar to traditional System Lambda $ / MWh
- **Part Two - Transmission Constraint (TC)**
  - Use Current Markets Methods to Adjust Scheduled Energy Prices
  - Use ACE Distribution Factors Method to Adjust Unscheduled Energy Prices
  - Scheduled Price = Unscheduled Price

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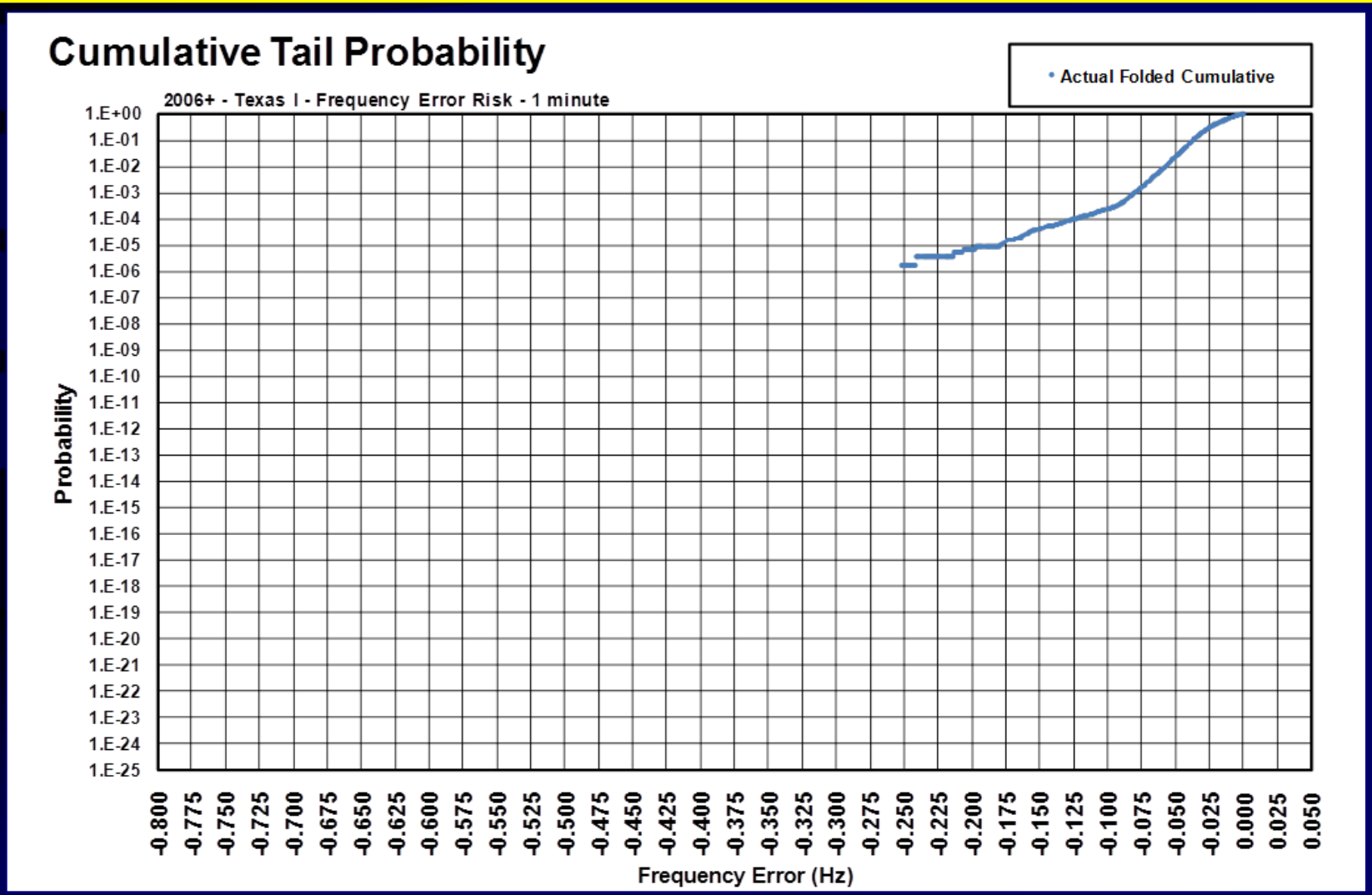
Frequency Error Tail Probability



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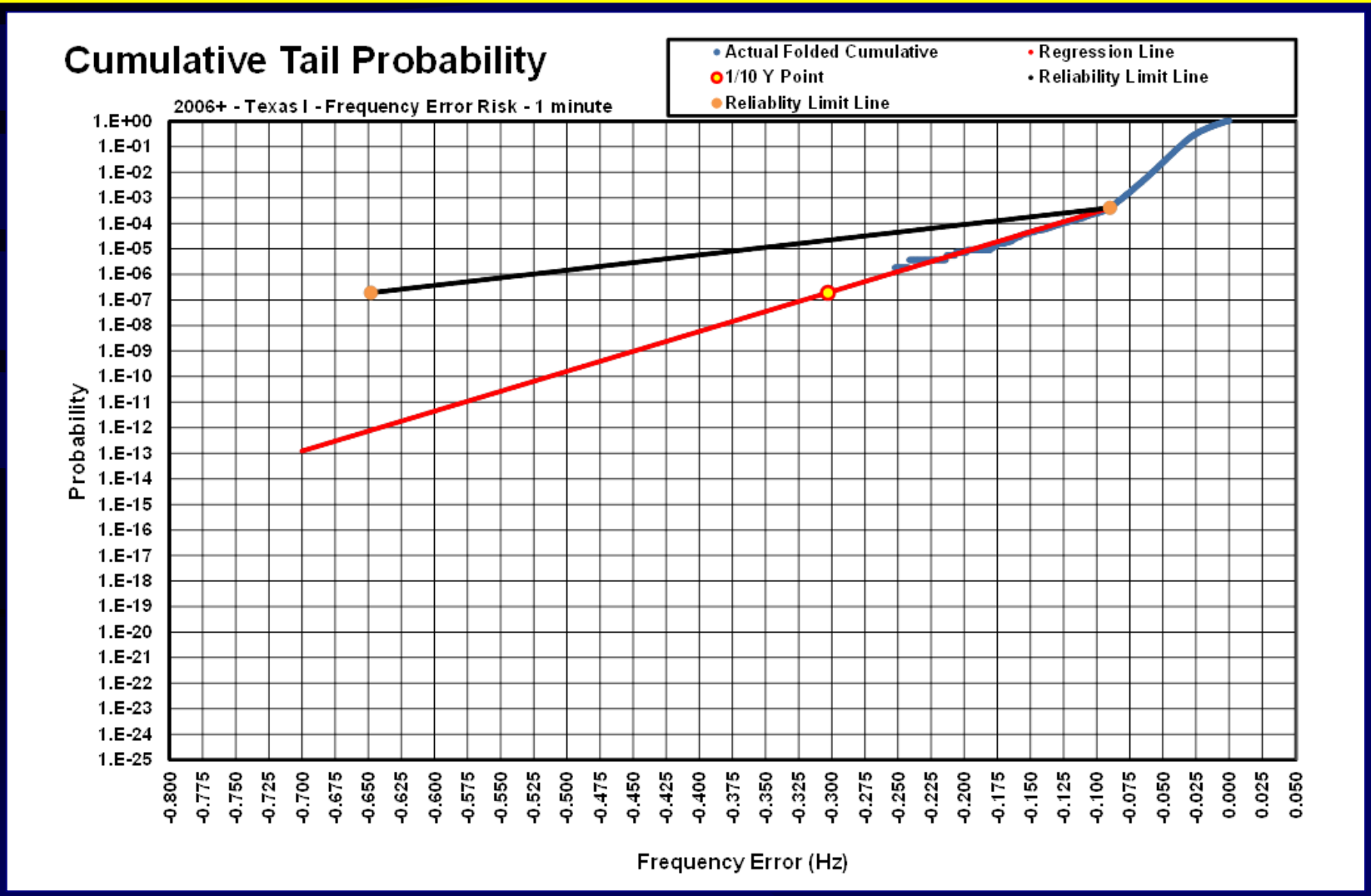
Regression Line & Intercept



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Three Part Market Design(2)

- **Part Three - Risk for Imbalance Energy**
  - Imbalance Energy = Unscheduled Energy
  - Start with BP & TC Prices for Scheduled Energy
  - Equal Risk = Equal Price : Risk Lambda $ / MWh
  - Risk from Frequency Error (FError) vs Risk Plot
  - Higher / Lower FError = Higher / Lower Risk
  - Higher / Lower Risk = Higher / Lower Price
  - Price Imbalance (Unscheduled) Energy Price @ BE + TC + Risk
  - Need FError : Price Relationship

Questions

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