Electric Power Group Presents
Phasor Data Mining Application – PDMA

Mining Phasor Data To Find The Hidden Gems In Your Archive

October 16, 2014

Presented by

Vivek Bhaman & Frank Carrera

Webinar Phone Number: (650) 479-3208

Welcome! The presentation will begin at 1pm EDT / 10am PDT.

For any technical issues with this webinar, please contact Kosareff@electricpowergroup.com or call (626) 685–2015

Today's PDMA Webinar Outline

I. About Phasor Data Mining Application (PDMA)
- Need
- Solution
- Data Sources
- Uses

II. Demonstration of PDMA Use Cases
1. Identifying events – Generation Loss
2. Finding Relevant Oscillation Modes in the Power Grid
3. Identifying Key PMUs for Oscillation Alarms
4. Focusing Frequency Response Analysis on relevant Generation Loss Events
5. Setting proper alarm thresholds based on historical behavior

Some Uses of PDMA

- Generation Loss – Loss of unit or a unit run-back outage
- Load Loss – Drop of load or a load trip
- Line Faults – Single Phase or Three Phase scenarios
- Line Trip – Change in Topology or Line Outage
- Oscillations – Inter-area, Control system, Regional
- Delayed Voltage Recovery – Elongated Low Voltage Conditions
- Grid Stress – High Power Flow or Increased Angle Difference

Need for PDMA

Issues & Challenges

Need for PDMA: Issues

- Establish realistic and significant thresholds
- Identify Oscillatory Vulnerabilities
  - Unknown Oscillations
  - Temporary Oscillations triggered by disturbances
- Determine System Unknowns
  - Near-Misses
  - Missed / Unrecorded Events
  - Identify situations of system vulnerability – combinations, correlations
- Quantify System Performance
  - How Many Events – Where, When, How Severe?
  - Missed Events

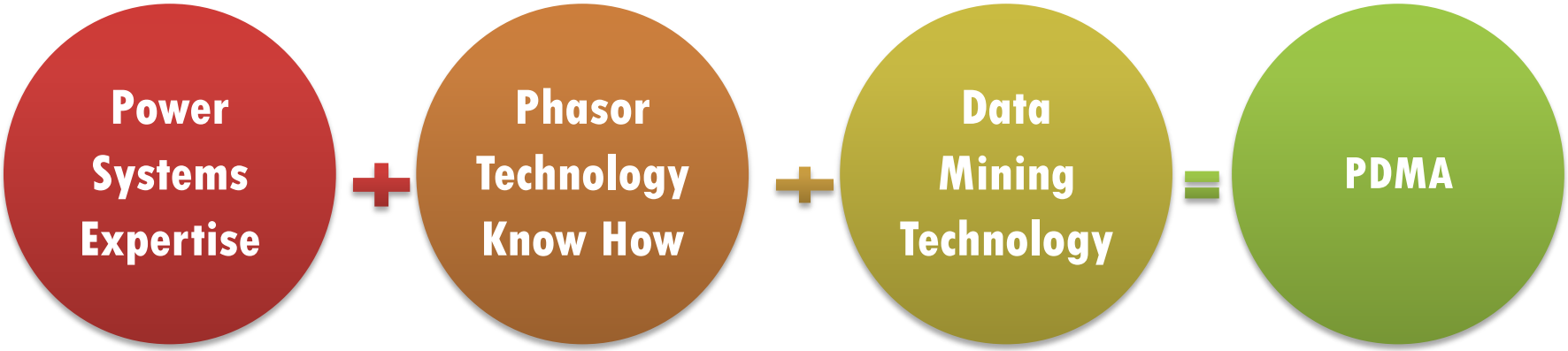
Need for PDMA: Challenges

- Volume of data to be mined
  - Terabytes being recorded everyday
  - Huge volumes of previously archived data to be processed
  - Multiple data sources and file formats
- Mining for Power Systems Information Vs. Extraction of Records
  - Derive meaningful information
    (extract → process /analyze → resultant information) Vs. “Pull Data”
  - Expertise required to translate data into information, e.g.
    - Identifying generation trips from frequency data
    - Correlating High Angle Values with Low Voltages to determine vulnerability
    - Algorithmic processing to identify oscillations
- State of Current Off-the Shelf Tools
  - Not built for mining per se
    - Volume, Data Handling and Expertise limitations
    - For preconfigured extractions (queries, views, look-ups)
  - Not Specific for Power Systems - General statistical analytics

What is PDMA?

Product Overview

PDMA – What it is



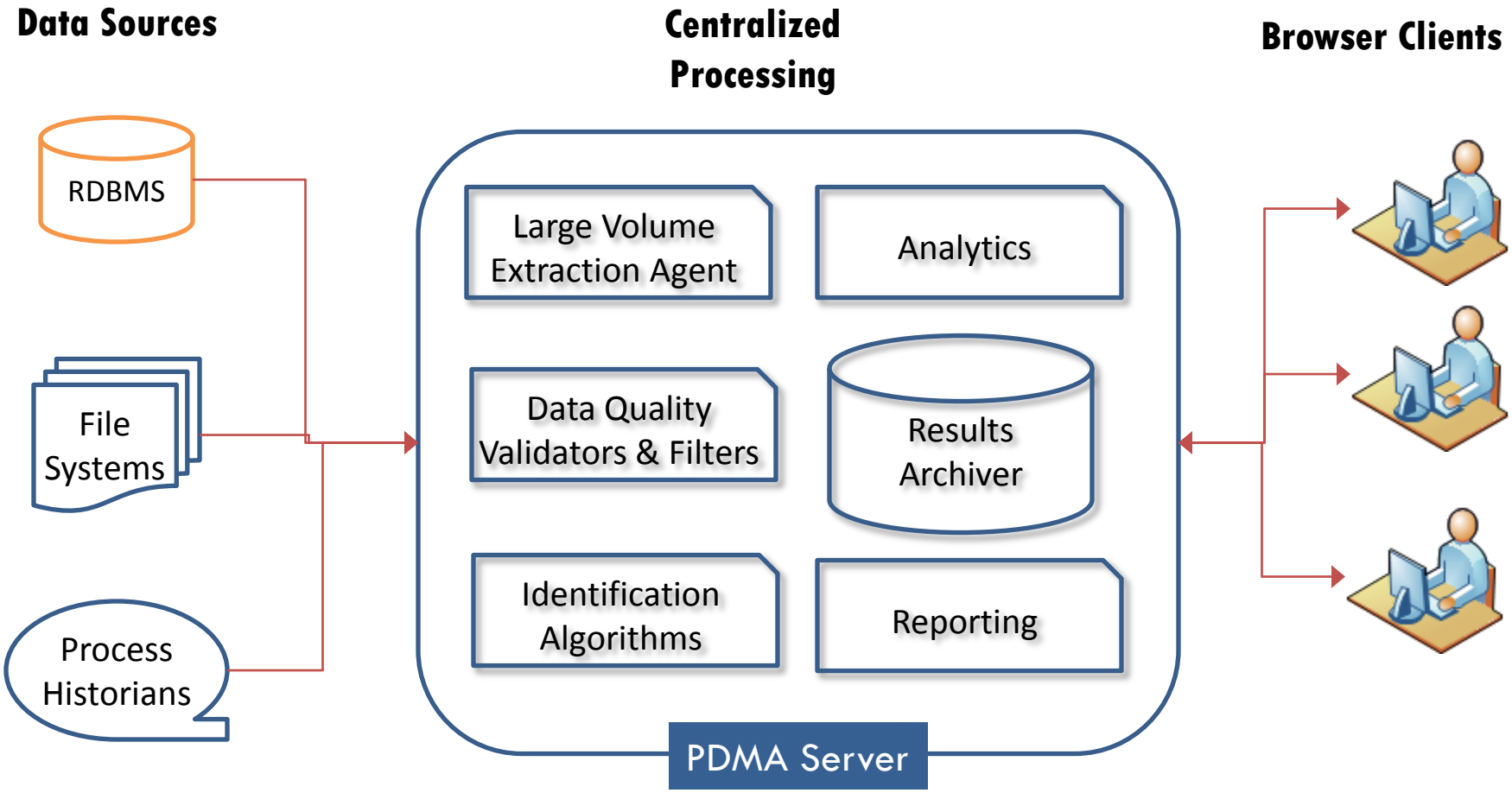
PDMA – What it is

- Designed for Power Systems analytics.
- Expert system to dig through huge volumes of phasor data to identify relevant events, behavior patterns and discover insights
- PDMA mines for “events” such as
  - Generation Loss – Loss of unit or a unit run-back outage
  - Load Loss – Drop of load or a load trip
  - Oscillations – Inter-area, Control system, Regional
  - Line Faults – Single Phase or Three Phase scenarios
  - Line Trip – Change in Topology or Line Outage
  - Delayed Voltage Recovery – Elongated Low Voltage Conditions
  - Grid Stress – High Power Flow or Increased Angle Difference

PDMA – 5 Solvers Functions

- **Value Violation**
  - Identifies Events based on different levels of threshold
- **Events – Generation Trip, Line Trip**
  - Identifies Events based on predefined templates (user configurable)
- **Oscillation**
  - Identifies Events that has modes with low damping & High Energy
- **Logical Combination – AND, OR**
  - Identifies Events based on combination of user defined combinations of metric thresholds
- **Baselining**
  - Provides Statistical information based on selected metrics

PDMA Architecture



Mining – It's all about the Data

- Multiple Sources
  - RTDMS DB
  - Phasor Archiver
  - COMTRADE Files
  - DST Files (BPA Phasor File Format)
  - OSI PI
  - eDNA
  - Other Flat File Formats
- Mine across multiple data sources
- Consolidate or Breakdown Mining Results
  - By Data Source
  - By Time Period
  - By Jobs

PDMA Demonstration – Walk Through

- Opening Screen
- Data Mining
  - Create a Job
  - Manage All Job
  - Export & Delete Job
- Analysis
  - Pivot Table Results
  - Trend Chart of Data
  - Charts & Graphs
- Report & Export Results
  - Save to PDF, DOCX, ect.
  - Report on single or combination of multiple jobs

PDMA Use Cases

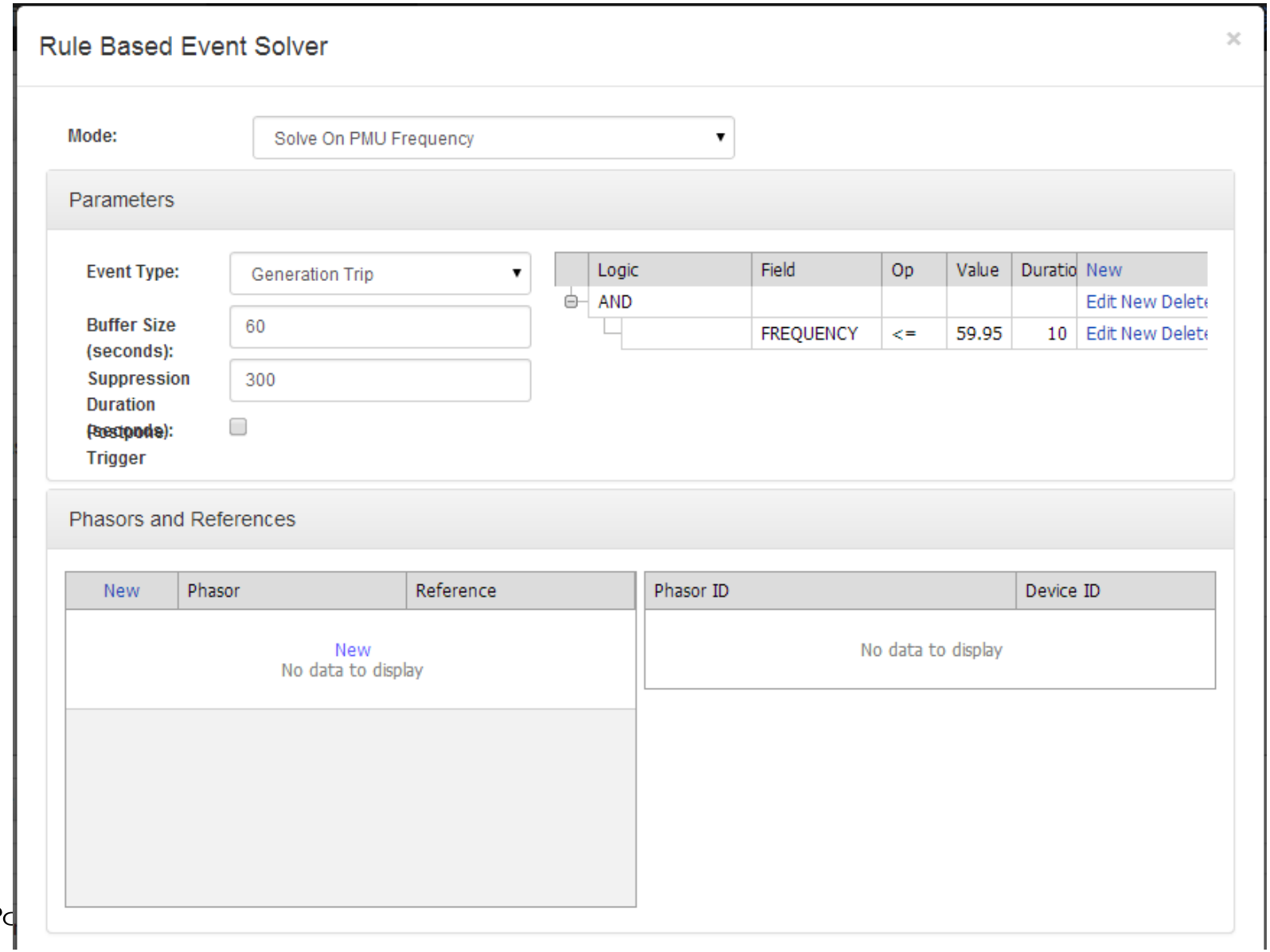
1. Mining for specific events – Generation Loss
2. Finding Relevant Oscillations
3. Identifying Key PMUs for Oscillation Alarms
4. Focusing Frequency Response Analysis on relevant Generation Loss Events
5. Setting proper alarm thresholds based on historical behavior

Use Case 1

Mining for events – Generation Loss

Example: Generation Loss Identification

Job Rule



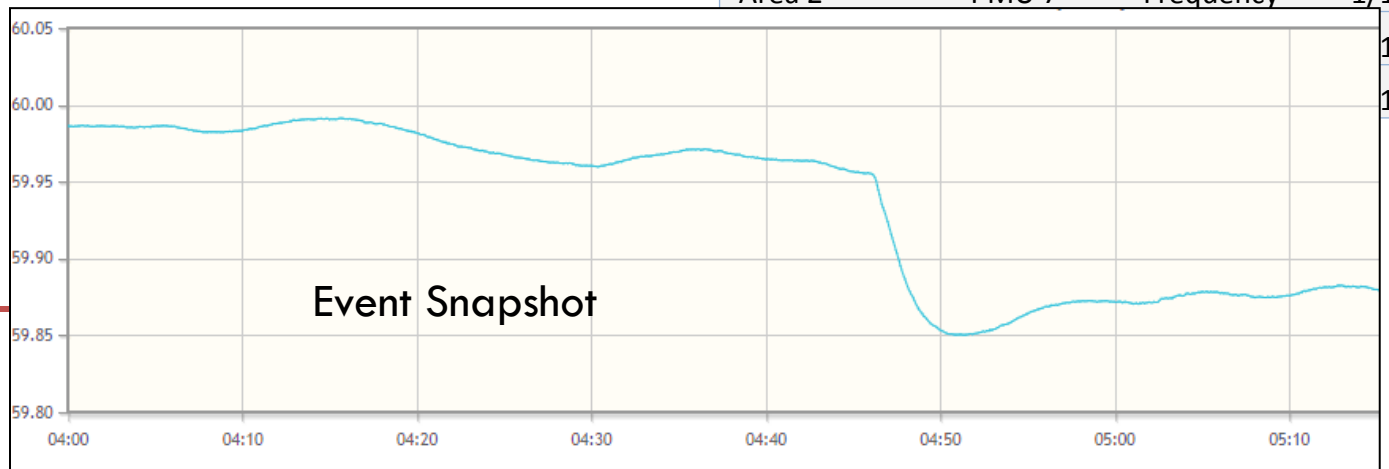
Generation Loss Mining : Results

Job Name	Event Type	Jan-12	Feb-12	Mar-12	Total Events	Rule
Unit Trip Events	Generation Loss	4	5	9	18	Frequency <= 59.95Hz over 10 sec duration

Event List : Jan-12
Event Time: 1/1/2012 07:37:55 AM
Event Time: 1/15/2012 08:04:44 PM
Event Time: 1/21/2012 07:34:04 PM
Event Time: 1/24/2012 05:47:45 PM

Event Time: 1/1/2012 07:37:55 AM

Area	PMU	Signal Type	Time
Area 1	PMU 1	Frequency	1/1/2012 7:37:55.200 AM
Area 1	PMU 2	Frequency	1/1/2012 7:37:55.000 AM
Area 1	PMU 3	Frequency	1/1/2012 7:37:55.000 AM
Area 1	PMU 4	Frequency	1/1/2012 7:37:55.000 AM
Area 2	PMU 5	Frequency	1/1/2012 7:37:55.000 AM
Area 2	PMU 6	Frequency	1/1/2012 7:37:55.000 AM
Area 2	PMU 7	Frequency	1/1/2012 7:37:55.000 AM
			1/2012 7:37:55.000 AM
			1/2012 7:37:55.000 AM



Event File

Use Case 2

Finding Relevant Oscillations

PDMA – Oscillation Mining: Rich Parameter Selection

Algorithm	Yule Walker Spectral
Algorithm Time Window	Time Duration for Algorithm in each step (recommend 60 s)
Results Interval	Time Duration for Algorithm Output in each step (recommend 60 s)
Damping Filter	Max Value in percentage that discards Modes greater than Max Value (recommend 8%)
Frequency Range Filter	Min and Max Value in Hertz (Hz) for Mode Filtering (recommended 0 to 15Hz)
Mode Energy Filter	Min Value that discards Modes below value
Other Algorithm Parameters	✓AR order ✓ MA order ✓ Number of data points for AR ✓ Nfft (Time Duration in seconds for FFT) ✓ Estimated Maximum Number of Modes ✓Mode Tolerance (Grouping Modes)

Meaningful Results:
What modes should operators monitor in real time?

Solver: 1 Job, 1 Oscillation Solver, 8 PMUs, 1-Month, Damping < 8%, Frequency 0-15, Energy > 0.1

Frequency Bands	#PMUs Observing Oscillations	# of Unique Oscillations	# of Unique Osc. Events	Osc. with Highest Energy	Mode with Highest Occurrence	Mode with Lowest Damping
Inter Area 0 - 1 Hz	3	2	8	0.6Hz	0.6Hz, (3)	0.3
Local Area 1 - 2 Hz	4	1	1	1.8Hz	1.8Hz	1.8
Controller 2 - 3 Hz	8	2	3	2.8Hz	2.8Hz	2.8

How many PMU's to be monitored for damping alarms?

1 Job, 1 Oscillation Solver ,1-Month, Damping < 0.1%, Frequency 0-15, Energy > 0.1

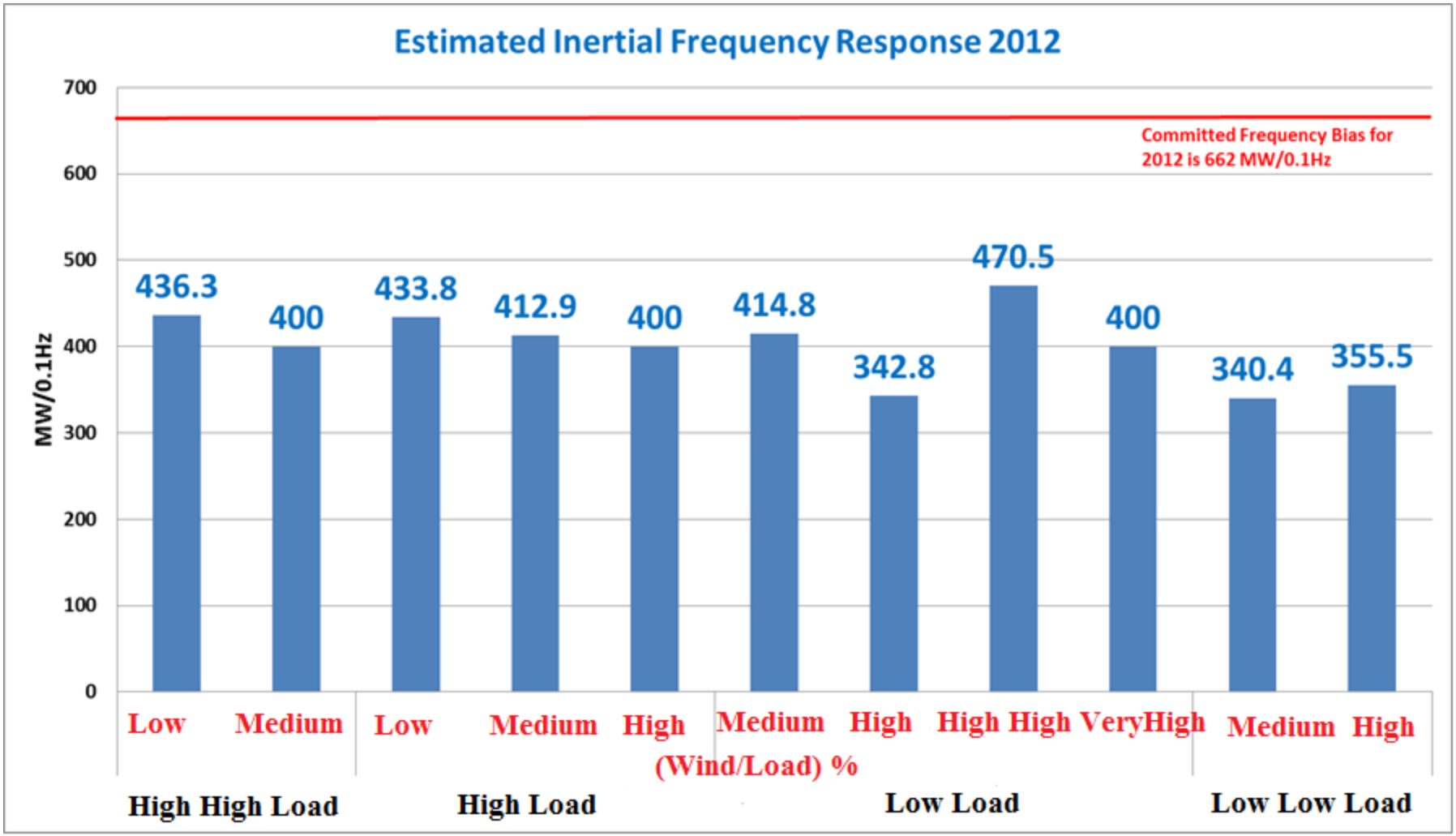
# of PMUs	60	40	20	8
# of Modes detected	6	5	5	5
# of Events detected	12	12	12	12

- *Monitoring 8 PMUs is as good as monitoring 60.*
- *Drill Down to see the list of "high visibility" PMUs*

Use Case 3

Focusing Frequency Response Analysis on relevant Generation Loss Events

Frequency Response Adequacy



Use Case 4

Setting proper alarm thresholds based on historical behavior

Mining Synchrophasor Data for Alarm Thresh

Data Mining

- **Identified Events Statistics**
  - Count of Events by
    - Event Type
    - Month
    - Total
    - Severity – Different levels of alarm threshold (high, medium & low)

By Event Type

Total Events

By Severity

By Month

Drop Filter Fields Here

Total Events | Year | Month | Severity Level

Event Type	2012												
	January			January Total	February			February Total	March			March Total	2012 Total
	HIGH	MEDIUM	LOW		HIGH	MEDIUM	LOW		HIGH	MEDIUM	LOW		
LOW_FREQUENCY	0	9	141	150	0	10	131	141	6	36	143	185	476
LOW_VOLTAGE_MAGNITUDE	46	35	66	147	38	25	47	110	158	43	72	273	530
HIGH_PHASE_ANGLE_CHANGE	5931	3	0	5934	3855	32	43	3930	7925	468	387	8780	18644
LOW_OSCILLATION_DAMPING	262	13	4	279	393	5	0	398	28	17	29	74	751
HIGH_PHASE_ANGLE_RATE_OF_CHANGE	2363	0	0	2363	1556	0	0	1556	41666	0	0	41666	45585

Conclusion

- PDMA is a tool for extracting Grid Performance Insight
  - Generation Loss Events
  - Line Trip Events
  - Sustained Oscillations
- PDMA is ideal for Setting Alarms
  - Focus Operators on real issues
  - Reduce / Remove noisy alarms
- PDMA finds the hidden gems in your Archive

Now and Next

Release Plan, Road Map

Near Term Road Map

Data Adapters	Data Quality	Analytics	Integration
• PI, eDNA, OpenHistorian, Flat Files • SE Data	• Advanced DQ Validation • Data Conditioning, Filters	• Advanced event identification • Combination & Correlation Analytics • Results management	• Statistical Engine

Release Plan

- Undergoing testing and UX fine-tuning
- Inviting Beta participants
  - Feedback, Design Input, Functional Requirements
- Scheduled for Commercial Release: January 2015

Questions and Answers

Phones lines are being un-muted

Thank You!

Electric Power Group

201 S. Lake Ave., Suite 400
Pasadena, CA 91101
(626)685-2015
www.ElectricPowerGroup.com