

# DOE/OE Transmission Reliability Program

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## Frequency Response Analysis Tool

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# Project Objectives

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- Federal Energy Regulatory Commission (FERC) defines in RM13-11:  
*“Frequency response is a measure of an Interconnection’s ability to stabilize frequency immediately following the sudden loss of generation or load, and is a critical component of the reliable operation of the Bulk-Power System, particularly during disturbances and recoveries.”*
- North American Electric Reliability Corporation (NERC) developed Frequency Response BAL-003-1 Standard, FERC approved the standard with effective date April 1<sup>st</sup> 2015.
- Frequency Response Analysis Tool (FRAT):
  - The tool calculates Frequency Response Measure (FRM) according to NERC BAL-003 standard.
  - The tool archives the historic events and baselines the system performance.
  - The tool automatically generates NERC FRS reports
  - The tool has build in statistical analysis and advanced visualization capabilities



# Frequency Response Analysis Tool

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- Developed under Bonneville Power Administration (BPA) and WECC JSIS technical guidance
- **Frequency response monitoring**
  - **Interconnection**
    - **Balancing Authority**
      - Power Plant (*Under development*)
        - » Individual Unit (*Under development*)
- Calculation NERC FRM using PMU and SCADA measurements
- Compliance reporting
- Baselining frequency response for interconnection and BA
- Supporting different data formats (csv, xml, OSIsoft PI, COMTRADE)
- Statistical Analysis



# Past major accomplishments

- FRAT (version 1.0) was released under an open source license in 2013
- Development was funded by DOE through ARRA program
- Received positive feedback from BPA, NERC, WECC JSIS, ISO New England, and ERCOT.



# FRAT use at BPA

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Bonneville Power Administration (BPA) is one of the early users of FRAT

BPA provides feedback on the application development

BPA uses frequency response baseline developed by FRAT for preparing its filings in response to FERC NOPR on BAL-003-1

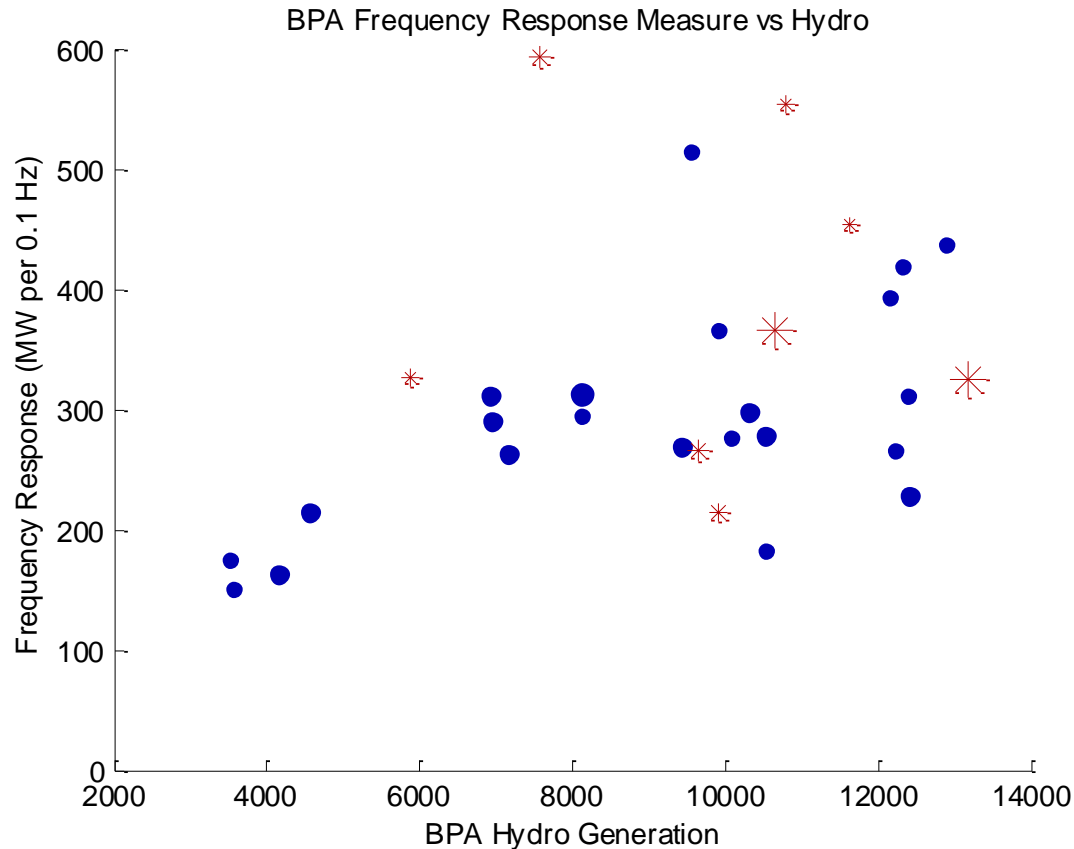
BPA uses the application for baselining its BA frequency response and determining the inventory of its frequency responsive reserves

BPA uses the application to monitor the impact of renewable generation on its frequency response performance



# FRAT use at BPA

Strong correlation between amount of hydro generation and BPA BA Frequency Response



Dots – external events  
Stars – internal events  
Size is proportional to  
MW lost

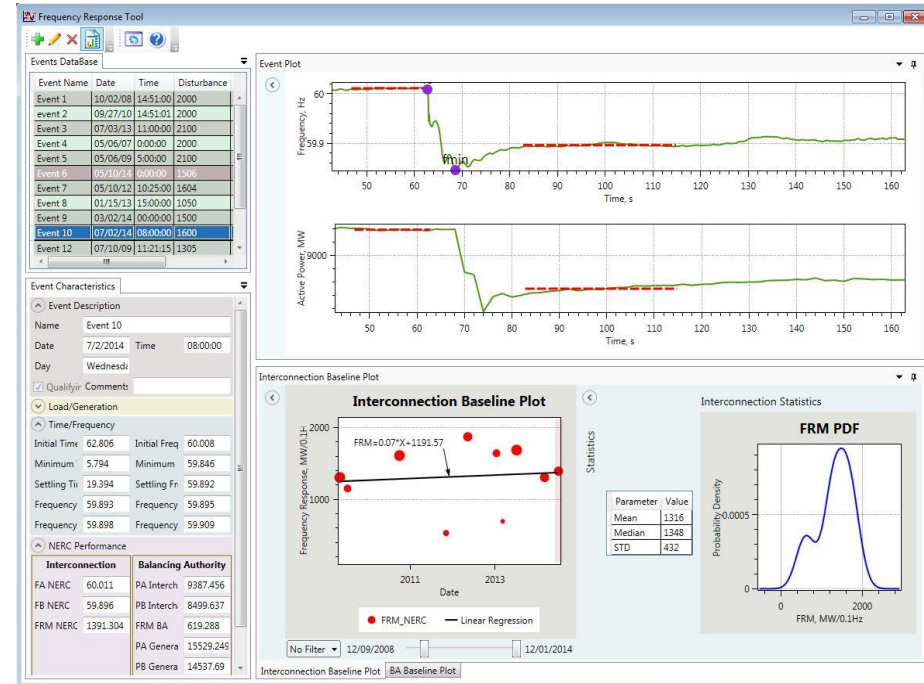




# Technical Accomplishments FY15

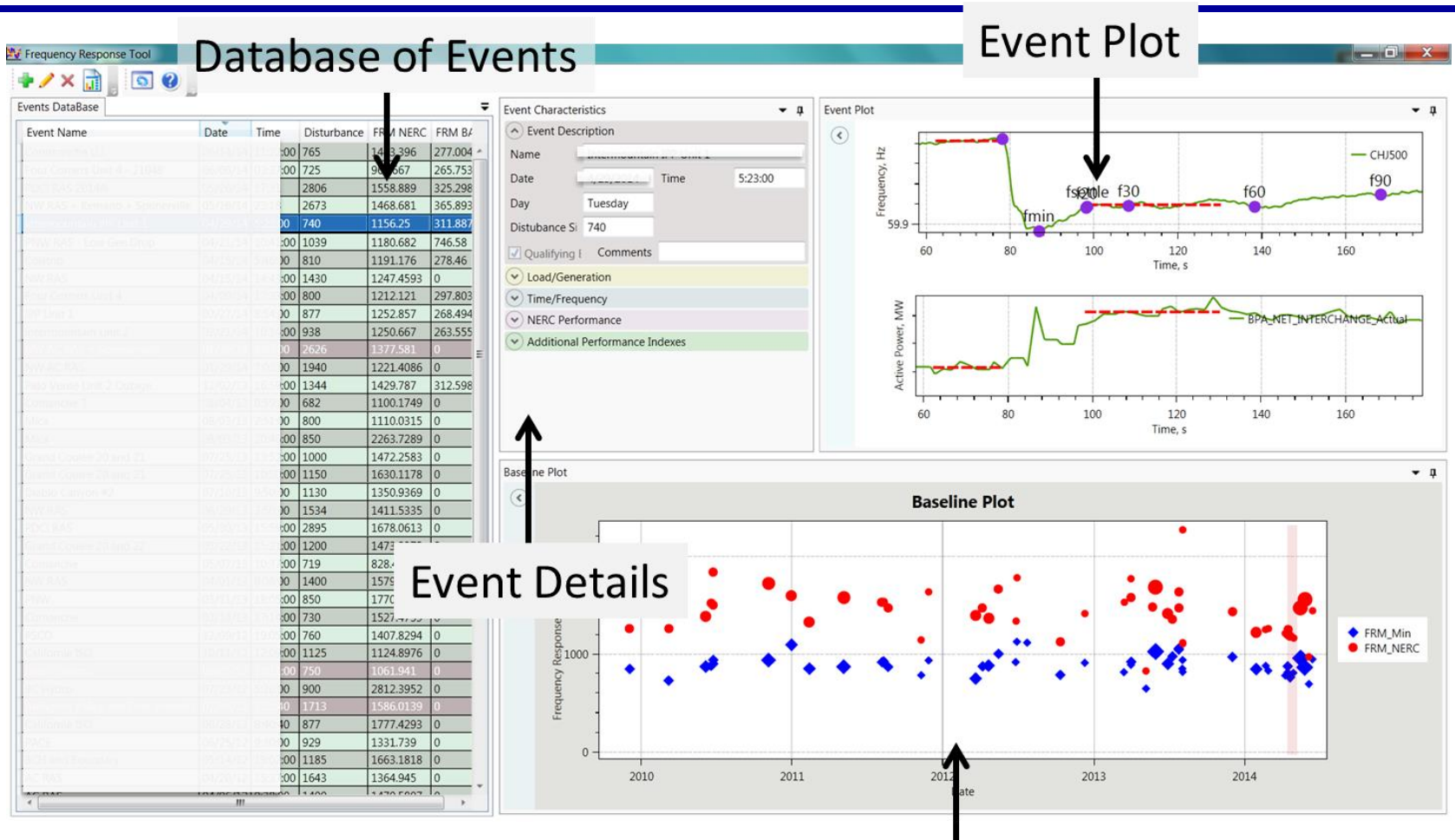
FRAT (version 2.0) was released under an open source license in September 2014

- New version is expanded to national use;
- New analytical functions including:
  - Calculation of the interconnection and balancing authority frequency response measure (FRM) according to the NERC BAL-003-01 Standard;
  - Calculation of the power plant frequency response;
  - Statistical analysis;
- New completely redesigned user interface;
- New advanced visualization;
- New reporting capabilities;
- Support of different data sources.



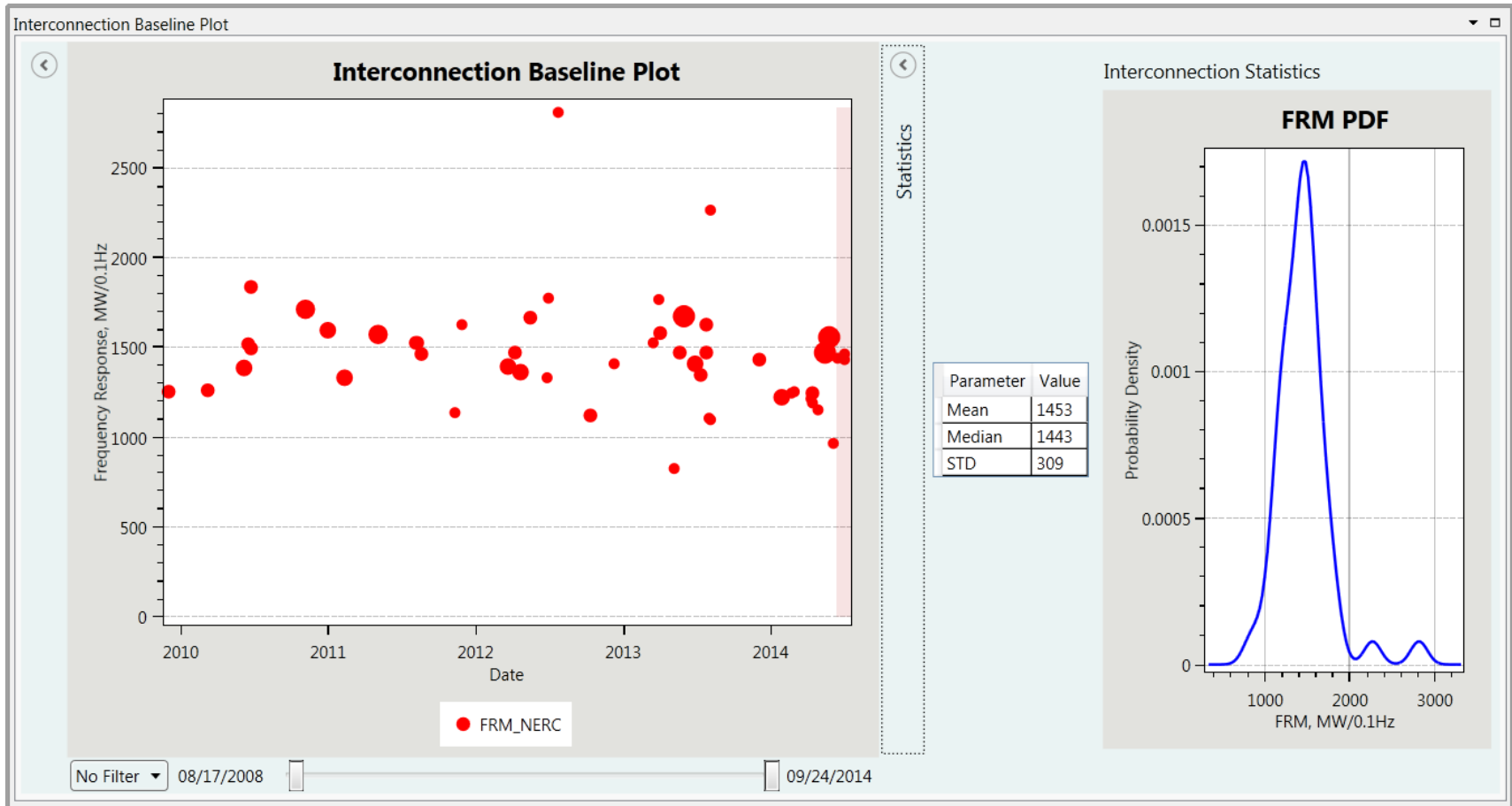


# Redesigned Graphical User Interface

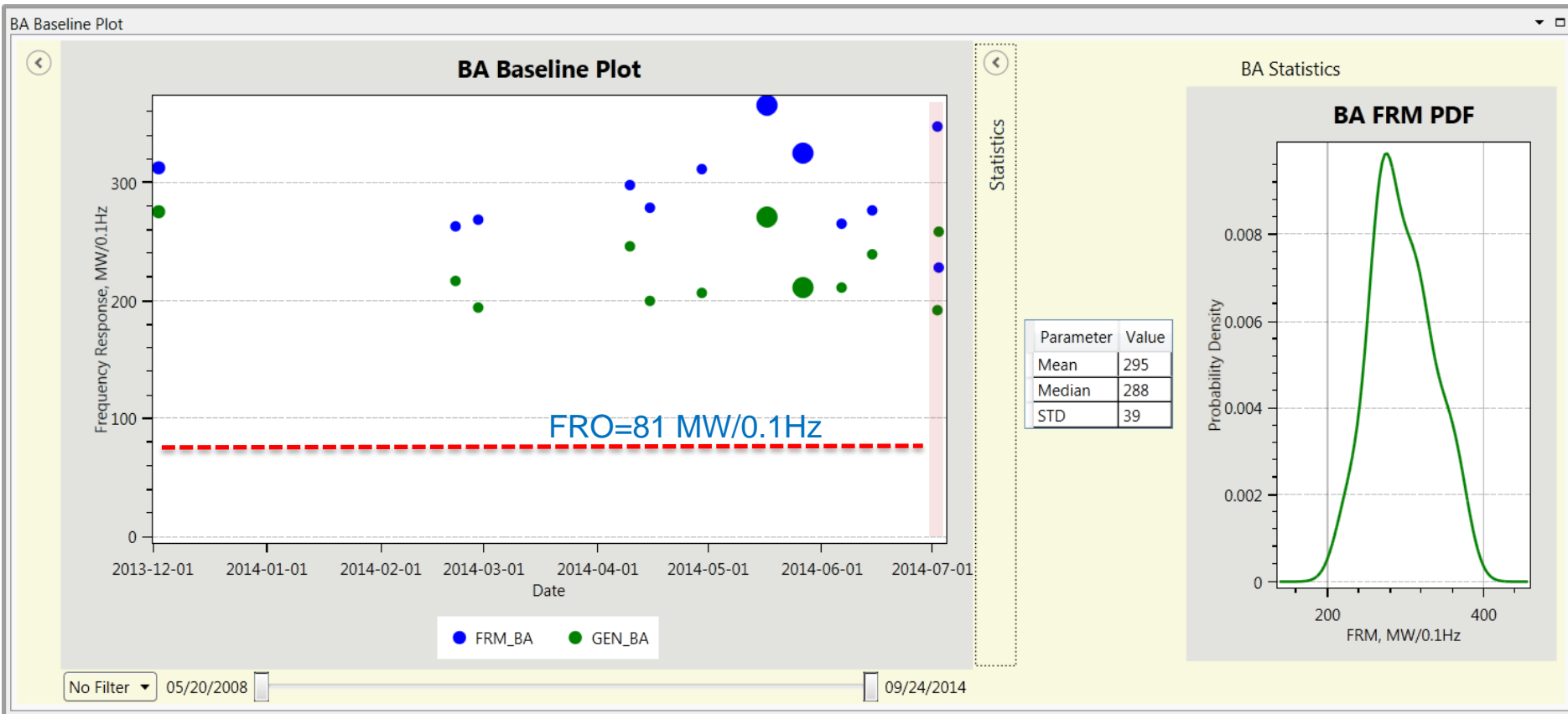


Performance Baseline

# Interconnection Performance



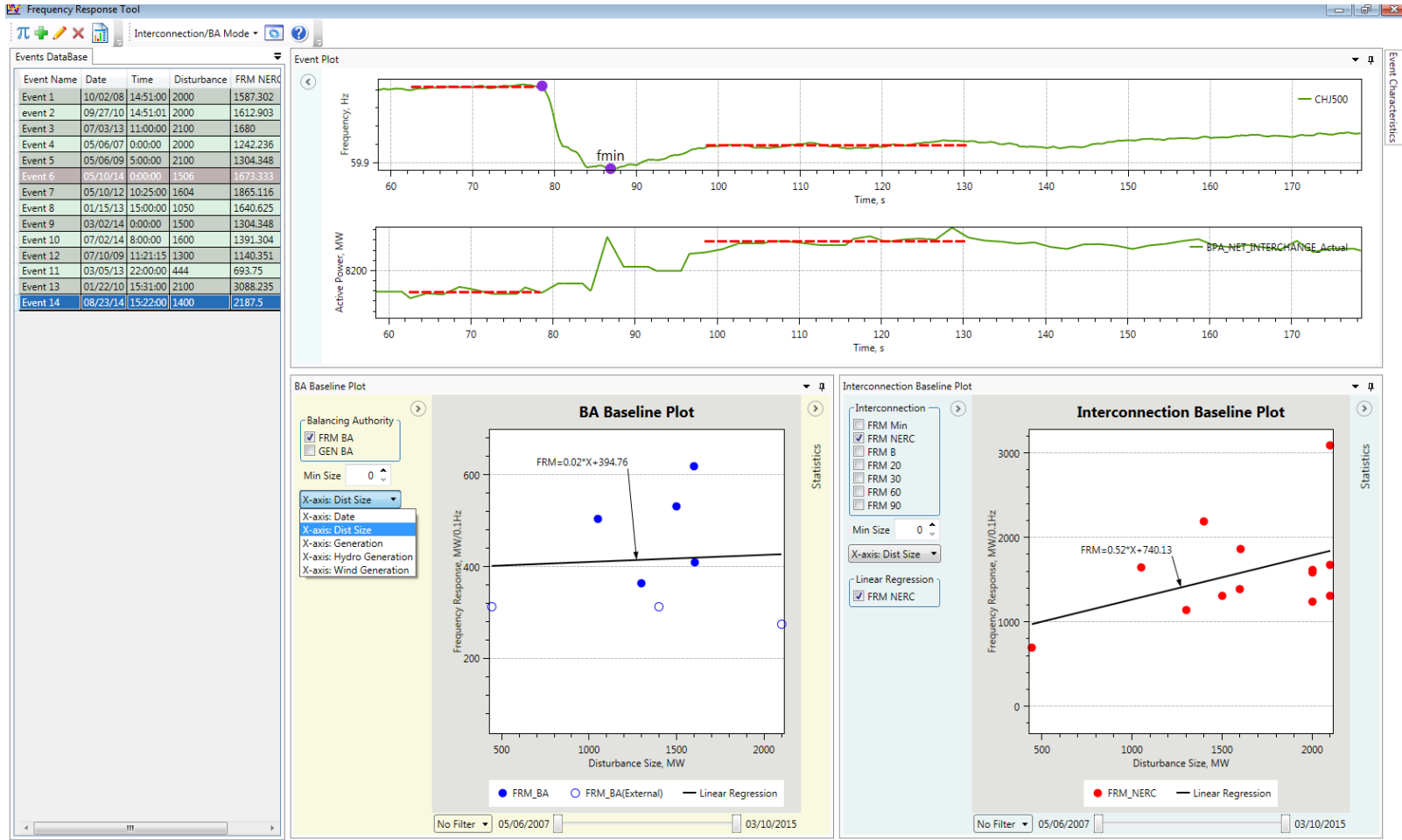
# Balancing Authority Performance



\*Interchange response is measured for compliance with NERC BAL-003-1  
Generation response is calculated to determine how much frequency response to acquire

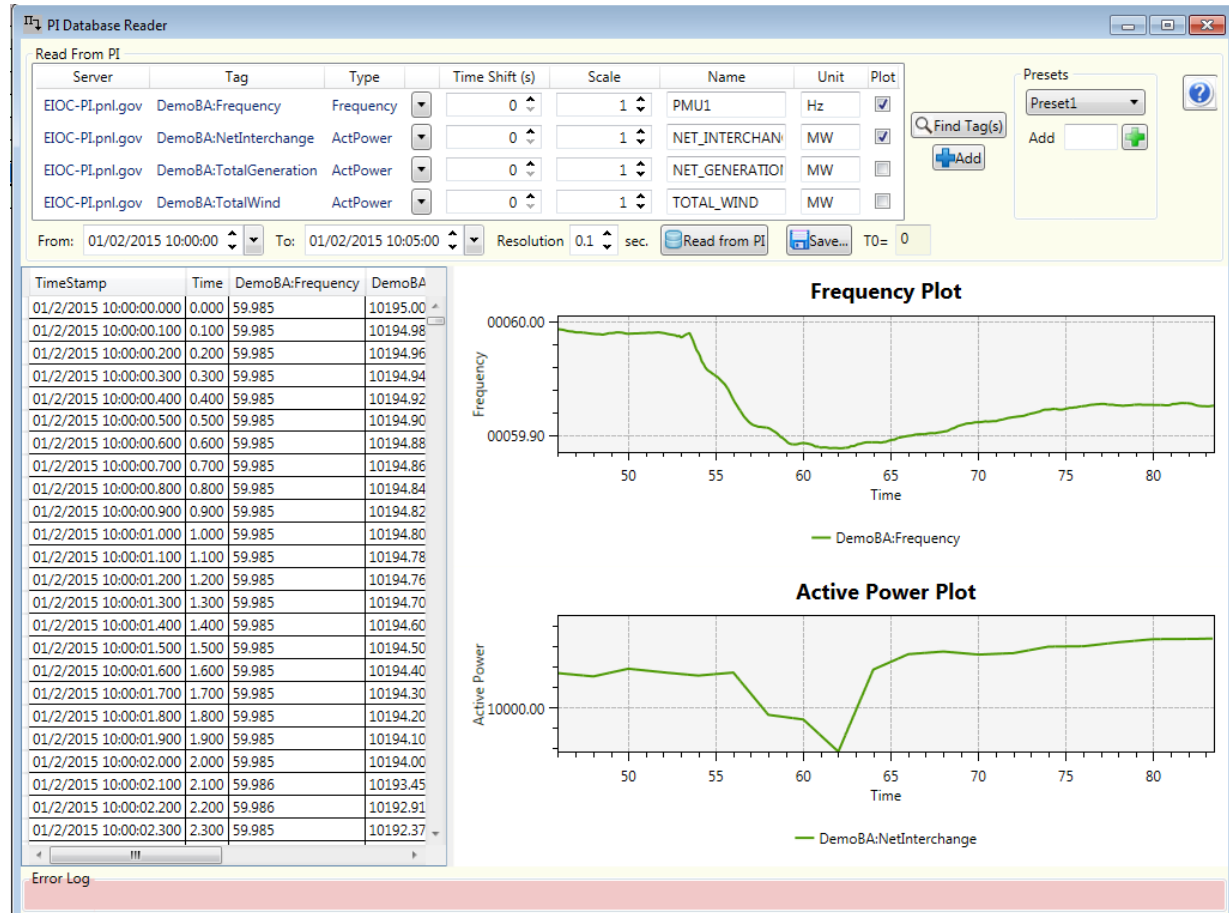


# Baselining



# OSIsoft PI database support

- Read information from PI server
- Configurable presets
- Time-series aligning

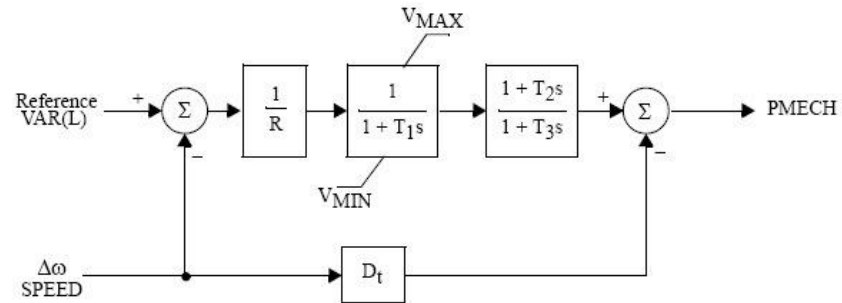


# Automated reporting

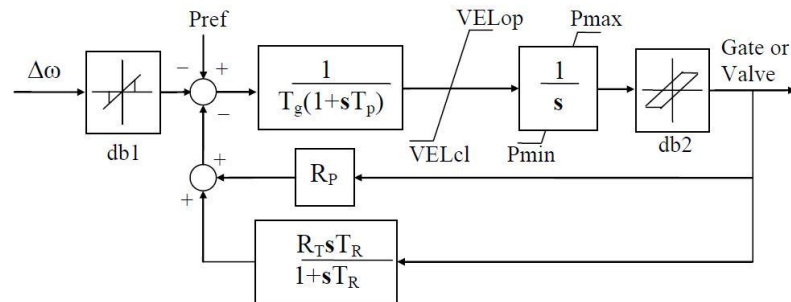


# Power Plant / Single Unit Performance

- Compare measurement based frequency response vs. model based
- Generic models of units
  - TGOV (steam)



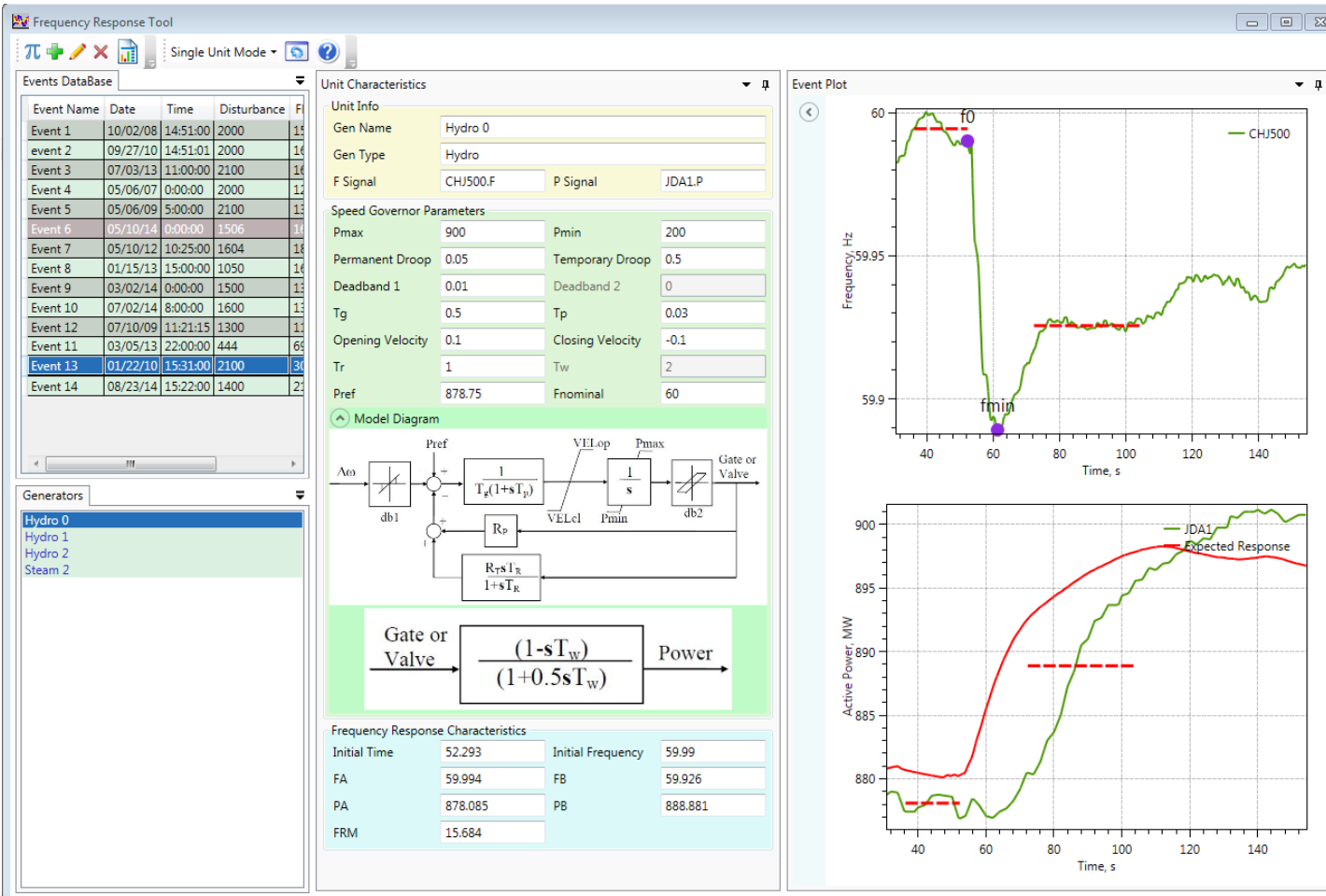
- IEEEG3 (hydro)



- Computation of unit FRM



# Power Plant Performance





# Deliverables FY15

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- FRAT report was published in December 2014.
- Conference paper presented at CIGRE GOTF in October 2014.
- New versions of the Frequency Response Analysis Tool and software documentation. Available at:
  - PNNL web page: <https://svn.pnl.gov/FRTTool>
  - NASPI software exchange portal

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#	Milestone/Deliverable	Target Date
1	<i>Tool specification</i>	December 2014 (completed)
2	<i>Prototype version of the tool</i>	March 2015 (completed)
3	<i>Incorporate user feedback and revise prototype</i>	September 2015
4	<i>Final tool release</i>	December 2015

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# Industry Outreach

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The FRAT application has been presented at multiple industrial events including:

- NERC Frequency Working Group
- NERC Resources Subcommittee
- NASPI working group meeting
- GIGRE Grid of the Future Symposium
- Electricity Reliability Council of Texas (ERCOT) phasor measurement task force
- WECC Joint Synchronized Information Subcommittee (JSIS)
- WECC Modeling and Validation Work Group (MVWG)
- Webinars for Independent System Operator (ISO) New England and ERCOT.



# Risk factors

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- Risk factors are low.
- Feedback and guidance from industrial users are very important for the success of the project.



# Future plans

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- Expanding analytical capabilities to meet user requirements.
- Automatically detecting frequency events (frequency triggers), perform analysis and generate FR reports
- Industry outreach:
  - Working closely with NERC (primarily with NERC Resources Subcommittee and Frequency Working Group) to promote nationwide dissemination of the tool among BAs and other electrical utilities.
  - Working closely with NERC and CERTS to establish continuing support and maintenance of the FRAT.
  - Working with BPA, ISO-NE, ERCOT, WECC, and other BAs and utilities to provide them FR tool support and also to receive their feedback.
  - Making presentations at NASPI, WECC JSIS, WECC MVWG, IEEE, CIGRE and other industrial meetings and workshops.

