Performance Assessment for Primary Frequency Response Update

PFRSTF

January 24, 2018

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Agenda

- Summary of changes from previous material
  - Changed Eco Min/Eco Max to Eco Min+ 5%/Eco Max – 5%
- Details on event selection
- Rolling Average Scoring
- Operating Priorities
- Tool Overview
- High level performance examples
- Examples of performance assessment

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When we will/will not evaluate a resource to provide PFR

- When we will evaluate a resource to provide PFR:
  - Unit is operating between **EcoMin+5%** and **EcoMax-5%**
    - **Example: a unit with a Eco Min of 50MW and Eco Max of 300MW would be evaluated for PFR performance between 52.5MW and 285MW**
  - And Unit is online providing energy and has available headroom (for low frequency periods) or foot room (for high frequency periods)
  - And / Or Unit is assigned reserves

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When will assessment take place?

- PJM will reserve the right to perform performance assessment between **20-30** times a year
  - **PJM will aim to find 2-3 frequency events per month for performance assessments, however system conditions may provide less opportunities – no set number of events will be prescribed**
  - Events selected will be ‘clean’ frequency excursions where frequency went outside the dead band and engaged governors
    - Frequency outsides +/- 40mHz
    - Frequency stays outside of dead band for 60 seconds
  - PJM will aim to select events in both directions
    - Events with high frequency (above 60.04) and events with low frequency (below 59.96)

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How events are selected

- Events selected will be ‘clean’ frequency excursions where frequency went outside the dead band and engaged governors
    - Frequency outsides +/- 40mHz
    - Frequency stays outside of dead band for 60 seconds
- PJM will evaluate all events over a monthly period and select the best 2 or 3 events from the month
    - The best events will be evaluated on how far outside the dead bands frequency went and how long frequency deviated.
    - Events could be caused by unit/load loss or just frequency drift.

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Pass/Fail Assessment

- Threshold will be set to determine Pass/Fail assessment
  - Unit will need to provide 50% of expected response to Pass (in MW)
  - Pass/Fail assessment will be down on a quarterly basis looks at a 12 month rolling window
  - Response measured within 20-52 seconds (alignment with BAL-003-1)
  - Sustain frequency response out to 60 seconds or duration of event
- Pass/Fail assessment due to some data quality
  - 10 second scan rates
  - Data dead band storage in historian
- Assessments will be performed on market units
  - Further breakdown assessments will be available upon request

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Rolling Window Scoring

- Quarterly assessments looking at 12-month rolling window
  - Assessment performed in Jan will look at all events selected from Jan of the previous year through Dec of the previous year
  - April evaluation will used April of the previous year through March of current year
  - July evaluation will used July of the previous year through June of current year
  - Oct evaluation will used Oct of the previous year through Sept of current year

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Rolling Window Scoring

- Scoring will be evaluated as average performance over 12 month window
  - Each event will be evaluated separately and then performance will be average for pass/fail determination
  - 50% or greater average performance will be considered passing
- Units can be evaluated on 20+ events over the 12 month period or just a few
  - Events will be determined on if the unit was expected to respond during the selected events
    - Headroom, Online, Regulation status, etc.

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Operating Priorities

- If a unit is providing Energy with set basepoint
  - Provide PFR based on droop characteristics
- If a unit is providing Energy and Ramping Up
  - If LOW frequency event, continue ramping at ramp rate
  - If HIGH frequency event, stop ramping for duration of freq. event
- If a unit is providing Energy and Ramping Down
  - If LOW frequency event, stop ramping for duration of freq. event
  - If HIGH frequency event, continue ramping at ramp rate
- If a unit is providing Regulation
  - Continue providing Regulation, can also provide PFR but will not undergo performance assessment for this event

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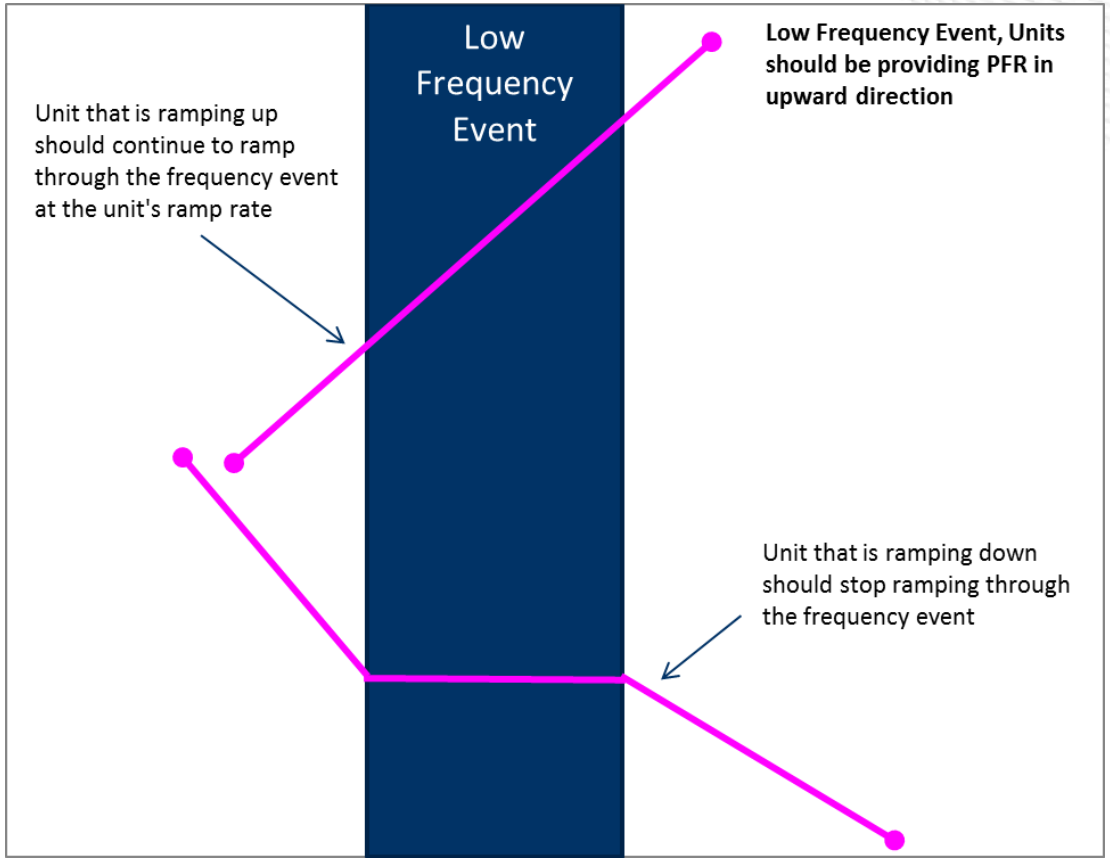
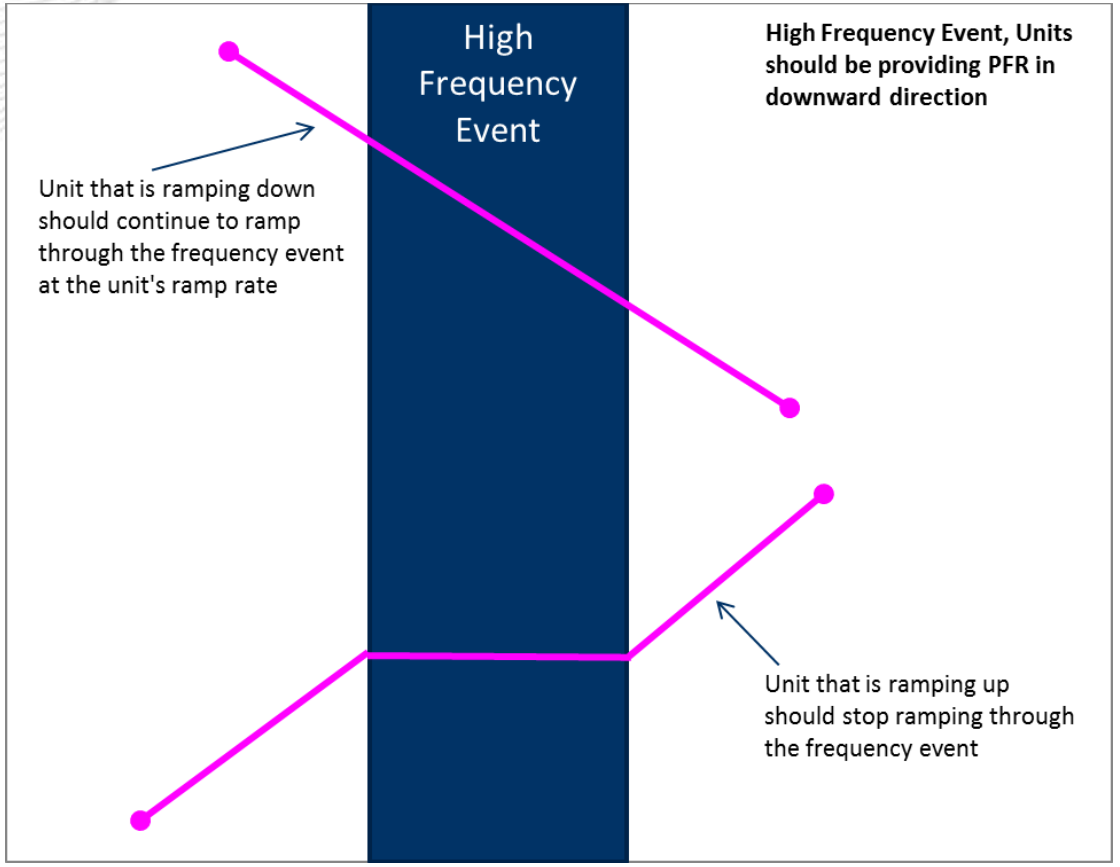
Unit Ramping and PFR





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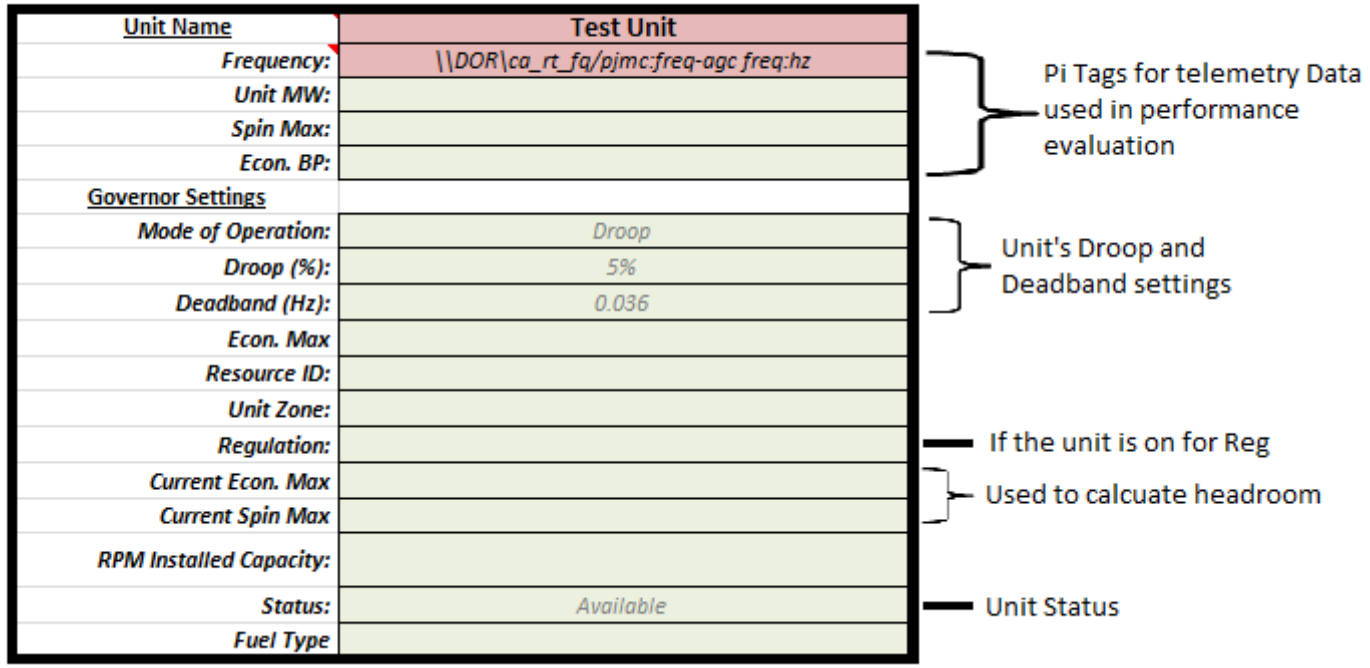
Tool Overview- Setup & Initial Information

- Initial Data need to set up performance assessment
  - Additional data for awareness (ex. fuel type, unit zone, etc.)
- Eco Max/Spin Max data coming from Markets Gateway
  - Important this data is accurate
- Droop/Dead band will be set to PJM requirements (5%/36mHz) unless exception documented



Unit Name	Test Unit
Frequency:	\\DOR\ca_rt_fq/pjmc:freq-agc freq:hz
Unit MW:	
Spin Max:	
Econ. BP:	
Governor Settings	
Mode of Operation:	Droop
Droop (%):	5%
Deadband (Hz):	0.036
Econ. Max	
Resource ID:	
Unit Zone:	
Regulation:	
Current Econ. Max	
Current Spin Max	
RPM Installed Capacity:	
Status:	Available
Fuel Type	

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Tool Overview- Data Collection

- Data is collected from 1 minute before the event T0 to 5 minutes after the event
  - Frequency, Unit Output, Spin Max, and Eco BP are all collected data
  - FR Capacity is a headroom calculation (Eco Max – Unit Output) for low frequency and (Unit Output – Eco Min) for high frequency
  - Droop Coefficient and Expect Response is the calculated response
  - Regulation and Output Before Event used for situational awareness to make sure the performance assessment is done correctly

	Date/Time	Frequency	Unit Output	Spin Max	FR Capacity	Droop Coefficient	Expected Response	EcoBP	Regulation	OUTPUT BEFORE EVENT
17:30:37	05-Dec-15 17:30:37	60.00350189	178.6999969	605	426.300003	1.33%	178.6999969	179	0	178.1999969
17:30:39	05-Dec-15 17:30:39	60.00422668	178.6999969	605	426.300003	1.36%	178.6999969	179		178.1999969
17:30:41	05-Dec-15 17:30:41	60.00427628	178.6999969	605	426.300003	1.36%	178.6999969	179		178.226944
17:30:43	05-Dec-15 17:30:43	60.00301743	178.6999969	605	426.300003	1.32%	178.6999969	179		178.3999939
17:30:45	05-Dec-15 17:30:45	60.00273895	178.6999969	605	426.300003	1.31%	178.6999969	179		178.3999939
17:30:47	05-Dec-15 17:30:47	60.00299835	178.6999969	605	426.300003	1.32%	178.6999969	179		178.3999939

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Tool Overview- Point A and B Calculation

- Two points within the data are calculated to be used in the performance evaluation
  - Expected and Actual response at Point A, measured from -16 to 0sec before the event
  - Expected and Actual response at Point B, measured from 20 to 52 sec after the event

Expected	Actual							
		17:31:23	05-Dec-15 17:31:23	59.99150085	178.8999939	605	426.100006	0.93%
		17:31:25	05-Dec-15 17:31:25	59.99150085	178.8999939	605	426.100006	0.93%
		17:31:27	05-Dec-15 17:31:27	59.9910202	178.8999939	605	426.100006	0.91%
		17:31:29	05-Dec-15 17:31:29	59.99001694	178.8999939	605	426.100006	0.88%
		17:31:31	05-Dec-15 17:31:31	59.98925781	178.8999939	605	426.100006	0.85%
		17:31:33	05-Dec-15 17:31:33	59.98851776	178.8999939	605	426.100006	0.83%
	Point A	17:31:35	05-Dec-15 17:31:35	59.98727417	178.8999939	605	426.100006	0.79%
178.9	178.9	17:31:37	05-Dec-15 17:31:37	59.98625946	178.8999939	605	426.100006	0.75%
		17:31:39	05-Dec-15 17:31:39	59.98551178	178.8999939	605	426.100006	0.73%
		17:31:41	05-Dec-15 17:31:41	59.9801445	178.8999939	605	426.100006	0.54%
		17:31:43	05-Dec-15 17:31:43	59.97330856	178.8999939	605	426.100006	0.31%
		17:31:45	05-Dec-15 17:31:45	59.96741867	178.8999939	605	426.100006	0.12%
		17:31:47	05-Dec-15 17:31:47	59.95941925	178.8999939	605	426.100006	-0.15%
		17:31:49	05-Dec-15 17:31:49	59.95429611	178.8999939	605	426.100006	-0.33%
		17:31:51	05-Dec-15 17:31:51	59.95155334	178.8999939	605	426.100006	-0.42%
		17:31:53	05-Dec-15 17:31:53	59.9495163	178.8999939	605	426.100006	-0.49%
		17:31:55	05-Dec-15 17:31:55	59.94900131	178.8999939	605	426.100006	-0.51%
	Point B	17:31:57	05-Dec-15 17:31:57	59.94875717	178.8999939	605	426.100006	-0.51%
181.6	178.9	17:31:59	05-Dec-15 17:31:59	59.94825745	178.8999939	605	426.100006	-0.53%
		17:32:01	05-Dec-15 17:32:01	59.94653702	178.8999939	605	426.100006	-0.59%
		17:32:03	05-Dec-15 17:32:03	59.94524384	178.8999939	605	426.100006	-0.63%
		17:32:05	05-Dec-15 17:32:05	59.94477463	178.8999939	605	426.100006	-0.65%
		17:32:07	05-Dec-15 17:32:07	59.9444809	178.8999939	605	426.100006	-0.66%
		17:32:09	05-Dec-15 17:32:09	59.94475937	178.8999939	605	426.100006	-0.65%
		17:32:11	05-Dec-15 17:32:11	59.9440155	178.8999939	605	426.100006	-0.67%
		17:32:13	05-Dec-15 17:32:13	59.94350052	178.8999939	605	426.100006	-0.69%
		17:32:15	05-Dec-15 17:32:15	59.94350052	178.8999939	605	426.100006	-0.69%
		17:32:17	05-Dec-15 17:32:17	59.94470978	178.8999939	605	426.100006	-0.65%
		17:32:19	05-Dec-15 17:32:19	59.945755	178.8999939	605	426.100006	-0.62%
		17:32:21	05-Dec-15 17:32:21	59.94549942	178.8999939	605	426.100006	-0.62%
		17:32:23	05-Dec-15 17:32:23	59.94525909	178.8999939	605	426.100006	-0.63%
		17:32:25	05-Dec-15 17:32:25	59.94548416	178.8999939	605	426.100006	-0.62%
		17:32:27	05-Dec-15 17:32:27	59.94599915	178.8999939	605	426.100006	-0.61%
		17:32:29	05-Dec-15 17:32:29	59.94527054	178.8999939	605	426.100006	-0.63%

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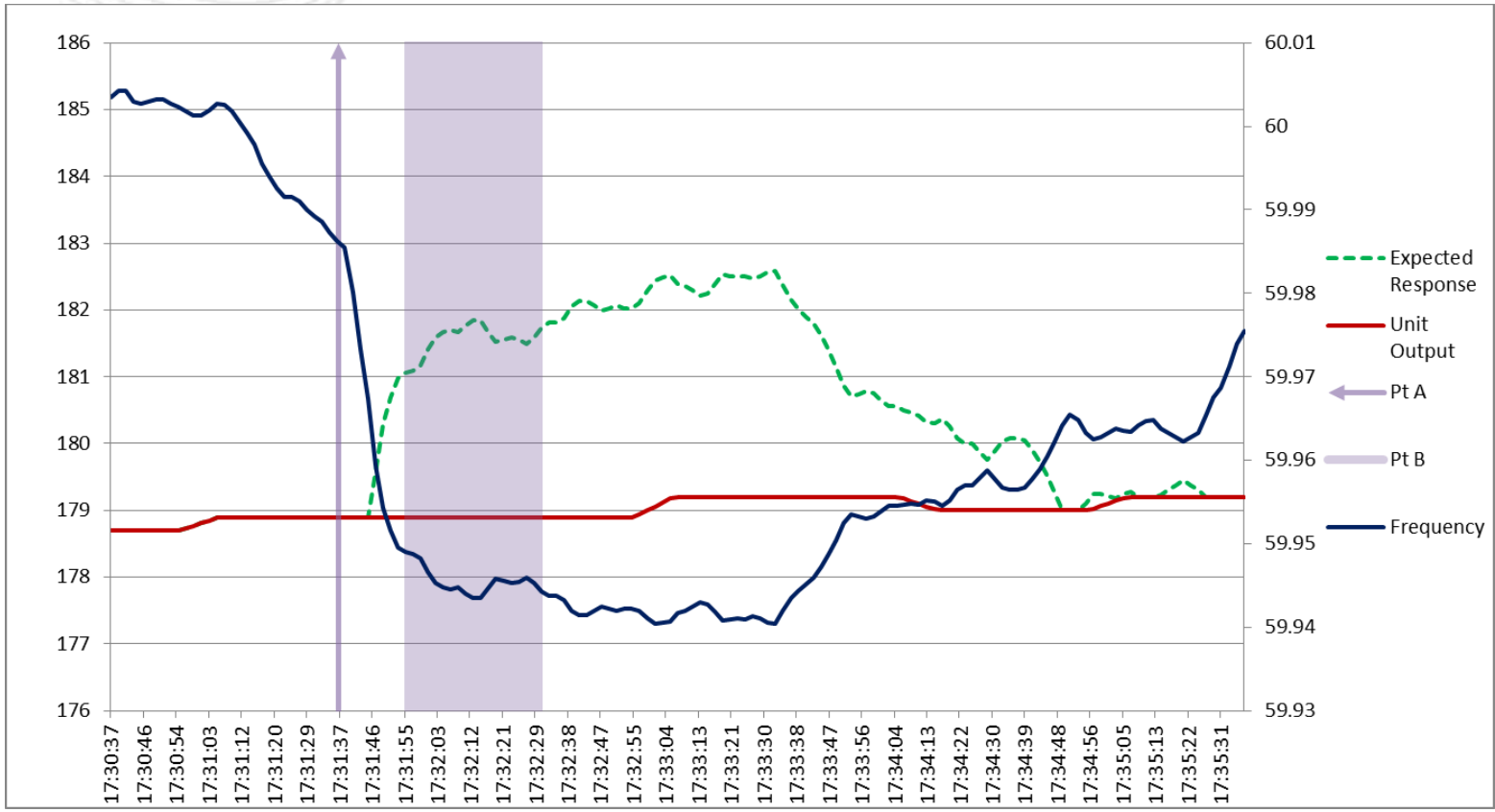
Tool Overview- Response Graph

- The full set of data is graphed
  - Event Data: Frequency Profile and Point A and Point B of the event
  - Unit Data: Unit output and Expected response



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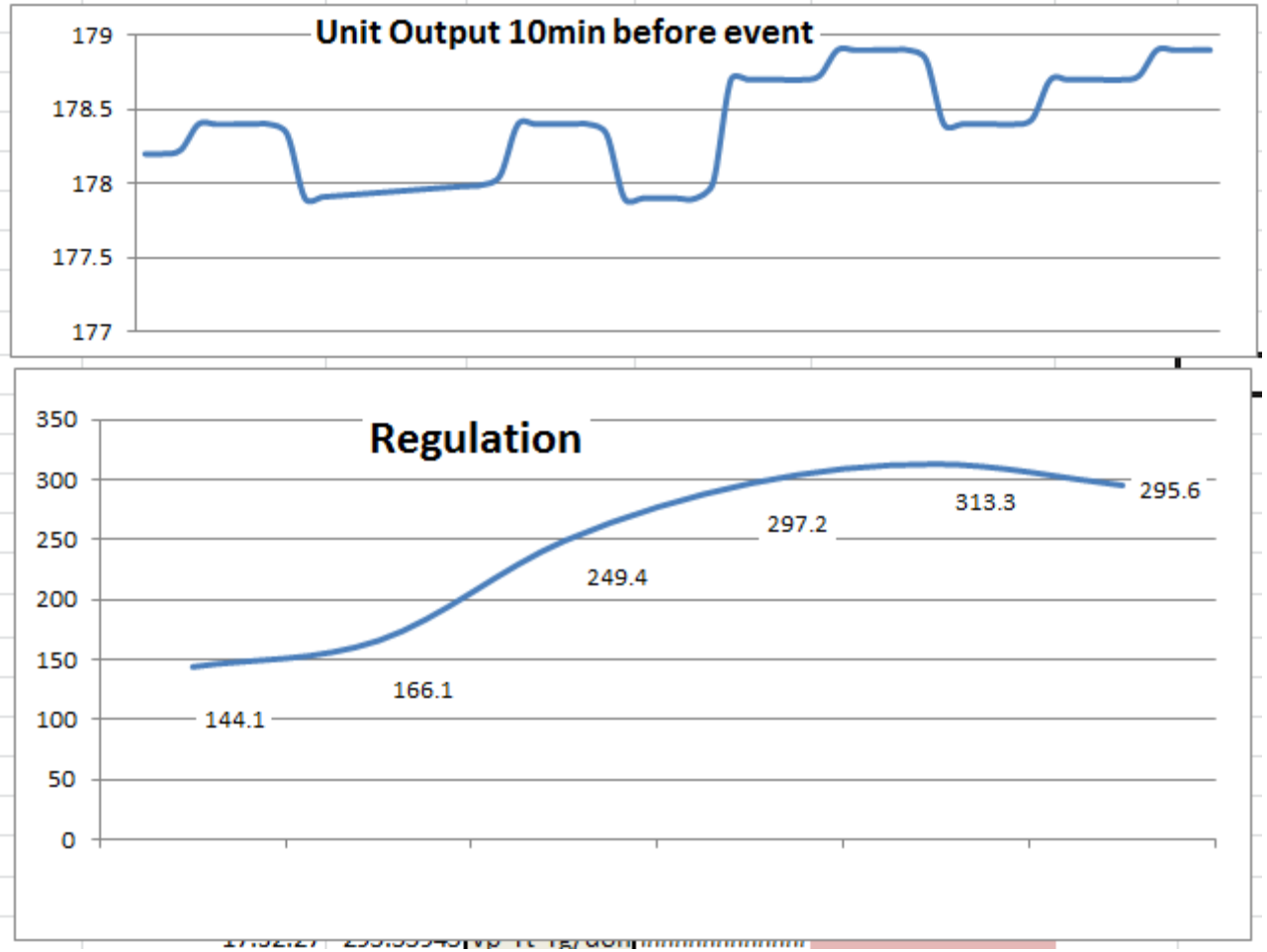
Tool Overview- Additional Data Graphs

- The addition data is also graphed
  - Unit Output 10min before the event shows the unit behavior before the event (ramping, etc.)
  - Regulation graph shows if the unit was providing regulation during the event time period



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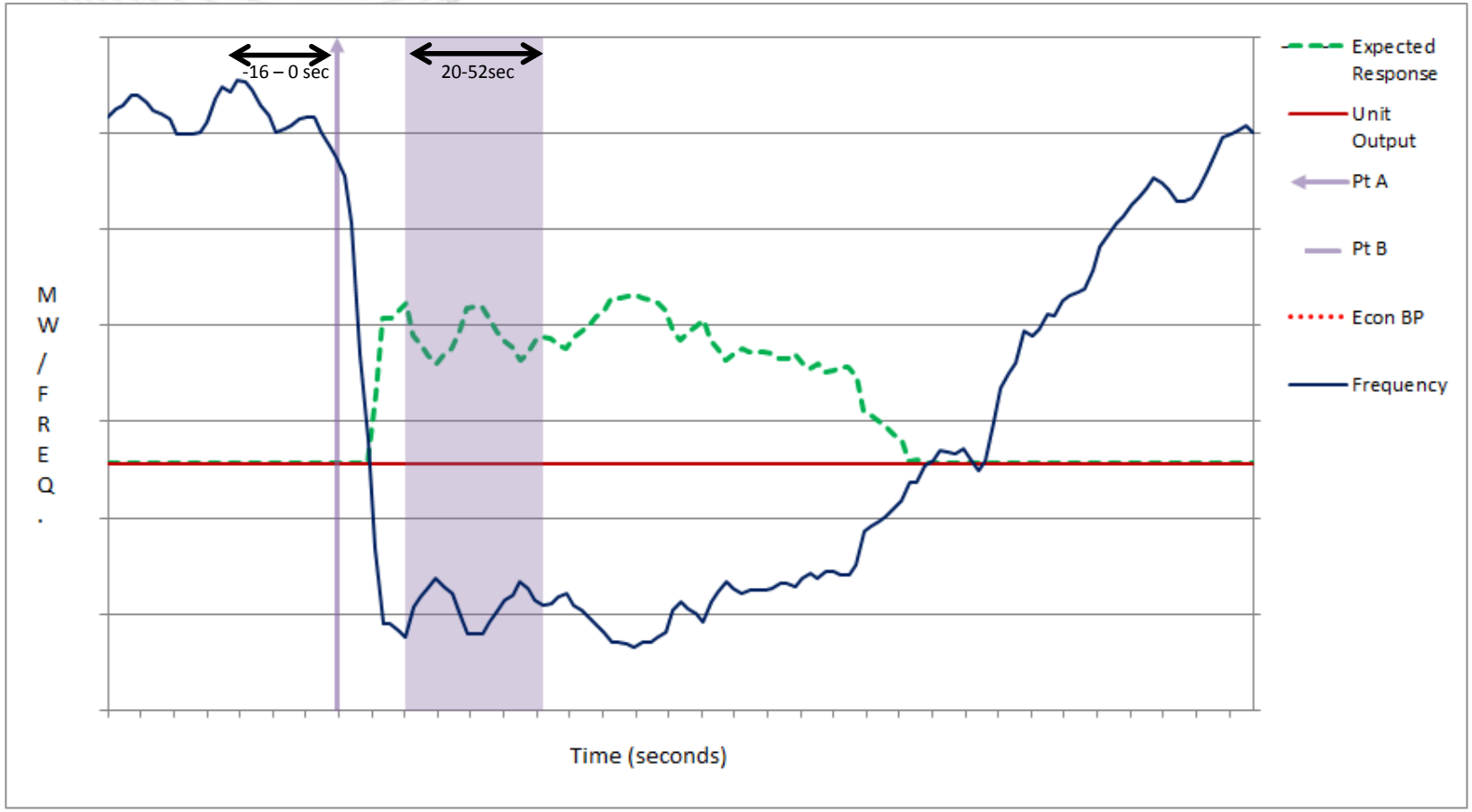
Example Response

- Example Data
- Low Frequency Event
- No requested ramping, unit will be evaluated on droop characteristics

- Evaluation done on average <u>actual output</u> at 20-52 sec AFTER frequency event compared to average <u>expected output</u> 20-52 sec AFTER frequency event
  - **Expected response= average MW of green dotted curve in purple band**



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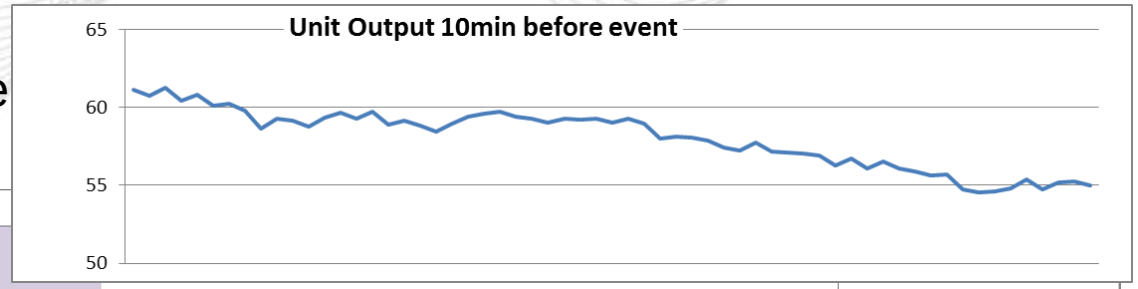
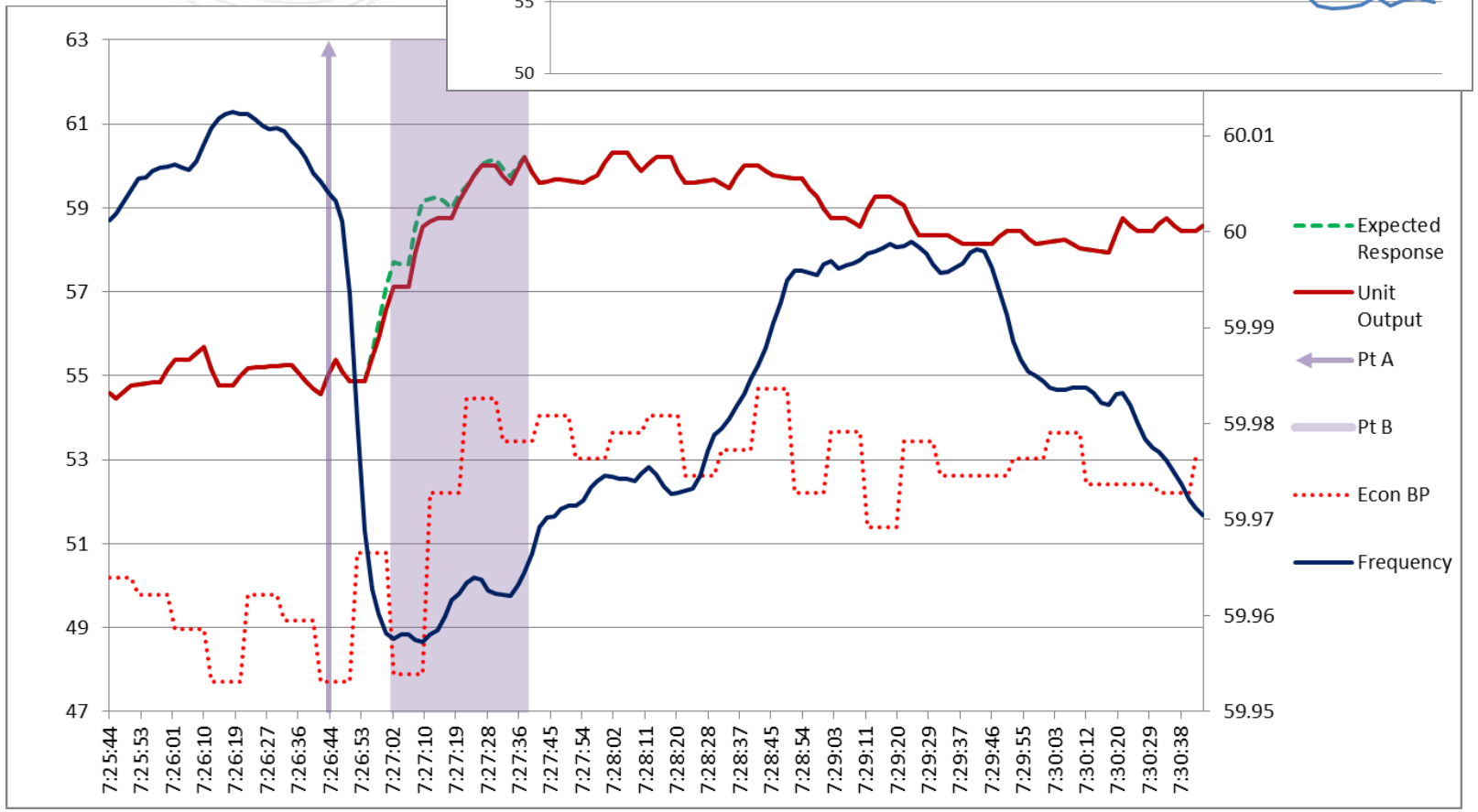
Unit Responding

- Point A
  - Starting MW = 55.1
- Point B
  - Expected MW= 59.3
  - Actual MW= 59.0
- Response
  - Expected:59.3-55.1 = 4.2MW
  - Actual:59.0–55.1= 3.9MW
- Performance Assessment
  - 1 - (Expected MW – Actual MW)/(Expected MW)
  - 1-((4.2- 3.9)/4.2) = 93%
  - PASS

- Eco Max = 325MW
- Small Eco BP change during this period





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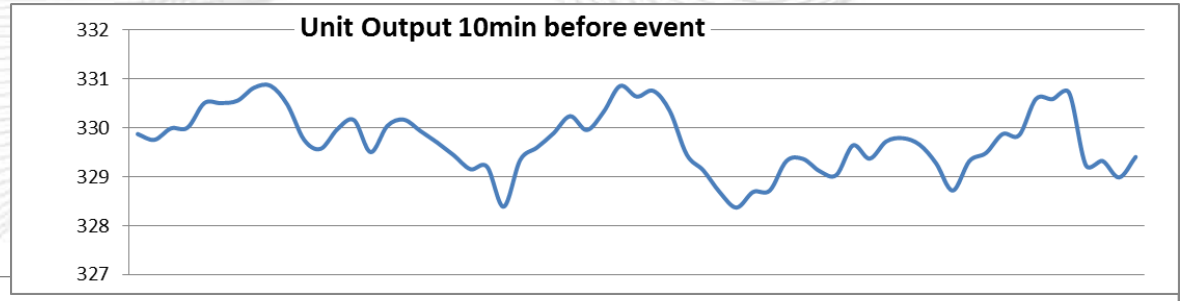
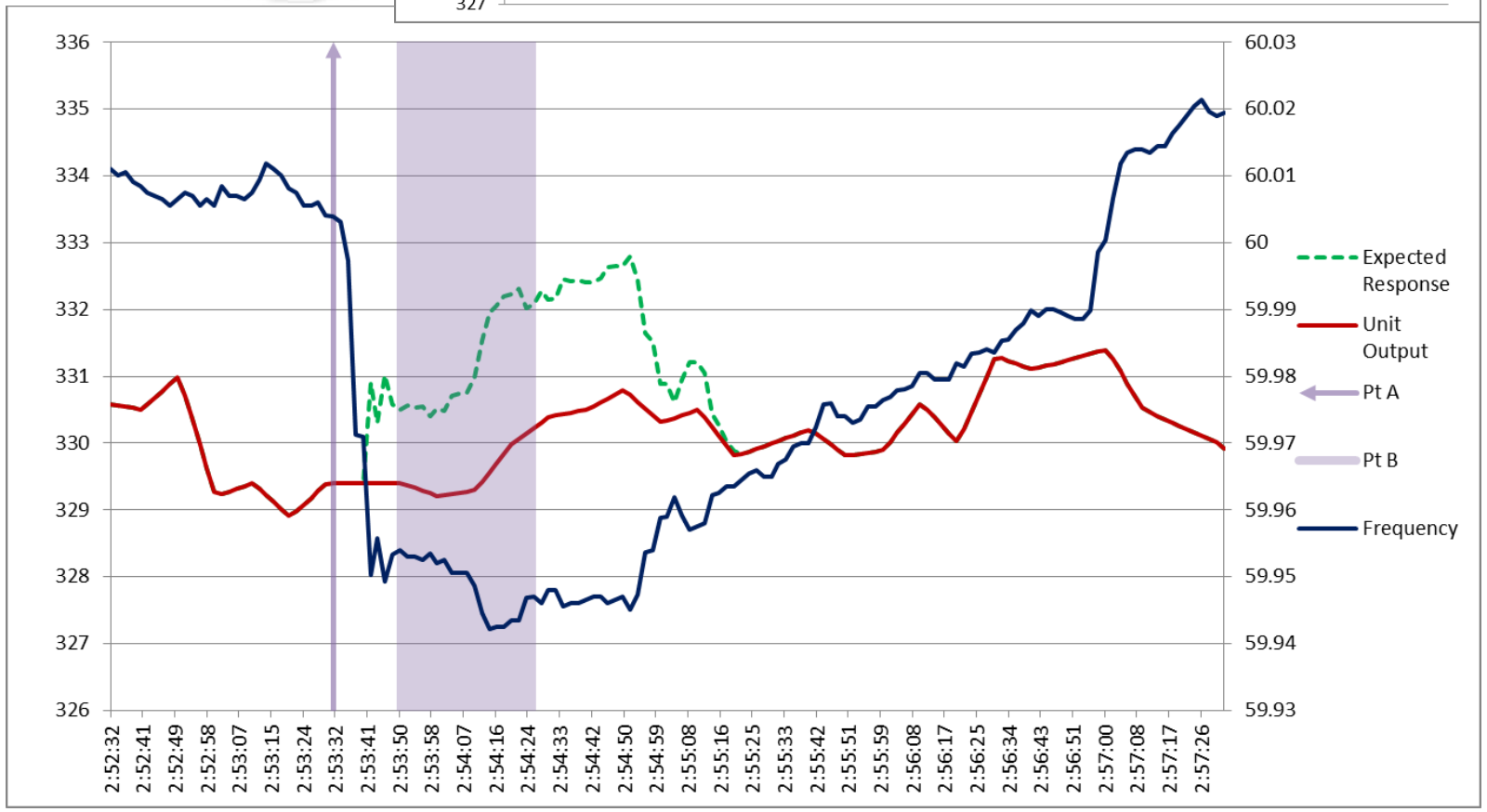
Unit not responding

- Point A
  - Starting MW = 329.1
- Point B
  - Expected MW=331.2
  - Actual MW= 329.5
- Response
  - Expected:331.2 – 329.1 = 2.1MW
  - Actual: 329.5 – 329.1 = 0.4MW
- Performance Assessment
  - 1 - (Expected MW – Actual MW)/(Expected MW)
  - 1-((2.1– 0.4)/2.1) = 19.1%
  - FAIL

- Eco Max = 650MW
- No change in Eco BP during this period





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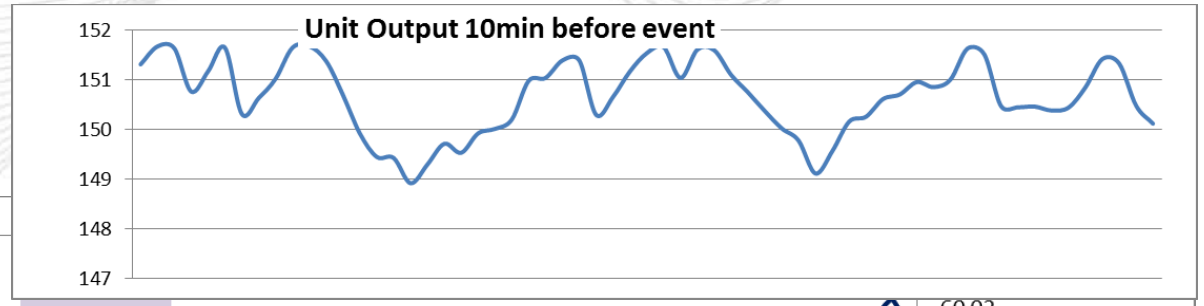
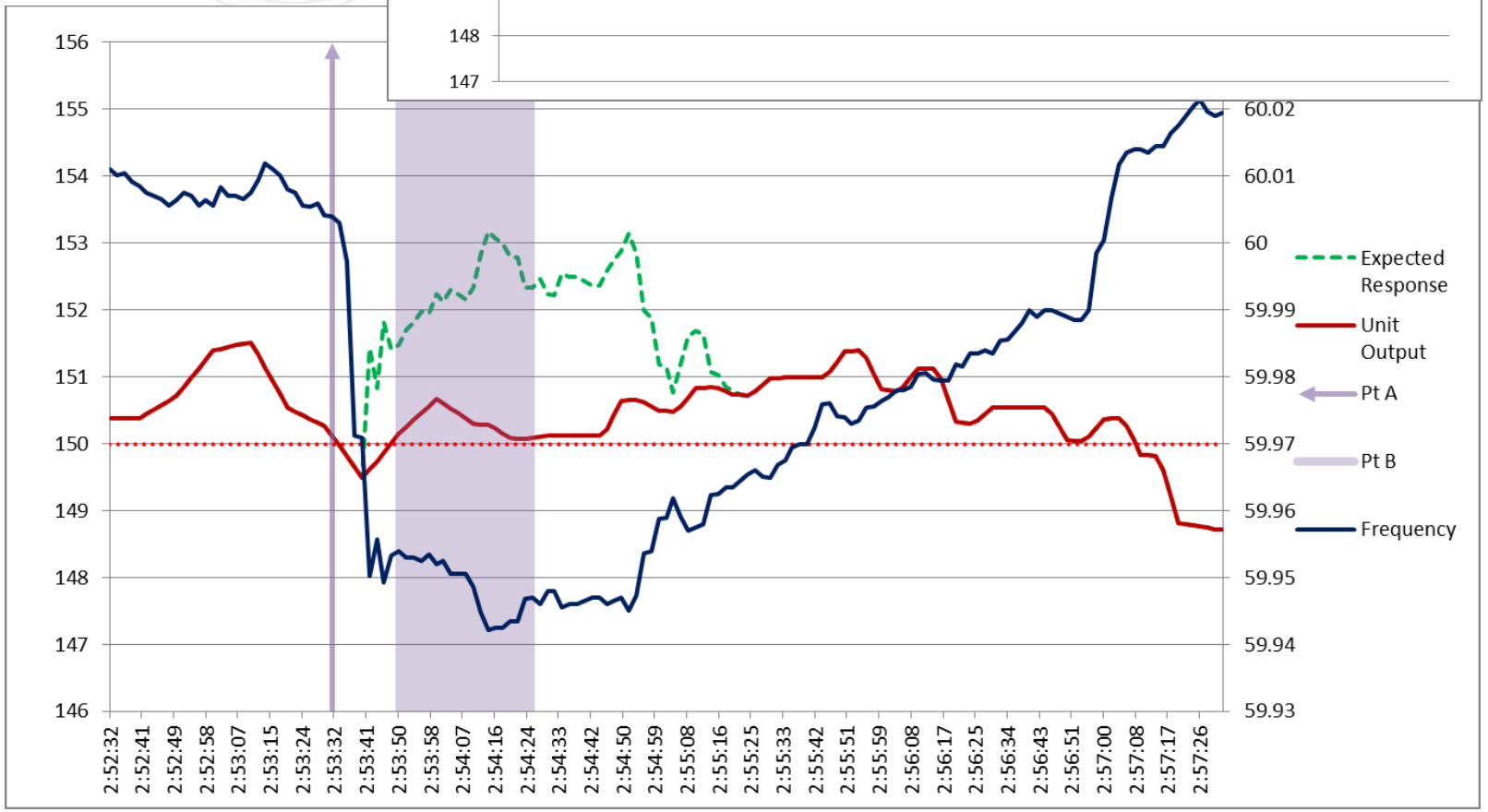
Unit not responding

- Point A
  - Starting MW = 150.5
- Point B
  - Expected MW= 152.4
  - Actual MW= 150.3
- Response
  - Expected:152.4 –150.5 = 1.9MW
  - Actual: 150.3 – 150.5 = -0.2MW
- Performance Assessment
  - 1 - (Expected MW – Actual MW)/(Expected MW)
  - 1-((1.9– -0.2)/1.9) = -11%
  - FAIL

- Eco Max = 550MW
- No change in Eco BP during this period





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Performance Assessment for Primary Frequency Response

PFRSTF

December 1, 2017

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Calculation

- Resources expected performance will be calculated with the primary frequency control calculation
  - Frequency below governor dead band

$$MW\ \text{Pr}\ imaryControl = \left[\frac{(HZ_{actual} - 60 + DB)}{(60 * Droop - DB)}\right] * (Frequency\ \text{Re}\ sponsiveCapacity) * (-1)$$

  - Frequency above governor dead band

$$MW\ \text{Pr}\ imaryControl = \left[\frac{(HZ_{actual} - 60 - DB)}{(60 * Droop - DB)}\right] * (Frequency\ \text{Re}\ sponsiveCapacity) * (-1)$$

  - 36mHz deadband (or less), 5% droop (or less)
    - Calculation will be performed with 36mHz and 5% droop unless different settings are communicated to PJM

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Pass/Fail Assessment

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  - Unit will need to provide 50% of expected response to Pass (in MW)
  - Pass/Fail assessment will be down on a quarterly basis looks at a 12 month rolling window
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  - Events selected will be ‘clean’ frequency excursions where frequency went outside the dead band and engaged governors
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    - Frequency stays outside of dead band for 60 seconds
  - PJM will aim to select events in both directions
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When will assessment take place?

- Process for non-performance
  - PJM will review first failed PFR assessment with stakeholder to discuss details of failed response
    - This is to ensure that failed attempt is not due to data issues, maintenance issues, etc.
    - This is a one-time review for PJM and the participant to work through any issues that are uncovered
  - Subsequent failed PFR assessment will be referred to IMM/FERC for follow-up
    - Participants will have the opportunity to provide data to document performance before referral if data issues are assumed for the failure
  - No monthly payments for cost of service until demonstrated successful performance (TBD based on compensation discussion)

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When we will/will not evaluate a resource to provide PFR

- When we will evaluate a resource to provide PFR:
  - Unit is operating between Eco Min+5% and Eco Max-5%
    - Example a unit with a Eco Min of 50MW and Eco Max of 300MW would be evaluated for PFR performance between 52.5MW and 285MW
  - And Unit is online providing energy and has available headroom (for low frequency periods) or foot room (for high frequency periods)
  - And/Or Unit is assigned reserves

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When we will/will not evaluate a resource to provide PFR

- When we will not evaluate a resource to provide PFR:
  - Unit is not currently providing real-time energy/reserves
  - Or Unit is not operating between Eco Min and Eco Max
  - Or Unit has an exception
    - Long-term exception developed through the exception process
    - Short-term exception based on current operating parameters
      - Documented in EDART – max 30 day exception
  - Or Unit is providing regulation

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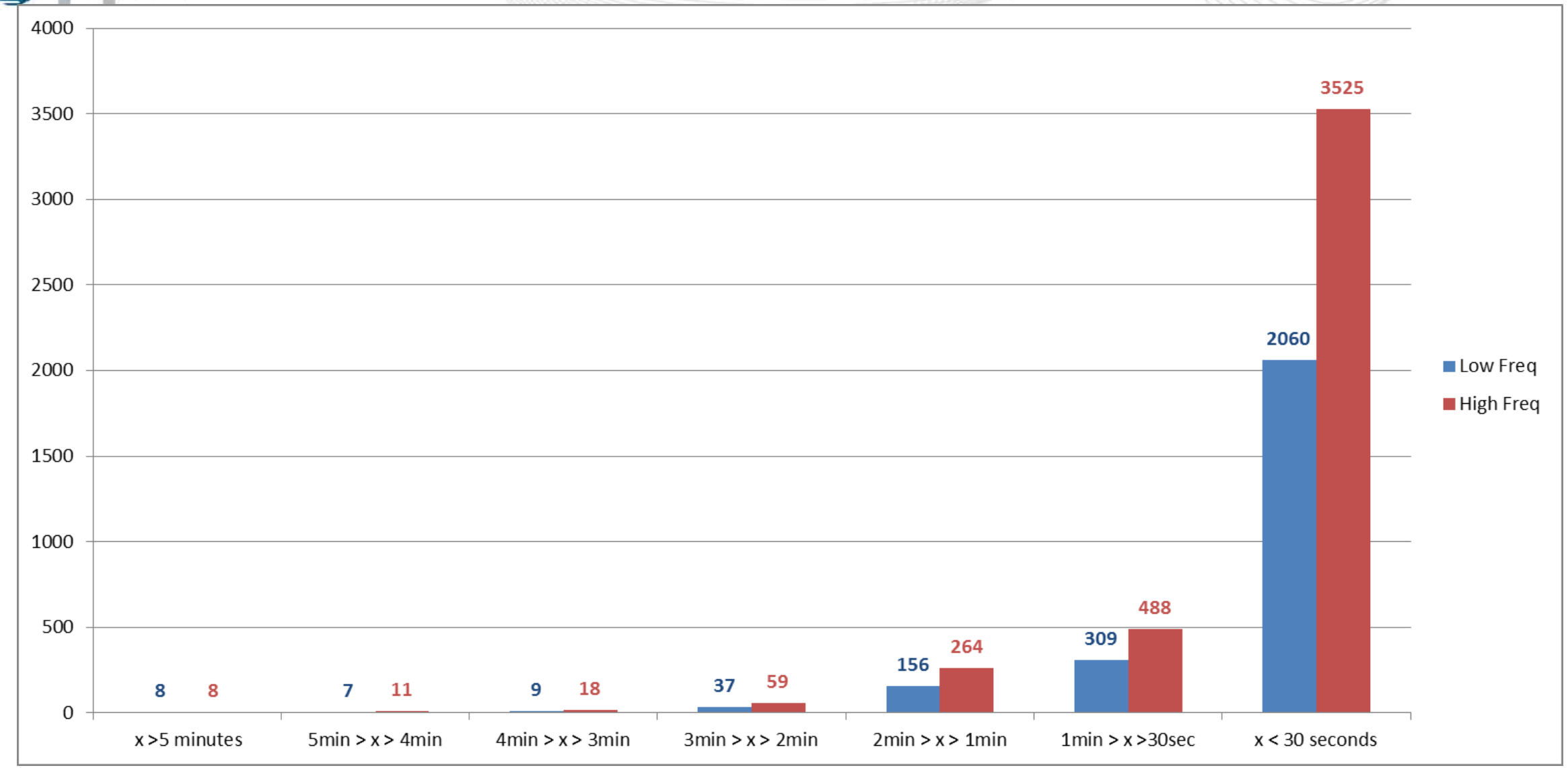
Frequency Profile Nov 2016 – Oct 2017



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