Performance Assessment for Primary Frequency Response Update

Danielle Croop
PFRSTF
March 21, 2018

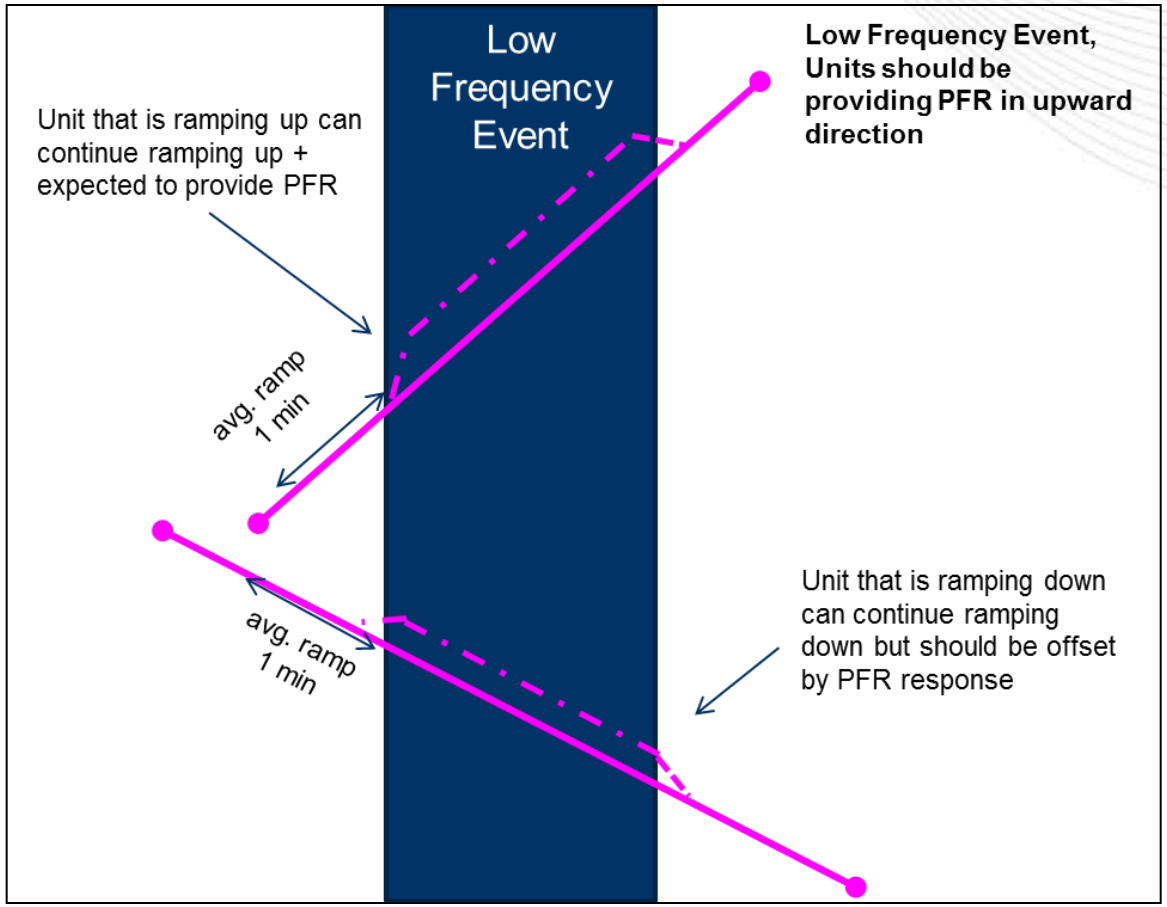
When will assessment take place?

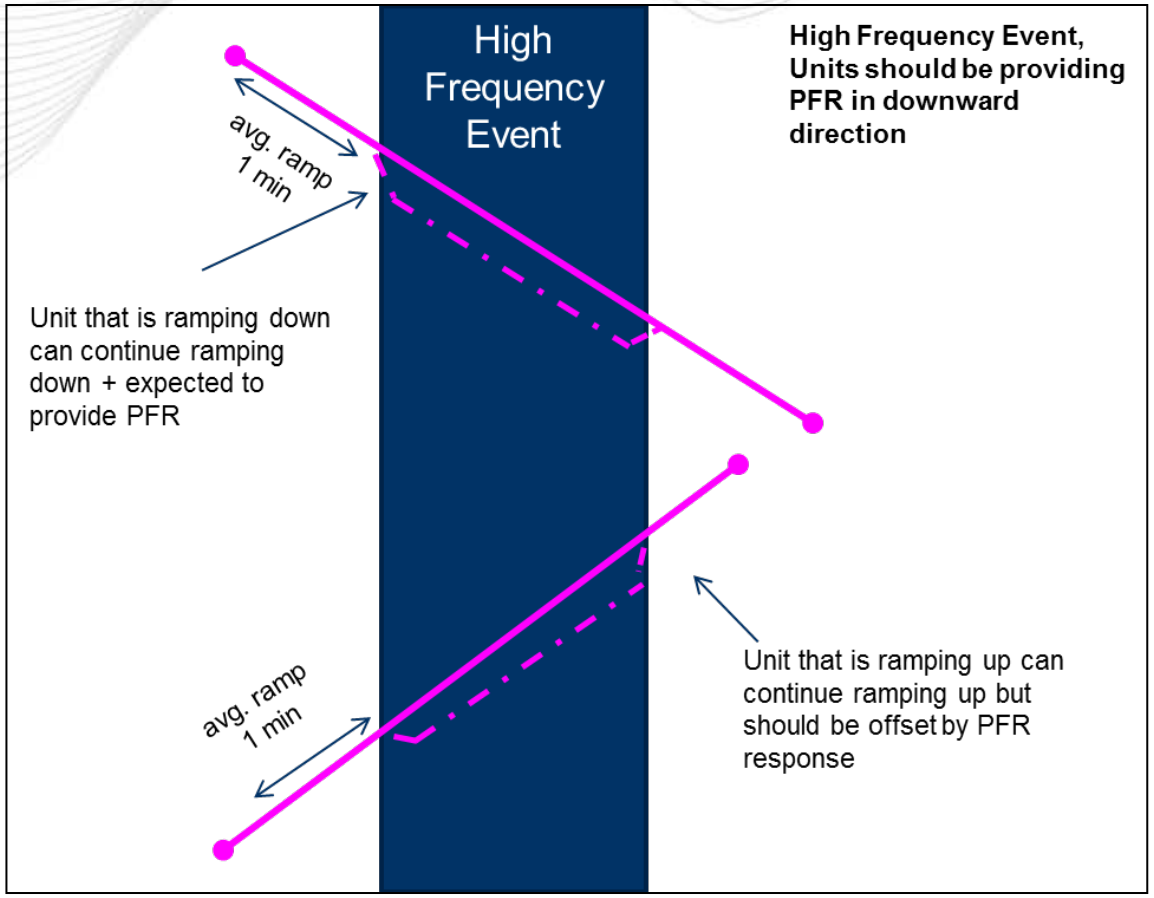
- PJM will reserve the right to perform performance assessment between 20-30 times a year
  - PJM will aim to find 2-3 frequency events per month for performance assessments, however system conditions may provide less opportunities
    - no set number of events will be prescribed
  - Events selected will be ‘clean’ frequency excursions where frequency went outside the deadband and engaged governors
    - Frequency outsides +/- 40mHz, and **Frequency minimum/maximum reaches +/- 53mHz**
    - Frequency stays outside of deadband for 60 seconds
    - **Initial definition of an “event” and can be changed over time based on observed system conditions**
  - PJM will aim to select events in both directions

Pass/Fail Assessment

- Scoring will be evaluated as average performance over 12 month window
  - Pass/Fail assessment will be down on a quarterly basis looks at a 12 month rolling window
    - Resources will need a minimum of **3 events** for quarterly assessment
    - PJM will look back further than 12 months if needed
  - 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
  - Events for which a resource is evaluated will be determined on if the unit was expected to respond during the selected events
    - Headroom, Online, Regulation status, etc

Unit Ramping and PFR





$$\text{Actual Response} = (\text{AvgMW}_{20\text{-}52\text{sec}} - \text{AvgMW}_{-16\text{-}0\text{sec}}) - \text{RampRate MW}_{20\text{-}52\text{sec}}$$

Additional Considerations

- Units will be measured on the droop and dead band PJM has documented
  - Initial verification will be performed
  - Default parameters will be set to 5% droop and 36mHz dead band

- Units without RT telemetry (per M-01)
  - Performance Assessment will not be performed with RT data
  - Required to submit data from a selected event or test results to demonstrate frequency response capability at least 1x per year.

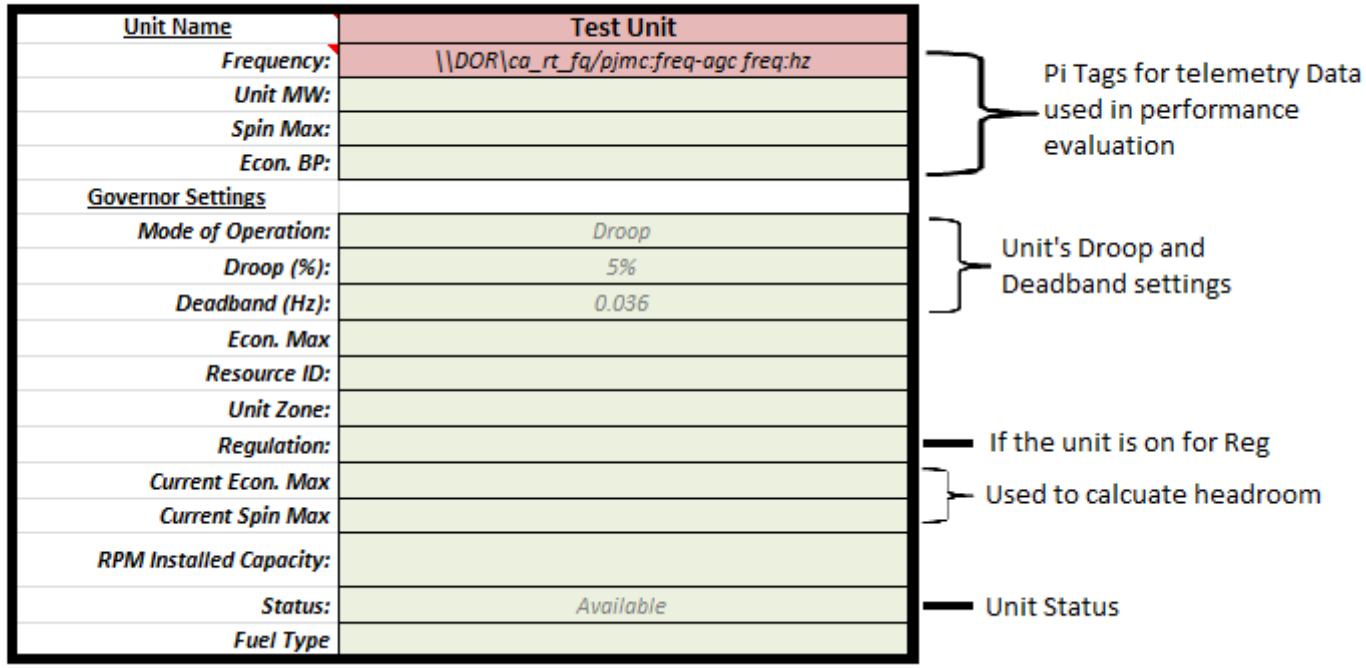
When will performance assessments start?

- When will performance assessments start?
  - The requirement to have Frequency Response capability would not be effective for 2 years after approval which is when “official” assessments will begin.
  - As part of the transition, “field trial” performance assessments will begin shortly after approval and results will be shared with unit owners.
    - This will allow for time to work out any data discrepancies.

Appendix

Tool Overview- Setup & Initial Information

- Initial Data need to set up performance assessment
  - Additional data for awareness (ex. fuel type, unit zone, etc.)
- EcoMax/SpinMax data coming from Markets Gateway
  - Important this data is accurate
- Droop/Deadband 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	

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 EcoBP are all collected data
  - FR Capacity is a headroom calculation (EcoMax – Unit Output) for low frequency and (Unit Output – EcoMin) 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

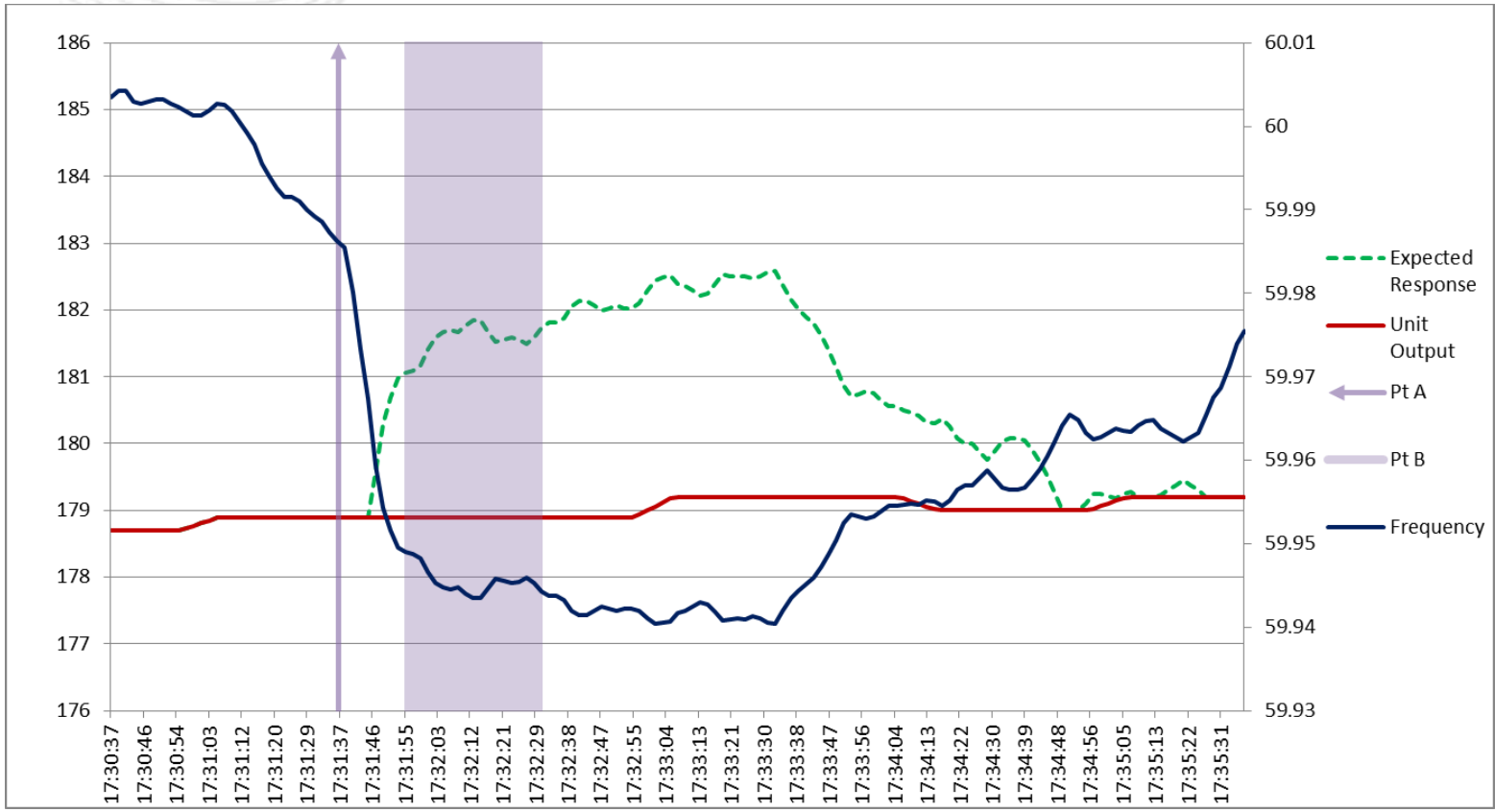
Tool Overview- Point A and B Calculation

- 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%

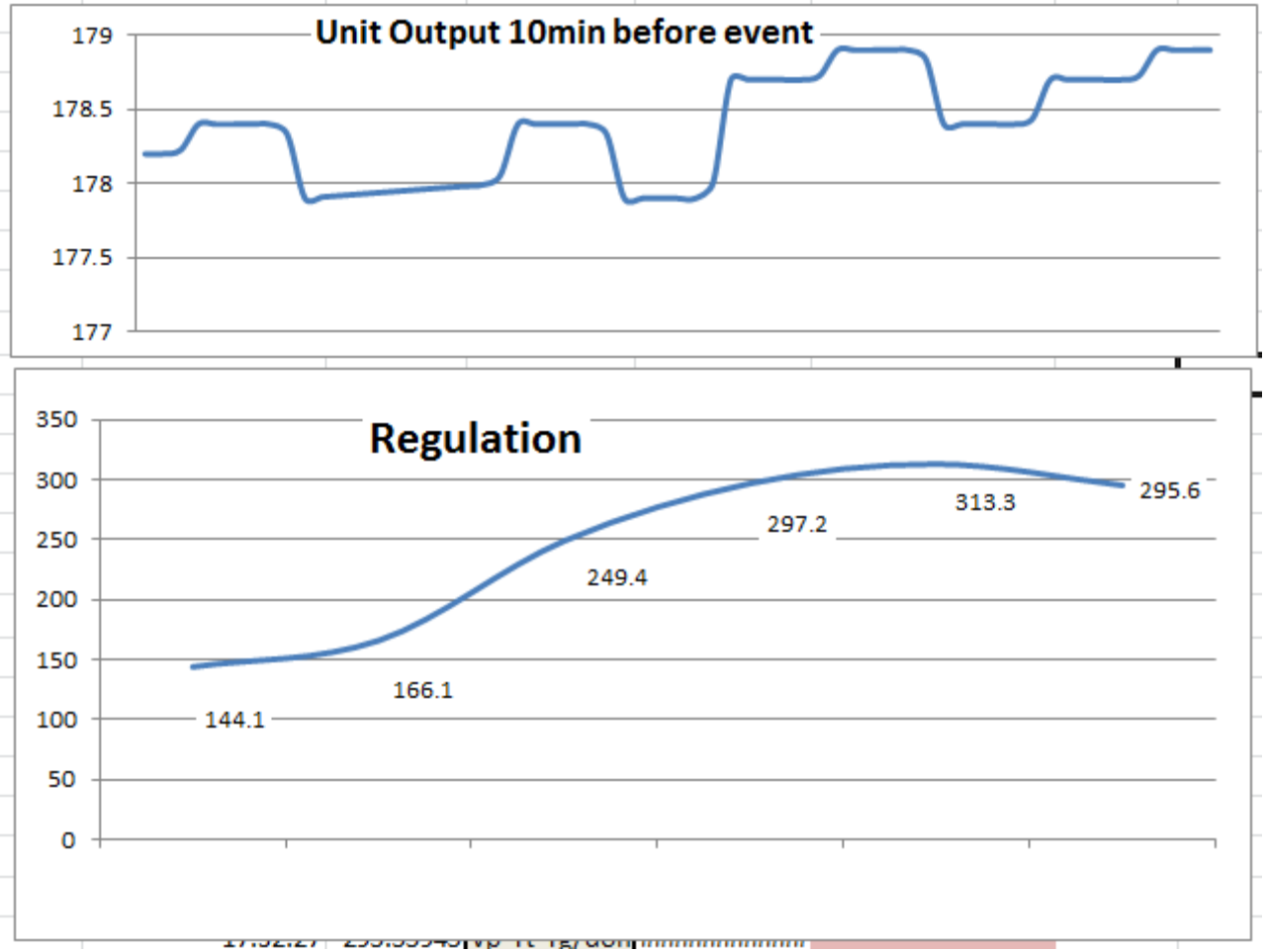
Tool Overview- Response Graph

- 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



Tool Overview- Additional Data Graphs

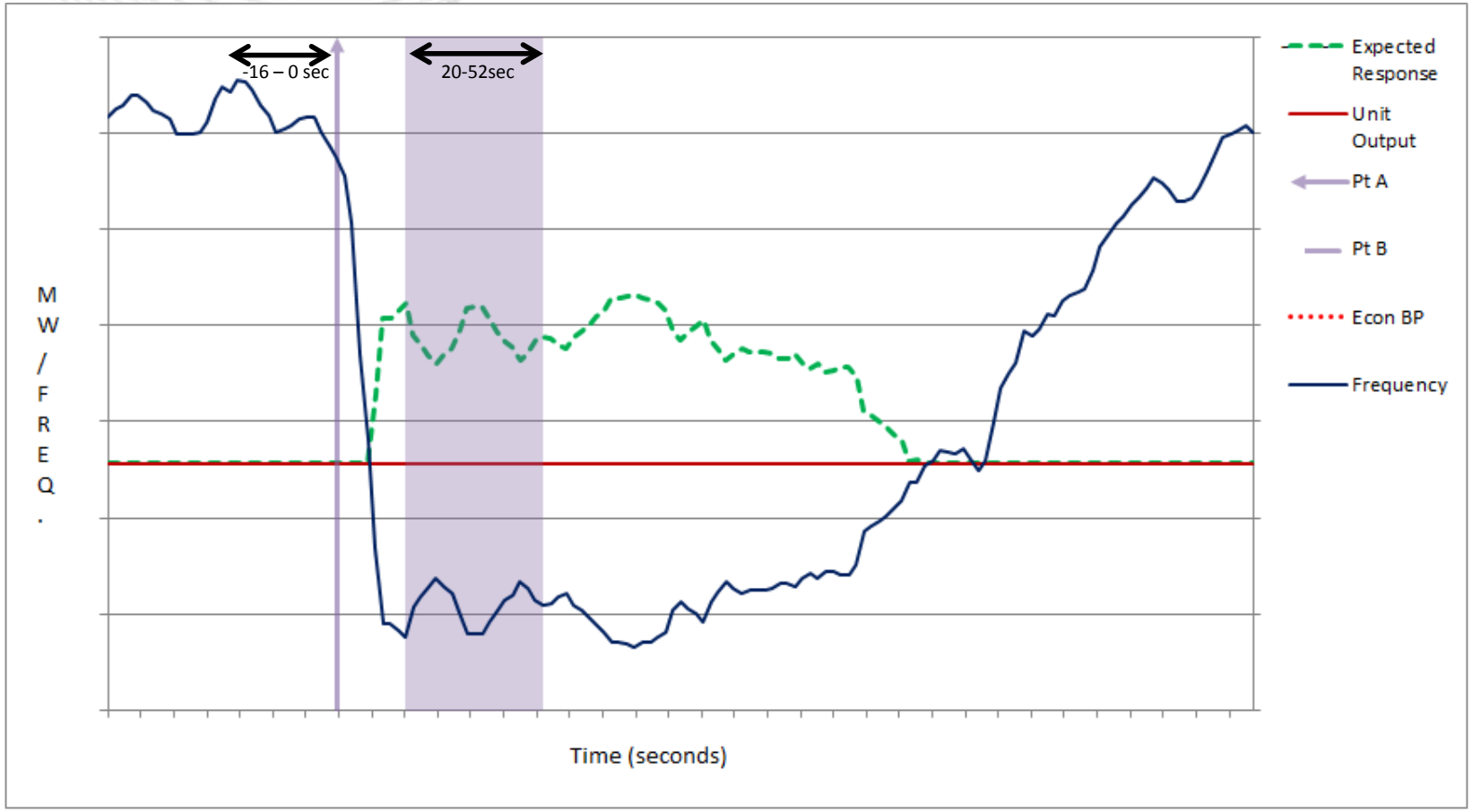
- The addition data is also graphed
  - Unit Output 10min before the event shows the unit behavior before the event (ramping, etc.)
  - Regulation graph shows if the unit was providing regulation during the event time period



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**



Calculation

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

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

  - Frequency above governor deadband

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

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