PJM Regulation Study Update

RMISTF

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Agenda

- Control Metric
- MRTS Curves for All Seasons

Control Metric

Determine ACE Control That Regulation Provides

- Metric options to determine Equivalent Controllability:
  - CPS-1: Greater than 100 on average is considered sufficient
    - Poor measure of reliability
  - |ACE| (or variants of ACE)
    - Law of averages causes ACE excursions to be improperly represented
  - ACE^2
    - Puts more emphasis on large ACE excursions
    - Represents regulation's ability to control ACE to 0

Control Metric

- Use ACE² as measure of reliability in order to determine equivalent control
  - Units of MW²

PS Adj. MW	RegD																				
RegA	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
0									168,916	166,022	163,486	161,708	158,806	156,940	156,060	154,732	153,181	151,957	150,908	148,894	147,964
50								157,963	155,178	152,646	149,298	146,343	144,334	141,969	141,264	139,846	138,388	137,161	135,414	135,446	
100							147,981	144,222	140,984	138,206	136,269	133,562	131,289	129,599	127,930	126,209	124,060	122,796	121,311		
150						139,583	135,066	130,614	127,398	125,067	121,320	119,103	116,815	114,803	112,816	111,891	110,587	108,790			
200					133,109	128,126	123,775	119,066	116,194	112,494	109,012	106,023	103,117	101,621	99,872	98,783	97,242				
250				130,503	122,466	117,266	113,088	108,583	104,653	100,499	96,561	94,148	91,661	89,639	87,606	86,124					
300			128,092	119,072	113,366	108,778	103,717	98,622	93,908	90,066	88,145	85,844	82,790	80,750	78,932						
350		130,366	119,267	111,484	105,004	99,268	94,524	89,391	84,830	82,658	80,740	78,052	74,661	71,946							
400	138,364	121,838	111,085	102,510	96,026	91,000	85,103	80,702	77,786	74,978	71,820	68,325	65,839								
450	129,098	113,412	103,248	94,259	88,033	82,534	77,764	74,705	71,342	68,775	65,881	62,647									
500	122,383	106,844	96,338	88,684	81,882	75,909	72,477	68,892	65,132	62,214	59,231										
550	116,322	100,892	90,113	82,017	75,844	70,835	66,467	62,825	59,345	56,642											
600	111,105	96,440	85,968	77,100	70,890	66,083	61,535	57,841	55,049												
650	107,164	91,234	80,696	72,125	66,514	61,173	56,936	53,918													
700	102,250	86,335	76,134	68,550	62,836	57,403	53,409														
750	98,214	82,648	73,029	64,961	59,158	54,027															
800	**94,297**	79,997	69,547	61,691	55,744																
850	91,737	76,563	66,667	58,974																	
900	89,059	74,140	64,408																		
950	86,928	72,194																			
1000	85,241																				

- During simulation, ACE² calculated at each 2 second study interval then averaged for the hour

Why do we need more regulation?

- CPS-1 metric does not accurately represent the need to control ACE to 0
- Controlling ACE to 0 represents an increase in reliability to grid operation
  - Better control for current system conditions
  - Reduce ACE excursions by correcting ACE more effectively
- Reduce system costs by mitigating deltas between generation and load on short term basis
  - Correct error in between economic dispatch solutions

Regulation Requirement

Determination of Requirement Level:

- Utilize information provided from studies (ACE^2 value)
  - Shows evidence additional regulation is needed during ramping hour
- Consider other factors which have an effect on regulation
  - Frequency Bias decrease of 14.27% in 2016 adds to lower CPS and higher BAAL minutes
  - Frequency Bias change from -1555MW/0.1Hz to -1333MW/0.1Hz
- Requirement increase in line with frequency bias change
  - Ramp Hours = 700*1.1427% = 800MW Effective
  - Non-Ramp Hours = 525*1.1427% = 600MW Effective
- <u>Requirements will be re-evaluated quarterly after new signal implementation</u>

MRTS Curves

Summary Results - Ramp

		Controllers Where MRTS = 1				Controllers Where MRTS = 0			
Ramp/ Non-Ramp	**Value**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**
Ramp	% Perf. Adj. RegD MW	34%	37%	34%	34%	63%	63%	62%	64%
	Perf. Adj. RegD MW	237	251	241	240	543	505	522	545
	Total Perf. Adj. MW (RegA+RegD)	708	677	698	706	861	803	838	858
	Effective MW Req.	800	800	800	800	800	800	800	800

- MRTS creation using the new controller with conditional neutrality and 30 minute energy storage
- RegD resources energy limitation modeled to match the mix of regulation type that historically clears for regulation

Summary Results – Non-Ramp

		Controllers Where MRTS = 1				Controllers Where MRTS = 0			
Ramp/ Non-Ramp	**Value**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**
Non-Ramp	% Perf. Adj. RegD MW	38%	36%	44%	34%	63%	70%	73%	69%
	Perf. Adj. RegD MW	199	192	219	183	472	475	444	481
	Total Perf. Adj. MW (RegA+RegD)	528	536	494	544	664	677	606	693
	Effective MW Req.	600	600	600	600	600	600	600	600

- MRTS creation using the new controller with conditional neutrality and 30 minute energy storage
- RegD resources energy limitation modeled to match the mix of regulation type that historically clears for regulation

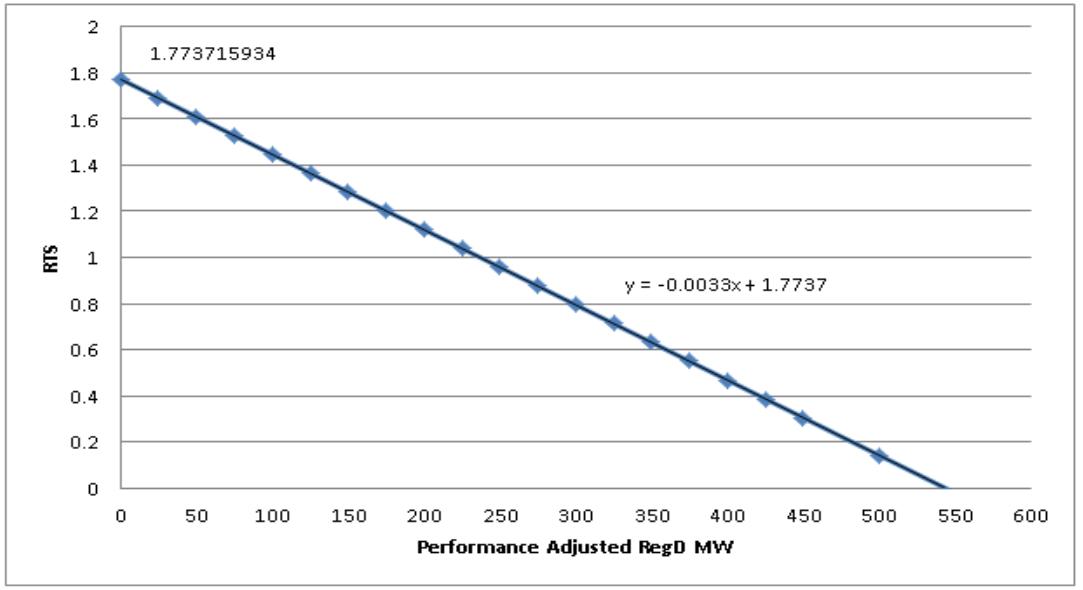
Appendix
(MRTS Curves)

Example Calculation

How the effective values are calculated:

- Example: What if I clear until MRTS = 1?
- $Solve\ for\ x\ of\ y = -0.00326363 * x + 1.77371593\ where\ y = 1$
  - $x = 237\ Perf.Adj.RegD\ MW$
- Now determine what the 237 Perf. Adj. RegD MW are worth in Effective MW
  - $\int_0^{237}(-0.00326363 * x + 1.77371593)dx$

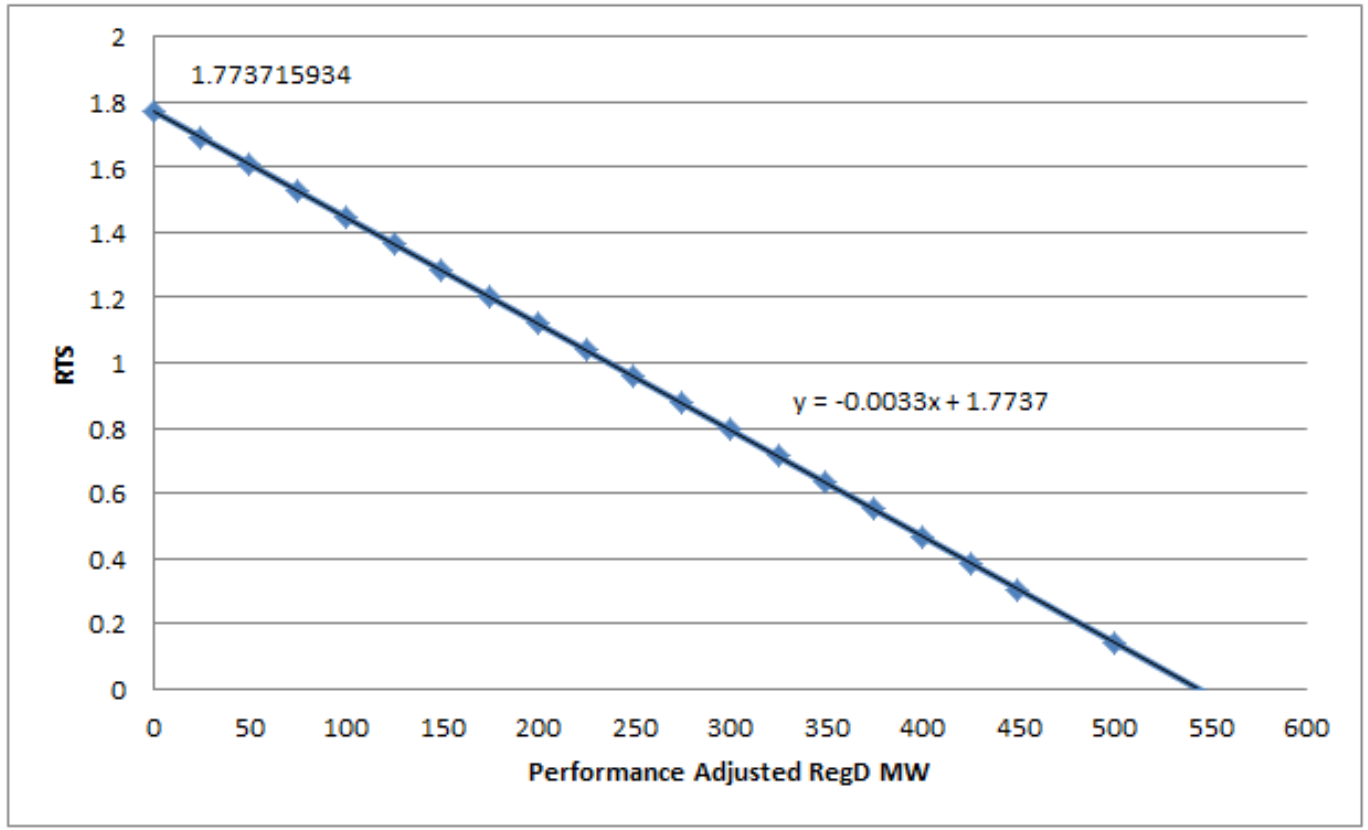
    $RegD = 328.7\ Eff.\ MW$
- $RegA = 800 - 328.7 = 471.3\ Perf.Adj.MW$
- $Total\ MW = 471.3 + 237 = 708.3\ Perf.Adj.MW$
- $RegD\ \%\ (Perf.Adj.) = 237/708.3 * 100 = 33.5\%$



Term	Value
MRTS	1.0
Perf. Adj. RegD MW	237.0
Eff. RegD MW	328.7
Perf. Adj. RegA MW	471.3
Total Perf. Adj. MW	708.3
Total Eff. MW	800.0
RegD % (Perf. Adj.)	33.5%

Fall Ramping MRTS Definition

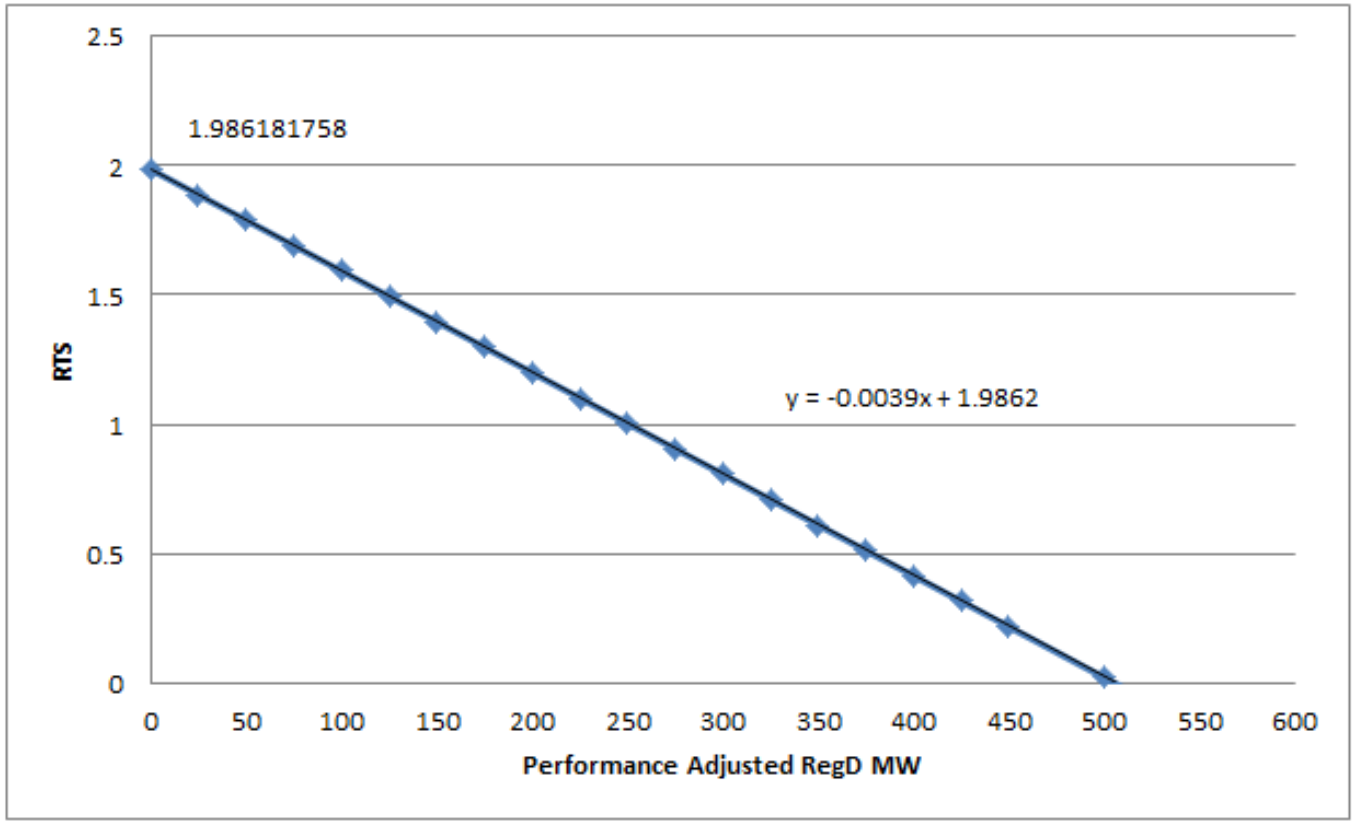
Requirement: 800 Effective MW



- MRTS = 1
  - 34% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 237 Perf. Adj. MW of RegD
- MRTS = 0
  - 63% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 543Perf. Adj. MW of RegD

Winter Ramping MRTS Definition

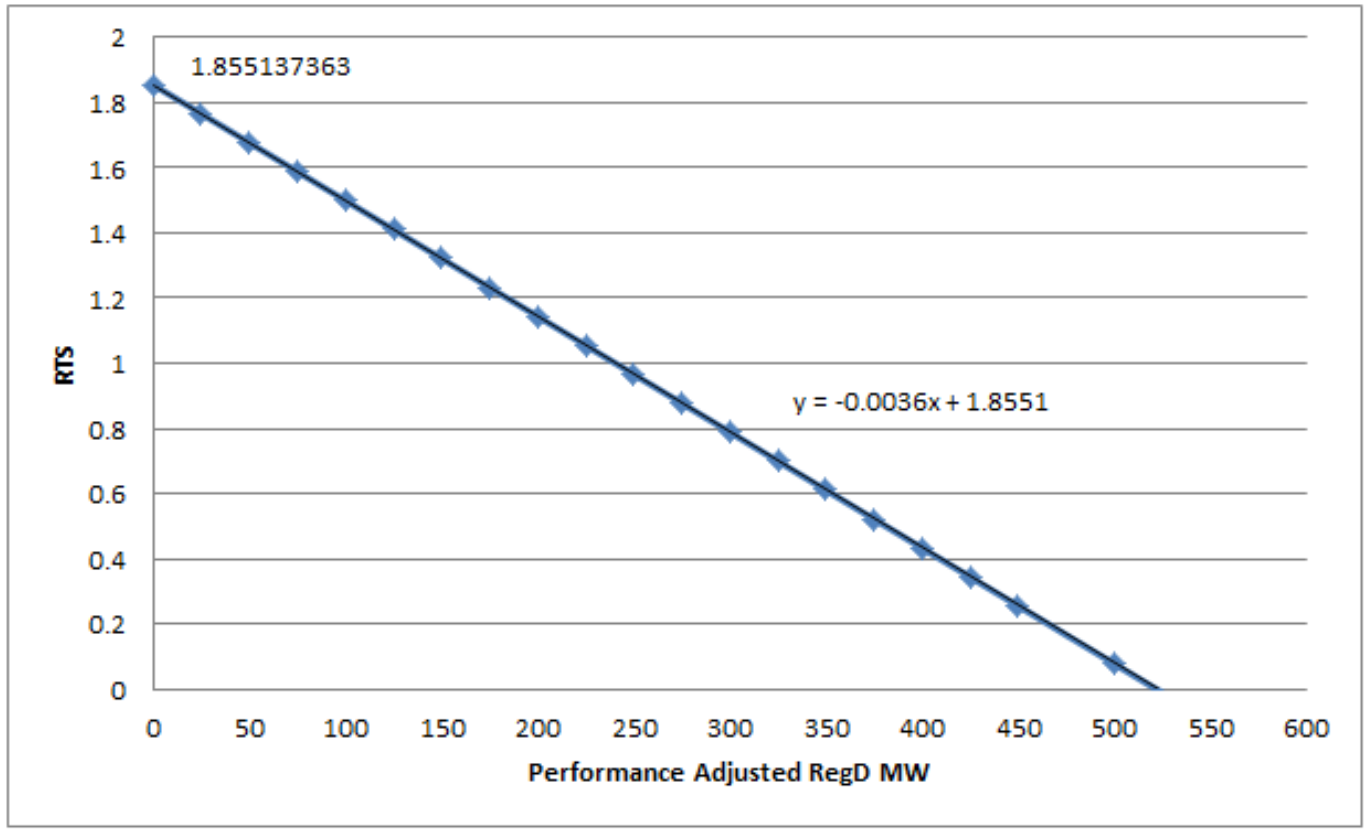
Requirement: 800 Effective MW



- MRTS = 1
  - 37% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 251 Perf. Adj. MW of RegD
- MRTS = 0
  - 63% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 505 Perf. Adj. MW of RegD

Spring Ramping MRTS Definition

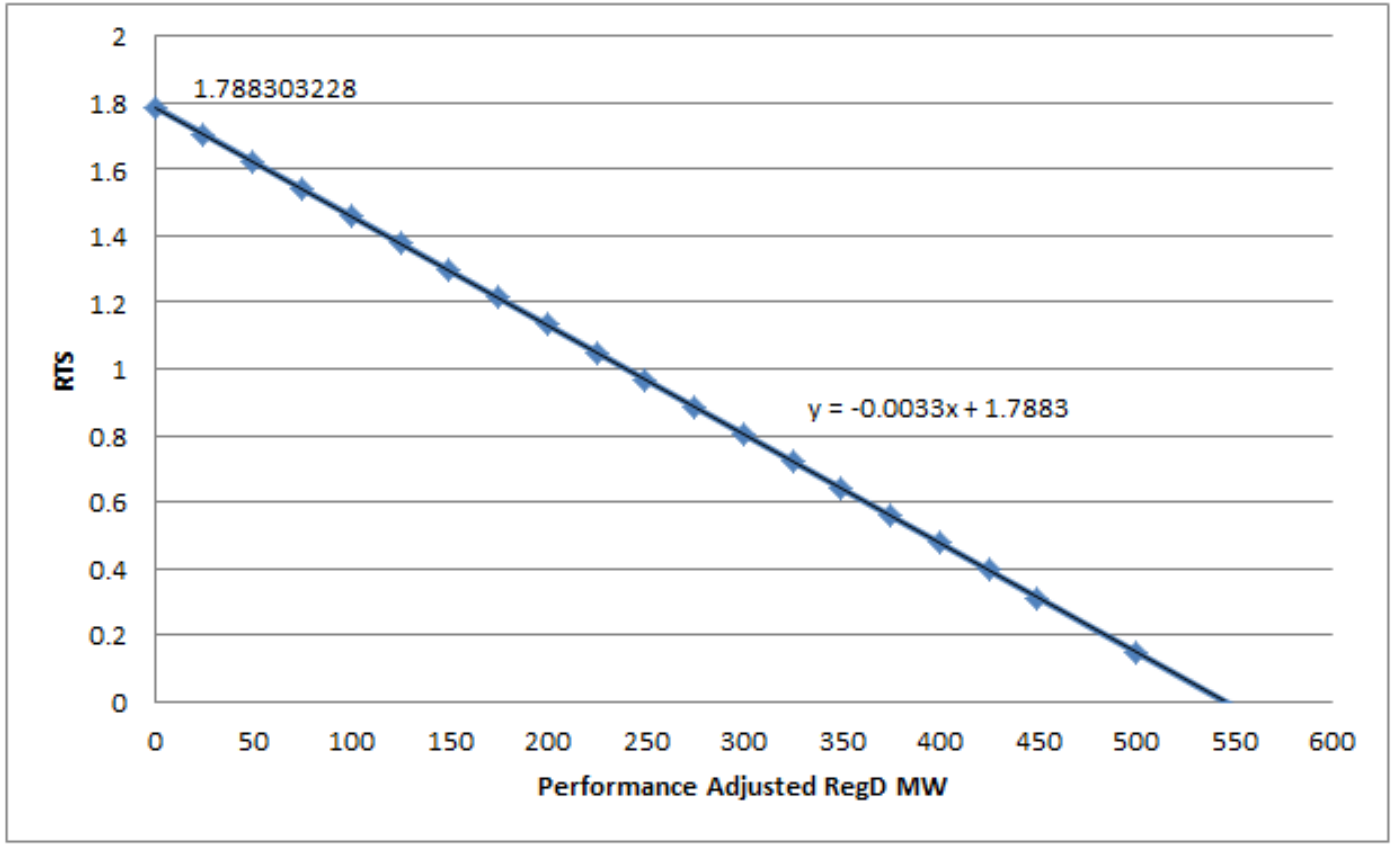
Requirement: 800 Effective MW



- MRTS = 1
  - 34% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 241 Perf. Adj. MW of RegD
- MRTS = 0
  - 62% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 522 Perf. Adj. MW of RegD

Summer Ramping MRTS Definition

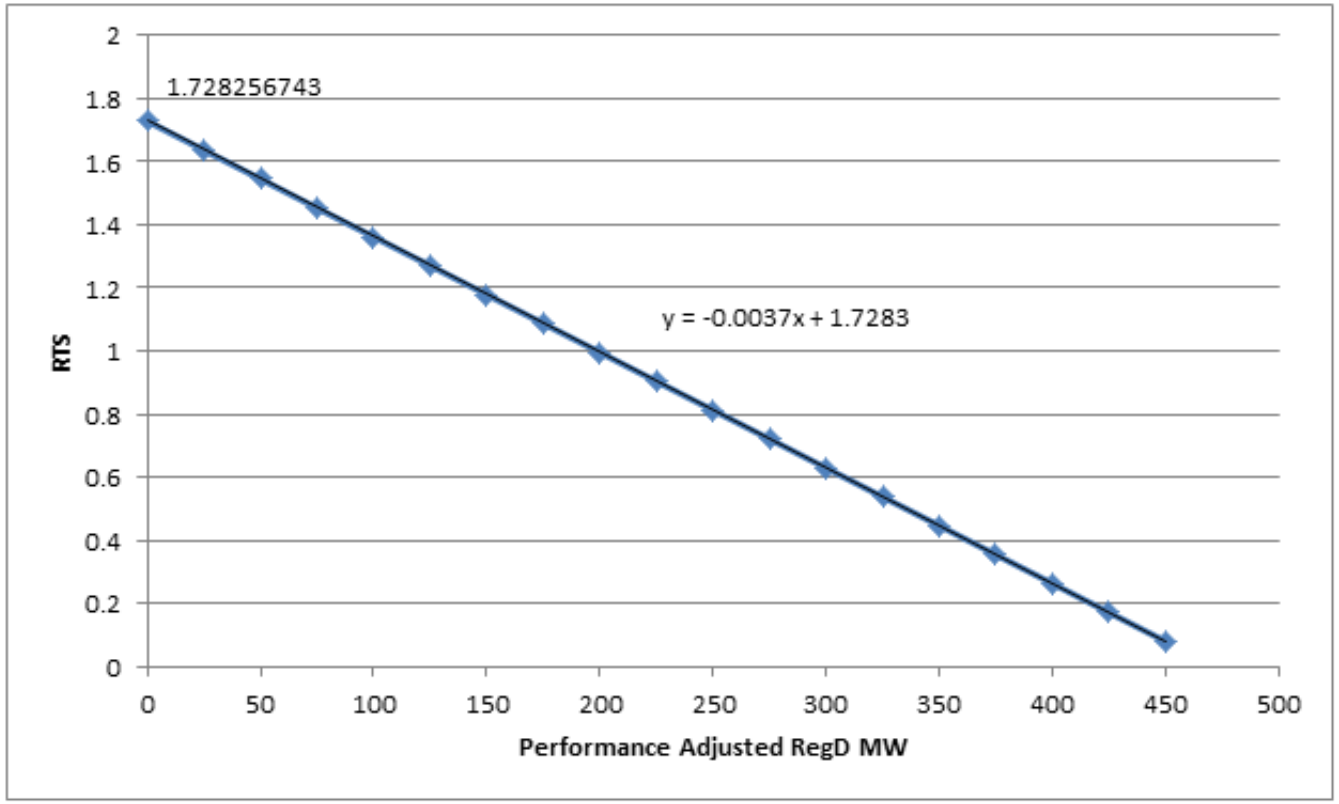
Requirement: 800 Effective MW



- MRTS = 1
  - 34% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 240 Perf. Adj. MW of RegD
- MRTS = 0
  - 64% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 545 Perf. Adj. MW of RegD

Fall Non-Ramping MRTS Definition

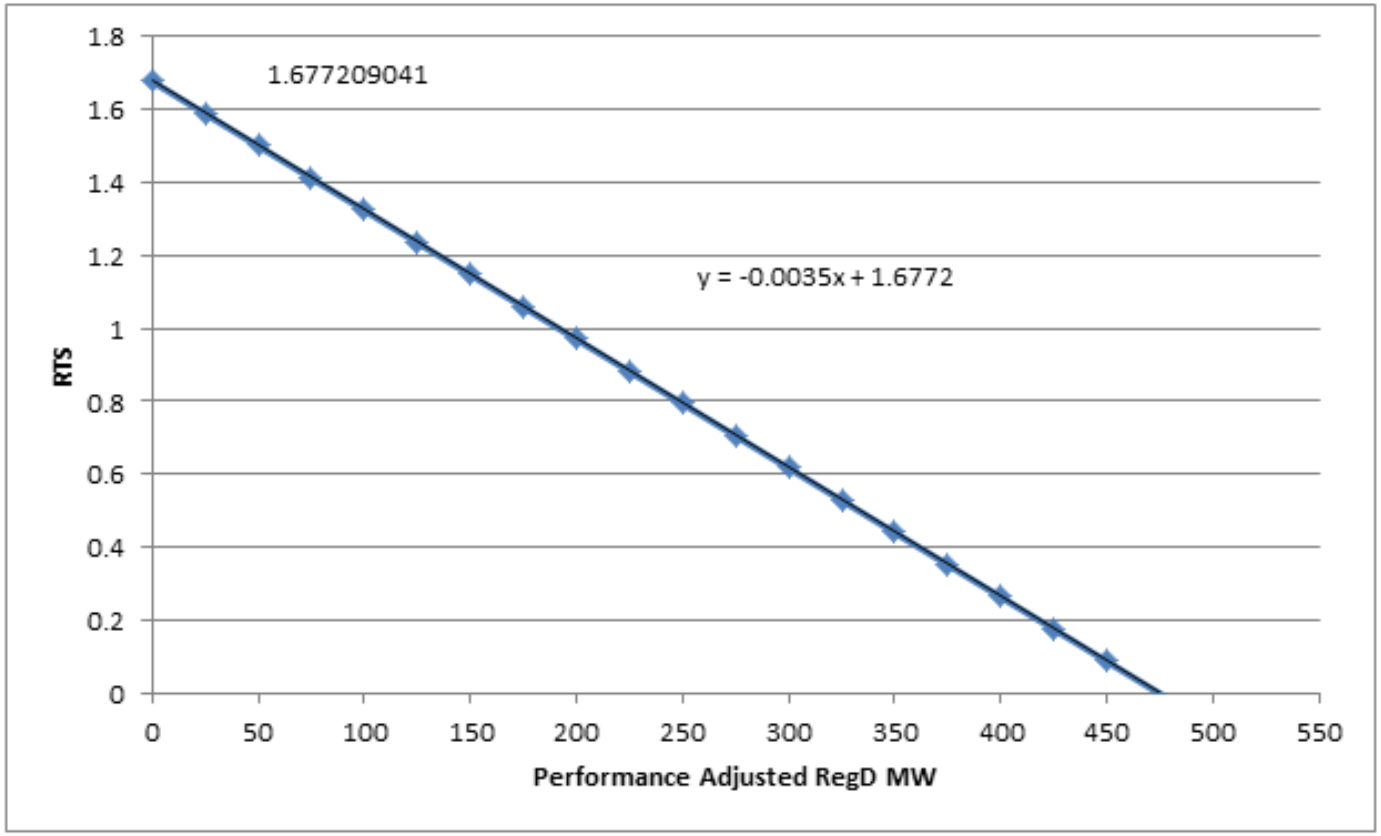
Requirement: 600 Effective MW



- MRTS = 1
  - 38% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 199 Perf. Adj. MW of RegD
- MRTS = 0
  - 63% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 472 Perf. Adj. MW of RegD

Winter Non-Ramping MRTS Definition

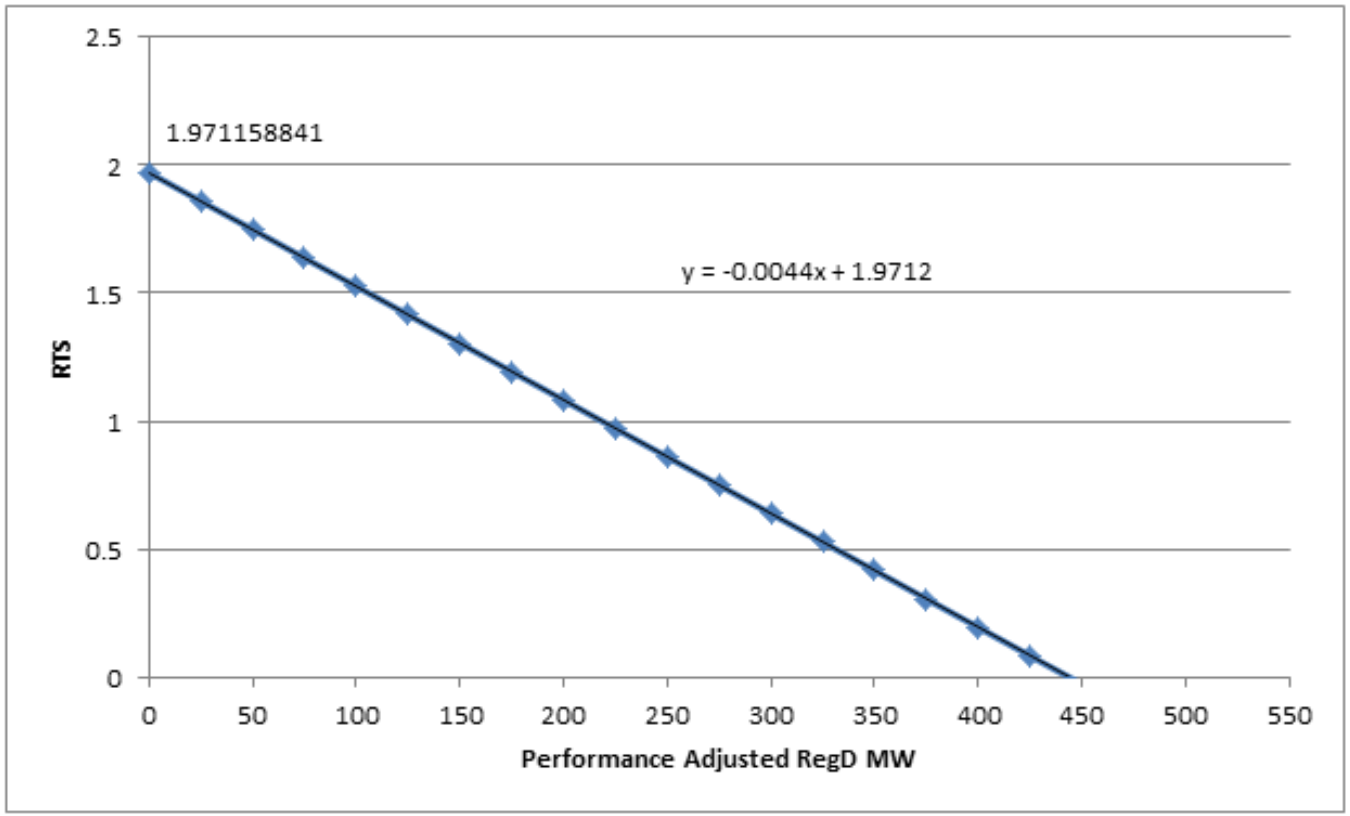
Requirement: 600 Effective MW



- MRTS = 1
  - 36% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 192 Perf. Adj. MW of RegD
- MRTS = 0
  - 70% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 475 Perf. Adj. MW of RegD

Spring Non-Ramping MRTS Definition

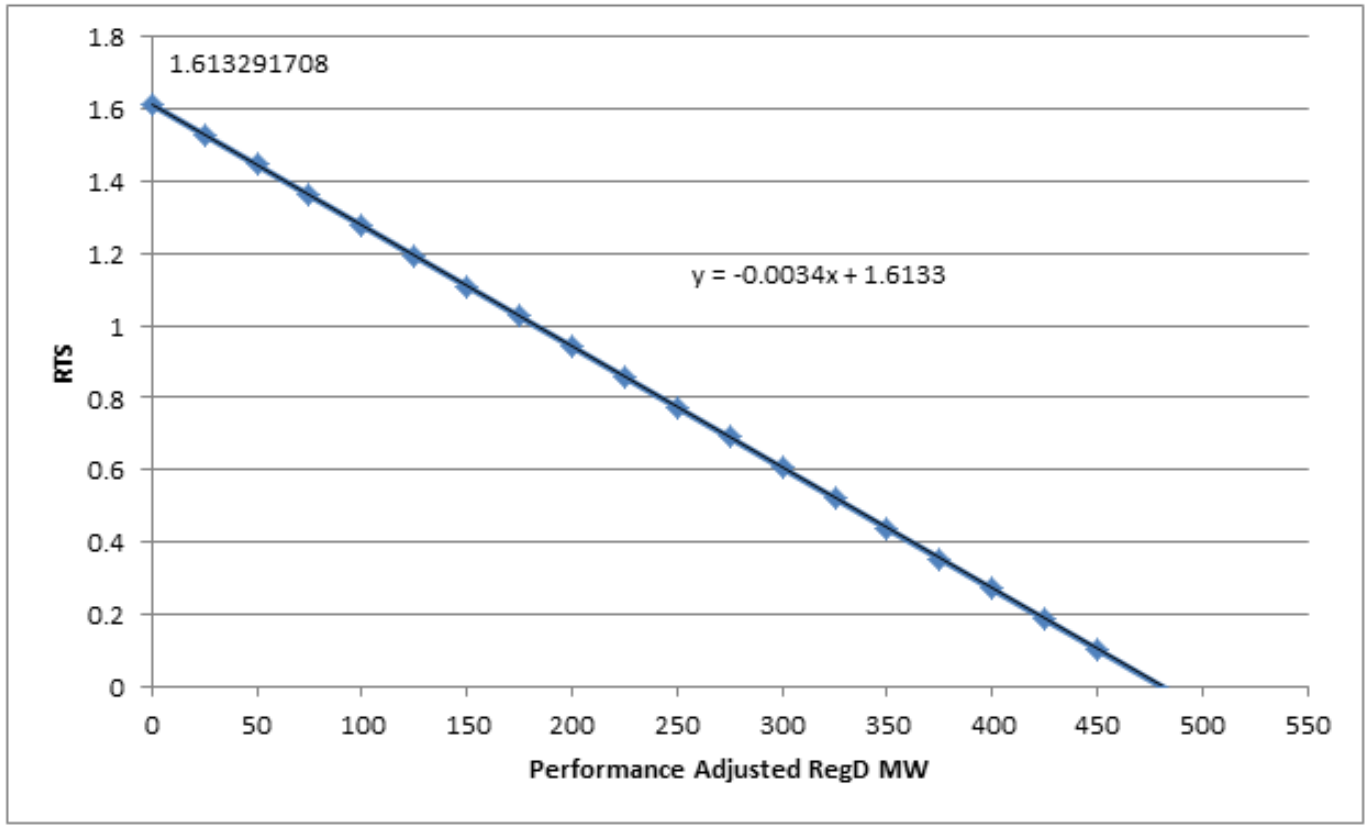
Requirement: 600 Effective MW



- MRTS = 1
  - 44% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 219 Perf. Adj. MW of RegD
- MRTS = 0
  - 73% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 444 Perf. Adj. MW of RegD

Summer Non-Ramping MRTS Definition

Requirement: 600 Effective MW



- MRTS = 1
  - 34% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 183 Perf. Adj. MW of RegD
- MRTS = 0
  - 69% Perf. Adj. MW of RegD make up total Regulation Requirement
  - 481 Perf. Adj. MW of RegD