



Regulation Clearing and Benefits Factor Calculation

Regulation Performance Impacts

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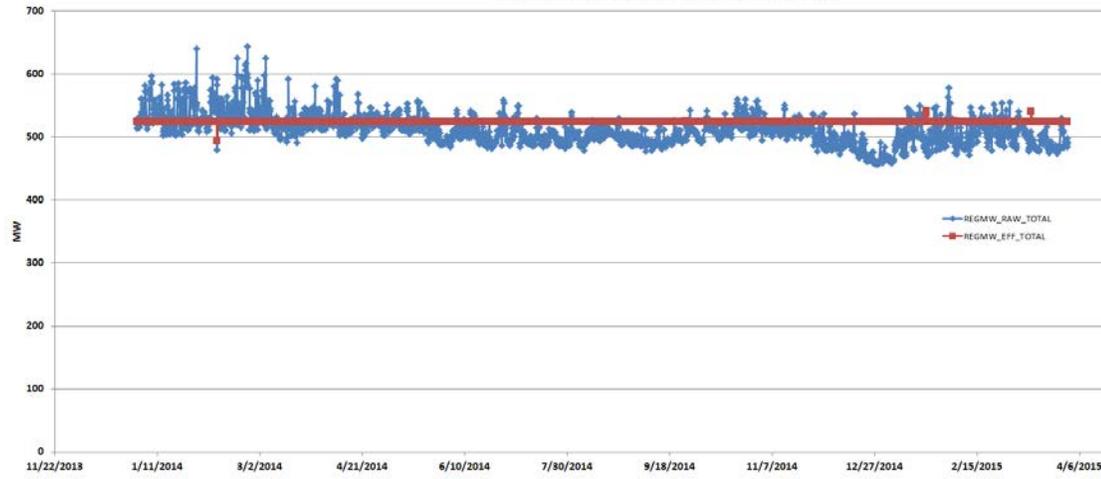
- Regulation is cleared every hour for one hour look-ahead
 - Pricing is done every 5 minutes along with energy LMP in real-time
- Regulation is cleared to meet the established requirements
 - 525 Effective MW for Off-peak (0000 – 0500)
 - 700 Effective MW On-Peak (0500 – 0000)
- One RTO Regulation market and therefore one uniform clearing price (RMCP)
 - Clearing is based on merit (cost, performance, and benefits to the system)
 - Clearing price separates into capability and performance clearing prices (CCP and PCP)
 - No clearing price based on signal type (RegA, RegD)
- The Area Control Error (ACE) is not a factor in the clearing process
 - Regulation is cleared one hour before operating time

- Regulation requirement is met with effective MW

$$\textit{Effective MW} = \textit{RegMW} * \textit{Performance Score} * \textit{Benefits Factor}$$

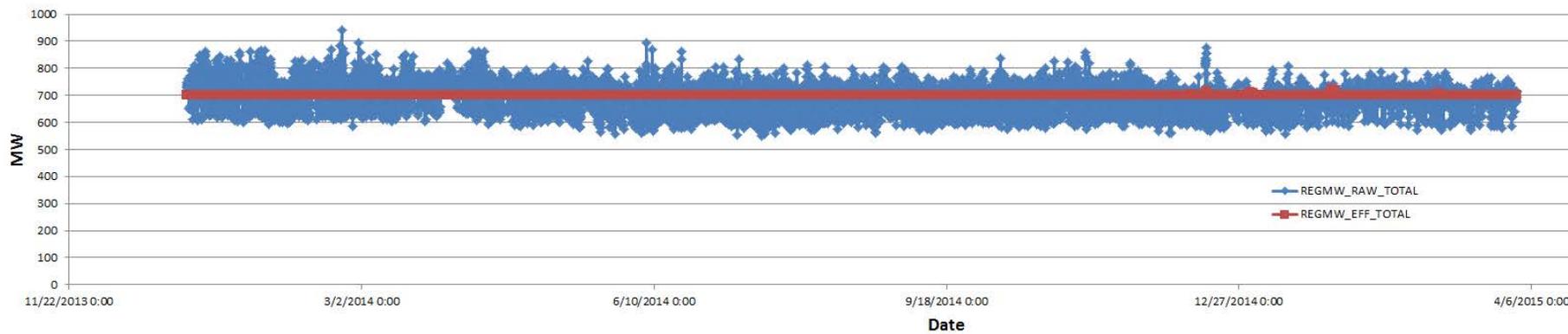
- Effective MW is used only in the market clearing
- Regulation Dispatch and Operation use RegMW (not effective MW)
- Market Settlements credit resources based on RegMW and performance (not effective MW)
- Example: A RegD of RegMW = 32: assume PS = 1.0, and BF = 2.5
 - Market: Effective MW = $32 * 1 * 2.5 = 80$
 - Operation and Dispatch: RegMW = 32
 - Market Settlements credit: based on RegMW and real-time performance score, and signal mileage ratio

Off-Peak Requirement: Effective MW vs. Actual



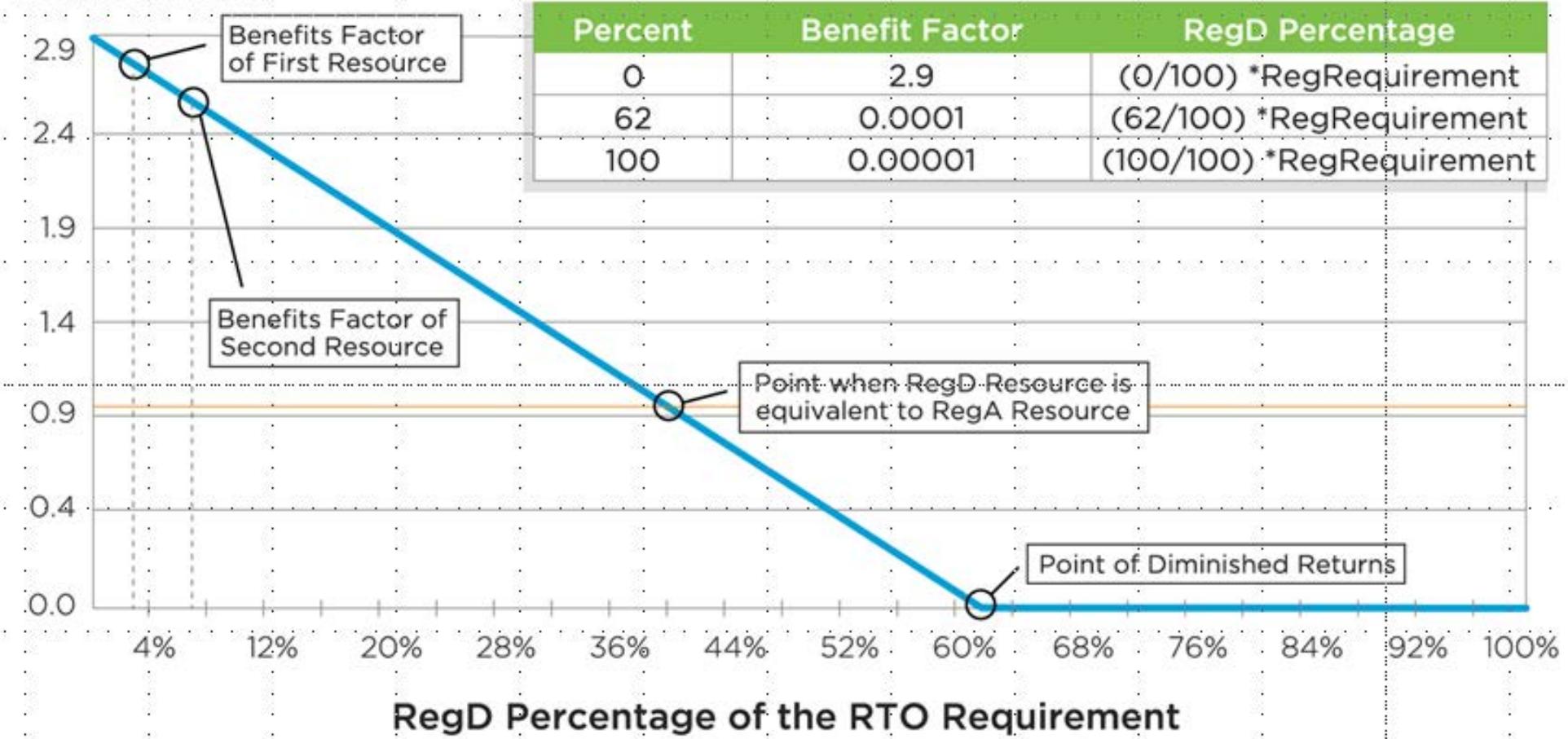
	Effective MW	Ave. Actual MW	Ave. MBF
Off	525	511	2.20
On	700	697	2.14

On-Peak Requirement: Effective MW vs. Actual



- The Benefits Factor (BF) models the rate of substitution between traditional RegA and dynamic RegD resources;
- It enables the market to translate a fast moving resource's regulation MW into traditional MW, or effective MW;
- It also adjusts the total cost of a RegD resource to make it attractive to the market clearing engine until the least cost optimum mix of RegD effective MW as a percentage of the regulation effective requirement;
- Resource specific BF is calculated for all eligible RegD resources during the regulation market clearing process;
- The benefits factor for RegA resource is 1

Benefits Factor



- BF is calculated for all eligible RegD resources
- The calculation is one of the initial steps in the regulation clearing and pricing
 - Clearing in Ancillary Service Market Optimizer (ASO) an hour ahead
 - Pricing in Locational Pricing Calculator (LPC) in real-time
- The Marginal Benefits Factor is the BF of the last RegD resource cleared to provide regulation service
 - MBF is a value determined after regulation clearing is completed
 - ❖ It has no effect in the regulation clearing
 - ❖ It is not used in regulation pricing
 - ❖ It is not used in the Market Settlement for regulation credit

- Step 1:
 - All eligible RegD resources are ranked in ascending order of the Adjusted Total Cost
 - ❖ The calculation uses LMP energy-only
 - ❖ The initial BF of all RegD are assumed to be 1

Adjusted Regulation Capability Cost (\$)	Adjusted Lost Opportunity Cost (\$)
$\frac{\left(\frac{\text{Capability Offer}}{\left(\frac{\$}{\text{MW}} \right)} \right)}{\left(\frac{\text{Benefits Factor of Offered Resource}}{\left(\text{Historic Performance Score} \right)} \right)} * \left(\frac{\text{Capability}}{\left(\text{MW} \right)} \right)$	$\frac{\left(\frac{\text{Estimated Lost Opportunity Cost}}{\left(\frac{\$}{\text{MW}} \right)} \right)}{\left(\frac{\text{Benefits Factor of Offered Resource}}{\left(\text{Historic Performance Score} \right)} \right)} * \left(\frac{\text{Capability}}{\left(\text{MW} \right)} \right)$
Adjusted Regulation Performance Cost (\$)	$\frac{\left(\frac{\text{Performance Offer}}{\left(\frac{\$}{\Delta \text{MW}} \right)} \right)}{\left(\frac{\text{Benefits Factor of Offered Resource}}{\left(\text{Historic Performance Score} \right)} \right)} * \frac{\left(\frac{\text{Historic Mileage of Offered Resource}}{\text{Signal Type}} \right) \left(\frac{\Delta \text{MW}}{\text{MW}} \right)}{\left(\text{Historic Performance Score} \right)} * \left(\frac{\text{Capability}}{\left(\text{MW} \right)} \right)$

- The Adjusted Total Cost in compact form

$$\textit{The Adjusted Total Cost} (\$) = \left(\frac{\textit{Cap \$} + \textit{LOC \$} + \textit{Perf \$}}{\textit{PS} * \textit{BF}} \right)$$

- The modeling equation has performance score and benefits factor as denominators
 - High PS resources will look cheaper to the clearing engine
 - RegD with $BF > 1$ looks cheaper, but $BF < 1$ looks expensive
 - The modeling is ineffective for instance when
 - ❖ Multiple resources regulation **self-scheduled**
 - ❖ Multiple resources offer at **\$0**

- Instance when multiple resources self-scheduled and/or offer at \$0 cost

Resource	Type	Reg Offer MW	Total Offer Cost (\$)	Offer Type	Perf Score	Effective MW (for BF)	Adjusted Total Cost (\$)
A	RegD	100	0	Economic	0.95	95	0
B	RegD	100	0	Economic	0.9	90	0
C	RegD	100	0	Economic	0.86	86	0
D	RegD	100	2	Self-Scheduled	0.7	70	0
E	RegD	100	3	Self-Scheduled	0.8	80	0
						421	

- Resources A through E have the same Adjusted Total Cost of \$0
- A- E look like a single resource with effective MW = 421
- A – E will be assigned the same BF which is **0.087**
- A revised equation that will factor in PS and BF when resources self-scheduled or offered at \$0 will be necessary

- Step 2: Initial Effective MW

$$\textit{Effective MW}_{\textit{initial}} = \textit{RegMW} * \textit{PS} * \textit{BF}$$

- BF is assumed = 1
- Effective MW can only be greater than or equal zero (not negative)
- Any resource with a negative BF is not eligible to clear for regulation

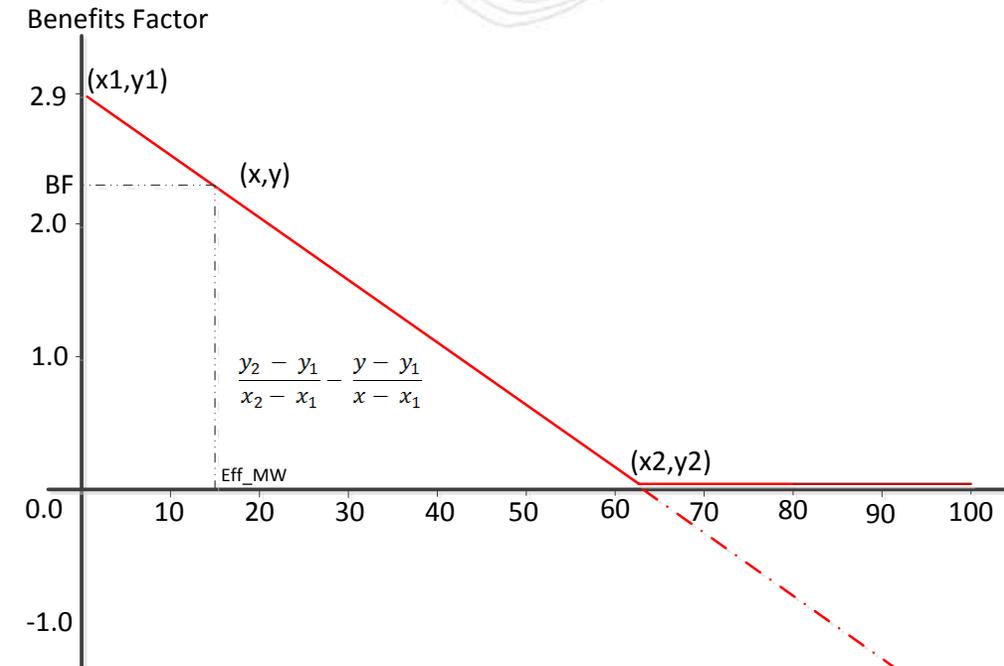
- Effective MW Summation Based on Adjusted Effective Cost Ascend

Resources	Type	Reg Offer MW	PerformanceScore	Adj_Total_Cost	Eff_MW_for_BF	Rolling Effective MW rank asc
H	REGD	20	0.976	1.024590164	19.52	19.52
J	REGD	20	0.946	1.057082452	18.92	38.44
K	REGD	1	0.944	1.059322034	0.944	69.12
P	REGD	31.5	0.944	1.059322034	29.736	69.12
Q	REGD	4	0.939	1.064962726	3.756	72.876
R	REGD	20	0.925	1.081081081	18.5	91.376
S	REGD	1.5	0.923	1.083423619	1.3845	92.7605
T	REGD	2	0.918	1.089324619	1.836	94.5965
U	REGD	1.4	0.917	1.090512541	1.2838	95.8803
V	REGD	2	0.909	1.100110011	1.818	97.6983
W	REGD	27	0.897	1.114827202	24.219	121.9173
X	REGD	1.8	0.884	1.131221719	1.5912	123.5085
Y	REGD	0.1	0.868	1.152073733	0.0868	123.5953
Z	REGD	0.1	0.826	1.210653753	0.0826	123.6779

- Resources with same adjusted total cost share the same BF

- Resource specific benefits factor determination
 - The BF is the intersection on the Y (BF) axis of the corresponding rolling effective MW on the X (percentage RegD) axis
 - The slope equation is:

$$BF_i = \frac{EffMW_i * (0.0001 - 2.9)}{Percentage RegD * RegReq} + 2.9$$



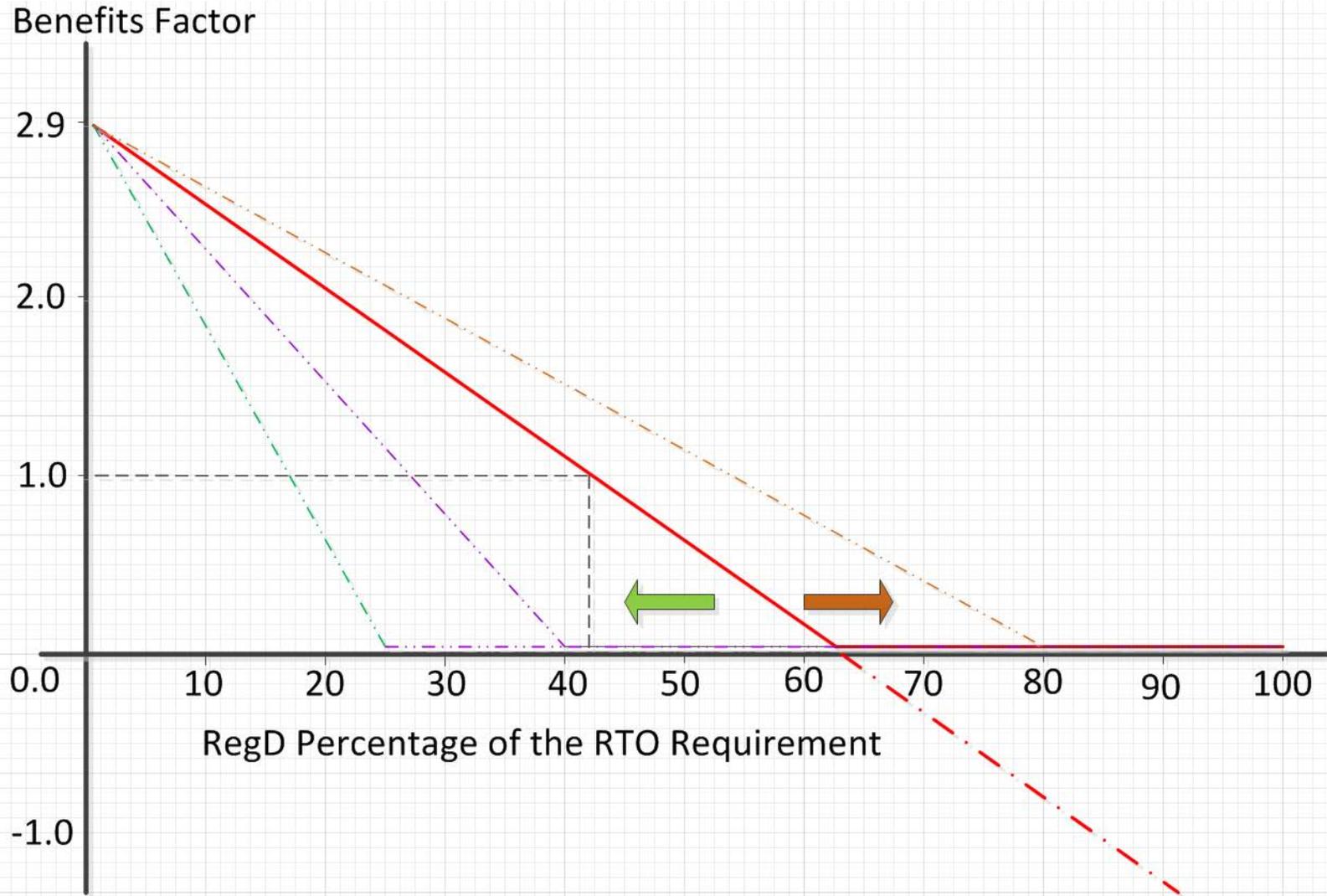


Benefits Factor Calculation Step 4 – Numerical Example

Resources	Type	Reg Offer MW	PerformanceScore	Adj_Total_Cost	Eff_MW_for_BF	Rolling Effective MW rank asc	Bfactor
H	REGD	20	0.976	1.024590164	19.52	19.52	2.7684
J	REGD	20	0.946	1.057082452	18.92	38.44	2.6408
K	REGD	1	0.944	1.059322034	0.944	69.12	2.4339
P	REGD	31.5	0.944	1.059322034	29.736	69.12	2.4339
Q	REGD	4	0.939	1.064962726	3.756	72.876	2.4085
R	REGD	20	0.925	1.081081081	18.5	91.376	2.2838
S	REGD	1.5	0.923	1.083423619	1.3845	92.7605	2.2744
T	REGD	2	0.918	1.089324619	1.836	94.5965	2.262
U	REGD	1.4	0.917	1.090512541	1.2838	95.8803	2.2534
V	REGD	2	0.909	1.100110011	1.818	97.6983	2.2411
W	REGD	27	0.897	1.114827202	24.219	121.9173	2.0778
X	REGD	1.8	0.884	1.131221719	1.5912	123.5085	2.0671
Y	REGD	0.1	0.868	1.152073733	0.0868	123.5953	2.0665
Z	REGD	0.1	0.826	1.210653753	0.0826	123.6779	2.0659

Effective MW (for BF Calc)	62% of 700	MBF
100	434	2.2318
200	434	1.5636
250	434	1.2296
300	434	0.8955
350	434	0.5614
400	434	0.2273
450	434	-0.1068
500	434	-0.4409
550	434	-0.775

- The x-intercept at 62% effective RegD relative to effective requirement
- The curve almost parallel to the x-axis beyond 62%



- The current curve allows for more RegD clearing than the right mix;
- The right mix should be consistent with operation experience with regulation dispatch for ACE control

- Two issues identified
 - Adjusted Total Cost formulation is ineffective in instances of RegD self-scheduled and/or offered at \$0;
 - ❖ Market Clearing Engine is unable to optimally procure RegA/D mix
 - The Benefits Factor curve is not coupled with the regulation requirement
 - ❖ More studies will be required to understand the relationship
- Benefits Factor is a modeling concept in Market
 - It is not used in Operations as part of regulation dispatch
 - It is not used in Settlement for regulation credit