

Market Monitor Report

MC Webinar
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Monitoring Analytics

Efficient, least cost market design requirements

- **Market design intended to minimize the cost to provide regulation using two different products but clear the resources in a single market**
 - **Requires accurate marginal rate of substitution (marginal benefit factor) be used in the optimization**
 - **Requires the use of a single price (or a single two part price pair) for settlement**
 - **Requires that the two products be defined, cleared and settled in equivalent units throughout**

Current Design

- **Market design intended to minimize the cost to provide regulation using two different products but clear the resources in a single market**
 - ~~Requires accurate marginal rate of substitution (marginal benefit factor) be used in the optimization~~
 - ~~Requires the use of a single price (or a single two part price pair) for settlement~~
 - ~~Requires that the two products be defined, cleared and settled in equivalent units throughout~~



Current Design

- **Due to the design issues the current market is:**
 - **Purchasing too much RegD in many hours**
 - **Negatively affecting the provision of regulation and reliability**
 - **Incorrectly compensating RegD in all hours**
 - **Sometimes too little**
 - **Sometimes too much**



Issue with current design: MBF not correctly defined

- **PJM has observed issues with regulation performance under conditions of system stress when the proportion of regulation provided by RegD exceeds 42 percent.**
- **Overprocuring RegD is counterproductive to providing reliable regulation service**



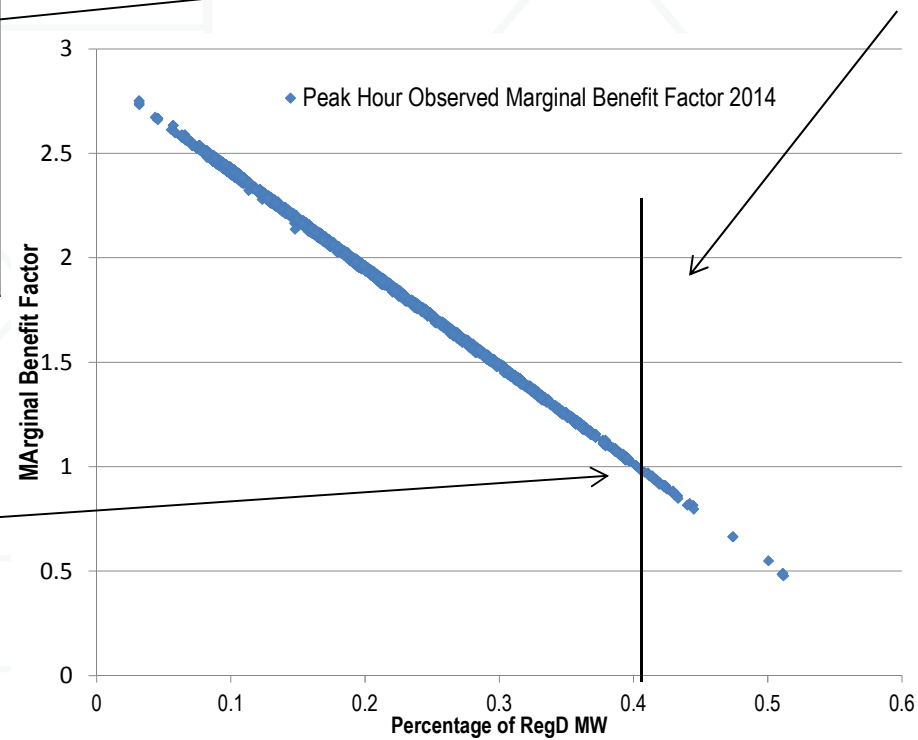
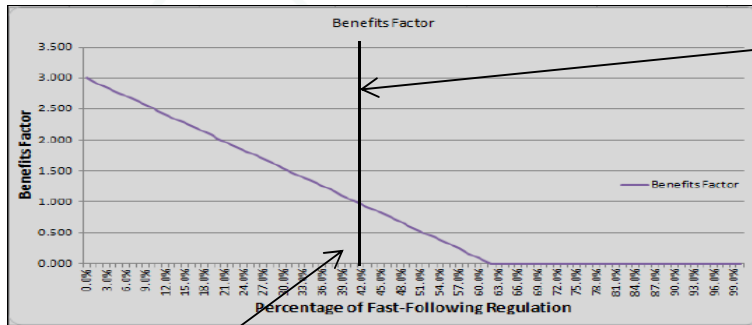
Issue with current design: MBF not correctly defined

- **Indicates that the market is buying too much RegD under certain market conditions**
- **Result of incorrect marginal benefit factor function describing the relationship between RegA and RegD**



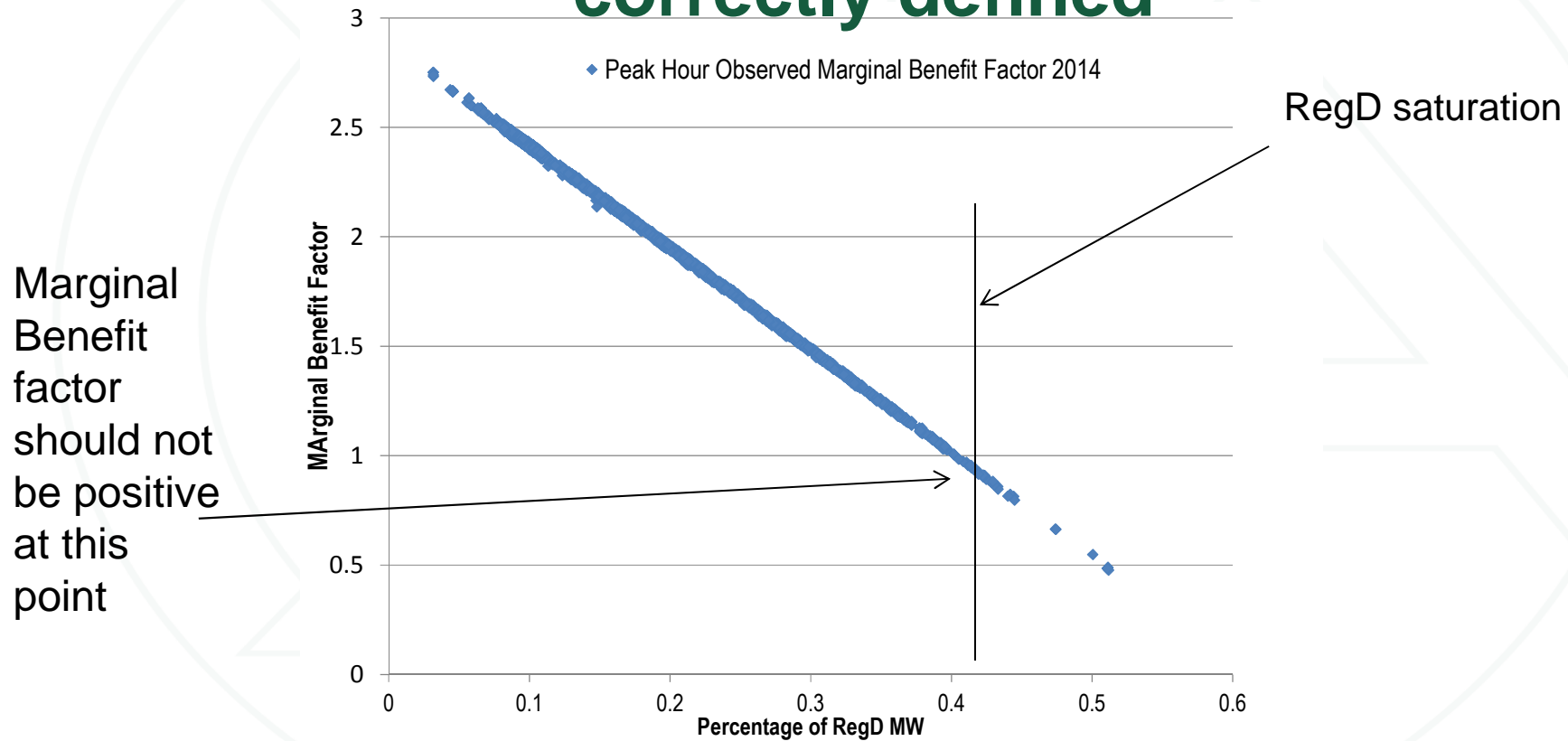
Issue with current design: MBF not correctly defined

RegD saturation



Marginal Benefit Factor should not be positive at this point

Issue with current design: MBF not correctly defined

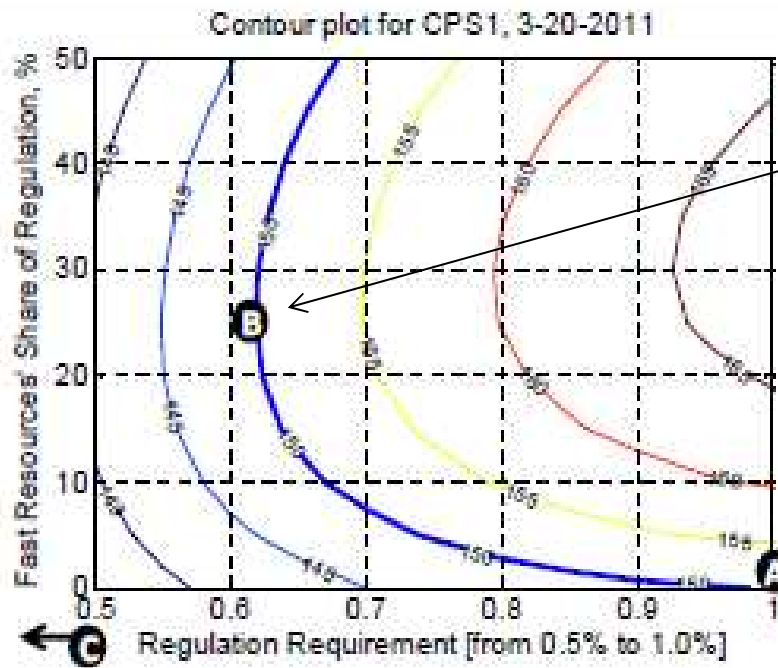


Issue with current design: MBF not correctly defined

- **KEMA study indicated that there were diminishing returns to RegD as a substitute for RegA in provided regulation returns.**
- **KEMA study showed that the marginal rate of substitution could go to zero or be negative.**



Issue with current design: MBF not correctly defined



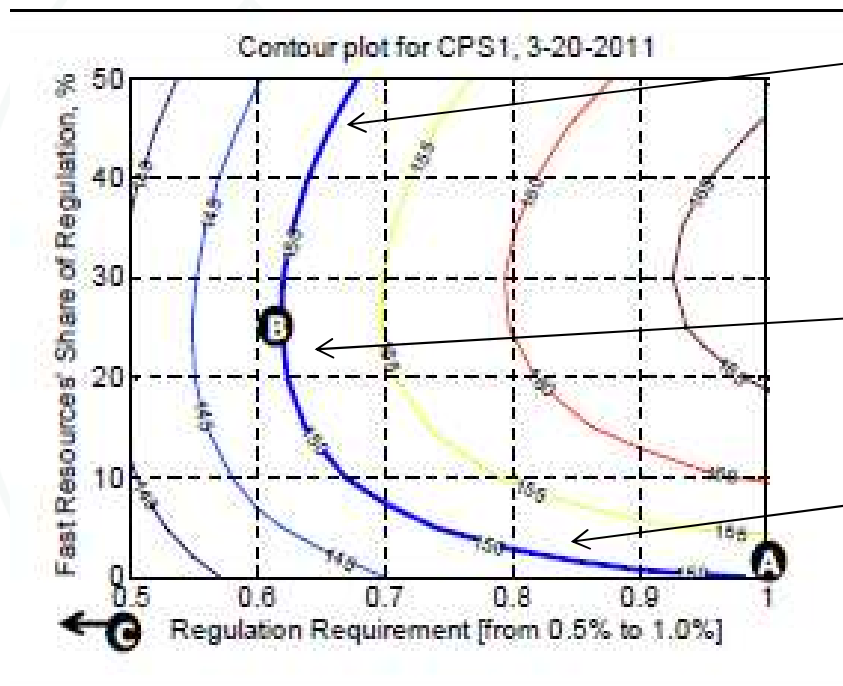
RegD MW
as Percent
of
Regulation
MW

Combinations of
RegA and RegD
that provide the
same CPS1 Scores

Slope of curve at any point
describes marginal rate of
substitution between RegA
and RegD for a given CPS1
Score.

Slope is the Marginal Rate
of Technical Substitution
(MRTS) or the marginal
benefit factor (MBF)

Issue with current design: MBF not correctly defined



MBF < 0 ←

Where MBF < 0, additional MW of RegD requires **additional** MW of RegA to provide the same CPS1 score

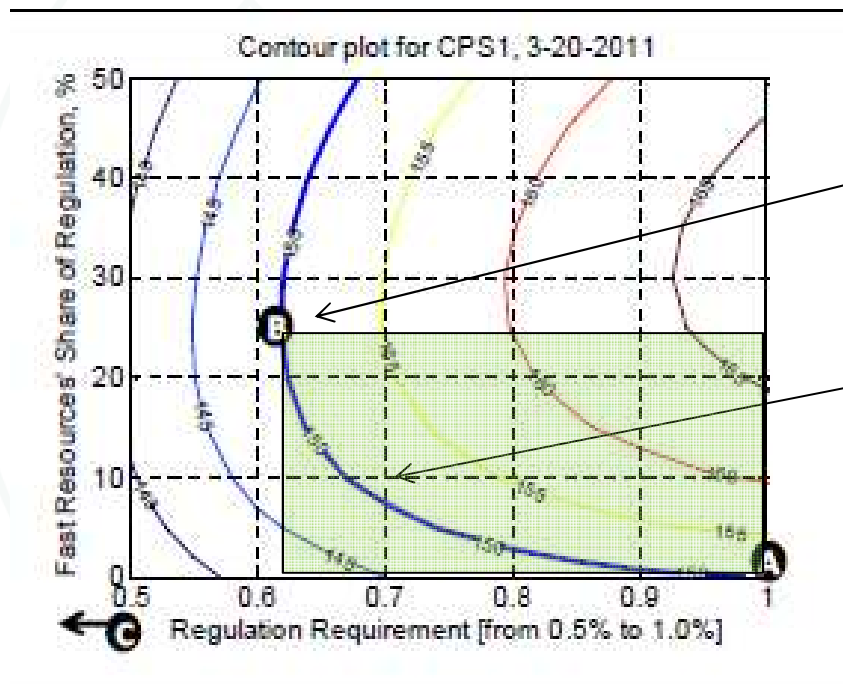
MBF = 0 ←

Where MBF = 0, additional MW of RegD provides no additional regulation benefit (no substitution for RegA).

MBF > 0 ←

Where MBF > 0, MW of RegD are substitutes for MW of RegA.

Issue with current design: MBF not correctly defined

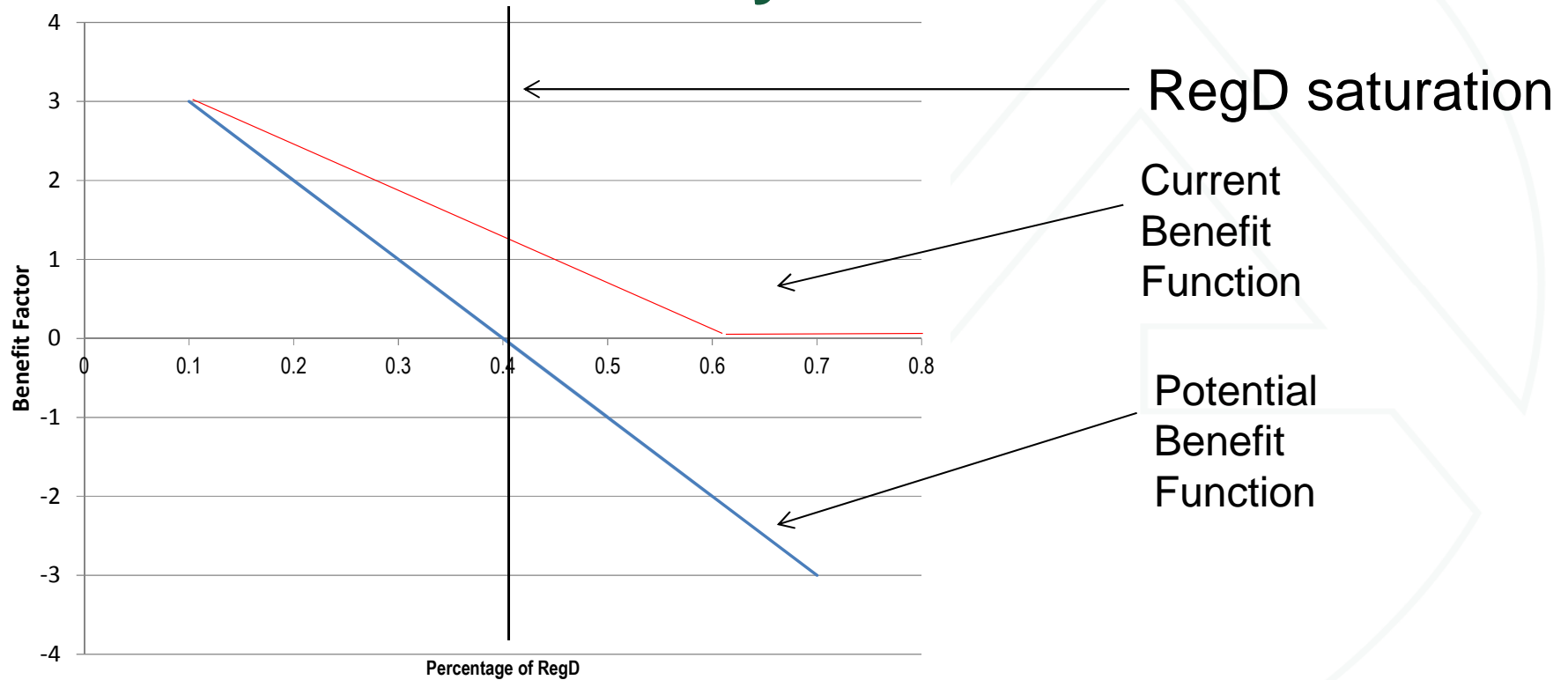


Combinations of RegA and RegD that provide the same CPS1 Scores

Properly defined BF in optimization would correctly limit solution space and result in least cost solution

$$\frac{MB_A}{P_A} = \frac{MB_D}{P_D}$$

Issue with current design: MBF not correctly defined



Marginal Benefit Factor should be uniformly applied

- **The Marginal Benefit Factor (MBF) should be uniformly applied so that the valuation used in optimization process is consistent with the valuation used in settlement.**
- **MBF used to convert all offers to effective MW of RegA MW and \$/effective MW of RegA.**



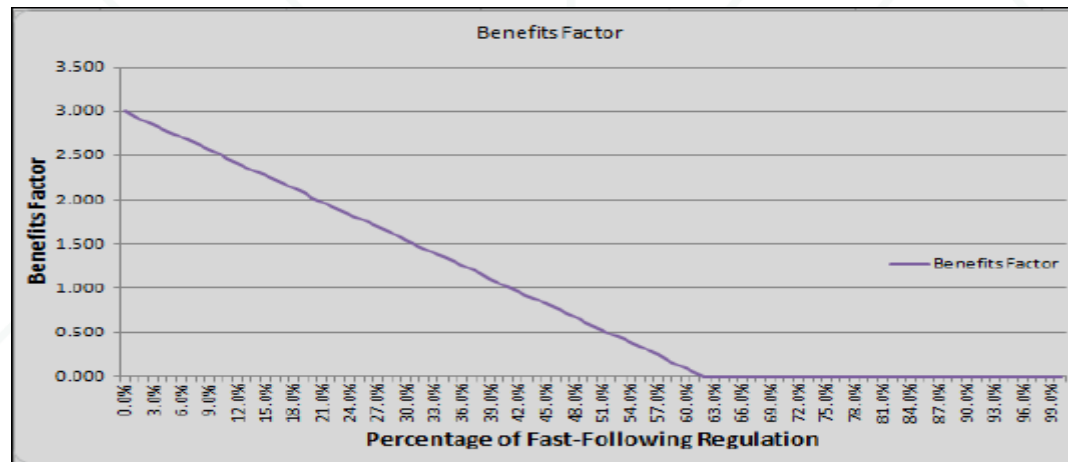
Marginal Benefit Factor should be uniformly applied

- **RegA resources have a MBF of one (base unit of measure).**
- **RegD resource MBF varies with the amount of RegD used as a percentage of total effective MW**
- **Use of MBF allows comparison of offers on the basis of equivalent units (effective MW of RegA)**



Marginal Benefit Factor should be uniformly applied

- MBF used to convert all offers in equivalent MW of RegA and \$/effective MW of RegA.



- Source: Manual 11, page 57

Marginal Benefit Factor applied to valuation in optimization

AdjustedTotalOffer =

$$\left(\frac{Capability(\$ / MW)}{BF * HistoricPerformance} + \frac{(Performance(\$ / \Delta MW) * HistoricRatio (Mile / MW))}{BF * HistoricPerformance} + \frac{LOC(\$ / MW)}{BF * HistoricPerformance} \right) * capMW$$

Converts all offers into a price per effective RegA MW for ranking:

$$P(\$ / effectiveMW) = (AdjustedTotalCost) / MW$$

Marginal Benefit Factor should be uniformly applied

- **Within hour 5 minute price set based on most expensive (marginal) offer, adjusted by actual performance, actual LOC and actual miles:**

Adj Offer (\$ / MW) =

$$\begin{aligned} & \frac{Capability (\$ / MW)}{MBF * ActualPerformance} \leftarrow \\ + & \frac{(Performance (\$ / \Delta MW) * ActualRatio (Mile / MW))}{MBF * ActualPerformance} \leftarrow \\ + & \frac{LOC (\$ / MW)}{MBF * ActualPerformance} \leftarrow \end{aligned} \quad \text{MBF}$$

Marginal Benefit Factor should be uniformly applied

- **This is a price per MW of effective RegA**
- **This price should be paid to each effective MW of RegA**
- **(Price) x (Actual Performance) x (Marginal Benefit Factor) x (MW)**



Done correctly, Marginal Benefit Factor is applied to valuation in settlement

- **Efficient Settlement for RegD:**

$$AdjM Offer (\$ / MW) * MW * ActualPerformance * MBF$$

Marginal BF



- **Efficient Settlement for RegA:**

$$AdjM Offer (\$ / MW) * MW * ActualPerformance$$



Marginal Benefits Factor is not currently applied to valuation in settlement

- **Current Settlement for RegD:**
 - **Benefit Factor not used for any component**
 - **Miles ratio applied to performance payment.**

MBF not applied to capacity or LOC component

$$\begin{aligned} & ((\textit{Capability}(\$ / MW) + \textit{LOC}(\$ / MW)) * \textit{ActualPerformance} * MW \\ & + \\ & \textit{Performance Price}(\$ / MW) * (\textit{MilesRatio}) * MW * \textit{ActualPerformance} \end{aligned}$$

Miles ratio used instead of MBF on performance component

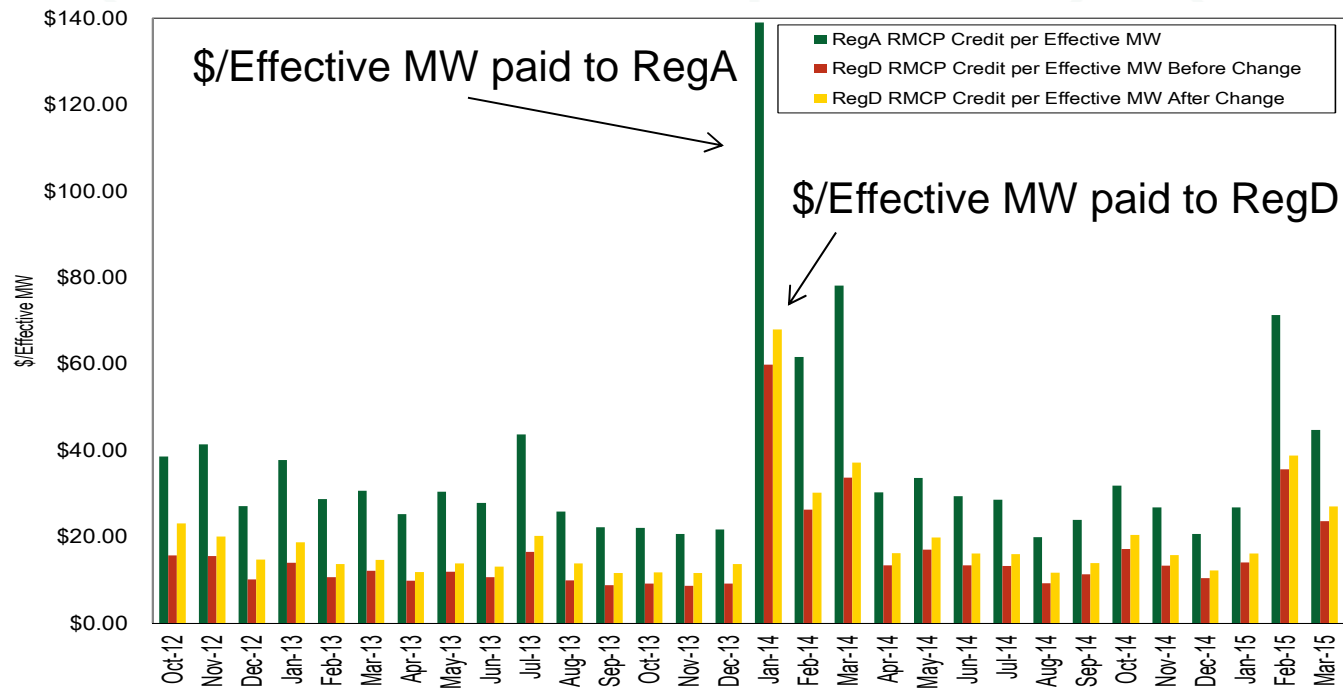
Example

	Performance	Historic Miles	Actual Miles	
RegA Resource	100%	5	5	← \$0.01 /mile
RegD Resource	100%	10	10	← \$0.005 /mile

	Total Price (\$/Effective MW)	Capacity Price (\$/Effective MW)	Performance Price (\$/Effective MW)
RegA Resource	\$20.05	\$20	\$0.05
RegD Resource	\$1.05	\$1	\$0.05

MBF	Price	Effective MW		Total payment if based on effective MW		Miles Ratio	Total payment based on current methodology		Difference in Payment
		RegA Resource (1 MW)	RegD Resource (1 MW)	RegA Resource (1 MW)	RegD Resource (1 MW)		RegA Resource (1 MW)	RegD Resource (1 MW)	
1	\$20.05	1	1	\$20.05	\$20.05	2	\$20.05	\$20.10	0.2%
2	\$20.05	1	2	\$20.05	\$40.10	2	\$20.05	\$20.10	-49.9%
0.5	\$20.05	1	0.5	\$20.05	\$10.03	2	\$20.05	\$20.10	100.5%

Credit per effective MW October 2012 – March 2015: IMM approach vs. Current



IMM approach vs. Current

Year	Month	RegA RMCP Credit per Effective MW	RegD RMCP Credit per Effective MW Before Change	RegD RMCP Credit per Effective MW After Change	RegD RMCP Credit per Effective MW Should Be	RegD Underpayment Before Change	RegD Underpayment After Change	Percent RegD Underpayment Before Change	Percent RegD Underpayment After Change
2012	Oct	\$38.61	\$15.72	\$23.16	\$38.61	\$22.89	\$15.44	59%	40%
2012	Nov	\$41.41	\$15.54	\$20.14	\$41.41	\$25.88	\$21.27	62%	51%
2012	Dec	\$27.11	\$10.14	\$14.77	\$27.11	\$16.97	\$12.34	63%	46%
2013	Jan	\$37.76	\$13.98	\$18.75	\$37.76	\$23.78	\$19.02	63%	50%
2013	Feb	\$28.79	\$10.72	\$13.72	\$28.79	\$18.07	\$15.07	63%	52%
2013	Mar	\$30.64	\$12.15	\$14.71	\$30.64	\$18.49	\$15.93	60%	52%
2013	Apr	\$25.31	\$9.85	\$11.84	\$25.31	\$15.45	\$13.47	61%	53%
2013	May	\$30.46	\$11.94	\$13.88	\$30.46	\$18.52	\$16.58	61%	54%
2013	Jun	\$27.84	\$10.68	\$13.13	\$27.84	\$17.15	\$14.71	62%	53%
2013	Jul	\$43.72	\$16.56	\$20.22	\$43.72	\$27.16	\$23.49	62%	54%
2013	Aug	\$25.81	\$9.93	\$13.86	\$25.81	\$15.88	\$11.96	62%	46%
2013	Sep	\$22.21	\$8.87	\$11.64	\$22.21	\$13.34	\$10.56	60%	48%
2013	Oct	\$22.07	\$9.22	\$11.81	\$22.07	\$12.85	\$10.26	58%	46%
2013	Nov	\$20.71	\$8.72	\$11.62	\$20.71	\$11.99	\$9.08	58%	44%
2013	Dec	\$21.77	\$9.22	\$13.74	\$21.77	\$12.55	\$8.03	58%	37%
2014	Jan	\$138.94	\$59.88	\$68.01	\$138.94	\$79.06	\$70.93	57%	51%
2014	Feb	\$61.64	\$26.35	\$30.24	\$61.64	\$35.29	\$31.40	57%	51%
2014	Mar	\$78.16	\$33.72	\$37.20	\$78.16	\$44.44	\$40.96	57%	52%
2014	Apr	\$30.33	\$13.45	\$16.28	\$30.33	\$16.89	\$14.05	56%	46%
2014	May	\$33.62	\$17.03	\$19.85	\$33.62	\$16.58	\$13.76	49%	41%
2014	Jun	\$29.45	\$13.45	\$16.16	\$29.45	\$16.00	\$13.29	54%	45%
2014	Jul	\$28.64	\$13.29	\$16.01	\$28.64	\$15.36	\$12.63	54%	44%
2014	Aug	\$19.96	\$9.29	\$11.73	\$19.96	\$10.67	\$8.23	53%	41%
2014	Sep	\$23.97	\$11.35	\$13.96	\$23.97	\$12.62	\$10.02	53%	42%
2014	Oct	\$31.91	\$17.21	\$20.45	\$31.91	\$14.70	\$11.46	46%	36%
2014	Nov	\$26.79	\$13.34	\$15.75	\$26.79	\$13.45	\$11.03	50%	41%
2014	Dec	\$20.70	\$10.46	\$12.28	\$20.70	\$10.24	\$8.42	49%	41%
2015	Jan	\$26.81	\$14.08	\$16.14	\$26.81	\$12.73	\$10.67	47%	40%
2015	Feb	\$71.32	\$35.66	\$38.80	\$71.32	\$35.66	\$32.52	50%	46%
2015	Mar	\$44.74	\$23.65	\$27.02	\$44.74	\$21.09	\$17.72	47%	40%
Average		\$37.04	\$16.18	\$19.56	\$37.04	\$20.86	\$17.48	56%	46%

46%
underpayment
to RegD per
effective MW,
assuming
current
MBF function is
correct

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