

Regulation Clearing and Benefits Factor Calculation

Regulation Performance Impacts

Operating Committee Meeting

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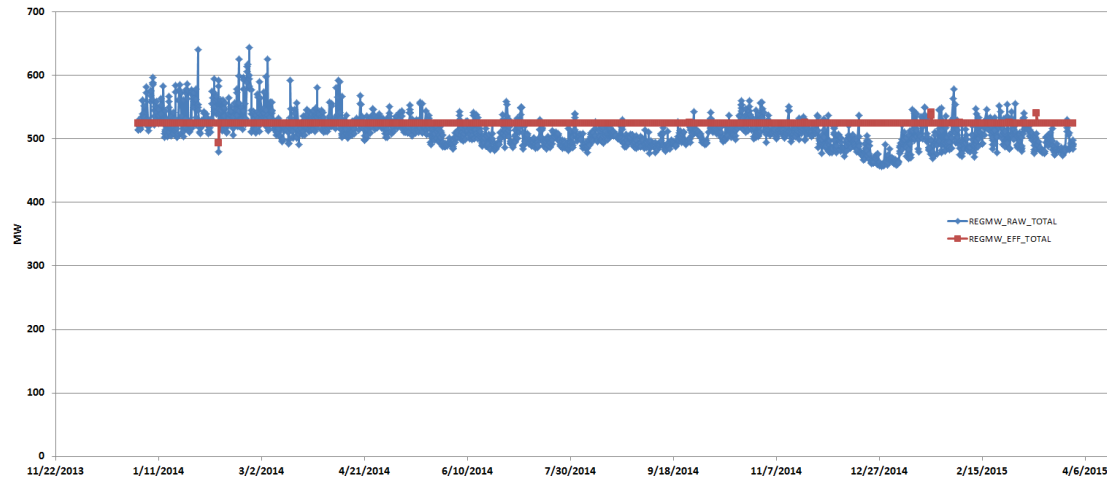
- Regulation is cleared every hour for one hour look-ahead
 - Pricing is done every 5 minutes along with energy LMP in real-time
- Regulation is cleared to meet the established requirements
 - 525 Effective MW for Off-peak (0000 – 0500)
 - 700 Effective MW On-Peak (0500 – 0000)
- One RTO Regulation market 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

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

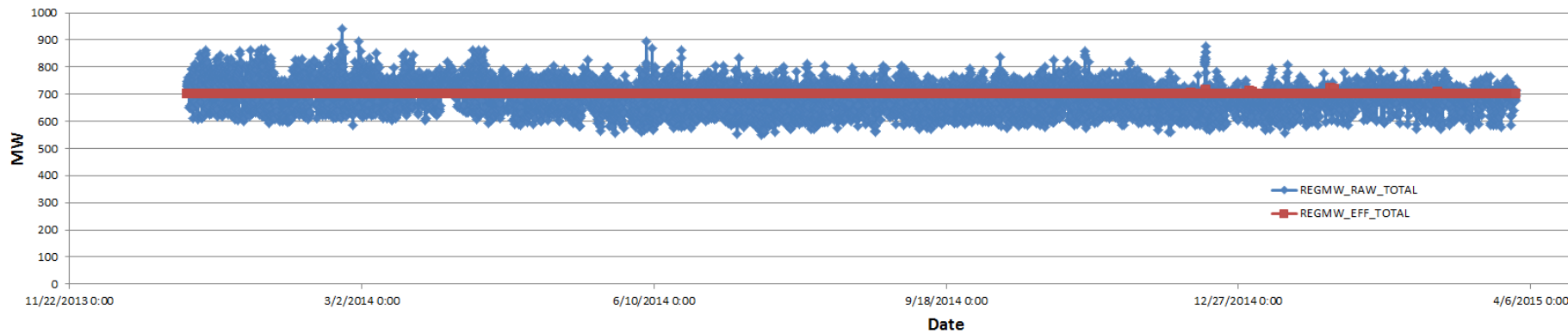
- Effective MW is used only in the market clearing
- Regulation Dispatch and Operation use RegMW (not effective MW)
- Market Settlements credit resources based on RegMW and performance (not effective MW)
- Example: A RegD of RegMW = 32: assume PS = 1.0, and BF = 2.5
 - Market: Effective MW = $32 * 1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



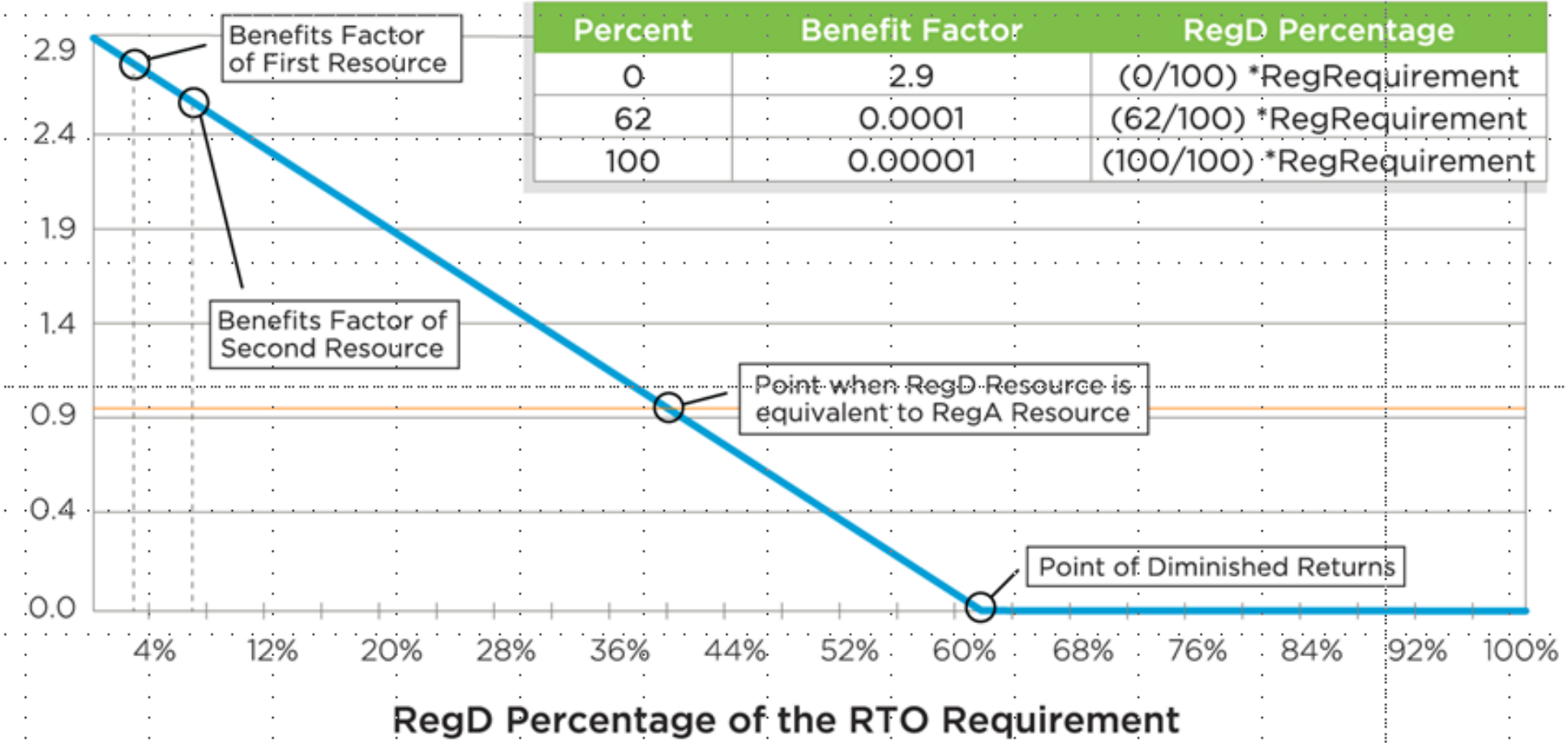
	Effective MW	Ave. Actual MW	Ave. MBF
Off	525	511	2.20
On	700	697	2.14

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

- Two Market Clearing 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 current Benefits Factor curve is not aligned with regulation signal type dispatch in Operation
 - ❖ RegD control signal at times in opposite of ACE control due to energy neutrality reset

- Step 1: Performance Adjusted MW

$$\textit{Performance Adjusted MW} = \textit{RegMW} * \textit{PS}$$

- ❑ Performance Adjusted MW is the same as initial effective MW (BF set to 1 for all)
- ❑ PS is the historic performance score of the resource
 - PS is a rolling average of actual hourly performance score of the last 100 hours a resource has operated or
 - PS is a weighted average of the initial or requalification scores that are then averaged with available actual hourly performance scores

- Step 2: Initial Adjusted Total Cost
 - 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 (\$)
$\frac{\left(\frac{\text{Capability Offer}}{\text{MW}} \right)}{\left(\text{Benefits Factor of Offered Resource} \right)} * \frac{\left(\text{Capability} \right)}{\left(\text{Historic Performance Score} \right)}$	$\frac{\left(\frac{\text{Estimated Lost Opportunity Cost}}{\text{MW}} \right)}{\left(\text{Benefits Factor of Offered Resource} \right)} * \frac{\left(\text{Capability} \right)}{\left(\text{Historic Performance Score} \right)}$
Adjusted Regulation Performance Cost (\$)	$\frac{\left(\frac{\text{Performance Offer}}{\Delta \text{MW}} \right)}{\left(\text{Benefits Factor of Offered Resource} \right)} * \frac{\left(\frac{\text{Historic Mileage of Offered Resource}}{\text{Signal Type}} \frac{\Delta \text{MW}}{\text{MW}} \right)}{\left(\text{Historic Performance Score} \right)} * \left(\text{Capability} \right) \text{ (MW)}$

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

- The modeling equation has performance score (PS) and benefits factor (BF) as denominators
 - Resources with high PS should look cheaper to the clearing engine
 - RegD resource with $BF > 1$ should look cheaper while $BF < 1$ should look expensive
 - The modeling equation is ineffective for instance when
 - ❖ Multiple resources self-scheduled for regulation
 - ❖ Multiple resources offered for regulation at \$0

Resource	Offer MW	Offer \$	Performance Score	Effective MW	Adjusted Total Cost \$
A	10	5	1.0	10	5
B	10	5	0.9	9	5.56
C	10	5	0.8	8	6.25
D	10	5	0.7	7	7.14
E	10	5	0.5	5	10

- Among the goals of the Performance Based Regulation is to value a higher performing resource than a low performer
- Resource A is valued more than B, then C ... because of the performance score
- The Adjusted Total Cost is the measure of chance to clear – the cheaper, the high chance

Resource	Offer MW	Offer \$	Performance Score	Effective MW	Adjusted Total Cost \$
A	10	0	1.0	10	0
B	10	0	0.9	9	0
C	10	0	0.8	8	0
D	10	0	0.7	7	0
E	10	0	0.5	5	0

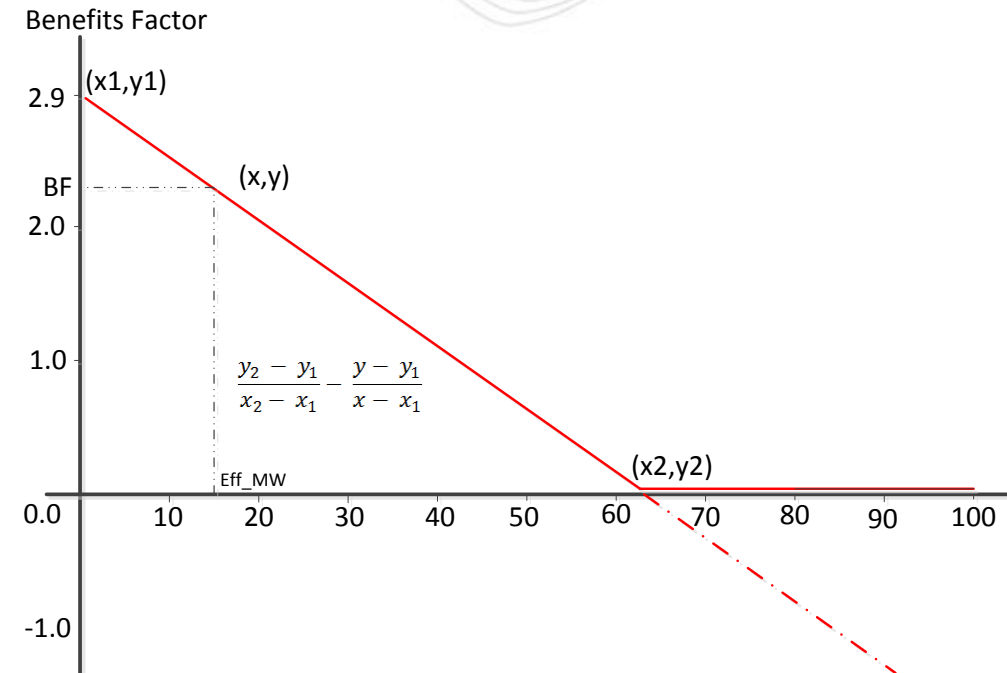
- The current cost modeling equation is not effective in instance of regulation self-scheduled or offered at \$0
- Resource A is not valued differently from E
- This issue has a negative effect on benefits factor calculation for RegD resources

- Effective MW Summation Based on Adjusted Total Cost (rank ascending)

Resource	Offer MW	Offer \$	Performance Score	Effective MW	Adjusted Total Cost \$	Rolling Eff_MW
A	10	0	1.0	10	0	39
B	10	0	0.9	9	0	
C	10	0	0.8	8	0	
D	10	0	0.7	7	0	
E	10	0	0.5	5	0	
F	10	0.01	0.5	5	0.02	44

- 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:

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



- Resource Specific Benefits Factor Assignment

Resource	Offer MW	Offer \$	Performance Score	Effective MW	Adjusted Total Cost \$	Rolling Eff_MW	Benefits Factor
A	10	0	1.0	10	0	39	2.6394
B	10	0	0.9	9	0		2.6394
C	10	0	0.8	8	0		2.6394
D	10	0	0.7	7	0		2.6394
E	10	0	0.5	5	0		2.6394
F	10	0.01	0.5	5	0.02	44	2.6060

➤ Resources with the same adjusted total cost share the same BF

Summary of Issue 1 and Recommendation

- BF with Current Logic

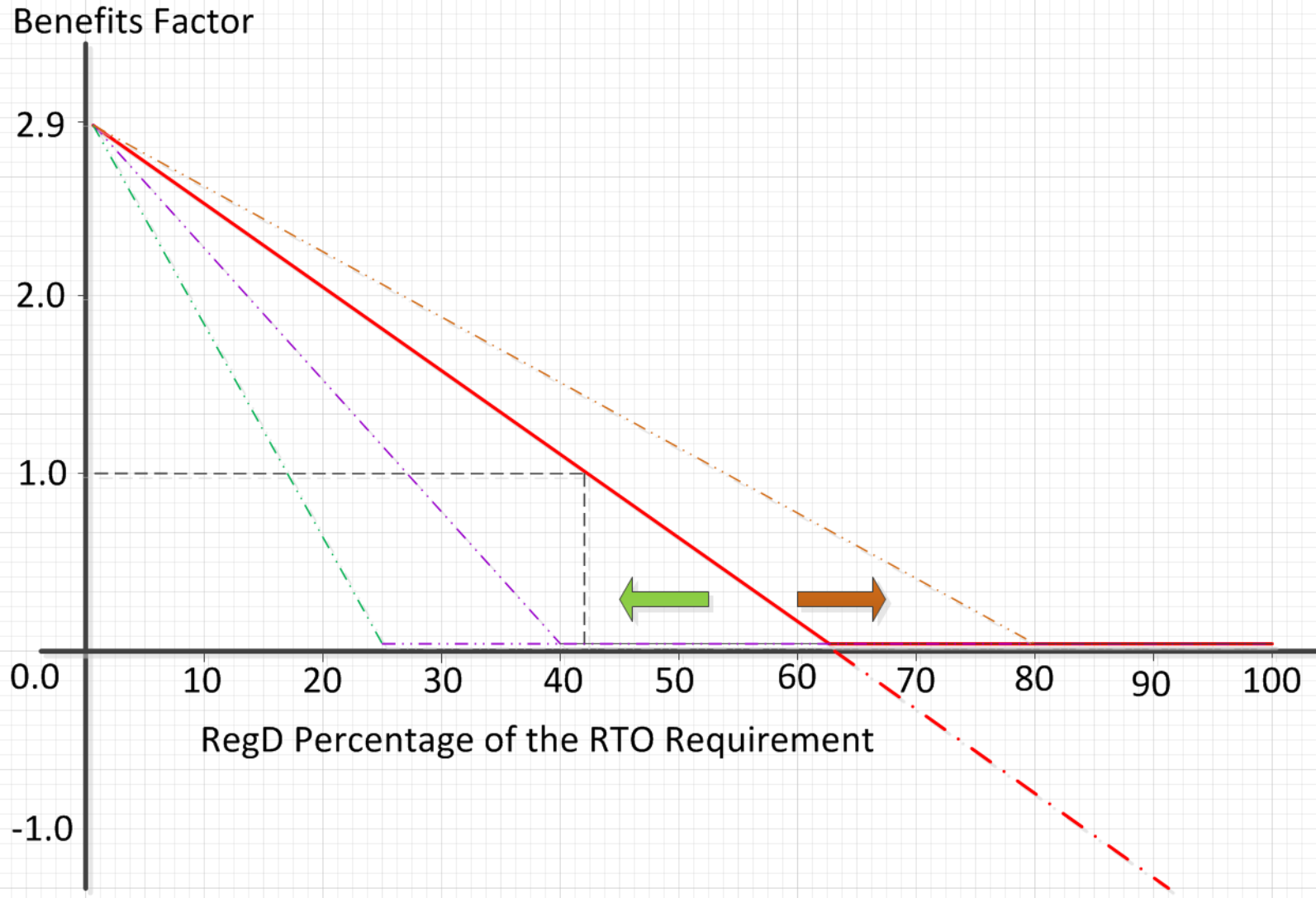
Perf_Adj_MW	BF	Eff_MW
10	2.6394	26.4
9	2.6394	23.8
8	2.6394	21.1
7	2.6394	18.5
5	2.6394	13.2
5	2.6060	13.0
Total Eff_MW		116

- BF with another logic

Perf_Adj_MW	BF	Eff_MW
10	2.8332	28.3
9	2.773	2.05
8	2.7196	21.8
7	2.6728	18.7
5	2.6394	13.2
5	2.6060	13.0
Total Eff_MW		120



- Current Adjusted Total Cost formulation is ineffective when resources self-scheduled or have offered at \$0
 - ❖ High performing resources are not well valued
 - ❖ Effective MW is lost and may result in unnecessary additional MW commitment from RegA or RegD
- Recommend a revision to the current Adjusted Total Cost formulation



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



Marginal Benefits Factor Lookup Table

Performance Adjusted MW (for BF calculation)

700	-26.1	-16.43	-11.6	-8.7	-6.766	-5.385	-4.35	-3.544	-2.9	-2.373	-1.933	-1.777	-1.561	-1.243	-0.967	-0.725	-0.322	0.0001
525	-18.85	-11.6	-7.975	-5.8	-4.35	-3.314	-2.537	-1.933	-1.45	-1.054	-0.725	-0.608	-0.446	-0.207	0.0001	0.1813	0.4834	0.7251
500	-17.81	-10.91	-7.457	-5.385	-4.005	-3.018	-2.278	-1.703	-1.243	-0.866	-0.552	-0.441	-0.287	-0.059	0.1382	0.3108	0.5985	0.8286
475	-16.78	-10.22	-6.939	-4.971	-3.659	-2.722	-2.019	-1.473	-1.036	-0.678	-0.38	-0.274	-0.127	0.0889	0.2763	0.4403	0.7136	0.9322
450	-15.74	-9.528	-6.421	-4.557	-3.314	-2.426	-1.761	-1.243	-0.828	-0.489	-0.207	-0.107	0.032	0.2368	0.4144	0.5697	0.8286	1.0358
425	-14.71	-8.838	-5.903	-4.143	-2.969	-2.13	-1.502	-1.013	-0.621	-0.301	-0.034	0.0602	0.1913	0.3848	0.5525	0.6992	0.9437	1.1393
400	-13.67	-8.147	-5.385	-3.728	-2.624	-1.835	-1.243	-0.782	-0.414	-0.113	0.1382	0.2273	0.3506	0.5327	0.6906	0.8286	1.0588	1.2429
375	-12.64	-7.457	-4.868	-3.314	-2.278	-1.539	-0.984	-0.552	-0.207	0.0754	0.3108	0.3943	0.51	0.6807	0.8286	0.9581	1.1739	1.3465
350	-11.6	-6.766	-4.35	-2.9	-1.933	-1.243	-0.725	-0.322	0.0001	0.2637	0.4834	0.5614	0.6693	0.8286	0.9667	1.0876	1.2889	1.4501
325	-10.56	-6.076	-3.832	-2.486	-1.588	-0.947	-0.466	-0.092	0.2072	0.452	0.656	0.7284	0.8286	0.9766	1.1048	1.217	1.404	1.5536
300	-9.528	-5.385	-3.314	-2.071	-1.243	-0.651	-0.207	0.1382	0.4144	0.6403	0.8286	0.8955	0.988	1.1246	1.2429	1.3465	1.5191	1.6572
275	-8.492	-4.695	-2.796	-1.657	-0.897	-0.355	0.0519	0.3683	0.6215	0.8286	1.0013	1.0625	1.1473	1.2725	1.381	1.4759	1.6342	1.7608
250	-7.457	-4.005	-2.278	-1.243	-0.552	-0.059	0.3108	0.5985	0.8286	1.0169	1.1739	1.2296	1.3066	1.4205	1.5191	1.6054	1.7492	1.8643
225	-6.421	-3.314	-1.761	-0.828	-0.207	0.2368	0.5697	0.8286	1.0358	1.2053	1.3465	1.3966	1.466	1.5684	1.6572	1.7349	1.8643	1.9679
200	-5.385	-2.624	-1.243	-0.414	0.1382	0.5327	0.8286	1.0588	1.2429	1.3936	1.5191	1.5636	1.6253	1.7164	1.7953	1.8643	1.9794	2.0715
175	-4.35	-1.933	-0.725	0.0001	0.4834	0.8286	1.0876	1.2889	1.4501	1.5819	1.6917	1.7307	1.7847	1.8643	1.9334	1.9938	2.0945	2.175
150	-3.314	-1.243	-0.207	0.4144	0.8286	1.1246	1.3465	1.5191	1.6572	1.7702	1.8643	1.8977	1.944	2.0123	2.0715	2.1232	2.2095	2.2786
125	-2.278	-0.552	0.3108	0.8286	1.1739	1.4205	1.6054	1.7492	1.8643	1.9585	2.0369	2.0648	2.1033	2.1602	2.2095	2.2527	2.3246	2.3822
100	-1.243	0.1382	0.8286	1.2429	1.5191	1.7164	1.8643	1.9794	2.0715	2.1468	2.2095	2.2318	2.2627	2.3082	2.3476	2.3822	2.4397	2.4857
75	-0.207	0.8286	1.3465	1.6572	1.8643	2.0123	2.1232	2.2095	2.2786	2.3351	2.3822	2.3989	2.422	2.4561	2.4857	2.5116	2.5548	2.5893
50	0.8286	1.5191	1.8643	2.0715	2.2095	2.3082	2.3822	2.4397	2.4857	2.5234	2.5548	2.5659	2.5813	2.6041	2.6238	2.6411	2.6698	2.6929
25	1.8643	2.2095	2.3822	2.4857	2.5548	2.6041	2.6411	2.6698	2.6929	2.7117	2.7274	2.733	2.7407	2.752	2.7619	2.7705	2.7849	2.7964
10	2.4857	2.6238	2.6929	2.7343	2.7619	2.7816	2.7964	2.8079	2.8171	2.8247	2.831	2.8332	2.8363	2.8408	2.8448	2.8482	2.854	2.8586
5	2.6929	2.7619	2.7964	2.8171	2.831	2.8408	2.8482	2.854	2.8586	2.8623	2.8655	2.8666	2.8681	2.8704	2.8724	2.8741	2.877	2.8793
1	2.8586	2.8724	2.8793	2.8834	2.8862	2.8882	2.8896	2.8908	2.8917	2.8925	2.8931	2.8933	2.8936	2.8941	2.8945	2.8948	2.8954	2.8959
0.1	2.8959	2.8972	2.8979	2.8983	2.8986	2.8988	2.899	2.8991	2.8992	2.8992	2.8993	2.8993	2.8994	2.8994	2.8994	2.8995	2.8995	2.8996
	10	15	20	25	30	35	40	45	50	55	60	62	65	70	75	80	90	100
	Effective RegD Percentage of the Regulation Requirement																	



Performance Based Regulation – One Page Summary

LOCALHOUR	RESOURCE	TYPE	SIGNAL	RAW_MW	EFF_MW	BF	MBF	PS	
10/21/2014 19:00	D1	GEN	REGD	150	197.1	1.567	0.477	0.838	
10/21/2014 19:00	D2	GEN	REGD	2	2.9	1.567	0.477	0.938	
10/21/2014 19:00	D3	GEN	REGD	20	29.9	1.567	0.477	0.955	
10/21/2014 19:00	D4	GEN	REGD	1.5	2.2	1.567	0.477	0.92	
10/21/2014 19:00	D5	GEN	REGD	20	29.6	1.567	0.477	0.945	
10/21/2014 19:00	D6	GEN	REGD	32	47	1.567	0.477	0.937	
10/21/2014 19:00	D7	DSR	REGD	1.5	2.3	1.567	0.477	0.959	
10/21/2014 19:00	D8	DSR	REGD	0.1	0.1	1.567	0.477	0.782	
10/21/2014 19:00	D9	DSR	REGD	0.1	0.1	1.567	0.477	0.781	
10/21/2014 19:00	D10	DSR	REGD	0.1	0.1	1.567	0.477	0.782	
10/21/2014 19:00	D11	DSR	REGD	0.1	0.1	1.567	0.477	0.781	
10/21/2014 19:00	D12	DSR	REGD	0.1	0.1	1.567	0.477	0.887	
10/21/2014 19:00	D13	DSR	REGD	0.8	0.8	1.567	0.477	0.675	
10/21/2014 19:00	D14	GEN	REGD	1.7	1.9	1.559	0.477	0.72	
10/21/2014 19:00	D15	DSR	REGD	0.1	0.1	1.558	0.477	0.883	
10/21/2014 19:00	D16	DSR	REGD	0.4	0.5	1.556	0.477	0.866	
10/21/2014 19:00	D17	DSR	REGD	0.2	0.3	1.555	0.477	0.865	
10/21/2014 19:00	D18	DSR	REGD	0.2	0.3	1.554	0.477	0.852	
10/21/2014 19:00	D19	DSR	REGD	0.9	1.2	1.549	0.477	0.842	
10/21/2014 19:00	D20	GEN	REGD	30	34.2	1.383	0.477	0.824	
10/21/2014 19:00	D21	GEN	REGD	30	29.9	1.219	0.477	0.819	
10/21/2014 19:00	D22	GEN	REGD	30	25.8	1.056	0.477	0.813	
10/21/2014 19:00	D23	GEN	REGD	61	31.7	0.787	0.477	0.662	48
10/21/2014 19:00	D24	GEN	REGD	69	21.3	0.503	0.477	0.615	34.7
10/21/2014 19:00	D25	GEN	REGD	4	1.8	0.478	0.477	0.942	1.9
10/21/2014 19:00	D26	DSR	REGD	0.3	0.1	0.477	0.477	0.84	0.1
10/21/2014 19:00	A1	GEN	REG	90	72.8	1	0.477	0.809	
10/21/2014 19:00	A2	GEN	REG	16	14.3	1	0.477	0.891	
10/21/2014 19:00	A3	GEN	REG	10	8.9	1	0.477	0.888	
10/21/2014 19:00	A4	GEN	REG	4.3	3.8	1	0.477	0.894	
10/21/2014 19:00	A5	GEN	REG	10	6.5	1	0.477	0.65	
10/21/2014 19:00	A6	GEN	REG	27.4	23.7	1	0.477	0.864	
10/21/2014 19:00	A7	GEN	REG	69	52.4	1	0.477	0.76	
10/21/2014 19:00	A8	GEN	REG	40	33	1	0.477	0.826	
10/21/2014 19:00	A9	GEN	REG	25	22.8	1	0.477	0.911	
10/21/2014 19:00	A10	DSR	REG	0.1	0.1	1	0.477	0.794	
10/21/2014 19:00	A11	DSR	REG	0.1	0.1	1	0.477	0.688	
				748	700				
					55				85

RegA Raw / Eff MW = 292 / 238

RegD Raw / Eff MW = 456 / 462

- Effect of the Adjusted Total Cost formulation
- Potential operation effect of high RegD percentage over RegA
- Effect of MBF < 1
- Effect of high Performance Score bunch

- Recommend a revision to the Adjusted Total Cost formulation
 - Incent a better regulation resources performance
 - Allows for a more accurate valuation of RegD
 - Formulation does not affect pricing but Benefits Factor ranking only
- Recommend a revision of the Benefits Factor Curve
 - Allows for optimal mix of RegD vs. RegA and align with current regulation dispatch practice
- Affected document for revisions if these recommendation are taken
 - No change to Tariff or Operating Agreement
 - Change to manual 11 section 3