Benefits Factor

Regulation Market Issues Sr. Task Force
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Introduction

- Purpose of presentation(s)
  - Compare and contrast PJM position on the issues with IMM
  - Provide additional background on the subject
  - Provide additional information on how and why we got to where we are now

PJM / IMM Agreement

No.	IMM Issues with Regulation	PJM Status
1	Potentially incorrect definition of the Benefits Factor Curve (degree of RegD MW tolerance for optimum system control)	**Agree**. The current BF curve at 62% does not support optimum system control. Regulation Performance Impacts passed a partial fix
2	Incorrect application of Benefits Factor in the clearing - non-unique BF to a price block when multiple RegD resources come up with same BF rank - Incomplete valuation of rate of substitution (area under the curve rather than just rectangle block)	**Agree**. The current modeling equation does not correctly handles instances of self-schedules and $0 adjusted total cost. Regulation Performance Impacts passed a partial fix.
3	Inconsistency in Settlement vs. Clearing/Pricing	**Agree. Further discussion required.**
4	Schedule used for calculation of RegLOC can be inconsistent with the schedule on which a resource is running for energy	**Agree**.

Key Takeaways

- Majority of issues with Performance Based Regulation are related to the Benefits Factor concept
- Issues exist in other Performance Based Regulation metrics/concepts as well:
  - Regulation signal formation and ACE control approach
  - RegA and RegD mileage calculation
  - RegLOC energy-schedule that results in over/under-value opportunity cost
- Issues are very interdependent and will need to be resolved simultaneously

Summary of Benefits Factor Issues

- An incorrectly defined Benefits Factor curve leads to under-valuing and/or over-valuing RegD effective MW
  - This has an effect on RegA procurement, which in turn affects the overall cost of Regulation to the market
- The Benefits Factor coefficients might not have been of the right spread for accurate rate of substitution between RegD and RegA effective MW for an optimal system control.
  - Is 2.9 the right value for the Y axis intercept?

Summary of Benefits Factor Issues Continued

- The Benefits Factor curve has not captured all necessary system characteristics so as to define the right RegD MW tolerance for optimal system control
  - Should factors other than ramp be taken into consideration in the rate of substitution between RegA and RegD?
- The cost adjustment modeling equations are not robust to correctly handle various participants bidding strategies for an efficient rate of substitution between RegD and RegA
  - The Regulation Performance Impacts tie breaking logic creates a rule that calculates the benefits factor ranking differently for self-scheduled resources and pool-scheduled resources. Should we have one model that can apply to all resources?

Performance Based Regulation Concepts

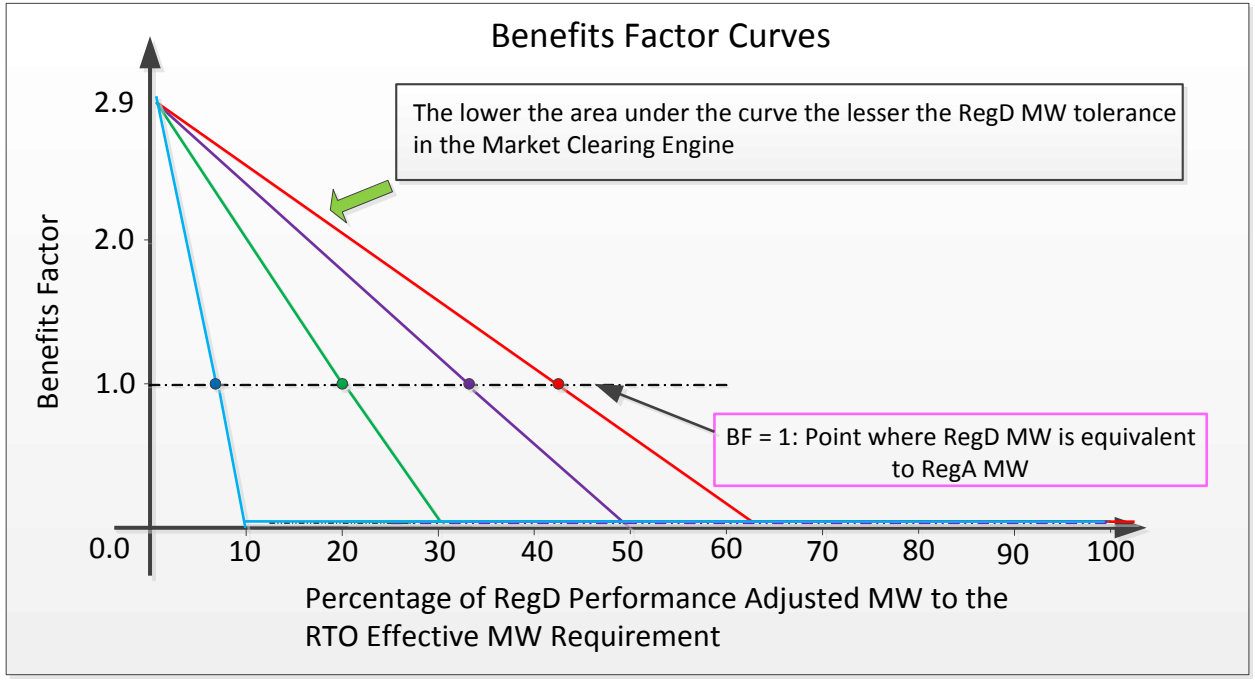
- Three Performance Based Regulation Concepts:
  - Benefits Factor – specific to resource of an identified signal type
  - Mileage (Mileage Ratio) – specific to signal type of resource
  - Performance Score – specific to resource
- The focus will be on Benefits Factor

Benefits Factor - Concept

- The Benefits Factor (BF) models the rate of substitution of dynamic RegD MW to traditional RegA MW
  - It enables the market to translate a fast moving resource's regulation MW into traditional MW, or effective MW
  - Resource specific benefits factor is the marginal point on the benefits factor curve that aligns with the last MW, adjusted by historical performance, that specific resource will add to the dynamic resource stack
  - Each RegD resource is assigned a decreasing and unique* benefits factor
    - (*) issue where the same BF is assigned to a block of resources that self-scheduled and/or those with zero adjusted total cost was addressed in the Regulation Performance Impacts
  - Since RegA MW is the reference (base unit of measure), Benefits Factor for RegA is set to 1

Benefits Factor Curve – Optimal RegD Tolerance

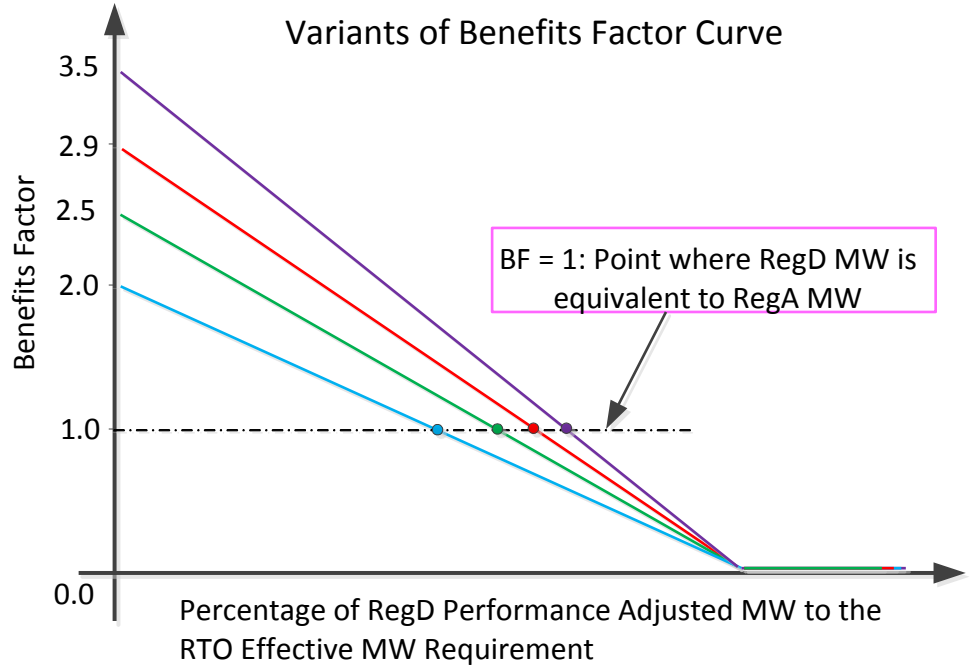
- Benefits Factor Curve describes the optimal RegD MW tolerance beneficial to a defined system control.
  - The area under the curve is bounded by defined Benefits Factor coefficient on the y-axis and the percentage of RegD performance adjusted MW relative to the RTO effective MW requirement on the x-axis



- Benefits Factor coefficient ranges from 2.9 to 0.00001
- Benefits Factor curve tends to zero and parallel with x-axis at 62%
- *It is very important to define a Benefits Factor curve that captures all the system characteristics so as to define the right RegD MW tolerance for optimal system control*
- *The tolerance of RegD percentage was endorsed in the Regulation Performance Impacts to be shrunk from 62% to 40%. The revised percent is subject to change based on further analysis*

Rate of Substitution of RegD MW to Equivalent RegA MW

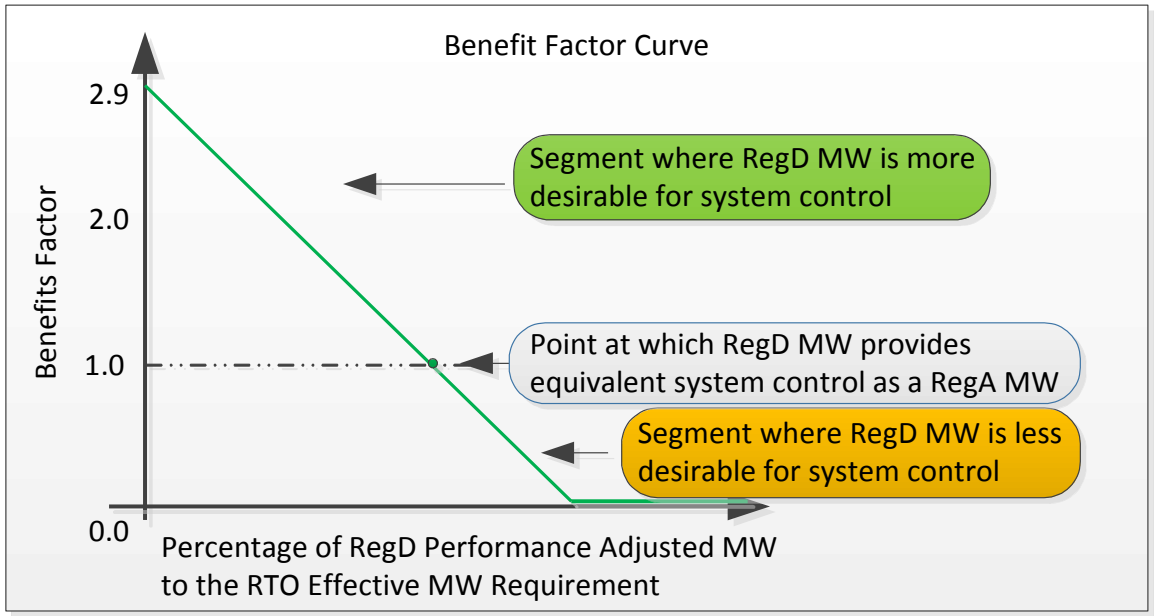
- How does the RegD to RegA rate of substitution translate to the Benefits Factor curve that starts at 2.9?
  - Should the curve have started from somewhere other than 2.9?



- How does the RegD to RegA rate of substitution translate in other variants of Benefits Factor curve?
  - Starting point above 2.9 will increase benefits of RegD MW relative to current value
  - Starting point below 2.9 will decrease benefits of RegD MW relative to current value

Benefits Factor Curve – Rate of Substitution

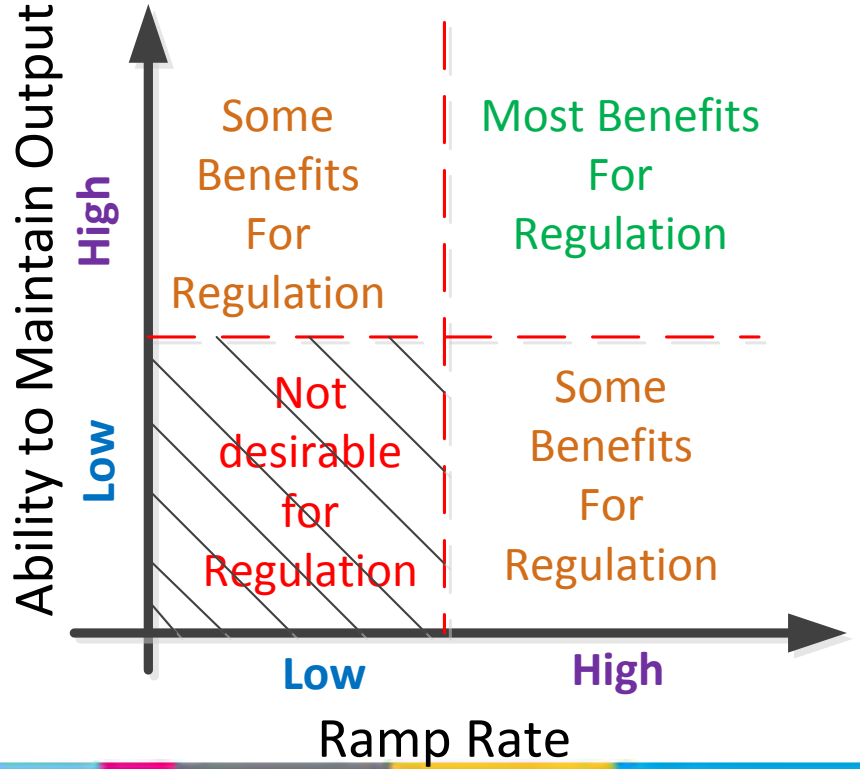
- Benefits Factor Curve provides a sliding scale which translates the relationship between RegD and RegA MW; rate of substitution
  - The sliding scale (BF) ranges from 2.9 to 0.00001
    - Segment where BF is greater than 1 makes RegD effective MW more desirable
    - Point where BF = 1 is where RegD and RegA effective MW are equivalent
    - Segment where BF is less than 1 makes RegD effective MW less desirable



- *Should we value the entire curve, or stop at the point where the rate of substitution is equivalent (BF = 1)?*

Factors Impacting the Rate of Substitution

- What constitutes the rate of substitution of RegD MW to RegA MW?
  - ❖ Currently it is RegD's high rate of response to regulation signal
- Should other parameters like the ability of a resource to maintain output be included in the determination of the ideal mix of regulation resources?



Benefits Factor Impact on Adjusted Total Cost of RegD Resources

- Benefits Factor adjusts the total cost of RegD MW to value its effectiveness for system control
  - Dividing each offer components by the resource specific Benefits Factor creates adjusted cost to reflect the benefits each resource will provide for system control
    - A Benefits Factor greater than 1 will make RegD effective MW looks less expensive
    - A Benefits Factor lesser than 1 will make RegD MW look more expensive
    - *The current adjusted cost modeling is not effective for instance of zero total cost and/or Regulation self-scheduled*

Adjusted Regulation Capability Cost ($)

$$\frac{\left(\text{Capability Offer}\ \left(\frac{\$}{MW}\right)\right)}{\left(\text{Benefits Factor of Offered Resource}\right)} * \frac{\left(\text{Capability}\ (MW)\right)}{\left(\text{Historic Performance Score}\right)}$$

Adjusted Lost Opportunity Cost ($)

$$\frac{\left(\text{Estimated Lost Opportunity Cost}\ \left(\frac{\$}{MW}\right)\right)}{\left(\text{Benefits Factor of Offered Resource}\right)} * \frac{\left(\text{Capability}\ (MW)\right)}{\left(\text{Historic Performance Score}\right)}$$

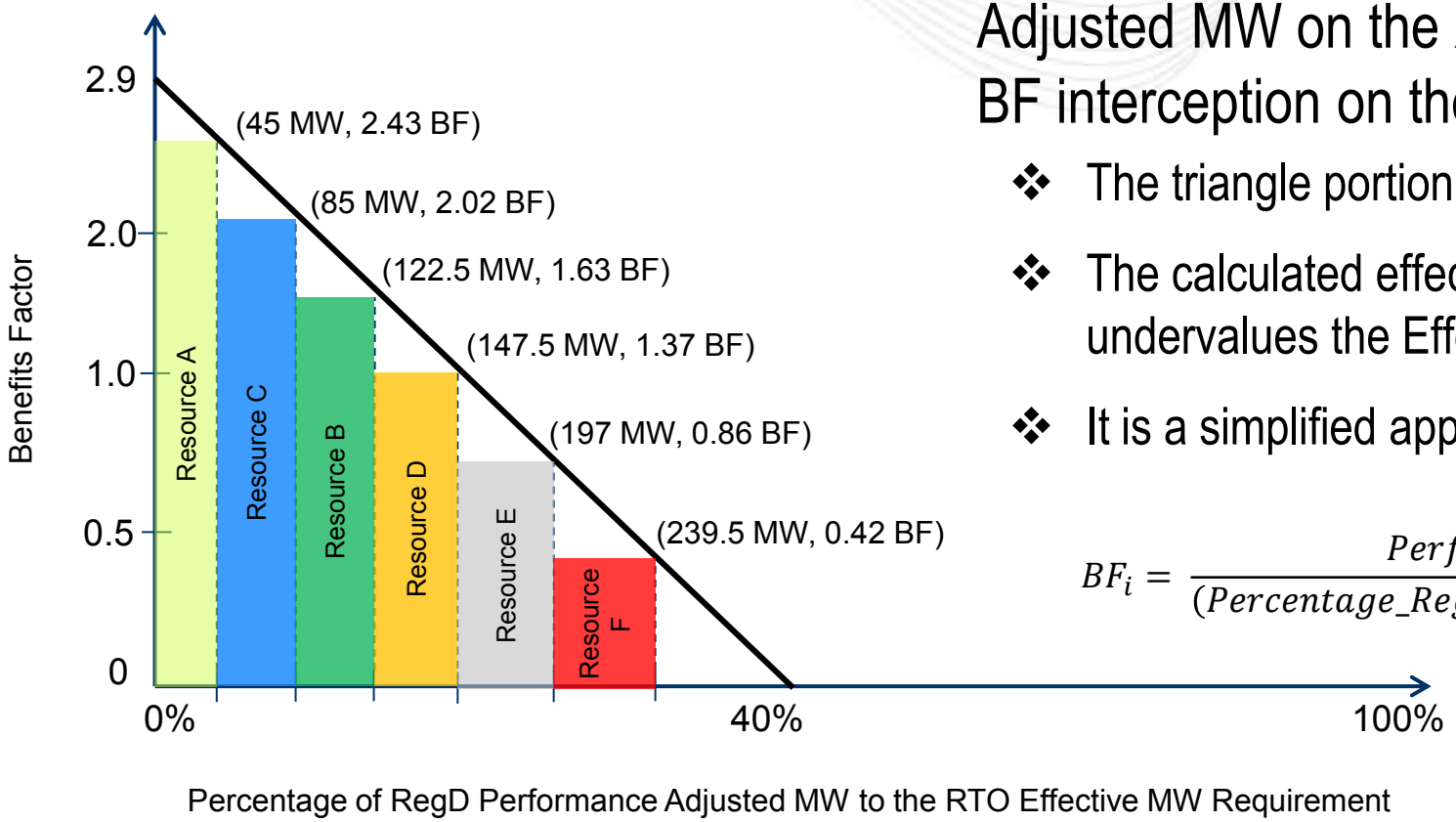
Adjusted Regulation Performance Cost ($)

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

- *Incorrect adjusted cost modeling leads to incorrect Benefits Factor assignment*
- *The cost adjustment modeling equations must be robust to correctly handle various participants bidding strategies for an efficient rate of substitution between RegD and RegA*
- *Regulation Performance Impacts has applied a patch by the way of tie-breaking logic. Is this an acceptable long-term solution?*

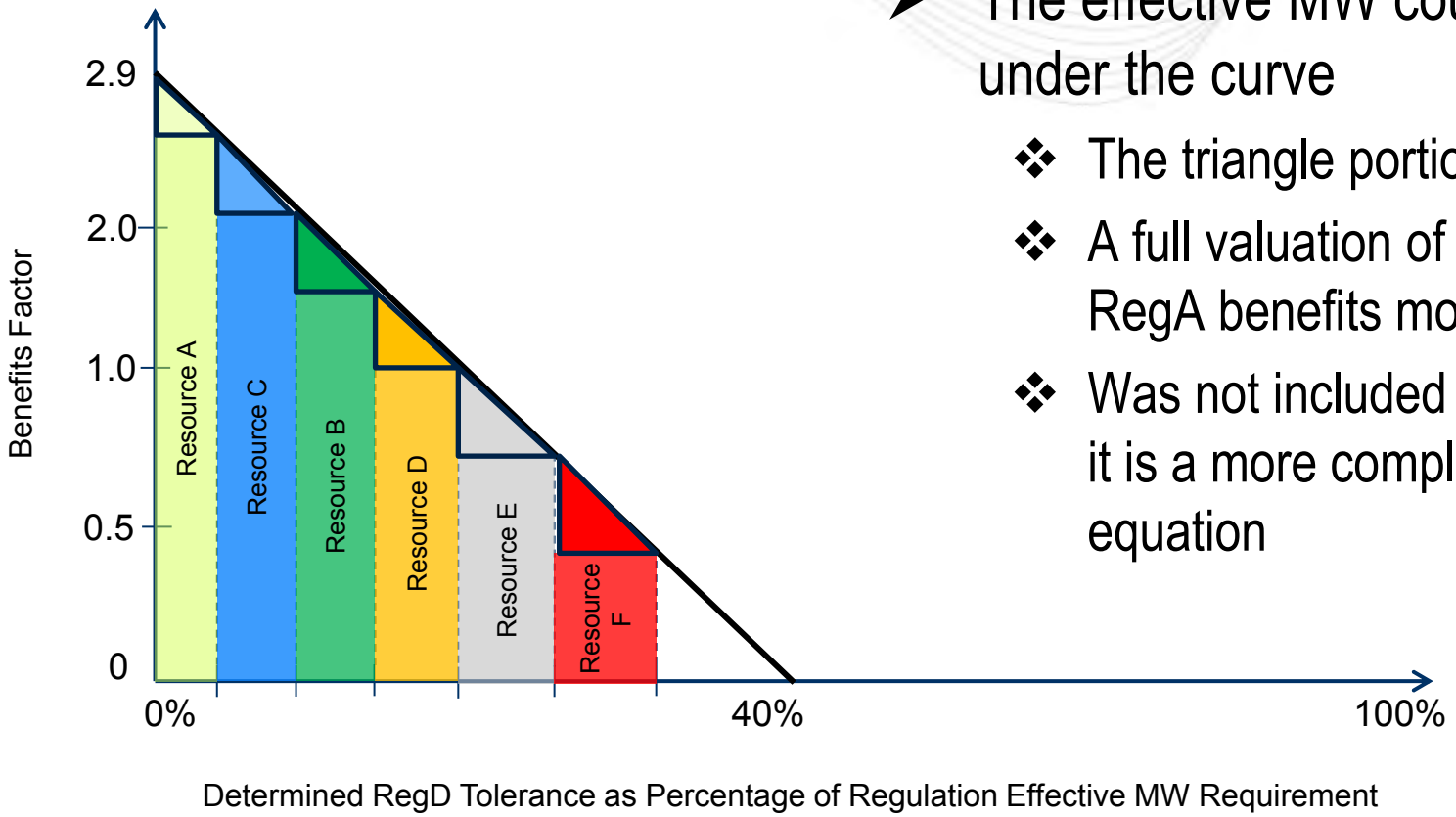
Resource-Specific Benefits Factor – Effective MW Using Last MW of Block

- The current effective MW is the product of Performance Adjusted MW on the X (RegD Percentage) axis and the BF interception on the Benefits Factor slope
  - The triangle portion is not included
  - The calculated effective MW is conservative and potentially undervalues the Effective MW of a RegD resource
  - It is a simplified approach with less computational burden



$$BF_i = \frac{Perf\_Adj\_MW_i * (0.0001 - 2.9)}{(Percentage\_RegD\_Perf\_Adj\_MW) * RTO\_Eff\_MW\_Req} + 2.9$$

Resource-Specific Benefits Factor – Effective MW as Area Under the Curve



- The effective MW could also be calculated as area under the curve
  - The triangle portion would also be included
  - A full valuation of the rate of substitution of RegD to RegA benefits modeling
  - Was not included in the original implementation because it is a more complex calculation – no easy modeling equation

Resource-Specific Benefits Factor – Impact on RegD Effective MW

- Benefits Factor adjusts RegD MW to value its effectiveness for system control
  - Multiplying RegD Performance Adjusted MW by its Benefits Factor creates effective MW to reflect benefits the RegD resource is assumed will provide for system control

$$Effective\ MW = Performance\ Adjusted\ MW * Benefits\ Factor$$

$$where\ Performance\ Adjusted\ MW = RegMW * Historic\ Performance\ Score$$

Resource	Performance Adjusted MW	Benefits Factor	Effective MW
RegD1	10	2.8	28
RegD2	10	1	10
RegD3	10	0.31	3.1

- *An Incorrect resource-specific BF will either over-value or under-value RegD effective MW, causing over or under procurement of RegA. This will have an effect on optimal system control and the overall cost of Regulation.*

Regulation Settlement

$$Regulation\ Capability\ Credit = RegMW * \mathbf{Actual\ Hour\ Performance\ Score} * Capability\ Clearing\ Price$$

$$Regulation\ Performance\ Credit = RegMW * \mathbf{Actual\ Hour\ Performance\ Score} * \mathbf{Actual\ Hour\ Mileage\ Ratio} * Performance\ Clearing\ Price$$

- Resource's hourly credits are adjusted based on
  - The real value of RegMW provided measured in real-time as the performance score;
  - The relative (RegD to RegA signal) amount of regulation work done measured in real-time as the mileage
    - There is a known issue with mileage during ACE excursion and Regulation pegging – This is a design that can be fixed
- Resource's hourly credits are NOT adjusted by Marginal Benefits Factor
  - No measure of actual benefits factor; only modeled benefits factor is available

Inclusion of RegD MBF in Settlement?

- Similar to other PBR metrics/concept, BF/MBF has been used to
  - Adjust the offer of RegD resources in the clearing process
  - Convert raw Reg MW to effective value which adjust RTO requirement

- Unlike other PBR metrics/concept, MBF has not been used in Settlement because FERC ruled not to adjust Regulation credit by the Marginal Benefits Factor

- PJM agrees that the exclusion of the MBF from settlements creates an inconsistency between clearing and settlement
  - PJM support for adding MBF to settlement will depend upon the selected implementation

Summary

- PJM agrees with IMM on majority of the identified issues with Performance Based Regulation
  - PJM requires additional discussion around the inclusion of the MBF in Regulation settlement
- Two of the identified issues have been addressed partially in the Regulation Performance Impacts stakeholder process
- The issues span Regulation concepts, regulation optimization in market, and Regulation signal formation and ACE control in Operation
- Majority of the issues are related to the Benefits Factor concept
- Issues are very interdependent and will need to be resolved simultaneously