The Flex DA/RT Co-Optimization Model Method:

A More Efficient Unit Commitment For an Uncertain Grid

FERC Technical Conference:
Increasing RT/DA Efficiency Through Improved Software
Washington, D.C.
June 22-24, 2015

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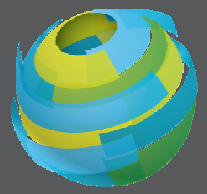

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Overview

1. Setting the DA Position: A Brief History
2. Proposed Methodology
3. Characteristics of the Modified Solution
4. Review of DA & RT Deviation - MISO
5. Modification of the Objective Function
6. Example Flex DA/RT
7. Benefits of the Flex DA/RT Methodology
8. Summary
9. Q/A Session

Setting the DA Position: A Brief History

- Minimize Expected Costs
  - DA Exposure is Hedged
  - Risks Are Managed
  - Portfolio is Positioned to Take Advantage of Real-Time Opportunities

Setting the DA Position: A Brief History

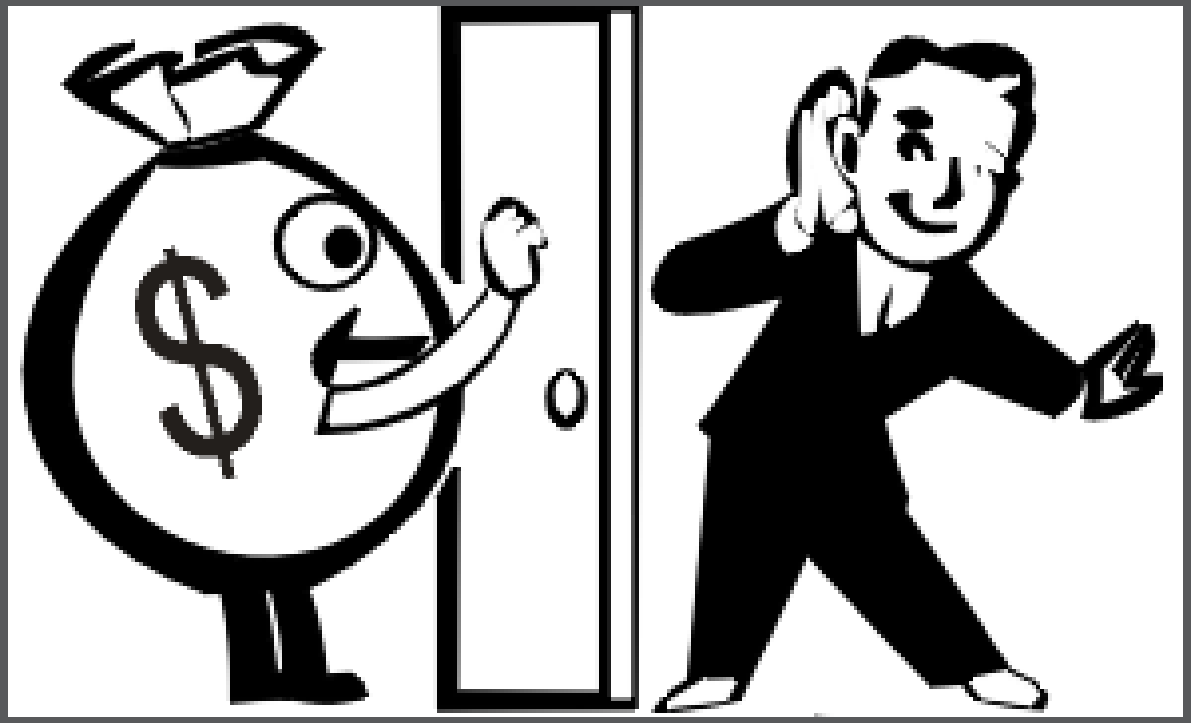
- Hedge
  - Use of One or More Positions Within a Portfolio to Offset All or Part of the Risks Associated With Other Positions Within the Portfolio

Setting the DA Position: A Brief History

- Risk
  - Associated With Future Outcomes Not in Your Control
  - Taking Risks Can Be Beneficial or Costly

Setting the DA Position: A Brief History

- Opportunity
  - Associated With Future Outcomes That Are in Your Control
    - E.g., Raising Generation When Prices Are High and Lowering Generation When Prices Are Low



Unit Commitment Today?

- **Hedging:**
  - Committing the Most Cost-Effective Combination of Resources That Offset the Forecasted Energy and Ancillary Requirements, While Respecting Transmission and Unit Operation Constraints
- **Risk:**
  - Acquisition of Spinning and Non-Spinning Reserves
  - Reliability Unit Commitment (RUC)
- **Opportunity?**

Proposed Methodology

- Monetize the Value of a Resource's Flexibility
  - Determine the Resource's "Call" and "Put" value
- Incorporate into the Objective Function
- Co-optimize with the Resource's Energy and Ancillary Benefits, **AND….**

Proposed Methodology

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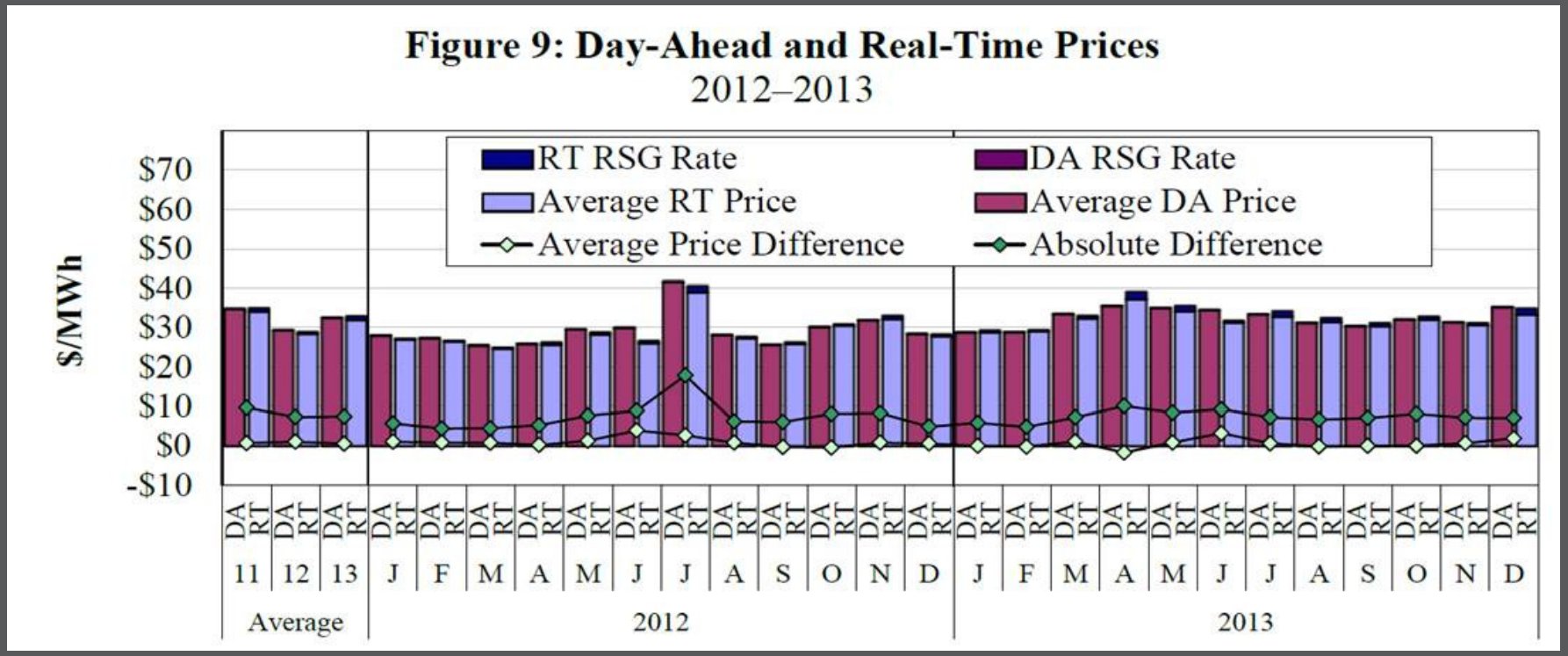
NO NEW CONSTRAINTS!

Three Characteristics of the Solution

- The More Flexibility a Resource Offers the RTO/ISO, the More Consideration that will be Given to the Resource for Commitment
- Flexible Resources will be Given the Most Consideration Where and When RT Price Volatility is Expected to Be Highest
- Only Resources Expected to Offer Cost Effective Flexibility Benefits Will Be Recommended For Commitment

Review of DA and RT Deviation: MISO

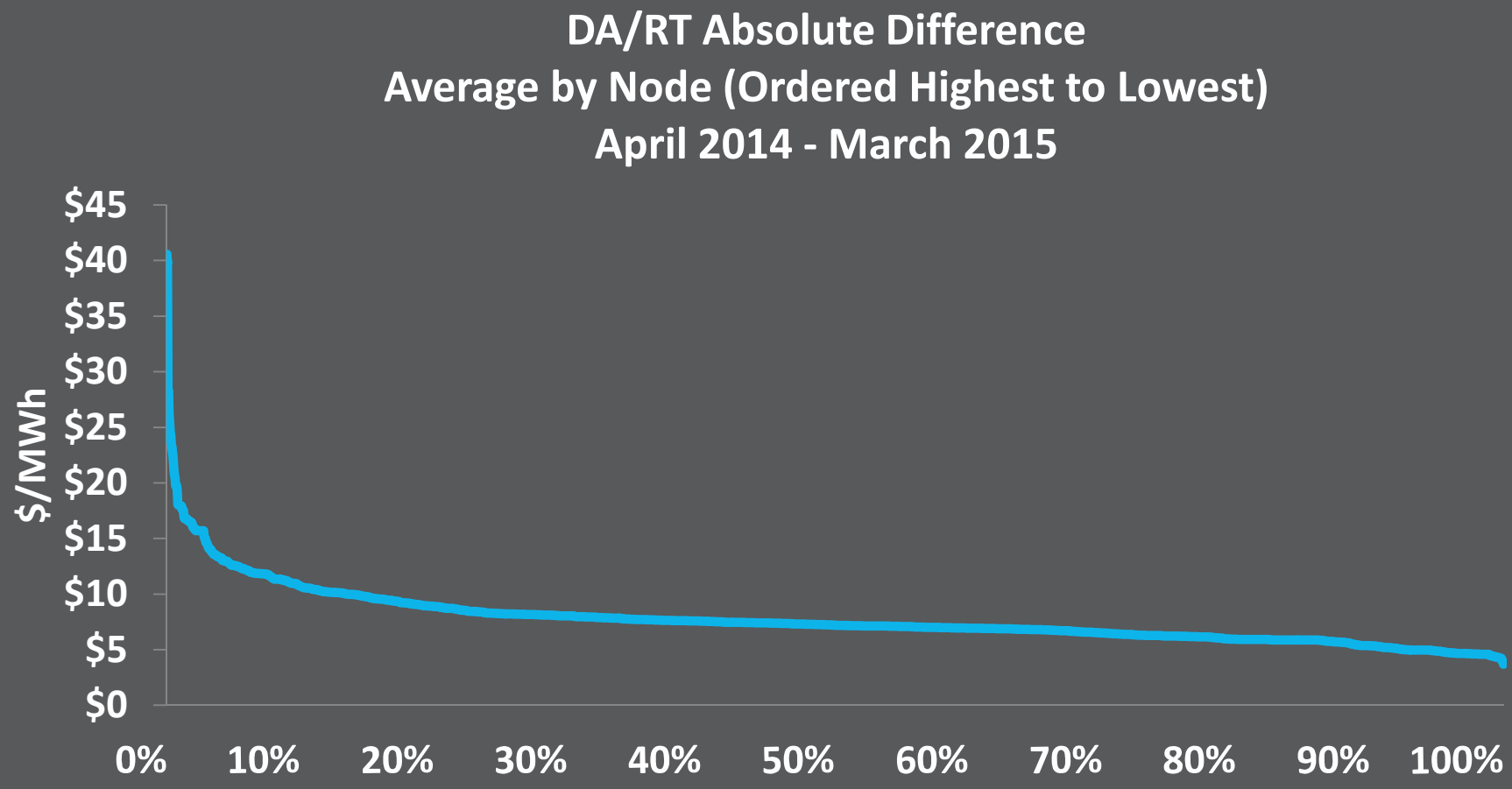


Source: Potomac Economics

"A Number of Factors, Such as Wind Output Volatility, Forced Generation or Transmission Outages, and Load Forecasting Errors, Can Cause Real-Time Prices to Be Significantly Higher or Lower Than Anticipated in the Day-Ahead"

– 2013 State of the Market Report For the MISO Electricity Markets By Potomac Economics

Review of DA & RT Deviation: MISO

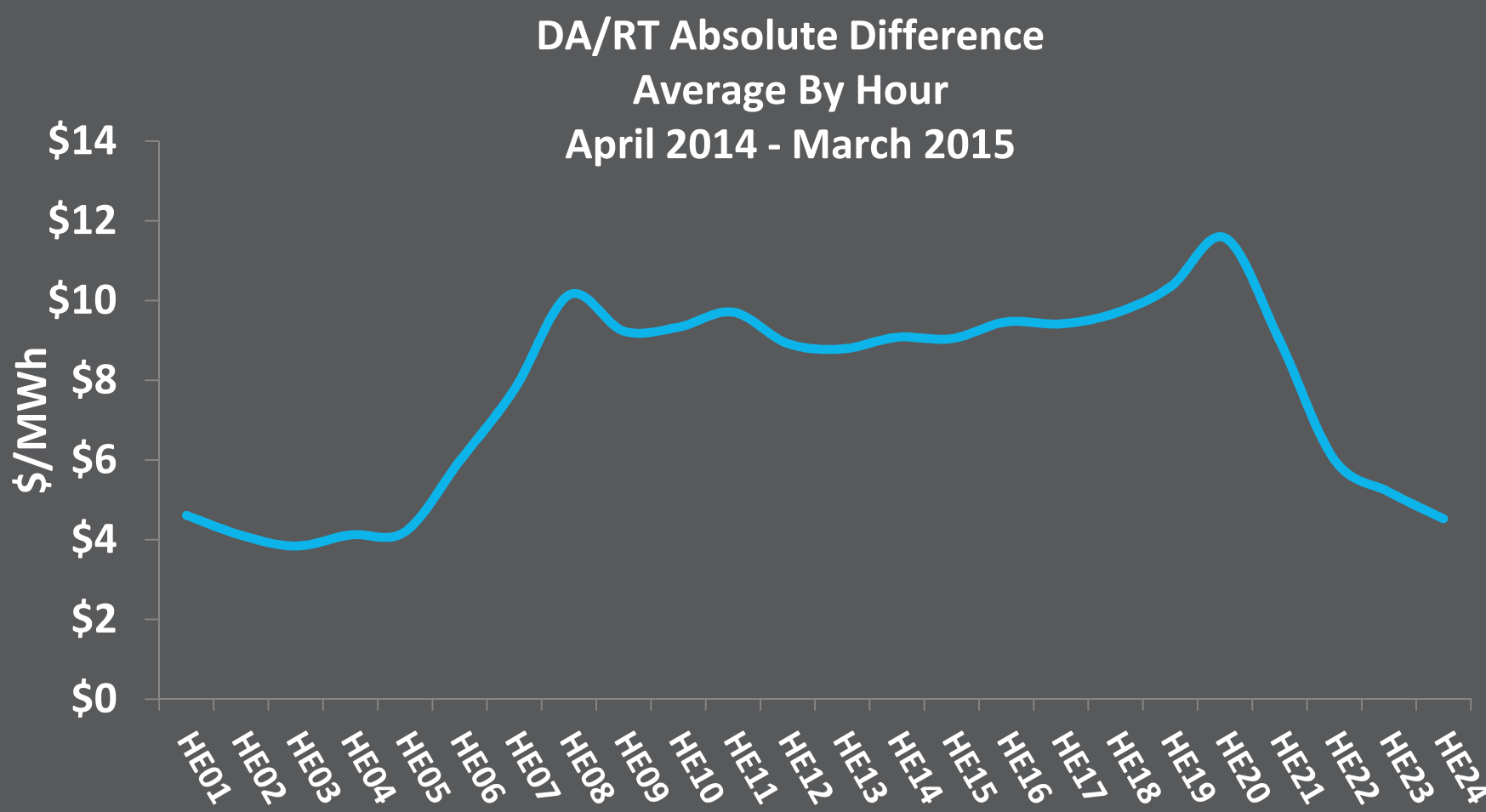


Average Absolute Difference - $7.67/MWh

Average DA Price - $31.85/MWh; Average RT Price $31.31/MWh

Source: MISO

Review of DA & RT Deviation: MISO



Source: MISO

Modified Objective Function

- INCREMENTAL COST X OUTPUT
  - LESS (RESOURCE ECON MAX – OUTPUT) X CALL PREMIUM
  - LESS (OUTPUT – RESOURCE ECON MIN) X PUT PREMIUM

Example Flex DA/RT: Assumptions

- Resource Operating Range
  - 40 MW to 160 MW at $35 Cost
- Assume Ramp Rate Very Fast
- Resource Does Not Qualify For Ancillaries
- RT LMP Pattern Resembles the Role of a Dice X $5 + $15
  - Equal Chance of $20, $25, $30, $35, $40, and $45
- Assume DA LMP Clears at $32.50
  - E.g., DA and Average RT Converge at $32.50
  - DA and RT LMPs Similar to MISO Averages of $31.85 and $31.31
  - Average Absolute DA/RT Deviation = $7.50, Similar to MISO Average of $7.67

Question: Should the Resource Clear DA?

Example Flex DA/RT – Assume 100 MWs "Flex" Clear

Resource Owner Perspective – DA Portion of Market	
Econ Max (MW)	160
Econ Min (MW)	40
Cost $/MWh	$35
DA LMP	$32.50
"Flex" Cleared MW DA	100
DA Revenue	$3,250
DA Cost	$3,500
DA Gain/(Loss)	($250)

Example Flex DA/RT – Assume 100 MWs "Flex" Clear

RT LMP $/MWh	Initial DA Position MW	Δ RT MW Dispatch Increase/ (Decrease)	Final MW Position	RTO Charge /(Credit) to Resource @ RT LMP	Resource Incremental Savings/(Cost) @ $35/MWh	RT Δ Operating Margin to Resource
$20	100	(60)	40	$1,200	$2,100	$900
$25	100	(60)	40	$1,500	$2,100	$600
$30	100	(60)	40	$1,800	$2,100	$300
$35	100	0	100	$0	$0	0
$40	100	60	160	($2,400)	($2,100)	$300
$45	100	60	160	($2,700)	($2,100)	$600
Average	**100**	**(10)**	**90**	**($100)**	**$350**	**$450**

DA Gain/(Loss)	**$(250)**
Expected RT Gain/(Loss)	**$450**
Expected Net Gain/(Loss)	**$200**

Example Flex DA/RT

Call and Put Value - $35 Resource		
RT LMP	**Call Value**	**Put Value**
$20.00	$0.00	$15.00
$25.00	$0.00	$10.00
$30.00	$0.00	$5.00
$35.00	$0.00	$0.00
$40.00	$5.00	$0.00
$45.00	$10.00	$0.00
Average	**$2.50**	**$5.00**

Modified Objective Function:

$35 x DA Output – (160 - DA Output) x $2.50 – (DA Output – 40) x $5.00

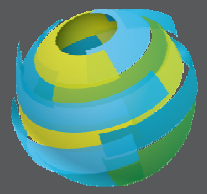
Benefits of Flex DA/RT

- Promotes the Use of Efficient Resources
- Promotes Stable and Predictable Prices
- Promotes the Efficient Use of Resources
- Promotes Fairness:
  - Likes Treated Like
  - Unlikes Treated Differently
- Reflects Present and Future Costs
- Promotes Innovation/Response to Change
- Feasible to Implement
- Easy to Understand

Summary

- Expected Value of Resource Flexibility
  - Significant and Overlooked in Most of Today's Unit Commitment Methodology
  - Can Be Monetized Through Determining a Resource's "Call" and "Put" Value, and Incorporated Directly Into the Objective Function
- The Flex DA/RT Method
  - Easy to Understand and Explain
  - Feasible, Economic, and Fair

Questions?



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