MIO Pricing in New York

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Market Pricing Working Group

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DRAFT—For Discussion Purposes Only

LECG

Agenda

The agenda for today's presentation is:

- **Multi-interval optimization pricing within New York's RTD model**
  - ***Algorithm similarities***
  - ***Pricing differences***
- **MIO Pricing Examples**
  - ***Pricing Principles when units have to ramp early***
- **Examples of actual NY MIO prices**

RTD Algorithm in New York - Similarities

The multi-interval optimizations have a number of similarities:

- **Both were put in place to eliminate the myopic tendencies of the 5-minute dispatches that preceded them**
- **The multi-interval optimizations allow the total cost of meeting load to be reduced**
  - ***This principle is consistent amongst the objective functions of nearly all electricity market operators and is at times described in the Ontario market as "maximizing the gains from trade"***
- **Both models optimize over 5 points in time spanning approximately one hour into the future**

RTD Algorithm in New York - Prices

New York determines its prices from the multi-step optimization pass:

- **This allows the impacts of re-dispatch costs associated with ramp constraints between the current and future periods to be reflected in the current periods LBMPs**

In the analyses that have been presented to this group regarding Ontario's MIO the prices come from a single step optimization that follows the multi-step optimization

- **Ramp constraints provided by the multi-step optimization are reflected in dispatch limits of the first time step but the re-dispatch costs associated with the ramp constraints do not show up in the period 1 prices**

Pricing When Resources Have To Ramp Early

When slower moving expensive resources have to be dispatched up while less expensive faster moving resources are ramped down in order to meet a net generation increase in a future period how should the price be set?

- **NY's price calculation approach follows the concept of evaluating the change in total cost of meeting load at the point in time that the price is being calculated – a so called incremental analysis**

Example

	Offer Price ($/MWh)	Bid Min (MW)	Bid Max (MW)	5-Minute Ramp Capability (MW)
Unit A	20	0	50	20
Unit B	28	0	30	10
Unit C	45	20	60	4
Unit D	60	40	70	2
Unit E	200	0	100	10

Myopic	**Current Output**	**Pd 1 Dispatch**	**Pd 2 Dispatch**	**Pd 1 Cost**	**Pd 2 Cost**	
Unit A	35	50	50	$ 1,000	$ 1,000	
Unit B	26	28	30	$ 784	$ 840	
Unit C	18	20	24	$ 900	$ 1,080	
Unit D	40	40	42	$ 2,400	$ 2,520	
Unit E	0	0	1	$ -	$ 200	**Total Cost**
Total	119	138	147	$ 5,084	$ 5,640	$ 10,724

MIO	**Current Output**	**Pd 1 Dispatch**	**Pd 2 Dispatch**	**Pd 1 Cost**	**Pd 2 Cost**	
Unit A	35	50	50	$ 1,000	$ 1,000	
Unit B	26	27	30	$ 756	$ 840	
Unit C	18	21	25	$ 945	$ 1,125	
Unit D	40	40	42	$ 2,400	$ 2,520	
Unit E	0	0	0	$ -	$ -	**Total Cost**
Total	119	138	147	$ 5,101	$ 5,485	$ 10,586

Example

The example shows the contrast between the myopic dispatch solution and the MIO dispatch solution:

- **The prices in the myopic dispatch would be $28 and $200 in the first and second periods respectively**
- **The price in the MIO solution is $28 in the first time period and is undefined in the second time period. Algorithmically, it must be greater than or equal to $60 and less than or equal to $200.**
  - ***If actual load in period 2 is higher than predicted in the period 1 dispatch the price will go to $200***
  - ***If actual load in period 2 is less than predicted in the period 1 dispatch the price will go to $60***
  - ***My understanding is that the "MIO incremental price" set by the IESO would in this instance be $60***

Example – Pd 1 Price Derivation

MIO	Current Output	Pd 1 Dispatch	Pd 2 Dispatch	Pd 1 Cost	Pd 2 Cost	
Unit A	35	50	50	$ 1,000	$ 1,000	
Unit B	26	27	30	$ 756	$ 840	
Unit C	18	21	25	$ 945	$ 1,125	
Unit D	40	40	42	$ 2,400	$ 2,520	
Unit E	0	0	0	$ -	$ -	**Total Cost**
Total	119	138	147	$ 5,101	$ 5,485	$ 10,586

MIO	Current Output	Pd 1 Dispatch	Pd 2 Dispatch	Pd 1 Cost	Pd 2 Cost	
Unit A	35	50	50	$ 1,000	$ 1,000	
Unit B	26	28	30	$ 784	$ 840	
Unit C	21	21	25	$ 945	$ 1,125	
Unit D	40	40	42	$ 2,400	$ 2,520	
Unit E	0	0	0	$ -	$ -	**Total Cost**
Total	122	139	147	$ 5,129	$ 5,485	$ 10,614

Change In Cost	$ 28

Example

But why is the first period price in the MIO solution only $28 when a MW of $45 power is being dispatched on Unit C in period 1?

- **The net revenue of Unit C over the two intervals $28 plus $60 is $88, only $2 short of the breakeven revenue for the unit**
- **The reason the model chooses to make this decision is that any reduction of the Unit C production in period 1 immediately increases the cost in period at a rate of $200/MWh**
- **This is known as a duality gap or knife edge situation**
- **If unit C had been a $44 unit it would be indifferent about being dispatched up in the first period as the anticipated $16 profit in period 2 offsets the $16 loss they would have to incur in the first period to receive that additional profit.**

Example

If the Unit D bid is now raised to $70 instead of $60 in the example how does the solution change?

- **The period 2 price now climbs to $70 so that the two period revenue has climbed to $98 then more than 1 MW of $45 energy would have been dispatched up in the first time period**
- **Unit C is now taken to a point in the first period where it is ramp constrained up.**
  - ***Even though the price in period 1 is $28 and the resource offers at $45 losing $17, the anticipated $25 profit in period 2 ($70 - $45) is worth that loss***
  - ***When a unit is ramp constrained up the clearing price should be greater than or equal to the offer price of the generator***
  - ***In a myopic world this is a single price single dispatch comparison***
  - ***Within the MIO when ramp constraints on generators bind it is a multi-period evaluation ($70 + $28 > $45 + $45)***

Example – Optimal vs. Sub-Optimal

MIO	Current Output	Pd 1 Dispatch	Pd 2 Dispatch	Pd 1 Cost	Pd 2 Cost		
Unit A	35	50	50	$ 1,000	$ 1,000		
Unit B	26	27	30	$ 756	$ 840		
Unit C	18	22	26	$ 990	$ 1,170		
Unit D	40	40	41	$ 2,800	$ 2,870		Now $70
Unit E	0	0	0	$ -	$ -	**Total Cost**	
Total	119	139	147	$ 5,546	$ 5,880	$ 11,426	

MIO	Current Output	Pd 1 Dispatch	Pd 2 Dispatch	Pd 1 Cost	Pd 2 Cost		
Unit A	35	50	50	$ 1,000	$ 1,000		
Unit B	26	28	30	$ 784	$ 840		
Unit C	21	21	25	$ 945	$ 1,125		
Unit D	40	40	42	$ 2,800	$ 2,940		Now $70
Unit E	0	0	0	$ -	$ -	**Total Cost**	
Total	122	139	147	$ 5,529	$ 5,905	$ 11,434	

Change In Cost	$ 8

Example

If the Unit D bid is now raised to $70 instead of $60 in the example how does the solution change?

- **Note that the total cost of the solution in the top table (optimal) is lower than the total cost of the bottom table (sub-optimal)**
- **The $28 price in the first intervals does not need to be increased for the dispatch decision on Unit C to be profitable and optimal**
  - ***It is the duality gap of the prior example that creates the seeming inequity for Unit C***

When a Unit is dispatched OOM who pays?

When a unit is dispatched out-of-merit it may require some form of supplemental payment

- **In the first example this would amount to a $2 uplift payment to Generator C in period 1**
- **NY has BPCG payments when units are dispatched up OOM and DA Margin Assurance payments in situations when generators are dispatched down OOM and are required to buy back at a loss**
  - ***This type of construct may be more opaque in Ontario given the CMSC and SGOL side payments that exist in today's settlements***

When a Unit is dispatched OOM who pays?

Assuming that the payment mechanism can be established the question becomes how should this be supplemental payment be recovered?

- **The main difficulty is that the costs are incurred in advance of the period when the benefits are accrued, i.e., the re-dispatch taken in the example reduces total cost in Period 2 and increases total cost in Period 1**
  - ***The payment to the generator would be in Period 1***
  - ***The benefits of the re-dispatch occur chiefly in Period 2***
- **Uplifts in Ontario are recovered from the loads within each dispatch cycle so the uplift would be paid by loads in Period 1**
  - ***The question then becomes whether it is reasonable to believe that the pattern of loads are significantly and systematically biased in such a way to penalize a particular group of loads***
  - ***From 5-minute to 5-minute period this is likely to be in the noise level of these calculations and shouldn't pose any systematic wealth transfer***

March 24, 2005 9:55:00 PM (prevailing ET)

TIME_STAMP	WEST	GENESE	CENTRL	NORTH	MHK VL	CAPITL	HUD VL	MILLWD	DUNWOD	N.Y.C.	LONGIL	HQ	NPX	OH
3/25/2005 2:55	(822.70)	(873.41)	(869.04)	(850.68)	(888.28)	(922.37)	(951.22)	(957.34)	(959.09)	(943.76)	(973.08)	(854.18)	(927.62)	(813.09)
3/25/2005 3:00	944.47	1,016.49	1,017.52	1,001.06	1,043.24	1,087.48	1,114.23	1,121.43	1,123.49	1,154.35	1,146.12	1,006.20	1,089.54	937.27
3/25/2005 3:15	62.02	66.67	66.47	65.66	68.29	71.19	72.94	73.48	73.62	75.71	75.03	65.93	71.39	61.89
3/25/2005 3:30	59.54	64.02	63.96	63.24	65.71	68.57	70.39	70.91	71.10	73.05	72.73	63.50	68.83	59.41
3/25/2005 3:45	56.03	60.12	60.18	59.57	61.90	64.59	66.36	66.85	66.97	68.96	71.80	59.82	64.89	55.90

TIME_STAMP	TCG_NAME	Regulation Price	10 Spin Price	10 Nonspin Price	30 Operating Price
3/25/2005 2:55	NYCA	40.00	-	-	-
3/25/2005 3:00	NYCA	250.00	-	-	-
3/25/2005 3:15	NYCA	62.84	-	-	-
3/25/2005 3:30	NYCA	60.29	-	-	-
3/25/2005 3:45	NYCA	56.38	-	-	-

TIME_STAMP	TCG_NAME	Regulation Price	10 Spin Price	10 Nonspin Price	30 Operating Price
3/25/2005 2:55	EAST	40.00	-	-	-
3/25/2005 3:00	EAST	250.00	21.53	-	-
3/25/2005 3:15	EAST	62.84	-	-	-
3/25/2005 3:30	EAST	60.29	-	-	-
3/25/2005 3:45	EAST	56.38	-	-	-

***** Pricing data presented in GMT**

April 12, 2005 12:55:00 AM (prevailing ET)

TIME_STAMP	WEST	GENESE	CENTRL	NORTH	MHK VL	CAPITL	HUD VL	MILLWD	DUNWOD	N.Y.C.	LONGIL	HQ	NPX	OH
4/12/2005 4:55	(171.43)	(178.43)	(181.94)	(181.20)	(185.07)	(190.05)	(195.76)	(196.31)	(196.68)	(189.61)	(111.91)	(182.49)	(192.07)	(169.95)
4/12/2005 5:00	223.89	233.32	238.39	237.91	242.75	249.27	256.29	256.77	257.50	266.68	263.78	239.60	251.69	221.71
4/12/2005 5:15	37.79	39.52	40.55	40.64	41.38	42.53	43.73	43.86	43.98	50.34	75.10	40.93	42.99	37.38
4/12/2005 5:30	30.37	31.76	32.66	32.76	33.33	34.29	35.29	35.39	35.49	42.46	74.45	32.99	34.66	30.00
4/12/2005 5:45	38.22	39.94	41.06	41.19	41.90	43.03	44.28	44.45	44.53	50.82	74.61	41.44	43.53	37.76

TIME_STAMP	TCG_NAME	Regulation Price	10 Spin Price	10 Nonspin Price	30 Operating Price
4/12/2005 4:55	NYCA	20.00	-	-	-
4/12/2005 5:00	NYCA	20.00	-	-	-
4/12/2005 5:15	NYCA	20.00	-	-	-
4/12/2005 5:30	NYCA	20.00	-	-	-
4/12/2005 5:45	NYCA	20.00	-	-	-

TIME_STAMP	TCG_NAME	Regulation Price	10 Spin Price	10 Nonspin Price	30 Operating Price
4/12/2005 4:55	EAST	20.00	-	-	-
4/12/2005 5:00	EAST	20.00	-	-	-
4/12/2005 5:15	EAST	20.00	-	-	-
4/12/2005 5:30	EAST	20.00	-	-	-
4/12/2005 5:45	EAST	20.00	-	-	-

***** Pricing data presented in GMT**

NY Prices

The price pattern observed in the preceding slides show a situation where either a large external transaction schedule change or significant quantities of generators turning off at the top of an hour creates a ramp constraint:

- **Low priced faster moving units are being held down while more expensive slower moving are ramped up**
- **The price is low in the first interval because an additional MW of load allows a cheap unit to be dispatched a MW higher in both the first and second periods thereby avoiding the dispatch of an expensive MW in the second, e.g. hypothetically $20 + $20 - $1,000 = -$960**

Would this be observed in MIO?

There are two reasons why the large negative price observed in the NY prices would not occur in MIO:

- **The NY multi-step pricing solution gives a different answer in this case than the single step pricing would have. The Ontario single step price will equal the incremental offer price of the lowest cost unit backed down to create upward ramp.**
- **Even if the multi-step prices were used, it is apparent from the results I have reviewed that the cheap resource in Ontario tends be capacity constrained in the second time period before it is ramp constrained which separates and 2nd period dispatch costs from first period price, i.e. the price would still have been $20 in the hypothetical posed on the previous slide.**
  - ***An additional MW of load in the first period is met by the $20 resource but this redispatch does not change anything in the second period***