Carbon Pricing

Calculating the LBMPc

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Revised to incorporate stakeholder tariff language feedback – revisions in green font.

Market Issues Working Group (MIWG)

May 30, 2019 Rensselaer NY

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Agenda

- Background
- Carbon* Impact to the LBMP (LBMPc) – Estimated Marginal Fuel Cost
- LBMPc Calculation – Inputs
- LBMPc Calculation – Fuel Prices by Region
- LBMPc Calculation – Variable Operations & Maintenance Cost
- LBMPc Calculation – Implied Heat Rate
- LBMPc Calculation – Carbon Emissions
- LBMPc Calculation – Social Cost of Carbon
- Carbon Pricing Timeline
- Appendix: LBMPc Examples

*Please note that throughout this presentation, the word "carbon" will be used to refer to Carbon Dioxide (CO_2).

Background

Background

- **This presentation expands upon the April 30, 2019 LBMPc MIWG presentation.***
  - Further detail is provided regarding the proposed LBMPc calculation.
  - Please note that the April 30, 2019 LBMPc presentation was reposted to reflect the NYISO's proposal to set the implied heat rate to zero when the calculated implied heat rate is below the minimum implied heat rate, as further outlined at slide 23.

*Link to the 4/30/2019 MIWG presentation: https://www.nyiso.com/documents/20142/6279405/4.30.2019_MIWG_Carbon_Pricing_LBMPc.pdf/8fd068cc-984d-a916-132d-15a507775756

Background

- **The IPPTF Carbon Pricing Proposal envisions including carbon pricing within the wholesale energy market using the existing offer structure.***
  - When appropriate, Market Participants can include carbon emissions costs in their economic offers.
  - The NYISO market software will not automatically calculate a carbon component of LBMP.
- **The NYISO will use an *ex post* calculation to estimate the LBMP carbon impact (LBMPc).**

*Link to IPPTF Carbon Pricing Proposal: https://www.nyiso.com/documents/20142/3911819/Carbon-Pricing-Proposal%20December%202018.pdf/72fe5180-ef24-f700-87e5-fb6f300fb82c

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How is the LBMPc used?

- **The $LBMP_C$ is needed to:**
  - Allocate the carbon credit to LSEs
    - Information on the proportional allocation methodology can be found in the February 4, 2019 MIWG materials.[1]
  - Prevent leakage and distortion of regional flows by charging imports and crediting exports the LBMPc.[2]
  - Provide market transparency
- **Note that internal generators are charged based on their actual emissions, not based on the $LBMP_C$.[3]**

1. Link to Carbon Residual Allocation presentation: https://www.nyiso.com/documents/20142/4815989/Carbon%20Pricing%20Residual%20Allocation%20FINAL.pdf/16101736-138a-e7ed-ad77-cbbef3141f16
2. Link to Carbon Pricing Import/ Export presentation: https://www.nyiso.com/documents/20142/4461032/1152019%20MIWG%20Carbon%20Pricing%20Transactions.pdf/d5b918ce-27e2-caf3-9935-138104168cde
3. Link to IPPTF Carbon Pricing Proposal: https://www.nyiso.com/documents/20142/2244202/IPPTF-Carbon-Pricing-Proposal.pdf/60889852-2eaf-6157-796f-0b73333847e8

Benefits

- **The NYISO's proposed LBMPc calculation provides a number of benefits:**
  - Transparent
  - Straightforward calculation of the LBMPc.
    - Marketers with imports/exports will be able to estimate their charge/credits, and LSEs will be able to estimate the carbon residual allocation.
  - Anticipate few intervals where LBMPc will need to be persisted.
  - Anticipate posting the LBMPc relatively soon after the RT LBMP posting.

LBMPc – Estimated Marginal Fuel Cost

LBMPc Calculation – Estimated Marginal Fuel Cost

- **Upon consideration of stakeholder feedback, the NYISO has revised its proposed LBMPc calculation.**
  - A variable operations and maintenance (VOM) cost will be subtracted from the LBMP.
  - This value will then be divided by the estimated marginal fuel cost ($/mmBTU), plus the cost of emissions ($/mmBTU).
- **As previously discussed, the NYISO will set the LBMPc to zero when the calculated LBMPc is less than zero.**

$$Emissions\ Cost_{ip} = (Emissions_{ip} * SCC_i)$$

$$\left(\frac{LBMP_{ip} - VOM_{ip}}{Fuel\ Cost_{ip} + Emissions\ Cost_{ip}}\right) = IHR_{ip}$$

$$LBMPc_{ip} = Max\left(\left(IHR_{ip} * Net\ SCC_i * Emissions_{ip}\right), 0\right)$$

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LBMPc Calculation - Inputs

LBMPc Calculation - Inputs

- **The NYISO will post several inputs that will be used in the LBMPc calculation:**
  - Fuel indices
  - Variable Operations and Maintenance Cost (VOM)
  - Minimum implied heat rate
  - Maximum implied heat rate
  - Assumed tons of carbon per mmBTU
  - RGGI price source
  - Social Cost of Carbon
- **Stakeholders will be kept informed as to updates to these values.**
- **The next few slides discuss these values.**

LBMPc Calculation – Fuel Indices by Region

LBMPc Calculation – Fuel Indices by Region

- **In response to stakeholder feedback, the NYISO will determine relevant transmission constraints that will be mapped to groups of Load Zones and fuel indices that are consistent with the NYISO's current reserve regions.**
  - The mapping to each Load Zone and fuel index are listed below.
- **The transmission constraint mapping and fuel indices used will be posted.**
  - The NYISO will not be posting fuel prices.

Region	Load Zone	Natural Gas Fuel Index
NYCA	A through K	NG TRANSCO Z6NY
EAST	A through E	NG DOMINION NP
	F through K	NG IROQUOIS Z2
SENY	A through F	NG IROQUOIS Z2
	G through K	NG TRANSCO Z6NY
NYC	A through I, & K	NG IROQUOIS Z2
	J	NG TRANSCO Z6NY
LI	A through J	NG IROQUOIS Z2
	K	NG TRANSCO Z6NY

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LBMPc Calculation – Fuel Indices by Region

- **The NYISO determined the frequency of the marginal natural gas fuel indices for each interval in January, July, and September 2018.**
  - There were 24,499 intervals considered in the analysis.
  - Totals in the table below sum to more than 100% because more than one fuel may be marginal in each interval.

Fuel Index	Number of Intervals	Percent of Total Intervals
NG TRANSCO Z6NY	17,204	67%
NG DOMINION NP	8,920	35%
NG IROQUOIS Z2	5,293	21%

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LBMPc Calculation – Fuel Indices by Region

- **Proxy generator bus prices will use a fuel consistent with the Zone into which the proxy sinks.**
  - The PJM Keystone proxy will use a blend of the fuel indices from different zones consistent with the LBMP calculation for that proxy.*
  - The O.H. Bruce proxy will use the fuel index from Zone A and Zone D
    - The fuel indices used for Zone A and Zone D will be equal in every interval under the NYISO's proposal.
  - HQ Cedars will use the fuel index from Zone D, while other HQ proxies listed will use the fuel index from Zone E.
    - The fuel indices used for Zone D and Zone E will be equal in every interval under the NYISO's proposal.

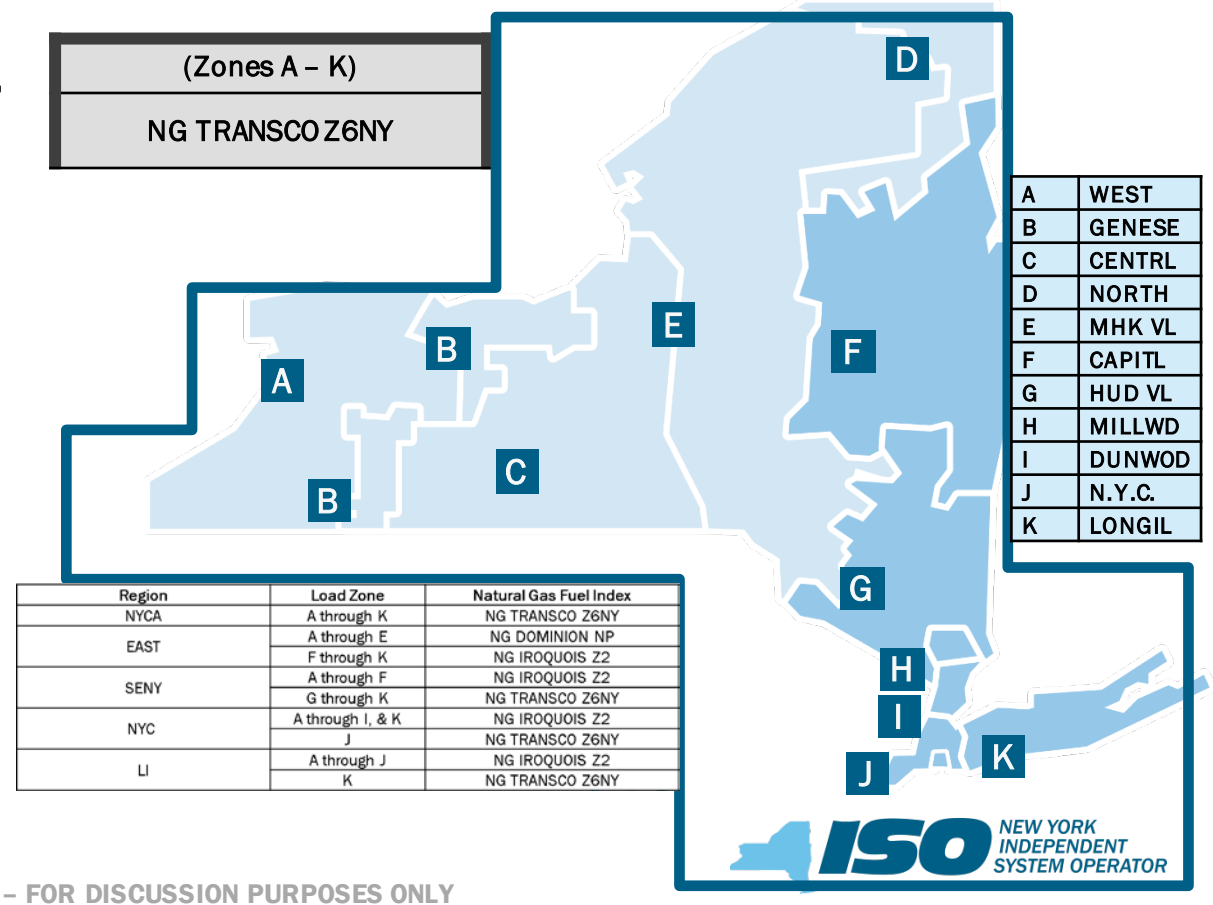
Proxy Generator Bus	PTID	Fuel Index used is the same as:
HQ		
HQ_GEN_IMPORT	323601	Zone E
HQ_LOAD_EXPORT	355639	Zone E
HQ_GEN_CEDARS_PROXY	323590	Zone D
HQ_LOAD_CEDARS_PROXY	355586	Zone D
HQ_GEN_WHEEL	23651	Zone E
HQ_LOAD_WHEEL	55856	Zone E
PJM		
PJM_GEN_KEYSTONE	24065	Zone A, Zone C, Zone I, Zone J
PJM_LOAD_KEYSTONE	55857	Zone A, Zone C, Zone I, Zone J
PJM_GEN_NEPTUNE_PROXY	323594	Zone K
PJM_LOAD_NEPTUNE_PROXY	355615	Zone K
PJM_GEN_VFT_PROXY	323633	Zone J
PJM_LOAD_VFT_PROXY	355723	Zone J
PJM_HTP_GEN	323702	Zone J
HUDSONTP_345KV_HTP_LOAD	355839	Zone J
ISO New England		
N.E._GEN_SANDY_POND	24062	Zone F
NE_LOAD_SANDY_PD	55858	Zone F
NPX_GEN_CSC	323557	Zone K
NPX_LOAD_CSC	355535	Zone K
NPX_GEN_1385_PROXY	323591	Zone K
NPX_LOAD_1385_PROXY	355589	Zone K
Ontario		
O.H._GEN_BRUCE	24063	Zone A, Zone D
OH_LOAD_BRUCE	55859	Zone A, Zone D

*The interchange percentages for the PJM – AC interface (PJM Keystone Proxy) are described at the following link: https://www.nyiso.com/documents/20142/2268509/NY-NJ_PAR_Interchange_and_OBF.pdf/b674eb7f-159e-1c8b-407a-17bda09b7b32

LBMPc Calculation – Fuel Indices by Region

- **When multiple constraints are binding, Transco Z6 will take priority over Iroquois Z2 and Dominion NP, while Iroquois Z2 will take priority over Dominion NP.**
  - Example 1:
    - If no transmission constraints bind that indicate a division of the identified regions, then Zones A through K will use Transco Z6 as the marginal fuel.

(Zones A – K)
NG TRANSCO Z6NY



A	WEST
B	GENESE
C	CENTRL
D	NORTH
E	MHK VL
F	CAPITL
G	HUD VL
H	MILLWD
I	DUNWOD
J	N.Y.C.
K	LONGIL

Region	Load Zone	Natural Gas Fuel Index
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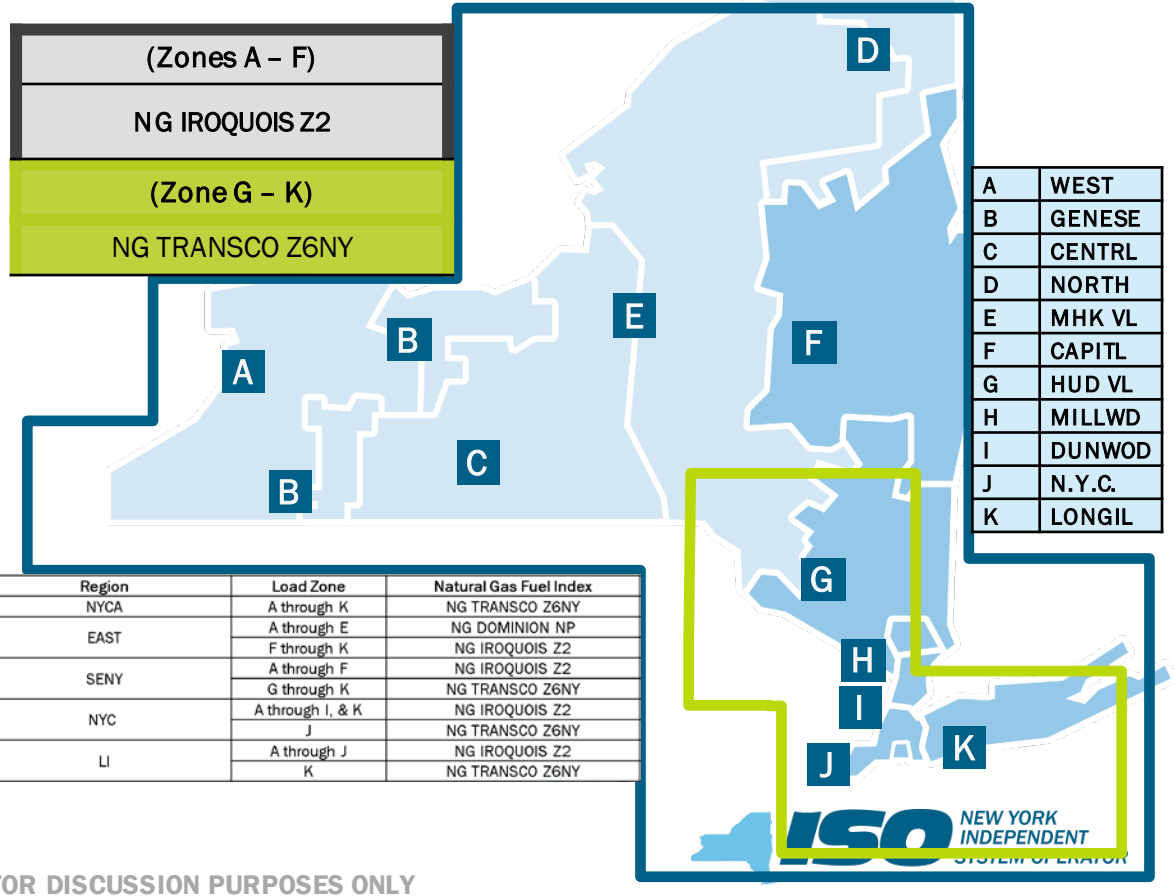
LBMPc Calculation – Fuel Indices by Region

- **When multiple constraints are binding, Transco Z6 will take priority over Iroquois Z2 and Dominion NP, while Iroquois Z2 will take priority over Dominion NP.**
  - Example 2:
    - If transmission constraints bind that indicate the East is active at the same time as SENY, then Zones A through F will use Iroquois Z2, while Zones G through K will use Transco Z6.



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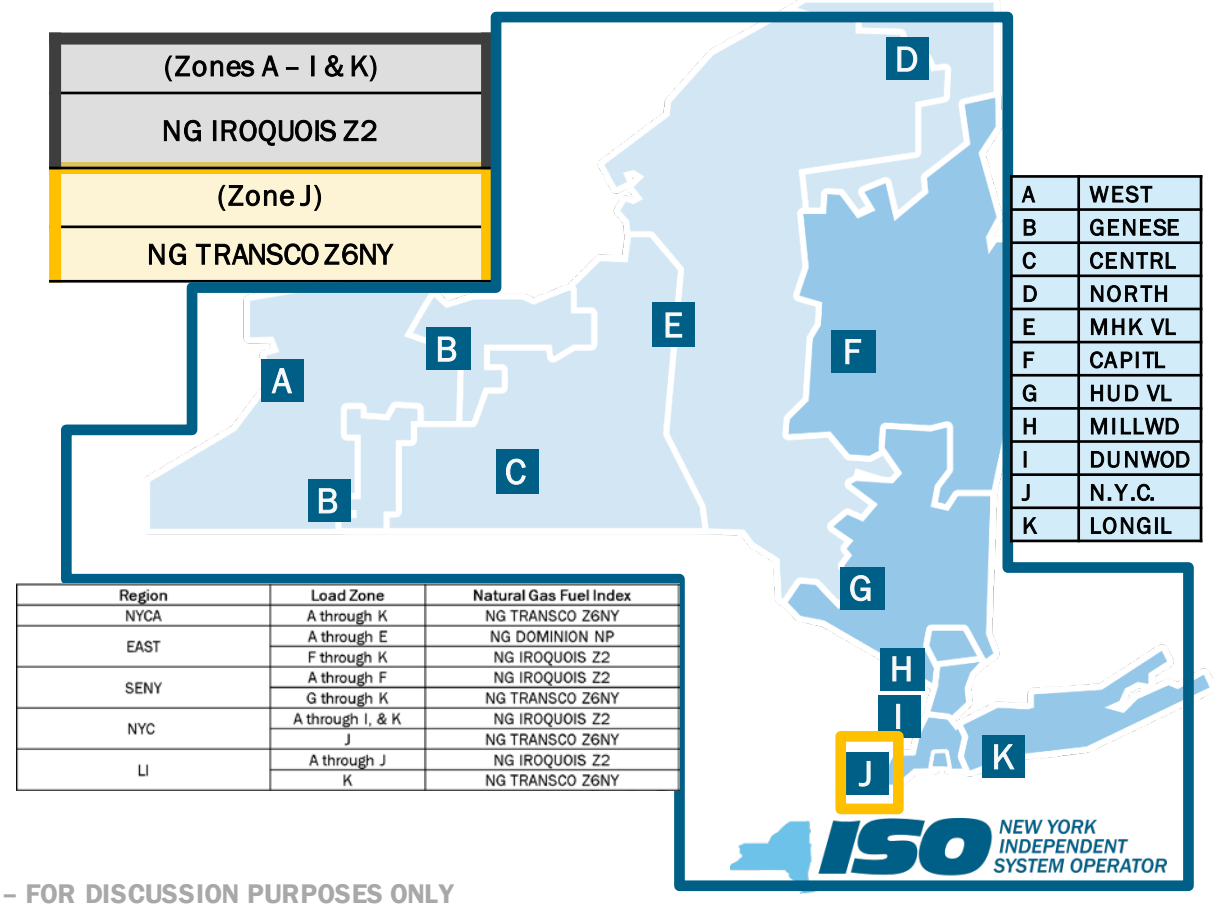
	J	NG TRANSCO Z6NY
LI	A through J	NG IROQUOIS Z2
	K	NG TRANSCO Z6NY

LBMPc Calculation – Fuel Indices by Region

- **When multiple constraints are binding, Transco Z6 will take priority over Iroquois Z2 and Dominion NP, while Iroquois Z2 will take priority over Dominion NP.**
  - Example 3:
    - If transmission constraints bind that indicate East is active at the same time as NYC, then Zones A through I & K will use Iroquois Z2 , while Zone J will use Transco Z6.



Region	Load Zone	Natural Gas Fuel Index
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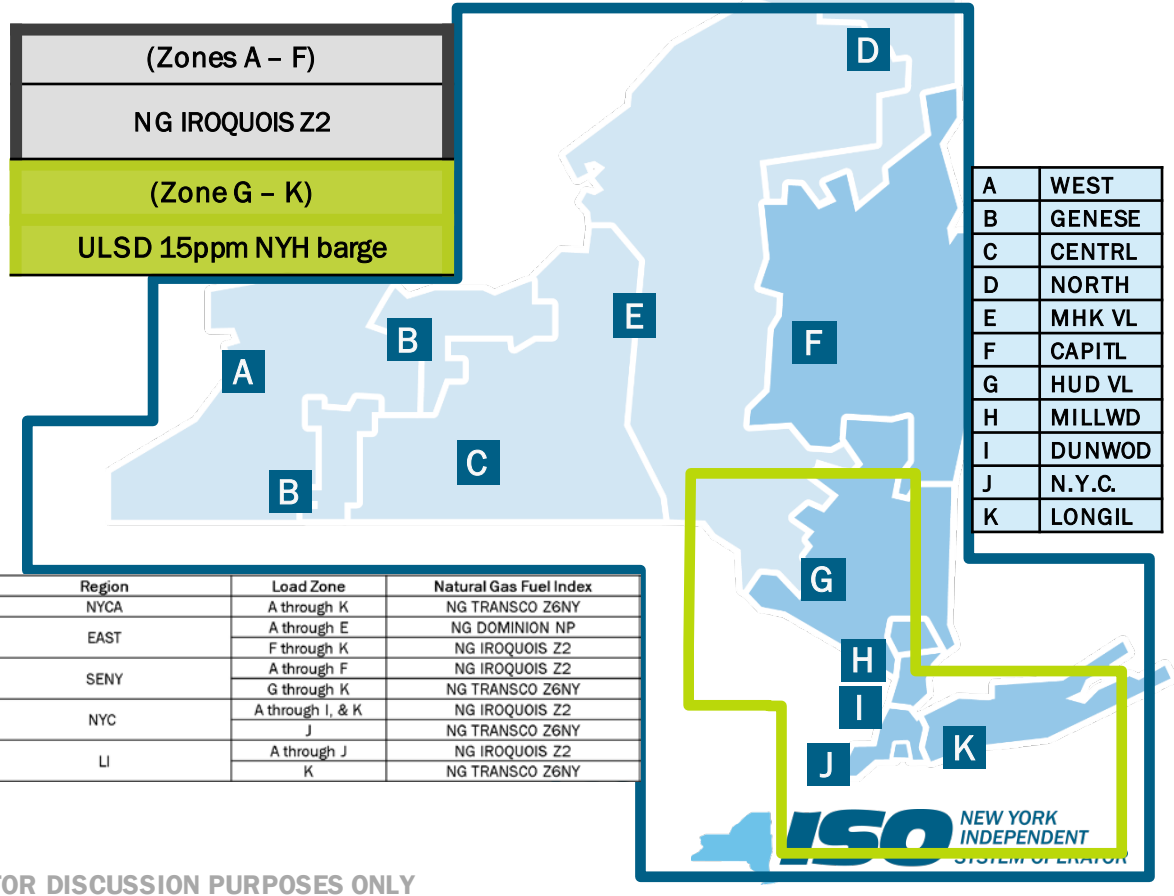
SENY	A through F	NG IROQUOIS Z2
	G through K	NG TRANSCO Z6NY
NYC	A through I, & K	NG IROQUOIS Z2
	J	NG TRANSCO Z6NY
LI	A through J	NG IROQUOIS Z2
	K	NG TRANSCO Z6NY

LBMPc Calculation – Fuel Indices by Region

If the price of Ultra-Low Sulfur Diesel (ULSD) is less than the natural gas fuel index for a region, then the price of ULSD will be used in the calculation of LBMPc.

- For example, assume the cost of ULSD 15ppm NYH barge is greater than Iroquois Z2, but less than Transco Z6.
  - If transmission constraints bind that indicate the East is active at the same time as SENY, then Zones A through F will use Iroquois Z2; if the cost of ULSD 15ppm NYH barge is less than the cost of Transco Z6, then Zones G through K will use ULSD 15ppm NYH barge.



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	K	NG TRANSCO Z6NY

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LBMPc Calculation – Variable Operations & Maintenance Cost

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LBMPc Calculataion – Variable Operations & Maintenance Cost

- **A variable operations and maintenance (VOM) cost will be subtracted from the LBMP, which will then be divided by the estimated marginal fuel cost ($/mmBTU), plus the cost of emissions ($/mmBTU).**
  - Subtracting a VOM cost in this manner performs the same function as the previously proposed fuel factor.
    - The NYISO will estimate the variable operations & maintenance cost used in the calculation, which will be posted to the NYISO website.
- **Upon implementation, the NYISO would use a VOM cost of $3.00.**

$$Emissions\ Cost_{ip} = (Emissions_{ip} * SCC_i)$$

$$\left(\frac{LBMP_{ip} - VOM_{ip}}{Fuel\ Cost_{ip} + Emissions\ Cost_{ip}}\right) = IHR_{ip}$$

$$LBMPc_{ip} = Max\left((IHR_{ip} * Net\ SCC_i * Emissions_{ip}), 0\right)$$

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LBMPc Calculation – Implied Heat Rate

LBMPc Calculation – Implied Heat Rate

- The implied heat rate produced by the calculation should be limited by a minimum and maximum value to maintain an appropriate LBMPc.
  - Without a maximum limit, the impact of shortage pricing (for example) on the LBMP would result in an implied heat rate that is inappropriately high.
  - Without a minimum limit, the impact of renewable generation (for example) on the LBMP would result in an implied heat rate that is inappropriately low.
    - The implied heat rate should be set to zero when less than the minimum limit and set to the maximum when above the maximum limit.
    - A low implied heat rate indicates that zero emission energy, that does <u>not</u> bid opportunity cost, is likely marginal.
  - The minimum and maximum heat rates would be posted.

LBMPc Calculation – Implied Heat Rate

- **Reference level heat rate data was queried for 2018 to determine the heat rate range within the NYCA. Upon implementation, the NYISO would :**
  - Use a minimum heat rate of 5 mmBTU/ MWh
  - Use a maximum heat rate of 21 mmBTU/ MWh

LBMPc Calculation – Carbon Emissions

LBMPc Calculation – Carbon Emissions

- **The calculated implied heat rate will be multiplied by the tons of carbon per mmBTU to determine the tons of carbon per MWh for the applicable marginal fuel.**
  - The tons of carbon per mmBTU used will be posted for each fuel type.
- **Upon implementation, the NYISO would us a carbon content of fuel oil and natural gas consistent with EIA estimates.***
  - The carbon content of Natural Gas used in the LBMPc calculation will be 0.059 tons/mmBTU
  - The carbon content of Fuel Oil used in the LBMPc calculation will be 0.081 tons/mmBTU

*Source: https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

LBMPc Calculation – Social Cost of Carbon

LBMPc Calculation – Social Cost of Carbon

- **The tons of Carbon emissions (tons/MWh) will be multiplied by the Net Social Cost of Carbon (in $/ton) to calculate the LBMPc (in $/MWh).**
  - The Social Cost of Carbon in effect would be posted.
  - The RGGI price source in effect would be posted.
- **Upon implementation, the NYISO would:**
  - Use a gross Social Cost of Carbon established by the PSC
  - Use the following RGGI price index: RGGI US allowance prompt month – Washington close^

*NYPSC Case No. 15-E-0302 – Proceeding on Motion of the Commission to Implement a Large-Scale Program and a Clean Energy Standard – *Order Adopting a Clean Energy Standard* (August 1, 2015).

^The NYISO intends to use RGGI price data consistent with current MMA processes, please see the NYISO Reference Level Manual, Section 6: https://www.nyiso.com/documents/20142/2923301/rl_mnl.pdf/ae26885c-9f44-b0bb-11ab-e09ac2431c69

Carbon Pricing Timeline

Carbon Pricing Timeline

MIWG Meeting Date	Topic/ Deliverable
~~Tuesday, January 15, 2019~~	~~Import/ Export Transaction Examples~~
~~Tuesday, January 22, 2019~~	~~Overview of Impacted Tariff Sections~~
~~Thursday, January 31, 2019~~	~~Credit Overview~~
	~~Tariff Revisions Discussion~~
~~Monday, February 4, 2019~~	~~Carbon Residual Allocation~~
~~Thursday, February 28, 2019~~	~~Tariff Revisions Discussion~~
~~Thursday, March 28, 2019~~	~~Analysis Group: Carbon Pricing Supplemental Analysis~~
~~Monday, April 8, 2019~~	~~LBMPc Calculation & Opportunity Cost Resources~~
~~Tuesday, April 30, 2019~~	~~Additional Design Topics as Necessary (LBMPc)~~
~~Wednesday, May 22, 2019~~	~~Tariff Revisions Discussion~~
~~Thursday, May 30, 2019~~	~~Additional LBMPc Discussion & Tariff Revisions Discussion~~
Tuesday, June 11, 2019	Tariff Revisions Review

Appendix: LBMPc Examples

Marginal Fuel Used is Natural Gas

Variable		Interval 1
I	LBMP ($/MWh)	$50.00
II	Variable O&M (VOM) Cost	$3.00
III	Natural Gas Price ($/mmBtu)	$2.50
IV	Tons of Carbon per mmBTU	0.059
V	Social Cost of Carbon ($/ton)	$48.30
VI	Estimated Emissions Cost ($/mmBTU) [IV*V]	$2.85
VII	(LBMP-VOM)/(Fuel Price+Emissions Cost) (mmBtu/MWh) [(I-II)/(III+VI)]	8.8
VIII	Implied Heat Rate (mmBtu/MWh) [If VII < 5, then 0; If VII>21, then 21, Else VII]	8.8
IX	Estimated RGGI Cost ($/ton)	$4.00
X	Net Social Cost of Carbon ($/ton) [V-IX]	$44.30
XI	Tons of Carbon per MWh [IV*VIII]	0.518
XII	LBMPc ($/MWh) [X*XI]	$22.96

*Variables and calculations on this slide are for example purposes only

^For this example, Maximum Implied Heat Rate = 21, Minimum Implied Heat Rate = 5

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Marginal Fuel used is Fuel Oil

Variable		Interval 1
I	LBMP ($/MWh)	$80.00
II	Variable O&M (VOM) Cost	$3.00
III	Fuel Oil Price ($/mmBtu)	$6.00
IV	Tons of Carbon per mmBTU	0.081
V	Social Cost of Carbon ($/ton)	$48.30
VI	Estimated Emissions Cost ($/mmBTU) [IV*V]	$3.91
VII	(LBMP-VOM)/(Fuel Price+Emissions Cost) (mmBtu/MWh) [(I-II)/(III+VI)]	7.8
VIII	Implied Heat Rate (mmBtu/MWh) [If VII < 5, then 0; If VII>21, then 21, Else VII]	7.8
IX	Estimated RGGI Cost ($/ton)	$4.00
X	Net Social Cost of Carbon ($/ton) [V-IX]	$44.30
XI	Tons of Carbon per MWh [IV*VIII]	0.629
XII	LBMPc ($/MWh) [X*XI]	$27.87

*Variables and calculations on this slide are for example purposes only

^For this example, Maximum Implied Heat Rate = 21, Minimum Implied Heat Rate = 5

Minimum Heat Rate Effective

- **Assume the minimum heat rate in effect is 5.0.**
  - In the following example, the implied heat rate calculated at row IX would have been 1.4, but this is below the minimum value, thus the implied heat rate is set to 0.

Variable		Interval 1
I	LBMP ($/MWh)	$10.00
II	Variable O&M (VOM) Cost	$3.00
III	Natural Gas Price ($/mmBtu)	$2.50
IV	Tons of Carbon per mmBTU	0.059
V	Social Cost of Carbon ($/ton)	$48.30
VI	Estimated Emissions Cost ($/mmBTU) [IV*V]	$2.85
VII	(LBMP-VOM)/(Fuel Price+Emissions Cost) (mmBtu/MWh) [(I-II)/(III+VI)]	1.3
VIII	Implied Heat Rate (mmBtu/MWh) [If VII < 5, then 0; If VII>21, then 21, Else VII]	0.0
IX	Estimated RGGI Cost ($/ton)	$4.00
X	Net Social Cost of Carbon ($/ton) [V-IX]	$44.30
XI	Tons of Carbon per MWh [IV*VIII]	0.000
XII	LBMPc ($/MWh) [X*XI]	$0.00

*Variables and calculations on this slide are for example purposes only

^For this example, Maximum Implied Heat Rate = 21, Minimum Implied Heat Rate = 5

Maximum Heat Rate Effective

- **Assume the maximum heat rate in effect is 21.0.**
  - In the following example, the implied heat rate calculated at row IX would have been 97.2, but this is above the maximum value, thus the implied heat rate is set to 21.0.

Variable		Interval 1
I	LBMP ($/MWh)	$500.00
II	Variable O&M (VOM) Cost	$3.00
III	Natural Gas Price ($/mmBtu)	$2.50
IV	Tons of Carbon per mmBTU	0.059
V	Social Cost of Carbon ($/ton)	$48.30
VI	Estimated Emissions Cost ($/mmBTU) [IV*V]	$2.85
VII	(LBMP-VOM)/(Fuel Price+Emissions Cost) (mmBtu/MWh) [(I-II)/(III+VI)]	92.9
VIII	Implied Heat Rate (mmBtu/MWh) [If VII < 5, then 0; If VII>21, then 21, Else VII]	21.0
IX	Estimated RGGI Cost ($/ton)	$4.00
X	Net Social Cost of Carbon ($/ton) [V-IX]	$44.30
XI	Tons of Carbon per MWh [IV*VIII]	1.239
XII	LBMPc ($/MWh) [X*XI]	$54.89

*Variables and calculations on this slide are for example purposes only

^For this example, Maximum Implied Heat Rate = 21, Minimum Implied Heat Rate = 5

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- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policy makers, stakeholders and investors in the power system

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