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VIA ELECTRONIC FILING

July 16, 2018

Martha Lynn Jarvis
Chief Clerk
North Carolina Utilities Commission
430 North Salisbury Street
Dobbs Building
Raleigh, North Carolina 27603-5918

Re: Docket No. E-22, Sub 418

Dear Ms. Jarvis:

Consistent with Article XIV of the Agreement and Stipulation of Settlement filed with the North Carolina Utilities Commission and the Commission's order of December 22, 2016, in the above referenced docket, Monitoring Analytics, LLC, acting in its capacity as the Independent Market Monitor for PJM Interconnection, L.L.C., submits the attached report. The report includes the information specified in Paragraph 6 of the Joint Offer of Settlement between Dominion North Carolina Power and PJM Interconnection, L.L.C., filed in Docket No. E-22, Sub 532, on December 10, 2004.

Please contact Joseph Bowring if you have any questions about this matter, at 610 271-8051 or at joseph.bowring@monitoringanalytics.com.

Yours truly,

A handwritten signature in blue ink that reads 'Jeffrey Mayes'.

Jeffrey Mayes, General Counsel

cc: Andrea R. Kells, Esq.



Monitoring
Analytics

**REPORT TO THE NORTH
CAROLINA UTILITIES
COMMISSION**

**Congestion in the Dominion Service
Territory in North Carolina:
2018**

The Independent Market Monitor for PJM

July 16, 2018

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Overview of Congestion Calculations

This report provides details of the congestion in the part of the Dominion Zone in North Carolina for the years 2016 and 2017.¹ Congestion is defined to be load payments in excess of generation revenues. Congestion calculations are for the part of the Dominion Zone in North Carolina and not for any specific organization. The report includes congestion event hours for the constraints which had the largest impact on congestion charges in the part of the Dominion Zone in North Carolina, either positive or negative, and the congestion charges associated with each constraint.²

This report, for the first time, provides two measures of congestion: Area Based Congestion and Constraint Based Congestion.

This report, for the first time, defines two approaches to calculating congestion paid by load in a defined area. Area Based Congestion is defined as the total congestion payments by load at the buses in the part of the Dominion Zone in North Carolina service territory minus the total congestion credits received by generation only at the buses in the part of the Dominion Zone in North Carolina.

Constraint Based Congestion is defined as the total congestion payments by load at the buses in the part of the Dominion Zone in North Carolina minus total congestion credits received by all generation that supplied that load, given the transmission constraints, regardless of location in the PJM system.

The MMU has previously reported Area Based Congestion in congestion reports for states. The total Area Based Congestion is the sum of all congestion for generators and load and virtuals with market activity at the buses in the part of the Dominion' Zone in North Carolina. By including only generation credits received by generation within a defined area, Area Based Congestion calculations ignores any credits associated with generation outside of the defined area that may, based on unit offers and transmission system capability, be supplying a portion of the load in the area.

¹ Any discussion of North Carolina congestion costs in this report refers to congestion costs associated with PJM related buses in the North Carolina, rather than the entire state of North Carolina.

² Congestion event hours are hours in which a transmission constraint is binding. In day ahead, an interval equals one hour. In real time, an interval equals five minutes. In order to have a consistent metric for day-ahead and real-time congestion frequency, real-time congestion frequency is measured using the convention that an hour is constrained if any one of its component five-minute intervals is constrained.

Constraint Based Congestion reflects differences between credits and charges caused by binding transmission limits on power flow from generators, regardless of location, to load in a specific area.

Constraint Based Congestion is a more accurate measure of congestion, which is the difference between load charges and generation credits caused by transmission constraints that provide access to low cost generation and require the use of higher cost local generation. Constraint Based Congestion reflects the underlying characteristics of the complete power system as it affects the defined area, including the nature and capability of transmission facilities, the offers and geographic distribution of generation facilities, the level and geographic distribution of incremental bids and offers and the geographic and temporal distribution of load.

Locational Marginal Price (LMP)

Components

LMP at a bus reflects the incremental price of energy at that bus. LMP at any bus can be deconstructed into three components: the system marginal price (SMP); the marginal loss component of LMP (MLMP); and the congestion component of LMP (CLMP).

SMP, MLMP and CLMP result from the least cost, security constrained dispatch of system resources to meet system load. SMP is the incremental cost of energy, given the current dispatch and given the choice of reference bus, or LMP net of losses and congestion. Losses refer to energy lost to physical resistance in the transmission and distribution network as power is moved from generation to load. The greater the resistance of the system to flows of energy from generation to loads, the greater the losses of the system and the greater the proportion of energy needed to meet a given level of load. Total losses refer to the total system wide losses as a result of moving power from injections to withdrawals on the system. Marginal losses are the incremental change in system losses caused by changes in the system load and generation patterns.³ The first derivative of total losses with respect to the power flow equals marginal losses. The marginal loss associated with meeting load at a specific bus is the MLMP at that bus. The CLMP at a bus reflects the incremental cost of relieving transmission constraints, while maintaining system power balance, at that bus.

Positive or negative CLMPs caused by a specific constraint at a specific bus indicate whether that constraint results in a higher or lower LMP at that bus relative to the

³ For additional information, see the *MMU Technical Reference for PJM Markets*, at “Marginal Losses,” <http://www.monitoringanalytics.com/reports/Technical_References/docs/2010-som-pjm-technical-reference.pdf>.

system marginal price. The total CLMP at a specific bus is the net sum of the positive and negative CLMPs caused by all binding constraints affecting that bus. Whether congestion credits or charges associated with generation or load at a bus are positive or negative is determined by whether the total CLMP is positive or negative at that bus. CLMPs are not congestion. CLMPs are a component of price.

Congestion occurs when available, least-cost energy cannot be delivered to all loads because transmission facilities are not adequate to deliver that energy. When the least-cost available energy cannot be delivered to load in a transmission constrained area, higher cost units in the constrained area must be dispatched to meet that load.⁴ The result is that the price of energy in the constrained area is higher than in the unconstrained area because of the combination of transmission limitations and the cost of local generation. Congestion is the difference between the total cost of energy paid by load in the transmission constrained area and the total revenue received by generation to provide that energy. Congestion equals the sum of day-ahead and balancing congestion.

Table 1 shows the real-time, load-weighted average LMP components for PJM for 2012 through 2017 and the real-time, load-weighted average LMP components for the part of the Dominion Zone in North Carolina for 2012 through 2017.⁵

⁴ This is referred to as dispatching units out of economic merit order. Economic merit order is the order of all generator offers from lowest to highest cost. Congestion occurs when loadings on transmission facilities mean the next unit in merit order cannot be used and a higher cost unit must be used in its place.

⁵ The PJM real-time, load-weighted price is weighted by accounting load, which differs from the state-estimated load used in determination of the energy component (SMP). In the Real-Time Energy Market, the distributed load reference bus is weighted by state-estimated load in real time. When the LMP is calculated in real time, the energy component equals the system load-weighted price. But real-time bus-specific loads are adjusted, after the fact, based on updated load information from meters. This meter adjusted load is accounting load that is used in settlements and is used to calculate reported PJM load-weighted prices. This after the fact adjustment means that the Real-Time Energy Market energy component of LMP (SMP) and the PJM real-time load-weighted LMP are not equal. The difference between the real-time energy component of LMP and the PJM-wide real-time load-weighted LMP is a result of the difference between state-estimated and metered loads used to weight the load-weighted reference bus and the load-weighted LMP.

Table 1 PJM and the Dominion Zone in North Carolina real-time, load-weighted average LMP components (Dollars per MWh): 2012 through 2017

	PJM				NC			
	Real-Time LMP	Energy Component	Congestion Component	Loss Component	Real-Time LMP	Energy Component	Congestion Component	Loss Component
2012	\$35.23	\$35.18	\$0.04	\$0.01	\$36.54	\$35.19	\$1.03	\$0.32
2013	\$38.66	\$38.64	\$0.01	\$0.02	\$40.31	\$38.49	\$1.61	\$0.22
2014	\$53.14	\$53.13	(\$0.02)	\$0.02	\$59.64	\$53.75	\$5.43	\$0.46
2015	\$36.16	\$36.11	\$0.04	\$0.02	\$40.58	\$37.03	\$3.09	\$0.46
2016	\$29.23	\$29.18	\$0.04	\$0.01	\$31.04	\$29.12	\$1.78	\$0.14
2017	\$30.99	\$30.96	\$0.02	\$0.01	\$32.42	\$30.77	\$1.26	\$0.38

Table 2 shows the PJM day-ahead, load-weighted average LMP components for 2012 through 2017 and the day-ahead, load-weighted average LMP components for Dominion’s service territory in the state of North Carolina.

Table 2 PJM and the Dominion Zone in North Carolina day-ahead, load-weighted average LMP components (Dollars per MWh): 2012 through 2017

	PJM				NC			
	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component	Day-Ahead LMP	Energy Component	Congestion Component	Loss Component
2012	\$34.55	\$34.46	\$0.11	(\$0.01)	\$36.05	\$34.80	\$0.96	\$0.29
2013	\$38.93	\$38.79	\$0.13	\$0.00	\$41.36	\$39.06	\$2.49	(\$0.20)
2014	\$53.62	\$53.38	\$0.26	(\$0.02)	\$57.46	\$53.82	\$3.93	(\$0.29)
2015	\$36.73	\$36.51	\$0.24	(\$0.01)	\$42.34	\$37.70	\$4.03	\$0.60
2016	\$29.68	\$29.55	\$0.14	(\$0.01)	\$32.01	\$29.93	\$2.02	\$0.05
2017	\$30.85	\$30.81	\$0.05	(\$0.02)	\$32.88	\$31.10	\$1.48	\$0.30

Table 3 shows the PJM real-time, monthly, load-weighted average congestion component of LMP for 2012 through 2017 and the real-time, monthly, load-weighted average LMP congestion component in the part of the Dominion Zone in North Carolina.

Table 3 PJM and the Dominion Zone in North Carolina real-time, monthly, load-weighted average LMP congestion component (Dollars per MWh): 2012 through 2017

	PJM						NC					
	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
Jan	\$0.02	\$0.03	(\$0.01)	\$0.02	\$0.03	\$0.01	\$0.56	\$2.95	\$33.08	\$0.96	\$3.86	\$2.14
Feb	\$0.01	\$0.02	(\$0.33)	(\$0.02)	\$0.02	\$0.02	\$0.69	\$0.51	\$1.79	\$2.29	\$2.27	\$0.86
Mar	\$0.04	\$0.02	(\$0.06)	(\$0.00)	\$0.04	\$0.03	\$1.49	\$1.65	\$12.60	\$6.67	\$1.97	\$0.45
Apr	\$0.07	\$0.01	\$0.02	\$0.03	\$0.07	\$0.01	\$1.53	\$0.59	\$0.40	\$5.16	\$4.44	\$0.87
May	\$0.05	\$0.03	\$0.04	\$0.13	\$0.02	\$0.02	\$1.90	\$2.08	\$3.09	\$3.68	\$0.00	\$1.27
Jun	\$0.03	\$0.03	\$0.03	\$0.06	\$0.02	\$0.01	(\$0.08)	(\$0.12)	\$1.67	\$5.30	\$0.90	\$0.10
Jul	\$0.04	(\$0.00)	\$0.01	\$0.02	\$0.03	\$0.02	\$0.89	(\$2.04)	\$0.21	\$3.01	\$0.25	\$0.84
Aug	\$0.02	\$0.00	\$0.01	\$0.02	\$0.04	\$0.01	\$2.26	\$5.33	\$2.06	\$1.68	(\$0.24)	\$0.71
Sep	\$0.07	(\$0.05)	\$0.02	\$0.04	\$0.07	\$0.08	\$0.70	\$4.29	\$2.76	\$0.68	\$2.77	\$2.44
Oct	\$0.06	\$0.02	\$0.05	\$0.06	\$0.06	\$0.02	\$2.49	\$0.62	\$3.83	\$3.03	\$4.21	\$3.37
Nov	\$0.03	\$0.00	\$0.05	\$0.05	\$0.02	\$0.01	(\$0.49)	\$1.96	(\$0.69)	\$2.53	\$2.05	\$1.25
Dec	\$0.01	(\$0.02)	\$0.02	\$0.04	\$0.02	(\$0.01)	\$0.50	\$1.60	\$0.19	\$2.67	\$0.44	\$1.17
Annual	\$0.04	\$0.01	(\$0.02)	\$0.04	\$0.04	\$0.02	\$1.03	\$1.61	\$5.43	\$3.09	\$1.78	\$1.26

Table 4 shows the PJM day-ahead, monthly, load-weighted average LMP congestion component for 2012 through 2017 and the day-ahead, monthly, load-weighted average LMP congestion component for the part of the Dominion' Zone in North Carolina. In January and March of 2014, the day-ahead, monthly, load-weighted average LMP congestion components for the Dominion's service territory in the state of Carolina were high due to cold weather.

Table 4 PJM and the Dominion Zone in North Carolina day-ahead, monthly, load-weighted average LMP congestion component (Dollars per MWh): 2012 through 2017

	PJM						NC					
	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
Jan	\$0.07	\$0.12	\$0.76	\$0.38	\$0.19	\$0.08	\$0.46	\$2.53	\$10.66	\$2.55	\$3.77	\$1.65
Feb	\$0.10	\$0.04	\$0.30	\$0.77	\$0.17	\$0.01	\$0.90	\$1.29	\$2.66	\$10.10	\$3.02	\$0.73
Mar	\$0.07	\$0.03	\$0.19	\$0.29	\$0.07	\$0.01	\$1.61	\$1.50	\$9.84	\$5.51	\$2.44	\$0.94
Apr	\$0.08	\$0.03	\$0.02	(\$0.06)	\$0.04	(\$0.02)	\$2.06	\$0.58	\$1.69	\$4.48	\$4.01	\$1.20
May	\$0.10	\$0.10	\$0.14	\$0.20	\$0.06	(\$0.06)	\$1.98	\$1.68	\$3.65	\$4.81	\$0.86	\$1.31
Jun	\$0.17	\$0.18	\$0.23	\$0.30	\$0.16	\$0.10	(\$0.20)	\$0.94	\$2.53	\$4.79	\$1.24	\$0.69
Jul	\$0.20	\$0.29	\$0.23	\$0.18	\$0.26	\$0.13	\$0.31	\$0.53	\$2.65	\$3.91	(\$0.16)	\$0.97
Aug	\$0.10	\$0.09	\$0.12	\$0.12	\$0.29	\$0.03	\$1.45	\$3.87	\$2.80	\$1.94	\$0.58	\$1.13
Sep	\$0.18	\$0.34	\$0.18	\$0.23	\$0.19	\$0.03	\$0.50	\$11.09	\$4.09	\$1.30	\$2.30	\$3.00
Oct	\$0.03	\$0.06	\$0.27	\$0.10	\$0.06	\$0.02	\$1.62	\$2.65	\$2.93	\$2.45	\$4.21	\$2.51
Nov	\$0.09	\$0.07	\$0.36	\$0.09	(\$0.01)	\$0.06	\$0.43	\$2.11	\$1.07	\$2.11	\$2.13	\$1.50
Dec	\$0.05	\$0.20	\$0.14	\$0.09	\$0.13	\$0.16	\$0.94	\$1.68	\$1.20	\$2.64	\$1.39	\$2.36
Annual	\$0.11	\$0.13	\$0.26	\$0.24	\$0.14	\$0.05	\$0.96	\$2.49	\$3.93	\$4.03	\$2.02	\$1.48

Congestion

Congestion Accounting

Total congestion costs equal net congestion costs plus explicit congestion costs. Net congestion costs equal load congestion payments minus generation congestion credits. Explicit congestion costs are the net congestion costs associated with point to point energy transactions. Each of these categories of congestion costs is comprised of day-

ahead and balancing congestion costs. Day-ahead congestion costs are based on day-ahead MWh while balancing congestion costs are based on deviations between day-ahead and real-time MWh priced at the congestion price in the Real-Time Energy Market.⁶

Load congestion payments, when positive, are the congestion cost to load in an area. Load congestion payments, when negative, are the congestion credit to load in an area. Negative load congestion payments result when load is on the lower priced side of a constraint or constraints. For example, congestion across the AP South Interface means lower prices in western control zones and higher prices in eastern and southern control zones. Load in western control zones will benefit from lower prices and receive a congestion credit (negative load congestion payment). Load in the eastern and southern control zones will incur a congestion charge (positive load congestion payment). The reverse is true for generation congestion credits. Generation congestion credits, when positive, measure the congestion credit to generation in an area. Positive generation congestion credits result when generation is on the higher priced side of a constraint or constraints. Generation congestion credits, when negative, measure the congestion cost to generation in an area. Negative generation congestion credits result when generation is on the lower priced side of a constraint or constraints.

For example, congestion across the AP South Interface means lower prices in the western control zones and higher prices in the eastern and southern control zones. Generation in the western control zones will receive lower prices and incur a congestion charge (negative generation congestion credit). Generation in the eastern and southern control zones will receive higher prices and receive a congestion credit (positive generation congestion credit).

PJM congestion accounting nets load congestion payments against generation congestion credits by billing organization. The net congestion bill for a zone or a constraint may be either positive or negative, depending on the relative size and sign of load congestion payments and generation congestion credits.

Area Based Congestion

When summed across a zone, the net congestion bill shows the overall congestion charge or credit for the buses in that zone, not including explicit congestion.

Because the net congestion bill for a zone only includes charges or credits incurred in the zone, the congestion bill for the zone is not a good measure of the amount of congestion

⁶ See Table 17 “Congestion Definitions,” for a summary of relevant definitions.

(the difference between what load is pays and generation is paid) paid by the load in that zone. Zonal congestion calculations do not, for example, account for the total difference between what the zonal load is paying in congestion charges relative to what the generation is paid that serves that load if the zone is a net importer or a net exporter of generation. Zonal congestion calculated for a zone that is a net importer of generation will tend to have overstated congestion, as the calculation does not account for external generation credits from external generation used to serve that load. Zonal congestion calculated for a zone that is a net exporter of generation will tend to have overstated generation congestion credits, as the calculation does not account for only the generation used to meet the zone's internal load.

Constraint Based Congestion

Constraint Based Congestion calculation corrects the shortcomings of the Area Based Congestion approach. Constraint Based Congestion includes all energy charges or credits incurred to serve load in the zone. Constraint Based Congestion is the congestion paid by that zone's load. Constraint Based Congestion calculations account for the total difference between what the zonal load pays in congestion charges net of what the generation that serves that load is paid, regardless of whether the zone is a net importer or a net exporter of generation.

Constraint Based Congestion calculates congestion on a constraint by constraint basis. On a system wide basis, congestion results from transmission constraints that prevent the lowest cost generation from serving some load that must be served by higher cost generation. Transmission constraints cause price separation (differences in LMP), defined by the marginal cost of resolving the constraint given the need to meet power balance requirements, indicated by the shadow price of the constraint. The LMP at any point is equal to the system marginal price (SMP) plus the shadow price of the constraint times the dfax of the binding constraint to the bus in question (the CLMP of the constraint at that bus).

The total congestion caused by a constraint is equal to the product of the constraint shadow price times the net flow on the binding constraint. Total congestion caused by the constraint can also be calculated using the CLMPs caused by the constraint at every bus and the net MW injections or MW withdrawals at every affected bus. Congestion associated with a specific constraint is equal to load congestion charges (CLMP of that specific constraint at each bus times load MW at each bus) caused by that constraint in excess of generation congestion credits (CLMP of that specific constraint at each bus times generation MW at each bus) caused by that constraint.

Constraint specific congestion is allocated to downstream (positive CLMP) load buses that paid the congestion caused by the constraint, in proportion to the congestion charges collected from that load due to that constraint. The congestion collected from each load bus due to a constraint is equal to the CLMP caused by that constraint times

the MW of load at that load bus. This calculation is done for both day-ahead congestion and balancing congestion.

Area Based Congestion and Constraint Based Congestion

Table 5 and Table 6 provide a summary of the total congestion charges in the part of the Dominion Zone in North Carolina, based on Area Based Congestion and Constraint Based Congestion.

Table 5 Total congestion costs (Dollars (Millions)) for the Dominion Zone in North Carolina by congestion method: 2016 through 2017

	Congestion Costs (Millions)	
	Area Based	Constraint Based
2016	\$9.4	\$6.7
2017	\$6.2	\$4.1

Table 6 Monthly a congestion costs (Dollars (Millions)) for the Dominion Zone in North Carolina by congestion method: 2016 through 2017

	Congestion Costs (Millions)			
	2016		2017	
	Area Based	Constraint Based	Area Based	Constraint Based
Jan	\$1.8	\$1.3	\$0.7	\$0.5
Feb	\$1.1	\$1.0	\$0.2	\$0.1
Mar	\$0.7	\$0.4	\$0.3	\$0.2
Apr	\$1.0	\$0.7	\$0.2	\$0.2
May	\$0.3	\$0.3	\$0.4	\$0.3
Jun	\$0.5	\$0.3	\$0.2	\$0.2
Jul	\$0.0	\$0.3	\$0.5	\$0.2
Aug	\$0.5	\$0.5	\$0.6	\$0.2
Sep	\$0.9	\$0.6	\$0.9	\$0.5
Oct	\$1.1	\$0.6	\$0.7	\$0.3
Nov	\$0.8	\$0.4	\$0.5	\$0.3
Dec	\$0.7	\$0.3	\$1.1	\$1.0
Total	\$9.4	\$6.7	\$6.2	\$4.1

The system marginal price (SMP) is uniform for all areas, while the total of the congestion components of Locational Marginal Price (LMP) will either be positive or

negative in a specific area, meaning that actual LMPs are above or below the SMP.⁷ The area affected by a constraint will have increased prices and the unconstrained area will have lower prices. If an area is located downstream from the constrained element, the area will experience positive congestion costs. If an area is located upstream from the constrained element, the area will experience negative congestion costs (lower prices).

Day-ahead congestion charges and credits are based on MWh and CLMP in the Day-Ahead Energy Market. Balancing congestion charges and credits are based on load or generation deviations between the Day-Ahead and Real-Time Energy Markets and CLMP in the Real-Time Energy Market. If a participant has real-time generation or load that is greater than its day-ahead generation or load then the deviation will be positive. If there is a positive load deviation at a bus where real-time CLMP is positive, positive balancing congestion costs will result. Similarly, if there is a positive load deviation at a bus where real-time CLMP is negative, negative balancing congestion costs will result. If a participant has real-time generation or load that is less than its day-ahead generation or load then the deviation will be negative. If there is a negative load deviation at a bus where real-time CLMP is positive, negative balancing congestion costs will result. Similarly, if there is a negative load deviation at a bus where real-time CLMP is negative, positive balancing congestion costs will result.

In order to provide a more detailed explanation of the congestion calculations from which the total congestion charges are derived, each category of congestion is defined and a table of the congestion charges or credits associated with each category is provided.

Net Congestion Bill

The net congestion bill is defined by PJM settlements. The net congestion bill is calculated by subtracting generating congestion credits from load congestion payments.

Load congestion payments are netted against generation congestion credits on an hourly basis, by participant, and then summed for the given period. Generation credits result either from the direct ownership of generation or from the purchase of supply from another entity via a bilateral transaction.

Both day-ahead and balancing load congestion payments and generation congestion credits are calculated.

⁷ The SMP is the price of the distributed load reference bus. The price at the reference bus is equivalent to the five minute real-time or hourly day-ahead load-weighted PJM LMP.

- **Day-ahead Load Congestion Payments.** Day-ahead load congestion payments are calculated for all cleared demand, decrement bids, and day-ahead energy sale transactions. (Decrement bids and energy sales can be thought of as scheduled load.) Day-ahead load congestion payments are calculated using load MWh and the congestion component of LMP (CLMP) for the load bus, decrement bid location, or the source of the sale transaction, as applicable.
- **Day-ahead Generation Congestion Credits.** Day-ahead generation congestion credits are calculated for all cleared generation, increment offers and day-ahead energy purchase transactions. (Increment offers and energy purchases can be thought of as scheduled generation.) Day-ahead generation congestion credits are calculated using generation MWh and the CLMP for the generator bus, increment offer location, or the sink of the purchase transaction, as applicable.
- **Balancing Load Congestion Payments.** Balancing load congestion payments are calculated for all deviations between a PJM participant's real-time load and energy sale transactions and their day-ahead cleared demand, decrement bids, and energy sale transactions. Balancing load congestion payments are calculated using MWh deviations and the real-time CLMP for each bus where a deviation from a member's day-ahead scheduled load exists.
- **Balancing Generation Congestion Credits.** Balancing generation congestion credits are calculated for all deviations between a PJM participant's real-time generation and energy purchase transactions and the day-ahead cleared generation, increment offers and energy purchase transactions. Balancing generation congestion credits are calculated using MWh deviations and the real-time CLMP for each bus where a deviation from a member's day-ahead scheduled generation exists.

Explicit Congestion Costs

Explicit congestion costs are the congestion costs associated with moving energy from one specific point to another across the transmission system. Such point to point transactions may be either internal to PJM or be import or export transactions.

- **Internal Purchases.** For internal purchases the explicit congestion costs equal the difference in CLMPs between the sink bus and source bus of the purchase multiplied by the transacted MWh. The buyer pays the congestion costs associated with internal purchases.
- **Import and Export Transactions.** For point to point and network secondary transmission customers, the Explicit Congestion costs equal the difference in CLMPs between the sink bus and source bus multiplied by the transacted MWh. The transmission customer pays the congestion costs associated with an import or export transaction.

The explicit congestion costs calculated for the part of the Dominion Zone in North Carolina represent the costs associated with point to point transactions that source or sink in the part of the Dominion Zone in North Carolina. For example, if a transaction is sourced in Pennsylvania and sinks in the part of the Dominion Zone in North Carolina, the charges would be based on the MWh of the transaction multiplied by the difference between the sink CLMP and the source CLMP. The resulting congestion costs are allocated to the zone and state of the sink location, in this case of the part of the Dominion Zone in North Carolina. The sink location is the buyer's location and reflects the cost to the buyer of the internal purchase or external transaction.

Table 7 shows the combined day-ahead and balancing load congestion payments, generation congestion credits, and explicit congestion costs for the part of the Dominion Zone in North Carolina for 2016 and 2017 using both Area Based and Constraint Based methods.

Table 7 Total for the part of the Dominion Zone in North Carolina congestion costs by category: 2016 and 2017

	Congestion Costs (Millions)				Grand Total
	Load Payments	Generation Credits	Explicit		
2016 Area Based	\$21.7	\$12.5	\$0.1		\$9.4
Constraint Based	\$6.0	(\$1.0)	(\$0.2)		\$6.7
2017 Area Based	\$16.8	\$10.6	\$0.1		\$6.2
Constraint Based	\$3.8	(\$0.3)	(\$0.0)		\$4.1

Table 8 shows the congestion costs categories separated by day-ahead and balancing to show the contributions from both the Day-Ahead and Real-Time Markets for 2016 and 2017 using both Area Based and Constraint Based methods.

Table 8 Total day-ahead and balancing for the part of the Dominion Zone in North Carolina congestion costs by category: 2016 and 2017

	Congestion Costs (Millions)								Grand Total
	Day-Ahead				Balancing				
	Load Payments	Generation Credits	Explicit	Total	Load Payments	Generation Credits	Explicit	Total	
2016 Area Based	\$21.0	\$12.0	\$0.8	\$9.7	\$0.8	\$0.5	(\$0.6)	(\$0.3)	\$9.4
Constraint Based	\$6.0	(\$1.2)	(\$0.1)	\$7.1	(\$0.1)	\$0.2	(\$0.2)	(\$0.4)	\$6.7
2017 Area Based	\$15.2	\$9.5	\$1.0	\$6.7	\$1.6	\$1.1	(\$0.9)	(\$0.5)	\$6.2
Constraint Based	\$3.6	(\$1.0)	\$0.1	\$4.6	\$0.2	\$0.6	(\$0.1)	(\$0.5)	\$4.1

Table 9 lists the top 15 constraints affecting the part of the Dominion Zone in North Carolina congestion costs for 2017.

Table 9 provides the type of constraints (Line, Transformer, Flowgate, or Interface), the location of the constraints and the congestion cost for the period analyzed.⁸

Table 9 Area Based Congestion cost details for the top 15 constraints affecting the part of the Dominion Zone in North Carolina congestion costs: 2017

Constraint	Type	Location	Congestion Costs (Millions)									Grand Total
			Day-Ahead				Balancing					
			Load Payments	Generation Credits	Explicit	Total	Load Payments	Generation Credits	Explicit	Total		
AP South	Interface	500	\$1.6	\$0.9	\$0.1	\$0.7	\$0.1	\$0.0	(\$0.0)	\$0.1	\$0.7	
Graceton - Safe Harbor	Line	BGE	\$2.0	\$1.2	\$0.2	\$1.0	\$0.2	\$0.2	(\$0.2)	(\$0.3)	\$0.7	
Conastone - Peach Bottom	Line	500	\$2.5	\$1.6	\$0.2	\$1.1	(\$0.1)	\$0.1	(\$0.3)	(\$0.4)	\$0.7	
Person - Sedge Hill	Line	Dominion	\$0.6	\$0.4	\$0.0	\$0.2	\$0.9	\$0.5	(\$0.0)	\$0.3	\$0.5	
Conastone - Otter Creek	Line	PPL	\$1.3	\$0.9	\$0.1	\$0.5	\$0.4	\$0.3	(\$0.1)	(\$0.0)	\$0.5	
Carson - Rawlings	Line	Dominion	\$0.9	\$0.6	\$0.0	\$0.3	\$0.4	\$0.3	(\$0.0)	\$0.2	\$0.5	
AEP - DOM	Interface	500	\$0.8	\$0.5	\$0.0	\$0.3	\$0.2	\$0.1	(\$0.0)	\$0.0	\$0.4	
Carolina - Lakeview	Line	Dominion	\$0.3	(\$0.1)	(\$0.0)	\$0.3	\$0.2	\$0.1	(\$0.0)	\$0.0	\$0.3	
Conastone - Northwest	Line	BGE	\$0.9	\$0.6	\$0.0	\$0.4	\$0.1	\$0.1	(\$0.0)	(\$0.0)	\$0.3	
5004/5005 Interface	Interface	500	(\$0.6)	(\$0.3)	(\$0.0)	(\$0.3)	(\$0.1)	(\$0.1)	\$0.0	(\$0.0)	(\$0.3)	
Roxana - Praxair	Flowgate	MISO	\$0.6	\$0.4	\$0.1	\$0.3	\$0.1	\$0.1	(\$0.1)	(\$0.1)	\$0.2	
Bedington - Black Oak	Interface	500	\$0.4	\$0.3	\$0.0	\$0.2	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.2	
Crozet - Dooms	Line	Dominion	\$0.5	\$0.3	\$0.0	\$0.2	\$0.1	\$0.1	(\$0.0)	(\$0.0)	\$0.2	
Brunner Island - Yorkanna	Line	Met-Ed	\$0.4	\$0.3	\$0.0	\$0.2	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.2	
Pleasant View - Ashburn	Line	Dominion	\$0.8	\$0.6	\$0.1	\$0.3	\$0.1	\$0.1	(\$0.1)	(\$0.1)	\$0.2	
Top 15 Constraints Total			\$13.1	\$8.2	\$0.8	\$5.7	\$2.6	\$2.0	(\$0.9)	(\$0.4)	\$5.4	
Other Constraints Total			\$2.9	\$1.9	\$0.2	\$1.3	(\$0.9)	(\$0.9)	(\$0.1)	(\$0.2)	\$1.1	
Total			\$15.2	\$9.5	\$1.0	\$6.7	\$1.6	\$1.1	(\$0.9)	(\$0.5)	\$6.2	

Table 10 lists the top 15 constraints affecting the part of the Dominion Zone in North Carolina Area Based Congestion costs for 2017. Table 10 provides the type of constraint (Line, Transformer, Flowgate, or Interface), the location of the constraint, the congestion event hours and congestion component of LMP contributed by the constraints for the period analyzed.

⁸ All the interfaces and the Mid-Atlantic 500 kV system are put in the 500 category for location. The Mid-Atlantic 500 kV system includes equipment that is located in the PENELEC, PPL, BGE, PEPCO, MetEd, PECO, PSEG, JCPL, DPL and AECO zones.

Table 10 Top 15 constraints affecting the part of the Dominion Zone in North Carolina Area Based Congestion costs: 2017

Constraint	Type	Location	Event Hours		Congestion Component	
			Day-Ahead	Real-Time	Day-Ahead	Real-Time
AP South	Interface	500	1,315	74	\$0.16	\$0.10
Graceton - Safe Harbor	Line	BGE	3,118	1,151	\$0.20	\$0.00
Conastone - Peach Bottom	Line	500	3,159	840	\$0.24	\$0.22
Person - Sedge Hill	Line	Dominion	1,249	210	\$0.05	\$0.00
Conastone - Otter Creek	Line	PPL	1,336	868	\$0.13	\$0.00
Carson - Rawlings	Line	Dominion	720	231	\$0.08	\$0.00
AEP - DOM	Interface	500	948	33	\$0.08	\$0.07
Carolina - Lakeview	Line	Dominion	78	3	\$0.03	\$0.00
Conastone - Northwest	Line	BGE	975	228	\$0.09	\$0.07
5004/5005 Interface	Interface	500	173	104	(\$0.06)	(\$0.11)
Roxana - Praxair	Flowgate	MISO	1,734	290	\$0.06	\$0.04
Bedington - Black Oak	Interface	500	1,215	61	\$0.04	\$0.03
Crozet - Doods	Line	Dominion	466	57	\$0.05	\$0.10
Brunner Island - Yorkanna	Line	Met-Ed	681	74	\$0.04	\$0.01
Pleasant View - Ashburn	Line	Dominion	473	85	\$0.08	\$0.02
Top 15 Constraints Total			17,640	4,309	\$1.28	\$0.54
Other Constraints Total			82,527	18,142	\$0.20	\$0.72
Total			99,694	22,366	\$1.48	\$1.26

Table 11 shows the Constraint Based Congestion cost details of the top 15 constraints affecting the part of the Dominion Zone of North Carolina for 2017. Table 11 provides the type of constraints (Line, Transformer, Flowgate, or Interface), the location of the constraints and the congestion cost for the period analyzed.

Table 11 Constraint Based Congestion cost details for the top 15 constraints affecting the part of the Dominion Zone in North Carolina: 2017

Constraint	Type	Location	Congestion Costs (Millions)								
			Day-Ahead			Balancing					
			Load Payments	Generation Credits	Explicit	Total	Load Payments	Generation Credits	Explicit	Total	Grand Total
Conastone - Peach Bottom	Line	500	\$0.5	\$0.0	\$0.0	\$0.5	\$0.0	\$0.0	\$0.0	\$0.0	\$0.6
AP South	Interface	500	\$0.4	(\$0.2)	(\$0.1)	\$0.5	(\$0.0)	\$0.0	\$0.0	\$0.0	\$0.5
Carson - Rawlings	Line	Dominion	\$0.3	(\$0.1)	\$0.0	\$0.4	\$0.0	\$0.0	\$0.0	(\$0.0)	\$0.4
Graceton - Safe Harbor	Line	BGE	\$0.4	\$0.1	\$0.0	\$0.3	\$0.0	\$0.0	\$0.0	\$0.0	\$0.3
AEP - DOM	Interface	500	\$0.1	(\$0.2)	(\$0.0)	\$0.3	\$0.0	\$0.0	\$0.0	\$0.0	\$0.3
Pleasant View - Ashburn	Line	Dominion	\$0.1	(\$0.1)	(\$0.0)	\$0.2	\$0.0	(\$0.0)	\$0.0	\$0.0	\$0.2
Conastone - Northwest	Line	BGE	\$0.2	(\$0.0)	(\$0.0)	\$0.2	\$0.0	\$0.0	\$0.0	\$0.0	\$0.2
Person - Sedge Hill	Line	Dominion	\$0.3	\$0.1	\$0.0	\$0.3	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.2
Conastone - Otter Creek	Line	PPL	\$0.3	\$0.1	(\$0.0)	\$0.2	\$0.0	\$0.0	\$0.0	\$0.0	\$0.2
Crozet - Doods	Line	Dominion	\$0.1	(\$0.0)	\$0.0	\$0.2	\$0.0	\$0.0	\$0.0	\$0.0	\$0.2
Carolina - Lakeview	Line	Dominion	\$0.1	(\$0.0)	\$0.0	\$0.1	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.2
Bedington - Black Oak	Interface	500	\$0.1	(\$0.1)	(\$0.0)	\$0.1	(\$0.0)	\$0.0	\$0.0	\$0.0	\$0.1
Three Mile Island	Transformer	500	\$0.1	(\$0.0)	(\$0.0)	\$0.1	(\$0.0)	(\$0.0)	\$0.0	\$0.0	\$0.1
Brunner Island - Yorkanna	Line	Met-Ed	\$0.1	(\$0.0)	(\$0.0)	\$0.1	(\$0.0)	(\$0.0)	\$0.0	\$0.0	\$0.1
Kenney - Stockton	Line	DPL	(\$0.0)	\$0.1	(\$0.0)	(\$0.1)	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	(\$0.1)
Top 15 Constraints Total			\$3.0	(\$0.4)	(\$0.0)	\$3.4	\$0.2	\$0.1	\$0.1	\$0.2	\$3.5
Other Constraints Total			\$0.6	(\$0.6)	\$0.1	\$1.2	(\$0.0)	\$0.5	(\$0.2)	(\$0.7)	\$0.6
Total			\$3.6	(\$1.0)	\$0.1	\$4.6	\$0.2	\$0.6	(\$0.1)	(\$0.5)	\$4.1

Table 12 lists the top 15 constraints affecting the part of the Dominion Zone in North Carolina Constraint Based Congestion costs for 2017. Table 12 provides the type of constraints (Line, Transformer, Flowgate, or Interface), the location of the constraints, the congestion event hours and congestion component of LMP contributed by the constraints for the period analyzed.

Table 12 Top 15 constraints affecting the part of the Dominion Zone in North Carolina Constraint Based Congestion costs: 2017

Constraint	Type	Location	Event Hours		Congestion Component	
			Day-Ahead	Real-Time	Day-Ahead	Real-Time
Conastone - Peach Bottom	Line	500	3,159	840	\$0.24	\$0.22
AP South	Interface	500	1,315	74	\$0.16	\$0.10
Carson - Rawlings	Line	Dominion	720	231	\$0.08	\$0.00
Graceton - Safe Harbor	Line	BGE	3,118	1,151	\$0.20	\$0.00
AEP - DOM	Interface	500	948	33	\$0.08	\$0.07
Pleasant View - Ashburn	Line	Dominion	473	80	\$0.08	\$0.02
Conastone - Northwest	Line	BGE	975	228	\$0.09	\$0.07
Person - Sedge Hill	Line	Dominion	1,249	210	\$0.05	\$0.00
Conastone - Otter Creek	Line	PPL	1,336	868	\$0.13	\$0.00
Crozet - Doods	Line	Dominion	466	57	\$0.05	\$0.10
Carolina - Lakeview	Line	Dominion	78	3	\$0.03	\$0.00
Bedington - Black Oak	Interface	500	1,215	61	\$0.04	\$0.03
Three Mile Island	Transformer	500	540	86	\$0.05	\$0.00
Brunner Island - Yorkanna	Line	Met-Ed	681	74	\$0.04	\$0.01
Kenney - Stockton	Line	DPL	321	347	(\$0.01)	(\$0.01)
Top 15 Constraints Total			16,594	4,343	\$1.32	\$0.61
Other Constraints Total			44,757	16,981	\$0.16	\$0.65
Total			61,351	21,324	\$1.48	\$1.26

Table 13 shows the Area Based Congestion Cost details of the top 15 constraints affecting the part of the Dominion Zone in North Carolina for 2016. Table 13 provides the type of constraints (Line, Transformer, Flowgate, or Interface), the location of the constraints and the congestion cost for the period analyzed.

Table 13 Area Based Congestion Cost details for the top 15 constraints affecting the part of the Dominion Zone in North Carolina: 2016

Constraint	Type	Location	Congestion Costs (Millions)										Grand Total
			Day-Ahead				Balancing				Total		
			Load	Generation	Payments	Credits	Explicit	Total	Load	Generation		Payments	
Conastone - Northwest	Line	BGE	\$7.9	\$4.8	\$0.3	\$3.4	(\$0.2)	\$0.1	(\$0.3)	(\$0.6)	\$2.8		
Bagley - Graceton	Line	BGE	\$5.0	\$2.9	\$0.1	\$2.2	(\$0.0)	\$0.1	(\$0.1)	(\$0.2)	\$2.0		
Graceton	Transformer	BGE	\$3.8	\$2.2	\$0.0	\$1.6	(\$0.1)	\$0.0	(\$0.0)	(\$0.2)	\$1.5		
Conastone - Peach Bottom	Line	500	\$1.7	\$1.1	\$0.1	\$0.7	(\$0.1)	\$0.0	(\$0.0)	(\$0.1)	\$0.7		
AP South	Interface	500	\$1.3	\$0.8	\$0.0	\$0.6	(\$0.0)	\$0.0	(\$0.0)	(\$0.0)	\$0.6		
Person - Halifax	Flowgate	MISO	\$0.9	\$0.4	(\$0.0)	\$0.5	\$0.0	\$0.0	\$0.0	\$0.0	\$0.5		
Brambleton - Loudoun	Line	Dominion	(\$1.5)	(\$1.0)	\$0.0	(\$0.5)	\$0.1	\$0.0	(\$0.0)	\$0.0	(\$0.5)		
AEP - DOM	Interface	500	\$1.0	\$0.6	\$0.1	\$0.4	\$0.2	\$0.1	(\$0.0)	\$0.1	\$0.5		
Kanawha River - Matt Funk	Line	AEP	\$1.5	\$1.0	\$0.0	\$0.5	(\$0.0)	(\$0.0)	(\$0.1)	(\$0.1)	\$0.4		
East Danville - Banister	Line	AEP	(\$0.8)	(\$0.5)	(\$0.0)	(\$0.3)	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.3)		
Conastone - Otter Creek	Line	PPL	\$0.7	\$0.4	\$0.0	\$0.3	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.3		
Bagley - Raphaerd	Line	BGE	\$0.5	\$0.3	\$0.1	\$0.3	\$0.0	\$0.0	(\$0.1)	(\$0.0)	\$0.3		
Bedington - Black Oak	Interface	500	\$0.6	\$0.4	\$0.0	\$0.2	\$0.0	\$0.0	(\$0.0)	\$0.0	\$0.2		
Meadow Brook - Strasburg	Line	AP	\$0.4	\$0.2	\$0.0	\$0.2	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.2		
Person - Halifax	Line	Dominion	\$0.0	\$0.0	\$0.0	\$0.0	\$0.3	\$0.1	\$0.0	\$0.2	\$0.2		
Top 15 Constraints Total			\$23.1	\$13.6	\$0.7	\$10.2	\$0.2	\$0.5	(\$0.6)	(\$0.9)	\$9.3		
Other Constraints Total			(\$2.2)	(\$1.6)	\$0.1	(\$0.4)	\$0.5	(\$0.0)	(\$0.0)	\$0.5	\$0.1		
Total			\$21.0	\$12.0	\$0.8	\$9.7	\$0.8	\$0.5	(\$0.6)	(\$0.3)	\$9.4		

Table 14 lists the top 15 constraints affecting the part of the Dominion Zone in North Carolina Area Based Congestion costs for 2016. Table 14 provides the type of constraint (Line, Transformer, Flowgate, or Interface), the location of the constraint, the congestion event hours and congestion component of LMP contributed by the constraint for the period analyzed.

Table 14 Top 15 constraints affecting the part of the Dominion Zone in North Carolina Area Based Congestion costs: 2016

Constraint	Type	Location	Event Hours		Congestion Component	
			Day-Ahead	Real-Time	Day-Ahead	Real-Time
Conastone - Northwest	Line	BGE	2,776	1,840	\$0.76	\$0.77
Bagley - Graceton	Line	BGE	3,313	1,685	\$0.49	\$0.00
Graceton	Transformer	BGE	3,117	1,298	\$0.37	\$0.00
Conastone - Peach Bottom	Line	500	2,407	699	\$0.17	\$0.10
AP South	Interface	500	1,076	14	\$0.13	\$0.01
Person - Halifax	Flowgate	MISO	719	5	\$0.09	\$0.00
Brambleton - Loudoun	Line	Dominion	380	31	(\$0.14)	(\$0.03)
AEP - DOM	Interface	500	1,604	5	\$0.09	\$0.05
Kanawha River - Matt Funk	Line	AEP	275	107	\$0.14	\$0.00
East Danville - Banister	Line	AEP	3,643	20	(\$0.08)	\$0.00
Conastone - Otter Creek	Line	PPL	309	158	\$0.07	\$0.00
Bagley - Raphaerd	Line	BGE	604	231	\$0.05	\$0.00
Bedington - Black Oak	Interface	500	1,515	105	\$0.06	\$0.03
Meadow Brook - Strasburg	Line	AP	1,111	98	\$0.04	\$0.00
Person - Halifax	Line	Dominion	-	217	\$0.00	\$0.08
Top 15 Constraints Total			22,849	6,513	\$2.23	\$1.00
Other Constraints Total			80,295	19,476	(\$0.21)	\$0.78
Total			103,144	25,989	\$2.02	\$1.78

Table 15 shows the Constraint Based Congestion cost details of the top 15 constraints affecting the part of the Dominion Zone in North Carolina for 2016.

Table 15 Constraint Based Congestion cost details for the top 15 constraints affecting the part of the Dominion Zone in North Carolina: 2016

Constraint	Type	Location	Congestion Costs (Millions)									
			Day-Ahead				Balancing				Grand Total	
			Load Payments	Generation Credits	Explicit	Total	Load Payments	Generation Credits	Explicit	Total		
Conastone - Northwest	Line	BGE	\$1.8	\$0.1	(\$0.1)	\$1.6	\$0.0	(\$0.1)	\$0.0	\$0.2	\$1.8	
Bagley - Graceton	Line	BGE	\$1.1	\$0.1	(\$0.0)	\$1.0	\$0.0	(\$0.1)	\$0.0	\$0.1	\$1.1	
Graceton	Transformer	BGE	\$0.6	(\$0.2)	(\$0.0)	\$0.9	(\$0.0)	(\$0.1)	\$0.0	\$0.1	\$0.9	
Kanawha River - Matt Funk	Line	AEP	\$0.1	(\$0.5)	(\$0.0)	\$0.6	(\$0.0)	(\$0.0)	\$0.0	\$0.0	\$0.6	
Conastone - Peach Bottom	Line	500	\$0.4	(\$0.0)	\$0.0	\$0.4	\$0.0	\$0.0	\$0.0	\$0.0	\$0.4	
AP South	Interface	500	\$0.3	(\$0.1)	(\$0.0)	\$0.4	\$0.0	\$0.0	\$0.0	\$0.0	\$0.4	
AEP - DOM	Interface	500	\$0.1	(\$0.2)	\$0.0	\$0.3	\$0.0	\$0.0	\$0.0	\$0.0	\$0.4	
Person - Halifax	Flowgate	MISO	\$0.5	\$0.3	(\$0.0)	\$0.2	\$0.0	\$0.0	(\$0.0)	(\$0.0)	\$0.2	
Meadow Brook - Strasburg	Line	AP	\$0.3	\$0.1	(\$0.0)	\$0.2	(\$0.0)	(\$0.0)	\$0.0	\$0.0	\$0.2	
Bedington - Black Oak	Interface	500	\$0.1	(\$0.1)	(\$0.0)	\$0.2	\$0.0	\$0.0	\$0.0	\$0.0	\$0.2	
Mercer IP - Galesburg	Flowgate	MISO	(\$0.1)	(\$0.3)	(\$0.1)	\$0.2	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.1	
Cayuga	Flowgate	MISO	(\$0.0)	(\$0.0)	\$0.0	\$0.0	(\$0.0)	\$0.1	(\$0.0)	(\$0.1)	(\$0.1)	
Cherry Valley	Transformer	ComEd	\$0.0	\$0.0	\$0.0	\$0.0	(\$0.0)	\$0.0	(\$0.1)	(\$0.1)	(\$0.1)	
Conastone - Otter Creek	Line	PPL	\$0.2	\$0.1	\$0.0	\$0.1	\$0.0	\$0.0	\$0.0	\$0.0	\$0.1	
Gomingo - Joshua Falls	Line	AEP	\$0.0	(\$0.0)	\$0.0	\$0.1	\$0.0	\$0.0	\$0.0	\$0.0	\$0.1	
Top 15 Constraints Total			\$5.5	(\$0.8)	(\$0.2)	\$6.0	\$0.0	(\$0.1)	\$0.2	\$0.3	\$6.3	
Other Constraints Total			\$0.6	(\$0.4)	\$0.1	\$1.1	(\$0.1)	\$0.3	(\$0.3)	(\$0.7)	\$0.4	
Total			\$6.0	(\$1.2)	(\$0.1)	\$7.1	(\$0.0)	\$0.2	(\$0.2)	(\$0.4)	\$6.7	

Table 16 lists the top 15 constraints affecting the part of the Dominion Zone in North Carolina constraint based congestion costs for 2016. Table 16 provides the type of constraint (Line, Transformer, Flowgate, or Interface), the location of the constraint, the congestion event hours and congestion component of LMP contributed by the constraint for the period analyzed.

Table 16 Top 15 constraints affecting the part of the Dominion Zone in North Carolina Constraint Based Congestion costs: 2016

Constraint	Type	Location	Event Hours		Congestion Component	
			Day-Ahead	Real-Time	Day-Ahead	Real-Time
Conastone - Northwest	Line	BGE	2,776	1,840	\$0.76	\$0.77
Bagley - Graceton	Line	BGE	3,313	1,685	\$0.49	\$0.00
Graceton	Transformer	BGE	3,117	1,298	\$0.37	\$0.00
Kanawha River - Matt Funk	Line	AEP	275	107	\$0.14	\$0.00
Conastone - Peach Bottom	Line	500	2,407	692	\$0.17	\$0.10
AP South	Interface	500	1,076	13	\$0.13	\$0.01
AEP - DOM	Interface	500	1,604	4	\$0.09	\$0.05
Person - Halifax	Flowgate	MISO	719	5	\$0.09	\$0.00
Meadow Brook - Strasburg	Line	AP	1,111	91	\$0.04	\$0.00
Bedington - Black Oak	Interface	500	1,515	102	\$0.06	\$0.03
Mercer IP - Galesburg	Flowgate	MISO	3,510	1,155	\$0.01	\$0.00
Cayuga	Flowgate	MISO	53	74	(\$0.00)	(\$0.01)
Cherry Valley	Transformer	ComEd	-	774	\$0.00	(\$0.02)
Conastone - Otter Creek	Line	PPL	309	158	\$0.07	\$0.00
Gomingo - Joshua Falls	Line	AEP	520	-	\$0.02	\$0.00
Top 15 Constraints Total			22,305	7,998	\$2.43	\$0.91
Other Constraints Total			34,791	16,935	(\$0.41)	\$0.86
Total			57,096	24,933	\$2.02	\$1.78

Conclusion

Total congestion charges, using both the Area and Constraint based metrics, decreased from 2016 to 2017 as a result of the decrease in the congestion component of LMP (Table 3 and Table 4).

Constraint Based Congestion was lower than Area Based Congestion in 2016 and 2017 because Area Based Congestion for the part of the Dominion Zone in North Carolina ignores congestion charges and credits contributed by or collected from load and generation in the portion of the Dominion Zone external to North Carolina.

Congestion Definitions

Table 17 Congestion Definitions

Congestion Category	Calculation
Day-Ahead Load Congestion Payments	Day-Ahead Demand MWh * Day-Ahead CLMP
Day-Ahead Generation Congestion Credits	Day-Ahead Supply MWh * Day-Ahead CLMP
Day-Ahead Net Congestion Bill	Day-Ahead Load Congestion Payments - Day-Ahead Generation Congestion Credits
Day-Ahead Explicit Congestion Costs	Day-Ahead Transaction MW * (Day-Ahead Sink CLMP - Day-Ahead Source CLMP)
Day-Ahead Total Congestion Costs	Day-Ahead Load Congestion Payments - Day-Ahead Generation Congestion Credits + Day-Ahead Explicit Congestion Costs
Balancing Load Congestion Payments	Balancing Demand MWh * Real-Time CLMP
Balancing Generation Congestion Credits	Balancing Supply MWh * Real-Time CLMP
Balancing Net Congestion Bill	Balancing Load Congestion Payments - Balancing Generation Congestion Credits
Balancing Explicit Congestion Costs	Balancing Transaction MW * (Real-Time Sink CLMP - Real-Time Source CLMP)
Balancing Total Congestion Costs	Balancing Load Congestion Payments - Balancing Generation Congestion Credits + Balancing Explicit Congestion Costs
Total Congestion Costs	Day-Ahead Total Congestion Costs + Balancing Total Congestion Costs

MWh Category	Definition
Day-Ahead Demand MWh	Cleared Demand, Decrement Bids, Energy Sale Transactions
Day-Ahead Supply MWh	Cleared Generation, Increment Bids, Energy Purchase Transactions
Real-Time Demand MWh	Load and Energy Sale Transactions
Real-Time Supply MWh	Generation and Energy Purchase Transactions
Balancing Demand MWh	Real-Time Demand MWh - Day-Ahead Demand MWh
Balancing Supply MWh	Real-Time Supply MWh - Day-Ahead Supply MWh