Section 6: 2015 Baseline MAPP Analysis

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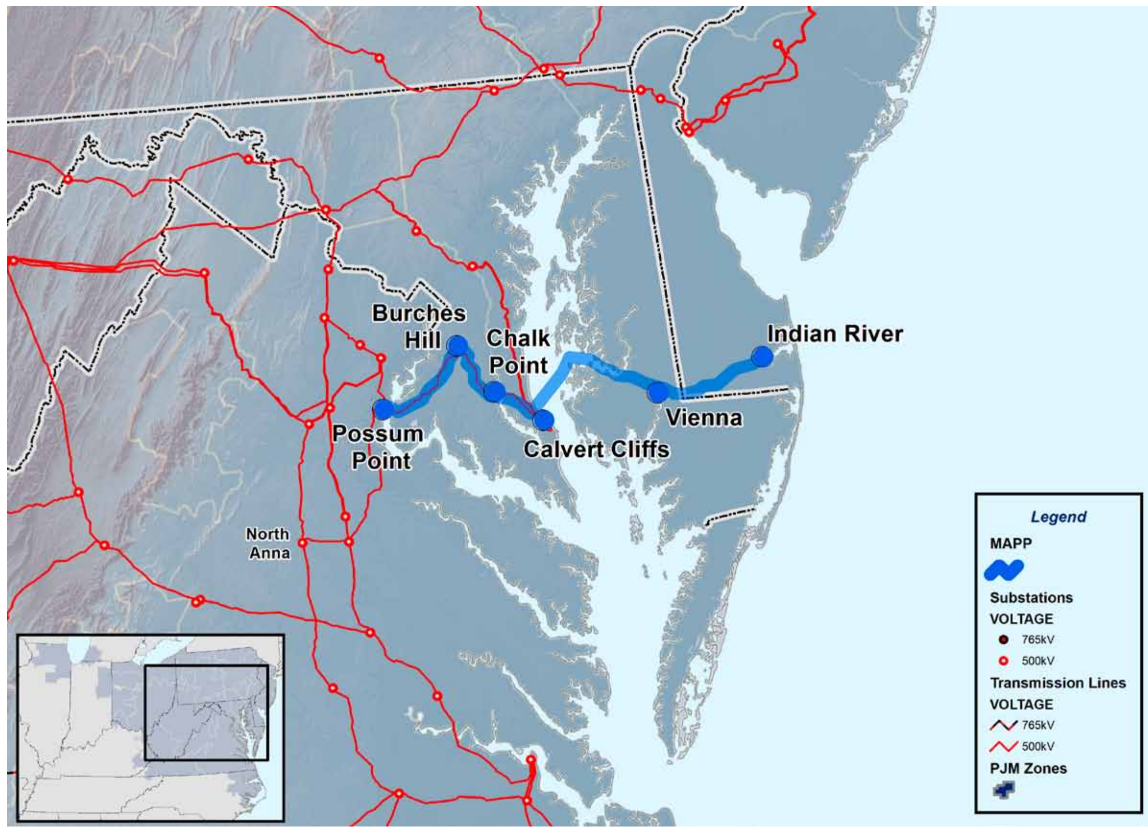
6.0: MAPP Line Background

The need for the MAPP project was first identified as part of PJM's 2007 Regional Transmission Expansion Plan (RTEP) Process. Analysis of projected 2012 system conditions at that time identified reliability criteria violations in the PJM Mid-Atlantic area throughout the 15-year planning horizon ending 2022. Following review of these violations with stakeholders, the MAPP project was ultimately selected as the most robust solution to resolve the identified overloads.

The MAPP 500 kV line as now configured would run from Possum Point 500 kV substation in Virginia to the Burches Hill 500 kV substation in Maryland. From there, the line would run to the Chalk Point 500 kV substation in Maryland and then to a point near the Calvert Cliffs 500 kV substation along the western shore of the Chesapeake Bay. At this point, there would be an AC-to-DC converter station. Two DC lines would run underwater from the converter station: one line would terminate at Vienna substation in Maryland and the other line would terminate at the Indian River substation in Delaware. The MAPP project is shown on Map 6.1.

Map 6.1: MAPP Transmission Line



The right-of-way route shown on this map is for illustrative purposes only and may not depict the actual route that may eventually be chosen. Substation locations may also be modified if more beneficial connections are determined by PJM.

Determination of Need

Analysis performed on the PJM system for 2014 as a part of the 2010 RTEP retool process determined that the MAPP Project was not required by June 1, 2014, as had been determined in the 2009 RTEP analysis.

However, based on the analysis performed on the PJM system for 2015 as a part of the 2010 RTEP process as described in **Sections 6.2** through **6.5**, including a review of several alternatives requested by stakeholders, PJM confirmed the need for the MAPP Project by June 1, 2015. Considering the effectiveness of the alternatives, the estimated costs and completion time for each alternative, the MAPP project was confirmed as the best alternative to resolve the identified criteria violations.

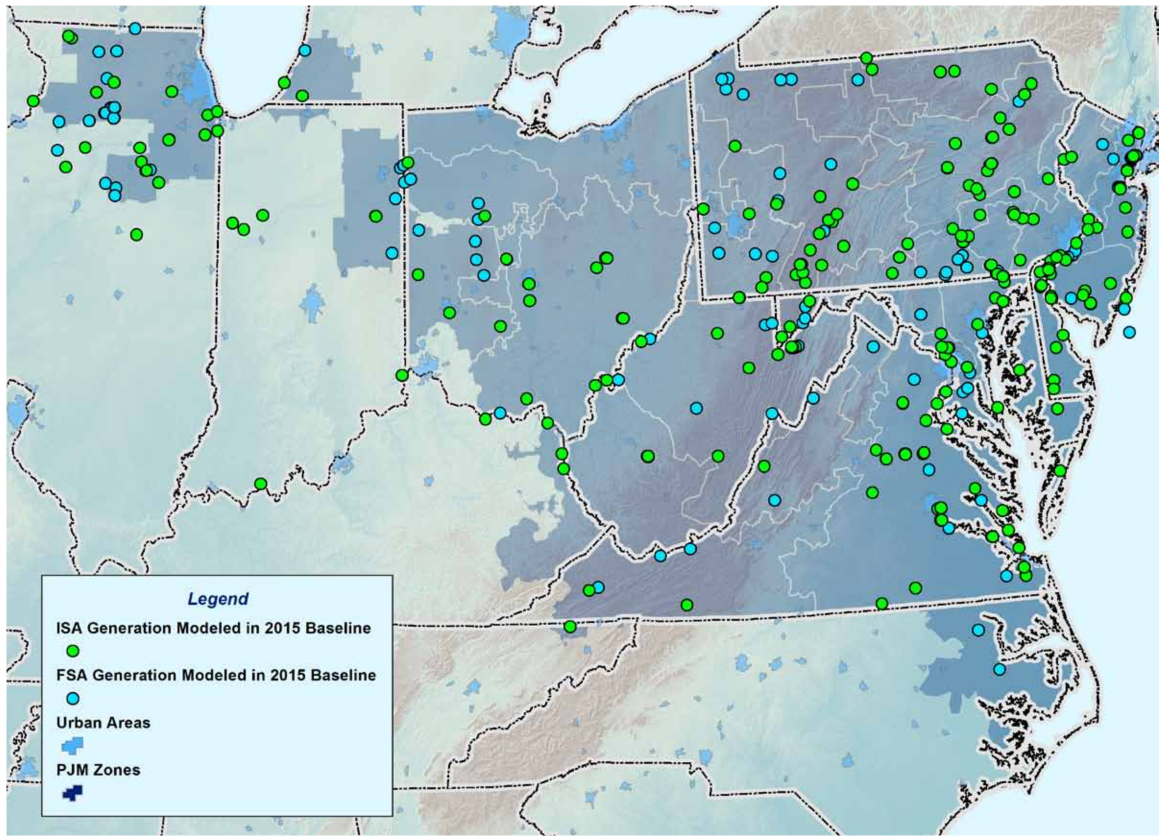
6.1: Summary of Key Modeling Assumptions

As described in **Section 2** and **Section 3**, PJM developed a series of 2015 power flow cases used throughout the 2010 Regional Transmission Expansion Plan (RTEP) process. These base cases were based on procedures and assumptions vetted with the PJM Transmission Expansion Advisory Committee (TEAC). Inputs used to develop the power flow cases included the 2010 PJM Load Forecast, updated interchange information, topology changes from the 2009 RTEP, and updated generation information, as described in **Section 2**.

Generation

With respect to the 2010 RTEP analysis of the 2015 system, all generation expected to be in service by June 1, 2015 was modeled, as part of the RTEP methodology described in **Section 2** and **3**. Each annual RTEP process includes new generation that has executed an Interconnection Service Agreement (ISA) or signed a Facilities Study Agreement (FSA) since the previous year's RTEP. A complete list of generators modeled in the 2015 baseline power flow case was presented at the February 10, 2010 PJM TEAC meeting. That "machine list" is accessible from PJM's website via the following URL link: http://pjm.com/committees-and-groups/committees/teac.aspx. Specific generators are depicted on maps in the respective **Section 14** state portions contained in of this report. Specific generator status information can be found in PJM's interconnection queues, also accessible from PJM's website via the following URL link: http://pjm.com/planning/generation-interconnection/generation-queue-active.aspx.

Map 6.2: ISA and FSA Generation Modeled in 2015 Baseline



PJM includes generators with executed FSAs in its power flow base case model in order to allow the generators to contribute to generator deliverability problems. However, PJM does not include a generator that only has an executed FSA – i.e., one that has not yet executed an ISA – to relieve system problems, for example in an area experiencing a capacity emergency in the load deliverability test. This approach ensures that the transmission system will be reliable whether or not the generator ultimately completes the interconnection process and goes into commercial operation. PJM uses this approach for an interconnection request that has not executed an ISA because of the remaining uncertainty as to whether that generator will ultimately go into service.

PJM uses the execution of the ISA as the indicator that a project can reasonably be expected to be placed into service and, therefore, be available to contribute to the resolution of violations of NERC Reliability Standards. Consequently, PJM has determined that those generators with an executed ISA should be modeled in all subsequent baseline analyses the same way an existing generation capacity resource is modeled, i.e., the generator is included in the baseline and is allowed to contribute to system problems and to relieve system problems.

ISA and FSA generating units modeled in 2010 RTEP analyses are shown on Map 6.2.

2010 vs 2009 Load Forecast for 2015

Load forecasting is a fundamental driver of resource adequacy requirements and transmission expansion plans. PJM issued a new load forecast report in January 2010 for 2010 through 2025. PJM RTO load without ATSI (i.e., the current PJM footprint) for 2015 was forecasted to be 152,119 MW, 709 MW (0.5 percent) greater than the 2009 forecast for 2015. (The PJM RTO load with ATSI included for 2015 from the 2010 forecast was 165,402 MW.) ATSI is expected to be integrated on June 1, 2011. The 2010 PJM forecast for the eastern Mid-Atlantic region of PJM for 2015 was 231 MW (0.6 percent) lower than the 2009 forecast for 2015. **Section 2.1** provides forecast comparisons and load growth projections.

PJM's 2010 forecasted 15-year RTO load growth rate remained the same at 1.7 percent. Table 6.1 compares the 2007, 2008 and 2009 load forecasts with the 2010 load forecast. Figure 6.1 depicts RTO totals for 2009 and 2010. Figure 6.2 shows a 10-year load growth rate comparison by sub region.

The PJM Load Forecast Report is used for modeling loads, and unrestricted peak loads are adjusted to account for changes energy efficiency (EE) and load management (LM) resources.

Demand Resources and EE initiatives are currently integrated into the RTEP based on the degree to which EE and LM programs clear PJM's Reliability Pricing Model (RPM) three-year-forward capacity market. Those resources that clear an RPM auction are factored into reliability analyses based on the circumstances under which the programs are expected to be implemented in actual operations. Additional discussion of DR and EE concepts can be found in **Section 2.2**.

The EE and LM projections in the 2010 Load Forecast Report reflect the May 2009 RPM results. PJM's 2009 load forecast for the Eastern Mid-Atlantic region contained no energy efficiency programs for 2015 but did contain 613 MW of load management. By contrast, the 2010 Load Forecast Report shows projected Eastern Mid-Atlantic EE programs of 20 MW and LM resources of 1,587 MW.

Figure 6.1: 10-Year Summer Load Forecast Comparison: 2009 and 2010

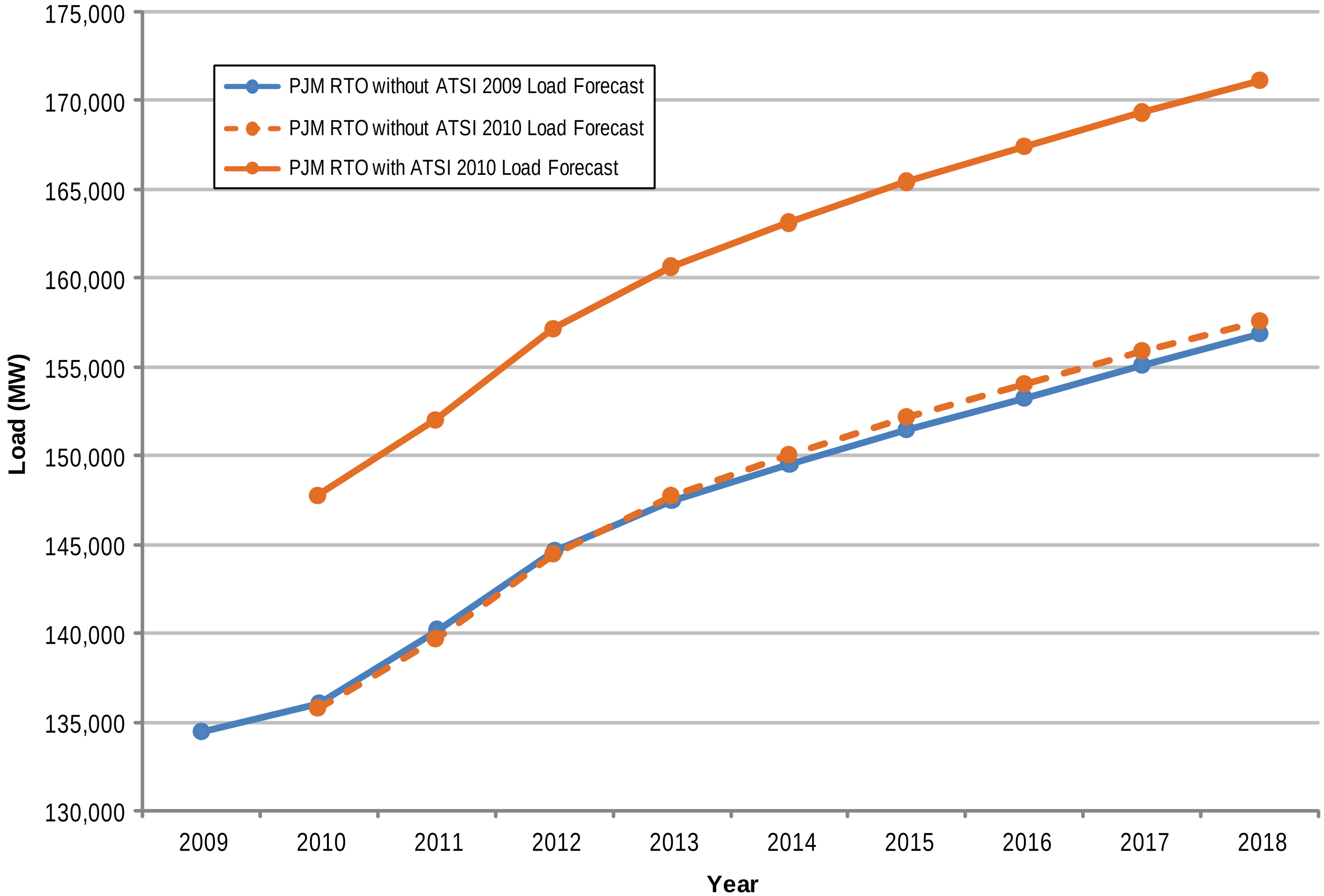


Table 6.1: 10-Year Summer Load Forecast Comparison

	2007 Load Forecast Report Summer Peak (MW)			2008 Load Forecast Report Summer Peak (MW)			2009 Load Forecast Report Summer Peak (MW)			2010 Load Forecast Report Summer Peak (MW)		
TO	2007	2017	Growth Rate (%)	2008	2018	Growth Rate (%)	2009	2019	Growth Rate (%)	2010	2020	Growth Rate (%)
Atlantic City Electric Company	2,758	3,373	2.0	2,829	3,673	2.6	2,692	3,533	2.8	2,734	3,443	2.3
Baltimore Gas and Electric Company	7,303	8,198	1.2	7,344	8,118	1.0	7,303	8,745	1.8	7,456	8,919	1.8
Delmarva Power and Light	4,076	4,919	1.9	4,192	5,047	1.9	3,972	4,882	2.1	4,023	4,601	1.4
Jersey Central Power and Light	6,333	7,688	2.0	6,478	7,897	2.0	6,357	7,621	1.8	6,440	7,611	1.7
Metropolitan Edison Company	2,853	3,349	1.6	2,929	3,432	1.6	2,866	3,334	1.5	2,920	3,444	1.7
PECO Energy Company	8,554	9,847	1.4	8,759	10,085	1.4	8,455	9,538	1.2	8,528	9,821	1.4
Pennsylvania Electric Company	2,824	3,248	1.4	2,850	3,157	1.0	2,786	3,305	1.7	2,843	3,420	1.9
PPL Electric Utilities Corporation	7,196	8,333	1.5	7,292	8,379	1.4	7,106	7,985	1.2	7,161	8,213	1.4
Potomac Electric Power Company	6,972	8,032	1.4	7,057	8,046	1.3	6,960	7,823	1.2	7,048	7,909	1.2
Public Service Electric and Gas Company	10,801	12,451	1.4	10,967	12,622	1.4	10,858	12,470	1.4	10,921	12,428	1.3
Rockland Electric Company	423	446	0.5	435	486	1.1	435	496	1.3	435	493	1.3
UGI	195	222	1.3	197	219	1.1	190	207	0.9	190	210	1.0
Diversity - Mid-Atlantic	-568	-659		-594	-689		-359	-427		-530	-385	-3.1
Mid-Atlantic	**59,720**	**69,447**	**1.5**	**60,735**	**70,472**	**1.5**	**59,621**	**69,512**	**1.5**	**60,169**	**70,127**	**1.5**
American Electric Power Company	24,206	27,464	1.3	23,939	26,736	1.1	23,682	26,554	1.2	23,287	26,631	1.4
Allegheny Power	8,630	9,427	0.9	8,688	9,475	0.9	8,538	9,889	1.5	8,661	9,909	1.4
American Transmission Systems, Inc.										13,040	14,888	1.3
Commonwealth Edison Company	23,076	28,159	2.0	23,654	28,524	1.9	22,472	27,722	2.1	22,536	27,965	2.2
Dayton Power and Light	3,524	4,035	1.4	3,597	3,962	1.0	3,399	3,945	1.5	3,368	3,835	1.3
Duquesne Light Company	2,949	3,282	1.1	2,942	3,241	1.0	2,862	3,257	1.3	2,883	3,318	1.4
Diversity - Western (including ATSI)	-1,504	-1,745		-1,413	-1,618		-1,252	-1,646		-1,684	-2,192	2.7
Western (including ATSI)	**60,881**	**70,622**	**1.5**	**61,407**	**70,320**	**1.4**	**59,701**	**69,721**	**1.6**	**72,091**	**84,354**	**1.6**
Dominion Virginia Power	19,167	23,222	1.9	19,353	23,157	1.8	18,982	23,603	2.2	19,779	25,387	2.5
Southern	**19,167**	**23,222**	**1.9**	**19,353**	**23,157**	**1.8**	**18,982**	**23,603**	**2.2**	**19,779**	**25,387**	**2.5**
Diversity - RTO (including ATSI)	-2,807	-3,469		-3,547	-3,842		-3,876	-4,219		-4,248	-5,144	1.9
PJM RTO (including ATSI)	**136,961**	**159,822**	**1.6**	**137,948**	**160,107**	**1.5**	**134,428**	**158,617**	**1.7**	**147,791**	**174,724**	**1.7**

Network Topology

Upgrades approved by the PJM Board along with merchant transmission projects expected to be in service by June 1, 2015 were modeled in PJM's 2015 power flow case. The TrAIL project, with an expected in-service date of June 1, 2011, was modeled in-service. Interchange values were consistent with approved long-term firm transmission service requests in PJM's OASIS system. Power flow cases also included upgrades to connect new generation for which System Impact Studies have been completed.

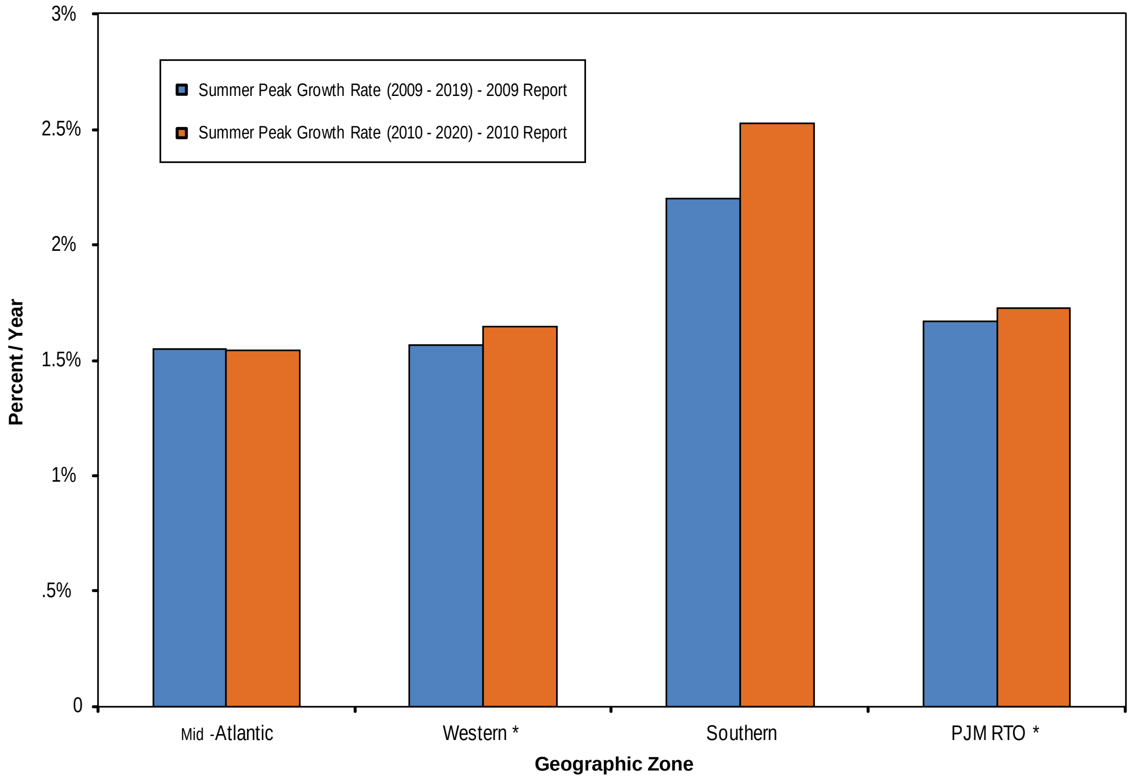
Modeling Impacts

As a possible outcome and consistent with sound, forward-looking planning practices, baseline reinforcements may be modified, advanced or deferred in future years if anticipated system conditions do not materialize, for example, changes in load forecasts or the status of generation and merchant transmission interconnection requests.

6.1.1 – Compliance with NERC Criteria

PJM's 2015 baseline assessment included base case thermal and voltage analysis, load deliverability thermal and voltage analyses, generation deliverability thermal and voltage analyses, common mode contingency analysis and baseline stability analysis. Contingency analysis included all PJM Bulk Electric System (BES) facilities, all other lower voltage facilities operated by PJM, and critical facilities in systems adjoining PJM, including tie lines between systems. Thermal and voltage limits employed were those specified by PJM Operations, as described in the PJM Transmission Operations Manual M-3, available on PJM's website via the following URL: http://www.pjm.com/documents/manuals.aspx.

Figure 6.2: 10-Year Summer Load Forecast Sub-Regional Growth Rate Comparison: 2009 and 2010



Baseline thermal and voltage analysis encompasses an exhaustive analysis of all BES facilities for compliance with NERC Category A (TPL-001), Category B (TPL-002) and Category C (TPL-003) events. In addition, consistent with NERC standard TPL-004, a number of extreme events including those judged to be critical from an operational perspective. PJM has conducted a comprehensive assessment of the ability of the PJM system to meet all applicable reliability planning criteria, per the methodologies as discussed more fully in **Section 3**.

*** NOTE**

Figure 6.2: PJM's 2010 Load Forecast incorporates the impact of ATSI: http://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.aspx.

PJM | DE | DC | IL | IN | KY | MD | MI | NJ | NC | OH | PA | TN | VA | WV

6.2: MAPP Need – Reactive Analysis

6.2.1 – Reactive Analysis Background

NERC Reliability Standards require that a transmission system be stable and within applicable equipment thermal ratings and system voltage limits. PJM assesses system voltage levels under Category A, B and C contingencies. To ensure the system will be within applicable system voltage limits and thus not violate NERC Reliability Standards. If the magnitude of the voltage is outside prescribed limits or the change in voltage (voltage drop) following the loss of an element of the bulk electric system is greater than a specified amount, then system upgrades must be identified to resolve the criteria violations. Permissible voltage magnitudes and voltage drop percentages are determined based on operational conditions at each substation. PJM 500 kV voltage drop is limited at many 500 kV substations to 5 percent.

Emergency voltage magnitude is limited to no lower than 0.97 per unit (i.e. 97 percent of nominal). Voltage magnitude and voltage drop limits are defined in more detail in **Section 3** of PJM Manual M-3, "Transmission Operations", available on PJM's website via the following URL link: http://www.pjm.com/~/media/documents/manuals/m03.ashx.

6.2.2 – Load Deliverability

As part of the 2010 Regional Transmission Expansion Plan (RTEP) baseline analysis PJM identified numerous voltage violations of NERC Reliability Standards. PJM identified multiple voltage collapse conditions in 2015 for the loss of a number of facilities for PJM's load deliverability procedure. The voltage violations projected under these tests are shown in Table 6.2 and depicted on Map 6.3. The violations are associated with NERC Category B contingencies. In each case, the contingency listed is projected to result in a voltage collapse prior to the Eastern Mid-Atlantic Capacity Emergency Transfer Objective (CETO) of 8,270 MW or the Mid-Atlantic CETO of 6,570 as applicable. For each contingency, Table 6.2 identifies the specific violations of NERC Reliability Standards that are projected to occur (a voltage drop violation, a voltage magnitude violation, or a voltage collapse violation, or some combination of the three violations), and the transfer level below the applicable CETO at which each violation occurs (the transfer deficiency). PJM identified 12 voltage drop violations, six voltage magnitude violations and 13 voltage collapse violations related to the need for the MAPP project beginning in June 2015.

For each specific contingency and specific application of PJM's load deliverability test, Table 6.2 identifies independent violations of NERC Reliability Standards associated with:

i. a projected post-contingency voltage drop greater than or equal to 5 percent (described as a $\mathbf{V}_{DROP}$ violation);

ii. a projected post-contingency voltage magnitude at or below the 0.97 per unit absolute voltage limit for 500 kV facilities (a $\mathbf{V}_{MAG}$ violation); and

iii. a projected voltage collapse. Table 6.2 shows that for each of the contingencies listed, voltage collapses occur before the required CETO has been reached.

Table 6.2 also shows the MW transfer at which system voltage becomes unstable and the difference between it and the applicable CETO. All of the voltage violations shown are for PJM's Eastern Mid-Atlantic load deliverability test or Mid-Atlantic load deliverability test. Each voltage violation shown in Table 6.2 is resolved by MAPP.

Each of the five distinct contingencies in Table 6.2 has a unique transfer deficiency at which voltage collapse occurs. Voltage drop and voltage magnitude violations, which occur at transfer levels lower than the voltage collapse transfer level, indicate the existence of conditions that can precede voltage collapse, especially considering their numerous and widespread nature.

The Keeney to Rock Springs 500 kV line contingency, shown in bold-faced font in Table 6.2, is projected to cause precipitous voltage collapse, with little or no warning to system operators. Unlike other violations on Table 6.2, this violation is not preceded by voltage drop or voltage magnitude violations. Voltage collapse is difficult to predict and control from an operational perspective.

Voltage violations for the contingency loss of the Keystone - Jacks Mountain line, the Hunterstown - Conastone line, the Conemaugh - Hunterstown line and the Possum Point - Burches Hill line are also resolved by the PATH project.

Map 6.3: 2015 Voltage Violations Driving Need for MAPP

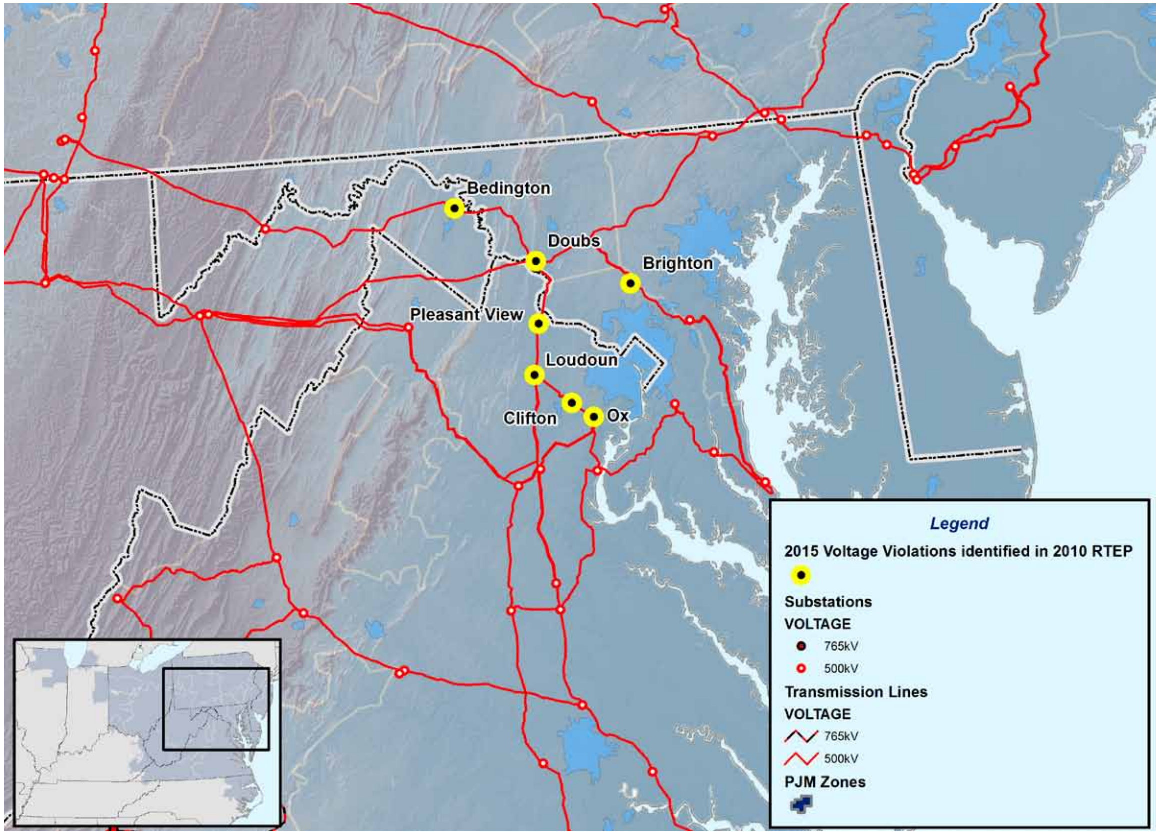


Table 6.2: 2015 Voltage Violations of NERC Reliability Standards Identified in the 2010 RTEP

	Contingency [1]	Reliability Test	500 kV Substation with	Transfer Level (MW)			Transfer Deficiency Below Applicable CETO (MW)		
			V_{DROP} or V_{MAG} Violation	V_{DROP} > 5%	V_{MAG} < 0.97 pu	Collapse	V_{DROP} > 5%	V_{MAG} < 0.97 pu	Collapse
1	**Keeney - Rock Springs**	**Eastern Mid-Atlantic Load Deliverability**	**-**	**-**	**-**	**7,767**	**-**	**-**	**-503**
2	Keystone - Jacks Mountain	Eastern Mid-Atlantic Load Deliverability	Doubs	7,928	7,928	7,959	-342	-342	-311
3	Keystone - Jacks Mountain	Eastern Mid-Atlantic Load Deliverability	Bedington	7,953	-	7,959	-317	-	-311
4	Keystone - Jacks Mountain	Eastern Mid-Atlantic Load Deliverability	Brighton	7,953	-	7,959	-317	-	-311
5	Hunterstown - Conastone	Eastern Mid-Atlantic Load Deliverability	Doubs	7,978	7,978	7,994	-292	-292	-276
6	Conemaugh - Hunterstown	Eastern Mid-Atlantic Load Deliverability	Doubs	8,014	8,014	8,024	-256	-256	-246
7	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Doubs	5,395	5,370	5,411	-1,175	-1,200	-1,159
8	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Pleasant View	5,395	5,395	5,411	-1,175	-1,175	-1,159
9	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Loudoun	5,401	5,407	5,411	-1,169	-1,163	-1,159
10	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Bedington	5,407	-	5,411	-1,163	-	-1,159
11	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Bedington	5,407	-	5,411	-1,163	-	-1,159
12	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Clifton	5,407	-	5,411	-1,163	-	-1,159
13	Burches Hill - Possum Point	Mid-Atlantic Load Deliverability	Ox	5,407	-	5,411	-1,163	-	-1,159

*** NOTE**

Table 6.2:

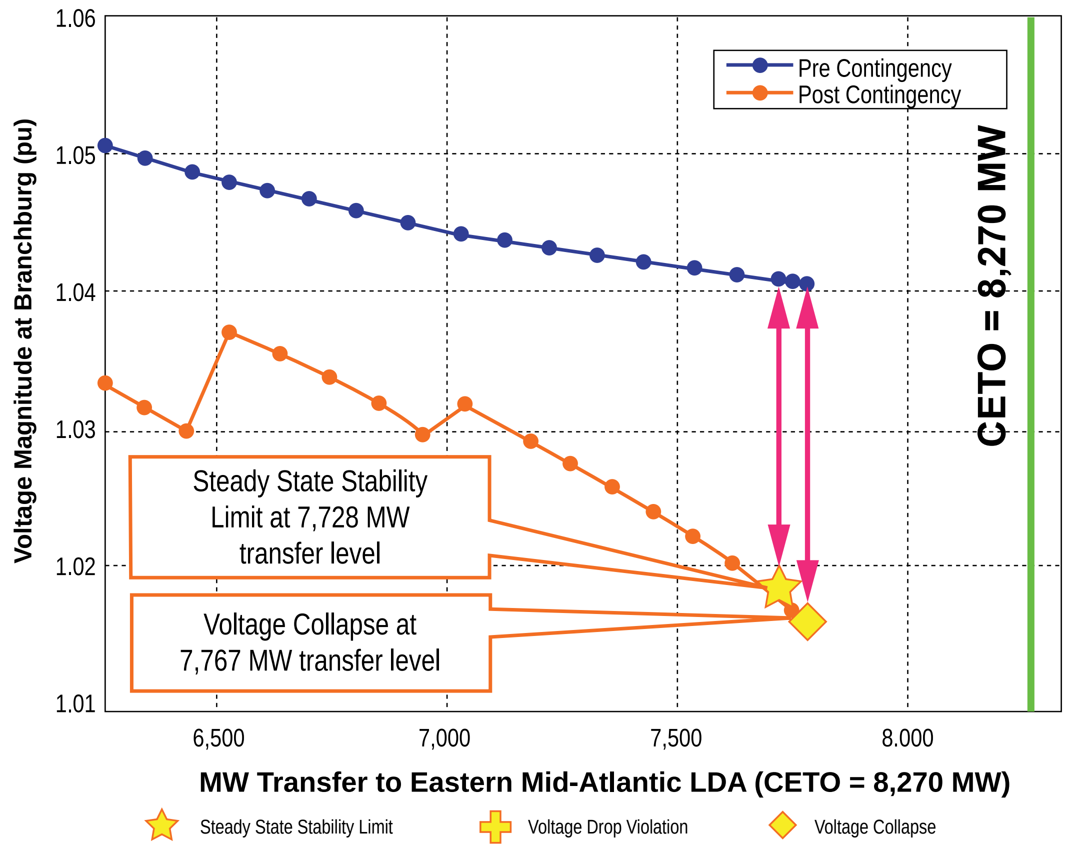
1. All contingencies are on PJM's 500 kV transmission system.
2. The Keeney - Rock Springs contingency, shown in **bold-faced type**, represents a projected voltage collapse not preceded by a voltage drop or voltage magnitude violation.

6.2.3 – PV Analysis

PJM has analyzed the relative severity of voltage collapse conditions identified in the 2010 Baseline Analysis. PV analysis can be used to show the existence of violations of NERC Reliability Standards, but it can also be used to determine the point at which the system becomes unstable. In a PV analysis, voltage conditions at a substation are represented on a curve, which shows the effect that increasing power transfers on a transmission line or set of lines has on voltage levels at the substation. Typically, as more power is transferred, voltage levels deteriorate and the more abrupt the decline in voltage levels, the more difficult the voltage problem is to control operationally.

Figures 6.3 and 6.4 provide the results of PV analyses PJM conducted in connection with the 2010 Baseline Analysis. These graphs show the change in voltage magnitudes at the Branchburg 500 kV substation, for the loss of the Keeney to Rock Springs 500 kV line as system power transfers are increased into the Eastern Mid-Atlantic LDA (Figure 6.3). The PV curves presented in these two figures clearly show the projected instability of the transmission system in 2015. Each curve is annotated to show the MW transfer levels at which the voltage drop, voltage magnitude, and/or voltage collapse violations are projected to occur.

Figure 6.3: MW Transfer to Eastern Mid-Atlantic LDA - Voltage Magnitude at Branchburg (for the loss of Keeny - Rock Springs)



In the scenario depicted in Figure 6.3, a voltage collapse is projected to occur at a power transfer level well below the 8,270 MW CETO required for the Eastern Mid-Atlantic load deliverability test. In other words, PJM's analyses show that for these potential capacity deficiencies, serious voltage problems will prevent PJM from delivering generation to the capacity-deficient area in amounts sufficient to resolve the capacity deficiency. Assuming that system operators are able to identify the impending voltage collapse in time, the only way to prevent it will be to reduce load in the capacity constrained area – that is, to shed customer load.

Figure 6.3 shows the voltage magnitude at the Branchburg substation in New Jersey as transfers to the Eastern Mid-Atlantic LDA increase for the contingency loss of the Rock Springs - Keeney 500 kV line. This figure shows that, with increasing levels of MW transfers to the Eastern Mid-Atlantic LDA, post-contingency voltage levels at the Branchburg Substation decline, reaching the steady state stability limit at a transfer level of approximately 7,728 MW, and a voltage collapse violation at a transfer level of approximately 7,767 MW. Each of these points occurs at a transfer level several hundred Megawatts below the 8,270 MW CETO.

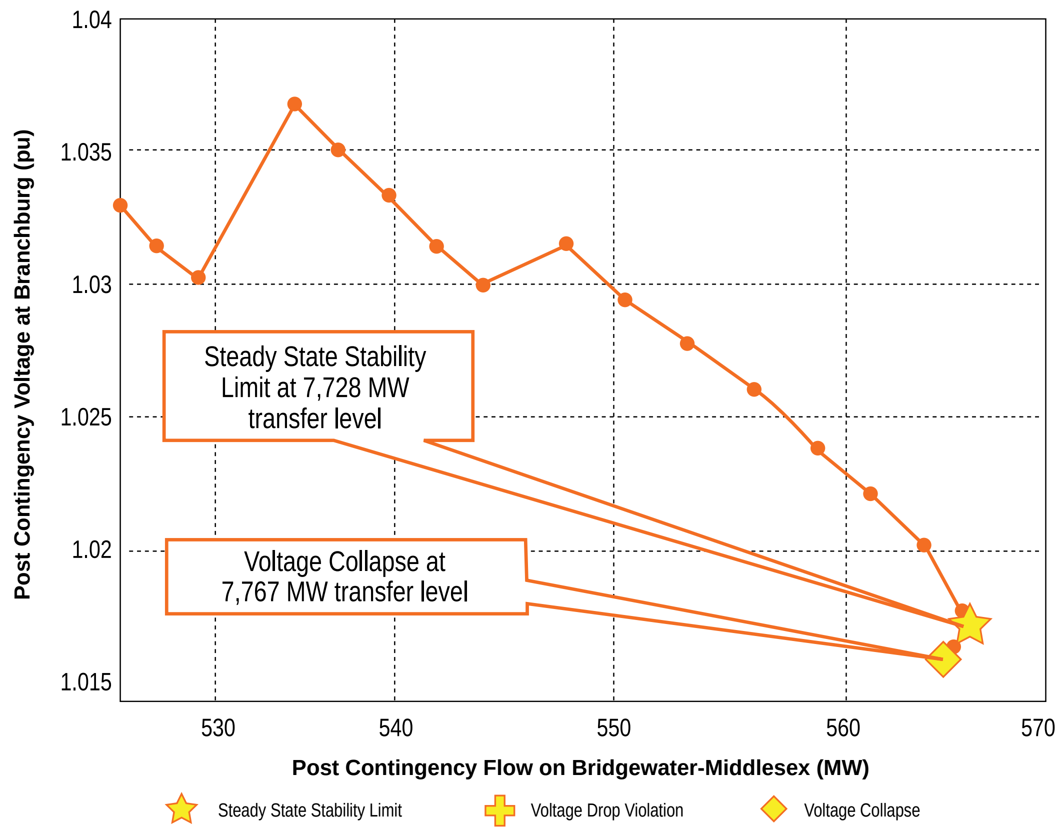
Approaching Voltage Collapse

PV curves can also show how increasing power flows on a given line can reach a critical point where further increases will cause the transmission system to collapse. In Figure 6.4 this critical point is very pronounced, indicating that a very slight increase in power transfer will cause the voltages to collapse from normal pre-contingency voltage levels following the contingency. This critical point is represented as the "steady state stability limit" in Figures 6.3 and 6.4. Figure 6.4 shows the post-contingency flow on the Bridgewater - Middlesex 230 kV line for the loss of the Keeney - Rock Springs 500 kV line.

Figure 6.4 shows that the PV curve turns well before the 0.97 per unit voltage magnitude limitation is reached. The steady state stability limit is represented as a yellow star at a flow of approximately 565 MW on the Bridgewater - Middlesex 230 kV line. This "star" point, as well as the voltage collapse point (represented by a diamond), correspond to the same points shown in Figure 6.3 and 6.4.

If presented with the situation shown in Figures 6.3 and 6.4 in real-time operations, system operators would have to take quick decisive action to relieve system loading by shedding load. Obviously, such situations leave little margin for operators to manage the system and prevent voltage collapse.

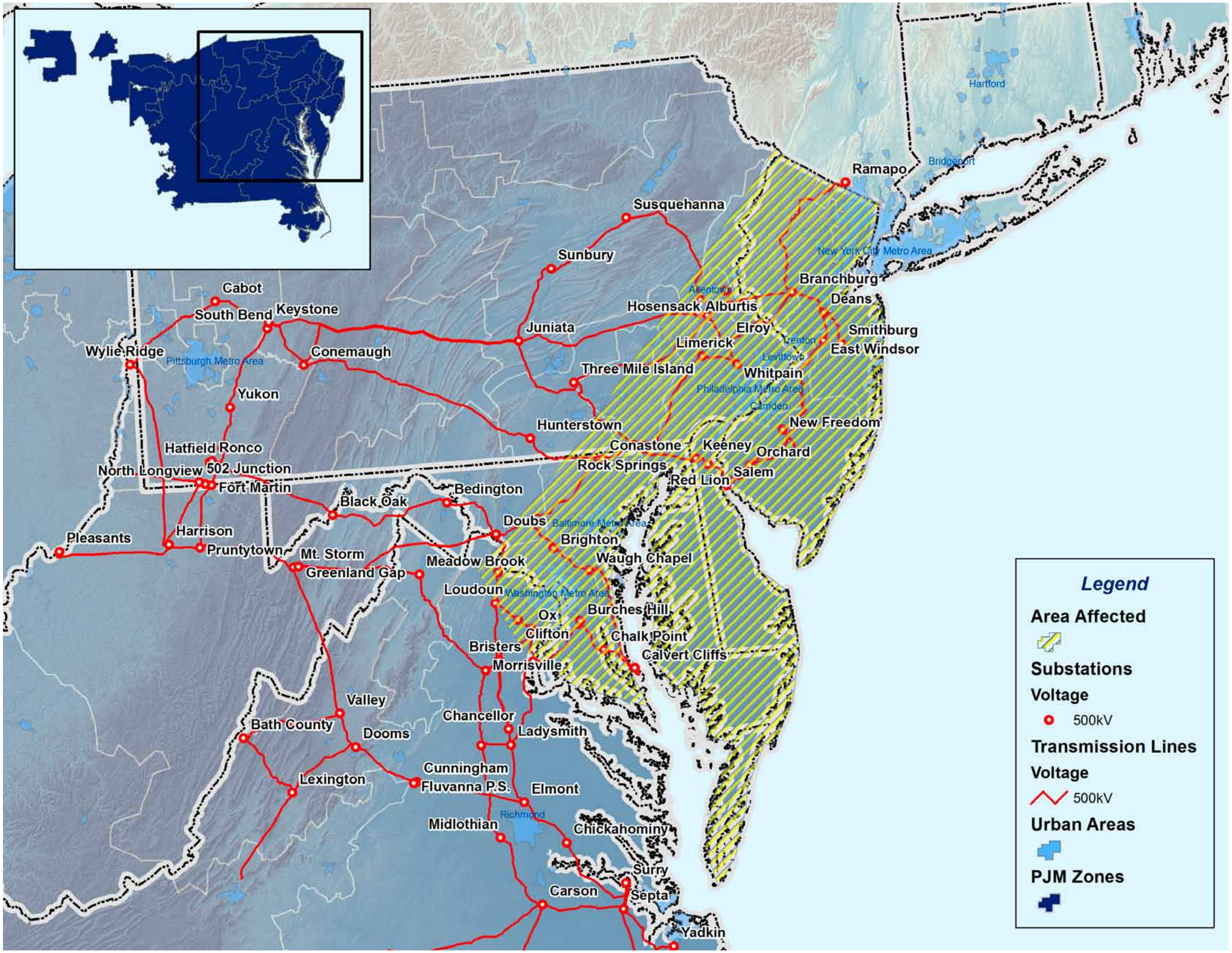
Figure 6.4: Post-Contingency Flow on the Bridgewater - Middlesex 230 kV Line for the Loss of the Keeney - Rock Springs 500 kv Line



Affected Area

Map 6.4 shows the area of PJM likely to be adversely affected by the voltage criteria violations identified in Table 6.2 if not effectively addressed. The shaded areas in Map 6.4 include substations with unacceptably low voltages or high voltage drops. Critically, the voltage violations occur at transfer levels well below those required to pass PJM's load deliverability test. Any end-user load that contributes to the flow on critically loaded facilities can be adversely impacted by voltage performance.

Map 6.4: Area Adversely affected by Voltage Violations Identified in 2010 Baseline Analysis



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6.3: Sensitivity Analyses – MAPP Impacts

As discussed in **Section 4.2**, PJM also conducted a number of sensitivity analyses within the context of the 2010 Regional Transmission Expansion Plan (RTEP) process cycle. The 2010 Sensitivity Analyses generally examined the impact of such issues as the integration of state renewable portfolio standards, state Demand Resource Programs and Energy Efficiency goals and the potential retirement of at-risk generation. If the likely impacts of public policy initiatives are realized then the potential exists that reliability criteria violations will occur sooner than identified in 2010 Baseline Analyses.

Although only the 2010 Baseline Analysis is at this point actionable within the context of the RTEP, the results of the 2010 Sensitivity Analyses offer a useful complement to the 2010 Baseline Analysis results in that they provide an idea of how the baseline results would be affected by adjusting certain inputs that in PJM's experience have been shown to have the potential to cause material changes in the location and timing of projected violations of NERC Reliability Standards out through PJM's 15-year planning horizon.

Summary of Results

In general, the results of these sensitivity analyses not only continue to show significant violations across the eastern portion of PJM out through 2025, but also show increasing west-to-east transfers over the system that will exacerbate the reactive problems underlying the need for the MAPP Project.

The 2010 sensitivity analyses discussed in **Section 4.2** generally demonstrated that need for MAPP based on identified reliability criteria violations will continue to exist for a range of changing assumptions. In general, the further integration of renewable resources, demand response resources, energy efficiency programs and the likely retirement of at-risk generation increased the power flow on key west-to-east transmission facilities. This accelerated the observance of reliability criteria violations on those facilities themselves. To the extent additional generation retires on the Delmarva Peninsula, the MAPP Project will help provide needed transfers into the area.

Impact of Off-Shore Wind

PJM's 2010 RTEP cycle of analyses also included an off-shore wind analysis at the request of Delaware, Maryland, New Jersey, the District of Columbia and Virginia, as described in **Section 4.2**. PJM conducted a high-level conceptual analysis that examined the integration off-shore wind generation of installed capacity amounts up to 30,000 MW at four injection points along the east coast: Hudson 230 kV, Larabee 230 kV, Indian River 230 kV and Fentress 500 KV. While more detailed analysis is required, this initial analysis showed that the MAPP Project helps to integrate off-shore wind onto and across the Delmarva Peninsula.

PJM | DE | DC | IL | IN | KY | MD | MI | NJ | NC | OH | PA | TN | VA | WV

6.4: MAPP Alternatives

PJM considered alternatives that included the following:

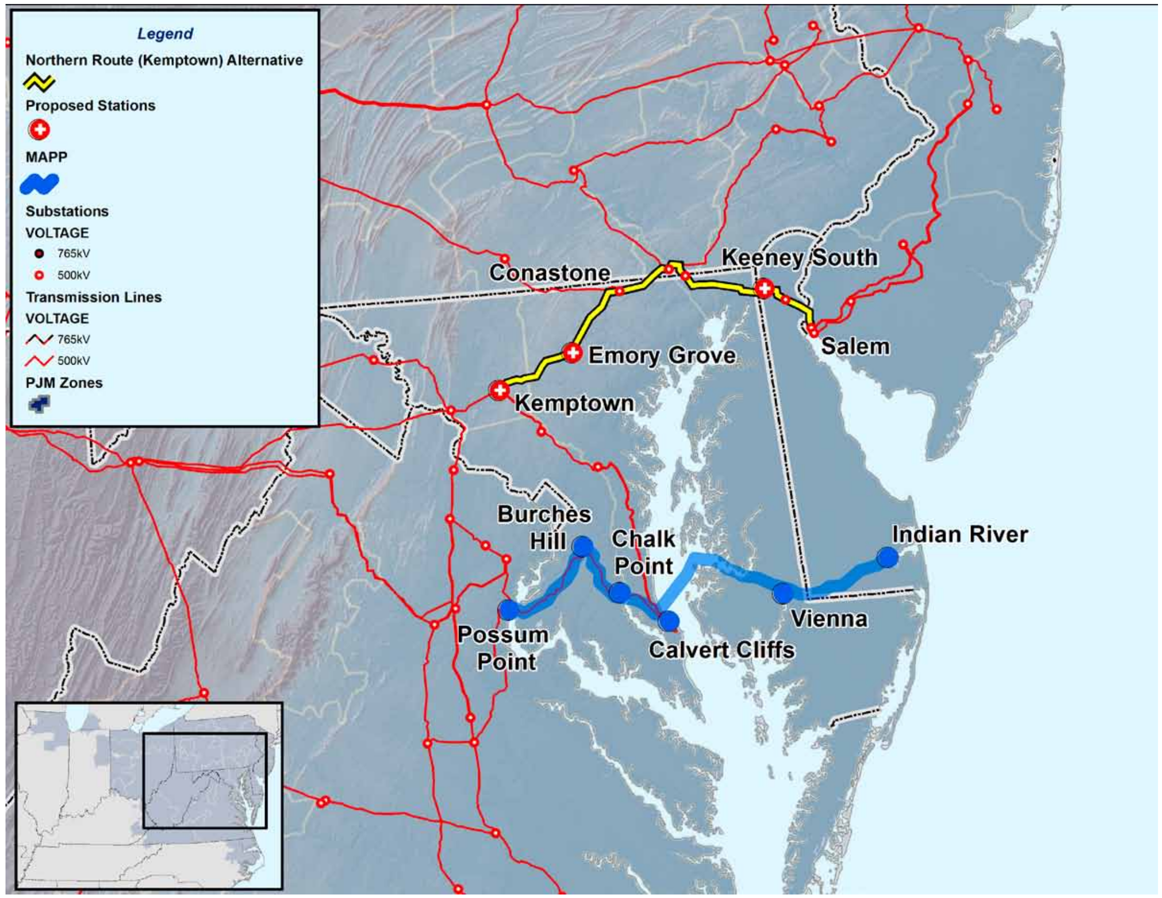
i. "transmission-only" alternatives;

ii. "transmission and reactive" alternatives that incorporate both transmission lines and reactive support, such as SVCs; and

iii. "reactive-only" alternatives, which generally are comprised of numerous SVCs which essentially are devices that can be installed on a transmission system to help to maintain voltages on the system.

The reactive-only alternatives were dismissed because they were demonstrated, analytically, to not be an effective long-term solution to the violations. Previous Regional Transmission Expansion Plan (RTEP) analyses have identified voltage violations for the loss of the Rock Springs - Keeney 500 kV. Reactive devices have been added at multiple stations in the Eastern Mid-Atlantic area of PJM. These incremental upgrades were required to address voltage magnitude or voltage drop violations. Successive RTEP analyses have shown the violations getting progressively worse to the point where the loss of the Keeney - Rock Springs 500 kV line results in voltage collapse.

Map 6.5: Northern Route (Kemptown) Alternative



The right-of-way route shown on this map is for illustrative purposes only and may not depict the actual route that may eventually be chosen. Substation locations may also be modified if more beneficial connections are determined by PJM.

6.4.1 – Northern Alternative

PJM evaluated a proposed Northern Alternative to the MAPP project. This alternative started at the new proposed Kemptown station and extended to a new Emory Grove substation and existing Conastone substations in Maryland. From Conastone, the Northern Alternative would cross into Pennsylvania to Peach Bottom. From Peach Bottom the Northern Alternative would cross back into Maryland and extend to a new station in Delaware south of the existing Keeney station. The Northern Alternative would originally have cut into the existing Keeney 500 kV substation. Subsequent evaluation revealed that doing so would be infeasible given substation space and configuration requirements. As a result, a new substation south of Keeney was proposed instead. From there the Northern Alternative would cross Delaware and the Delaware River to the Salem station in southern New Jersey. Map 6.5 shows the Northern Alternative route.

6.4.2 – Comparison of Project Characteristics

The Northern Alternative was found to be comparable to the MAPP project in terms of its effectiveness at resolving the identified criteria violations. Both options solve the Eastern Mid-Atlantic reactive issues through 2019.

Table 6.3 shows a comparison of rights-of-way, states, estimated costs and construction lead times. The Northern Alternative would take longer to complete and its estimated cost is greater than that of the MAPP project. Also, the Northern Alternative, without a strong source into Kemptown, is less robust than MAPP.

Table 6.3: Project Characteristics

	Mileage			States	Cost	Construction Lead Time
	Existing ROW	New ROW	Total			
MAPP	97	16*	152	MD,D E, VA(less than 1/2 mile)	$1.20B	56 Months (4.66 Years)
Northern Route (Kemptown)	30.5	94.7	125	MD,PA,DE,NJ	$1.22B - $1.54B	111 Months (9.25 Years)

*** NOTE**

Table 6.3
Agreements are in place for the entire 16 miles, an additional 39 miles underwater will be built under permit from the State.

6.5: RTEP Comparison of Alternatives

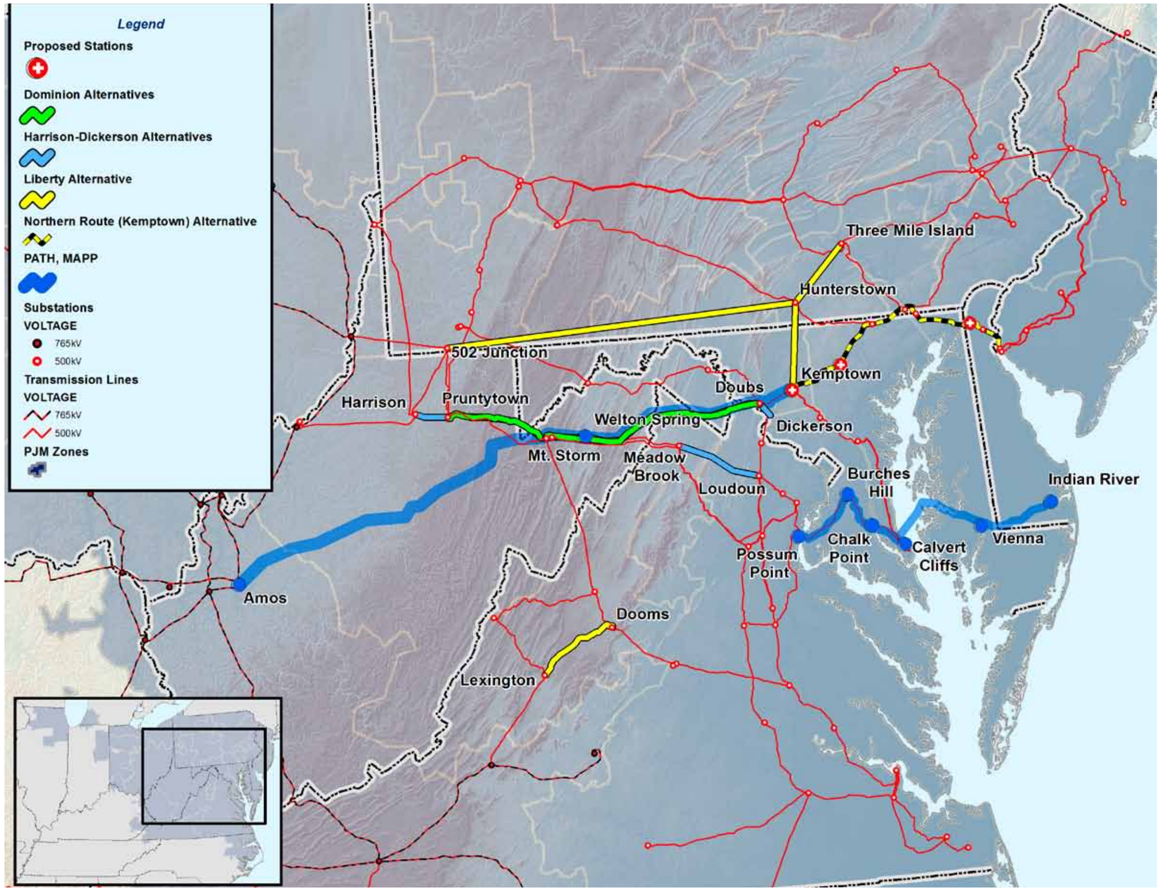
PJM evaluated the Northern Alternative and the MAPP Project by comparing their ability to solve identified reactive criteria violations. These comparisons are presented and discussed in **Section 6.5.1** through **Section 6.5.3**.

6.5.1 – Reactive Analysis

PJM 2010 RTEP analysis of MAPP transmission alternatives included a reactive study in terms of Eastern Mid-Atlantic LDA import capability under a variety of scenarios with respect to both MAPP and PATH. Map 6.6 shows the location of the alternatives considered.

A series of reactive analyses provide the basis for the comparisons shown in Figures 6.5, 6.6 and 6.7. These comparisons revealed that all combinations of upgrades provided import capability greater than the required CETO through 2019. However, closer examination revealed that the Northern Alternative is less robust than MAPP without a strong source into Kemptown.

Map 6.6: MAPP and PATH Alternatives



The right-of-way route shown on this map is for illustrative purposes only and may not depict the actual route that may eventually be chosen. Substation locations may also be modified if more beneficial connections are determined by PJM.

Figure 6.5 presents the relative strength of MAPP and the Northern Alternative in terms of Eastern MAAC import capability, as studied in combination with the PATH project and Liberty proposal, discussed in **Section 5** to solve reliability criteria violations further west in PJM.

- Liberty Project plus MAPP
- Liberty Project plus the Northern Alternative
- PATH plus MAPP
- PATH plus the Northern Alternative

Likewise, Figure 6.6 presents the relative strength of MAPP and the Northern Alternative in terms of Eastern MAAC import capability, as studied in combination with Dominion Alternatives, also discussed in **Section 5** to solve reliability criteria violations further west in PJM.

- Dominion Alternative 1 plus MAPP
- Dominion Alternative 1 plus the Northern Alternative
- Dominion Alternative 2 plus MAPP
- Dominion Alternative 2 plus the Northern Alternative
- Dominion Alternative 3 plus MAPP
- Dominion Alternative 3 plus the Northern Alternative

Figure 6.5: EMAAC Alternative Comparison 1

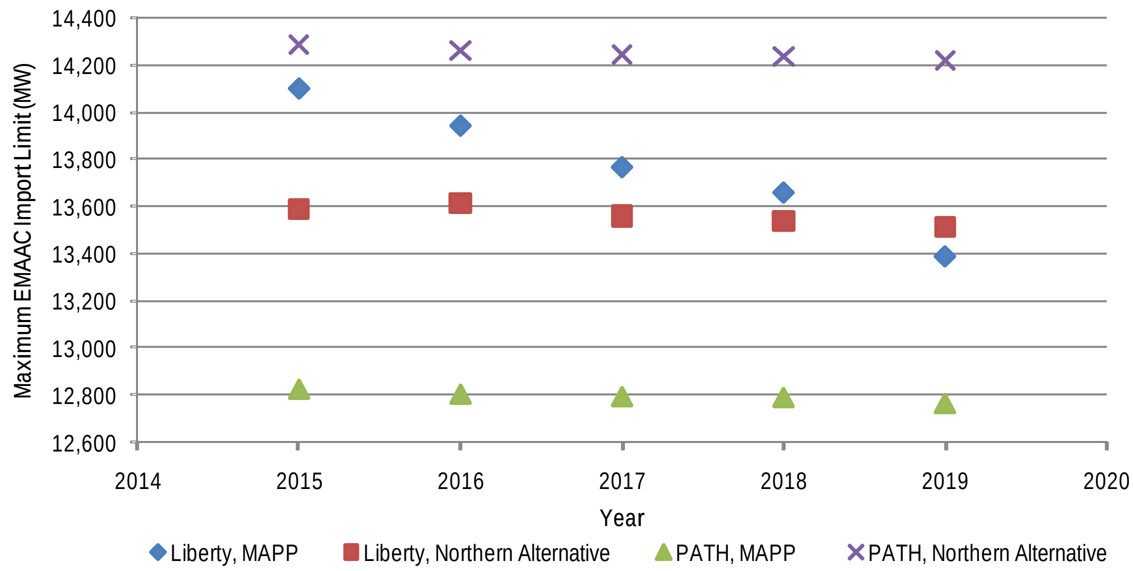


Figure 6.6: EMAAC Alternative Comparison 2

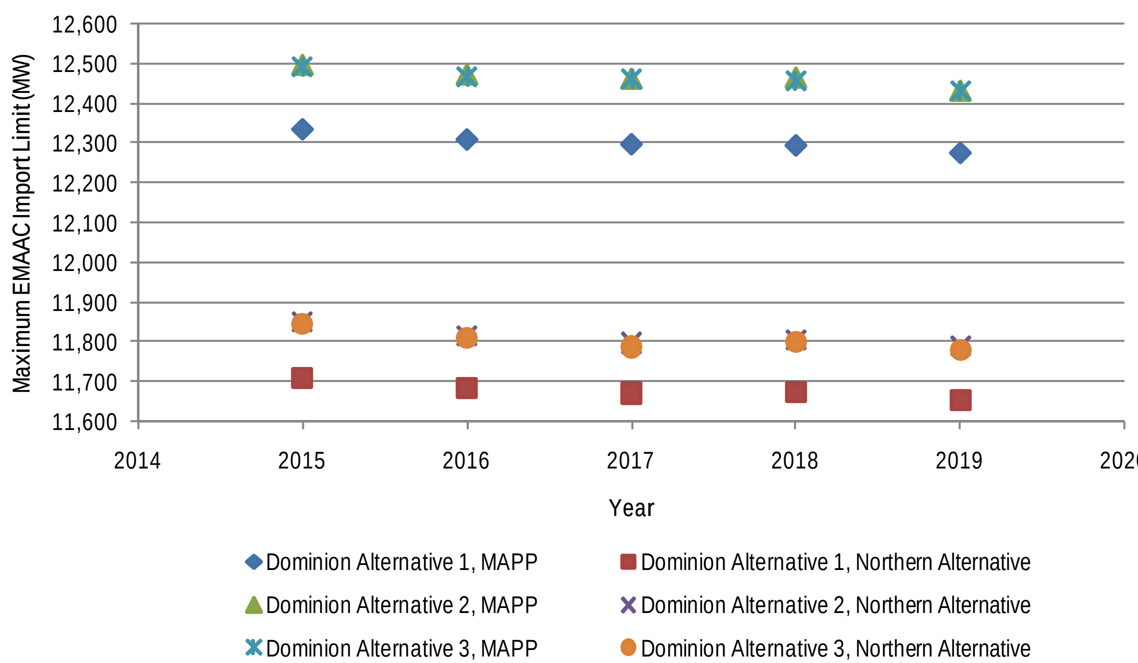


Figure 6.7 provides the results of the combinations provided in Figures 6.5 and 6.6 plus a linear representation of base case conditions, absent any upgrades.

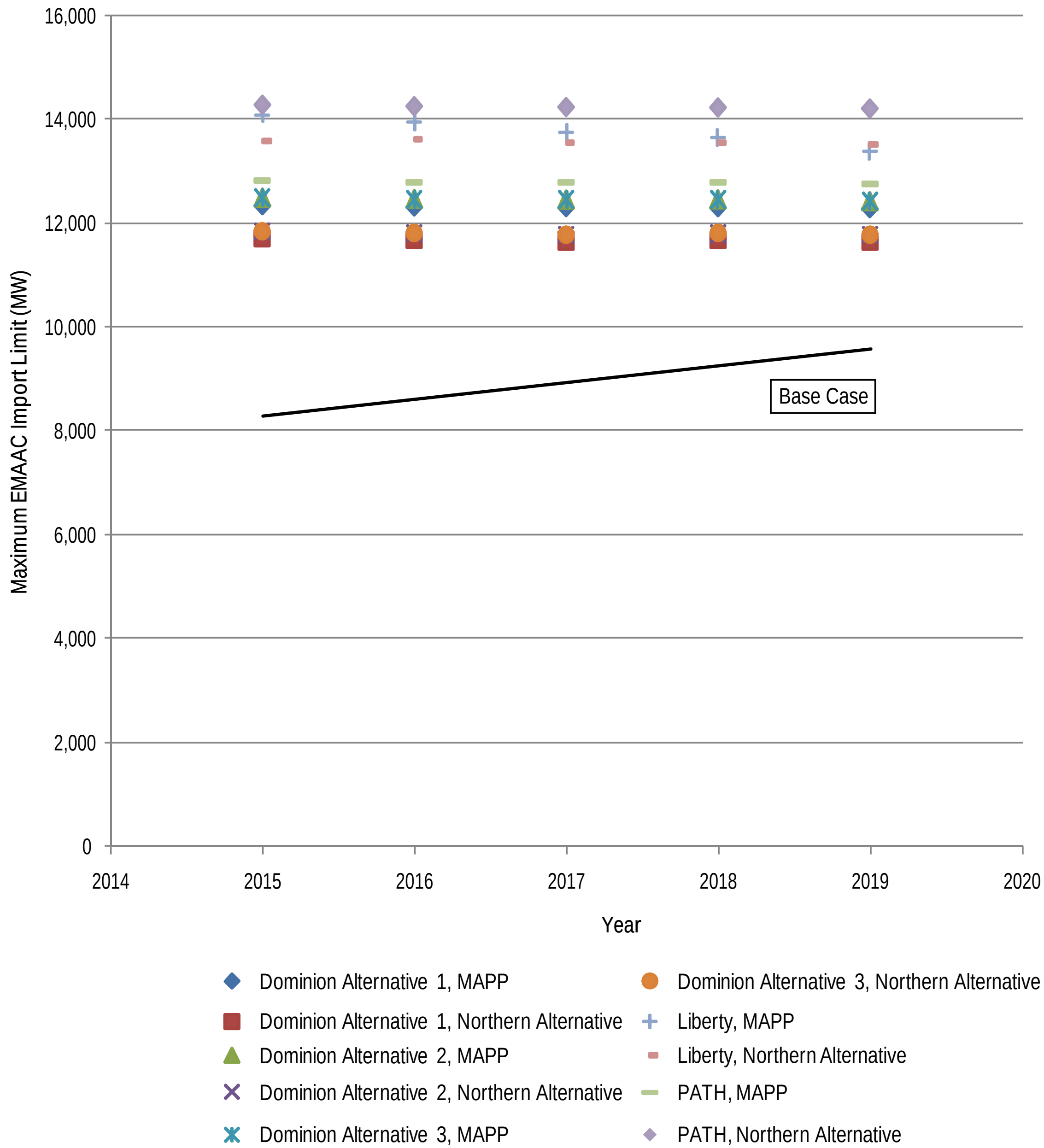
6.5.2 – Northern Option Conceptual Study Results

Burns & McDonnell Engineering Company, an independent consultant, performed a conceptual study of the Northern Alternative: identification and evaluation of a potential overhead 500 kV transmission line from the Kemptown Substation in Maryland to Salem/Hope Creek Substation in New Jersey.

The purpose of this conceptual study was to assess the feasibility of the Northern Alternative at a high level using available public-sector data. Specifically, the study included an assessment of siting, real estate acquisition, engineering, construction, and potential environmental impacts related to the proposed transmission line and substations.

The study revealed that construction of a new 500 kV transmission line and construction and/or expansion of associated substations would likely be feasible. However, the Project would likely have a number of challenging issues to address including the following: siting, real estate, eminent domain authority, permitting, environmental impact and project construction. The complexity of these issues would likely extending the schedule for project completion. The time frame and costs required to energize the line would likely be significant based on the need to cross four different states and nine counties and the issues and constraints described above.

Figure 6.7: EMAAC Alternative Comparisons 3



The study estimated total project cost in the range of $1.22 to $1.54 billion. Project duration from project kickoff to energization was estimated at approximately 111 months based on a low-risk schedule.

The complete study is available on PJM's website via the following URL: http://www.pjm.com/~/media/committees-groups/committees/teac/20101006/20101006-northern-option-conceptual-study.ashx.

6.5.3 – MAPP Project Validated

Based on the analysis performed on the PJM system for 2015 as a part of the 2010 RTEP process as described in **Sections 6.2** through **6.5**, PJM confirmed the need for the MAPP Project by June 1, 2015. Considering the effectiveness of the alternatives, the estimated costs and the estimated time to complete each alternative, the MAPP project was ultimately selected as the best alternative to resolve the identified criteria violations.

Preliminary 2011 PJM RTEP process analysis suggests that the need for the PATH line has moved several years beyond 2015. The outlook for a slower economic recovery – reflected in the reduced load growth rates in PJM's January 2011 published forecast – has led the PJM Board to direct transmission owners to suspend efforts on the PATH line pending a more complete analysis in 2011 of all RTEP upgrades, including MAPP. **Section 5** of this report discusses the PATH suspension.