7.0: Overview

7.0.1 – Summary of Key Modeling Assumptions
In recognition of the dynamic nature of study assumptions, PJM’s 2009 RTEP analysis included a 2013 system retool assessment, originally conducted as part of the 2008 RTEP process. Retool analysis provides PJM with the opportunity to address uncertainties associated with earlier decisions and identify whether upgrades are still required when originally identified.

PJM incorporated a number of changes into the 2009 RTEP retool analysis to reflect the changes since 2008. Results of the 2008 RTEP analysis are available in the 2008 RTEP Report which is available at: http://www.pjm.com/documents/reports/rtep-report.aspx.

Generation
With respect to the 2009 RTEP Retool of the 2013 system, all generation expected to be in service by June 1, 2013 was modeled, based on PJM’s RTEP methodology described in Section 2.3.

2009 Load Forecast vs. 2008 Forecast, for 2013
Load forecasting is a fundamental driver of resource adequacy requirements and transmission expansion plans. PJM issued a new load forecast report in January 2009 for 2009 through 2024. PJM RTO load for 2013 was forecasted to be 147,442 MW, 2,053 MW (1.4 percent) less than the 2008 forecast for 2013. Likewise, the 2009 PJM forecast for the Mid-Atlantic region of PJM for 2013 was 64,706 MW (1.7 percent) less than the 2008 forecast.

Please refer to Section 2.1.3 for detailed forecast comparisons and load growth projections. Figures in Section 2.1.3 provide RTO and Sub-regional load forecast trends, respectively.

Load Management
PJM’s RTEP process analyses model the impact of load management. This includes the impact of Demand Resources (DR) and Energy Efficiency (EE) that have cleared PJM’s Reliability Pricing Model (RPM) three-year-forward capacity market. Additional discussion of load management concepts can be found in Section 2.2 and Section 3.4.3.

The 2013 retool in PJM’s 2009 RTEP cycle of analyses modeled the impact of the 1,996 MW of load management that was forecasted for 2010/2011 based on DR and ILR commitments for the Mid-Atlantic region through the RPM process, consistent with the 2009 Load Forecast Report. The 1,996 MW included Interruptible Load for Reliability (ILR). The 2008 RTEP included 1,018 MW of DR for the Mid-Atlantic region, which also included the impact of ILR, per the respective business rules in place for the respective Load Forecast for the 2008 RTEP cycle.

As a result of recent rule changes, importantly, ILR was treated as a stand-alone resource in RPM auctions for 2011 and all relevant years preceding that point. Subsequent to 2011, ILR is eliminated. A description of recent rule changes can be found in Section 2.2. Additional information is also included in PJM load forecast reports, available online via the following URL link: http://www.pjm.com/planning/resource-adequacy-planning/load-forecast-dev-process.aspx.

Network Topology
Upgrades approved by the PJM Board along with merchant transmission projects expected to be in service by June 1, 2013 were incorporated into PJM’s 2009 Retool analysis of 2013. Interchange values used in the 2009 retool analysis of the 2013 system were consistent with approved long-term firm transmission service requests in PJM’s OASIS system.
Section 7

7.1: Amos - Welton Springs - Kemptown (PATH Line)

7.1.1 – Background
The Amos - Welton Springs - Kemptown 765 kV line, shown on Map 7.1, was approved by the PJM Board of Managers in June 2007. Also known as the Potomac Appalachian Transmission Highline (PATH), this backbone transmission line was identified to resolve deliverability reliability criteria violations throughout the 15-year planning horizon, including overloads on the following 500 kV lines across Central Pennsylvania and the Allegheny Mountain areas of PJM, beginning in 2012, as shown on Map 7.1.

- Mt. Storm - Doubs 500 kV line
- Keystone - Jack’s Mountain 500 kV line
- Jack’s Mountain - Juniata 500 kV lines #1 and #2

Originally identified in PJM’s 2007 RTEP, the required in-service date for the PATH Line was June 1, 2012. PJM’s 2007 RTEP report provides additional discussion of the reliability criteria violations driving the need for the PATH line approved by the PJM Board. That report can be found on PJM’s Web site via the following URL link: http://www.pjm.com/documents/reports/rtep-report.aspx.

Siting Considerations
Originally comprising a 765 kV segment from Amos to Bedington and a 500 kV segment from Bedington to Kemptown, transmission owners encountered siting issues associated with the Bedington substation and the line segment from Bedington to Kemptown. As a result, changes have been made to the configuration of PATH.

Instead of a Bedington mid-point, PATH now comprises a 765 kV line from the Amos station in West Virginia to a new mid-point station located at Welton Springs along the Mount Storm Meadowbrook portion of the TrAIL line in West Virginia, continuing at 765 kV to Kemptown, Maryland, as shown on Map 7.1.

The PATH line will no longer go through Bedington substation. The new Welton Springs substation will include two 765 / 500 kV transformers and a 765 kV static VAR compensator (SVC). Transformation at Welton Springs and Kemptown substations will interconnect the 765 kV to existing 500 kV backbone transmission facilities. Retool analyses modeled PATH with this new configuration.

7.1.2 – Retool Results
The results of PJM’s retool analysis in the 2008 RTEP process revealed 500 kV overloads in the region beginning in 2013 and continuing through 2023. Thus, the 2008 RTEP determined that, based on the updated assumptions available at that time, the Amos - Kemptown 765 kV line was needed by June 1, 2013.

PJM conducted another retool in 2009 which revealed that the 2013 in-service date could be deferred for one year until 2014, based on updated assumptions including a revised load forecast, updated generation additions, withdrawals and retirements and updated transmission topology. Results showed that without the PATH line, no thermal overloads were identified in 2013. This analysis assumed the TrAIL project in-service. TrAIL is under construction by respective transmission owners and is targeted for June 2011 completion.

While no criteria violations were identified in a 2013 retool, PJM’s 2009 baseline deliverability analysis, however, identified widespread thermal and reactive criteria violations beginning in 2014, confirming need for the PATH line, as discussed in more detail in Sections 8.1.

PJM’s 2009 RTEP process also included a conceptual study commissioned by PJM to ascertain the feasibility of integrating high voltage direct current (HVDC) technology into the PATH project. The results of this study are also discussed in Section 8.1.

* NOTE
Jack’s Mountain was originally named Airydale.
Map 7.1: Amos - Kemptown (PATH) 765 kV Line and TrAIL 500 kV Backbone Transmission Lines

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.
7.2: MAPP Transmission Line

7.2.1 – Background
PJM’s 2008 RTEP analyses revealed that the MAPP project, shown on Map 7.2 was needed to resolve NERC criteria violations in the Mid-Atlantic area of PJM throughout its 15-year planning horizon ending in 2023. Based on 2008 RTEP results, the MAPP line would be needed by June 1, 2013. That analysis is discussed in PJM’s 2008 RTEP report, accessible from PJM’s Web site via the following URL link: http://www.pjm.com/documents/reports/rtep-report.aspx.

7.2.2 – Retool Analysis
PJM’s 2009 Retool analysis assessed MAPP on a 2013 system to affirm continuing need for the line. Based on this updated analysis the required in service date has been deferred for one year until June 1, 2014.

Based on the results of PJM’s 2009 RTEP process retool analyses, without the MAPP project the PJM system will experience severe voltage collapse under certain contingency conditions as early as June 2014. In addition, 17 thermal reliability criteria violations were identified between 2014 and 2023. These results are discussed in detail in Section 8.2, as part of 2014 baseline analysis results.

PJM’s 2009 RTEP process included additional examination of the MAPP HVDC configuration aspects of the Calvert Cliffs to Vienna and Calvert Cliffs to Indian River segments. The operability and controllability aspects of HVDC technology provides sufficient means to solve identified reliability criteria violations such that the Indian River to Salem segment of the line, for the duration of PJM’s 15-year planning horizon, is not required. Consequently, the Indian River to Salem segment of the MAPP project has been removed from PJM’s RTEP.

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.
7.3: Branchburg - Roseland - Hudson 500 kV Transmission Line

7.3.1 – Background
PJM’s 2008 RTEP process identified more than 20 thermal and reactive reliability criteria violations in Northern New Jersey. PJM recommended a Branchburg - Roseland - Hudson transmission line, shown on Map 7.3, to resolve these violations.

7.3.2 – Reconfirming Need
The complexity of the 2009 RTEP process retools of previous years – 2010, 2011 and 2012 – in northern New Jersey demonstrated to PJM, as the 2013 retool neared completion, that the newer 2010 RTEP input data needed to provide specific definitive results regarding reconfirmation of need for the Branchburg - Roseland - Hudson (B-R-H) 500 kV line. Consequently, reassessment of the B-R-H line will comprise a key part of PJM’s 2010 RTEP process analyses.

7.3.3 – Line Options Studied
A study was completed in 2009 which explored two B-R-H options – one at 500 kV and one at 230 kV – for their ability to resolve identified reliability criteria violations. While each alternative resolved reactive issues, the 500 kV alternative provided a solution to all near term thermal violations and did not require upgrading of underground 230 kV circuits, a significant disruption to system operations.

Map 7.3: Branchburg - Roseland - Hudson 500 kV 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.
**Option 1: 500 kV Alternative**
Alternative 1 consists of a new overhead 500 kV circuit from Branchburg to Roseland, conversion of the overhead Roseland - Turnpike 138 kV circuit to 500 kV and extending this circuit to a new 500 kV Hudson substation. In addition, this alternative would convert the overhead Hudson - Bergen circuit (F-1306) from 138 kV to 230 kV and upgrade the Hudson substation for 80 kA. This will require modifications to nine substations. The alternative is estimated to cost $1.2 billion and take 4.5 to 5.0 years to complete (including permitting, engineering, procurement and construction).

**Option 2: 230 kV Alternative**
Alternative 2 consists of modifying the overhead Roseland - Kearny 230 kV circuit, looping it into the Athenia Substation, converting the overhead Roseland - Kearny 138 kV circuit to 230 kV, reconductoring 7 individual underground 138 kV circuits (totaling 38.5 miles) for 230 kV service, upgrading the Hudson substation for 80 kA and converting the overhead Hudson - Bergen circuits (F-1306 & E-1305) from 138 kV to 230 kV. This will require modifications to 12 substations. This alternative is estimated cost is $907 million and take 5.0 - 5.5 years to complete (including permitting, engineering, procurement and construction).

### 7.3.4 – Comparison of Line Option Risk Factors
PJM commissioned outside consultants to conduct a comparative independent evaluation and provide a recommended upgrade option based on permitting issues, technical risks, cost, schedule and overall complexity of both options.

Tables 7.1, 7.2, 7.3, and 7.4 compare costs and potential risk factors including permitting,

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<thead>
<tr>
<th>Table 7.1: Risk Factor Comparison: Permitting and Environmental</th>
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<tbody>
<tr>
<td><strong>Risk Factor Comparison: Permitting and Environmental</strong></td>
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<tr>
<td><strong>Option 1</strong></td>
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<tr>
<td>Permitting: There are no regulatory issues that would prevent the necessary permits from being granted.</td>
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<tr>
<td>Public Opposition: Opposition to the Susquehanna - Roseland 500 kV line continues to intensify and increases difficulty risk to public approval of the Branchburg - Hudson line. FERC backstop option is available but would adding time to permitting approval process.</td>
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<tr>
<td>Koppers Superfund Site: The Hudson 500 kV substation requires land acquisition and completion of remediation work. The smaller footprint provided by a GIS would reduce time or possibly eliminate the need for remediation. This would also allow for an shorter overall construction duration.</td>
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<tr>
<td>Great Swamp National Wildlife Refuge: The new 500 kV Branchburg-Roseland line is located along the boundary of the Great Swamp which may involve review by the US Fish and Wildlife Service.</td>
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<tr>
<th>Table 7.2: Risk Factor Comparison: Engineering and Construction</th>
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<tr>
<td><strong>Risk Factor Comparison: Engineering and Construction</strong></td>
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<tr>
<td><strong>Option 1</strong></td>
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<tr>
<td>Hackensack River Crossing: The Hudson 500 kV substation will require an overhead river crossing to connect the 230 kV Hudson and 345 kV Farragut lines. Some of the existing overhead lines may need to be relocated to support this option.</td>
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<td>Hackensack River Crossing: This overhead line will require ~300 foot towers and FAA Authorization due to height and proximity to Newark Airport.</td>
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environmental impacts, engineering challenges, construction aspects, outage sequencing and other factors.

7.3.5 – Conclusions and Recommendations
500 kV Option 1 represents the lower risk system upgrade alternative with less system impact during construction and a shorter overall construction schedule when compared to Option 2.

**Option 1**
Option 1 involves more new construction. However, outage and cutover requirements are generally less complicated and of shorter duration for new construction. Option 1 is all overhead construction. The majority of the outages for the adjacent lines will be short for monopole construction. Longer duration outages will only be required for the line being rebuilt for the higher voltages. Additionally, overhead lines can be restored more quickly if emergency conditions arise.

**Option 2**
Option 2 will require multiple transfers from permanent power to temporary power and then back to higher voltage permanent feeds, adding to reliability concerns. Additionally, because of the nature of underground cables and splicing during the construction of Option 2, substations will be operating without one of their normal feeds, thus reducing reliability for months at a time. While technically feasible, Option 2 presents elevated environmental and schedule risks due to the age of the underground piping system that cannot be fully quantified prior to the onset of construction.

### Table 7.3: Risk Factor Comparison: Construction Planning and Outage Sequencing

<table>
<thead>
<tr>
<th>Risk Factor Comparison: Construction Planning and Outage Sequencing</th>
<th>Option 1</th>
<th>Option 2</th>
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<tbody>
<tr>
<td>Simultaneous Line Outages: All four transmission lines in the Roseland - Hudson right of way will be required for safety during 500 kV monopole erection (includes the two circuits that will be replaced and the two adjacent circuits for safety).</td>
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<tr>
<td>Construction Schedule: conceptual level schedule developed for duration estimate. A more definitive system outage and reliability studies must be completed.</td>
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<tr>
<td>System reliability: Maintaining system reliability will be a challenge during the multi-year Reconductoring plan. Two substations are presently served by only two underground lines; replacement of each line will leave each station connected to only one feed source. Further study is required to develop a construction sequencing and outage duration plan that maintains acceptable system reliability.</td>
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<tr>
<td>Increased fault levels: Increased fault levels resulting from higher voltages in the distribution system need to be evaluated to determine the capability of existing distribution equipment and for the need to upgrade equipment within the PSE&amp;G distribution system.</td>
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### Table 7.4: Other Factors

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<tr>
<th>Risk Factor Comparison: Positive Factors</th>
<th>Option 1</th>
<th>Option 2</th>
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<tr>
<td>New Construction: Predominantly new construction requiring relatively short duration outages. The fewer number of, and shorter duration of outages required for Option 1 should result in higher system reliability during construction as compared to Option 2.</td>
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<tr>
<td>Distribution System Impacts: Option 1 will have less impacts on the PSE&amp;G distribution system due to the limited amount of work in substations at distribution system voltage levels.</td>
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<tr>
<td>Adequate Right-of-Way: Based on preliminary analysis, there is sufficient space within existing right-of-way’s to accommodate the new and upgraded overhead lines.</td>
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<td>A majority of the transmission line upgrades are underground and therefore less visible to the public.</td>
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<td>Fewer permits required and reduced public scrutiny expected when compared to Option 1.</td>
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<tr>
<td>With the use of GIS equipment, it may be possible to construct the Hudson 230 kV substation at the existing location eliminating the need to work at the Koppers superfund site.</td>
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7.4: 2013 Retool: NERC Category C

2013 retool analysis conducted as part of PJM’s 2009 RTEP process identified the following NERC Category C type violations and required RTEP modifications. The upgrades discussed below are shown on Map 7.4.

Northeast Pennsylvania

PJM identified Category C-3 type voltage violations in the Jenkins area of Northeastern Pennsylvania (shown on Map 7.4) for the loss of Jenkins - Stanton 230 kV line and the loss of Jenkins - Susquehanna 230 kV line. The proposed solution is to convert the Jenkins 230 kV yard into a 3-breaker ring bus and install a second Jenkins - Stanton 230 kV line. The estimated project cost is $7.74 million for the Jenkins substation rearrangement and $3.34 million for the Jenkins-Stanton 230 kV line. With required in-service date of June 1, 2013.

Southern New Jersey

The 2009 RTEP Retool for 2013 identified low voltage magnitude and voltage drop violations in the Lincoln, Landis, and Sherman areas of Southern New Jersey for several 138 kV line contingency combinations. The recommended upgrade is to build a new Lincoln - Landis 138 kV line. The estimated project cost is $12.5 million and the expected in service date is June 1, 2013.

In addition, low voltage magnitude violations in the Motts Farm area of Southern New Jersey were identified for several contingency combinations. The recommended upgrade to resolve these violations is to install a 35 MVAR capacitor at the Motts Farm 69 kV bus. The estimated project cost is $2.8 million with a required in-service date of June 1, 2013.

Delmarva Peninsula

PJM 2009 retool analysis also revealed that two baseline upgrade projects approved to resolve reliability criteria violations on the Delmarva Peninsula are no longer required. Specifically, the baseline upgrade to rebuild Indian River - Bethany 138 kV line is now cancelled in light of the baseline upgrade to build a new Indian River-Bishop 138 kV line.

Also, the baseline upgrade to rebuild Steele - Church 138 kV line is cancelled. This upgrade addressed thermal violations in the area, but does not address the reactive violations. The new proposed upgrade is to build a second Glasgow - Mt Pleasant 138 kV line which resolves both the thermal and reactive violations. This project has an estimated cost of $16.3 million with a required in-service date of June 1, 2013.