Section 1: Executive Summary

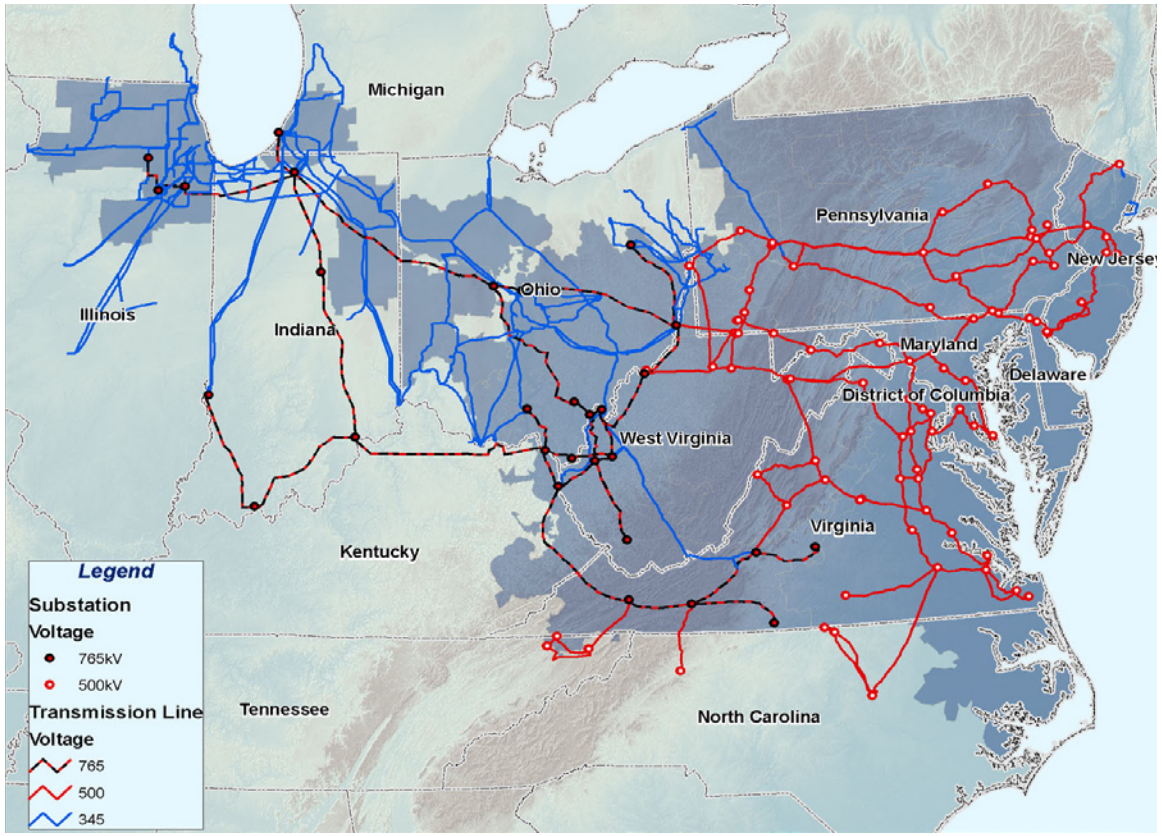
PJM DE DC IL IN KY MD MI NJ NC OH PA TN VA WV

PJM's Regional Transmission Expansion Plan (RTEP) identifies transmission system upgrades and enhancements to preserve the reliability of the electricity grid, the very foundation for thriving competitive wholesale energy markets. As a Federal Energy Regulatory Commission (FERC) approved Regional Transmission Organization (RTO), one of PJM's core functions encompasses regional transmission planning activities to address the reliability needs of a region that encompasses more than 164,000 square miles in 13 states and the District of Columbia, as shown on MAP 1.1.

The RTEP planning horizon permits PJM to assess reliability criteria violations up to 15 years forward, conduct market efficiency scenario analyses and perform reliability-based sensitivity analyses. New RTEP recommendations are submitted to PJM's independent Board of Managers (PJM Board) periodically throughout the year as they are identified. These recommendations include the following:

- Solutions to maintain reliable service to long-term firm customers by addressing transmission reliability constraints revealed by baseline reliability analyses.
- Direct connection, transmission enhancements associated with generation and merchant transmission interconnection requests

MAP 1.1: PJM Backbone Transmission System



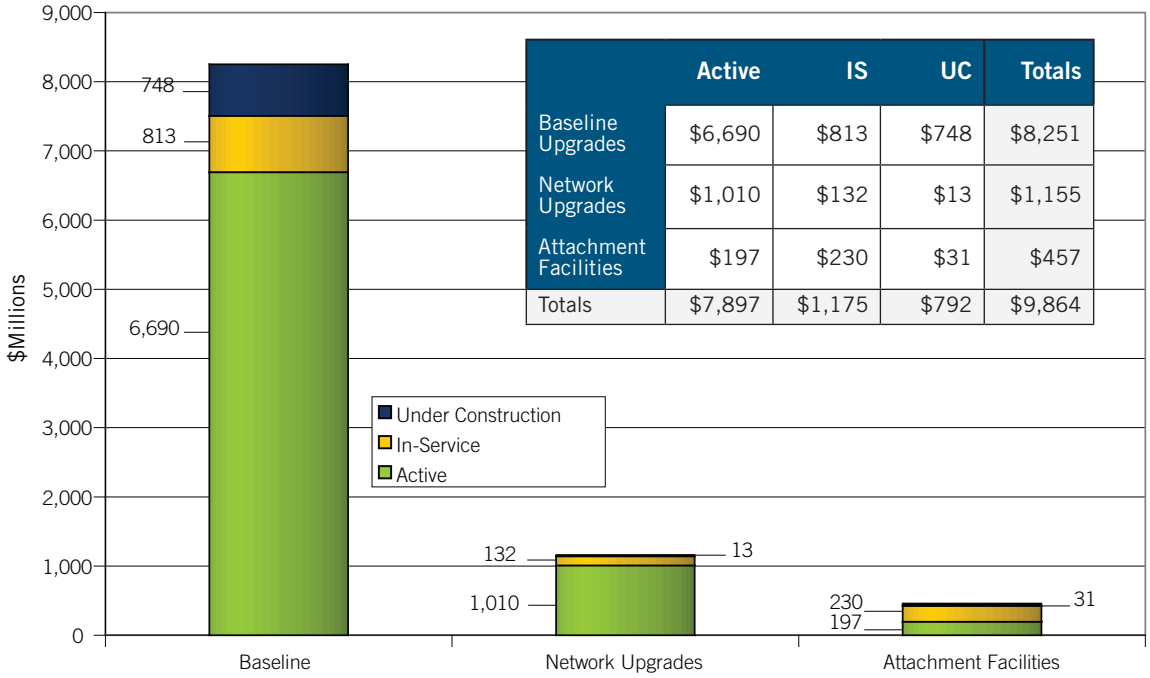
- Necessary network transmission enhancements in response to interconnection requests
- Cost responsibility allocations for baseline reliability upgrades

PJM's RTEP process includes both five year and 15-year dimensions. Specifically, five-year planning enables PJM to assess and recommend transmission upgrades to meet forecasted near-term load growth and to ensure the safe and reliable interconnection of new generation and merchant transmission projects seeking interconnection within PJM. The 15-year horizon permits consideration of many long-lead-time transmission options. Longer lead times allow consideration of larger magnitude upgrades that more efficiently and globally address reliability issues. This can be, typically, a higher voltage upgrade that addresses many lower voltage violations simultaneously. Longer lead times also allow a plan to consider the effects of other ongoing system trends such as long-term load growth, the impacts of generation retirements and aggregate generation development patterns across the system. This could include reliability issues posed by clusters of development based on innovative coal or nuclear technologies, renewable energy sources, or proximity to fuel sources.

Approved Upgrades to Enhance System Total $9.8 Billion

The PJM Board has authorized more than $9.8 billion of transmission upgrades and additions since RTEP process inception in 1997. Nearly $2 billion of this is under construction or already in-service. This figure includes more than $ 5.0 billion approved in 2007 alone that are indicative of an accumulated need for backbone remedies. $8.25 billion of baseline transmission network upgrades across PJM ensure that established reliability criteria will continue to be met. A summary of upgrades by status appears in FIGURE 1.1. At the same time, $1.6 billion of additional transmission upgrades will add more than 36,000 megawatts (MW) of new generating resources and accommodate the interconnection of several merchant transmission projects.

FIGURE 1.1: Status of Baseline, Network and Attachment Facility Connection Upgrades

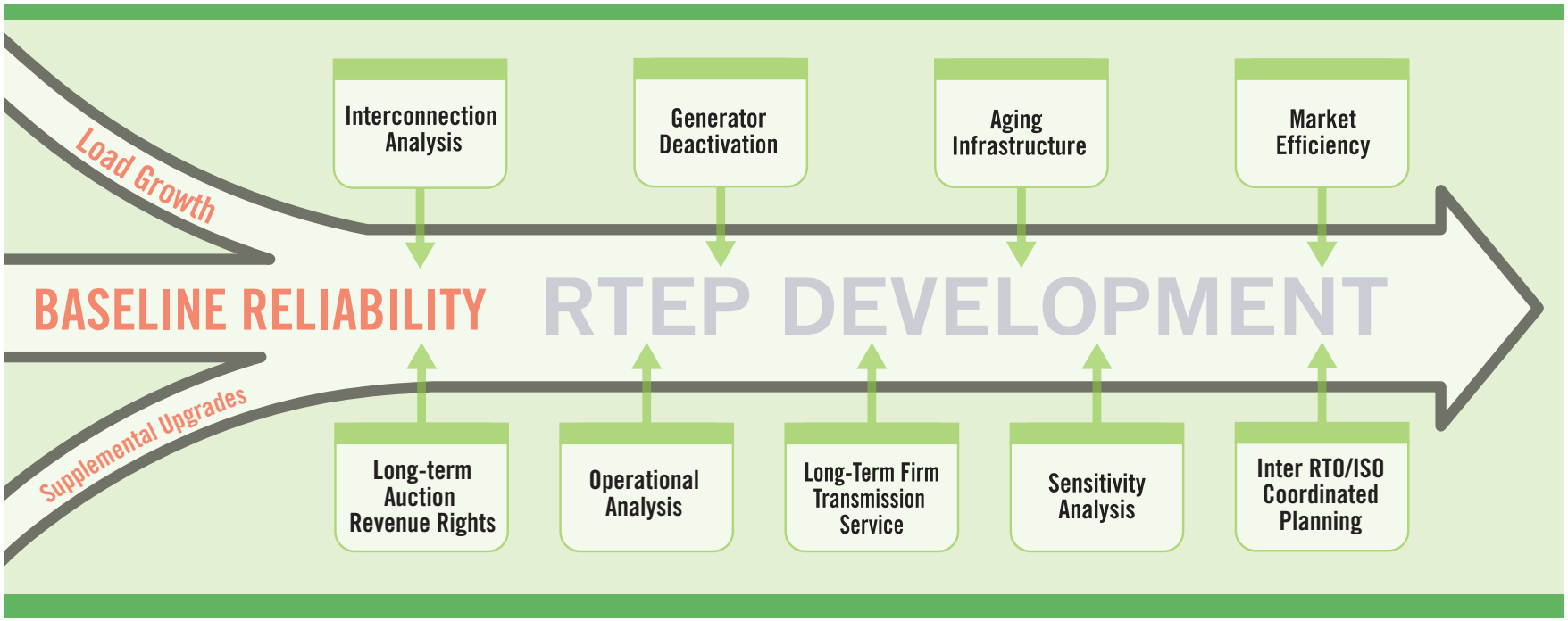


	Active	IS	UC	Totals
Baseline Upgrades	$6,690	$813	$748	$8,251
Network Upgrades	$1,010	$132	$13	$1,155
Attachment Facilities	$197	$230	$31	$457
Totals	$7,897	$1,175	$792	$9,864

NOTE

36,000 MW comprises the amount of queued generation in PJM that is in-service, under construction or has been approved by the PJM Board, through 12/31/07 for interconnection in PJM with all necessary network upgrades and attachment facilities. If the generation with suspended ISAs, and associated attachment and network upgrades is included, the 36,000 MW increases another 1,700 MW to 37,700 MW.

FIGURE 1.2: RTEP Development Drivers



Expansion Planning Drivers

Since its inception in 1997, PJM's RTEP Process has continued to adapt to the planning needs of RTO members and the mandates of the Federal Regulatory Energy Commission. Initially, PJM's RTEP consisted mainly of upgrades driven by load growth and generating resource interconnection requests. Today, myriad drivers are considered in PJM's RTEP process as discussed in **Section 2** and summarized here in FIGURE 1.2.

The RTEP Process during 2007 culminated with PJM Board approval of those system upgrades necessary to resolve reliability criteria violations identified through 2012 and beyond. Now part of PJM's RTEP, these new upgrades are integrated "on top of" existing RTEP upgrades approved between 1999 and December 31, 2006.

Three New 765 and 500 kV Backbone Transmission Lines

The PJM 2006 RTEP report discussed the 502 Junction – Mt. Storm – Meadow Brook – Loudoun 500 kV circuit (Loudoun Line) approved by the PJM Board in June 2006. As that report indicated, this facility resolves reliability criteria violations in 2011 to provide critical support to the eastern Mid-Atlantic PJM area and to maintain reliability in Northern Virginia and the Baltimore/Washington D.C. area. The PJM 2006 RTEP report, published February 27, 2007, is accessible from PJM's Web site via the following URL link: http://www.pjm.com/planning/reg-trans-exp-plan.html.

Board Approval of New Backbone Facilities

Reliability and System Integration Benefits

With the Loudoun line in place as part of the RTEP in June 2006, PJM initiated a series of analyses throughout the rest of 2006 and 2007. These analyses considered a number of transmission options to resolve reliability criteria violations through 2021 and beyond. Additionally, the options were compared with respect for their overall degree of system support.

Transmission options were considered in some 30 alternative combinations, the scope of which was described in **Section 4** of the PJM 2006 RTEP report. The 2006 and 2007 analyses yielded a number of key conclusions that guided selection of a "package" of upgrades submitted to and approved by the PJM Board in 2007:

1. Alternatives that provide a source into Roseland provide a significant benefit to mitigate overloads in northern New Jersey.

2. Alternatives that provide a source into Deans or Salem provide minimal benefit for mitigating overloads in northern New Jersey.

3. Lines that terminate at South Canton, Kammer or Amos in western PJM each mitigate the remaining reliability criteria violations along PJM's western and central interfaces as identified in the 15-year horizon.

4. From a market efficiency perspective, alternatives that connect back to the AEP 765 kV system provide the greatest opportunity for eastern load centers to access additional economical energy from western generating resources.

5. Alternatives that integrate emerging aggregated power source areas with load centers provide another degree of benefit by anticipating system trends and market needs. These include projects that address reliability issues posed by clusters of development based on innovative coal or nuclear technologies, renewable energy sources, or proximity to fuel sources.

After consideration of many options, the outcome of all these analyses was a proposal to the PJM Board to approve the addition of the three best alternatives for new backbone transmission facilities, as shown on MAP 1.2.

The PJM Board formally approved the first two of these facilities in June 2007 and the third in October 2007.

1. **Susquehanna – Lackawanna - Jefferson – Roseland 500 kV Circuit:**
PJM 2007 RTEP analyses identified numerous overloads on critical circuits across Eastern Pennsylvania and Northern New Jersey that will exceed their conductor rating as early as 2013. A number of load deliverability and generator deliverability violations were identified in northern New Jersey in the 2006 RTEP. 2007 baseline analysis revealed that a number of these violations will occur sooner than anticipated in the 2006 RTEP. The addition of the Susquehanna – Lackawanna – Jefferson – Roseland 500 kV line reduces northern New Jersey overloads to a point that future overloads are not expected until at least 2016 and in a number of cases, beyond 2022.

This circuit would create a strong link from generation sources in north-central Pennsylvania, including the Susquehanna nuclear station, across northeastern Pennsylvania into New Jersey. In addition, the line could also be extended from Susquehanna at its western end to integrate with a cluster of new coal-fired generation resources in central Pennsylvania, currently under development through PJM's interconnection process. The line as currently proposed is estimated to cost $932 million with a desired in-service date of June 1, 2012.

2. **Amos - Bedington – Kemptown 765 and 500 kV Circuit:**
The 2006 RTEP projected that the Airydale – Juniata and Keystone – Conemaugh 500 kV lines would exceed their conductor ratings in 2019 and 2021 respectively. Results of the 2007 baseline assessment (which included 502 Junction – Mt. Storm – Meadow Brook – Loudoun 500 kV circuit) indicate that those lines now will be overloaded as early as 2012. In addition, PJM's 2007 RTEP analyses identified additional multiple 500 kV overloads between 2012 and 2022. In contrast, the addition of the Amos – Bedington – Kemptown line alleviates overloads to a point that future overloads are not expected until at least 2021 and beyond 2022

Bringing a strong source into Kemptown will reduce the flow on existing PJM 500 kV west to east transmission paths and provide significant benefits to the constrained Baltimore / Washington area. Amos is a relatively strong source with 2,100 MW of generating capacity that ties into the AEP 765 kV system. Kemptown is a key location in the constrained Baltimore / Washington area. The line as proposed by AEP is estimated to cost $1.8 billion.

3. **Possum Point – Calvert Cliffs – Indian River – Salem 500 kV Circuit (the Mid-Atlantic Power Pathway or "MAPP" project):**
2007 PJM RTEP analysis assessed the impact of the MAPP project on area load deliverability violations expected to occur over the 15-year planning horizon. These issues are commonly identified on the Delmarva peninsula, the result of limited north-to-south transmission coupled with limited internal generating resources. The addition of the MAPP project resolves most of the violations beyond PJM's 15-year planning horizon and provides a strong path for generation injection in to the southern part of the peninsula.

The MAPP project will also provide an additional transmission path across the PJM eastern interface and significantly improve voltage profiles across eastern Mid-Atlantic PJM. Further, the Artificial Island complex which contains the Salem and Hope Creek generating units has limited stability margins. The addition of the MAPP project will improve the transient stability margins of these units. The project will also help to integrate area generation currently in PJM's interconnection queue.

As proposed, the PHI MAPP 500 kV circuit will run from Possum Point, Virginia to the Salem 500 kV station in New Jersey, as shown on MAP 1.2. The 220 mile long line is expected to be built primarily along existing right-of-ways and is intended to pass through Burches Hill, Chalk Point, Calvert Cliffs, Vienna, Indian River and Cedar Creek stations. The line is expected to be overhead construction with the exception of the Chesapeake Bay crossing which is expected to be submarine cable construction. The line is estimated to cost $1.05 billion, as proposed.

Next Steps for New Backbone Facilities

Since the PJM Board approval in 2007, responsibility for implementation has moved to individual transmission owners. The first step is the preparation and submittal of siting applications to respective state jurisdictions in which the new facilities will be built.

Additional Key Reliability Upgrades

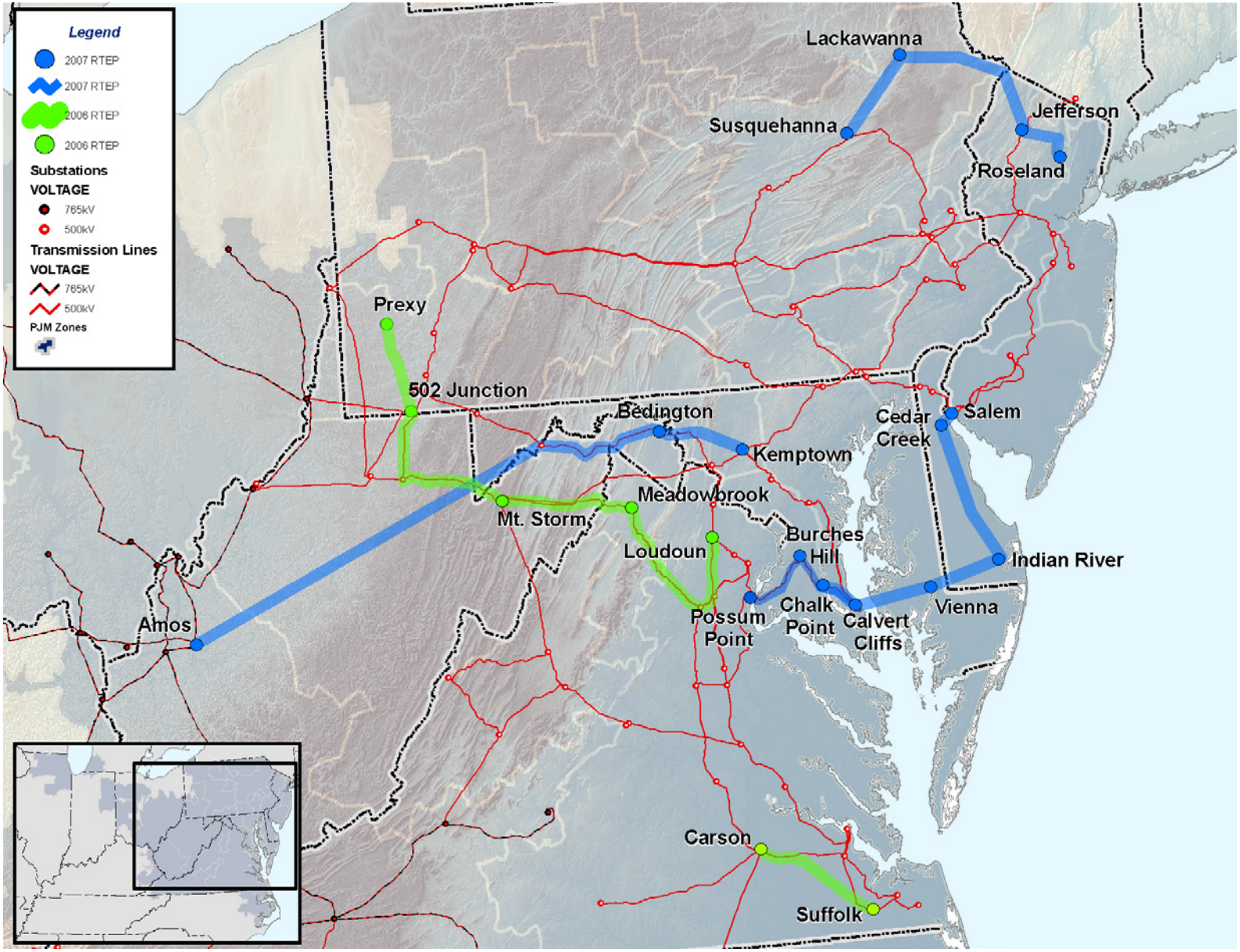
In addition to the three new major backbone transmission lines summarized above, the PJM Board also approved a number of other key upgrades in 2007 to resolve identified reliability criteria violations. These include the following.

MAAC Load Deliverability

The PJM RTEP 2012 MAAC load deliverability analysis revealed a number of widespread voltage and other issues, the result of growing power transfers to eastern Mid-Atlantic PJM load centers. A number of upgrades – including over 2,100 MVAR of new capacitors – are required to resolve identified reliability criteria violations. These RTEP upgrades include the following:

- 875 MVAR of additional capacitors in PPL and PENELEC.
- 800 MVAR of additional capacitors in BGE and PEPCo
- 450 MVAR of additional capacitors in AP
- New 500/230 kV transformers at Burches Hill in PEPCo and Brighton in BGE

MAP 1.2: Approved PJM Backbone Transmission Lines



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

Operational Performance – Transformer Infrastructure

PJM's RTEP process incorporates a probabilistic risk assessment (PRA) methodology to evaluate the risk associated with 500/230 kV transformers. PJM 2007 RTEP PRA initiatives addressed 500/230 kV transformer installations at Keeney in DPL and Elmont in Dominion. In addition, PJM's 2007 RTEP process included an evaluation using similar risk factors for the Kammer 765/500 kV transformer.

- ***Keeney:*** Transmission expansion plans have addressed an improving 500/230 kV transformer risk assessment at DPL's Keeney substation. 2007 PRA review revealed that the need for three spares has been reduced to two (an existing spare plus one new spare), the result of PHI-DPL action to address paper and oil moisture through means that include improved on-line monitoring.
- ***Elmont:*** PRA analysis recommended relocation of an existing system spare 500/230 kV transformer to Elmont. In 2007, subsequent to the move, a bank at Elmont failed requiring replacement with the recently relocated spare. While PRA cannot predict individual failures, reliability and economic impacts were minimized as a result of reduced outage duration.
- ***Kammer***: The Kammer 765/500 kV transformer is approaching its end of life, as demonstrated most recently last spring with the failure of one phase. That phase was replaced with an existing spare, leaving no spare available. In addition, since 2005, the facility has experienced over 3,300 hours of congestion totaling more than $220 million. 2007 RTEP analysis has shown the transformer overloaded in 2012 (the age of the facility notwithstanding). That overload is expected to be alleviated with the addition of the Amos – Bedington – Kemptown line in 2012. Given the age of the facility and its growing susceptibility to failure, a new larger transformer has been approved and incorporated into PJM's RTEP with an expected in-service date of June 2009.

Operational Performance – Post-Contingency Line Loading Relief Warnings (PCLLRWs)

The purpose of a PCLLRW in operations is to provide advance notice to a transmission owner(s) of the potential for manual load dump in their area(s). PJM planning and operating joint staff assessment of Summer 2007 operations in light of existing approved baseline transmission expansion upgrades in western PJM revealed that the following upgrades would alleviate more than 580 hours of PCLLRW events:

- Replacement of AP's North Shenandoah 138/115 kV transformer, scheduled for completion in May 2008.
- Installation of a fourth Meadowbrook 500/138 kV transformer by AP, scheduled for completion in May 2008.
- Installation of a fourth Bedington 500/138 kV transformer by AP, scheduled for completion in May 2009.
- Installation of a breaker failure auto-restoration scheme AP's Bedington 500 kV bus, scheduled for completion in June 2010.

Merchant Transmission

The Bergen HVDC / Hudson Transmission Project (queue position O66) would connect PSEG and New York City, from PSEG's Bergen 230 kV substation in northern New Jersey to Consolidated Edison's W. 49th Street 345 kV substation. Firm Transmission Withdrawal Rights of 670 MW are requested. The project developer anticipates a late 2010 in-service date. If constructed, the facility will withdraw 670 MWs of firm energy from Bergen station in northern New Jersey. As of December 31, 2007 a facilities study is underway. System Impact study results have revealed that the 670 MW withdrawal of power at Bergen would introduce almost two dozen overloads, requiring $450 million of network upgrades throughout the PSEG, JCPL, METEd, PENELEC, PPL, PEPCo and Dominion TO zones. Half of these overloads are expected to occur prior to 2015.

Other Reliability Upgrades

Many other upgrades across PJM, smaller in scope but no less important, were also approved by the PJM Board in 2007 and are discussed in **Section 3** of this report.