

Transmission Expansion Advisory Committee
(TEAC)
Recommendations to the PJM Board

PJM Staff Whitepaper
February 2016



EXECUTIVE SUMMARY

The PJM Board of Managers previously approved changes to the Regional Transmission Expansion Plan (RTEP) on December 16, 2015, totaling \$489.47 million, primarily to resolve identified reliability criteria violations.

Since that time PJM has identified a number of changes to previously approved baseline projects resulting in an increase of \$84.26 million. In addition to the changes to previously approved baseline reliability upgrades, PJM staff is also recommending several market efficiency projects to address energy market and capacity market congestion. These market efficiency projects, which were solicited through the 2014/15 long-term RTEP proposal window, have an estimated cost of \$20.48 million and are expected to mitigate at least \$300 million in energy market congestion over the next 15 years, and provide total annual savings of \$118 million in capacity load payments in RPM. The net impact to the RTEP to include these new upgrades and changes to previously approved projects is an increase of \$104.74 million.

With these changes, the RTEP will include over \$28,382.97 million of transmission additions and upgrades since the first plan was approved by the Board in 2000.

On February 17, 2016, the elements of the 2016 RTEP for the additional baseline upgrades were presented for the Board Reliability Committee's (BRC) consideration and for recommendation to the PJM Board for approval and inclusion in the RTEP. The PJM Board approved the changes as described below.



SUMMARY OF RESULTS

In 2012 PJM filed proposed changes to the Operating Agreement in compliance with FERC Order 1000. Those changes were approved by the FERC and were implemented for the first time as part of the 2014 RTEP. As part of that implementation, PJM administered the first Long Term Market Efficiency Proposal Window from November 2014 through February of 2015.

2014/2015 Long-Term Market Efficiency Proposal Window:

Market Efficiency Analysis is a part of the overall Regional Transmission Planning Process (RTEP) to accomplish the following objectives:

1. Determine which reliability upgrades, if any, have an economic benefit if accelerated or modified.
2. Identify new transmission upgrades that may result in economic benefits.
3. Identify economic benefits associated with “hybrid” transmission upgrades. Hybrid transmission upgrades include proposed solutions which encompass modification to reliability-based enhancements already included in RTEP that when modified would relieve one or more economic constraints. Such hybrid upgrades resolve reliability issues but are intentionally designed in a more robust manner to provide economic benefits in addition to resolving those reliability issues.

Market Efficiency analysis is conducted using a market simulation tool which models the hourly security-constrained commitment and dispatch of generation over a future annual period. Economic benefits of transmission upgrades are determined by comparing results of simulations which include the study upgrade to results of simulations which do not include the study upgrade. Projects are measured using two Tariff/Operating Agreement criteria. First, the project must address congestion as simulated in the Market Efficiency analysis. Second, the project benefits must exceed the costs by at least 25 percent. Project benefits are measured by comparing the benefits in the form of net load payments and/or production costs with and without the proposed project for a 15-year study period.

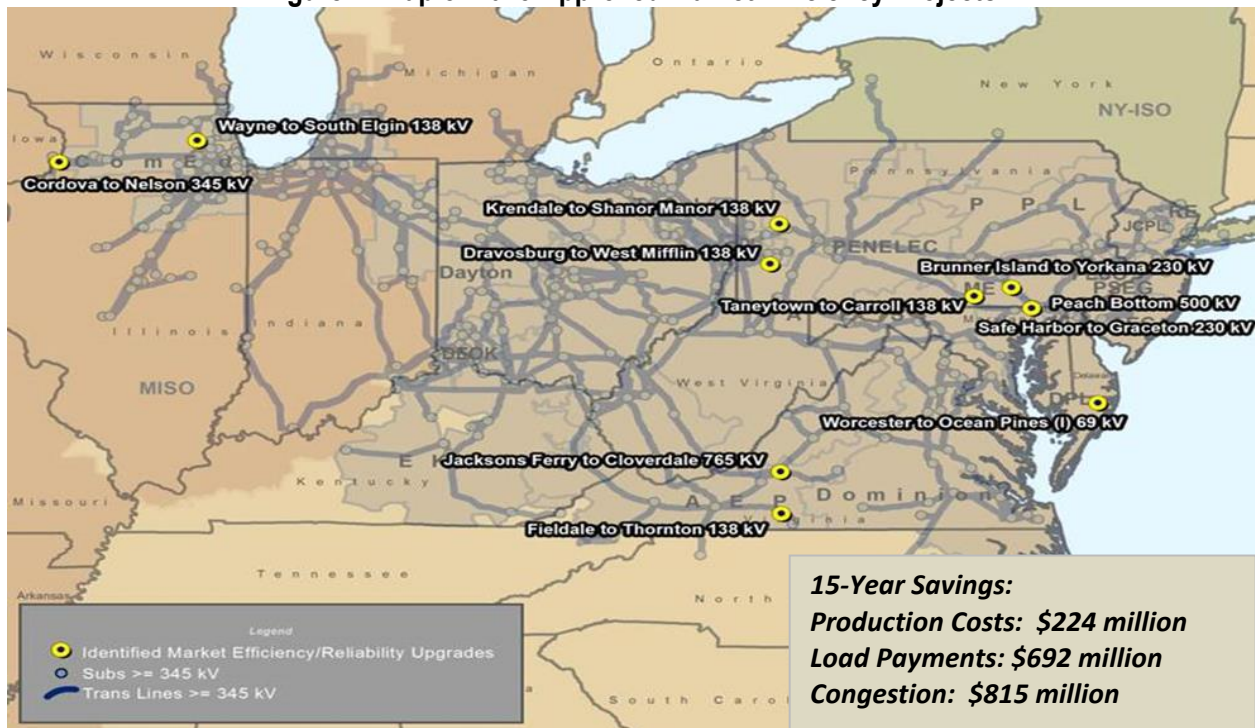
Prior to opening the 2014/15 long-term proposal window, PJM staff provided entities with a list of facilities, along with simulated congestion dollars. PJM received 93 project proposals to address either future simulated congestion or capacity costs from the 2014/15 long-term window.

The Submitted proposals ranged in costs from \$0.1 to \$432 million and included Transmission Owner upgrades as well as Greenfield projects from incumbent transmission owners and non-incumbent entities.

Market Efficiency 2015 Approved Projects

In 2015, the PJM Board approved 11 Market Efficiency projects for inclusion in the 2015 RTEP. These projects, consisted of upgrades to existing equipment and were designated to the incumbent transmission owners. Figure 1 on the next page shows the location of the approved projects.

Figure 1: Map of 2015 Approved Market Efficiency Projects



Following the October 2015 Board meeting, PJM staff continued to assess two groups of projects. The first group included projects submitted to address congestion associated with PJM IROL (Interconnected Reliability Operating Limit) reactive interfaces. The second group included projects submitted to address increased capacity costs from restricted Capacity Emergency Transfer Limits (CETL) encountered in PJM's Reliability Pricing Model (RPM) auctions for the COMED Locational Deliverability Area (LDA). As result of this assessment PJM staff is recommending additional Market Efficiency projects to be included in the RTEP. The recommended projects are described below.

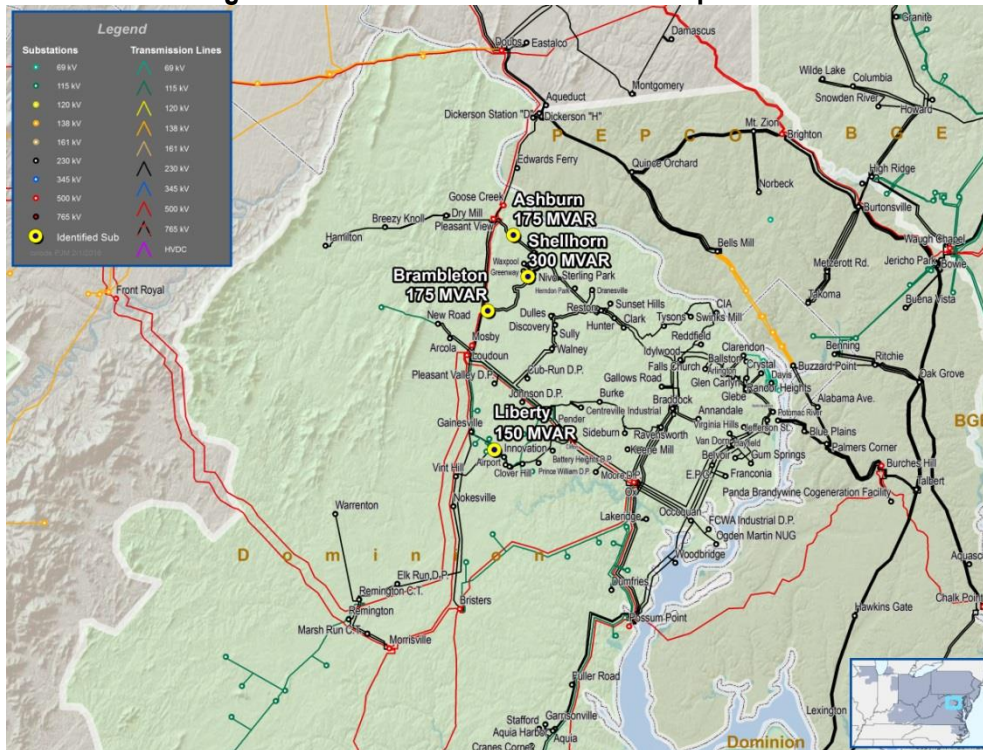
IROL Market Efficiency Baseline Project B2729 – Optimal Capacitor Configuration

As mentioned above, PJM staff continued to assess separate projects directed at congestion associated with PJM IROL (Interconnected Reliability Operating Limit) reactive interfaces. Specifically these projects

were recommended to reduce congestion on either the AP-South or AEP-DOM reactive interfaces¹. Of the 41 projects proposed to address the reactive interface congestion, six projects provided the most benefits. Many of these projects provided area reactive support through distributed capacitor installations. The addition of capacitors can help to maintain system voltages during heavy transfers however the addition of too many capacitors in a local area could create operational problems. PJM Markets, Planning, and Operations collaborated to select the optimal set of capacitors from those that were submitted in the proposal window.

Based on the PJM analysis, a capacitor configuration that provides high market congestion benefits, high reliability, and allows for optimal operational impact was selected as solution. The recommended locations are depicted in the Figure 2, and consist of new capacitor installations of 175 MVAR, 175 MVAR, 300 MVAR, and 150 MVAR at the existing Brambleton, Ashburn, Shelhorn, and Liberty 230kV substations, respectively. These upgrades to existing equipment will be designated to the incumbent transmission owner.

Figure 2: Location of Recommended Capacitors



¹ PJM reactive interface limits are thermal limit (MW) values that correlate to power flows beyond which voltage violations may occur



Table 1. Recommended Market Efficiency Project for PJM IROL Reactive interface

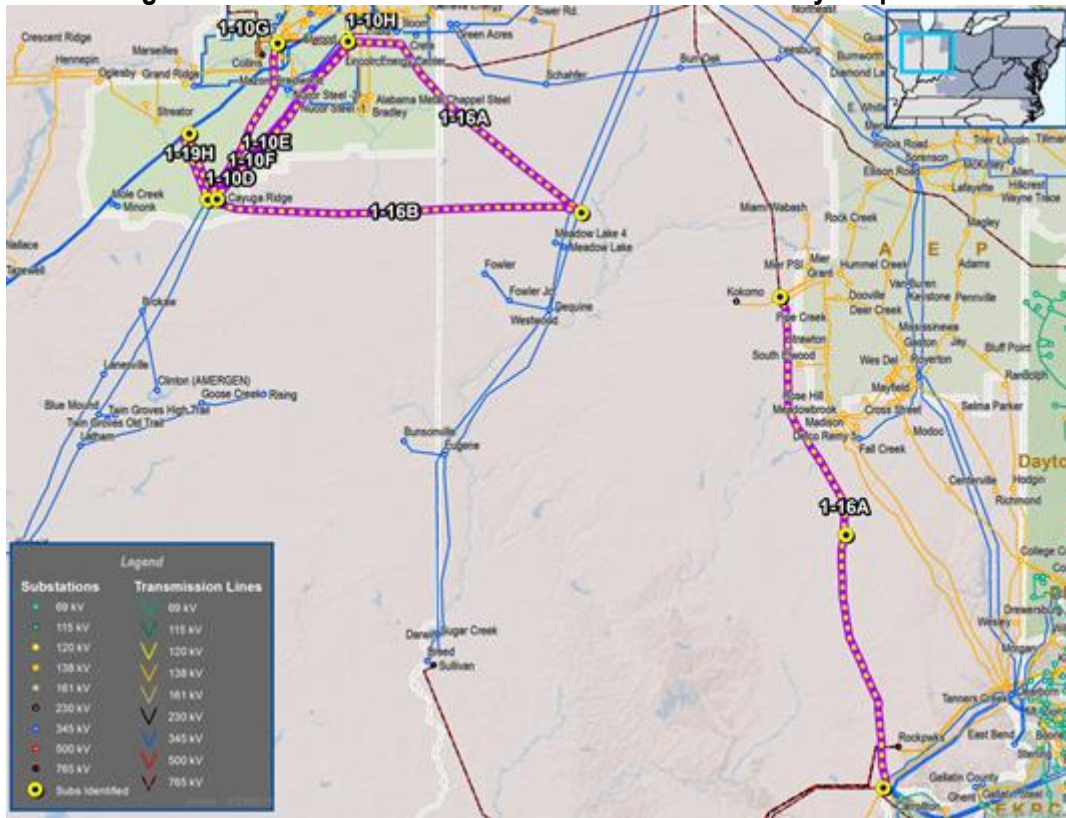
PJM Baseline ID	PJM Window Project ID	Project Description	Transmission Zone	Constraint Project Addresses	Project Cost (\$M)	ISD
b2729	Combination of several different proposals	Optimal Capacitors Configuration: New 175 MVAR capacitor at Brambleton, new 175 MVAR capacitor at Ashburn, new 300 MVAR capacitor at Shelhorn, new 150 MVAR capacitor at Liberty	Dominion	AP-South	\$8.98	2019

The project is expected to cost \$8.98 million and the required in service date is June 1, 2019. The cost allocation for this project is provided in Attachment A of this document.

RPM Market Efficiency Baseline Project B2728 – Mitigation of Loretto – Wilton Center 345kV Sag Limitation

During the 2014/2015 Long-Term Market Efficiency Proposal Window, PJM received nine proposals to address congestion on the Loretto to Wilton Center 345 kV line, in the COMED area. These nine proposals were received from three entities and their cost ranged from \$11.5 million to \$290 million. Two entities were not incumbent PJM transmission owners and the third entity was a PJM transmission owner, ComEd. Following the 2018/19 Reliability Pricing Model (RPM) Base Residual Auction (BRA) in August of 2015, imports into the COMED LDA were limited by the Loretto to Wilton Center 345 kV line. As a result, the nine proposals that were originally submitted to address energy market congestion on the Loretto to Wilton Center 345 kV line could also provide capacity market (i.e. RPM) benefits.

Figure 3: Loretto - Wilton Center 345kV Market Efficiency Proposals



The capacity benefits associated with the proposed projects were determined using the methodologies specified in Schedule 6 of the PJM Operating Agreement. PJM's annual capacity benefit calculation for regional facilities is weighted 50 percent to change in total system capacity cost and 50 percent to change in net load capacity payments for zones with a decrease in net load capacity payments as a result of the proposed project. PJM's annual capacity benefit calculation for lower voltage facilities is weighted 100 percent to zones with a decrease in net load capacity payments as a result of the proposed project. Change in net load capacity payment comprises the change in gross capacity payment offset by the change in capacity transfer rights.

PJM determined the impact of each of the nine proposed projects on the COMED LDA Capacity Emergency Transfer Limit (CETL). By increasing the capability of the LDA's limiting element (i.e. Loretto to Wilton Center), the COMED zone and other LDAs may be able to satisfy capacity requirements at a lower overall cost. PJM simulated the RPM process for multiple study years with the updated CETL values and measured each projects capacity benefits over a 15 year period.

The total Market Efficiency benefit of a project is the summation of the energy market benefit and the capacity market benefit. The energy market benefits were derived from the 2015 sensitivity case analysis and the capacity benefits were derived from the RPM simulation analysis.

The project shown in Figure 4 provides the highest total Market Efficiency benefit and was recommended for Board approval for inclusion into the RTEP. An annual estimated \$118 million in capacity payment benefits is achieved when the COMED LDA is limiting. This project is an upgrade to existing equipment, is designated to the incumbent transmission owner, increases the summer normal rating on the Loretto – Wilton 345 kV line by over 150 MVA, and increases the emergency rating by almost 250 MVA.

The recommended solution is to eliminate sag limitations on the Loretto – Wilton Center 345kV line, and upgrade station conductor at Wilton Center. The estimated cost is \$11.5 million and the required in service date is June 1, 2019. The cost allocation for this project is provided in Attachment A of this document.

Figure 4: RPM Recommended Project Loretto - Wilton Center 345kV

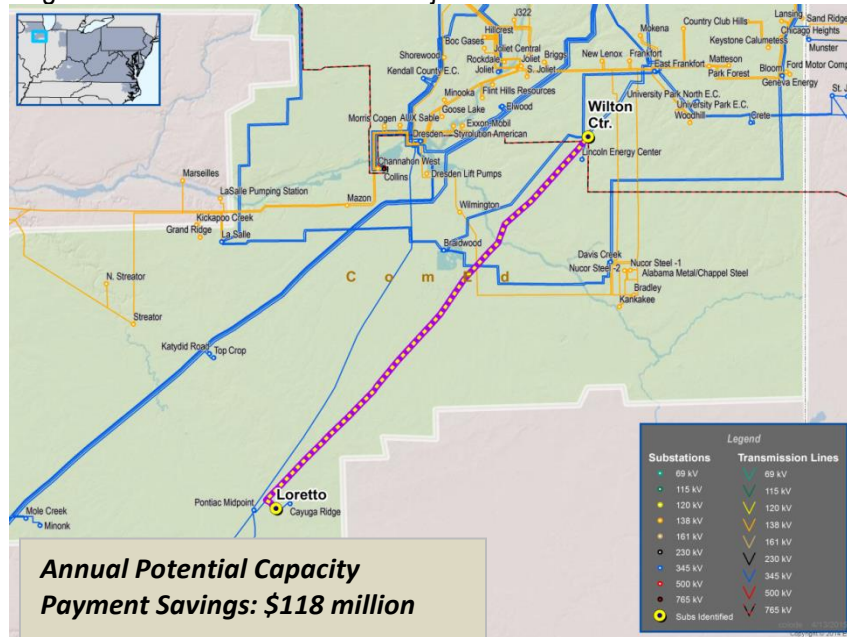


Table 2. Recommended Market Efficiency Projects for RPM

PJM Baseline ID	PJM Window Project ID	Project Description	Transmission Zone	Constraint Project Addresses	Project Cost (\$M)	ISD	Total B/C Ratio (Energy+RPM)
b2728	201415_1-10D	Mitigate sag limitations on Loretto - Wilton Center 345 kV Line and replace station conductor at Wilton Center	ComEd	Lorretto to Wilton CTR 345 kV	\$11.5	2019	64.46

Changes to Previously Approved Projects

Cost and scope of a number of previously approved RTEP baseline projects have been changed. In addition, a number of projects have been cancelled as they are no longer required. The net result of these



changes to previously approved baseline projects is a net increase in the RTEP of \$84.26 million. Some of the more significant cost changes are noted below.

PPL has provided PJM with an updated cost estimate for the previously approved RTEP project B2006 which includes the installation of a new Lauschtown 500/230kV substation, the construction of a new 230/69kV Lauschtown substation, and the construction of a new 69/138kV transmission from Lauschtown 230/69kV sub to Brecknock and Honeybrook areas. The additional estimated cost for B2006 is \$15.6 million.

Also, the scope of the previously approved RTEP project B2187 to install four 230kV breakers at Shellhorn has been modified to install two additional 230kV breakers at Shellhorn and terminate the Enterprise – Brambleton 230kV line into Shellhorn. The additional circuit breakers are required to address new N-1-1 criteria violations that were not identified initially. The additional estimated cost is \$2 million.

Finally, the scope of the previously approved RTEP project B1912 to install three +/- 125 MVar STATCOM at three different 230kV substations (Landstown, Yadkin, and Fentress) has been modified to install a fourth +/- 125 MVar STATCOM at Chesapeake and to install a +/-125 MVar STATCOM at Lynnhaven 230kV in lieu of Yadkin. The new configuration will improve dynamic reactive capability in the area. The additional estimated cost is \$35 million.

Review by the Transmission Expansion Advisory Committee (TEAC)

The results of the analyses summarized in this report were reviewed with the TEAC and Subregional RTEP Committees over several meetings throughout 2015 and 2016. The most recent analysis, along with recommended solutions, were reviewed at the January 7, 2016 TEAC meeting. Written comments were requested to be submitted to PJM communicating any concerns with the recommendation and any alternative transmission solutions for consideration.

Cost Allocation

Preliminary cost allocations to multiple transmission zones for the approved projects are shown in Attachment A.

Cost allocations for the projects were calculated in accordance with the Schedule 12 of the OATT. Baseline reliability project allocations are calculated using a distribution factor methodology that allocates the cost to the load zones that contribute to the loading on the new facility. The market efficiency projects are allocated to the load zones that benefit from the project. The allocations will be filed at FERC 30 days following approval by the Board.

Board Approval

The PJM Board Reliability Committee endorsed the new baseline projects and associated cost allocations. The PJM Board Reliability Committee recommended to the Board the approval of the baseline upgrades to the 2016 RTEP, and the PJM Board of Managers have approved the changes to the RTEP.

Market Efficiency and Project Multiple Zone Allocations

Upgrade ID	Description	Cost Estimate (\$M)	Trans Owner	Cost Responsibility	Required IS Date
b2729	Optimal Capacitors Configuration: New 175 MVAR capacitor at Brambleton, new 175 MVAR capacitor at Ashburn, new 300 MVAR capacitor at Shelhorn, new 150 MVAR capacitor at Liberty	\$8.98	DOM	AECO - 1.96%, BGE - 14.37%, DOM - 35.11%, DPL - 3.76%, JCPL - 3.31%, LINDVFT - 0.29%, METED - 2.52%, NEPTHVDC - 0.63%, O66HVDC - 0.34%, PECO - 6.26%, PEPCO - 20.23%, PLGRP - 3.94%, PSEG - 7.29%.	6/1/2019
b2728	Mitigate sag limitations on Loretto - Wilton Center 345 kV Line and replace station conductor at Wilton Center	\$11.50	COMED	AEP - 3.34%, COMED - 92.02%, DUQ - 1.21%, FE-ATSI - 3.43%.	6/1/2019