Transmission Expansion Advisory Committee Meeting

July 11, 2006
• RTEP Baseline update
• RTO / ISO Seams Issues
• Interconnection Planning Impact Studies
• Aging Infrastructure
• FERC Order on Jurisdiction of Distribution Facilities Interconnection
• FERC Order on Wind and Impact on Queues
RTEP Update and Review of Transmission Alternatives
PJM is in the process of updating both the 2010 and 2011 RTEP basecases. This is necessary to accommodate generation interconnection projects, merchant interconnection projects and firm transmission service requests that have recently proceeded beyond the Impact Study stage of the process.

The 2010 RTEP basecase is the reference model for the queue O interconnection project System Impact Studies. At the time of completing the 2010 RTEP (March 2006 TEAC), the majority of queue N interconnection project Impact Studies were not complete. Since that time, all queue N Impact Studies have been completed. A 1000 MW firm transmission service request has also executed a TSA. These projects and their associated network upgrades have been added to the 2010 RTEP basecase and PJM is working with the Transmission Owners to resolve any new system problems that are identified.
A similar update will need to be completed for the 2011 RTEP basecase. The 2011 basecase is the reference model for the queue P interconnection project System Impact Studies. As such, all interconnection projects through queue O will need to be included in the 2011 RTEP basecase. These are targeted for completion by September of 2006.

Both the 2010 and 2011 RTEP updates will be provided at the next TEAC. That update will also include short circuit results through 2011.
In general, it is important to note that the RTEP is continually updated to account for new interconnection studies, queued generator withdrawals and generators that execute an ISA. These updates typically do not result in drastic changes to the overall RTEP but can result in acceleration or deferral of existing problems and solutions. In certain instances these updates can also result in new system problems and solutions.

All of these changes are explained and discussed at the Transmission Expansion Advisory Committee so that all participants are fully informed as to the drivers for the various RTEP modifications.
PJM identified an overload on Mt. Storm – Doubs 500 kV in 2011 and an overload on Pruntytown – Mt. Storm 500 kV in 2014. The recommended and approved solution to these overloads is to build a new 502 Junction – Mt. Storm – Meadow Brook – Loudoun 500 kV circuit. The estimated cost is $850 million with a June 2011 in-service date.
System Upgrade Needed by June 2011 (5 years)

The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that will eventually be selected.
Several of the alternatives studied to relieve the Mt. Storm – Doubs 500 kV and Pruntytown – Mt. Storm 500 kV overloads are listed below and on the following slide:

- Second line from Mt. Storm – Doubs 500 kV – This alternative does not alleviate the Pruntytown – Mt. Storm 500 kV overload and instead causes the overload to occur in 2011 instead of 2014.

- New 500 kV circuit between Mt. Storm and Loudoun – This alternative does not alleviate the Pruntytown – Mt. Storm 500 kV overload and instead causes the overload to occur in 2011 instead of 2014.
• Wylie Ridge – Prexy – 502 Junction – Mt. Storm – Bedington – Kemptown 500 kV – this alternative provides a transfer capability of approximately 4550 MW above the base system. The transfer capability is limited by Mt. Storm – Doubs 500 kV.

• 502 Junction – Mt. Storm – Meadowbrook – Loudoun 500 kV – this alternative provides a transfer capability of approximately 5300 MW above the base system. The transfer capability is limited by Mt. Storm – Doubs 500 kV. All AP South overloads are resolved through 2021.

The transfer capability was determined using a DC load flow based on a 2016 RTEP model with all approved system upgrades modeled. No reactive limits were studied. The source for the transfer was the Western Region and the sink was the Mid-Atlantic Region.
There are two areas with problems identified on the PJM system through 2021 that still require transmission solutions.

• Northern New Jersey – there were 17 overloads identified. The majority of these were on the 230 kV system and occurred from 2015 through 2021. The Transmission Owners have provided upgrades to relieve a few of the problems but new transmission is still expected to be needed to resolve the overall import issue into Northern New Jersey.

• Western / Central Interface – Overloads on three 500 kV circuits along the PJM Western and Central interfaces occur in 2019 and 2020.
## Northern New Jersey Overloads

<table>
<thead>
<tr>
<th>Test Resulting in Highest Overload</th>
<th>Year That Facility Loading Exceeds Conductor Rating</th>
<th>Overloaded Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Deliverability</td>
<td>2015</td>
<td>East Windsor - Smithsburg 230 kV</td>
</tr>
<tr>
<td>Generator Deliverability</td>
<td>2015</td>
<td>Greystone - Whippany 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2016</td>
<td>Cox's Corner - Lumberton 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2016</td>
<td>Branchburg - Readington 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2016</td>
<td>Whippany - Roseland 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2016</td>
<td>Kittatinny - Pohatcong 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2016</td>
<td>Hosensack - Elroy 500 kV</td>
</tr>
<tr>
<td>Generator Deliverability</td>
<td>2016</td>
<td>Atlantic - Larrabee 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2016</td>
<td>Lumberton - Cookstown 230 kV</td>
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<td>Load Deliverability</td>
<td>2017</td>
<td>Branchburg - Flagtown 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2017</td>
<td>Flagtown - Somerville 230 kV</td>
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<tr>
<td>Generator Deliverability</td>
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<td>Somerville - Bridgewater 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2017</td>
<td>Martins Creek - Portland 230 kV</td>
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<tr>
<td>Generator Deliverability</td>
<td>2019</td>
<td>Portland - Kittatinny 230 kV</td>
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<td>Generator Deliverability</td>
<td>2019</td>
<td>Portland - Greystone 230 kV</td>
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<td>Load Deliverability</td>
<td>2020</td>
<td>Pleasant Valley - Lawrence 230 kV</td>
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<tr>
<td>Load Deliverability</td>
<td>2021</td>
<td>Readington - Roseland 230 kV</td>
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System Upgrade Needed by June 2015 (9 years)
## Western & Central Interface Overloads

<table>
<thead>
<tr>
<th>Test Resulting in Highest Overload</th>
<th>Year That Facility Loading Exceeds Conductor Rating</th>
<th>Overloaded Facility</th>
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<tbody>
<tr>
<td>Load Deliverability</td>
<td>2019</td>
<td>Airydale - Juniata 500 kV Circuit 1</td>
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<tr>
<td>Load Deliverability</td>
<td>2019</td>
<td>Airydale - Juniata 500 kV Circuit 2</td>
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<tr>
<td>Load Deliverability</td>
<td>2020</td>
<td>Keystone - Conemaugh 500 kV</td>
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</table>
Western & Central Interface Overloads

System Upgrade Needed by June 2019 (13 years)
Two types of studies were performed by PJM to evaluate the strength of the transmission alternatives.

**Transfer Study**

The base system model used for all transfer studies was a 2016 RTEP basecase. The RTEP 2016 basecase contains all system upgrades previously approved by the PJM Board. Also, the case was modified so that the FCITC analysis would only be limited by conductor ratings.

FCITC (First Contingency Incremental Transfer Capability) – for the purposes of this presentation the FCITC is based on a transfer from PJM Western Region generation to PJM Mid-Atlantic Region load. The facility which limits the FCITC and the FCITC MW value provides an indication of the relative benefit of each alternative.
Baseline Study

PJM modeled each alternative in the 2011 RTEP basecase and determined the impacts to the Northern New Jersey and Western/Central interface overloads through the next 15 years.

The tests applied for the baseline review were generator deliverability, Mid-Atlantic Region load deliverability and Eastern Mid-Atlantic load deliverability since these were the tests that resulted in the majority of system problems.
Transmission Alternatives

**Alternative 1**
Keystone - Sunbury 500 kV
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 2**
Keystone - Sunbury 500 kV
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV

**Alternative 3**
Keystone - TMI 500 kV
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 4**
Keystone - TMI 500 kV
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV

**Alternative 5**
Kammer - TMI 500 kV
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 6**
Kammer - TMI 500 kV
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV

**Alternative 7**
Keystone - Farmers Valley - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 8**
Possum Point - Calvert Cliffs - Salem 500 kV

**Alternative 9**
Wylie Ridge - Prexy 500 kV
Mt. Storm - Bedington - Kemptown 500 kV
Kemptown - Rock Springs - Hope Creek 500 kV

**Alternative 10**
Amos - Kemptown - Deans 765 kV

**Alternative 11**
Amos - Kemptown 765 kV
Kemptown - Rock Springs - Hope Creek 500 kV

**Alternative 12**
Kammer - TMI 765 kV
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 13**
Kammer - TMI 765 kV
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV
**Transmission Alternatives**

**Alternative 1:**
Keystone - Sunbury 500 kV
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**FCITC = 3442 MW limited by Mt. Storm - Doubs 500 kV**
(This amounts to a 988 MW increase in transfer capability from the basecase).

<table>
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<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 1 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
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<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>3442</td>
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<td>Pruntytown - Mt. Storm 500 kV</td>
<td>2844</td>
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<td>1419</td>
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<td>Hosensack - Elroy 500 kV</td>
<td>3490</td>
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<td>4329</td>
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<tr>
<td>Keystone - Airydale 500 kV</td>
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<td>Lexington - Dooms 500 kV</td>
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<td>Harrison - Pruntytown 500 kV</td>
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<td>4514</td>
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</table>

* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 1 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

• The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.

• The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
**Alternative 2:**
Keystone - Sunbury 500 kV
Bossards - Jefferson - Roseland 500 kV

**FCITC = 3329 MW limited by Mt. Storm - Doubs 500 kV**
(This amounts to a 875 MW increase in transfer capability from the basecase.)

<table>
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<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 2 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
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<td>Mt. Storm - Doubs 500 kV</td>
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<td>Pruntytown - Mt. Storm 500 kV</td>
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<td>Kammer 765/500 kV</td>
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<td>Lexington - Dooms 500 kV</td>
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* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 2 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

• The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.

• The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
Transmission Alternatives

**Alternative 3:**
Keystone - TMI 500 kV
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**FCITC = 3699 MW limited by Mt. Storm - Doubs 500 kV**
(This amounts to a 1245 MW increase in transfer capability from the basecase.)

<table>
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<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 3 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
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* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 3 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.

- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
Alternative 4:
Keystone - TMI 500 kV
Bossards - Jefferson - Roseland 500 kV

FCITC = 3641 MW limited by Mt. Storm - Doubs 500 kV
(This amounts to a 1187 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 4 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
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* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 4 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

• The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.

• The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
**Alternative 5:**
Kammer - TMI 500 kV
Second Kammer 765/500 kV transformer
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**FCITC = 2782 MW limited by Kammer 765/500 kV transformer**
(This amounts to a 328 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 5 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
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<tr>
<td>Mt. Storm - Doubs 500 kV</td>
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* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 5 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.
- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
Alternative 6:
Kammer - TMI 500 kV
Second Kammer 765/500 kV transformer
Bossards - Jefferson - Roseland 500 kV

FCITC = 2772 MW limited by Kammer 765/500 kV transformer
(This amounts to a 318 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 6 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
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<td>Pruntytown - Mt. Storm 500 kV</td>
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* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 6 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.
- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.

Legend:
- Identified Substations
- Possible ROWs

Substations:
- VOLTAGE
  - 795 kV
  - 500 kV
  - 345 kV
  - 230 kV

Transmission Lines:
- VOLTAGE
  - 230 kV
  - 345 kV
  - 500 kV
  - 795 kV

Kammer – TMI 500 kV Option
Bossards – Martins Creek – Portland 500 kV Option
Portland – Jefferson 500 kV Option
Jefferson – Roseland 500 kV Option
**Alternative 7:**
Keystone - Farmers Valley - Lackawanna - Jefferson - Roseland 500 kV

**FCITC = 3384 MW limited by Mt. Storm - Doubs 500 kV**
(This amounts to a 931 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 7 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>3384</td>
<td>931</td>
</tr>
<tr>
<td>Pruntytown - Mt. Storm 500 kV</td>
<td>2844</td>
<td>4193</td>
<td>1349</td>
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<tr>
<td>Hosensack - Elroy 500 kV</td>
<td>3490</td>
<td>6585</td>
<td>3095</td>
</tr>
<tr>
<td>Keystone - Airydale 500 kV</td>
<td>3519</td>
<td>6839</td>
<td>3320</td>
</tr>
<tr>
<td>Keystone - Conemaugh 500 kV</td>
<td>3604</td>
<td>7042</td>
<td>3438</td>
</tr>
<tr>
<td>Airydale - Juniata 500 kV #1</td>
<td>3706</td>
<td>6720</td>
<td>3014</td>
</tr>
<tr>
<td>Kammer 765/500 kV</td>
<td>3768</td>
<td>3858</td>
<td>90</td>
</tr>
<tr>
<td>Airydale - Juniata 500 kV #2</td>
<td>3820</td>
<td>6863</td>
<td>3044</td>
</tr>
<tr>
<td>Lexington - Dooms 500 kV</td>
<td>4018</td>
<td>4478</td>
<td>460</td>
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<tr>
<td>Harrison - Pruntytown 500 kV</td>
<td>4111</td>
<td>4487</td>
<td>375</td>
</tr>
</tbody>
</table>

* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 7 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.
- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
Alternative 8: Possum Point - Calvert Cliffs - Salem 500 kV

FCITC = 2036 MW limited by Pruntytown - Mt. Storm 500 kV
(This amounts to a 418 MW decrease in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 8 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>2361</td>
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<tr>
<td>Pruntytown - Mt. Storm 500 kV</td>
<td>2844</td>
<td>2036</td>
<td>-809</td>
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<tr>
<td>Hosensack - Elroy 500 kV</td>
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<td>5446</td>
<td>1957</td>
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<tr>
<td>Keystone - Airydale 500 kV</td>
<td>3519</td>
<td>4512</td>
<td>992</td>
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<td>Keystone - Conemaugh 500 kV</td>
<td>3604</td>
<td>4615</td>
<td>1011</td>
</tr>
<tr>
<td>Airydale - Juniata 500 kV #1</td>
<td>3706</td>
<td>4715</td>
<td>1010</td>
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<td>Kammer 765/500 kV</td>
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<td>3788</td>
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<tr>
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</tbody>
</table>

* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 8 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- Most of the overloads in Northern New Jersey were not resolved with this alternative.
- The Western and Central interface overloads were resolved with this alternative.
Possum Point – Calvert Cliffs – Salem 500 kV Option

The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
**Alternative 9:**
Wylie Ridge - Prexy 500 kV  
Mt. Storm - Bedington - Kemptown 500 kV  
Kemptown - Rock Springs - Hope Creek 500 kV

FCITC = 59 MW limited by Pruntytown - Mt. Storm 500 kV  
(This amounts to a 2395 MW decrease in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 9 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>6690</td>
<td>4237</td>
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<tr>
<td>Pruntytown - Mt. Storm 500 kV</td>
<td>2844</td>
<td>59</td>
<td>-2785</td>
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<tr>
<td>Hosensack - Elroy 500 kV</td>
<td>3490</td>
<td>5965</td>
<td>2475</td>
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<tr>
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<td>Keystone - Conemaugh 500 kV</td>
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<td>Airydale - Juniata 500 kV #1</td>
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<td>1929</td>
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<td>Kammer 765/500 kV</td>
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<td>Airydale - Juniata 500 kV #2</td>
<td>3820</td>
<td>5782</td>
<td>1962</td>
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<td>Lexington - Dooms 500 kV</td>
<td>4018</td>
<td>3566</td>
<td>-453</td>
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<tr>
<td>Harrison - Pruntytown 500 kV</td>
<td>4111</td>
<td>3277</td>
<td>-834</td>
</tr>
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</table>

* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 9 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

• Most of the overloads in Northern New Jersey were not resolved with this alternative.

• The Western and Central interface overloads were resolved with this alternative.

• The AP South Interface had an overload on Pruntytown – Mt. Storm 500 kV and Harrison – Pruntytown 500 kV.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
**Alternative 10:**
Amos - Kemptown - Deans 765 kV
Kemptown 765/500 kV #1 and #2
Deans 765/500 kV #1 and #2

**FCITC = 6554 MW limited by Mt. Storm - Doubs 500 kV**
(This amounts to a 4101 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase</th>
<th>Alternative 10</th>
<th>FCITC Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>6554</td>
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<tr>
<td>Pruntytown - Mt. Storm 500 kV</td>
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<td>Keystone - Airydale 500 kV</td>
<td>3519</td>
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<td>Keystone - Conemaugh 500 kV</td>
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<td>Airydale - Juniata 500 kV #1</td>
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<td>Kammer 765/500 kV</td>
<td>3768</td>
<td>7898</td>
<td>4129</td>
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<td>Airydale - Juniata 500 kV #2</td>
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<td>5043</td>
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<td>Lexington - Dooms 500 kV</td>
<td>4018</td>
<td>10698</td>
<td>6679</td>
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<td>Harrison - Pruntytown 500 kV</td>
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* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 10 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- Most of the overloads in Northern New Jersey were not resolved with this alternative.

- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
**Transmission Alternatives**

**Alternative 11:**
Amos - Kemptown 765 kV  
Kemptown 765/500 kV #1, #2 and #3  
Kemptown - Rock Springs - Hope Creek 500 kV

**FCITC = 6851 MW limited by Mt. Storm - Doubs 500 kV**  
(This amounts to a 4397 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 11 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>6851</td>
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<td>7598</td>
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<td>3519</td>
<td>8292</td>
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<td>Keystone - Conemaugh 500 kV</td>
<td>3604</td>
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<td>Airydale - Juniata 500 kV #1</td>
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<td>7536</td>
<td>3830</td>
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<tr>
<td>Kammer 765/500 kV</td>
<td>3768</td>
<td>7853</td>
<td>4084</td>
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<tr>
<td>Airydale - Juniata 500 kV #2</td>
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<td>Lexington - Dooms 500 kV</td>
<td>4018</td>
<td>10615</td>
<td>6597</td>
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<tr>
<td>Harrison - Pruntytown 500 kV</td>
<td>4111</td>
<td>10094</td>
<td>5983</td>
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</tbody>
</table>

* No significant 230 kV or 345 kV FCITC reduction identified
PJM also modeled Alternative 11 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

• Most of the overloads in Northern New Jersey were not resolved with this alternative.

• The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
### Transmission Alternatives

**Alternative 12:**
Kammer - TMI 765 kV  
TMI 765/500 kV #1, #2 and #3  
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**FCITC = 6706 MW limited by Mt. Storm - Doubs 500 kV**  
(This amounts to a 4253 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 12 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>6706</td>
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<tr>
<td>Pruntytown - Mt. Storm 500 kV</td>
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<td>Hosensack - Elroy 500 kV</td>
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<td>6944</td>
<td>3454</td>
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<td>3519</td>
<td>10698</td>
<td>7179</td>
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<tr>
<td>Keystone - Conemaugh 500 kV</td>
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<td>3706</td>
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<td>3768</td>
<td>8350</td>
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<td>Airydale - Juniata 500 kV #2</td>
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<td>7213</td>
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<td>Lexington - Dooms 500 kV</td>
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<td>7055</td>
<td>3036</td>
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<tr>
<td>Harrison - Pruntytown 500 kV</td>
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<td>10953</td>
<td>6841</td>
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</table>

* TMI 230 kV outlet limitations
PJM also modeled Alternative 12 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.

- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
Alternative 13:
Kammer - TMI 765 kV
TMI 765/500 kV #1, #2 and #3
Bossards - Jefferson - Roseland 500 kV

FCITC = 6623 MW limited by Mt. Storm - Doubs 500 kV
(This amounts to a 4169 MW increase in transfer capability from the basecase.)

<table>
<thead>
<tr>
<th>Facility</th>
<th>Basecase FCITC (MW)</th>
<th>Alternative 13 FCITC (MW)</th>
<th>FCITC Change (MW)</th>
</tr>
</thead>
<tbody>
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<td>Mt. Storm - Doubs 500 kV</td>
<td>2454</td>
<td>6623</td>
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<tr>
<td>Pruntytown - Mt. Storm 500 kV</td>
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<td>Keystone - Airydale 500 kV</td>
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<td>Kammer 765/500 kV</td>
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<td>4576</td>
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<td>Lexington - Dooms 500 kV</td>
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<td>Harrison - Pruntytown 500 kV</td>
<td>4111</td>
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<td>6810</td>
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</table>

* TMI 230 kV outlet limitations
PJM also modeled Alternative 13 in the 2011 RTEP baseline case and determined the impact to the overloads identified through 2021.

- The majority of Northern New Jersey overloads were resolved through 2021 with this alternative.

- The Western and Central interface overloads were resolved with this alternative.
The ROW routes shown on this diagram are for illustrative purposes only and they may not depict the actual route that could eventually be selected. The substation locations may also be modified if a more beneficial connection is determined.
Transmission Alternatives

**Alternative 1**
Keystone - Sunbury 500 kV  
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 2**
Keystone - Sunbury 500 kV  
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV

**Alternative 3**
Keystone - TMI 500 kV  
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 4**
Keystone - TMI 500 kV  
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV

**Alternative 5**
Kammer - TMI 500 kV  
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 6**
Kammer - TMI 500 kV  
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV

**Alternative 7**
Keystone - Farmers Valley - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 8**
Possum Point - Calvert Cliffs - Salem 500 kV

**Alternative 9**
Wylie Ridge - Prexy 500 kV  
Mt. Storm - Bedington - Kemptown 500 kV  
Kemptown - Rock Springs - Hope Creek 500 kV

**Alternative 10**
Amos - Kemptown - Deans 765 kV

**Alternative 11**
Amos - Kemptown 765 kV  
Kemptown - Rock Springs - Hope Creek 500 kV

**Alternative 12**
Kammer - TMI 765 kV  
Susquehanna - Lackawanna - Jefferson - Roseland 500 kV

**Alternative 13**
Kammer - TMI 765 kV  
Bossards - Martins Creek - Portland - Jefferson - Roseland 500 kV
## FCITC Change (MW) For PJM West To PJM Mid-Atlantic Transfer

### Transmission Alternatives

<table>
<thead>
<tr>
<th>Facility</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
<th>Alternative 4</th>
<th>Alternative 5</th>
<th>Alternative 6</th>
<th>Alternative 7</th>
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<tr>
<td>Mt. Storm - Doubs 500 kV</td>
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<td>Pruntytown - Mt. Storm 500 kV</td>
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<td>1237</td>
<td>1782</td>
<td>1678</td>
<td>3077</td>
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<td>1349</td>
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<td>Harrison - Pruntytown 500 kV</td>
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<td>504</td>
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<td>127</td>
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<td>90</td>
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<tr>
<td>Lexington - Dooms 500 kV</td>
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<td>581</td>
<td>567</td>
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<td>4477</td>
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<tr>
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<tr>
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## FCITC Change (MW) For PJM West To PJM Mid-Atlantic Transfer

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<th>Alternative</th>
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<tbody>
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<td>Mt. Storm - Doubs 500 kV</td>
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<td>Pruntytown - Mt. Storm 500 kV</td>
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## Comparison of Transmission Alternatives

### Western / Central Problems

- Alternative 1
- Alternative 2
- Alternative 3
- Alternative 4
- Alternative 5
- Alternative 6
- Alternative 7
- Alternative 8
- Alternative 9
- Alternative 10
- Alternative 11
- Alternative 12
- Alternative 13

### Northern New Jersey Problems

- Alternative 1
- Alternative 2
- Alternative 3
- Alternative 4
- Alternative 5
- Alternative 6
- Alternative 7
- Alternative 8
- Alternative 9
- Alternative 10
- Alternative 11
- Alternative 12
- Alternative 13

### AP South Interface

- Alternative 1
- Alternative 2
- Alternative 3
- Alternative 4
- Alternative 5
- Alternative 6
- Alternative 7
- Alternative 8
- Alternative 9
- Alternative 10
- Alternative 11
- Alternative 12
- Alternative 13

---

- The alternative provides a significant benefit.
- The alternative has some positive benefit.
- The alternative provides a negative or minimal benefit.
Northern New Jersey Overloads

- The alternatives that provide a source into Roseland provide a significant benefit to the Northern New Jersey overloads.

- The alternatives that provide a source into Hope Creek or Salem provide minimal benefit for the Northern New Jersey overloads.

- The alternatives that provide a source into Deans would require significant 230 kV and/or 500 kV facility additions to provide a benefit to the Northern New Jersey overloads.
Comparison of Transmission Alternatives

**Western / Central Interface**
- All alternatives provide some benefit to the western and central interface limits.

**AP South Interface**
- All alternatives except for 8 and 9 provide some benefit to the AP South Interface.
  
  - Alternatives 5 and 6 have transformation issues at Kammer.
  
  - Alternatives that connect back to the AEP 765 kV system provide the most benefit for the AP South Interface.
• Develop short list of alternatives
  - Determine underlying system problems and preliminary upgrades required to resolve reliability problems

• Review of additional alternatives
  - Alternative 8 extended west to the 765 kV or 500 kV systems in Dominion or AEP.
  - Extending “Keystone” alternatives back to the 765 kV system in the Kammer or South Canton area.
  - Others?
• Right-of-Way Feasibility

• Review of 500 kV, 765 kV or double circuit 500 kV construction

• Review impact of significant generation changes

• Market Efficiency Analysis
RTO / ISO Seams Issues
Large Regional Scope

Coordinated Regional System Planning

- Joint Operating Agreement - PJM and MISO
- Northeast Planning Protocol - PJM, NY, NE
- PJM/MISO/TVA Joint Coordination Agreement
- PJM/PEC Joint Operating Agreement
Interconnection Planning
Impact Study Results
# Impact Study Completion Review

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<thead>
<tr>
<th>Queue</th>
<th>Project Name</th>
<th>TO</th>
<th>MW</th>
<th>MWC</th>
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## Queue Withdrawals

### Withdrawn since last TEAC

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O32 Mountaineer 756 kV

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©2006 PJM
P61 Gavin #1 756 kV

Legend

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<td>115kV</td>
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<td></td>
<td>69kV</td>
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P61 Gavin #1 756 kV

POI

Marysville

Mountaineer

Culloden

P61
20 MW

1320 MW

#1

1300 MW

#2
Q31 Wagner 34 kV

34.5 kV

H. A. Wagner Station

BG&E Facilities
N.C.
N.O.
33714-A
33716-C

BG&E Facilities
Interconnection Customer Facilities
Millennium Chemicals

33714-A
33716-C

Tie Switches (N.C.)
N.C.
N.O.

34.5 kV - 4.16 kV

13 kV

115 kV

115 kV

115 kV

Millennium Chemicals
33714
33716

#Q31

4.16 kV

Load
Load

Spare
4.16 kV

N.O.

#3A #3B

#2A #2B #1A #1B

#Q31

4.16 kV

To 4160 V Load and 4160/480 V Transformers with 480V Load

Spare
4.16 kV

N.O.

#3A #3B

#2A #2B #1A #1B

#Q31

4.16 kV

115 kV

+10 MW
O39 Sunbury-Dauphin 69 kV; O40 Pine Grove – Frailey 69 kV; O26 Pine Grove 69 kV
O26 Pine Grove 8 MW and O40 Pine Grove – Frailey 44 MW

- **O26 Pine Grove**
  - 8 MW
  - Point of Interconnection
  - New Facilities
  - 230 kV
  - 69 kV
  - <69 kV

- **O40 Pine Grove**
  - 44 MW
  - Point of Interconnection

- **Other Locations**
  - Sunbury
  - Eldred
  - Frackville
  - Reed
  - Cleveland
  - Fairview
  - Westwood NUG
  - Foster Wheeler NUG
  - Williamstown
  - Frailey
  - Fishbach

- **Power Plants**
  - Reed
  - Cleveland
  - Fairview
  - Westwood NUG
  - Foster Wheeler NUG
  - Williamstown
  - Frailey
  - Fishbach

- **Transmission Lines**
  - 230 kV
  - 69 kV
  - <69 kV

- **Point of Interconnection (POI)**
Q37 Loganton 12 kV

Loganton 69-12 kV

New
69 kV
12 kV
<12 kV
load

+ 0.2 MW
Q37 Loganton 0.2 MW

New or Queue Facilities
69kV
12kV
<12kV
POI (Point of Interconnection)

1. Lock Haven 69kV
2. Lycoming
3. Lycoming

Flemington
Lock Haven
CTC
Loganton
PPL EU
Schrack Farms
Load

©2006 PJM
Q44 Elizabethtown

Elizabethtown 69-12 kV

Legend

Queues Fuel Type
- Biomass
- Coal
- Diesel
- Methane
- Natural Gas
- Wind

Substations Voltage
- 785 kV
- 500 kV
- 345 kV
- 230 kV
- 138 kV
- 115 kV
- 69 kV
- 34.5 kV

Transmission Lines Voltage
- 785
- 500
- 345
- 230
- 138
- 115
- 69
- 34.5

0.3 MW
Aging Infrastructure
• Concerns about “Aging Infrastructure”
  – 50% of PJM’s 500-230kV transformers are approaching 40 years of age, considered to be near the end of useful life for a transformer

• Transformers have special problems
  – Long lead times for repairs and procurement
  – Difficult logistic and transportation issues

• De-Ratings of Branchburg, Wiley Ridge and Kammer Transformers
  – Highlights the economic consequences of transformer outages; i.e., increased congestion costs
Benefits of a PRA Approach

• Provides an Optimal Transformer Replacement Policy
  – Reductions in expected PV costs by managing retirements

• Provides an Optimal Spare Transformer Deployment Policy
  – The right number in the right locations
  – The right type of spare (old/new; remote/local/switchable)

• Provides Dynamic Risk Reduction
  – Feedback mechanism that continually re-adjusts the PRA model based on implementation of risk-mitigating actions
PJM developed a PRA Model that integrated three key elements:

- Failure probabilities
- Failure consequences (ABB Congestion Model)
- Risk Reduction Policy Model

The goal is to minimize the total expected PV cost of the PJM 500-230kV transformer fleet and maximize reliability.
• Least-cost strategy for repair/replacement
  – Projected PV savings of 27% in forecast cash flows

• High-value testing strategy
  – Replacement decisions guided by risk + test results

• Maximizing the value of spare transformers
  – Right location
  – Right type
  – Right quality (new versus retired)
Risk = Probability × Consequence

• Failure Probability
  – Expressed either as a failure rate or an outage probability

• Consequence
  – Defined in this model as most conservative incremental costs of dispatching out-of-merit generation due to transformer outages = unhedgeable congestion cost differential
  – Costs are location-specific and time-dependent
Factors Affecting Failure Probabilities

- **Age and condition of the transformer**
  - PJM derived time-dependent hazard rate curves from historical survivorship data
  - TO’s developed a Condition Assessment Standard
  - Particular designs, manufacturers and vintages were factored in (some of these are known to have higher failure rates) and ranked appropriately

- **External factors**
  - Hurricanes, tornadoes
  - Common-mode and multiple-dependent failures
• PJM Congestion Analysis Model

  – Takes one transformer bank outage at a time and computes the resulting incremental cost of generation after re-dispatch
  – The incremental costs are totaled over 12 months to give an annual consequence for each bank ($/year)
Results of Congestion Model

- Model was derived from 2009 Base Case
  - All 217 500-230kV transformer banks were force ranked in the order of their outage consequences
  - Results are highly market-sensitive and confidential
  - PJM will continue to refine the Congestion Model

- There is one group of 12 transformer banks having outage consequences ranging between $40 Million/year and $300 Million/year per bank.
Risk Reduction Policy Model

- Proactive Replacement vs. Continued Operation with Monitoring
- Adjustments to the number and types of spare transformers
  - Switchable standby spare (~ hours to restore)
  - Site specific spare (~ days to restore)
  - Remote system spare (~ weeks to restore)
  - Spare quality (new vs. retired)
- Installing Redundant Banks or Substations
  - Avoids service disruptions
  - Risk of failure can be minimized or eliminated
Sample data show PV savings of around $280 Million could be realized through an optimal replacement policy (assumes constant fleet loss consequence of $16M/bank):
Next Steps

• Currently:
  – PJM refining the PRA Model.
  – Compare the avoided risks using a common-spec approach versus a regional-spec approach
• July 18, 2006:
  – Final PRA results based on the refined PRA model.
• September 15, 2006:
  – Final Transformer Prioritization
• October 15, 2006:
• December 15, 2006:
  – Order First Transformers
NEW FERC ORDER: JURISDICTION OF DISTRIBUTION FACILITIES
• New FERC Order issued on Feb. 22
  – ER06-407-000
  – ER06-408-000

• Order changes PJM’s current practice for interconnections to the PJM system that are on distribution systems.

• Pre - Order, PJM regards all applications for generator interconnection the same regardless of whether the IC occurs on a distribution or transmission line.
Recent FERC Order states:

FERC does not have jurisdiction over an interconnection where the interconnection customer seeks to interconnect to a “local distribution” facility that is unavailable for jurisdictional transmission service under a Commission-approved OATT at the time an interconnection request is made.
FERC asserts jurisdiction over interconnections to local distribution facilities if:

- pre-existing generation interconnection

- wholesale transaction over these local distribution facilities prior to the new interconnection request being made.
• The FERC Order clarifies a principal that has evolved through various FERC proceedings.
  – Order No. 2003
  – Order No. 2006

• The FERC Order helps clarify an area that was subject to interpretation in the past.
Current Impact to Projects in the PJM Queue

• The majority of PJM’s developers that are in the queue for interconnection to a distribution system are on systems with no pre-existing interconnection.

• Therefore these interconnections will not be FERC jurisdictional.

• PJM will maintain jurisdiction over the sale portion of the interconnection, but not the distribution line itself.
• By letter of March 27, 2006, PJM notified the developers of projects affected by the FERC Order that:
  – PJM continues to exercise authority over the wholesale sales from generation interconnected to distribution facilities.
  – PJM developed a form of “Wholesale Market Participation Agreement” (WMPA) for three parties – PJM, Developer, and TO.
  – Developers and TO’s must work with the State Commissions to facilitate the interconnection portion of the project.
The Wholesale Market Participation Agreement

• The WMPA parallels the ISA to a large extent.

• Developers are advised to enter PJM’s queue and studied for system impacts – no change to this process.

• WMPA contains provisions for network and local upgrades.

• WMPA will not contain provisions for attachment facilities – these are now state jurisdictional.
• Developers and TOs are advised to contact their respective state commissions for further guidance concerning the interconnection process for a distribution system.

• Disputes about the interconnection on the distribution system will be managed through the state commissions.

• PJM will not be a signatory to distribution interconnection agreements.
• State Commissions are aware of this jurisdictional order.
  – Some states have a well established IC process

• PJM is managing the transition.

• PJM contacted parties in the queue and explained the new process.
• Per Order No. 2003 – “Local distribution” is a legal term used in the Federal Power Act and defined in Order No. 888 by the seven factor test below. FERC does not have jurisdiction over this type of facility.
• **Distribution** is a “vague” term according to FERC but normally used to refer to lower-voltage lines that are not networked and that carry power in one direction. Some of these lower voltage facilities are used for jurisdictional purposes such as carrying power to a wholesale power customer for resale and are included in a public utility’s OATT, others in this category will be “local distribution” facilities and not FERC jurisdictional.
How to determine what is a distribution facility?

- Parties will determine if the interconnection is FERC jurisdictional; this could be accomplished in the scoping meeting.

- Parties will enter PJM’s queue, evaluate eligibility and proceed with either an ISA or a WMPA.
What about the developers’ rights to an interconnection on a distribution system?

• The initial interconnection on a distribution line for a wholesale transaction will be subject to the oversight of the TO and the State Commission.

• The second interconnection on the line for a wholesale transaction would be subject to FERC jurisdiction for purposes of dispute resolution.
Contact Information

- Parties with questions can continue to work with PJM Planning as they do now.

- Legal questions may be directed to:

  Janine Durand, Senior Counsel
  PJM Interconnection
  email: duranj@pjm.com
Wind Generation

FERC Order 661 & 661a

Mahendra Patel
Generation Analysis
PJM Interconnection
FERC Order for Wind Generation Interconnection:

Issued (661) : June 2, 2005  
Revised (661a) : Dec. 12, 2005

Main Provisions:

- Low Voltage Ride through (LVRT)
- Power Factor Design Criteria (Reactive Power)
- Supervisory Control & SCADA Modeling

PJM accepted most of these in its compliance filing
Low voltage ride through (LVRT)

Wind Generation Plant shall remain in-service

- during a normally cleared three phase fault
- phase to ground fault with delayed clearing
- and subsequent post-fault voltage recovery period.
Power Factor Design Criteria (Reactive Power)

Wind Generation Plant shall maintain a power factor within 0.95 leading to 0.95 lagging if the Transmission Provider’s System Impact Study shows that it is required to ensure reliability.
Supervisory Control & SCADA

Wind Generation Plant shall provide SCADA capability that can receive instructions (Information and control capability requirements to be agreed to by the Generation Interconnection Customer and the Transmission Provider)
FERC did recognize that updating, improving and validating models used to evaluate interconnection of wind plants is essential, and encouraged the industry to address these needs through technical groups.
IMPACT Studies:

- Load Flow Study (Generator deliverability study)
- Short Circuit Study
- Stability Study
Impact Study -

- Assess Transmission Needs to Meet applicable Reliability Criteria
- Assign cost responsibilities of required system upgrades
Operational considerations:

Intermittent nature of wind generation could affect Regulating and Reserve requirements

&

Larger forecast uncertainty may be an issue

Impact Study does not address these issues
Plant Models:

PJM requires aggregate Plant Models are practical

Standard models built in the simulation programs (rather than user written models) are required
Power Factor Design Criteria (Reactive Power)

- FERC staff Report on ‘Reactive Power Supply and Consumption’ sited lack of ‘consistent and transparent planning standards for reactive power’
Reactive Power planning is complex

Voltage Stability or Voltage Collapse Issue

Voltage Instability (Loss of Voltage Control)
Inability of the system to meet Reactive Demand

Voltage Collapse (Loss of Voltage)
Uncontrollable Rapid loss of voltage
Past wide area disturbances caused by Voltage Stability or Voltage Collapse

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PJM Study Process for Power Factor Design Criteria (Reactive Power) & Low Voltage Ride through (LVRT)

Load Flow:

We will model wind generation plant with its GSU & apply voltage and voltage drop criteria for all applicable contingencies & will Require Reactive Source to mitigate any violations.

Stability:

We will simulate criteria contingencies using Wind Generation Plant model provided by generation interconnection customer & will require Reactive Source for instability or possible tripping of the plant by the plant’s protective relays.