2013 Market Efficiency

- 2013 Market Efficiency Analysis represents transition year to reflect second part of 24 month RTEP cycle.
  - 24 month cycle began in January of 2012
  - Includes update of significant assumptions
## Market Efficiency 24 Month and 12 Month Cycles

<table>
<thead>
<tr>
<th>Year 0</th>
<th>Year 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>Jan</td>
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<tr>
<td>Feb</td>
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<td>Mar</td>
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<td>Nov</td>
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<tr>
<td>Dec</td>
<td>Dec</td>
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</tbody>
</table>

### 24-month cycle

- **Develop Assumptions (Y1, Y5)**
- **Market Efficiency Analysis (Y1, Y5)**
  (Accelerations and Modifications)
- **Identify and evaluate Solution Options (Accelerations and Modifications)**
- **Final Review with TEAC and approval by Board**

### 12-month cycle

- **Develop Assumptions (Y1, Y5)**
- **Market Efficiency Analysis (Y1, Y5)**
  (Accelerations and Modifications)
- **Identify and evaluate Solution Options (Accelerations and Modifications)**
- **Final Review with TEAC and approval by Board**

### 24-month cycle

- **develop Assumptions (Y5, Y8, Y11, Y15)**
- **Market Efficiency Criteria Analysis (Y5, Y8, Y11, Y15)**
- **Market Efficiency Analysis (Y5, Y8, Y11, Y15)**
- **Identify proposed solutions**
- **Update significant assumptions (Y4, Y7, Y10, Y14)**
- **Analysis of market solutions and support of benefits of reliability solutions (Y4, Y7, Y10, Y14)**
- **Independent Consultant reviews of buildability**
- **Adjustments to solution options by PJM on analysis**

### 12-month cycle

- **Develop Assumptions (Y1, Y5)**
- **Market Efficiency Analysis (Y1, Y5)**
  (Accelerations and Modifications)
- **Identify and evaluate Solution Options (Accelerations and Modifications)**
- **Final Review with TEAC and approval by Board**
Market Simulation Input Data

- Study years
  - 2014 and 2018 to study approved RTEP projects for accelerations and modifications.
  - 2017, 2020, 2023, and 2027 to study new enhancements.

- PROMOD IV model from Ventyx

- Underlying input data contained in PROMOD Powerbase (February 2012 update)
  - 2013 update to loads, generation, demand resources, emissions, and fuels
  - Include EKPC zone in PJM
• Power flow models
  - 2014 PJM and external world topology based on the 2012 summer case from the 2011 ERAG MMWG series power flow base case
    • Additional significant upgrades will be added which will be in service by end of 2013.
  - 2017 and later PJM topology will be based on the 2017 RTEP case that was used in the 2012 RTEP
    • Includes all PJM Board approved upgrades thru February 2013
  - 2017 and later external world model based on 2017 summer case from 2011 ERAG MMWG series power flow base case.
Key Input Parameters

- Fuel prices
- Load and energy
- Demand resource
- Future generation
- Emissions price
- Transmission constraints
- Carrying charge rate and discount rate
Figure 1 - Fuel Price Assumptions

- Coal
- Gas
- OIL-H
- OIL-L
PJM zonal peak and zonal energy forecast from 2013 Load Forecast Report

Table 1 - PJM Peak Load and Energy Forecast

<table>
<thead>
<tr>
<th>Load</th>
<th>2013</th>
<th>2014</th>
<th>2017</th>
<th>2018</th>
<th>2020</th>
<th>2023</th>
<th>2027</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak (MW)</td>
<td>154,712</td>
<td>157,793</td>
<td>166,320</td>
<td>167,922</td>
<td>171,477</td>
<td>176,548</td>
<td>183,188</td>
</tr>
<tr>
<td>Energy (GWh)</td>
<td>819,195</td>
<td>835,603</td>
<td>884,564</td>
<td>894,019</td>
<td>915,237</td>
<td>942,569</td>
<td>978,583</td>
</tr>
</tbody>
</table>

Notes: 1.) Reduced by cleared Energy Efficiency (EE) from RPM.
2.) Includes EKPC Zone.
3.) Model inputs are at the zonal level, to the extent zonal load shapes create different diversity - modeled PJM peak load may vary.
• Model zonal demand resources consistent with Table B-7 of the 2013 Load Forecast Report.

<table>
<thead>
<tr>
<th>Table 2 - Forecast PJM Demand Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Resource (MW)</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
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<td></td>
</tr>
</tbody>
</table>
Future Generation

- Generation model includes all existing in-service generation plus actively queued generation with an executed ISA less planned generator deactivations [1]

- To meet the installed reserve requirement for study years 2020, 2023 and 2027, 1,900 MW, 6,100 MW and 13,800 MW of additional capacity will be added to model, respectively. See Figure 2.

- For study years 2020, 2023, and 2027 - new generation will be added in proportion to the regional location and generation type of active generation projects without signed ISAs through Generation Interconnection Queue Y2. See Table 3.

[1] Modeled deactivations include those received on or before of 2/12/2013.
(http://www.pjm.com/planning/generation-retirements/~/media/planning/gen-retire/pending-deactivation-requests.ashx)
Figure 2 - PJM Market Efficiency Reserve Margin

- Forecasted Summer Peak Net Internal Demand
- Reserve Requirement
- Existing + Expected New Generation - Retirement

Future Generation

13,800 MW
6,100 MW
1,900 MW

MW

210,000
200,000
190,000
180,000
170,000
160,000
150,000
140,000
130,000


Year
Table 3 – Percent of added capacity by region and generator type to maintain PJM reserve margin

<table>
<thead>
<tr>
<th>Region</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Gas</th>
<th>Oil</th>
<th>Wind</th>
<th>Other Renewables</th>
<th>Total Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>AECO/DPL/JCPL/PECO/PSEG</td>
<td>0.8%</td>
<td>0.0%</td>
<td>21.6%</td>
<td>0.0%</td>
<td>0.4%</td>
<td>0.8%</td>
<td>23.6%</td>
</tr>
<tr>
<td>AEP/APS/COM/DAY/DUQ/ATSI/DEOK/EKPC</td>
<td>1.1%</td>
<td>4.6%</td>
<td>30.2%</td>
<td>0.1%</td>
<td>5.3%</td>
<td>1.5%</td>
<td>42.7%</td>
</tr>
<tr>
<td>BGE/PEP</td>
<td>0.0%</td>
<td>0.0%</td>
<td>8.6%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.4%</td>
<td>9.0%</td>
</tr>
<tr>
<td>DOM</td>
<td>0.0%</td>
<td>0.0%</td>
<td>6.7%</td>
<td>0.0%</td>
<td>0.3%</td>
<td>0.2%</td>
<td>7.3%</td>
</tr>
<tr>
<td>ME/PN,PPL</td>
<td>0.1%</td>
<td>0.0%</td>
<td>16.7%</td>
<td>0.0%</td>
<td>0.5%</td>
<td>0.1%</td>
<td>17.4%</td>
</tr>
<tr>
<td>Total for PJM</td>
<td>2.0%</td>
<td>4.6%</td>
<td>83.8%</td>
<td>0.1%</td>
<td>6.5%</td>
<td>3.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
• National CO2 emission price set to zero for all study years
  – Reflects the stalled federal legislation regarding greenhouse gases and CO2

• RGGI State (MD, DE) CO2 emission price non-zero for all study years
  – See Figure 3

• SO2 & NOx emission price set to zero for all study years
  – CSAPR vacated in 2012.
  – CAIR rules in place, less stringent requirement
Figure 3 - CO2 Emission Price Assumptions

- National CO2
- RGGI CO2 (Maryland, Delaware)
Transmission Constraints

- **Thermal Constraints**
  - NERC Book of Flowgates
  - Planning study results for monitored facilities and monitored/contingency pair facilities
  - Historical PJM congestion events

- **Voltage Constraints**
  - PJM reactive interface limits
  - MW limits based on historical values and voltage stability analysis
  - RTEP upgrades impact future reactive interface limits
Carrying Charge Rate and Discount Rate

- Discount rate and levelized carrying charge rate developed using information contained in TO Formula Rate sheets (Attachment H) [1]
  
- Discount rate based on weighted average after-tax embedded cost of capital [2]
  
  Discount rate = 7.7%

- Levelized annual carrying charge rate based on weighted average net plant carrying charge levelized over an assumed 45 year life of project [3]

  Levelized Annual Carrying Charge Rate = 16.7%

[2] Average weighted by TO total capitalization
[3] Average weighted by Total Transmission Plant In service included in PJM Tariff
Next Steps

- Determine reactive interface ratings and monitored events
- PJM Board review of input assumptions
- Begin analysis with regular updates to TEAC