Capacity Markets for a Decarbonised Power Sector: Challenges and Lessons
A Case Study of Forward Capacity Markets

Presented by Meg Gottstein, Principal
Brussels, April 2011
The Regulatory Assistance Project (RAP)

**RAP** is a global NGO providing technical and policy assistance to government officials and agency staff on energy and environmental issues. RAP is funded by several foundations and government agencies. RAP has worked in more than 20 nations and 50 provinces and states, and now works closely with the European Climate Foundation in Brussels.

**Meg Gottstein** is a Principal at RAP working on European Programmes

Formerly an Administrative Law Judge for the California PUC (utilities regulator) and policy advisor to the President Commissioner, Regional Program Manager with the US Department of Energy, consultant for the National Governor’s Association and policy analyst for the California Energy Commission. BA in Economics/German, Tufts University; Masters in Public Policy, Harvard University.

Recent assignments include work with the UK Department of Energy and Climate Change, the ECF 2050 Roadmap Project, the US Western Climate Initiative, the California Public Utilities Commission and the Chilean Minister of Energy.
Teeing Up The Challenge: Some Observations

- None of the capacity markets to date have been designed in the context of enabling and sustaining a largely decarbonised power sector
  - i.e., one dominated by generation low/near-zero running costs & substantial proportion of intermittent renewables
  - Where system reliability “dimensions” differ greatly from past/present
    - a range of flexible, reliability resources
    - demand “flexing” will be key (not just peak-shaving)
    - And “sum of the parts” will not easily=the system whole
  - Or have considered how the market incentives they create affect the decarbonisation agenda

- Case in Point: Leading “forward” capacity markets in the US have done very well on the demand-side, but overall:
  - Are working at cross purposes with decarbonisation objectives
  - Do not address the reliability challenges of a decarbonised power sector
The Challenge Question:

Will Power Sector Decarbonisation Turn Traditional Wisdom on its Head?
Meeting EU 2020 Renewables targets will introduce a paradigm shift:
UK Electricity Market Reform: Achieving a low carbon system goes beyond 2020 targets.....

Requires near-full decarbonisation of UK power system during 2030s, with 30% of electricity demand being met by renewables by 2020.
What will happen to residual demand patterns (Is meeting “peak” the primary reliability dimension? )

Western Denmark system—winter demand patterns

Source: Security of Supply from a UCTE Perspective, Paul-Frederik Bach, April 2004
Western Denmark system with \(\approx 18\%\) of energy from wind

By Comparison: UK target under EMR = 30\% renewables by 2020

Source: Security of Supply from a UCTE Perspective, Paul-Frederik Bach, April 2004
will now need to shape, not just shave, demand

And energy efficiency is needed to keep overall system costs affordable in the power system

Source: ECF Roadmap 2050 Study
With low/zero running cost resources increasingly on the margin

Returns on capital will be squeezed into a few hours a year*

*data based on UK runs by Pöyry
Forward Capacity Markets Design and Experience (US)
Capacity Market Context and Goals:

- Introduced into well-functioning, mandatory wholesale power pools with good liquidity and strong market power oversight
  - “PJM” and New England ISO—collectively = 1/5 of EU-27
- Provide price signal for new investment to meet system peak loads (*not to balance increasing renewables*)
- Revenue substitute for “capped” energy market
- Capital contribution for marginal units (gas)
- Novel: Allow all demand-side resources to compete
  - Demand response, energy efficiency, on-site generation
FCMs cover regions with installed generation capacity on the order of:

- 22% of the EU-27 member states combined
- The combined installed generation capacity of Poland, Germany and Belgium

**LEGEND**

ISO New England territory
PJM territory - covers all or most of the state
PJM territory - covers part of the state
“Forward” Capacity Markets (FCM)

• Run by the system operator of the mandatory power pools in each region (different market than UK)
  – Peak demand forecasted in region for a future delivery year (several years in advance)
  – Resources bid on a “forward” basis—commit to being available during peak demand periods (as forecasted) for the delivery year

• Administrative auction; single price paid to all
  – Existing and new resources submit bids and get paid the single clearing price in the market (similar to energy-only)
  – An “insurance premium” ($/MW-day) above their energy sales

• Costs allocated to load-serving entities & customers
Requirements For Participating

• Qualifications package
  – Peak capacity to be delivered
  – Documentation of funding
  – Added requirements for demand resources:
    • Plans for “customer acquisition”
    • Measurement and verification plans

• Length of commitment: 1 to 5 years
• Cost analysis
• Financial assurance
Good News about Forward Capacity Markets:

- Addressed looming capacity shortages
  - (reason for FCMs in the first place)
- Recognise demand-side resources as reliability resources to a degree never before in markets
  - **impressive participation**
    - 2012/2013 delivery year, **10,600 MW* of demand side resources cleared** the regional auctions based on price alone
  - **they can perform reliably**
  - **their participation reduces system costs**
But There’s “Bad News” about FCMs:

*Putting Theory into Practice difficult:*

- Volatility (boom-bust) continues
- High transaction costs
  - Qualification, financial assurance, M&V
- *Little evidence of new investments*
  - Keep a lot of old plants “going”, some upgrades
  - Resources with other revenue streams

*Following the money = carbon & windfalls*
Cumulative PJM Capacity Revenues ($42 billion)

- Coal—Existing: 30.01%
- Gas—Existing: 31.83%
- Hydro—Existing: 4.91%
- Nuclear—Existing: 21.06%
- Oil—Existing: 8.14%
- Other Renewables—Existing: 0.68%
- Other Renewables—Planned: 0.05%
- Demand Resources: 2.43%
- Energy Efficiency Resources: 0.07%

~70% to existing fossil-fueled plants; 20% to “legacy” nuclear; where are the new gas peakers?

Source: Market Monitoring Analytics (PJM)
Notes for PJM Forward Capacity Market Revenues:

- All PJM revenues for all auctions for the 2007/2008 Delivery Year through the 2013/2014 Delivery Year
  - Total revenue = $42.1 billion
- Planned resources are new units that did not previously exist
- Existing resources are existing units and any modifications to existing resources
- DR resources are demand side capacity resources.
- EE resources are energy efficiency resources.
Where to go from here?

- Specify the “design specs” for reliability resources required for a secure, resilient, decarbonised (and integrated) system
  - Not only a question of sufficient production capacity—will depend on a production “system” with the right package of qualities.
  - “Predict and provide” paradigm will need to be altered
- And the role of system operators in ensuring that the power system “as a single machine” functions, over short- and long-term
  - Can those qualities be effectively “devolved” as resource adequacy obligations on individual energy suppliers?
Where to go from here? (cont)

- **More targeted approaches** to acquire needed reliability resources/products for the system **should be considered:**
  - That are *market-based*, but also recognise the essential role system operator in *real-time balancing* and permit trading over a range of timescales that also *supports investment decisions*
  - There is *innovative thinking in this area*, including how to address the “missing money” issue—and how to design EU-market compatible

- **If a full-market is considered:** Need to address “where the money goes” issues with respect to carbon and windfalls
### TSO-brokered options for flexible resources as alternative to imbalance

#### TSO-brokered flexibility market

Participants choose to:
- buy peak capacity option and agree utilisation price, or
- face imbalance prices set to reflect marginal cost of provision

#### Contracts

Peaking plant (or demand reduction) financed by option contracts

Wholesale market energy prices remain unpolluted
“You can’t solve a problem with the same thinking that created it.”

- Albert Einstein
“You can’t solve a problem with the same market rules that created it.”

- Meg Gottstein
About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

▪ Promote economic efficiency
▪ Protect the environment
▪ Ensure system reliability
▪ Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

Meg Gottstein, Principal; mgottstein@raponline.org
Additional Slides

- Ensuring that generation in receipt of capacity payments does not overly benefit from scarcity pricing in adjacent market(s).
- Illustration of “how FCMs work”
- Additional detail on auction results (demand-side, wind, supply-side additions, PJM zonal prices)
- ISO-NE auction—graphic
- PJM Auction—graphic
Can Member State Initiatives be Accommodated in an Integrated EU Electricity Market?

• If a Member State does initiate capacity payments:
  – Is there a way to ensure that generation in receipt of those payments does not overly benefit from scarcity pricing in an adjacent market, and distort trade?

• RAP has some thoughts on this....

(see Annex 2, of “Advancing Both European Market Integration and Power Decarbonisation,” April 2011)
Coupling “Energy Only” and “Capacity Payments” Electricity Markets

Figure A1: shaded area = additional income (€/MWh) of capacity payment to all plant declared available in X. All capacity that clears the auction also receives the marginal energy price €PX/MWh.

Figure A2: market X coupled with “energy only” market Y, and exports ΔXY MW, results in increased marginal price PY. If the market X capacity payment remained unchanged, generation in market X would receive additional capacity payments due to the “energy only” nature of market Y.

To avoid this: capacity payments are reduced by a €/MW amount equivalent to PY-PX. But market X generation that did not clear in the uncoupled market but did clear in the coupled market has capacity payment reduced by the difference between PY and bid price. Generation that did not clear in the coupled market continue to receive the full capacity payment.
Does the European Target Model Prevent External Generation from Participating in a Capacity Market?

In a low carbon electricity system, I/C capacity likely to be under-utilised when renewable resource is reduced and generation capacity scarce.

External generation contracts could provide a useful option, even if not backed by “firm” I/C capacity.
Observations on Capacity Markets & Payment Mechanisms to Date*:

- Design focus: Enhancing resource firmness/adequacy to meet system peak loads
- Strategy: Acquire an adequate “stack” of committed capacity that “adds up”
  - Plants running 24/7 as valuable as dispatchable, flexible generation or demand resources
  - One-dimensional forecasting challenge: What’s future system peak demand?
  - Can allocate responsibility and costs to individual suppliers, such that sum of parts = whole
- Predicated on: Conventional resource mix and dispatch order
  - Baseload (24/7) attributes of demand/generation resources “matched” well for most hours
  - Need to shave—not flex—demand (up and down) to maintain reliability at least cost
- Underlying Economic Theory: Provide the “missing money”
  - that scarcity pricing in energy-only markets would provide to all resources operating during system shortage if pricing signals in those markets were left to their own devices

*Based primarily on North America Experience
System Operator (SO) Plans “Forward” for the Region

2012 Projection of Peak Demand = 10,000 MW (incl. reserves)
Each “Load Serving Entity” (LSE) * is obligated for its 50% share

R₁ = 3500 MW capacity
“Self Supply” Resources
(LSE₁ owned/under contract)

SO purchases capacity in 2012 at the 2009 auction clearing price

* LSE can be regulated utility or competitive retail supplier
The Regional Capacity Auction (3 years “Forward”)

- Supply = Capacity Committed “Forward”
- Demand = SO Forecast of Capacity Requirements
- Bid Price = $ per MW-day
- Quantity = MW
- Cleared Capacity = 10000

R_1-R_7 = Capacity offered by Supply-Side (New built, Existing, Uprates) and Demand-Side (Energy Efficiency, Demand Response, Distrib. Gen);
Self-supply (R_1) bids in a “zero” price; New Resources set clearing price

P* clearing price paid to all capacity clearing auction
System Operator Pays Cleared Resources at $P^*$ and Bills LSEs (Note: Self-Supply capacity is a “wash”)

$LSE_1$ pays its share of regional demand (5000 MW) adjusted for self-supply $R_1$ for a net payment of 1500 MW @ $P^*$

$LSE_2$ pays its share of regional demand: 5000 MW @ $P^*$

In 2012:
Total regional peak demand of 10,000 MW Supplied by $R_1 + R_2 + R_3 + R_4 + R_5$. $LSE_1$ and $LSE_2$ are each responsible for 50% of regional peak demand.

$R_1 = 3500$ MW of “Self Supply” Resources ($LSE_1$ owned/under contract)
Time Line – New Generation

- **Auction #1**
  - Qualification Period
  - Construction Period
  - Delivery Period

MW supply

Qualification Period

Construction Period

Delivery Period

MW for FCA#1

Month/Year

Time Line – Energy Efficiency
Demand-Side Resources in the 2012/2013 Auctions

PJM

- Demand-Side Resources Cleared: **7,616.2 MW**
  - Demand Response (including on-site, distributed generation): 7,047.3 MW
  - Energy Efficiency: 568.9 MW
- Out of 136,143.6 MW Total Cleared

ISO-NE

- Demand-Side Resources Cleared: **2,898 MW**
  - Demand Response: 1,206 MW
  - Energy Efficiency: 975 MW
  - Distributed Generation-Fossil Fuel: 86 MW
  - Distributed Generation-Renewable Energy: 0.7 MW
  - Real-Time Emergency Generation: 630 MW*
- Out of 36,996 MW Total Cleared

*Real-Time Emergency Generation in ISO-NE is limited to 600 MW. Payments to generators are reduced on a pro-rated basis if a higher amount clears.
Demand-side participation reduces cost of reliability

ISO-NE Calculation for a single year:*
- D3 reduced costs by ~$290 million
- Savings >15% of total cost

Note: substantial savings in PJM capacity auctions, too.

* FCA-1 Installed Capacity Requirement = 32,305 MW
  - 2,554 MW of demand resources cleared
  - Surplus of 2,047 MW at floor price of $4.50/kW-month
  - Without D3, auction clears between $5.63 to $5.25
### Demand-Side Results (ISO-NE)

<table>
<thead>
<tr>
<th>FCA</th>
<th>Net ICR*, MW</th>
<th>FCA Clearing Price, $/kW-Month</th>
<th>FCA Prorated Price, $/kW-Month</th>
<th>DR MW</th>
<th>% ICR</th>
<th>EE MW</th>
<th>% ICR</th>
<th>DG MW</th>
<th>% ICR</th>
<th>Total Demand Resources MW</th>
<th>% ICR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCA 1</td>
<td>32,305</td>
<td>$4.50</td>
<td>$4.25</td>
<td>1,853</td>
<td>5.7%</td>
<td>655</td>
<td>2.0%</td>
<td>46</td>
<td>0.1%</td>
<td>2,554</td>
<td>7.9%</td>
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<tr>
<td>FCA 2</td>
<td>32,528</td>
<td>$3.60</td>
<td>$3.12</td>
<td>1,953</td>
<td>6.0%</td>
<td>890</td>
<td>2.7%</td>
<td>93</td>
<td>0.3%</td>
<td>2,937</td>
<td>9.0%</td>
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<tr>
<td>FCA 3</td>
<td>31,965</td>
<td>$2.95</td>
<td>$2.54</td>
<td>1,836</td>
<td>5.7%</td>
<td>975</td>
<td>3.0%</td>
<td>87</td>
<td>0.3%</td>
<td>2,898</td>
<td>9.1%</td>
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<tr>
<td>FCA 4</td>
<td>32,127</td>
<td>$2.95</td>
<td>$2.52</td>
<td>2,055</td>
<td>6.4%</td>
<td>1,167</td>
<td>3.6%</td>
<td>128</td>
<td>0.4%</td>
<td>3,349</td>
<td>10.4%</td>
</tr>
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</table>
## D3 Resources are Reliable:
**ISO-NE Real-Time DR Obligation and Performance by Load Zone**

<table>
<thead>
<tr>
<th>Load Zone</th>
<th>Total Net CSO</th>
<th>Average Aggregate Performance*</th>
<th>Percent Net CSO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecticut</td>
<td>226.83</td>
<td>170</td>
<td>33.9</td>
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<tr>
<td>West Central Massachusetts</td>
<td>79.59</td>
<td>79</td>
<td>11.9</td>
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<tr>
<td>Northeast Massachusetts</td>
<td>70.74</td>
<td>46</td>
<td>10.6</td>
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<tr>
<td>Southeast Massachusetts</td>
<td>45.23</td>
<td>30</td>
<td>6.8</td>
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<tr>
<td>Rhode Island</td>
<td>27.76</td>
<td>27</td>
<td>4.1</td>
</tr>
<tr>
<td>Vermont</td>
<td>23.71</td>
<td>29</td>
<td>3.5</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>29.11</td>
<td>33</td>
<td>4.4</td>
</tr>
<tr>
<td>Maine</td>
<td>166.22</td>
<td>239</td>
<td>24.8</td>
</tr>
<tr>
<td><strong>New England</strong></td>
<td><strong>669</strong></td>
<td><strong>653</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

* Additional meter data corrections to address data quality issues will adjust the net performance. The values noted above adjust for known problems and anomalies.
System Load vs. Forecast

Thunderstorms move through South Western CT

- DR Dispatch to 669 - 13:50
  23408 MW
- DR Dispatch +30 Minutes
  23680 - 22754 = 926 MW
- DR Dispatch +60 Minutes
  23770 - 22606 = 1164 MW
- DR Dispatch to 300 - 16:24
  23900 - 22558 = 1342 MW
- DR Dispatch to 0 - 16:57
  23710 - 22413 = 1297 MW
Wind Resources in the Capacity Auctions

- Capacity markets are concerned about resources available on-peak hours – i.e., their on-peak capacity factor.
- Wind is primarily an energy resource, not a capacity resource.
- Treatment of Wind in PJM Capacity Market
  - Deemed 13% on-peak capacity factor: For every 100 MW of wind resources, 13 MW are eligible to meet capacity requirements.
  - 323.4 MW cleared the most recent auction – 95% of amount offered*
  - Represents a large nameplate rating – 2,488 MW
- Treatment of Wind in ISO-NE Capacity Market
  - Use data to demonstrate winter/summer qualified capacity (Not deemed)
  - Capacity factor adjusted over time based on performance during specified hours
  - 166 MW cleared the most recent auction**
  - Nameplate rating is perhaps an order of magnitude larger

**Compiled from auction results at http://www.iso-ne.com/markets/othrmkts_data/fcm/cal_results/ccp13/fca13/index.html
# Supply-Side Additions in PJM Capacity Market

<table>
<thead>
<tr>
<th>Delivery Year</th>
<th>CT/GT</th>
<th>Combined Cycle</th>
<th>Diesel</th>
<th>Hydro</th>
<th>Steam (Coal)</th>
<th>Nuclear</th>
<th>Solar</th>
<th>Wind</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td></td>
<td></td>
<td>18.7</td>
<td>0.3</td>
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<td></td>
<td></td>
<td>19.0</td>
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<tr>
<td>2008/2009</td>
<td></td>
<td></td>
<td>27.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93.1</td>
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<td>2009/2010</td>
<td>399.5</td>
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<td>23.8</td>
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<td>53.0</td>
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<td></td>
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<td>476.3</td>
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<td>2010/2011</td>
<td>283.3</td>
<td>580.0</td>
<td>23.0</td>
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<td></td>
<td></td>
<td>1027.7</td>
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<tr>
<td>2011/2012</td>
<td>416.4</td>
<td>1135.0</td>
<td></td>
<td></td>
<td>704.8</td>
<td>1.1</td>
<td></td>
<td></td>
<td>2332.5</td>
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<td>2012/2013</td>
<td>403.8</td>
<td>585.0</td>
<td>7.8</td>
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<td></td>
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<th>Capacity From Reactivated Units</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
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<tr>
<td>2010/2011</td>
<td>160.0</td>
<td></td>
<td>10.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>170.7</td>
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<tr>
<td>2011/2012</td>
<td>80.0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>181.0</td>
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<tr>
<td>2012/2013</td>
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<td></td>
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Supply-Side Additions in PJM Capacity Market (cont.)

<table>
<thead>
<tr>
<th>Uprates to Existing Capacity Resources</th>
<th>Delivery Year</th>
<th>CT/GT</th>
<th>Combined Cycle</th>
<th>Diesel</th>
<th>Hydro</th>
<th>Steam (Coal)</th>
<th>Nuclear</th>
<th>Solar</th>
<th>Wind</th>
<th>Total</th>
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<td>114.5</td>
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<td>13.9</td>
<td>80.0</td>
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<td>92.0</td>
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<td></td>
<td>536.0</td>
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<td>2008/2009</td>
<td>108.2</td>
<td>34.0</td>
<td>18.0</td>
<td>105.5</td>
<td>196.0</td>
<td>38.4</td>
<td></td>
<td></td>
<td>500.1</td>
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<tr>
<td></td>
<td>2009/2010</td>
<td>152.2</td>
<td>206.0</td>
<td>162.5</td>
<td>61.4</td>
<td>197.4</td>
<td></td>
<td>16.5</td>
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<td>796.0</td>
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<td></td>
<td>2010/2011</td>
<td>117.3</td>
<td>163.0</td>
<td>48.0</td>
<td>89.2</td>
<td>160.3</td>
<td></td>
<td></td>
<td></td>
<td>577.8</td>
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<td></td>
<td>2011/2012</td>
<td>369.2</td>
<td>148.6</td>
<td>57.4</td>
<td>186.8</td>
<td>292.1</td>
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<td>8.7</td>
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<td>1062.8</td>
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<td>231.2</td>
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<td>56.8</td>
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<td>785.5</td>
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<tr>
<td></td>
<td>Total - All Additions</td>
<td>2835.6</td>
<td>3015.9</td>
<td>214.5</td>
<td>396.3</td>
<td>2035.1</td>
<td>906.2</td>
<td>1.1</td>
<td>439.8</td>
<td>9844.5</td>
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Offered versus Cleared Capacity in PJM Auctions—By Resource Type (incremental and existing generation units)

<table>
<thead>
<tr>
<th>Delivery Year</th>
<th>Data</th>
<th>Coal</th>
<th>Distillate Oil (No.2)</th>
<th>Gas</th>
<th>Kerosene</th>
<th>Nuclear</th>
<th>Other - Gas</th>
<th>Other - Liquid</th>
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<tbody>
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Source: PJM, website table

Note: Energy efficiency was first eligible to bid in PJM’s auction for the 2012/2013 delivery year
Capacity Markets Results

Figure 2 – Base Residual Auction Resource Clearing Prices

RPM Base Residual Auction Resource Clearing Prices (RCP)