PowerGEM

Power Grid Engineering & Markets

"PJM Perfect Dispatch"
Implementation Experience

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Disclaimer

▸ Focus of this presentation is on the conceptual issues and implementation details rather than the actual PJM results.

▸ Visit www.pjm.com for more details on the Perfect Dispatch results and Perfect Dispatch performance metrics.

This presentation reflects PowerGEM opinions and experience and does not represent or reflect opinions of PJM or any other PowerGEM clients.
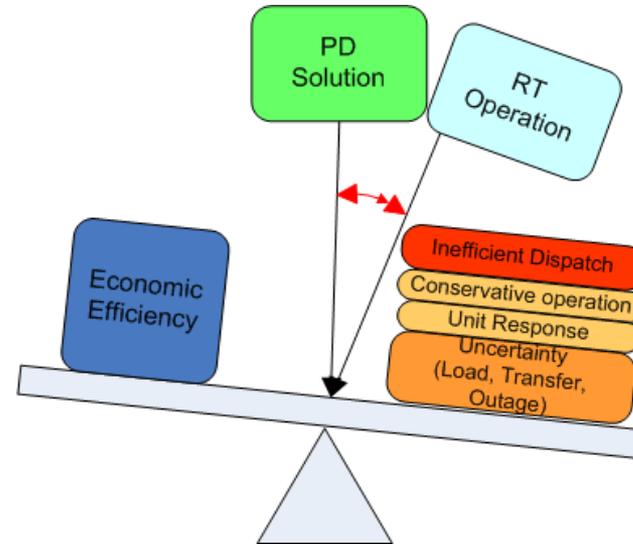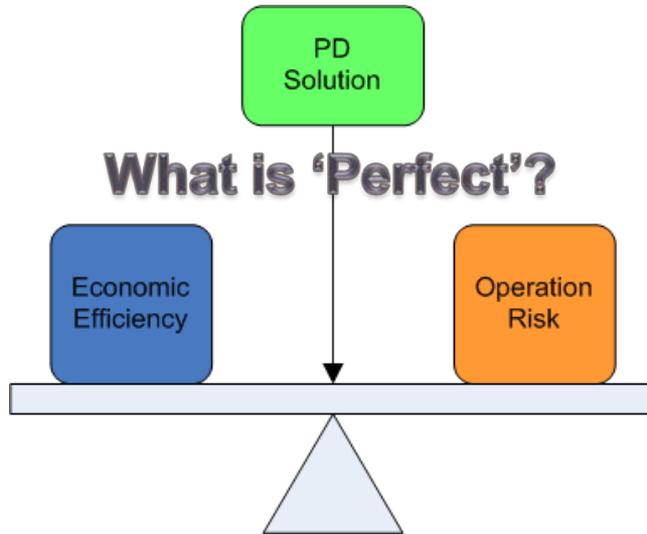
Perfect Dispatch Background

▶ Over the last 10-20 years, significant efforts have been made to implement and improve market-based grid dispatching. But the means to measure and analyze the overall dispatching efficiency somewhat lagged.

▶ PJM, driven by the goal to achieve operational efficiency excellence, wanted to develop a process to measure RT dispatch against the "perfect" as a way to analyze the efficiency of its dispatch operations and to spur continuous improvement in dispatching.

▶ Perfect Dispatch (PD) development started in 2007 initiated by PJM. PJM started executing PD daily beginning April 1, 2008.

▶ Perfect Dispatch has been bringing significant savings to PJM members. (The estimated savings in production costs in 2009 for PJM members were more than $122 million. http://pjm.com/about-pjm/newsroom/~/media/about-pjm/newsroom/downloads/perfect-dispatch-fact-sheet.ashx)

Perfect Dispatch Concept

▸ What is the "Perfect" dispatch?

▸ How far are we from being perfect?

▸ How can we quantify this?

▸ Ok, we probably will never be perfect, but what can we do to get better?

Perfect Dispatch Concept
Backcasted Real Time Production Cost

▸ The Perfect Dispatch for a given day is the calculated, hypothetical unit commitment and dispatch that would result in the lowest production cost while maintaining reliability.

▸ "Perfect Dispatch" solution is hypothetical and <u>could never be achieved</u> in actual operations.

   – RT uncertainties in the future system conditions

   – Dispatch deviations for self-scheduled units

▸ PD serves as a valuable baseline for measuring performance and identifying opportunities to improve the dispatching process.

▸ The PD metric is a measurement of the ability of dispatch operations to minimize PJM's system production cost while meeting reliability requirements.

Perfect Dispatch Methodology

- Apply DA SCUC algorithm and full day solution time window to find what would be 'Perfect' performance in RT if all required information would be available in advance:
  - Assume after the fact the perfect knowledge of the system conditions (load, transactions, outage…);
  - Honor 'all' reliability constraints;
  - 24 hour solution window, but with the smaller time step.

- PD Objective function doesn't change – minimize Bid Production Cost (BPC).

- The Perfect Dispatch metrics is based on BPC:

$$\Delta BPC = BPC_{RT} - BPC_{PD}$$

  - ΔBPC measure the "absolute" possible saving.

 - How much of ΔBPC reduction can be achieved?

Life Cycle of the "Single Market Day"

- Forward Markets:
  - DA – forward financially binding market, ~90% of the energy/revenues
  - RAC – reliability review after DA, not financially binding

- Real-Time (RT):
  - Short term forward solution window, executed many times
  - Limited subset of units are optimized by SCUC
  - Focus more on the short term dispatch

- What can be done after RT market is closed?
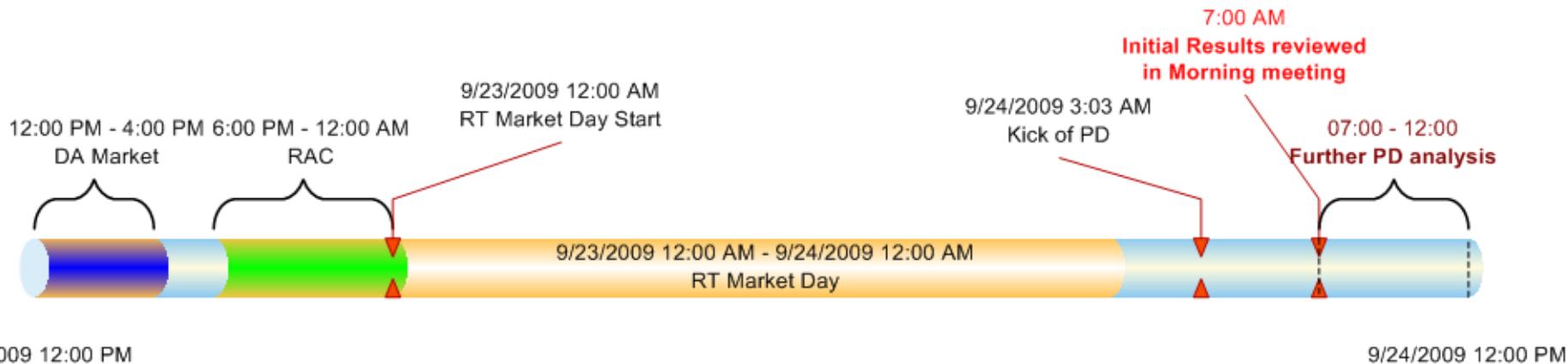
2009 Perfect Dispatch Performance
Percentage of Perfect
January 1, 2009 - July 31, 2009

From PJM OC meeting of 8/17/2009

Legend: Daily % of Perfect · YTD Running Average — Threshold — Target — Exceeds
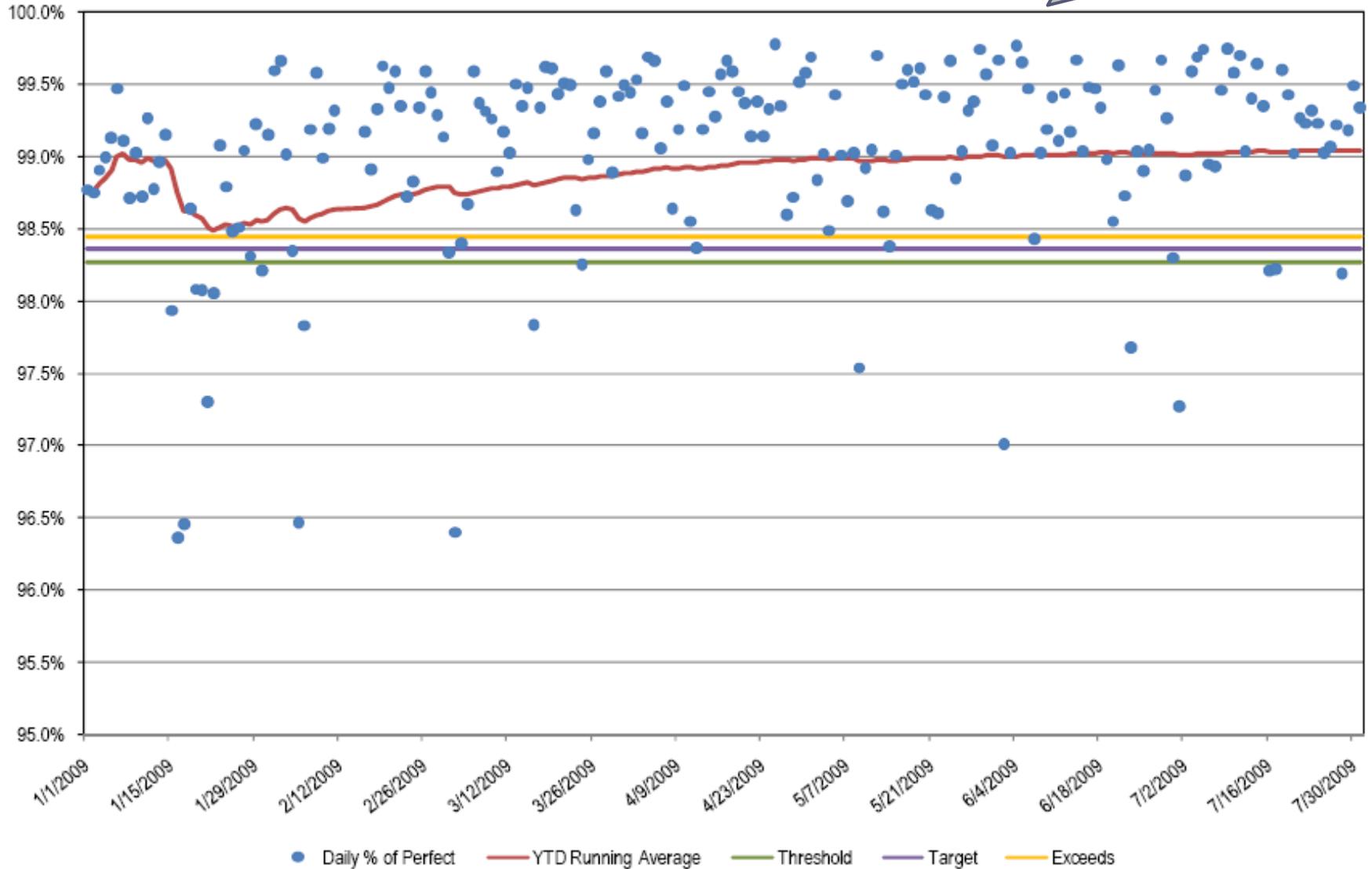
PD Implementation Methodology

▶ **PD performs incremental redispatch starting from the actual grid performance.**

- ▶ RT actual grid conditions outside of PJM footprint and RT. Interchanges are honored as happened
- ▶ Self Scheduled generators are fixed at RT dispatch.
- ▶ Branch flows are modeled incrementally from RT dispatch.

▶ **PD provides a great degree of simulation flexibility in modeling many RT realities.**

- ▶ DA commitment is honored.
- ▶ Only RT dispatchable units can be optimized by PD.

PD is a Vendor/SCUC Model Real Life Test

▸ Before we can test if PJM RT dispatch is perfect, PD software itself needs to pass "Perfect Dispatch" test.

  ▸ PD software can provide an overly optimistic result if we do not account for "RT Reality".

▸ Unique Challenges in PD implementation.

  ▸ How good are SCUC mathematical models?

  ▸ Market participants performance.

  ▸ Implementation issues and data needed to run PD.

    ▸ For PD PJM saves 288 EMS state estimate snapshots per day (every 5 minutes) which then may be utilized by PD (since summer 2007)

Unique Challenges in PD Implementation

▸ How good are SCUC models?

   ▸ Unit models in DA are simplified, especially during transitional periods of starts/stops and ramping.

▸ Unit response and out of merit dispatch by market participants.

   ▸ Forward market SCUC assumes "ideal unit performance" according to bid-in parameters.

   ▸ What happens if unit bid doesn't match unit production cost?

▸ Modeling of coordinated external flowgates.

▸ Non-dispatchable CTs setting the price in RT.

Considerations for Improving Dispatch

▸ If "RT life" is never perfect, what can be done to improve?

▸ Need to separate and quantify:

  ▸ Factors under PJM control in RT – mainly generators dispatch and limited UC.

  ▸ Factors under limited PJM control.

    ▸ Market participants behavior such as units not following dispatch.

  ▸ Factors out of PJM control.

    ▸ Uncertainties in load forecast

    ▸ External interchanges

    ▸ Outages

Perfect Dispatch Real Time Main Applications

▸ **Real Time Benchmarking Tool**

   ▸ Measuring the performance and efficiency of RT grid operations from a market point of view on the systematic daily basis.

▸ **Real-time Dispatching Review Tool**

   ▸ Provide insight into the causes of 'imperfectness' in RT operations.

   ▸ Give recommendations to PJM dispatching staff about what changes (mainly in unit commitment) could be made during the previous day that would improve grid performance.

▸ **High Quality Real Time Market Simulation Tool**

   ▸ Guide market design thoughts.

   ▸ **Diagnose** where the market rules, short term commitment and dispatch scheduling procedures, and software could be improved.
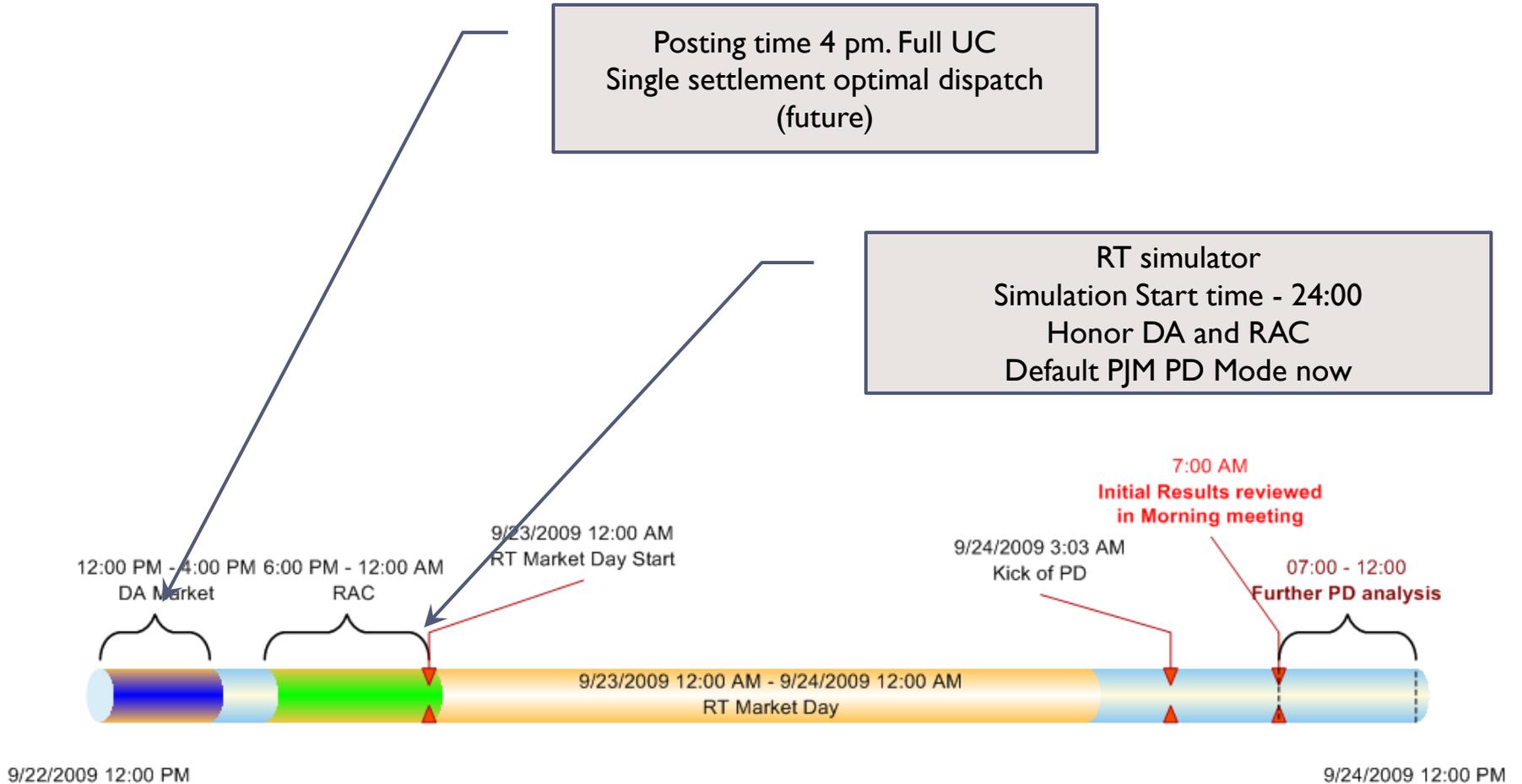
Perfect Dispatch as a RT Dispatch Analysis Tool

▶ PD can be used to perform in depth analysis and provide timely feedback to operators:

  ▶ Review steam unit commitment decisions made during RAC period

  ▶ Review CT commitment decisions during RT period

  ▶ Constraint control analysis

  ▶ Identify units not-following-dispatch that have most impact on the market performance

  ▶ Focus on commitment for specific period of day (partial day analysis)

  ▶ Load forecast error contribution

Perfect Dispatch – As a Market Study Tool

▸ PD is a high quality Real-time Market simulator. Can be used to do a variety of market design studies:

  ▸ Impact of demand response load on the market

  ▸ RT impact, for example, from increased use of renewable resources

  ▸ Marginal loss modeling

  ▸ Impact of the unit's poor performance

▸ PD can also perform full optimization to simulate a single settlement market for more general market studies

RT SCUC vs. Single Settlement SCUC

Posting time 4 pm. Full UC
Single settlement optimal dispatch
(future)

RT simulator
Simulation Start time - 24:00
Honor DA and RAC
Default PJM PD Mode now

12:00 PM - 4:00 PM 6:00 PM - 12:00 AM
DA Market   RAC

9/23/2009 12:00 AM
RT Market Day Start

7:00 AM
Initial Results reviewed
in Morning meeting

9/24/2009 3:03 AM
Kick of PD

07:00 - 12:00
Further PD analysis

9/23/2009 12:00 AM - 9/24/2009 12:00 AM
RT Market Day

9/22/2009 12:00 PM

9/24/2009 12:00 PM

PD for non-LMP Markets

▶ PD concept can be applied to non-LMP market entities.

▶ Similar objective:

  ▶ Minimize Production Cost

▶ Similar methodology:

  ▶ Establish a perfect real-time dispatch solution by PD

  ▶ Measure RT dispatch against 'Perfect' solution

▶ Primary difference compared to LMP markets – dispatch and UC are driven by cost rather than bids.

Conclusions

▶ PD is a successful attempt to respond to the industry's need to measure and analyze the overall real-time dispatching.

▶ PD implementation was able to help RTO :

   ▶ improve its dispatching efficiency;

   ▶ bring significant savings to RTO members;

   ▶ perform market design studies.

▶ PD is new and evolving concept; so is its implementation.

References

1. www.pjm.com/documents/~/media/documents/presentations/20100506-wtb-2010-annual-meeting-prepared-remarks.ashx

2. www.pjm.com/about-pjm/newsroom/~/media/about-pjm/newsroom/downloads/perfect-dispatch-fact-sheet.ashx

3. www.pjm.com/~/media/committees-groups/committees/oc/20090818/20090818-item-10-perfect-dispatch-update.ashx

4. B. Gisin, Q. Gu, J. Mitsche, S. Tam, H. Chen, "Perfect Dispatch – as the Measure of PJM Real Time Grid Operational Performance". Accepted for IEEE PES, July 2010;

Questions?