1. World model diversity: This is clearly a key issue. I suggest more analysis of actual historical diversity, PJM to neighbors.

    a. Historical data, with zone and hourly data on PJM peaks, and neighbor loads relative to their peaks. I had done something like this last fall (http://www.pjm.com/~/media/committees-groups/committees/pc/20151008/20151008-item-07c-wilson-comments-on-irm.ashx, slide 8).

    Response: Please see attached file (Attachment A). We have provided the per-unitized load for each of the individual neighboring areas as well as for the World at the time of the Top 5 PJM hourly peaks.

    While PRISM cannot estimate the amount of reserves that each of the neighboring regions has available at the time of the PJM peaks, the runs that we made in MARS, and the resulting CBOTs presented in the previous RAAS meeting, fully capture the individual areas' reserves and the impact they have in the PJM LOLE.

    b. Historical data on typical neighbor reserve margins relative to their criteria. I believe they are each nearly always above criteria, and the notion of all of them being at criteria simultaneously I expect has never occurred, so it is extremely conservative.

    Response: This information is not readily available. Furthermore, past actual reserves are not indicative of future reserves since some of the neighboring areas do not have Installed Reserve Margins requirements (such as TVA and VACAR). Even for those areas that do have an IRM requirement, it is not straightforward to forecast the future mix of resources that will meet such a requirement. This mix of resources is important to consider since some of the resources might be available to provide assistance only when the neighboring regions are experiencing an emergency (and not necessarily when only PJM is experiencing an emergency).

    Therefore, we believe that modeling the regions at criteria (1 in 10) is a reasonable assumption that avoids the near-impossible task of accurately forecasting future reserves and future resource mix for neighboring areas.

    c. Some discussion of how the PRISM modeling does/doesn't represent the hourly and daily PJM-World diversity.

    Response: PRISM uses a daily load model aggregated by week which only provides an estimate of the actual hourly and daily diversity between PJM and the World. For validation purposes, we have made runs in MARS in which an accurate representation of the hourly and daily diversity between each neighboring region and PJM is used. The resulting CBOTs were presented in the previous RAAS.

    d. Some discussion of likely peak hours conditions in the future, mentioning scarcity pricing, DR, PRD, price-response that isn't PRD, non-capacity resources, capacity resource over-performance, etc. in PJM and neighboring regions.

    Response: see Response to bullet b above

2. CBM.

    a. Again, I doubt the members believed they were establishing a resource adequacy modeling assumption (hard constraint) when they put that language in the RAA. And I think it takes it a step even farther to treat it as a real-time operational limit. Perhaps you should put the RAA language before the group, and the group may want to ask the members for interpretation..

    Response: We will show the RAA language in the upcoming RAAS meeting

    b. One option to consider is to drop the World model, and set CBOT = CBM, in light of the many ways assistance is under-represented. Wouldn't that be simple! Something to consider. Would still be very conservative.

    Response: It would certainly be simple. However, the MARS runs have shown that it might not be reasonable to do so.

3. GE-MARS.

    a. I'd be interested in more details of the key GE MARS modeling assumptions and how they were set; and which are the key drivers of results.

    Response:

    Capacity Model: Based on the 2015 RRS capacity model data for PJM and the neighboring areas. In addition, MARS requires a table indicating the average number of times a unit goes from being online to being offline (and vice versa) within a year (State Transitions table).

    Load Model: Combination of 11 individual load shapes from period 2002-2012 and Load Forecast Uncertainty obtained as described in attached slides (Attachment B). The same LFU was used for the 11 load shapes.

    Topology: PJM, MISO, TVA, VACAR, NYISO, ISONE. TVA and VACAR are in the pool SERC while NYISO and ISONE are assigned to pool NPCC. PJM and MISO are not assigned to any pool.

    "Transmission" Model: Simultaneous Transfer limits taken from the NPCC CP-8 WG model. PJM Simultaneous imports/exports capped at CBM=3500. Assistance priority: within pool first, next in the following order: PJM, MISO, TVA, VACAR, NYISO, ISONE.

    Solution Methodology: each area is solved to be at 1 in 10.

    Key Driver for CBOT results: The Load Shape is critical. On the other hand, a different LFU might change the Single Area IRM and the Two Area IRM but their difference (i.e., the CBOT) tends to remain constant. Additionally, for the load shapes that yield a large CBOT (2003, 2008, 2011), an increase in the CBM would increase the CBOT. Load shapes that yield a low CBOT are unlikely to benefit from an increase in the CBM as the limiting factor is the coincidence in PJM-World peaks.

    b. I suggest you calculate IRM using PRISM and MARS using as similar assumptions as possible, with some sensitivity analysis of the assumptions that seem to drive the differences. And perhaps a summary table of differences in the assumptions.

Response: The typical load shape used by PJM when performing reliability studies with the NPCC CP-8 Working Group is from 2002. Using the 2002 load shape, the assumptions listed in the response immediately above, and then adjusting the monthly peaks so that they match the per-unitized monthly peaks in the 2015 PJM Load Forecast (to make it consistent with the 2015 RRS), we obtain a 2019 single area IRM of 18.4 and a 2019 two-area IRM of 17.2. In the 2015 RRS, the corresponding results were 18.2 and 16.5.

These results are especially sensitive to the load shape and LFU considered.

Summary Table of Differences in Assumptions:

| **Capacity Model** | | |
|---|---|---|
| **Item** | **PRISM** | **MARS** |
| EEFORd | 2010-2014 | 2010-2014 |
| Planned Outage Factor | 2010-2014 | 2010-2014 |
| ICAP | 2015 RRS | 2015 RRS |
| Planned Outage Schedule | Levelizing Reserves | Levelizing Reserves |
| Available Capacity Probability Table | Convolution | Monte Carlo |
| Ambient Derates | 2500 MW | 2500 MW |
| State Transitions | Not needed | By Class Average |
| **Load Model** | | |
| **Item** | **PRISM** | **MARS** |
| Hourly Load Shape | Not needed | 2002 |
| Load Forecast Uncertainty Frequency | Weekly (normal distribution) | Monthly (normal distribution) |
| Load Forecast Uncertainty | Load Model 2003-2012 | Sampled from PRISM Load Model 2003-2012 |
| Discretization LFU | 21 points per week | 7 points per month |
| Monthly Peaks Adjustment | From 2015 PJM Load Forecast | From 2015 PJM Load Forecast |
| **World** | | |
| **Item** | **PRISM** | **MARS** |
| Topology | Combined World Area (1) | Individual World Areas (5) |
| Capacity Benefit Margin (CBM) | 3500 MW | 3500 MW |
| Transmission Limits | Not modeled | Per NPCC-CP8 WG |
| Installed Reserves | Combined World at 1 in 10 | Each Individual Area at 1 in 10 |
| Priority Assistance | Not needed | Within Pool First; then PJM, MISO, TVA, VACAR, NYISO, ISONE |
| **Other** | | |
| **Item** | **PRISM** | **MARS** |
| Demand Response | No DR is modeled for PJM or World | No DR is modeled for PJM or World Areas |

| | | |
|---|---|---|
| Loss of Load Margin | 0 MW | 0 MW |

c. Is it true your implementation of MARS doesn't have internal PJM regions, as suggested by slide 13? As I'm sure you know, NPCC's model has five internal PJM regions (https://www.npcc.org/Library/Resource%20Adequacy/2014%20NERC%20RAS%20Probabilistic%20Assessment%20NPCC%20Region%20(March%2031,%202015).pdf, p. 22). I suggest you think about what difference it would make to have a more granular GE MARS implementation, and present this to the group. Also, I'd be interested in what MARS has to say with respect to zonal requirements.

Response: It is true. No internal PJM regions were modeled, or equivalently, the limits on the internal PJM interfaces were set to infinity. If internal constraints are modeled, the IRM can be greater than or equal to the IRM without internal constraints (it cannot be less). Similarly, the CBOT in a model with internal constraints can be less than or equal to the CBOT in a model without internal constraint (it cannot be greater). In other words, a model with no internal constraints minimizes the IRM and maximizes the CBOT.

d. I suggest you revisit the 2010 MARS-PRISM report scope, and update that as to advantages/disadvantages, cost to switch over, etc.

Response: This is out of the scope of our assumptions examination this year

4. Load model: I hope it's clear that the key issue about load model is PJM-world diversity. So the load model selection process can be greatly simplified or eliminated if we can determine that, given other conservative assumptions, the load model should not put PJM and World peaks in the same week.

Response: We agree that the PJM-World Load diversity is a key issue. However, it is not the only issue when it comes to the load model; selecting a load model that matches the Load Forecast's CP1 distribution is also a key part of the load selection process. This is shown in the spreadsheet we sent you on 09/25/2015 where we present all the Single Area IRMs and Two Area IRMs computed with the 45 Load Model candidates we had for the 2015 RRS (re-sent as Attachment C). The Single Area IRM value ranges from 17.3% to 19.4% (while the Two Area IRM ranges from 15.8% to 18.1%).

The assumption that PJM and the World cannot peak in the same week is part of the Load Model Selection as it currently stands.

5. Posting analysis: Again, please consider posting the data behind your analysis when its convenient and not too voluminous, I have in mind especially the one supplemental slide that was very detailed.

Response: We posted the supplemental slide on the RAAS website. The data used to derive those slides is not very user-friendly.