Comments on Final Draft 2009 Reserve Requirements Study: Peak Load Value Used in IRM and FPR Calculations

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PJM Planning Committee Meeting
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Issue: "Denominator" for IRM Calculation

- Goal: Find IRM to satisfy "one day in ten years"
- Approach: Use probabilistic PRISM model
- Result: IRM expressed as:

  Installed Capacity / Median Annual Net Peak
  - Required by ReliabilityFirst BAL-502-RFC-02
  - Assumed in the RPM design
- Problem: The IRM has been calculated using a different (and lower) weekly peak load value
  - This overstates the IRM needed to satisfy 1-in-10
  - Leads to purchasing excess capacity under RPM, etc.

ReliabilityFirst Standard BAL-502-RFC-02

…

R1.1 Calculate a planning reserve margin that will result in the sum of the probabilities for loss of Load for the integrated peak hour for **all days of each planning year[1]** analyzed (per R1.2) being equal to 0.1. (This is comparable to a "one day in 10 year" criterion) …

R1.1.2 The planning reserve margin developed from R1.1 shall be expressed as a **percentage of the median[2] forecast peak Net Internal Demand** (planning reserve margin).

[1] The **annual period** over which the LOLE is measured, and the resulting resource requirements are established (June 1st through the following May 31st).

[2] The median forecast is expected to have a **50% probability of being too high and 50% probability of being too low (50:50).**

[emphasis added]

Definitions and Synonyms

- "Median" = "50/50"
- Median [Annual/August/Week 8] peak = the load value that is forecast to have a 50% chance of being exceeded by the actual peak during the specified time interval
- Median peak over a single week is also called "Expected Weekly Maximum" or EWM
- Median annual peak = median summer peak, almost (the chance of the peak occurring outside summer is very small)

IRM = Installed Capacity / Median Annual Peak
Sounds simple, so how can we get it wrong?

- Two aspects of the PRISM modeling approach make this just a little complicated:
  - In the PRISM model, load, rather than installed capacity, is varied to find the 1-in-10 solution point; so we can't simply divide by the forecast peak load
  - The load model happens to be parameterized around the median *weekly* peak of one of the 52 weeks in the model, not the median annual peak

No problem, the needed median annual peak load corresponding to any solution point is easily calculated. This calculation is not in dispute.

Illustration of PRISM Model's Determination of the 1-in-10 IRM (1)

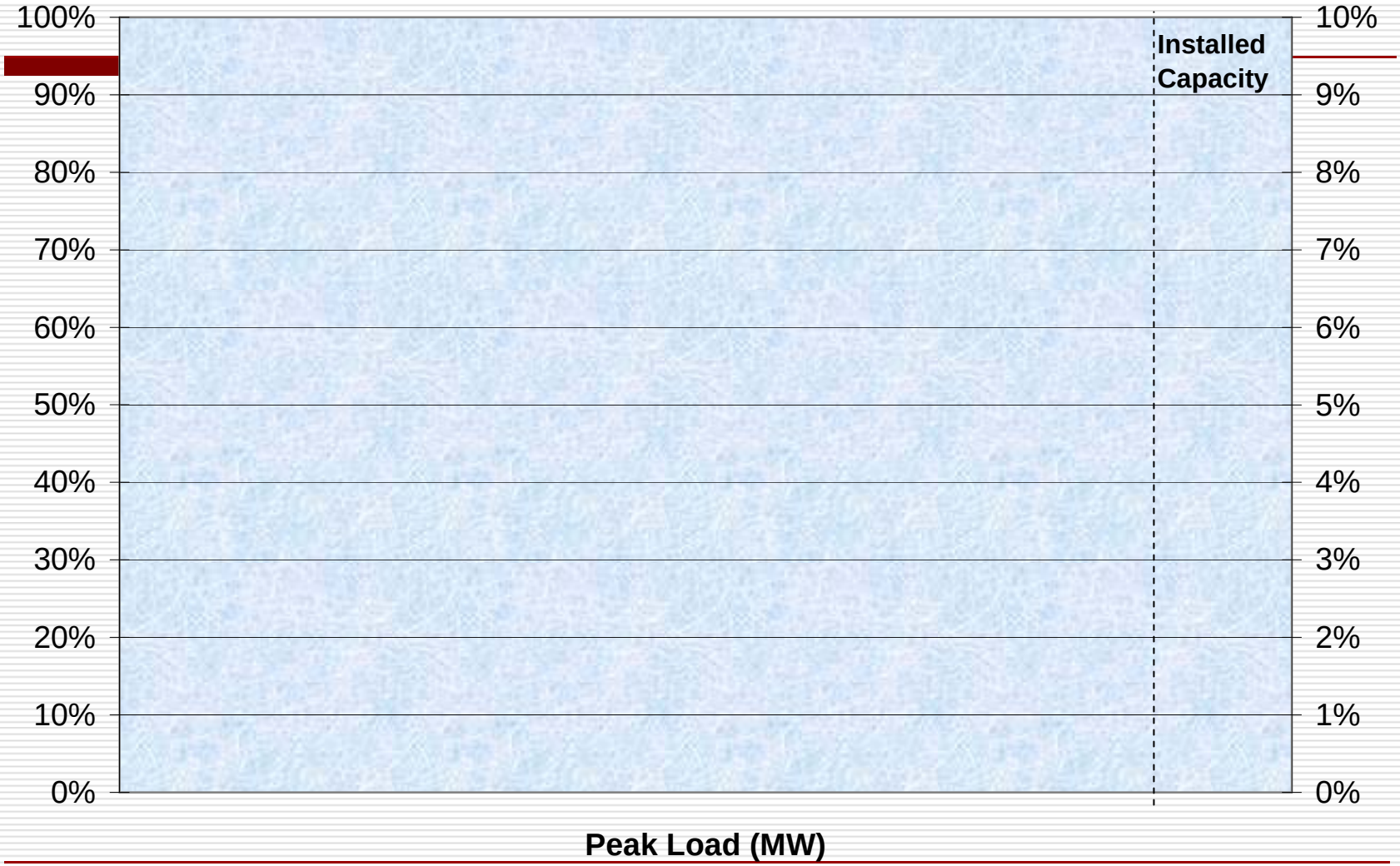


Illustration of PRISM Model's Determination of the 1-in-10 IRM (2)

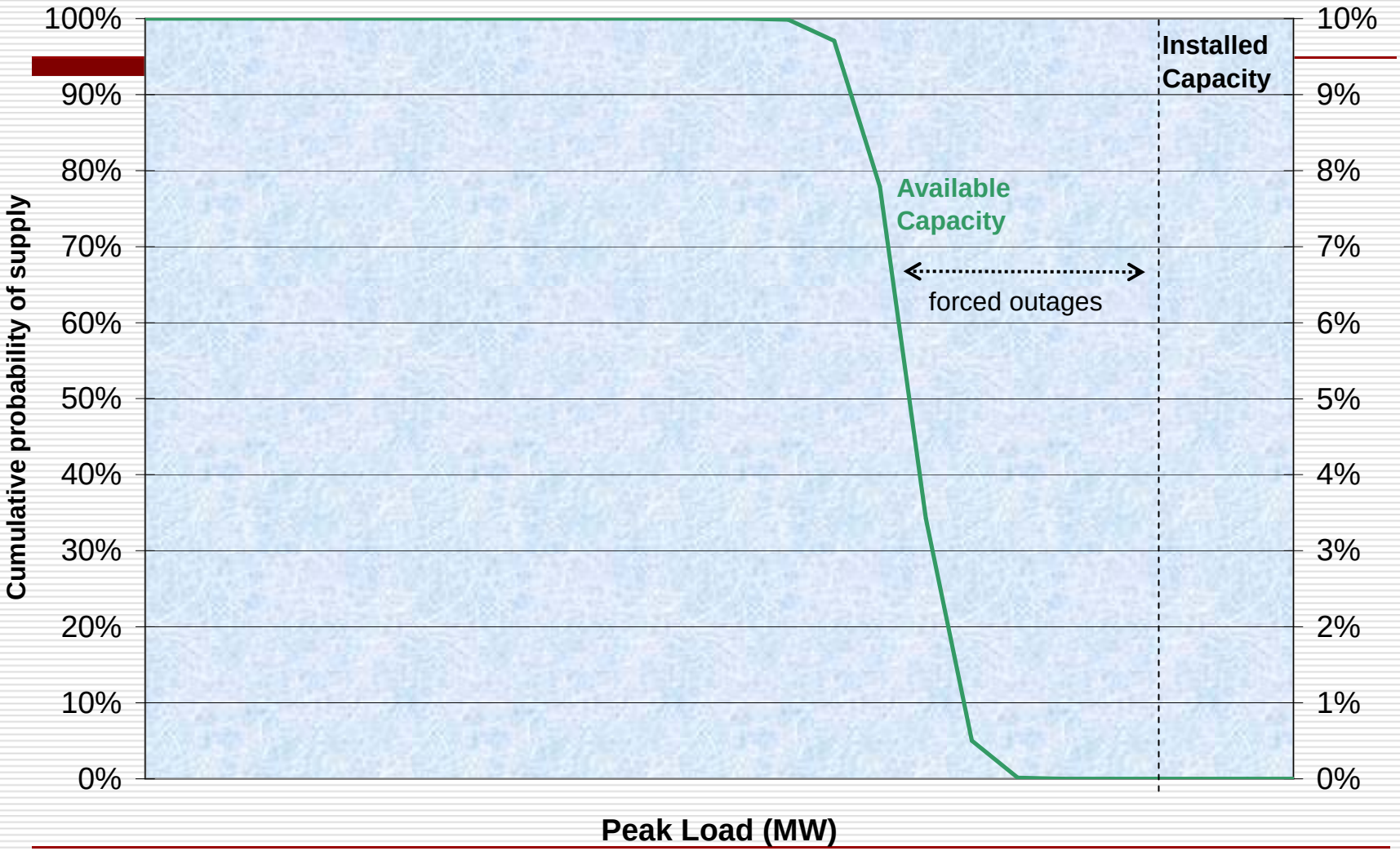


Illustration of PRISM Model's Determination of the 1-in-10 IRM (3)

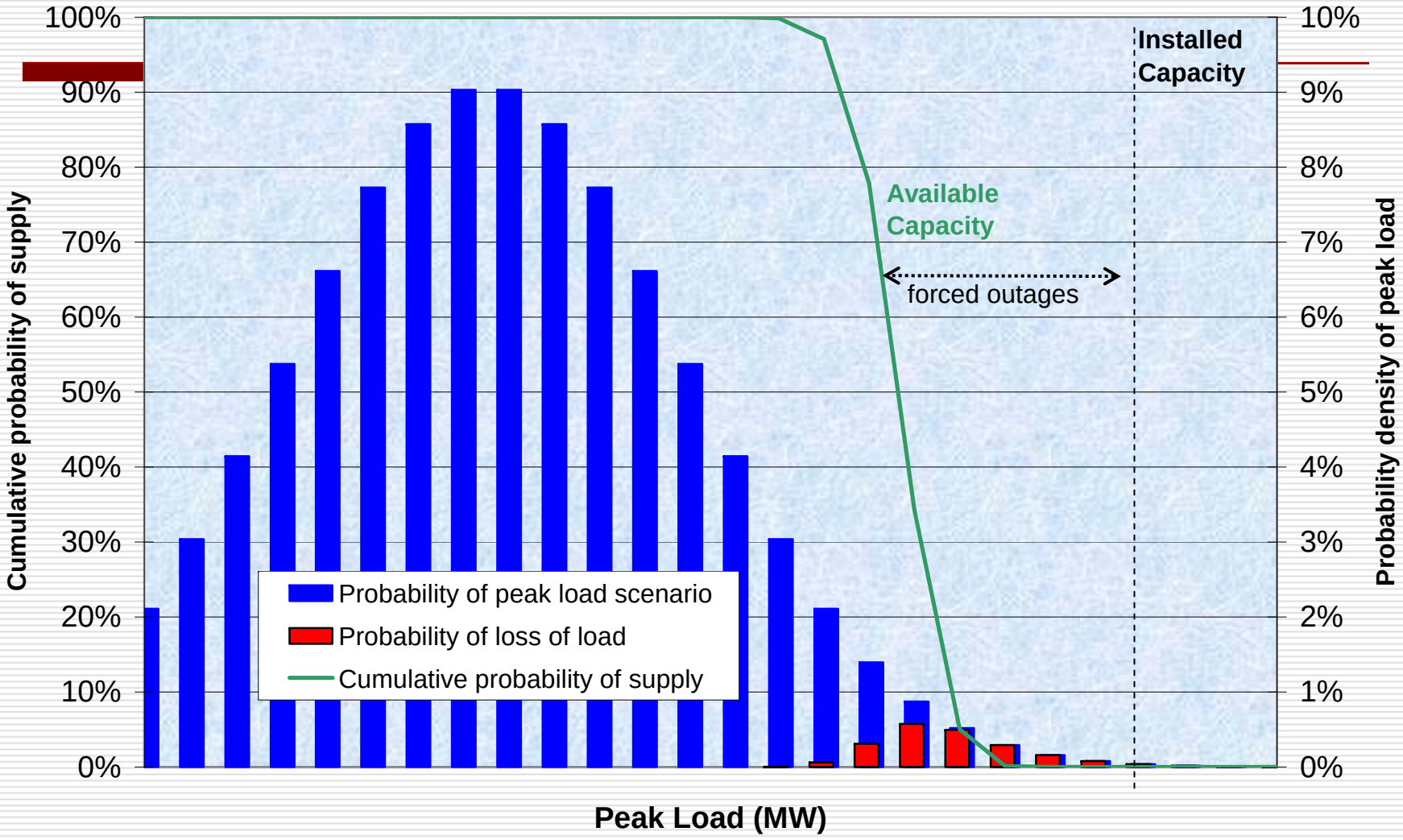


Illustration of PRISM Model's Determination of the 1-in-10 IRM (4)

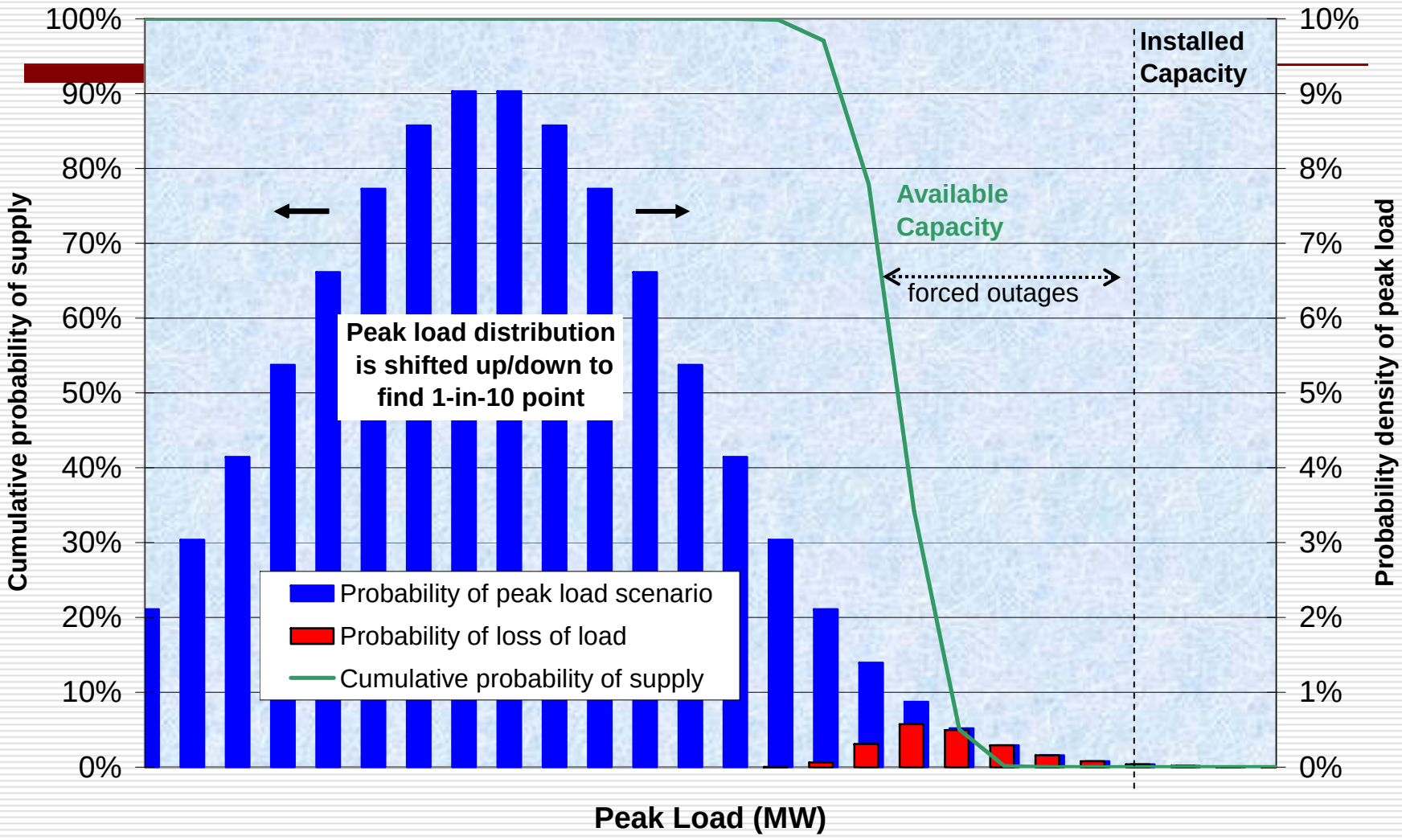
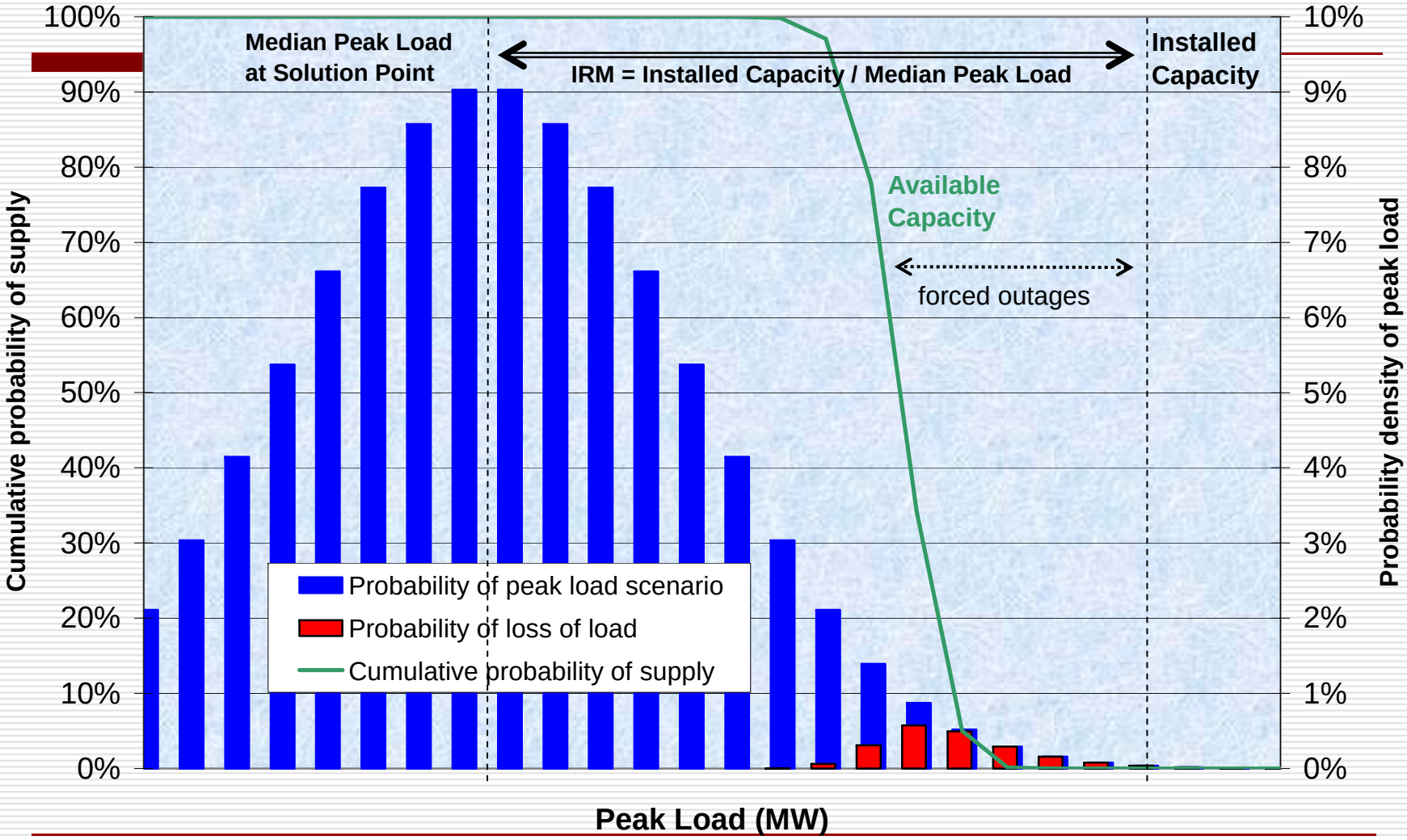


Illustration of PRISM Model's Determination of the 1-in-10 IRM (5)



Arguments for Using the Wrong Peak Load Value Reflect Incorrect Application of Probability Concepts

- Draft Final 2009 RRS uses the wrong peak load value for the IRM and FPR calculations
- Language has been added to defend the value used; the arguments are incorrect and reflect confusion around probability concepts

Draft Final RRS 2009: The Errors Reflect Confusion of Four Concepts

1. Forecast median peak load values over broader periods (season, month) are thought to equal forecast median peaks over narrower periods (week, day); but they will generally be a bit higher.
2. The week in the PRISM probabilistic load model with the highest daily mean/median is confusingly referred to as the "peak week" and it is suggested that the peak always occurs in this week, but in the simulation peaks also occur in other weeks with some probability.
3. The probability the peak will exceed a value is confused with the expected number of times the peak will exceed it.
4. Confusion leads to the view that there are alternative definitions of median peak load; but there is only one definition and the correct median annual peak load value must be used to maintain consistency with the load forecast.

Source of Confusion #1:

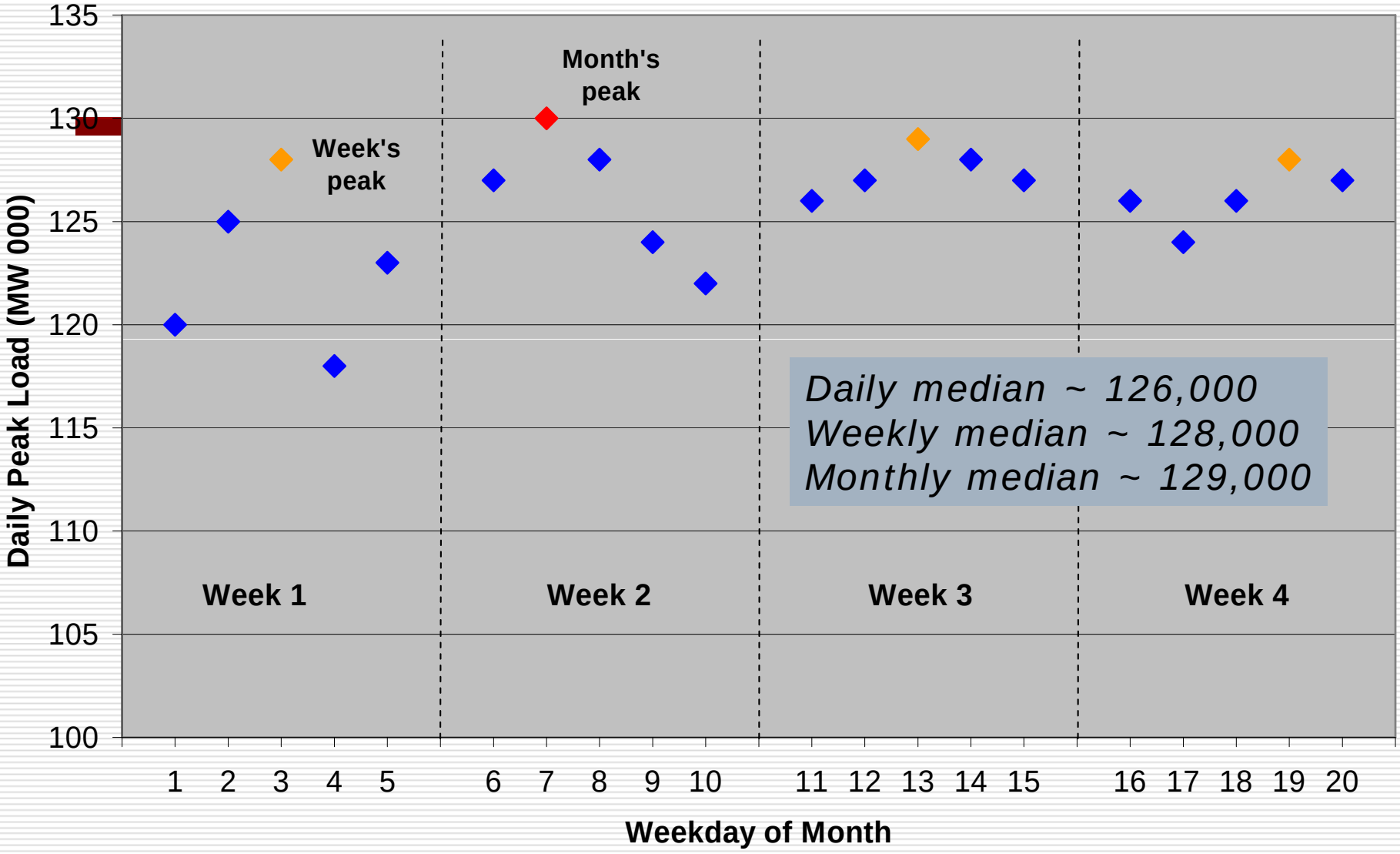
Median Peaks Over Season/Month/Week/Day

- Question: Suppose the median value of the daily peak load on a single day in the last week of July, 2013 is forecast to be 150,000 MW (based on historical weather, etc.); how will the forecast median value of the *weekly* peak over this same week compare to the forecast daily median?

Median Peaks Over Season/Month/Week/Day (cont'd)

- Answer: The anticipated median value of the *weekly* peak load will be a little greater than the median of the daily peak
  - The weekly peak is the maximum from five "draws" from the probability distribution of a daily peak for the week (5 weekdays per week)
- This fact is recognized in the PRISM load model, RRS reports, and PJM Manuals

Illustration: Daily, Weekly and Monthly Actual Peaks



Median Peaks Over Season/Month/Week/Day (cont'd)

- Median Monthly Peak <?> Median Weekly Peak?
  - Similarly, the median peak load for July 2013 will be greater than the median peak load for any one of the weeks of July 2013
- Median Seasonal Peak <?> Median Monthly Peak?
  - The median peak load across the entire summer will be greater than the median peak load for just July (or June or August)

Example (from Load Forecast Review Session)

- Forecast median June peak = 170 MW
- Forecast median July peak = 190 MW
- Forecast median August peak = 180 MW
- Forecast median Summer peak = 200 MW

- Forecast median summer peak is greater than that of any one month
- The combined probability that a peak in June, July or August will exceed 200 MW is 50%

Confusion Around This Concept Was Reflected in the Load Forecast Review Session (slide 69)

To Insure Consistency between Annual, Seasonal and Monthly Peaks

Set Maximum Summer Monthly Peak Equal to Summer Seasonal Peak

		Per unit of Summer max	Distribute seasonal peak across months
June	170	0.895	179
July	190	1.000	200
August	180	0.947	189
Summer	200		200

This adjustment for "consistency" is inconsistent with the fact that these are forecasts of <u>median</u> values

*Median seasonal peak is **>** median monthly peak*

Source of Confusion #2:
PRISM Model's Week 10: "Peak Week"? No

- PRISM load model represents 52 weeks probabilistically (mean, standard deviation)
- The means by week are set based on historical data; the data is "ordered" high to low before aggregation, to preserve variance
- Week 10's mean is based on the historical weeks with the highest expected weekly maximum (not necessarily highest actual peak); it has the highest mean
- But Week 10 is not the "peak week" in the probabilistic load model; there's a 37% chance some other week will exceed it, and significant LOLE occurs in other weeks.

PJM Staff's Analysis Confirms: Week 10 Median Peak Is Less Than The Median Annual Peak

- Spreadsheet posted by staff July 27:
  - 59.9% chance the median annual peak will exceed the Week 10 median peak (EWM)
  - So the median annual peak must be higher (~ 1%)

Source of Confusion #3:

Alternative Definitions of Median Summer Peak??

Final Draft RRS, p. 20:

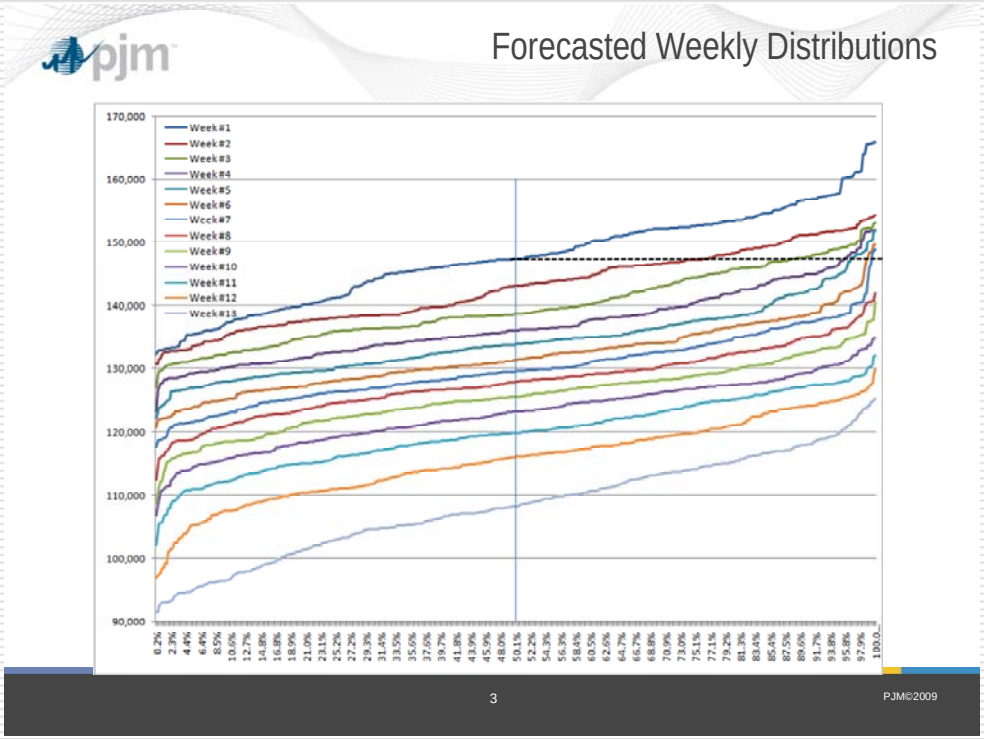
> "The debate over the correct peak load to use in the denominator when stating the IRM calculated in PRISM is essentially a debate over the definition of a "50/50" summer peak load. The IRM is applied to the "50/50" peak day load that is produced by the PJM load forecast model so it is critical that the PRISM "50/50" peak load be consistent with the load forecast model "50/50" peak day load."

There is only one definition of a median summer peak load. It is that load value believed to have a 50% chance of being greater than, 50% chance of being less than, the actual peak over the course of the summer.

Load Forecast Model's "Week #1" Is the Distribution of Annual Peak

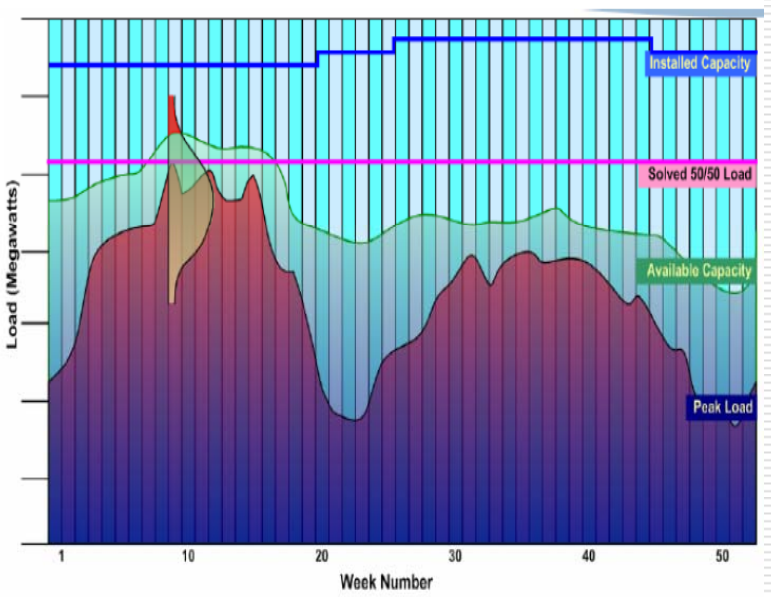
The load forecast model distribution shown to RRAWG collects the annual peaks from all weather simulations into a single distribution (called "week #1").

By construction, "Week #1" represents the distribution of annual peak, and its median point is the forecast median annual peak load.



PRISM Model's "Week 10" Does Not Represent the Distribution of Annual Peak

By contrast, PRISM models 52 weeks as probabilistically independent with mean and standard deviation. Week 10, confusingly referred to as the "peak" week, has the highest mean and is the *most likely* to have the highest value (the annual peak), but in the model, 37% of the time another week has a higher value.



If PRISM were changed such that week 10's peak must be the annual Peak and other weeks' peaks must be lower (as in the load forecast distribution), it's a different load model, and produces a lower IRM.

These Confusions Have Resulted In Errors In the Final Draft RRS Report and its IRM, FPR

Final Draft RRS, p. 13:

"In PRISM, the IRM is expressed as a percent of the Expected Weekly Maximum (EWM) of the peak week of the summer. The EWM of the peak week of the summer also represents the 50/50 peak on the peak day of the summer. Therefore, the IRM produced is consistent with the 50/50 Summer Peak forecast."

Incorrect – there is no single "peak week of the summer" in the simulation; PRISM models the probability that any week can be the peak. Week 10 is often the peak, but there is a 37% chance within PRISM that the peak will be in some other week.

Errors In the Final Draft RRS Report (cont'd)

Final Draft RRS, p. 20:

"To maintain consistency with the load forecast model definition of a "50/50" peak day load, the IRM calculated in PRISM must be expressed as a percentage of the Expected Weekly Maximum (EWM) of the peak week. The probability of peak load exceeding this EWM on the peak day (in the peak week) is 50%. Thus the EWM of the peak week is the "50/50" load associated with the peak day of the summer. The official load forecast, to which the IRM is applied, is also the "50/50" load associated with the peak day of the summer. Therefore, the denominator in the IRM calculation is consistent with the 50/50 peak load forecast."

Again, incorrect – there is a 62.7% chance, within the PRISM probabilistic load model, that the (annual) peak will exceed the EWM of the so-called "peak week" (week 10). By contrast, the load forecasting process correctly applies the concept of a median forecast.

Errors In the Final Draft RRS Report (cont'd)

Final Draft RRS, p. 20 (*new text not reviewed by WG*):

"The LOLE model considers loads across all weeks of the year. It must recognize that the 50/50 peak day load may also be exceeded on other days of the year. (For instance, in a very hot summer, all top 5 CP days may exceed the 50/50 peak day load forecast.) This is the reason that the solved load in PRISM could be other than a 50/50 load when viewed across the summer. There is a greater than 50% chance that any day over the summer (including the peak day) may exceed the 50/50 peak day load. This is also true for the PJM load forecast model."

Incorrect: This confuses the probability the peak exceeds the forecast with the expected number of times the forecast is exceeded, a different concept and number (Source of Confusion #4).

Expected Number of Times Forecast Peak is Exceeded > Probability Peak is Exceeded

Forecast Load Value:	Value (MW):	Probability annual peak exceeds this value:	Expected number of times per year a daily peak exceeds this value:
Week 10 EWM	166,466	63%	0.78
Median Annual	168,293	50%	0.58

Calculations are in a spreadsheet posted on PJM Connect.
These results are the same for any solution point (September 10 value shown, more recent values have not been reported).

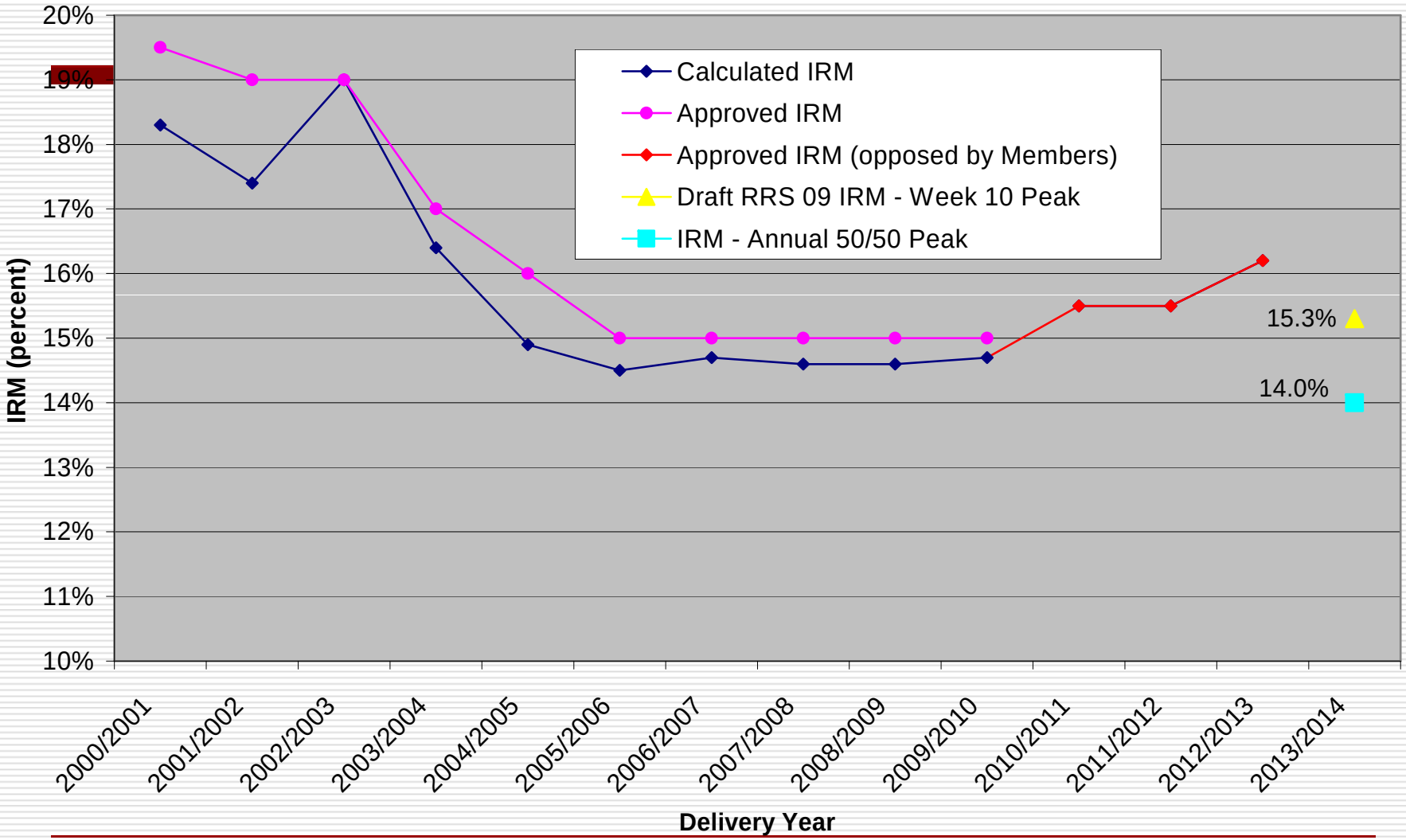
Summary: 2009 Load Model w/ATSI
(details in a spreadsheet posted on PJM Connect)

Load value:	Probability annual peak will exceed this value:	Probability Week 10 peak will exceed this value:
166,466 ("Solution point" = Expected Weekly Maximum of week 10)	0.6	**0.5**
168,293 (Calculated median annual peak corresponding to solution point; Sensitivity Analysis #20)	**0.5**	0.4
Ratio, median annual peak to EWM week 10 (load model base parameter), 2009 Load Model:	**1.010973** (holds for any solution point)	

The IRM Based on the Correct Median Annual Peak Value Is Still Conservative

- The 2009 RRS still reflects some extremely conservative assumptions that raise the IRM:
  - Use of the bell-shaped, “normal” distribution for load; overstates likelihood of extreme peaks
  - 2500 MW derate due to ambient conditions; ignores over-performance of other resources in peak hours
  - Neighboring regions treated as a single region; ignores diversity among them, understates potential assistance
  - Neighboring regions assumed planned to have only enough capacity to meet their coincident 1-in-10; ignores independent planning for non-coincident peaks

The Proposed IRM of 14% Is In Line With Long-Term Trends As the RTO Grows and Outage Rates Improve



Motion (from Sept. 10, Oct. 13 RRAWG meetings)

- The Installed Reserve Margin calculations should use the annual 50/50 peak load (net internal demand), consistent with ReliabilityFirst standards and RPM design
- The annual 50/50 peak load value at any solution point of the 2009 load model w/ATSI is 1.010973 times the load model base parameter (Expected Weekly Maximum of week 10)

IRM and FPR Values Corrected to Use Median Annual Peak

- For **2012/2013**: IRM 14.1%, FPR 1.0698
- For **2013/2014**: IRM 14.0%, FPR 1.0686

These values are consistent with BAL-502-RFC-02 and RPM and result in meeting 1-in-10.

The IRM and FPR values in the draft final report are not calculated consistent with BAL-502-RFC-02, and result in approximately 1-in-11.