Probabilistic Methods in Resource Adequacy Planning at PJM

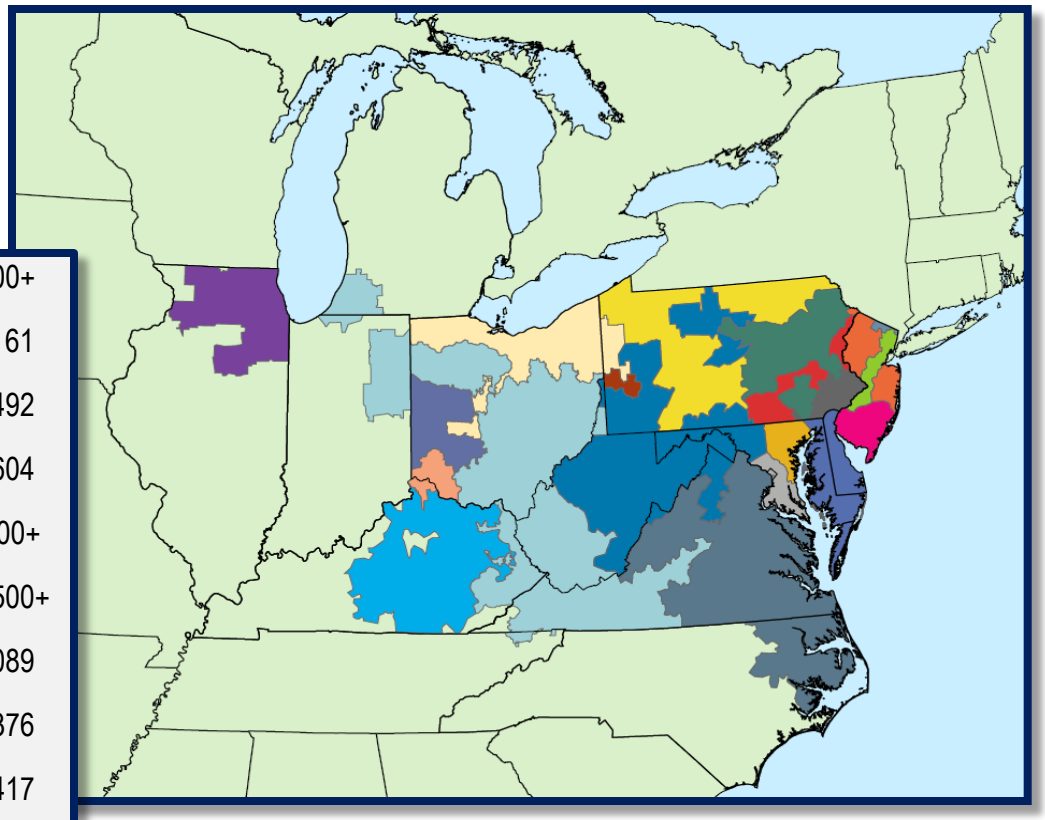
IEEE PES General Meeting

July 2015, Denver CO

PJM RTO

Members	900+
Millions - people served	61
Peak Load (MW)	165,492
Generating Capacity (MW)	183,604
DR and EE (MW)	11,100+
Transmission Lines (Miles)	62,500+
Energy (GW - 2013)	791,089
Generation Sources	1,376
Area Served (Sq Miles)	243,417
States served	13 + DC

21% of U.S. GDP



Motivation

- Sources of uncertainty in resource adequacy planning
  - Load
  - Resource Performance
    - Generation
    - Demand Response
  - Transmission
- Main concern for adequacy planners

  If X = Sum of Available Resources at time t

  Y = Load at time t

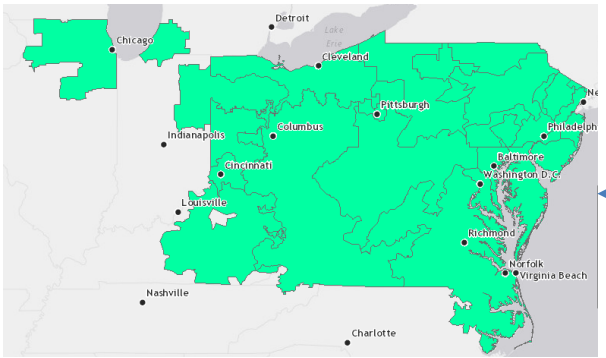
  then a **Loss of Load Event** (LOLE) takes place when X < Y
- Ensure availability of adequate capacity resources
  - Capacity market (PJM's Reliability Pricing Model)

Probabilistic Adequacy Studies at PJM

- Reserve Requirement (aka Installed Reserve Margin Study)
- Capacity Emergency Transfer Objective (CETO)
- Demand Response (DR) Caps

Reserve Requirement Study (RRS)

- Objective
  - Compute Installed Reserve Margin (IRM)
  - IRM then is used to construct a downward sloping demand curve in Reliability Pricing Model (RPM)
- Approach



PJM

Capacity Benefit Margin (CBM)

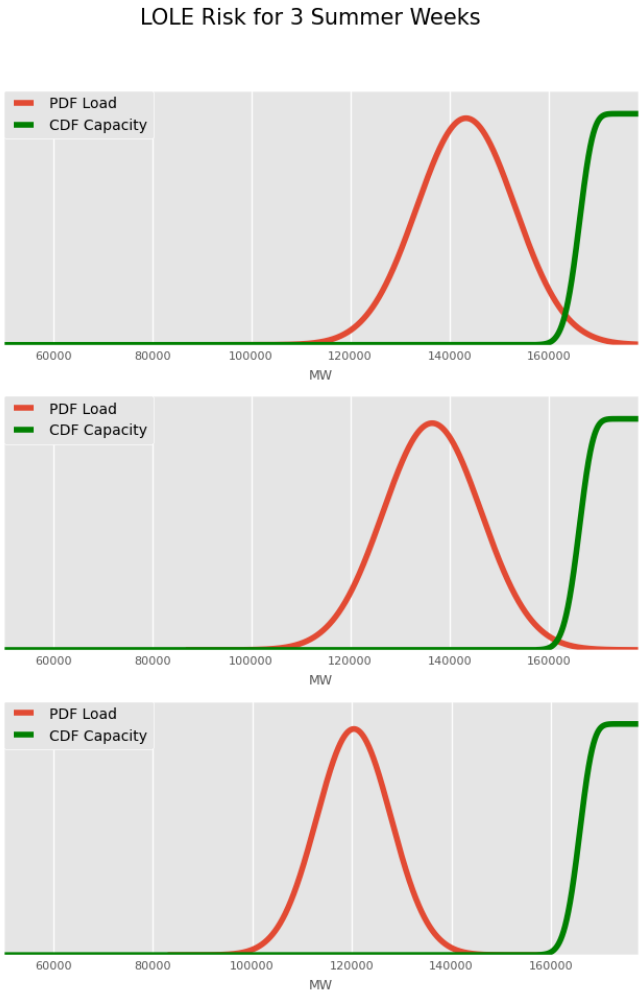
MISO
ISO-NE
NYISO
TVA
VACAR

World

Reserve Requirement Study (RRS)

- Inputs (for PJM and World)
  - Generation
    - Expected Generation fleet (capturing expected additions, retirements)
    - Forced Outage Rates (EFORd)
      - Rate assumed to provide the probability that a unit is unavailable on a forced outage at the time of demand
    - Planned Outage Requirement
      - Deterministic amount of weeks
  - Load
    - Profile throughout the year (e.g. monthly/weekly/weekday peaks)
      - From the PJM load forecast (which assumes 50/50 weather)
    - Statistical distribution for weekday peaks
      - Normally distributed (captures uncertainty in weather/economics)
      - Parameters of distribution obtained from historical loads

Reserve Requirement Study (RRS)



The same comparison is made for the remaining
49 weeks of the target year.

Study criteria: total annual LOLE = 0.1 events/yr.

In other words, LOLE = $\sum_{year} E(X < Y) = 0.1$

Reserve Requirement Study (RRS)

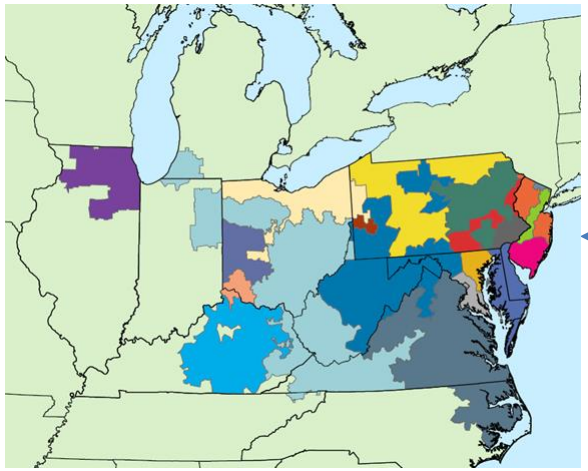
- Output
  - Installed Reserve Margin (IRM) = Total Installed Generation / Solved Annual Peak Load
  - Forecast Pool Requirement (FPR) = IRM * (1- Average Forced Outage Rate)

Capacity Emergency Transfer Objective (CETO)

- Similar to the RRS
  - But applied to Locational Deliverability Area (LDA)
- Objective
  - Compute CETO for each LDA (i.e., amount of imports needed) which then is compared to the Capacity Emergency Transfer Limit (CETL)
  - Also, total amount or resources (including CETO) is then used to construct demand curve in RPM for the LDA

Capacity Emergency Transfer Objective (CETO)

- Approach



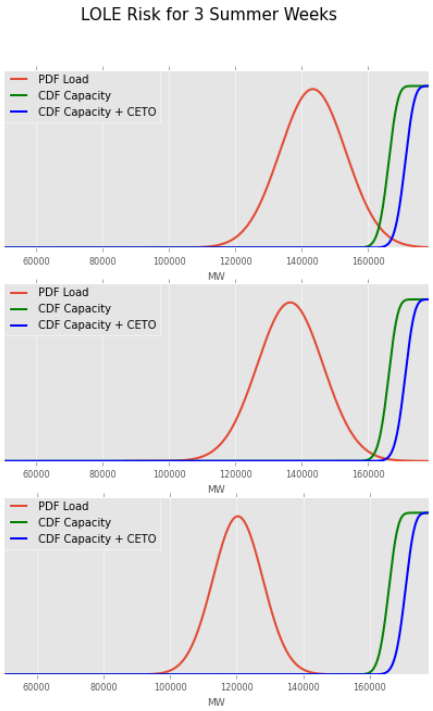
LDA

Other LDAs (inside PJM) and/or neighboring World regions

Capacity Emergency Transfer Objective (CETO)

- Inputs
  - LDA's Generation and Load (similar to RRS)
- Criterion

Total annual LOLE = 0.04 events/yr.



Capacity Emergency Transfer Objective (CETO)

- Output
  - CETO
  - Reliability Requirement = CETO + Total Internal Generation * (1-Average Forced Outage Rate)
    - Used in RPM
- CETL is also used in RPM

Total LOLE Risk due to Transmission and Capacity Adequacy

Zone	CETL (MW)	Capacity Adequacy LOLE Risk (events/year)	Transmission LOLE Risk (events/year)	Total LOLE Risk (events/year)
LDA X	CETO	0.1	0.04	0.14
LDA Y	> CETO	0.1	< 0.04	< 0.14

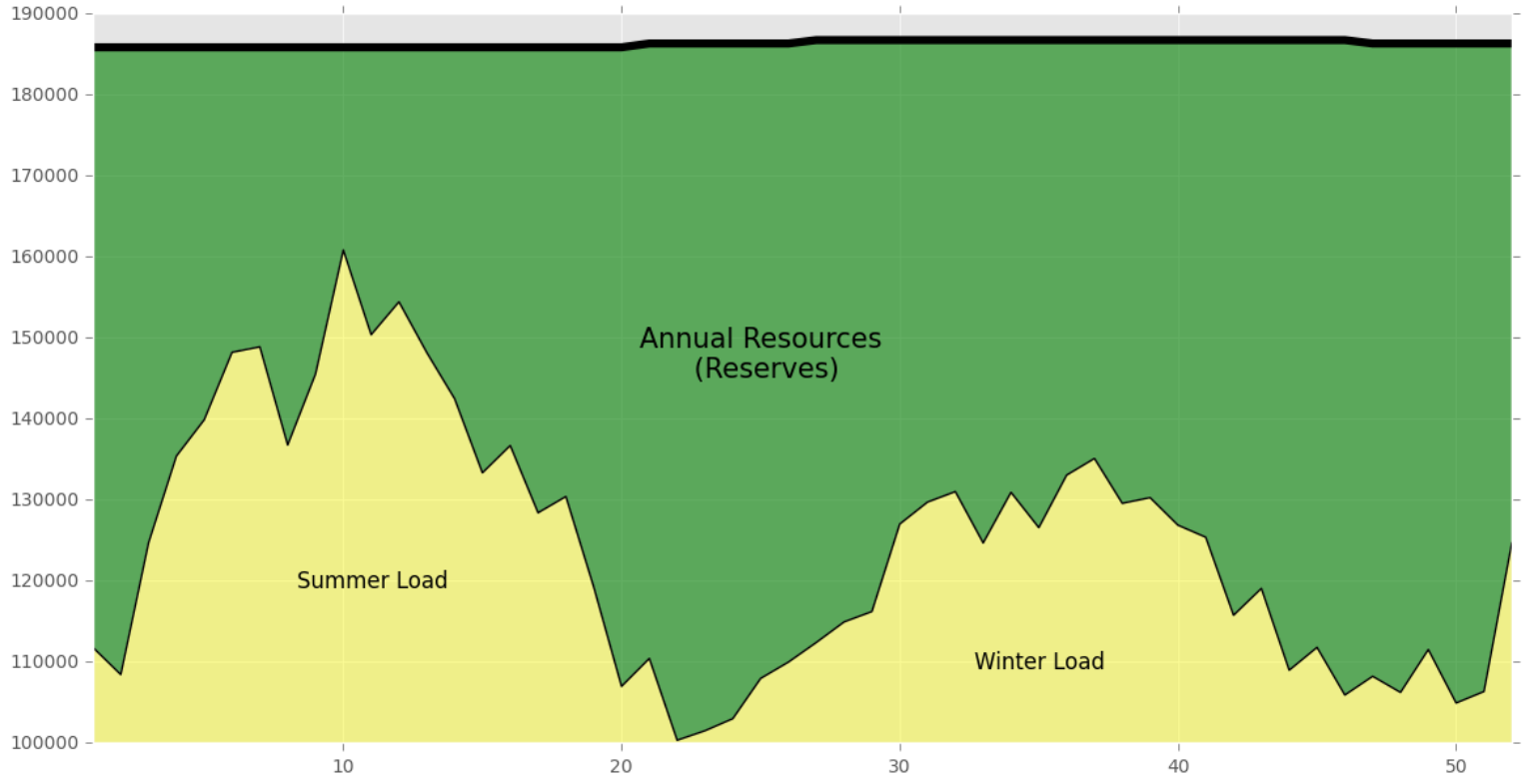
RRS and CETO in RPM

- So far we have set the reliability requirements for PJM and the LDAs based on these probabilistic studies
- Those requirements are in Unforced Capacity (UCAP) terms
  - Recall the multiplication by (1-Average Forced Outage Rate) in the FPR and RR computations
- In RPM, each resource (generation, DR, EE) has a UCAP valuation
  - And they compete to meet the UCAP requirement
- Some resources, however, are not available during the entire year
  - E.g. Limited DR, Extended Summer DR
  - PJM does not reduce their UCAP valuation due to these limitations
  - PJM sets caps for these resources instead

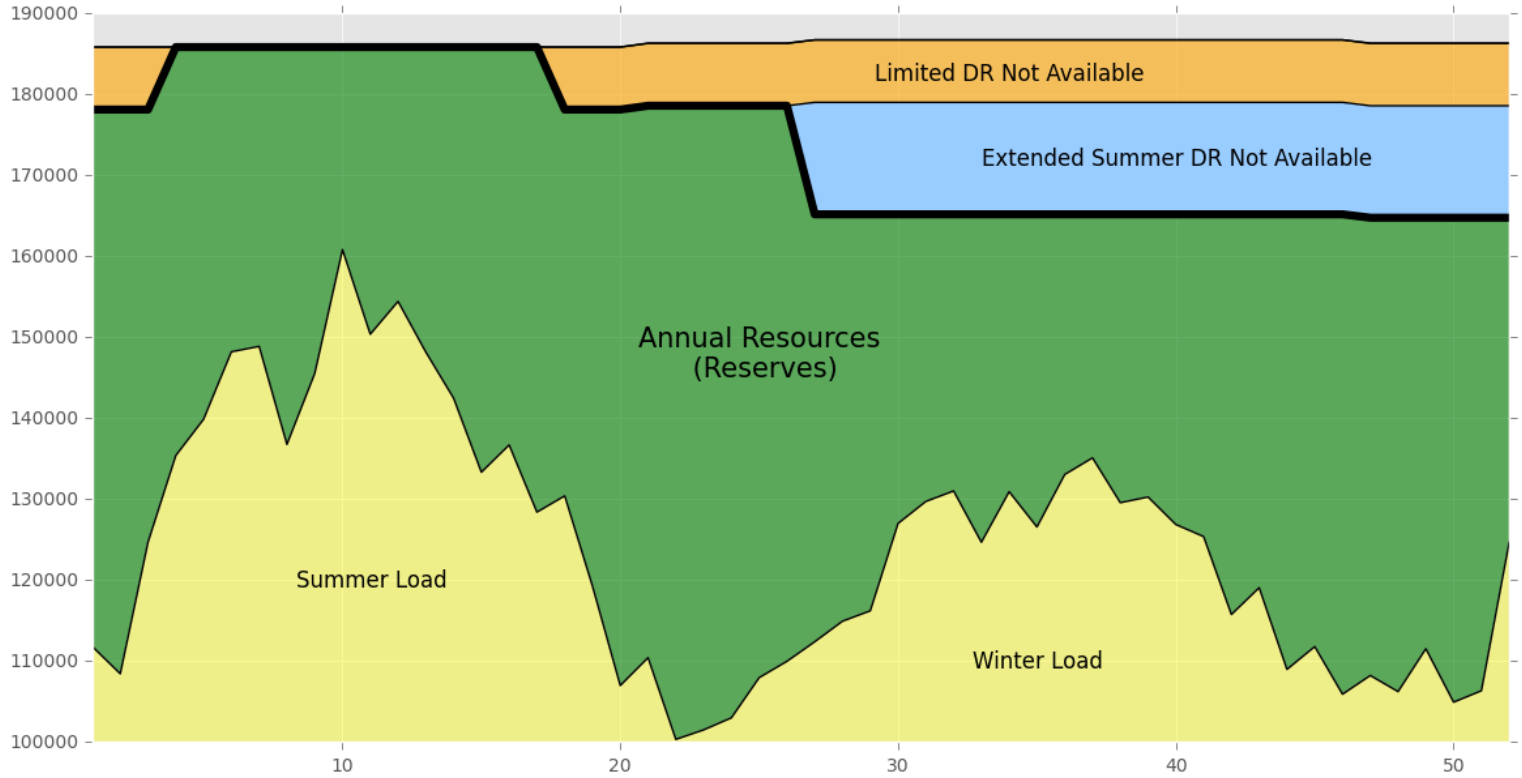
Limited DR and Extended Summer DR RPM Requirements

Requirement	Limited DR	Extended Summer DR
Availability	Any weekday, other than NERC holidays, during Jun. - Sep. period of delivery	Any day during Jun. - Oct. period and following May of delivery
Maximum Number of Interruptions	10 interruptions	Unlimited
Hours of Day Required to Respond (Hours in EPT)	12 – 8:00 p.m.	10 a.m. – 10:00 p.m.
Maximum Duration of Interruption	6 Hours	10 Hours

Reserves in PJM resulting from RRS



(Potential) Reserves in PJM after an RPM auction



Demand Response (DR) Caps

- Objective
  - Compute caps for DR products D with limited availability so that their clearing in RPM (displacing annual availability products) does not pose reliability concerns
- Approach
  - Caps are computed at the RTO and at the LDA levels

$$\max\ D$$

s.t.:

$$\sum_{year} E(G + D < Y) = 0.1 + \alpha \qquad \text{With } X = G + D$$

$$G + D = \text{IRM}$$

Demand Response (DR) Caps

- Inputs
  - Load distribution from IRM/CETO case
  - Capacity distribution from IRM/CETO case
- Procedure: we solve the optimization problem by inspection
  - Capacity distribution gets shifted to the left during periods (weeks) where DR is not available
    - Implicit assumption: DR displaces average performing generation
    - We make some corrections for reduction of maintenance requirements due to DR displacing generation

Demand Response (DR) Caps

- Additional Tests
  - Limited DR product has two additional limitations
    - Can be called up a maximum of 10 times
    - Can be called up for a maximum of 6 hours in each call
  - Additional caps are computed based on:
    - Probability of needing DR more than 10 times
    - Probability of needing DR more than 6 hours
- For Limited DR in some LDAs, the cap based on the probability of needing DR more than 6 hours is the most limiting cap.

Demand Response (DR) Caps

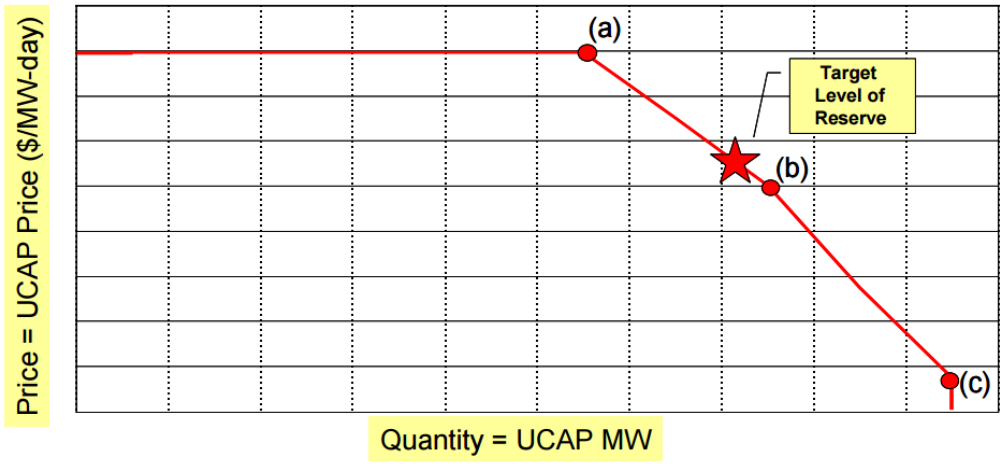
- Output
  - DR Cap expressed as a percentage of the Reliability Requirement for RTO and the LDAs

Actual Inputs to RPM 2017/2018 Delivery Year

- RTO
  - IRM = 15.7%
  - FPR = 1.0916
  - Reliability Requirement (RR) = 179,545 MW
  - Limited DR Cap = 4.1%
  - Limited DR + Extended Summer DR Cap = 9.3%
- LDA (MAAC)
  - CETO = 4,420 MW
  - Reliability Requirement (RR) = 71,534 MW
  - Limited DR Cap = 6.1%
  - Limited DR + Extended Summer DR Cap = 11.5%
  - CETL = 7,393 MW

Usage of Probabilistic Studies' Outputs in RPM

For the RTO and each LDA modeled in RPM:



Demand Curve for RPM
(Target Level of Reserve = RR)

If,
G_i = Internal Annual Resources
G_e = Resources Imported
D = Limited Availability Resources

Then, RPM's clearing mechanism considers
the following constraints

$$G_e \leq CETL$$
$$D \leq Cap_D$$

Other Probabilistic Studies for Resource Adequacy at PJM

- NERC Probabilistic Assessment
  - Designed to assess the reliability of a system on a future year by calculating Expected Unserved Energy (EUE) and Loss of Load Hours (LOLH)
- Winter Weekly Reserve Target
  - Designed to schedule maintenance during the winter season

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