Education: Other Resource Adequacy Reliability Metrics

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Resource Adequacy Planning
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Other Well-Known Reliability Metrics

- Loss of Load Hours (LOLH)
  - Expected amount of hours of loss of load in a certain period (e.g., a year)
  - Focus is on **duration** of loss of load events
- Expected Unserved Energy (EUE)
  - Expected amount of unserved energy in a certain period (e.g., a year)
  - Focus is on **magnitude** of loss of load events

LOLE, on the other hand, focuses on the frequency of loss of load events

Loss of Load Hours (LOLH)

- To understand the calculation of the LOLH metric, consider the following example including two cases:
  - Assume that there are 100 different annual scenarios for a future delivery year (where each scenario is equally likely to occur i.e., probability of each scenario is 0.01)
  - **Case 1**: Assume that when simulating those 100 scenarios, there are 10 scenarios with two hours of loss of load each
    - Then, the LOLH calculation is as follows

      LOLH = (10 x 2 hours/year x 0.01) + (90 x 0 hours/year x 0.01) = 0.2 hours/year
  - **Case 2**: Assume that when simulating those 100 scenarios, there are 8 scenarios with two hours of loss of load each and 1 scenario with four hours of loss of load
    - Then, the LOLH calculation is as follows

      LOLH = (8 x 2 hours/year x 0.01) + (1 x 4 hours/year x 0.01) + (91 x 0 hours/year x 0.01) = 0.2 hours/year

Note that both cases above have the same LOLH. Note also that the calculation above does not consider the frequency or magnitude of the loss of load events. For instance, regarding frequency, the scenario with 4 hours of loss of load in Case 2, could have arisen from 4 days having one hour of loss of load each or 1 day having four hours of loss of load

Expected Unserved Energy (EUE)

- To understand the calculation of the EUE metric, consider the following example including two cases:
  - Assume that there are 100 different annual scenarios for a future delivery year (where each scenario is equally likely to occur i.e., probability of each scenario is 0.01)
  - **Case 1**: Assume that when simulating those 100 scenarios, there are 10 scenarios with 500 MWh of unserved energy each
    - Then, the EUE calculation is as follows

      EUE = (10 x 500 MWh/year x 0.01) + (90 x 0 MWh/year x 0.01) = 50 MWh/year
  - **Case 2**: Assume that when simulating those 100 scenarios, there is 1 scenario with 4000 MWh of unserved energy and 1 scenario with 1000 MWh of unserved energy
    - Then, the EUE calculation is as follows

      EUE = (1 x 4000 MWh/year x 0.01) + (1 x 1000 MWh/year x 0.01) + (98 x 0 MWh/year x 0.01) = 50 MWh/year

Note that both cases above have the same EUE. Note also that the calculation above does not consider the frequency or duration of the loss of load events. For instance, regarding duration, the scenario with 1000 MWh of unserved energy in Case 2, could have arisen from 1 hour with 1000 MWh of unserved energy or 10 hours with 100 MWh of unserved energy each

LOLE, LOLH, EUE Shortcomings

- It is clear that **none** of the 3 well-known resource adequacy reliability metrics **single-handedly** provides the full picture
- If a system had 3 loss of load events in a year as follows
  - July 17th: 1 hour, 1000 MWh unserved energy
  - August 31st: 4 hours, 30 MWh unserved energy each hour
  - January 20th: 3 hours, 1000 MWh unserved energy each hour
- LOLE: 3 days/year (fails to capture that the January 20th event is more severe than the August 31st event)
- LOLH: 8 hours/year (fails to capture that in 4 of those hours the loss of load was much larger than in the other 4)
- EUE: 4120 MWh/year (fails to capture that the unserved energy is distributed across 3 days, and that the January 20th event is more severe)

Can LOLE, LOLH and EUE be combined?

- They can be combined, but since LOLE, LOLH and EUE are expressed in **different** units (days/year, hours/year, MWh/year), a “**unifying**” factor needs to be introduced
  - Such factor can be **Value of Lost Load (VOLL)** estimated depending on the nature of each event
- For instance, in the previous slide example, let’s assume that:
  - **Each MWh** of unserved energy during a 1 hour, 1000 MWh July (summer) loss of load event has a **VOLL = VOLL 1**
  - **Each MWh** of unserved energy during a 4 hour, 30 MWh each hour August (summer) loss of load event has a **VOLL = VOLL 2**
  - **Each MWh** of unserved energy during a 3 hour, 1000 MWh each hour January (winter) loss of load event has a **VOLL = VOLL 3**

Can LOLE, LOLH and EUE be combined?

- Then, the total cost of the 3 events in the example can be estimated as

  Total Cost = VOLL 1 x 1,000 MWh + VOLL 2 x 120 MWh + VOLL 3 x 3,000 MWh

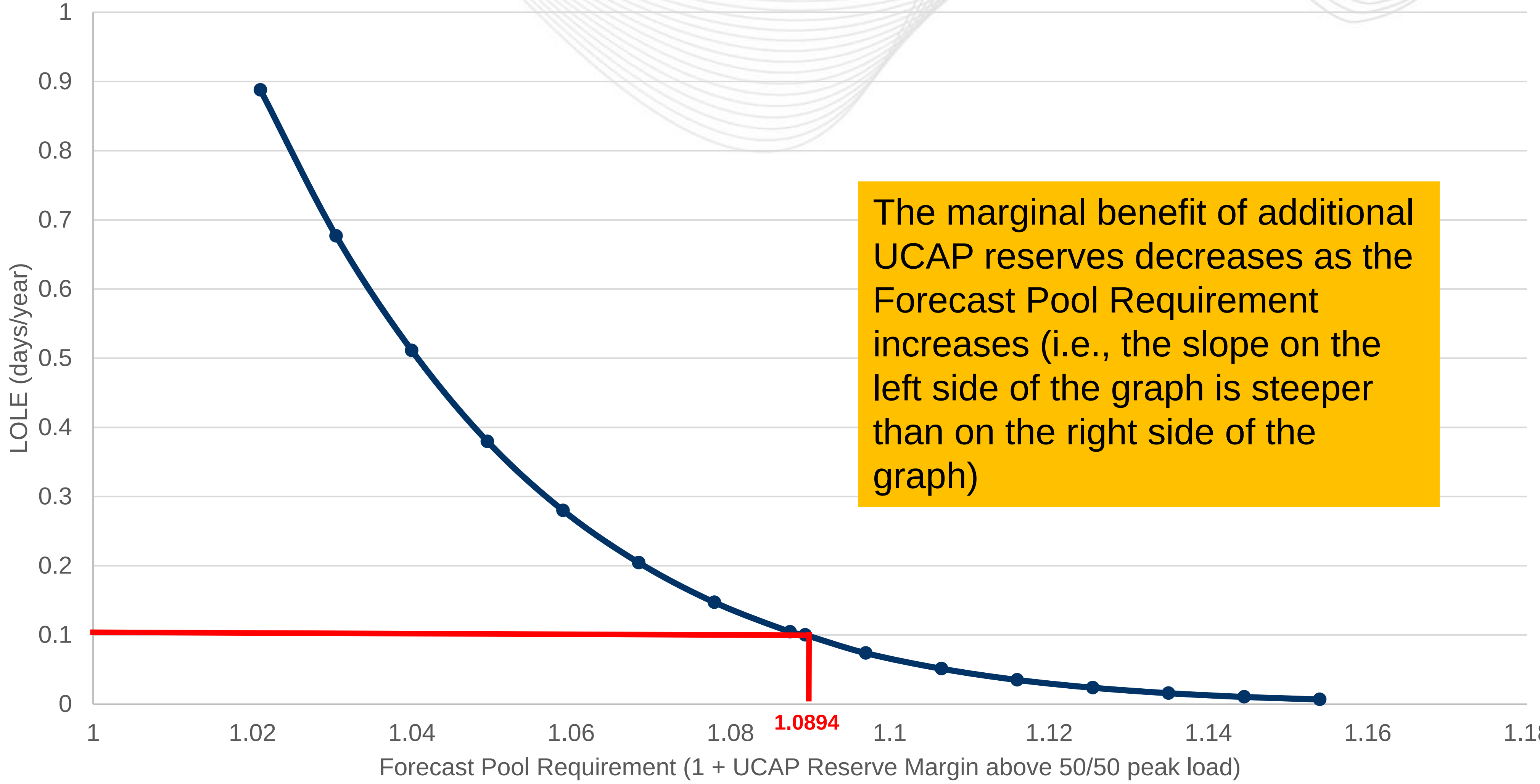
- While a metric like the above allows us to combine LOLE, LOLH and EUE, it can be **challenging** to estimate the VOLL values

- There are potentially **other ways to combine** LOLE, LOLH and EUE that don't rely on VOLL values but we will cover them later in the presentation

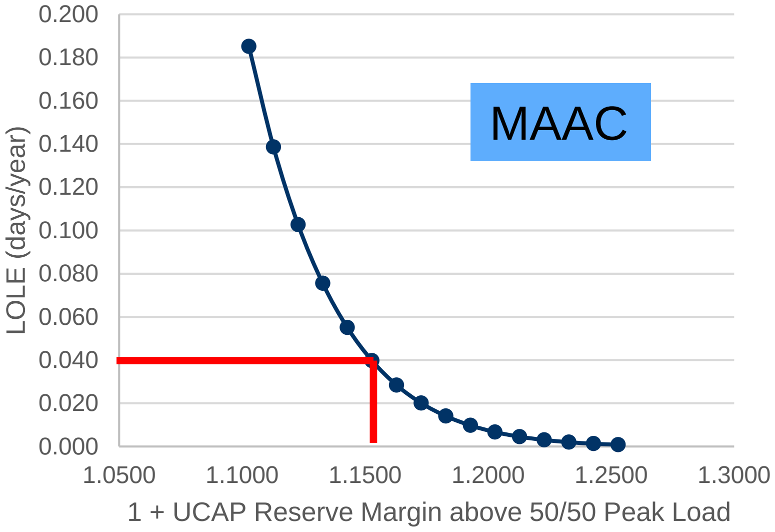
Resource Adequacy Target Levels

- As reviewed in the December RASTF meeting, PJM currently uses **0.1 days/year** as the LOLE target for the RTO and the **0.04 days/year** as the LOLE target for the LDAs.
- Because the targets are based on LOLE, they **do not** consider **duration**, **magnitude** of loss of load events.
- The Resource Adequacy target is intended to represent the **minimum** amount of reliability that PJM should achieve **on average**
  - In practice, the target level is achieved via the **VRR curve** in RPM. The VRR curve is developed based on the above target but **other considerations** are also taken into account as part of the Quadrennial Review (e.g., frequency with which the system falls below the 0.1 days/year target and cost)
  - Under a system that is expected to change in the future, what changes to the RA target should be considered?

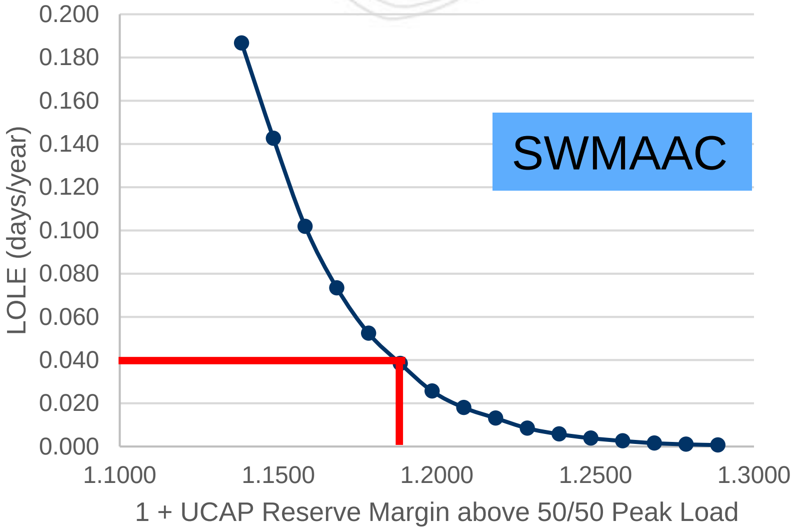
Resource Adequacy Levels - LOLE vs FPR (RTO)

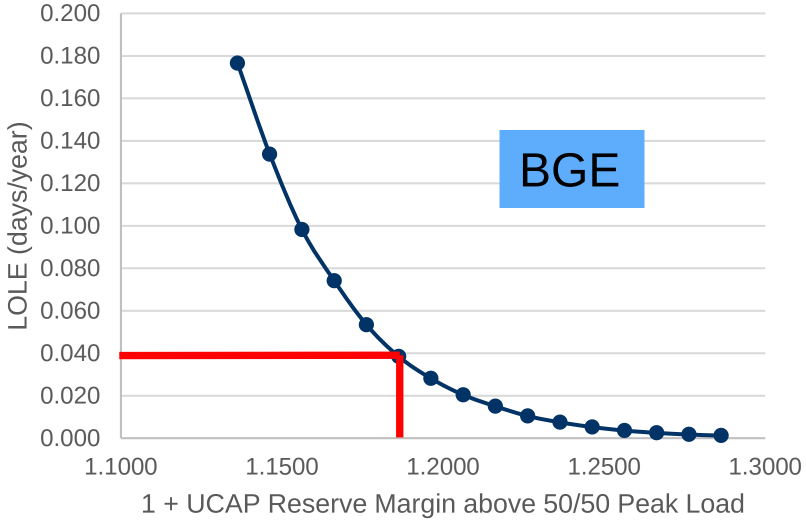


Resource Adequacy Levels - LOLE vs UCAP Reserve Margin (Selected LDAs)



The marginal benefit of additional UCAP reserves decreases as the UCAP Reserve Margin increases (i.e., the slope on the left side of the graph is steeper than on the right side of the graph)





Additional comments

- Graphs showing the relationship between UCAP Reserve Margin vs LOLH or EUE are likely to have a similar shape as the previous graphs
- After setting target levels for reliability metrics, additional options for combining reliability metrics arise by using logical operators
  - For example, if the target level for LOLE is X and the target level for EUE is Y, then a couple of ways in which the metrics can be combined are
    - LOLE = X **AND** EUE= Y (both metrics need to meet the target)
    - LOLE = X **OR** EUE = Y (one of the metrics needs to meet the target)

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