PJM RESOURCE ADEQUACY METRICS AND ACCREDITATION

By Mark Spencer

May 26, 2022

About LS Power

LS Power is a development, investment and operating company focused on the North American power and energy infrastructure sector

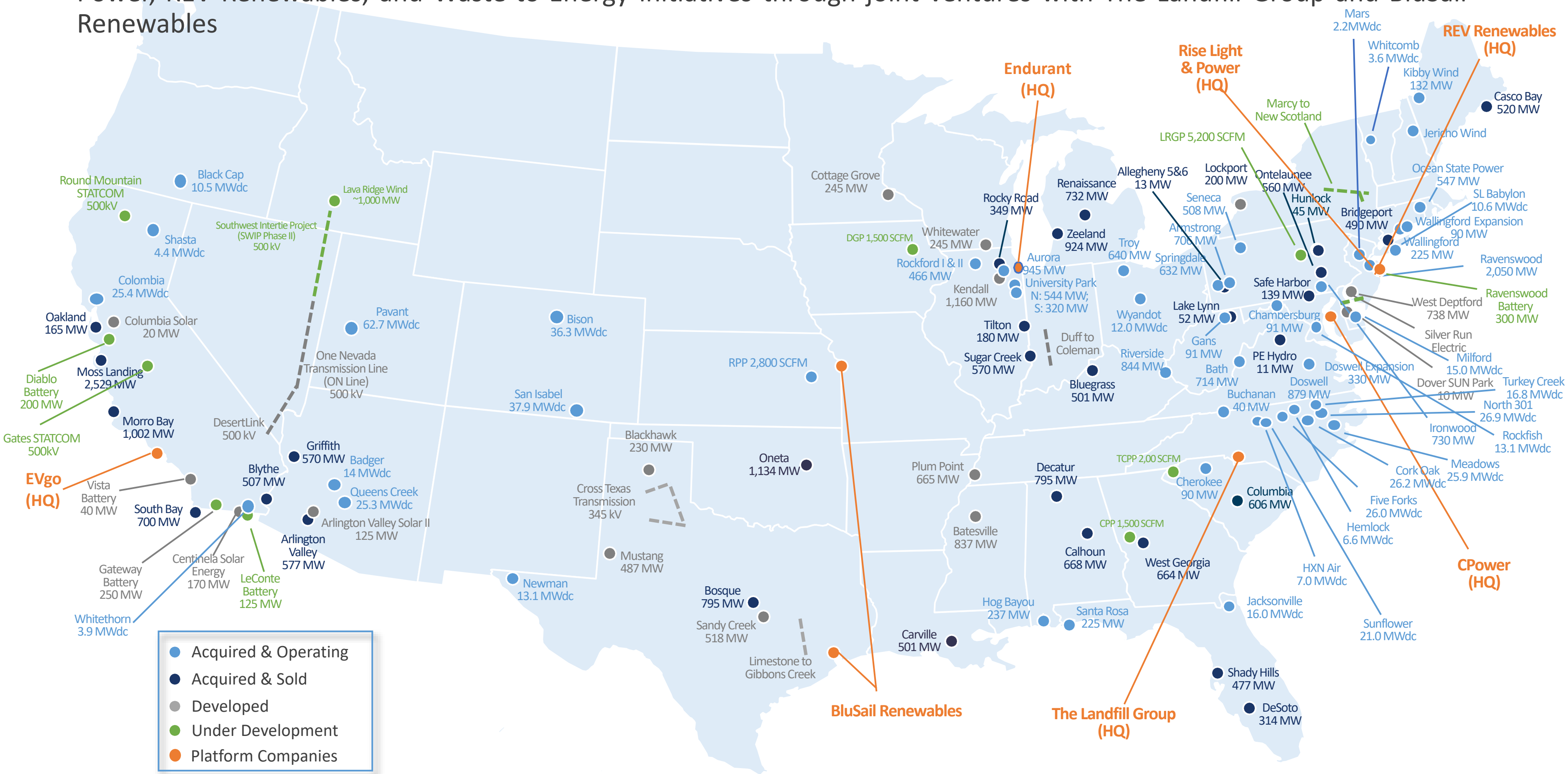
- Founded in 1990, LS Power has 280 employees across its principal and affiliate offices in New York, New Jersey, Missouri, Texas and California
- LS Power is at the leading edge of the industry's transition to low-carbon energy by commercializing new technologies and developing new markets
  - **Utility-scale power projects across multiple fuel and technology types**, such as pumped storage hydro, wind, solar and natural gas-fired generation
  - **Battery energy storage**, market-leading utility-scale solutions that complement weather dependent renewables like wind and solar energy
  - **High voltage electric transmission infrastructure**, which is key to increasing grid reliability and efficiency, as well as carrying renewable energy from remote locations to population centers
  - **Established Energy Transition Platforms,** including CPower (demand response and energy efficiency); Endurant Energy (microgrids); EVgo (EV charging); REV Renewables (renewable generation and energy storage); Rise Light & Power (NYC's largest energy provider); and Waste-to-Renewable Fuel initiatives
- In total, LS Power has developed, constructed, managed and acquired competitive power generation and transmission infrastructure, for which we have raised over **$48 billion in debt and equity financing**
  - **Developed over 13,000 MW** of power generation (both conventional and renewable) across the United States
  - **Acquired over 32,000 MW** of power generation assets (both conventional and renewable)
  - **Developed over 660 miles of high voltage transmission**, with ~400 miles of additional transmission under development

Utilize deep industry expertise as owner/operator

LS Power Project Portfolio

Extensive development/operating experience across multiple markets and technologies

- With over **$48 billion** in equity and debt raised, LS Power has developed and acquired **over 100 Power Generation projects** (renewable and conventional), 7 Transmission projects, and 7 Battery Energy Storage projects
- LS Power's **Energy Transition Platforms** include CPower Energy Management, Endurant Energy, EVgo, Rise Light & Power, REV Renewables, and Waste-to-Energy initiatives through joint ventures with The Landfill Group and BluSail Renewables



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Our Motivation

- PJM is soliciting stakeholder perspectives regarding current and proposed accreditation models;
- Some stakeholders have identified concerns, which we largely share, with the existing accreditation methodology for dispatchable resources; and
- We think sharpening price signals over applying class averages would better incent unit-specific investment in reliability.

Our Concerns

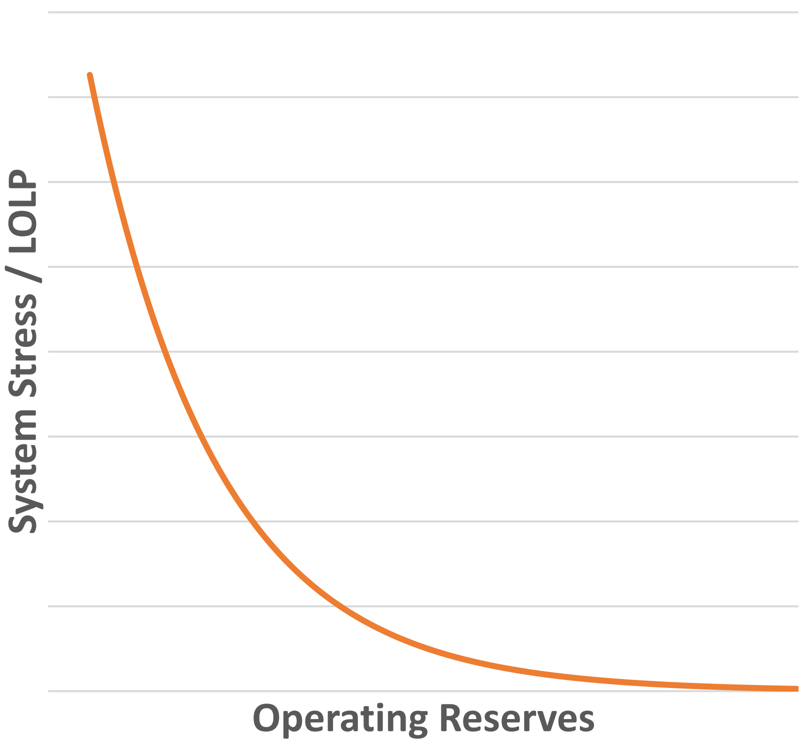
- Current UCAP does not differentiate generator performance between hours of system stress and less stressed system conditions;
- Use of ELCC as the primary accreditation tools will shield poor performers and discourage investment in reliability; and
- As more renewables serve load, their very intermittency may cause unpredictable patterns of system stress. The connection between the probability of load shedding and gross peak load may be weakened – i.e., system stressed hours may likely occur more randomly as wind and solar droughts take place at different times.

Our Proposal – Design Principles Revisited

Design Principles	Design Elements
Measure/quantify system stress (new since 4/11)	Use LOLP vs Operating Reserve curve or similar design to transparently and objectively quantify system risk
Weigh stressed hours more heavily	Create a weighted average, unit-specific performance metric that places more weight on system stressed intervals
Measure unit-specific (or non-) performance	Ensure performance metric is focused on unit-specific performance and minimizes class averaging
Create forward-looking market signals to incent investment in reliability	Ensure the revenues at risk are more than the investment cost to deliver expected reliability performance
Ensure price signal create sufficient exit signals	Create expectations of materially reduced revenues with if poor performance persists
Use class-average approaches only when unit-specific metrics are inadequate	Ensure correlated outage risk is wholly within the sellers' accredited values and not on the demand side quantity

Proposal: Developing a weighting curve

- A curve that represents system stress as a function of a measured variable – e.g., Operating Reserves is necessary to weight unit-specific performance as a function of system stress;
- Many analytical methods exist to establish Loss-of-Load-Probability (LOLP) – operating reserve relationships.
  - An LOLP curve defines the probability of load shedding occurring at a given operating reserve level.
  - To be clear, the LOLP-reserve relationship is a reliability identity, not a pricing tool.
- ERCOT [1] and PJM [2] already compute the LOLP-reserve relationship.
  - Relationship based on historical factors, including the probability of forced outages, probability of load forecast error and probability of wind forecast error.



[1a] https://lmpmarketdesign.com/papers/Hogan_ORDC_042513.pdf

[1b] https://www.ercot.com/files/docs/2013/10/03/568nprr_03_attachment_1___draft_methodology_for_implementing.doc

[2a] = https://www.pjm.com/-/media/committees-groups/committees/mic/2021/20210609/20210609-item-08-reserve-price-formation-ordc-education.ashx

[2b] = https://pjm.com/-/media/committees-groups/task-forces/epfstf/20180523/20180523-item-03-simplified-operating-reserve-demand-curve.ashx

Proposal – EUOR vs. EFOR

- Current methodology uses Equivalent Forced Outage Rate (EFOR)
  - Includes only forced outages and forced derates
- Our proposal uses the Equivalent Unplanned Outage Rate (EUOR)
  - Includes EFOR plus maintenance outages (MO), maintenance outages extensions (ME), and maintenance derates (D4)
- Considerations
  - Resources are unavailable during an MO/D4/ME
  - Adding MO/D4/ME only impacts a generator if it is in an outage/derate and system stress occurs
  - Allows generators to take MOs without restriction, but they retain the risk of how it may impact their accreditation.
  - Both are existing NERC GADS metrics

A Maintenance Outage is:

"…an outage which can be deferred beyond the next weekend but requires that the unit be removed from service before the next Planned Outage. Characteristically, these Maintenance Outages may occur throughout the year, have flexible start dates, are much shorter than planned outages, and have a predetermined duration established at the start of the outage."

§3.6.3 PJM eGADS User Manual

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Proposal: Weighting based on system stress

- Actual performance is weighted relative to the stress the system measures during the interval – i.e., performance during intervals of system stress count more towards a generator's accredited value
- Considerations:
  – While we propose Loss-of-Load-Probability (LOLP), there may be other proxies to represent system stress that can be computed prospectively
  – Does not require extreme conditions to differentiate performance across intervals. E.g., in a "mild" year system stress is not equal in every interval, and performance during the highest system stressed hours (even in a "mild" year) are given more weight
  – We propose to use the higher of $EUOR_w$ and $EFOR_d$. For resources that have low capacity factors, use of the higher would minimize the incentive to offer above their marginal cost and if their performance is generally poor would provide an incremental incentive to invest in reliability

$$EUOR_W = \frac{\sum_{i=1}^{n} LOLP_i \times EUOR_i}{\sum_{i=1}^{n} LOLP_i}$$

Where,

i = actual interval

n = count of actual intervals for a given delivery period

LOLP = loss of load probability for a given interval

EUOR = equivalent unplanned outage rate for a given interval

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Proposal: Developing a balanced look-back period

- A look-back period that is not too long and not too short will sharpen the investment signals and support proper exit signals

- We propose the look-back period to be 3 years and averaged over the entire period – i.e., not the arithmetic average of each year. Averaging over the entire period will better weight stressed hours if the other years are relatively unstressed.

- Considerations:
  - A longer look-back period will tend to create significant, long-term penalties for otherwise sound performers that may have a random outage that happens to coincide with stressed system conditions.
  - A shorter look-back period may not generate sufficient exit signals for resources that have not invested in reliability

$$EUOR_W = \frac{\sum_{i=1}^{n} LOLP_i \times EUOR_i}{\sum_{i=1}^{n} LOLP_i}$$

Where,

i = actual interval

n = count of actual intervals for a given delivery period

LOLP = loss of load probability for a given interval

EUOR = equivalent unplanned outage rate for a given interval

Proposal: Mechanics of $EFOR_D$ & $EUOR_W$ Computation

- **Consider three 100 MW resources on system with a 10 intervals evaluation period.**
- **Unit 1** is on outage for 3 intervals and those intervals are similarly distributed to system's annual aggregate profile.
  - EFORd = 0.3 while EUORw = 0.33,
  - **Unit 1 receives a UCAP of 67 MW** based on its EUORw.
- **Unit 2** is *also* on outage for 3 intervals but all of these intervals are unstressed.
  - EFORd = 0.3 while EUORw = 0.
  - **Unit 2 receives a UCAP of 70 MW**, based on its EFORd, because EUORw < EFORd.
- **Unit 3** has fewer outages but each of these outages occur in higher stress periods.
  - EFORd = 0.2 while EUORw = 0.5
  - **Unit 3 receives a UCAP of 50 MW**, based on its EUORw.

		On Outage		
Period	**LOLP**	**Unit 1**	**Unit 2**	**Unit 3**
1	0.0%	FALSE	TRUE	FALSE
2	8.3%	TRUE	FALSE	FALSE
3	0.0%	FALSE	TRUE	FALSE
4	25.0%	TRUE	FALSE	TRUE
5	25.0%	FALSE	FALSE	TRUE
6	25.0%	FALSE	FALSE	FALSE
7	0.0%	TRUE	TRUE	FALSE
8	8.3%	FALSE	FALSE	FALSE
9	0.0%	FALSE	FALSE	FALSE
10	8.3%	FALSE	FALSE	FALSE
Nominal Ratings				
EFORd		30.0%	30.0%	20.0%
EUORw		33.3%	0.0%	50.0%
Final EUORw		**33.3%**	**30.0%**	**50.0%**
UCAP (MW)		**66.7**	**70.0**	**50.0**

Proposal: Shift outage variability from load to suppliers with an adjustment component

- What is outage variability?
  - Outages vary from hour-to-hour so, for example, a system with a 5% average outage rate might have 2% outage in some hours and 7% in others.
  - If thermal resources are accredited based on their unit-specific performance then the entire system is deficient capacity because of the probability of overlapping outages.
  - Traditionally, system planners embed a higher reserve margin in PRM capacity requirements to account for this outage variability, which results in load directly paying for this risk.
- We propose to use ELCC to compute a class-average outage variability component and add this result to the unit-specific metric as an adjustment, termed $Adj_{Asym\ Outages}$
  - Adjusting downward thermal accreditation for systemic outage variability aligns treatment for thermal and renewable resources.

Proposal: Pulling it all together

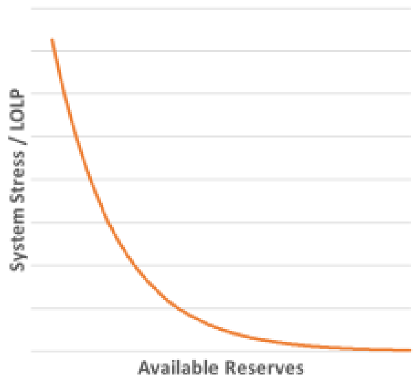
- The primary accreditation tool for thermal resources is EUORw with an class-average adjustment for asymmetric outage risk

$$UCAP = ICAP \times \left(1 - Max(EUOR_W, EFOR_d) - Adj_{Asym\ Outages}\right)$$

- Where:

$$EUOR_W = \frac{\sum_{i=1}^{n} LOLP_i \times EUOR_i}{\sum_{i=1}^{n} LOLP_i}$$

- And LOLP is a curve that represents measures system stress:



How would the existing ELCC methodology affect thermal resources?

- Setting aside that datasets necessary to model thermal resource performance under various weather conditions and the factors for that performance have not yet been developed, consider:
  - A thermal generator that performs poorly during a stressed interval. If the current ELCC methodology is applied, the poor performance has no material effect on the class-average and the PJM "ELCC Resource Performance Adjustment" dilutes the poor performance across the highest 200 coincident peak load hours over the past *decade*
  - A thermal generator is considering investing in resiliency. If the current ELCC methodology is applied, future performance is averaged across the top 200 peak load hours over the past *decade* – *i.e.,* it would take up to 10 years to fully realize the benefits of the investment.
- In the first case, poor performance is watered down, and in the latter case investment signals are weakened.
- Since PJM is a summer peaking system, unit-specific winter performance may not even be captured in the adjustment factor. The highest winter peak load day doesn't even make into the top 10 highest summer peak load days

Why it is not necessary to have a long look back period?

- Consider Resource A that invests in reliability and Resource B that does not and have the following availability:

	Resource A	Resource B
Baseline availability	96%	93%
Availability during an extreme event	90%	80%

- Applying probability weighting, ~14-17% of capacity revenues (compared to Resource A) across the entire 3-year look-back period are at risk for Resource B:

Probability of Event	Post-Event's Contribution Toward Future Accreditation Weighting	% of Capacity Revenues at Risk
1-in-10	30%	13.4%
1-in-15	50%	15.6%
1-in-20	70%	16.6%

- A 7 year look back period places 27-34% of capacity revenues at risk for the entire look back period. See Appendix for detailed calculations.

Conclusion

- No ELCC can capture the diversity and complexity of thermal resources – e.g., critical systems within a plant, exact fuel arrangements, etc. would have to be modelled to achieve accurate results.
  - Where predominant inputs – i.e., insolation and wind velocity – are unchangeable, utilizing historical weather data to predict future performance is an acceptable methodology – i.e., ELCC

- Applying class average approaches to resources with diverse features would tend to reduce investments in reliability

- If future performance can be changed, a unit-specific accreditation model may improve future performance through proper investment signals.

- Consequently, we propose an enhanced unit-specific accreditation methodology that: (a) places performance risk during extreme events at the unit level, and (b) encourages investment in enhancing system reliability/resiliency

Thank You

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