PJM Fifth Quadrennial Review: E&AS Discussion

PRESENTED TO

PJM Market Implementation Committee

February 11, 2022

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PA Consulting is the leading North American energy market advisor for financial investors through the clean energy transition.

Since 2011, we have supported more than 700 electric infrastructure purchases, sales, financings, appraisals or development projects in every U.S. power market across all major asset classes.

650+ GW

of North American power transaction support across 700+ deals, since 2011

200+ GW

of power transaction support in PJM since 2011 across all technologies

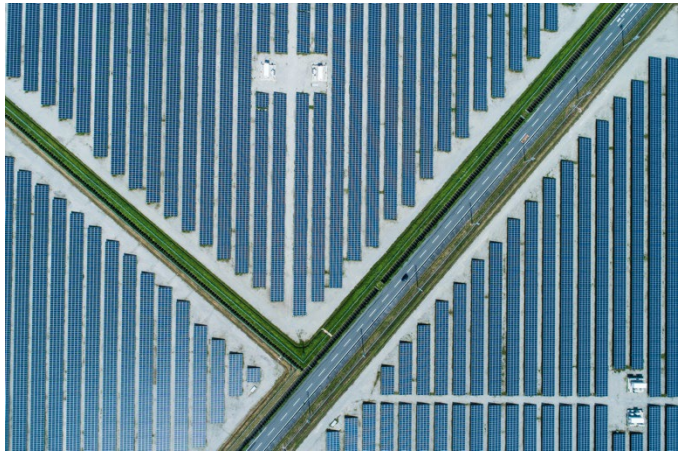
20+ GW

of combined cycle and combustion turbine development support in PJM since 2011

Our work in the PJM footprint is well beyond transaction advisory:

- We supported PSEG **before the New Jersey Board of Public Utilities** regarding Zero Emissions Credits.
- We supported a winning bidder before the **Maryland Board of Public Service Commission** within the most recent Offshore Wind solicitation.
- We submitted affidavits before FERC in previous PJM CONE assessments.

"We have worked on the majority of the largest renewable generation and thermal M&A transactions in North America."

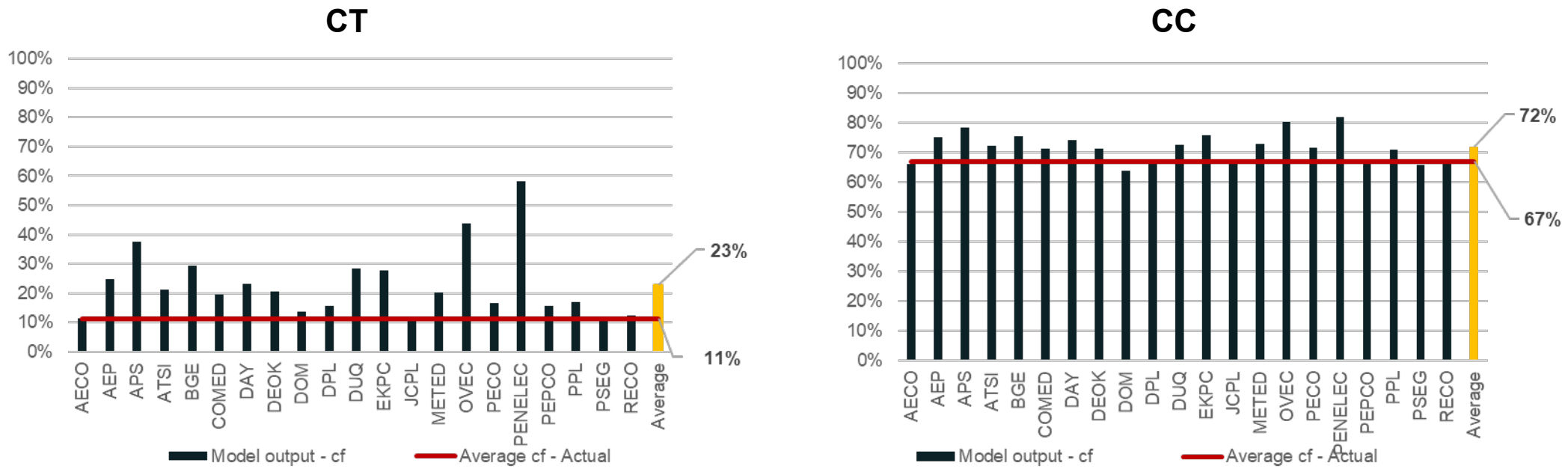


Key Observations and Recommendations

Key Observations	Recommendations
The CT & CC reference units are likely over earning both energy margins (high run time) and ancillary service revenues (high capture rates)	**Calibrate modeling outputs (not just inputs) to the real-world observations**. This could be achieved through several means: • Backcast the reference units to see if margins and operations reflect similar profiles to recent development projects. • Calibrate the modeled AS (regulation specifically) revenues by considering regulation market size, number of units participating, and the unit's probability clearing in the regulation market.
Key dispatch parameters including ramp rates, VOM, and natural gas costs may not reflect real world operations. *Hard to estimate costs, previously captured in the CT's 10% cost adder, need to be reflected in CONE structure.*	**Reality check key dispatch parameters** against recent development projects. For example, ensure that: • Modeled ramp rates are consistent with actual bid ramp rates PJM has observed. • Ensure that modeled units are not under recovering major maintenance costs (I.e. accrued major maintenance costs on a $/MWh & start basis are sufficient to meet modeled run hour expectations). • Natural gas costs reflect sufficient transportation costs.
Investment time horizons are declining, not increasing.	**Consider using an investment life shorter than 20 years** (versus expanding to 30 years); Investment life should not be conflated with potential project life.
The sloped VRR curve help meet the reliability objectives a more cost effectively than a vertical (or more vertical) demand curve and mitigates new reliability risks.	PJM should **not overlook the challenges other regions have faced with increased renewable generation**; a sloped demand curve will help cost effectively retain resources needed for reliability.

Key Observation: Operations of the reference CT & CC are higher than observed history, suggesting that there is an overestimation energy margins.

Reference Unit Capacity Factors (2022/23) vs Observed History (%)[1]

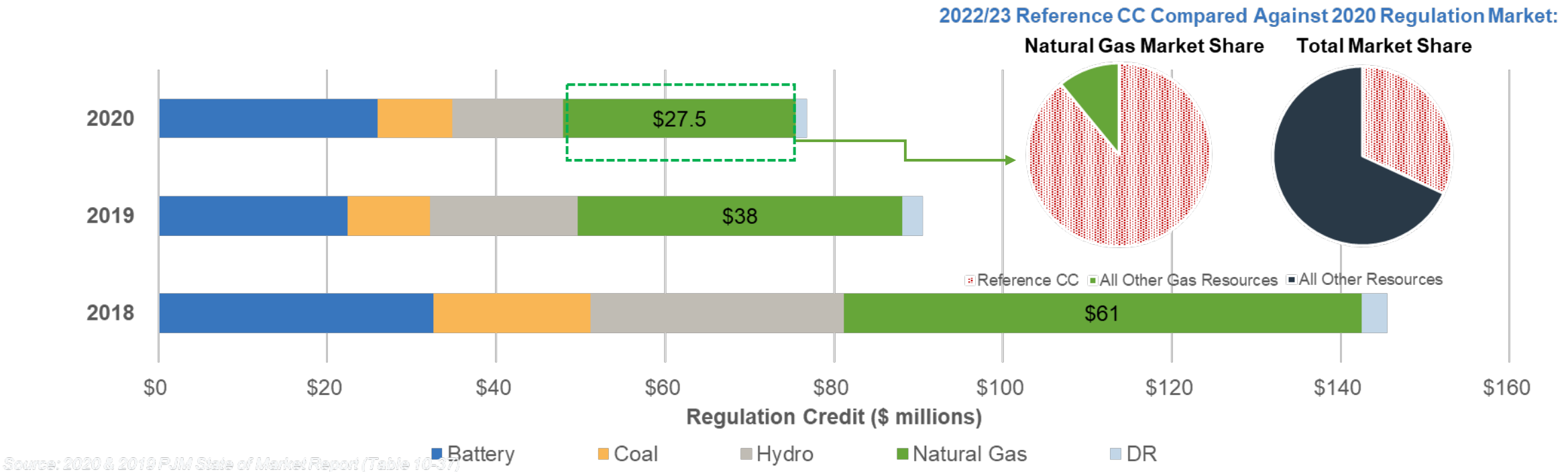


- Higher operations than observed history suggests that the reference units may be over earning compared with real world generators.
  - This may indicate that modeled dispatch parameters are not reflecting a unit's true marginal cost or that the model assumes perfect execution.
  - For example, assumed ramp rates may be faster than units are actually operated, natural gas transportations costs may be higher that assumed, VOM may be higher, etc.

[1] **Footnote:**
- CC historical average annual capacity factor is from 2018-2020 for all combined cycles built in the PJM market during the 2017-2019 timeframe.
- CT historical average annual capacity factor is from 2018-2020 for all combustion turbines built in the PJM market during the 2012-2017 timeframe, due to the limited amount of *new* combustion turbines in the PJM market.

Key Observation: The reference CC & CT are earning ancillary revenue in excess of what a generator may reasonably expect.

Historical PJM Regulation Market Share ($ million) by Fuel Source[1,2]



Source: 2020 & 2019 PJM State of Market Report (Table 10-37)

- The **single reference CC** is expected to capture **~90%** of total regulation revenue earned by the **180 participating PJM natural gas generators** in 2020[1]; if combined with reference CT, the two facilities are >100% of total 2020 gas regulation revenue.
- In terms of the MW size of 2020[1] reg market, a single reference CC is expected to capture ~75% of the regulation market of all PJM natural gas generators on a volume basis.

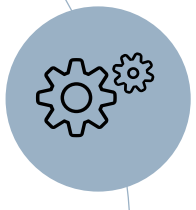
[1] Source: 2020 State of the Market Report for PJM, Page 510, Table 10-37.
[2] Source: 2019 State of the Market Report for PJM, Page 498, Table 10-37.

Key Observation: True Net CONE for thermal generation investment occurs over a longer time horizon than a single delivery year considered for the BRA purpose.

Investment life expectations of a generation assets are decreasing (and not increasing)

Thermal generation investors are concerned about long-term (i) policy & regulatory risk, and (ii) declining expectations in spark spreads, as the clean energy transition moves forward. Illinois recently established the Clean Energy Jobs Act (SB 2408) with a target of 100% clean energy as well as interim goals that will require natural gas plant closures.

•This is a trend not just in PJM, but also in other regions strong clean energy aspirations. For example, NYISO proposed moving from a 20-year to a 17-year (and declining) economic life for thermal reference units to be consistent with state clean energy policy.

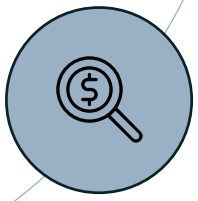


The historical entry of thermal generation at capacity price levels below modeled net CONE does not indicate such price is sufficient to procure additional market entry.

Most near-term investors in PJM thermal generation have generally taken a view that as the market tightens capacity prices will rise; Investors may be willing to earn lower than expected average returns in the near-term to meet long-term investment thresholds.

The equity enthusiasm observed for PJM natural gas-fired resources in the last decade is waning.

It is more difficult today—than five years ago—for developers to raise capital. This may be among the reasons we are seeing a preferences towards 1x1 combined cycles, where the ability to phase constructions reduces risk of the overall project if sufficient equity is not committed to the project.

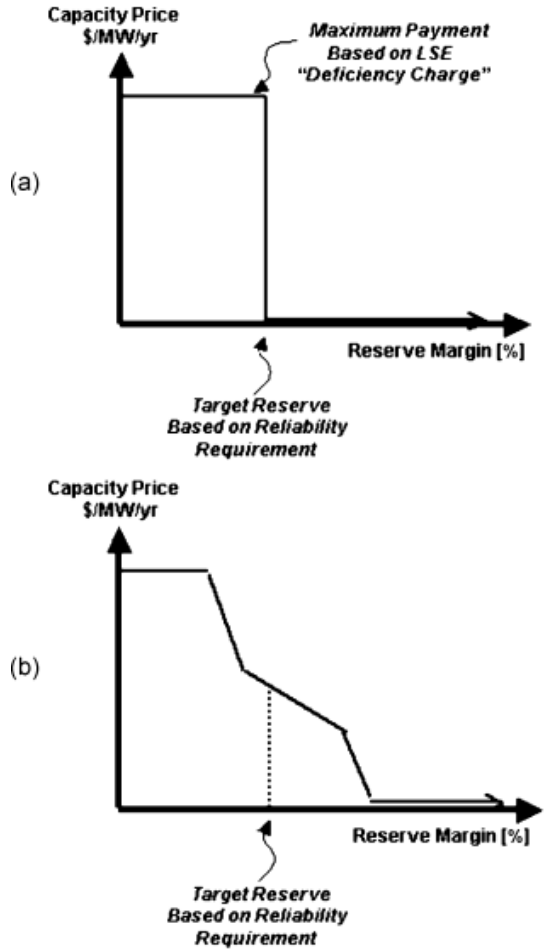


There are real costs—that are difficult to estimate—that occur over a project's lifecycle that need to be included within an estimate of Net CONE.

Observable market behavior indicates that generators routinely utilize allowable cost markups to capture costs that may be difficult to estimate over a project's lifecycle. For example, generators face real costs associated with unexpected maintenance, non-perfect execution, shifting regulations, and other relevant factors. The removal of the 10% cost adder in the calculation of Net CONE requires that such real costs be quantified and captured within the calculation of Net CONE.

Key Observation: The sloped VRR Curve (i) allows for the purchase of additional cost-effective reliability, and (ii) mitigates future reliability risks.

- **Key objectives of demand (VRR) curve are at a minimum two-fold:**
  - Maintaining reliability based on PJM's established rules; and
  - Providing the appropriate entry and exit signals for power generating resources.
- **A sloped demand curve can simultaneously lower costs to consumers and increase investment relative to the vertical (or more vertical) demand curve** by providing greater price stability (versus stronger boom-and-bust cycles of a vertical demand curve).
  - This is driven, among other factors, by increased cost savings from lower capital cost to generators due to reduced risk and risk premiums (Hobbs, 2007); in other words, a significant shift in the demand curve shape cannot be evaluated in isolation from how it will impact investor behavior and the appropriate investment parameters (i.e. return on equity) to incent that entry.
- **This is critically important in an increasing renewable generation environment**, where there is more inherent uncertainty appropriate levels of capacity.
  - As intermittent renewable generation has been added to the grid in other regions, in addition to adjusting ELCC methodologies, some system operators have increased reserve margin targets to ensure reliability.
  - In lieu of changing reserve margin, a sloped demand curve provides insurance policy to ensure that sufficient capacity remains in the market to avoid the resource shortfalls seen in regions like California where capacity needs are acute and out-of-market contracts are sometimes needed.
  - Even the energy-only market of ERCOT is implementing changes to spread the hours over which scarcity prices (a proxy for capacity premiums) are seen and may implement a forward-looking hedging obligation for load to ensure reliability.



Source: Hobbs *et al*., A Dynamic Analysis of a Demand Curve-Based Capacity Market Proposal: The PJM RPM Model, IEEE Paper, 2007

About PA.

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