CAPSTF-CPAWG Analysis, Scope to Date

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OPSI's Competitive Policy Achievement Working Group (CPAWG) asked PJM on July 28, 2022, to analyze several market design alternatives for the forward procurement of clean energy (henceforth, CPAWG's request; Annex A).

The analysis's scope described here reflects CPAWG's request and feedback received from stakeholders at the Aug. 17 and Sept. 13 CAPSTF meetings.

PJM will prioritize the CPAWG's request received in July and already discussed by stakeholders. PJM solicited additional stakeholders' requests on Sept. 27, 2022. The analysis's scope could vary as we continue developing the model and based on additional priorities and the timeline set by stakeholders.

Summary of the CPAWG's Request

The CPAWG asked PJM to compare the status quo with four mechanisms for the forward procurement of capacity and regional or state-specific clean energy products. These four mechanisms are:

D1. A Forward Clean Energy Market (FCEM) followed by PJM's capacity market (RPM) with the same planning horizon of three years and a commitment period of one year

D2. An Integrated Clean Capacity Market (ICCM)

D3. RPM with an added clean capacity constraint

D4. The overlay of options D1 and D3

The CPAWG suggested ~~5% for the friction cost in the status quo and~~ to include in two side cases voluntary demand for the regional clean energy products equal to 10%-20%-30% with a slope of +/-5%.

The CPAWG suggests 5% for the friction cost in the status quo. A voluntary centralized market should improve welfare–because it offers new trading possibilities—but the model cannot properly assess the magnitude of these benefits as noted by some stakeholders. Instead, PJM will map system costs for a range of friction costs to inform varied stakeholders' opinions.

The request also asks PJM to assess commitment periods beyond one year and to use historical data to define a subset of renewable resources that do not participate in the capacity market. Currently, PJM is not planning on modeling these features.

Other Assumptions

- **Simulation horizon:** 2023–2030.
- **Frequency:** Annual for forward markets, hourly for the energy market.

- **Entry and exit:** Existing resources that do not clear in the capacity market exit in the delivery year; new resources that clear in the capacity market enter in the delivery year.
- **Offers:** Existing resources offer at net going-forward cost in the forward markets and marginal cost in the energy market. New resources offer at the net cost of new entry in the forward markets and become "existing" if they clear. In designs D2 and D4, resources in the FCEM account for expected capacity payments; if they clear in the FCEM, they participate in RPM and offer zero.
- **Existing resource types modeled:** The model will account for combined cycle (natural gas), combustion turbines (natural gas), internal combustion engines (oil), steam coal, steam gas~~, combined cycle with carbon capture and storage~~, solar, onshore wind, offshore wind, run-of-river, pump storage, four-hour battery, and demand response.
- **Resource types that can enter the market:** Solar, onshore wind, offshore wind, four-hour battery, combined cycle, combustion turbine, combined cycle with carbon capture and storage. New combined cycle and combustion turbine can be built in Pennsylvania, West Virginia, Indiana, Ohio, Kentucky.
- **Footprint:** The study will cover PJM's footprint.
- **Transmission**: Transmission capacity is unlimited.
- **Geographic and unit heterogeneity**: The model partitions PJM's footprint into 37 geographic areas resulting from the intersection of 22 zones and 14 jurisdictions. Each geographic area will have a representative resource for each existing technology type and a separate one for each technology type that can enter the market. Fuel costs will include transportation costs. Fuel transportation costs and renewables' hourly profiles will vary by location.
- **States' policies:**
  - **Renewable portfolio standard (RPS)**: The model will account for states' Tier 1 RPS targets, geographic and technology eligibility rules with some simplifications, and offshore wind and battery targets. It will abstract from BTM solar or use PJM's 2022 official load and BTM solar forecasts to net RPS requirements of BTM solar generation.
  - **Retirement**: The model will reflect the potential impacts on retirements from state and federal policies – Illinois' Climate and Equitable Jobs Act, New Jersey's carbon dioxide emissions reduction from electric generating units proposal, state IRPs, EPA's Coal Combustion Residuals rule, Effluent Limitation Guidelines updated in 2020, and the Cross State Air Pollution "Good Neighbor" proposal.
  - **Nuclear**: ~~After currently enacted state funding mechanisms expire,~~ New Jersey's plants offer zero in the forward markets and receive make-whole payments until currently enacted state funding mechanisms expire; Illinois' plants offer based on the net going-forward cost throughout the simulation horizon.
  - **Offshore wind and state-mandated batteries**: Offer zero in the forward markets and receive make-whole payments.
- **Inflation Reduction Act (IRA):** The IRA will be modeled as a 30% reduction of the annualized CAPEX for solar, onshore wind, offshore wind, and four-hour battery.

If time allows it, and for a few selected cases, PJM could simulate the following:

- New resources offering at net going-forward cost instead of the net cost of new entry
- Resources requiring a risk premium in the sequential auction formats D1 and D4

- The effect of the IRA on the adoption of carbon capture technologies

Markets' Structure and Interaction

The model will have three components to simulate the forward markets, the energy market, and the effective load carrying capability (ELCC). The forward market component maximizes benefits minus procurement costs. It allows for downward-sloping demand curves for RTO's capacity and RTO's clean or renewable energy, as well as multiple regional capacity products and state and technology-specific RPS modeled as hard constrained. The energy market component is a linear model with perfect dispatch. The ELCC component will reflect the current PJM methodology.

The model cycles through these three components and produces the capacity expansion yearly. A more detailed explanation of the forward and spot markets' interactions follows.

Suppose we know resources' expectations for energy profits in year *t+3*. Given ELCCs and capacity factors' estimates for *t+3*, we create offer and demand curves using the *Offers* assumption above and solve the year *t* forward markets with delivery year *t+3*. This solution determines the resource mix for year *t+3* – see assumption *Entry and Exit* above. We use this resource mix to:

- Update the ELCC values for the year *t+1* forward markets with delivery year *t+4*
- Run the energy market using year *t+4* load and fuel prices forecasts to obtain capacity factors (accounting for curtailments) and investors' energy profits expectations for year *t+4*

We now have all inputs to simulate year *t+1* forward markets with delivery year *t+4*. And so on for years *t+2*, *t+3*, etc.

Outcomes

The model will produce entries and exits, costs and prices for capacity, clean energy, hourly energy, hourly emissions and shortages. It will also deliver generation, emissions, costs, revenues and profits for each representative resource as defined above.

Data

The model will use PJM's official 2022 load forecast and rely on Energy Exemplar's Eastern Interconnection data set for other information. Demand response bidding into the capacity market will reflect cleared offers in the Base Residual Auction for the 2023/2024 delivery year or publicly available data.

Timeline

Initial results for three cases will be presented at December 16's CAPSTF meeting. These three cases could be 2A, 2B, and 2C from the CPAWG's request~~will be available by the end of 2022~~.

Final results will be available by the end of the first quarter, 2023, including answers to the revised IMM and Constellation's analysis requests.

PJM can accommodate REsurety's analysis request after the end of the first quarter, 2023, based on stakeholders' indications. The analysis would require three weeks.

Annex A: OPSI CPAWG Analysis Request

Competitive Policy Agreement Working Group (CPAWG)

Analysis Request to PJM

The CPAWG assisted by RMI and Brattle staff has developed these proposed scenarios and corresponding outputs to inform PJM's modeling and analysis of various clean procurement market constructs. CPAWG believes this information will inform its position as these discussions advance, both in the CPAWG and CAPSTF.

Scenario	Assumptions & Desired Outputs
All	*Outputs* • Price and total procurement costs of clean attributes, region-wide, by product, and by state and/or other voluntary buyer • Energy market and capacity market consumer costs region-wide and by state • Societal costs (production and going-forward investment), region-wide • Resource entry/exit, region-wide and by state, technology type • GHG emissions, region-wide • Is reliability requirement met? (Y/N) • Are state clean energy goals met? (Y/N)
1. Status quo Model all state policy goals (RECs, ZECs, storage, offshore wind, DERs, DR etc.) for 2030.	*Assumptions:* Provide a summary of policy assumptions by state for OPSI CPAWG review and adjustment. Include a realistic level of "friction" (transaction costs, etc.) and non-coordination as associated with the lack of a regional marketplace. OPSI suggests 5 % would be an appropriate placeholder for this value. *Outputs: See "all" above*
2. Regional clean attribute market scenarios	*Assumptions*

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A regional market for clean energy attribute credits (“CEACs”) could be modeled in several different ways; we recommend the following sub-scenarios:
2A. Market for multiple state REC products: Each of the various state RPS products (Tier I RECs, solar RECs, in-state RECs, etc.) are procured through a central auction. Benefits of the regional marketplace modeled based on removing “frictions” from Scenario #1.
2B. Co-optimization with capacity market: Same as #2A, but include realistic assumptions regarding improved resource selection due to co-optimization between capacity and REC procurements (rather than time-sequential FCEM, which precedes capacity auction).
2C. Market for a common REC: One REC product that reflects the overlap in state Tier I REC resources (i.e., wind, solar, geothermal, qualifying biomass and methane) is procured through a central auction; assume existing contracts are honored (e.g., OSW already selected); all other REC & ZEC products continue to be procured as today.
2D. Add Voluntary Demand for New Region-wide REC product: Same as #2C, but add 10%, 20%, and 30% voluntary demand for regional REC product (nuclear not eligible).
2E. Add Voluntary Demand for Region-wide CEAC product: Same as #2C, but add 10%, 20%, and 30% voluntary demand for regional CEAC product (renewable and nuclear are both eligible).
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• Market efficiencies including lower transaction costs and added transparency eliminate “frictions” and reduce clean attribute procurement costs 5% compared to Status Quo
• Use historical analysis to determine the volume of renewable supply that has not offered/cleared in the capacity market, and carry this assumption into the regional attribute market scenarios
• Voluntary demand participation: Use a sloping demand curve with target quantity +/-5%. For cost allocation purposes, report costs allocated to voluntary buyers separately (agnostic as to whether buyers are cities, corporates, or other consumers)
Outputs: See “all” above, plus:
• Compare regional clean attribute market simulations with different commitment periods for cleared resources (e.g., 1 year, 3 year, 7+years) and assess impact on outcomes.
• Model a version of a regional clean attribute market in which there is a must-offer requirement into the capacity market for resources that participate in the clean attribute market; assess how outcomes differ.
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3. Clean capacity constraint
Addition of a tranche for clean capacity within existing RPM, where eligible resources include renewables, storage, EE, DR, and nuclear
Otherwise identical to #1 (Status Quo)
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Outputs: See “all” above, plus:
• Note impact on capacity prices and consumer costs for states/LDAs purchasing clean capacity tranche as well as those that are not
• Model scenarios with lower/higher levels of clean capacity requirements. “Clean capacity”
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	costs are allocated only to those states for whom the clean capacity has been procured.
4. Combo clean attribute market (MWh, renewable only) and clean capacity constraint (MW UCAP, all clean supply is eligible including renewable, DR, EE, battery, nuclear) This scenario would layer scenarios #2C and #3 together, reflecting a world in which states and other buyers can meet their goals through a regional attribute market and/or clean capacity constraint.	*See "all" above, plus:* • Note impact on capacity prices for states/LDAs participating in clean capacity market as well as those that are not • Note any variation in clean procurement costs between this and scenarios 2, 3
5. Option for state-specific variations of the above Individual states may request state-specific scenario analysis.	*Will focus on states' specific questions and scenarios*