Proposed Reform of the PJM Capacity Market

1. Product definition

Capacity is the planned for capability of a resource (physical asset) to deliver energy or provide ancillary services to firm load; in the case of demand response, capacity is the planned for capability of the resource to curtail firm load.

2. Reliability Risk and Risk Drivers

Resource adequacy is a function of load and resource performance. The principal risk is that the as-modeled conditions used to set the requirements and procure resources differ materially from the realized conditions. The system has run short when a set of low probability high impact events have converged (i.e., extreme adverse weather conditions, fuel delivery failures, transmission network failures, mechanical failures, PJM load forecast error, PJM commitment and dispatch decisions). Regional exposure to these types of "black swan" events leading to and caused by capacity resource *force majeure* are not manageable by individual resources, but rather are best addressed by the diversified resource portfolio that PJM procures.

3. Procurement Metric and Level

Metric | Expected unserved energy (EUE) is a useful reliability measure going forward, as the penetration of energy limited resources increases. This metric can be set at a level equivalent to the LOLE target and offers diagnostic benefits to the market; LOLE based on assessment of hourly LOLP is essentially equivalent to EUE.

Level/Requirement | The two major reliability events (Polar Vortex and Elliott) are best considered extreme tail events, i.e., under most operating conditions, the PJM RPM procures enough capacity in aggregate (set aside locational or portfolio diversity concerns for the moment) to meet the RA needs. However, using the RPM to procure sufficient resources to cover all possible tail events could result in overbuying and overbuilding the system for the preponderance of conditions -- an inefficient use of limited resources. PJM could consider procuring a balanced portfolio in terms of geography and fuel mix to ensure the diversity needed to manage the observed tail risks. Alternatively, we propose procuring capacity in two tranches:

- Base Capacity (BC) | an amount procured based on *expected* load carrying capability of the system given as-modeled resource characteristics (e.g., *expected/normal* weather, resource availability, production profiles)
- Insurance Capacity (IC) | an amount procured to address the *extreme* loss of load exposure, e.g., derived from tail weather conditions and other identified low probability events that produce force majeure resource unavailability – black swan events

The reliability planning models used to set the requirements for each type of capacity would include distributions around load, resource availability (forced and scheduled outages) and max deliverable energy, and renewable resource production. These distributions would all be correlated with weather

conditions. Ideally, the capacity requirements would be set using a planning model with hourly granularity on an adjusted ICAP basis.

- The base requirement would be set so that the portfolio would meet the annual LOLE target, assuming expected system performance.
- The insurance requirements would be an incremental amount calculated as the difference between the requirement established assuming system performance under extreme tail conditions and the base requirement.

4. Performance Assessment

Base Capacity would be required to offer available Cleared Capacity into the DA and RT markets every day. Cleared Capacity would be the cleared portion of the qualified and accredited capacity values used in the reliability planning models (see Accreditation below). Any hour that the resource is unavailable (in whole or part), it would not be paid. Base Capacity would not be subject to CP-like penalties.

PJM will purchase Insurance Capacity to cover force majeure conditions. Insurance Capacity would be required to be available to PJM in all hours. Insurance Capacity would submit offers into the DA/RT market at tariff-specified rates (say $800/MWh, so that Insurance Capacity is called in dispatch before the region goes short Primary Reserve at $850/MWh). PJM would commit Insurance Capacity only under (emergency) conditions as specified in the rules. Insurance capacity would be paid a daily capacity rate when available and the energy clearing price when dispatched.

Failure to deliver would result in the following for the two different types of capacity:

- Base capacity | if unavailable in any hour during a dispatch day, the resource is not paid for that hour
- Insurance capacity | if unavailable at any time during a dispatch day when emergency conditions are declared (or if a resource fails to be committed and dispatched as ordered), in addition to foregoing the hourly capacity payment, a penalty calculated as 120 x the daily capacity payment is assessed (after 3 non-performance events, removed as IC for the balance of the delivery year). *[Additional details about what triggers an "event" and defines an "event" meriting penalty need be further considered. This design is not adopting the current PAI trigger and duration approach.]*

The IC penalty rate is purposefully high because LDs do not adequately cover load loss. IC resources will collect large sums to deliver the insurance service in a few but critical moments. Failure is extremely costly to the market. For example, the time between the Polar Vortex and Elliott was almost a decade, and the costs of both events was very high.

5. Qualification and Accreditation

Qualification | All capacity must be fully deliverable to firm load. Base Capacity must demonstrate that it has made all commercially reasonable arrangements to maximize availability, consistent with good utility practice. Insurance Capacity must be available to PJM to commit within 2 hours and dispatch on demand; have a verifiable firm fuel source (e.g., on site fuel or multiple pipelines) that allows for continuous operation for at least 24 hours; firm fuel supply and delivery contracts; demonstrated ability

to operate through extreme temp/humidity conditions; and demonstrated financial capacity to absorb non-performance penalties.

Accreditation | The accredited resource value is the maximum amount of capacity (Base or Insurance) that can be offered into the auction. Each resource will have a pair of accredited values – a base and an insurance value – for each hour in the year, ranging from zero to the audited capability capped by its CIR. The accredited values will equal the resource's adjusted ICAP (similar to UCAP and perhaps comparable to the IMM's EAF concept). Adjusted ICAP reflects the historical resource availability and ambient air adjustments (thermal) or production (intermittent resources) data that are evaluated in the reliability model to set the base and insurance requirements. In this way, the accreditation values will correspond to the "as-modeled" adjusted ICAP assumed for resources of the same class used to set requirements in the planning model. For each resource, the two accredited values that will be used in the auction (BC and IC) will be the average adjusted base and insurance ICAP for all hours in the year for the corresponding type of capacity.

6. Obligations of Capacity Resources

Cleared resources would offer hourly adjusted ICAP into the DA/RT markets. If a cleared resource's actual hourly availability (thermal) or production (intermittent resource) is materially like that assumed in the planning model, then the resource's average delivered ICAP will equal (within a small tolerance) the accredited value and the total revenues earned from the capacity market will equal the clearing price times its accredited (cleared) value. E.g., a combined cycle plant would have an ambient air temperature adjusted max capacity. Its hourly accredited ICAP would be based on those values. A solar plant would have a daily production profile based on expected solar irradiance as modeled. Its hourly accredited ICAP would be based on those values. (Note that a solar unit would have an ICAP of zero at night, thus no available ICAP, so it would not be paid at night).

All cleared capacity will have an obligation to offer its as-modeled hourly ICAP into the DA and RT markets. Base Capacity will submit energy offers into the DA and RT markets at prices that reflect short-run opportunity costs; Insurance Capacity will submit energy offers at a tariff specified rate (e.g, $800/MWh; the idea is to ensure Insurance Capacity is dispatched before region is short of Primary Reserves when ORDC = $850/MWh). Capacity resources are required to follow all PJM dispatch instructions. (Note that a capacity resource that is available and has offered correctly into the DA/RT markets but is not committed or dispatched by PJM is paid for its capacity).

Expected resource fuel limitations should be reflected in the modeling of the capacity requirements. As proposed, resources would offer available ICAP in all hours. If a resource chooses to bid to conserve fuel (not Max. E), it may not receive full capacity payment in those hours. The expected impact of fuel limitations would have been modeled and been reflected in the requirements, and thus priced.

7. Enhancements to the Capacity Procurement Process

Base Capacity and Insurance Capacity could be purchased through separate mechanisms or through a simultaneous auction that clears both Base and Insurance capacity (preferred). Self-Supply Entities (SSE) must be able to self-supply their obligation; any needs not self-supplied will be purchased through the capacity market. If an SSE has sufficient resource portfolio to cover both Base and Insurance

requirements, then it is self-supplied and self-insured. An SSE can allocate assets in its resource portfolio to Base or Insurance – taking on differential operating expectations and non-performance exposures.

The auction will simultaneously clear the Base and Insurance requirements, minimizing the total cost of procuring both. PJM should consider purchasing Insurance Capacity for commitment periods of up to 3-years, rather than 1-year for Base Capacity (this would allow the seller to spread the risk of non-performance over a longer period). In this case, PJM would procure Insurance Capacity in rolling tranches, so it is not procuring more than 1/3 of its total Insurance capacity requirement in any given auction cycle; maximizing competition and providing a straightforward mechanism to replace non-performing resources. If PJM does not commit the full 1/3 in one year, it would seek to commit the delta with the additional 1/3 in subsequent auction.

PJM should also consider provisions that would allow obligation holders to mitigate against potential penalties if in-kind capacity is secured before the dispatch day. Replacement capacity, both Base and Insurance, can be part of the market. Resources could secure replacements bilaterally or through a PJM facilitated mechanism. Additionally, if Insurance Capacity, for example, fails three times (and thus is removed as IC for the balance of the delivery year), PJM could run a special procurement to backfill or wait until the upcoming regularly scheduled auction and procure replacement IC in addition to the normal tranche.

8. Remaining Design Seasonal Resource Adequacy Construct

A seasonal construct may be superior to the existing annual model. The appropriate choice of seasonal periods and number of seasons is an empirical matter that requires analysis. Preferably the requirements model is hourly and the delivery obligations / accreditation construct hourly, so seasons are moot.

9. Supply-Side Market Power Mitigation Rules

All (Base and Insurance) qualified capacity resources “must offer” at a minimum as Base Capacity. Resources can (voluntary) also submit an offer for part or all of its qualified and accredited Insurance Capacity. All resources must be able to fully reflect their opportunity costs.