Reform of PJM's Resource Adequacy Market Design

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EAST KENTUCKY POWER COOPERATIVE
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Overview

THIS PRESENTATION REFLECTS EKPC'S CURRENT THINKING

- EKPC's working definition of capacity is the planned for capability of a resource (physical asset) to deliver energy or provide ancillary services to firm load in each hour
- The purpose of the capacity market is to procure the lowest cost portfolio of capacity that meets the resource adequacy target (i.e., otherwise unmeet regional EUE)
- A good capacity market design supports efficient allocations of capital and coordinates the timely entry and exit of resources, consistent with maintaining regional reliability
- Cleared capacity must provide the opportunity to recover risk-adjusted going forward costs less expected E&A
- A resource must be able to manage/mitigate the risks it takes on when assuming a capacity commitment; a highly punitive penalty structure is counter-productive
- The market must allow *self-supply* to meet resource adequacy obligations; the capacity market must not impose a preferred portfolio on a load serving entity

Major Capacity Market Design Issues

Reliability risk modeling | how to best represent in the planning model the region's exposure to unserved firm load in each hour of the year due insufficient supply

Resource adequacy (capacity) requirements | how much capacity PJM needs to procure through the market to assure resource adequacy meets the reliability target given the expected load and characteristics of the supply, and relevant correlates

Resource qualification | the rules that establish whether a resource can sell capacity

Resource accreditation | the mechanism used to establish how much capacity a resource can sell

Market clearing mechanism | the rules and model that govern and implement the economic balancing of supply and demand, establishing capacity positions and prices

Resource performance obligations | the rules establishing the performance obligations of capacity resources and the consequences of non-performance

Market power mitigation | the rules to constrain the capacity market offers to those consistent with what one would expect from a competitive market

Reliability Risk Modeling

Design principles

- 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)

Proposal

- At a high level, EKPC and PJM's preferred approaches to modeling the region's reliability risks are similar
- EKPC proposes to model resource adequacy assuming hourly granularity, including weather, ambient air reductions, production profiles, forced and planned outages
- Locational deliverability will be represented using a modified transmission system planning model topology
- Risks associated with extreme (outlier) weather and fuel delivery force majeure will be modeled as emergency conditions

Resource Adequacy Requirement

Design principles

- The “planning model” used to establish the resource adequacy “requirement” must be consistent with the performance expectation in the market model, including generation outages, production profiles, extreme weather, transmission capability, etc
- The capacity market needs to secure a portfolio of resources that in aggregate meets reliability target; Individually, each resource does not have to perform through all potential events
- The calculated resource adequacy requirements are the amount of supply needed to meet firm energy load in each hour of the capacity delivery year

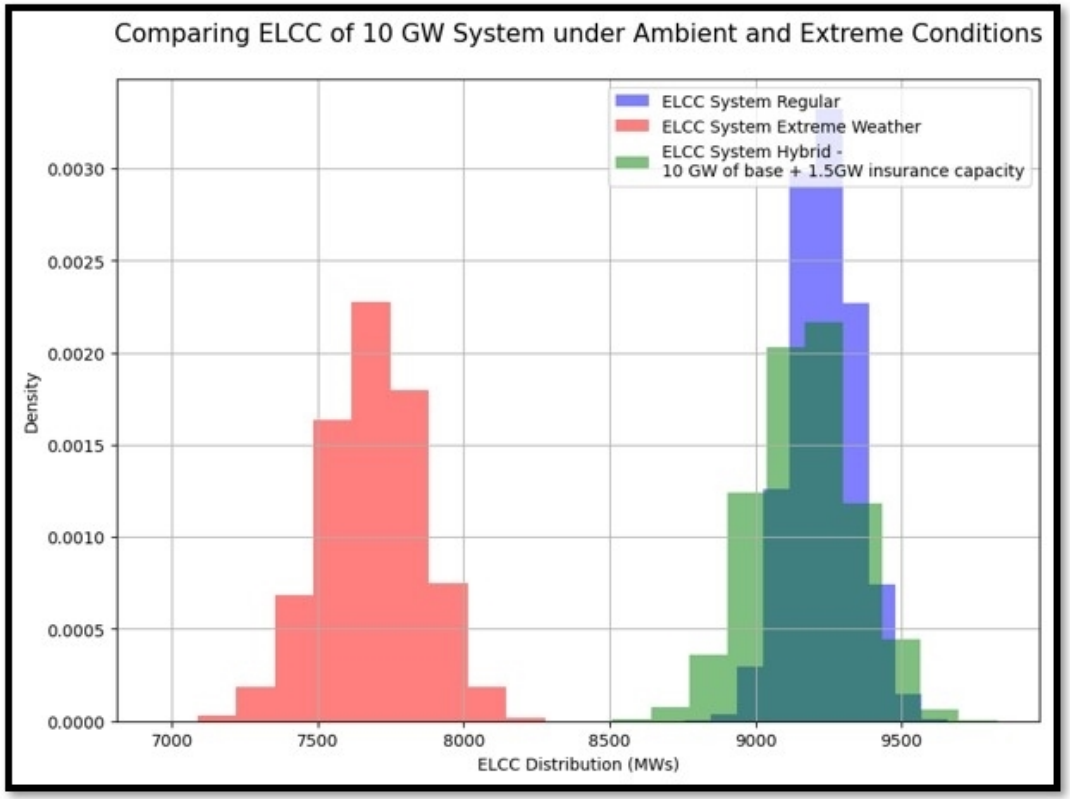
Proposal

- The reliability target will be based on EUE
- We propose two products: Base Capacity (BC) and Emergency Capacity (EC)
- BC requirement is set to meet target EUE assuming expected/normal weather, resource availability, production profiles
- EC requirement is set to meet target EUE assuming extreme weather conditions and other identified outlier events
- Assuming the same resource set, but adjusting performance assumptions, the EC requirement is an amount calculated as the difference between the adequacy requirement established assuming system performance under extreme weather / outlier conditions and the BC requirement

Resource Adequacy Requirement: Example (structured to illustrate concept)

1. Assume a hypothetical 10,000 MW system which broadly shares the portfolio characteristics of PJM
2. Calculate the following system ELCC distributions for the system under Base and Emergency conditions
3. The difference between P90 of both distributions is approximately 1,500 MWs suggests that the procurement of 1,500 MW of EC above the BC will insure the system against an Elliott-like event (note that the example assumes by construction that EC is nearly perfect, see EC qualification requirements)

Unit Type	# Units	Actual Capacity MW	% Total MW	Forced Outage Rates % - **base conditions**	Unit Size	Extreme weather forced outage rate % - **used in model**	Emergency actual outage Elliott observed %
CC	234	3,411	34%	3.1%	14.58	30%	38%
CT	358	1,400	14%	4.8%	3.91	30%	38%
Diesel	78	33	0%	10.3%	0.42	25%	17%
Coal	167	2,651	27%	9.7%	15.88	15%	17%
Nuclear	31	1,783	18%	0.9%	57.51	7%	7%
Hydroelectric	20	480	5%	15.9%	24.00	20%	20%
Solar	26	101	1%		3.87		
Wind	25	141	1%		5.66		



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Resource Qualification

Proposal

- All resources must be fully deliverable to firm load
- Base Capacity and Emergency Capacity must demonstrate maximum dependable output (ICAP) via periodic testing (like PJM's proposal)
- Qualified ICAP is limited to CIR value
- Base Capacity has no special "winterization" requirements beyond those recommended by NERC (different from PJM)
- Emergency Capacity must satisfy the following:
  - 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; or equivalent technical capability
  - firm fuel supply and delivery contracts
  - demonstrated ability to operate through extreme temp/humidity conditions; and
  - demonstrated financial capacity to absorb non-performance penalties.

Resource Accreditation

Design principles

- A resource's accredited value is the maximum amount of capacity that is can offer into the capacity auction
- The accredited value is an accounting value that simplifies the process of making a capacity offer and performing capacity market settlements

Proposal

- The accredited MW is the average of the hourly "Adjusted ICAP" values

  UCAP = average hourly adjusted ICAP

- Adjusted ICAP is the qualified ICAP modified to reflect weather correlated ambient air reductions and outages (thermal resources) or weather correlated production profiles (intermittent renewable resources) in each hour
- Resources that qualify as BC and EC will have both BC and EC accreditation values
- For existing resources, the adjustment parameters are based on historical data
- For new resources, the adjustment parameters are based on like-class data until sufficient actual performance data is collected

Resource Accreditation: Example (structured to illustrate concept - no actual data)

Thermal Resource							
ICAP	50.0	MW					
UCAP	40.5	MW					
Sample Days				Sample Days			
183	Adjustments			182	Adjustments		
Hour	Availability	Ambient air	Adj ICAP	Hour	Availability	Ambient air	Adj ICAP
1	0.8	0.98	39.2	1	0.95	0.88	41.8
2	0.8	0.98	39.2	2	0.95	0.88	41.8
3	0.8	0.98	39.2	3	0.95	0.88	41.8
4	0.8	0.98	39.2	4	0.95	0.88	41.8
5	0.8	0.98	39.2	5	0.95	0.88	41.8
6	0.8	0.98	39.2	6	0.95	0.88	41.8
7	0.8	0.98	39.2	7	0.95	0.88	41.8
8	0.8	0.98	39.2	8	0.95	0.88	41.8
9	0.8	0.98	39.2	9	0.95	0.88	41.8
10	0.8	0.98	39.2	10	0.95	0.88	41.8
11	0.8	0.98	39.2	11	0.95	0.88	41.8
12	0.8	0.98	39.2	12	0.95	0.88	41.8
13	0.8	0.98	39.2	13	0.95	0.88	41.8
14	0.8	0.98	39.2	14	0.95	0.88	41.8
15	0.8	0.98	39.2	15	0.95	0.88	41.8
16	0.8	0.98	39.2	16	0.95	0.88	41.8
17	0.8	0.98	39.2	17	0.95	0.88	41.8
18	0.8	0.98	39.2	18	0.95	0.88	41.8
19	0.8	0.98	39.2	19	0.95	0.88	41.8
20	0.8	0.98	39.2	20	0.95	0.88	41.8
21	0.8	0.98	39.2	21	0.95	0.88	41.8
22	0.8	0.98	39.2	22	0.95	0.88	41.8
23	0.8	0.98	39.2	23	0.95	0.88	41.8
24	0.8	0.98	39.2	24	0.95	0.88	41.8

Intermittent Renewable Resource					
ICAP	50.0	MW			
UCAP	14.0	MW			
Sample Days		Sample Days		Sample Days	
122	Adjustments	122	Adjustments	121	Adjustments
Hour	Production	Hour	Production	Hour	Production
1	0	1	0	1	0
2	0	2	0	2	0
3	0	3	0	3	0
4	0	4	0	4	0
5	0	5	0	5	0
6	0	6	5	6	0
7	5	7	10	7	5
8	15	8	20	8	15
9	25	9	30	9	25
10	35	10	40	10	35
11	40	11	45	11	40
12	50	12	50	12	47.5
13	47.5	13	50	13	47.5
14	42.5	14	50	14	35
15	35	15	40	15	25
16	20	16	30	16	15
17	5	17	15	17	5
18	0	18	5	18	0
19	0	19	0	19	0
20	0	20	0	20	0
21	0	21	0	21	0
22	0	22	0	22	0
23	0	23	0	23	0
24	0	24	0	24	0

Market Clearing Mechanism

Proposal

- We propose fundamental changes to the clearing mechanism
- Each capacity market offer is (UCAP MW, $/MW-day).
- The unit-specific UCAP offers are translated into a set of daily 24-hourly adjusted ICAP schedules using the planning data from the accreditation model
- We propose an hourly market clearing model that is roughly analogous to the DA market clearing model
- The market “schedules” capacity against the resource adequacy requirement expressed as a firm energy requirement to ensure that there is sufficient energy in each hour
- The clearing price is in $/MW-day, performance assessment and payments are hourly
- A resource needs to clear only one hour in the year to gain a capacity commitment for the year; the highest cost resource cleared in any hour, sets the annual price for the market.
- The transmission topology is reflected in the market using a (maybe like the FTR model) N-0 planning model that reflects the transmission maintenance outage schedule
- Simultaneously clear the lowest cost set of resources that meet the BC and EC requirements in all hours. Resources will take a BC position or an EC position, not both
- BC is purchased annually for annual positions; EC can be purchased in tranches (some discretion around timing and quantity). EC commitments are for 3-years periods

Market Clearing Mechanism: Example (structured to illustrate concept - no actual data)

	U1	U2	U3	U4	U5	U6
UCAP MW	2.7	5.8	38	45	50	25
Price $/MW-day	50.0	135.0	65.0	35.0	25.0	95.0

	U1	U2	U3	U4	U5	U6	
Cleared positions	**2.7**	**0.0**	**38**	**45**	**50**	**25**	
Clearing price	**95**	**/MW-day**					

Day i -- 24 hour unit-specific UCAP to hourly schedule translation

	U1	U2	U3	U4	U5	U6
1	0	10	38	48	52	25
2	0	10	38	48	52	25
3	0	10	38	48	52	25
4	0	9	38	48	52	25
5	0	8	38	48	52	25
6	1	6	38	48	52	25
7	3	4	38	48	52	25
8	5	4	38	48	52	25
9	6	3	38	48	52	25
10	7	3	38	48	52	25
11	8	3	38	48	52	25
12	10	3	38	48	52	25
13	10	3	38	48	52	25
14	8	3	38	48	52	25
15	5	3	38	48	52	25
16	2	3	38	48	52	25
17	0	3	38	48	52	25
18	0	3	38	48	52	25
19	0	4	38	48	52	25
20	0	6	38	48	52	25
21	0	8	38	48	52	25
22	0	10	38	48	52	25
23	0	10	38	48	52	25
24	0	10	38	48	52	25

Day i clearing -- clearing an amount in an hour sets a position equal to UCAP

Load_i		U1	U2	U3	U4	U5	U6
103.8	1	0.000	0.000	0.100	1.000	1.000	0.000
95.2	2	0.000	0.000	0.000	0.899	1.000	0.000
103.8	3	0.000	0.000	0.100	1.000	1.000	0.000
103.2	4	0.000	0.000	0.084	1.000	1.000	0.000
111.2	5	0.000	0.000	0.293	1.000	1.000	0.000
113.9	6	1.000	0.000	0.339	1.000	1.000	0.000
115.6	7	1.000	0.000	0.332	1.000	1.000	0.000
120.4	8	1.000	0.000	0.405	1.000	1.000	0.000
122.1	9	1.000	0.000	0.424	1.000	1.000	0.000
124.6	10	1.000	0.000	0.462	1.000	1.000	0.000
130.5	11	1.000	0.000	0.592	1.000	1.000	0.000
140.8	12	1.000	0.000	0.811	1.000	1.000	0.000
144.3	13	1.000	0.000	0.903	1.000	1.000	0.000
146.2	14	1.000	0.000	1.000	1.000	1.000	0.006
145.4	15	1.000	0.000	1.000	1.000	1.000	0.094
144.5	16	1.000	0.000	1.000	1.000	1.000	0.179
141.1	17	0.000	0.000	1.000	1.000	1.000	0.124
137.8	18	0.000	0.000	0.994	1.000	1.000	0.000
138.6	19	0.000	0.000	1.000	1.000	1.000	0.024
135.2	20	0.000	0.000	0.926	1.000	1.000	0.000
130.0	21	0.000	0.000	0.788	1.000	1.000	0.000
124.6	22	0.000	0.000	0.646	1.000	1.000	0.000
115.9	23	0.000	0.000	0.419	1.000	1.000	0.000
107.3	24	0.000	0.000	0.191	1.000	1.000	0.000
Clearing objective		109730.1					

Resource Performance Obligations

Proposal

- Performance is measured in each hour of the year
- All capacity resources must submit compliant offers into the DA and RT markets
- BC: offer available ICAP into the DA and RT markets in each hour; energy offers reflect variable operating costs
- EC: offer available ICAP into the DA and RT markets in each hour; energy offer is the greater of variable operating costs or $800/MWh
- All capacity resources must submit compliant ancillary services offers in line with their capabilities and as constrained by energy offer requirements
- All resources will adhere to PJM testing requirements and may self-schedule for required testing or other regulatory requirements
- BC and EC resources are paid an amount equal to hourly available ICAP x the applicable hourly capacity rate for all capacity properly offered into the DA market
- If EC is unavailable at any time during a dispatch day when emergency conditions are declared, EC foregoes the hourly capacity payment and incurs a penalty calculated as *120 x the daily capacity rate x UCAP* (after 3 non-performance events, removed as EC for the balance of the delivery year).
- BC and EC resources may, prior to the DA market offer deadline. assign qualified replacement UCAP to meet an obligation; commercial arrangements are bilateral
- A resource that correctly offers its available ICAP but is not committed or dispatched by PJM is paid for its capacity – irrespective of system conditions

Resource Performance: Example (structured to illustrate concept - no actual data)

[1]	Case 1		Case 2	
Capacity type	BC	EC	BC	EC
ICAP_MW	75.0	75.0	75.0	75.0
UCAP_MW	67.5	74.3	67.5	74.3
Available_MW	67.5	74.3	60.0	74.3
$/MW-day [2]	100.0	185.0	100.0	185.0
$/MWh	4.17	7.71	4.17	7.71
Actual availability	90%	99%	80%	99%
Hours Available	7,884.0	8,672.4	7,008.0	8,672.4
EC days [3]		-		1
Raw Payment	2,217,375	4,963,594	1,752,000	4,963,594
Penalty	-	-	-	1,649,460
Final settlment	2,217,375	4,963,594	1,752,000	3,314,134
[1] Case 1 assumes that all parameters used to set UCAP equal actual values; Case 2 assumes BC availability is lower and there is 1 EC day				
[2] BC and EC clearing prices				
[3] EC days are those days with one or more hours of emergency conditions and the EC resource is unavailable				

Market Power Mitigation

Proposal

- All qualified BC must submit an offer into the capacity market; EC may submit an offer for emergency capacity
- Capacity offers are risk-adjusted going-forward costs less expected net energy and ancillary service revenue
- BC offers require no risk adjustment
- EC offers are exposed to penalty risk over multiple year commitment window; e.g., a Conditional Value at Risk (CVaR) construct would estimate the risk exposure
- As proposed, PJM is not obligated to purchase the entire EC requirement at one time and may prefer to procure in tranches; additionally, PJM may impose a budget constraint (like VRR) on EC procurement, limiting exposure to high costs