ELCC – IMM Proposal

Capacity Capability
Senior Task Force

August 12, 2020

IMM

Monitoring Analytics

IMM Proposal

- **The IMM supports using the Effective Load Carrying Capability (ELCC) method to determine the capacity values for intermittent resources.**
- **The ELCC analysis incorporates the random nature of intermittent resources and a well designed ELCC analysis should be consistent with the energy market.**
- **But implementing ELCC is complex and there are multiple stages.**
  - **Creating an ELCC curve or surface**
  - **Integrating ELCC curve into market clearing**

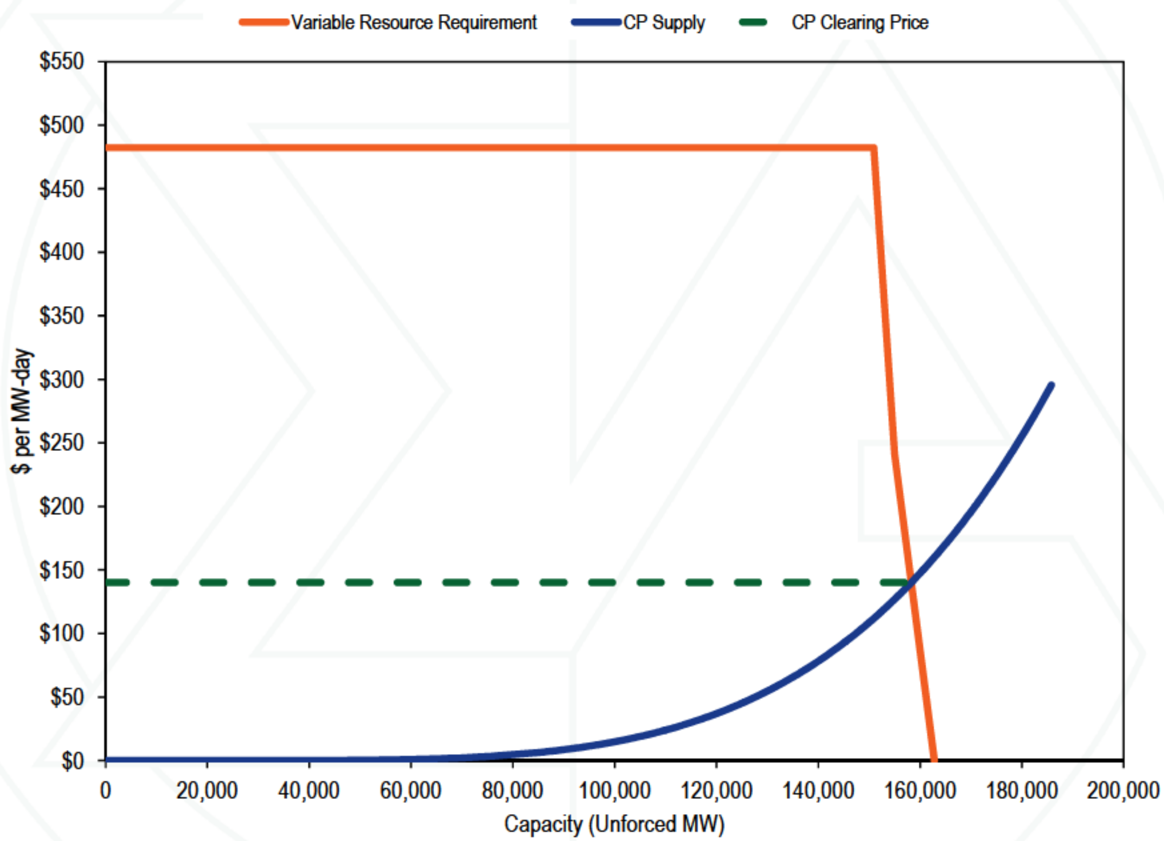
IMM Proposal

- The IMM proposal is based on competitive market principles:
  - Marginal determination of the ELCC capacity value
  - Dynamic, market based ELCC capacity values will change as the resource mix changes
- The PJM proposal is not based on competitive market principles.
- The joint stakeholder proposal is not based on competitive market principles.

Economic Fundamentals

- **RPM Demand Curve for ELCC MW**
  - **Defines a willingness to pay for every MW**
- **Supply Curve for ELCC MW**
  - **Defines the least cost combination of resource types based on offers and interactions among the resource types for every total MW point of ELCC supply**
  - **Supply curve is based on a production function using multiple inputs**
  - **Provides a single price at every point on the curve reflecting the marginal price of ELCC MW at every MW level**

PJM RPM



Variable Resource Requirement
CP Supply
CP Clearing Price
$550
$500
$450
$400
$350
$300
$250
$200
$150
$100
$50
$0
$ per MW-day
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
Capacity (Unforced MW)

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Fundamentals

- **Production function for load carrying capacity using input a and input b:** $Q = Q(a, b)$
- $Q_a > 0$ **and** $Q_b > 0$
- **Price of a is a function of a:** $\boldsymbol{P_a}(a)$
- **Price of b is a function of b:** $P_b(b)$
- **Cost of production (purchasing input a and input b):** $C = aP_a(a) + bP_b(b)$
- **Subject to an output constraint:** $Q(a, b) = Q_0$
- **Objective is to minimize cost for a given output level**
- **The Lagrangian: L=** $aP_a(a) + bP_b(b) + \mu(Q_0 - Q(a, b))$

Fundamentals

- To minimize cost, need to satisfy these first order conditions (notation is simplified):
- $\boldsymbol{L_{\mu}}$= $aP_a + bP_b + \mu(Q_0 - Q(a,b))$
- $\boldsymbol{L_a = P_a + \mu Q_a = 0}$
- $\boldsymbol{L_b = P_b + \mu Q_b = 0}$

- **Note, this result indicates:** $\boldsymbol{\frac{P_a}{Q_a} = \frac{P_b}{Q_b} = \mu}$

Fundamentals

- At the optimal (least cost) solution the input price/marginal product ratio must be the same for each input.
- The Lagrange multiplier (the shadow price of the production constraint) is the marginal production cost in the optimal (least cost) solution.
- This is the marginal price of capacity (the clearing price)
- In the optimal solution every input is paid the same in terms of their marginal contribution to output.

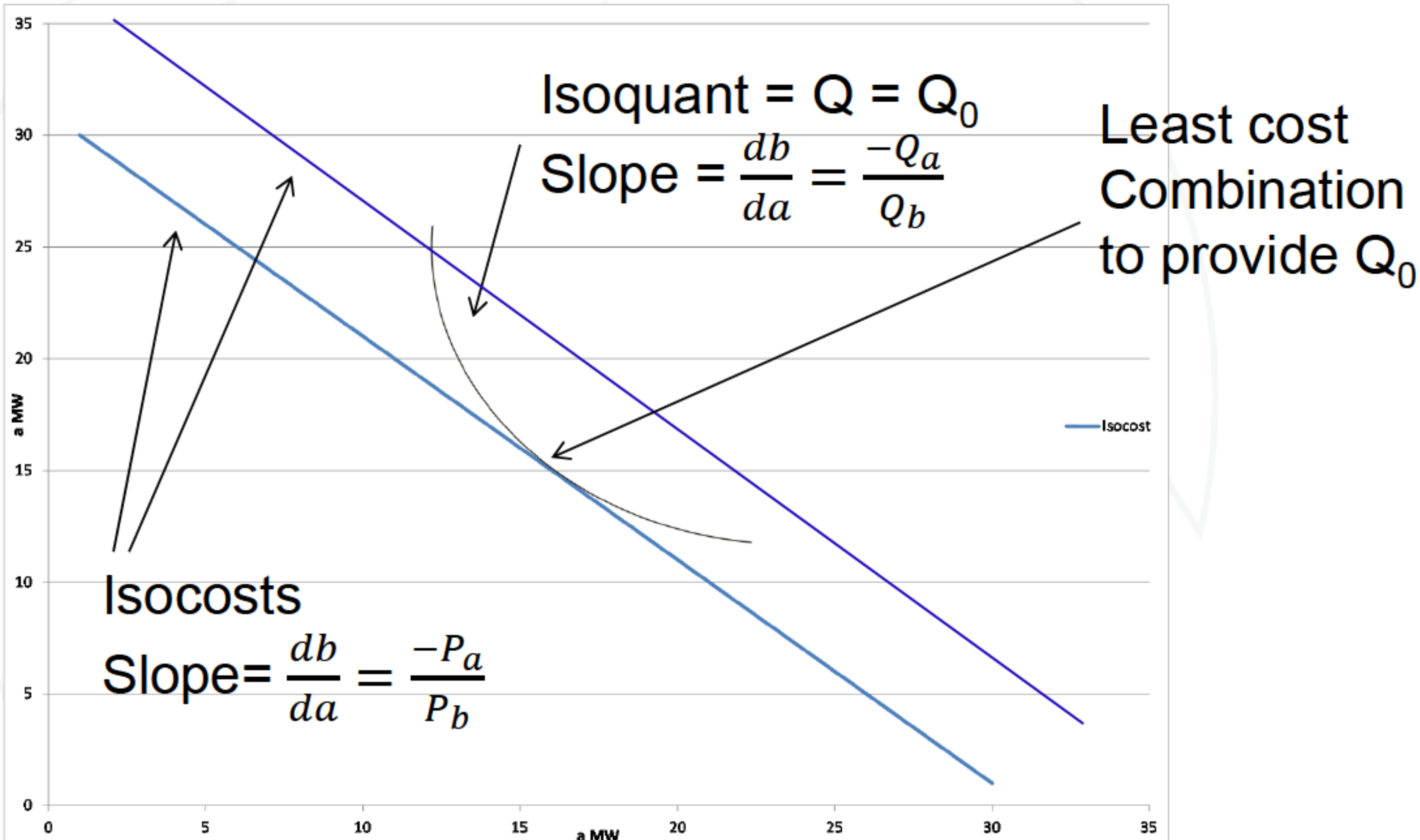
Fundamentals

- $\frac{P_a}{Q_a} = \frac{P_b}{Q_b} = \mu$
- **This can be rewritten again as:**
- $\frac{P_a}{P_b} = \frac{Q_a}{Q_b}$
- **At the cost minimizing solution, the marginal rate of technical substitution (MRTS= $\frac{Q_a}{Q_b}$) equals the ratio of input prices ($\frac{P_a}{P_b}$).**
- **In the optimal solution every input is paid the same in terms of their marginal contribution to output.**

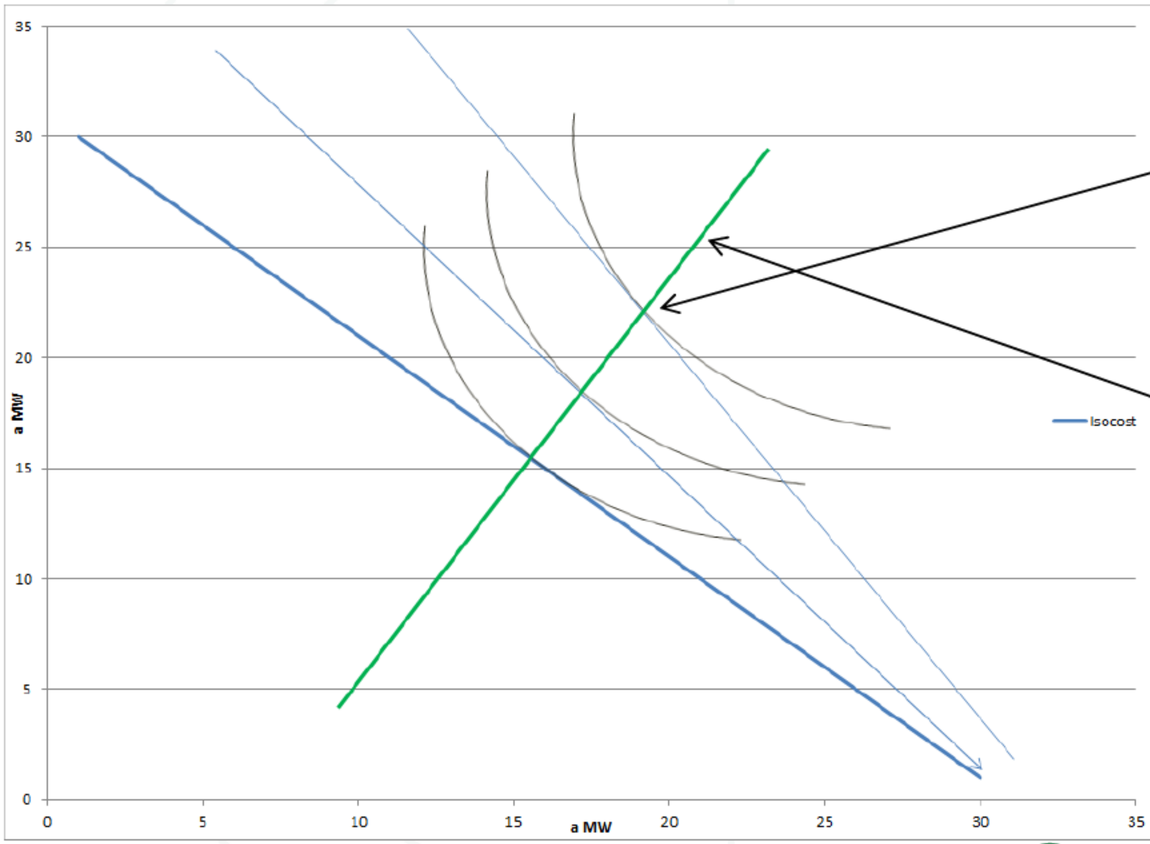
Fundamentals

- $\frac{P_a}{P_b} = \frac{Q_a}{Q_b}$
- (MRTS= $\frac{Q_a}{Q_b}$) equals the negative slope of the isoquant (different combinations of a and b provide the same level of capacity output).
- $\frac{P_a}{P_b}$ equals the negative slope of an isocost (different combinations of a and b have the same total cost).
- Where the two curves are tangent, result is the least cost solution for the combination of a and b in the production function.

Fundamentals



Fundamentals

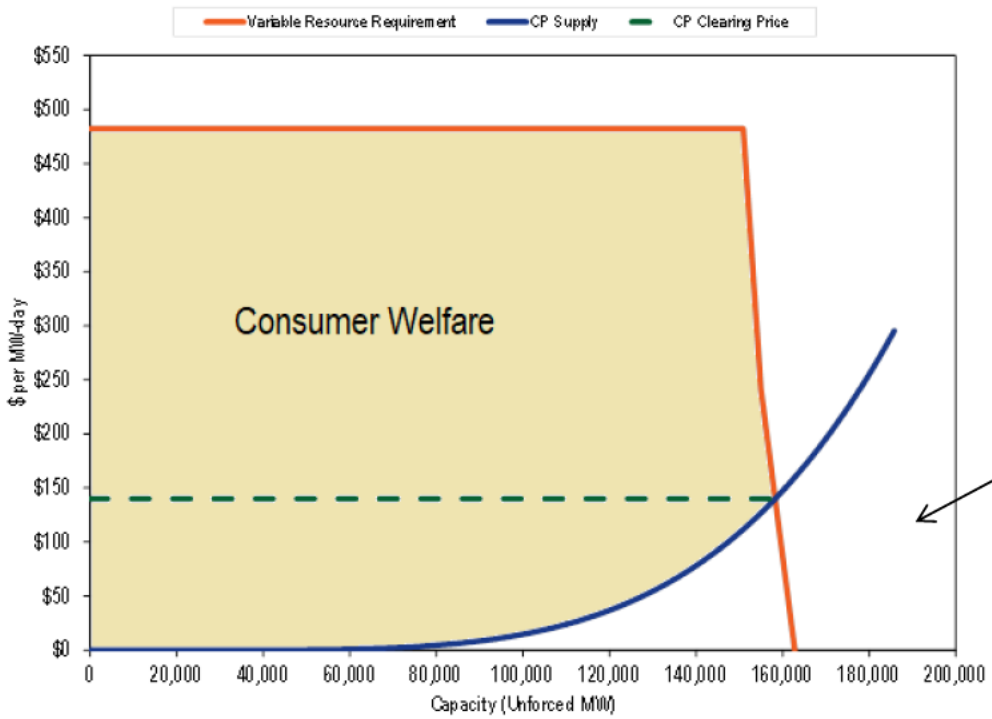


Change output

Basis of ELCC Supply Curve

Monitoring Analytics

PJM RPM



$$\frac{P_a}{Q_a} = \frac{P_b}{Q_b} = \mu$$

At every point on the supply curve

$$P(Q) = \mu(Q)$$

Prices based on marginal not average.

Settlement on marginal ELCC not average.

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RPM Market Clearing

- **Objective is to maximum consumer welfare – the area between the VRR curve and the supply curve**

Consumer Welfare = VRR – Supply(ELCC(T,W, S))

where T is the MW from a thermal resources,

W is the unadjusted MW from wind resources (ICAP),

S is the unadjusted MW associated with a solar resource (ICAP)

Performance Obligation

- Performance obligation of intermittent resources should be consistent with the ELCC analysis
- For each intermittent class an expected 24 hour profile is an input to ELCC analysis
- The performance obligation for an individual generator is the expected 24 hour profile for the generators unadjusted capacity.

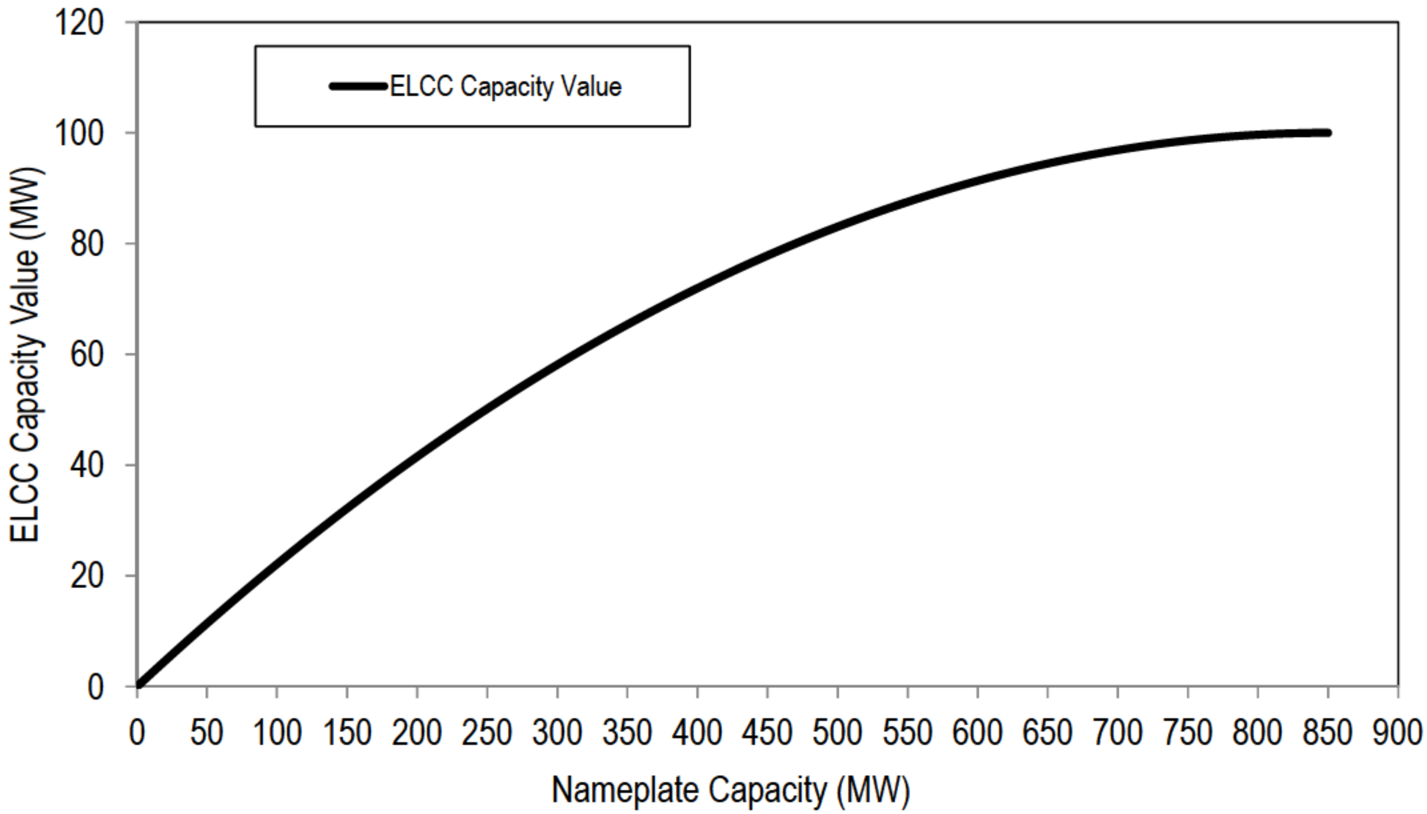
Marginal ELCC

- **The ELCC function will be an input into the capacity auction**
- **The ELCC curve will be used in the market clearing optimization to dynamically determine the cost and the contribution to meeting the reliability requirement of offers from intermittent resources.**
- **In the final optimal market solution, the marginal cost is equal to the marginal benefit for intermittent resources.**
- **The marginal ELCC will define the market clearing ELCC for all cleared intermittent resources.**

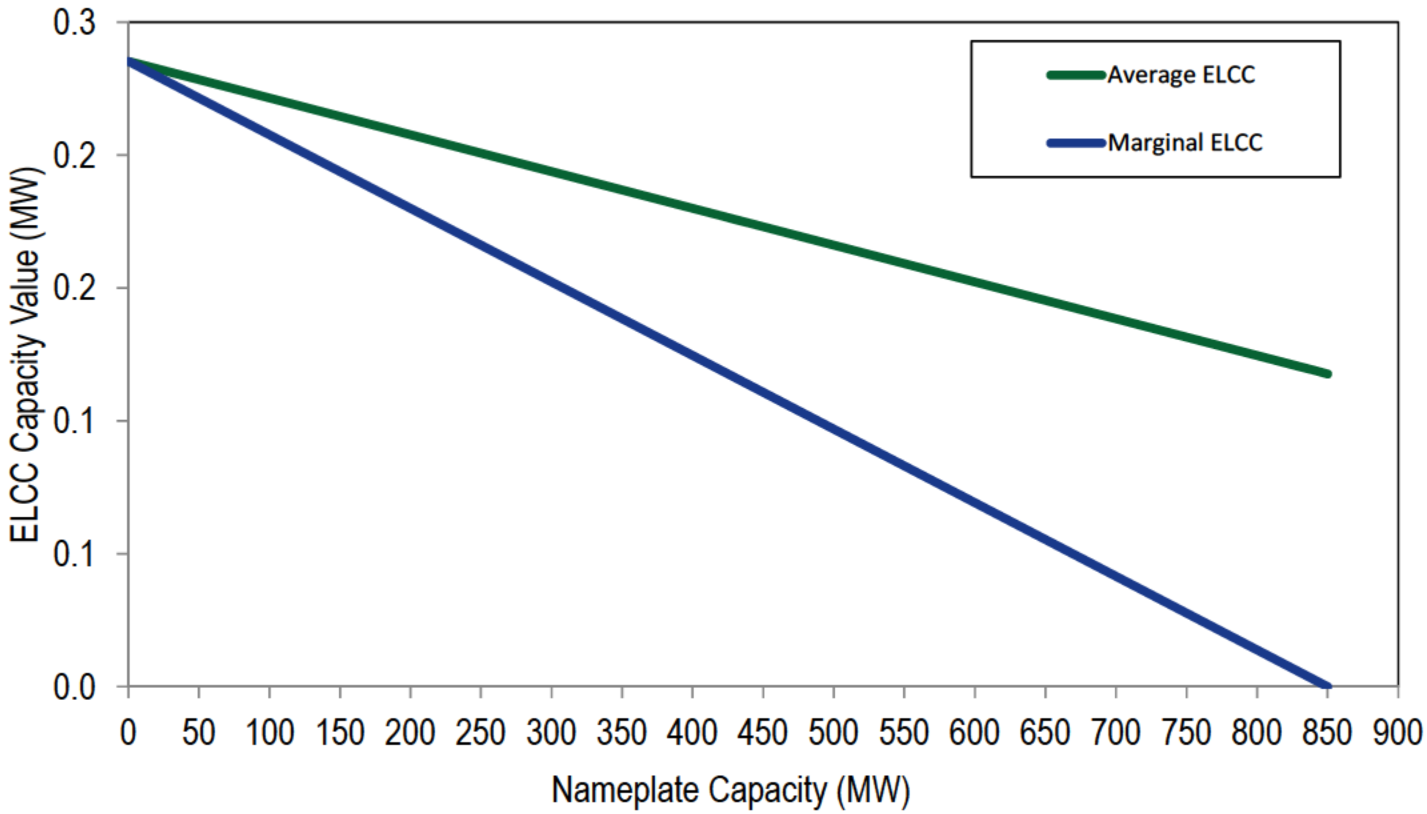
Average ELCC

- Use of an average ELCC is not consistent with an efficient market clearing.
- Use of an average ELCC will result in:
  - an inefficient market outcome
  - with over procurement
  - over payment of intermittent resources
  - an inefficient displacement of traditional resources

Total ELCC Curve



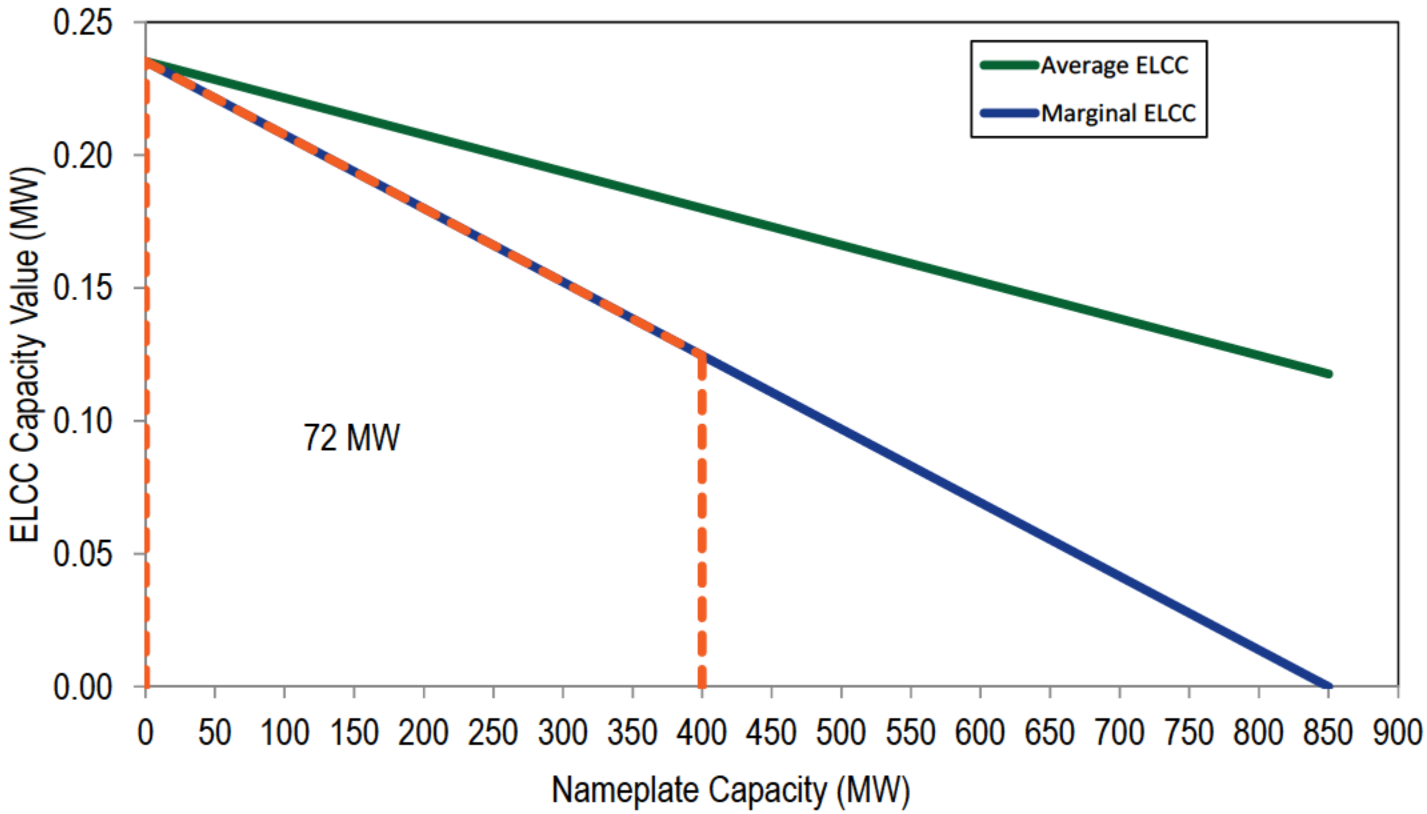
Marginal and Average ELCC Curves



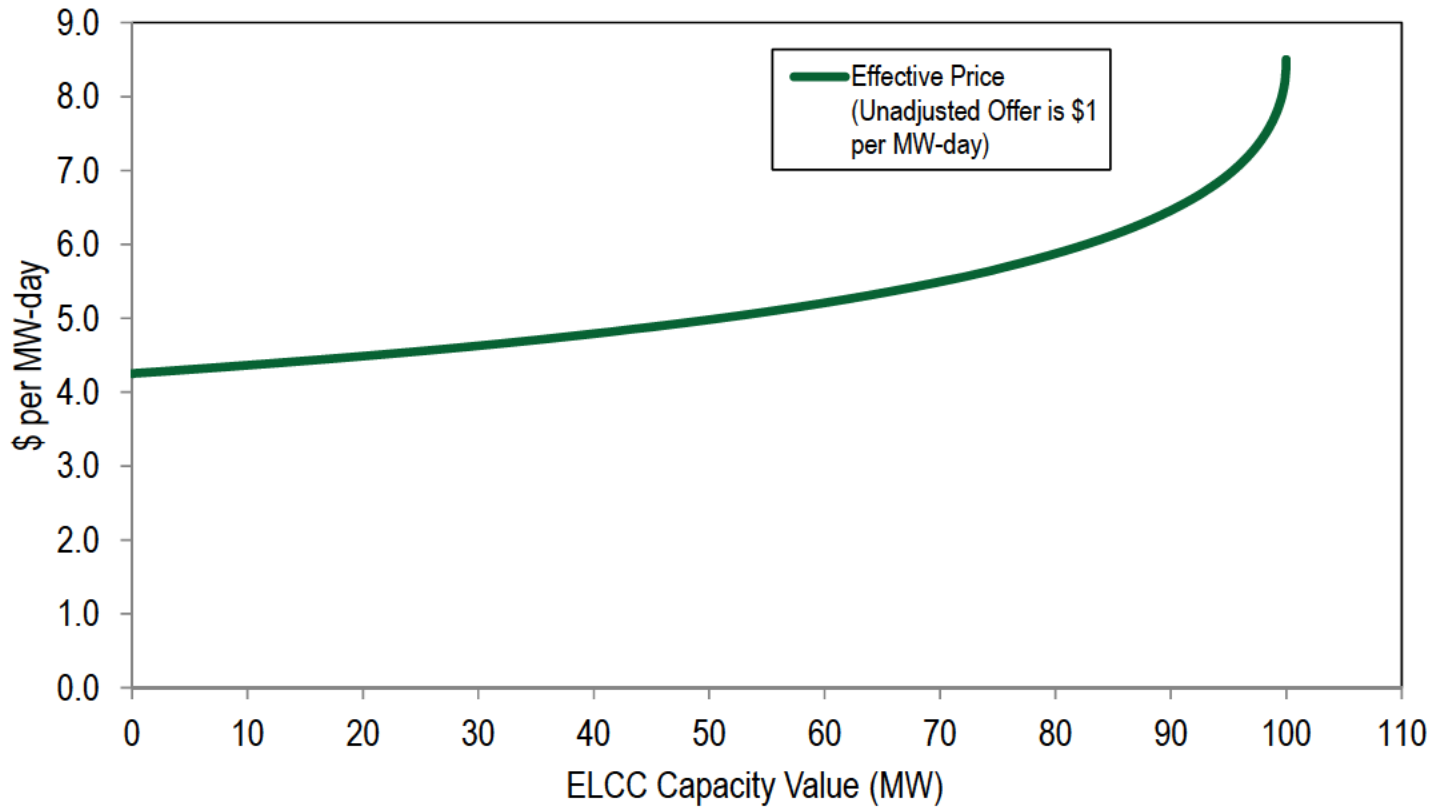
Marginal ELCC Example

- **Auction clears with 400 MW of nameplate capacity**
  - **Marginal ELCC is 12.46 percent**
  - **Average ELCC is 18.00 percent**
- **The market would clear UCAP MW equal to the area under the marginal ELCC curve, 72 MW in this example**
- **Note that the Average ELCC x 400 MW = 72 MW**
  - **There are no missing MW**

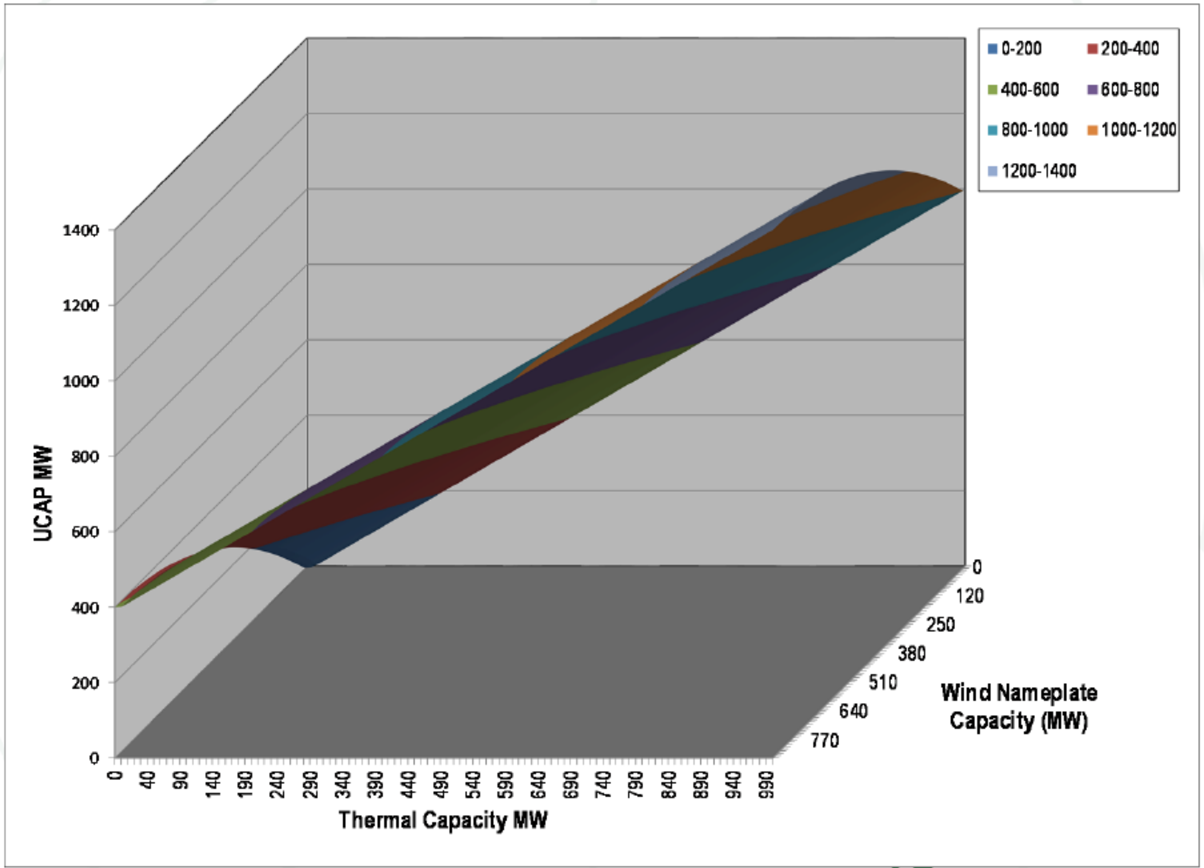
Marginal ELCC Example



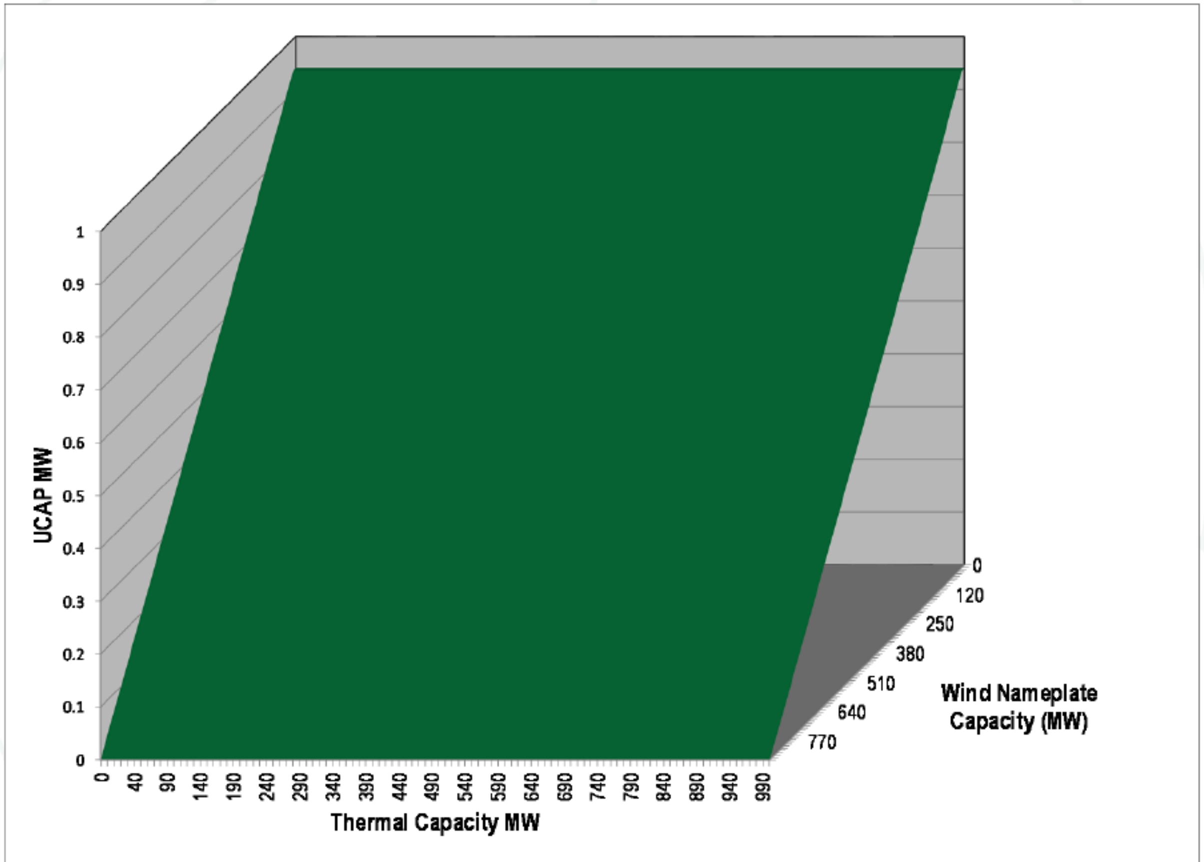
Supply curve for Wind after ELCC adjustments



ELCC Surface



Marginal ELCC



Vintage Treatment / Transition Period

- **Fixed or predefined ELCC capacity values through a vintage policy or a transition phase will result in inefficient outcomes and an increased cost to load**
- **Fixed or predefined ELCC capacity values will favor older technology over newer technology**
- **Fixed or predefined ELCC capacity values will lead to over procurement of specific resource types, displacement of more efficient resources and incorrect proportions of resources**
- **Fixed or predefined ELCC capacity values will make the system less reliable than the ELCC analysis predicts**

Vintage Treatment / Transition Period

- Vintage treatment or a transition period will shift risk from resource owners to customers.
- The point of markets is to assign risk to market participants best able to manage it.
- Resource owners can manage the risks they face.
- Vintage treatment would require customers to pay for costs associated with outdated technology and with overstated capacity value.
- PJM would need to make ad hoc adjustments at customers' expense to maintain target reliability.

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