Discussion of Status Quo Market Participation by Solar-Battery Hybrids

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September 10, 2020

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Status Quo for Hybrid Market Participation

- Without significant interaction between the components: separate market modeling.
  - Several such plants in PJM today (mostly wind and battery storage)
- With significant interaction between the components (e.g., restrictive shared power constraint, can’t charge from grid, DC-coupling): single market modeling.
  - Separate market modeling for such units presents several challenges today.
- **Only Energy Storage Resources that opt in to the Order 841 model can schedule and be dispatched for negative energy (i.e., charging).**
  - **Under Order 841, hybrids are not Energy Storage Resources**

Status Quo for Hybrid Market Participation

- All resources scheduling energy with a dispatchable range in real time can be co-optimized for energy and ancillary services (i.e., Regulation and Synchronous Reserve).

- With single market modeling of hybrids, all settlements and ancillary service measurements are at the point of interconnection (POI).
  – Therefore, in order to avoid charges associated with deviation from economic dispatch, and in order to provide ancillary services, the plant controller would have to control the storage and the solar such that the sum (as measured at the point of interconnection) meets PJM's dispatch.

Configurations vs. Status Quo Market Participation

Inverter sharing and physical configuration	DC-coupled	DC-coupled	AC-coupled	AC-coupled	AC-coupled, no interactions between components*
Grid charging	Open loop	Closed loop	Open loop	Closed loop	Open loop
Additional Capacity MW eligibility beyond solar alone—**status quo**	Yes	No	Yes	No	Yes
Additional Capacity MW eligibility beyond solar alone—**PJM proposal for ELCC at CCSTF**	Yes	Yes**	Yes	Yes**	Yes
PJM-preferred Energy and Capacity market modeling	Single unit	Single unit	Single unit	Single unit	Option for 1 or 2 units
Status quo scheduling/dispatch of charging energy	No	N/A	No	N/A	Yes if 2 units

**e.g., because MFO ≥ total MW capacity of all inverters.*

***Note that PJM's 2d-draft ELCC results show ~the same value for closed loop hybrids as for open loop hybrids.*

Appendix: Proposal for ELCC for Hybrids

Deployment (in Gigawatts) for the 6 Scenarios

#	Wind	Solar	Storage (4,6, or 10 hour)	Storage (8 hour)	Solar + Storage Hybrid (Open Loop)	Solar + Storage Hybrid (Closed Loop)	Hydro w/o Storage	Landfill Gas	Hydro w/ Storage
1	12	7	0.4	5	0.3	0.3	0.7	0.3	2
2	15	11	0.9	5	0.5	0.5	0.7	0.3	2
3	19	16	1.5	5	0.8	0.8	0.7	0.3	2
4	22	22	2	5	1	1	0.7	0.3	2
5	23	31	3	5	2	2	0.7	0.3	2
6	25	40	5	5	2	2	0.7	0.3	2

2nd Draft ELCC Results w/ New ESR as 4-hour Duration

#	Wind	Solar	Storage (4 hour)	Storage (8 hour)	Solar + Storage Hybrid (Open Loop)	Solar + Storage Hybrid (Closed Loop)	Hydro w/o Storage	Landfill Gas	Hydro w/ Storage
1	10%	65%	92%	100%	97%	97%	49%	58%	100%
2	9%	59%	86%	98%	96%	96%	48%	59%	97%
3	9%	49%	74%	95%	86%	86%	51%	63%	97%
4	9%	40%	75%	93%	85%	85%	51%	62%	94%
5	9%	33%	81%	94%	74%	73%	51%	61%	92%
6	9%	27%	79%	94%	71%	71%	51%	59%	94%

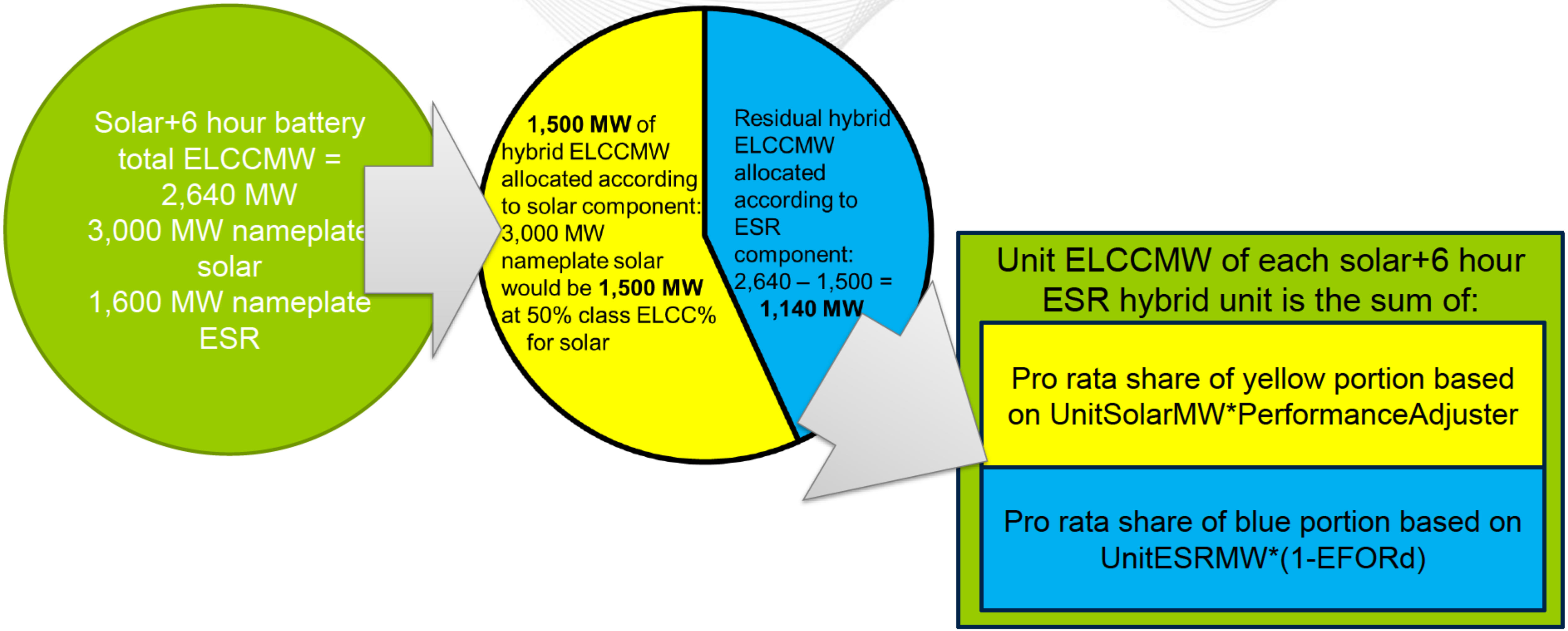
PJM Proposal for Capacity Capability Value of Hybrids*

1. Calculate ELCC reliability value of entire hybrid class
2. Use a heuristic to allocate those MW among hybrid units (big vs small ESR) incl. performance adjuster
3. Unit ELCC capacity capability value

ELCC = Effective Load Carrying Capability

**capacity capability proposals are currently under discussion at the [Capacity Capability Senior Task Force](#).*

ELCC Model Example: Solar + 6hr ESR Open Loop



ELCC Model for Hybrids

- Each class of hybrid resources to be modeled separately. Each will have a separate hybrid class total ELCCMW calculated. There would be a total of 12 classes:
  - Open loop (i.e., capable of charging from grid)-- Solar+4 hour ESR, Solar+6 hour ESR, solar+10 hour ESR, other Gen+4 hour ESR, other Gen+6 hour ESR, other Gen+10 hour ESR
  - Closed loop (i.e., incapable of charging from grid)-- Solar+4 hour ESR, Solar+6 hour ESR, solar+10 hour ESR, other Gen+4 hour ESR, other Gen+6 hour ESR, other Gen+10 hour ESR
- Total ELCCMW per class would be allocated to each unit in the class via 2 metrics for each unit:
  1. [Solar/other gen nameplate MW]*PerformanceAdjuster
  2. [ESR nameplate]*(1-EFORd)
- The share of the hybrid class total ELCCMW that is allocated by each of the two above metrics is based on:
  A. Share of the hybrid class total ELCCMW corresponding to the solar/other gen ELCC. I.e.: [total nameplate solar/other gen]*[Class ELCC% of the solar/other gen class]
  B. Share of the hybrid class total ELCCMW corresponding to the ESR is the residual ELCCMW after subtracting the solar/other gen ELCC MW identified in step A above.

ELCC: Hybrid Class and Unit Example

- ELCC model shows 2,640 MW total ELCCMW value for class of solar+6 hour storage.
- This class has 3,000 MW total nameplate of solar components and 1,600 MW total nameplate of ESR components.
- The ELCC% for the solar-alone class is 50%.
- The 2,640 MW hybrid class ELCCMW is divided into:
  - 3,000 MW * 50% = 1,500 MW related to the solar components
  - 2,640 MW – 1,500 MW = 1,140 MW related to the ESR components
- A given hybrid unit will have ELCC credit based on the sum of:
  - [1,500 MW/3,000 MW]*[Unit solar nameplate MW]*[PerformanceAdjuster] plus
  - [1,140 MW/1,600 MW]*[Unit ESR nameplate MW]*[1-EFORd]
- A hybrid with 100 MW solar and 25 MW storage, 110% solar Performance Adjuster, and 10% EFORd, would therefore have an ELCCMW of:
  - 0.5*100*110% = 55 MW, plus
  - 0.7*25*(100% - 10%) = 15.8 MW

→ **70.8 MW**

Hybrid Deployment Scenarios for ELCC model

- Developed from Queue numbers
- Subtracted from solar, storage, and other relevant deployment assumptions via vendor forecast

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