Market Models & Forecasting for Hybrid Power Plants
The value of partitioning responsibility, even when letting go is difficult

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Definition

Hybrid Resource: A combination of multiple technologies that are physically and electronically controlled by the Hybrid Owner/Operator behind the point of interconnection ("POI") and offered to the grid operator (or to the customer) as a *single resource*

If treated as multiple resources, it is "co-located" rather than "hybrid"
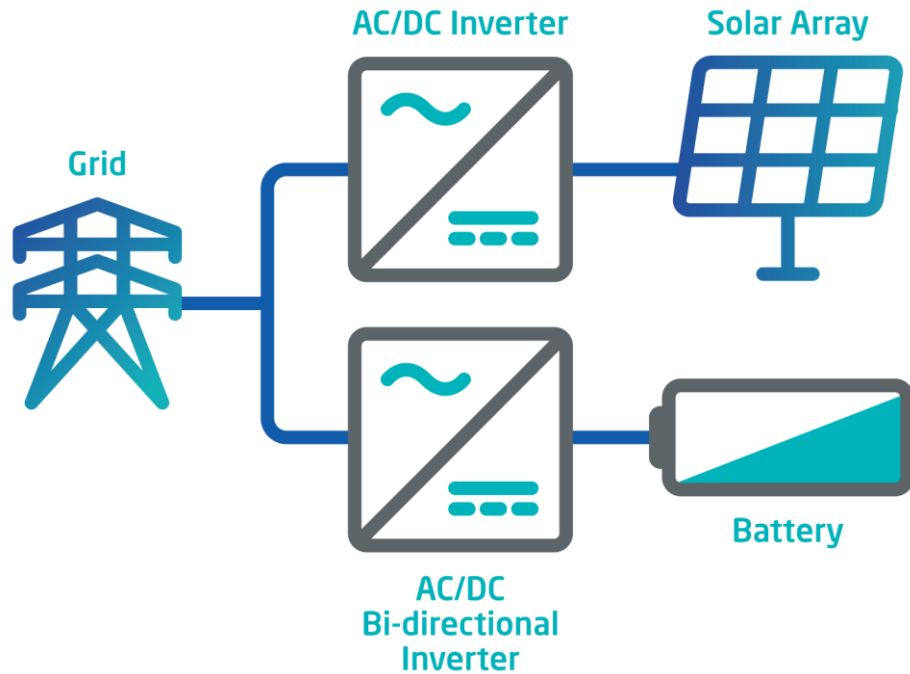
A "True" Hybrid Resource

Uses an "intelligent agent" approach that internalizes the characteristics of the components behind the POI and offers energy and services at the POI like a conventional resource, but with more flexibility and fewer constraints through coordinated use of energy, storage, power electronics and software technologies
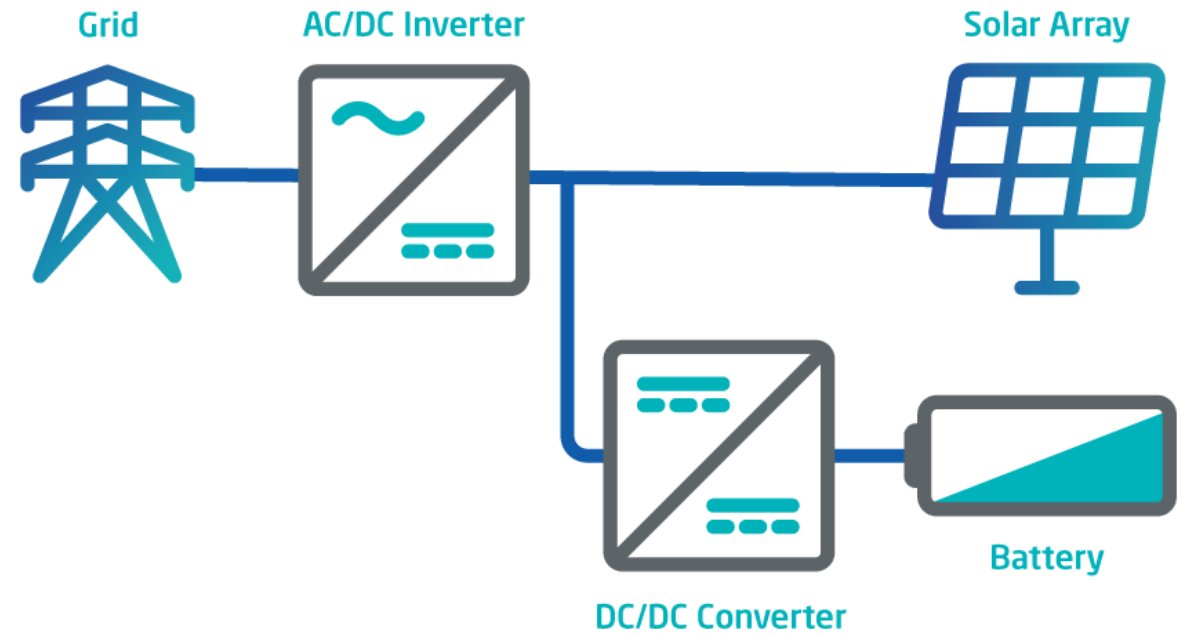
Or said more simply…

With sufficient energy, storage, electronics and software, we can emulate any kind of electrical machine that we want

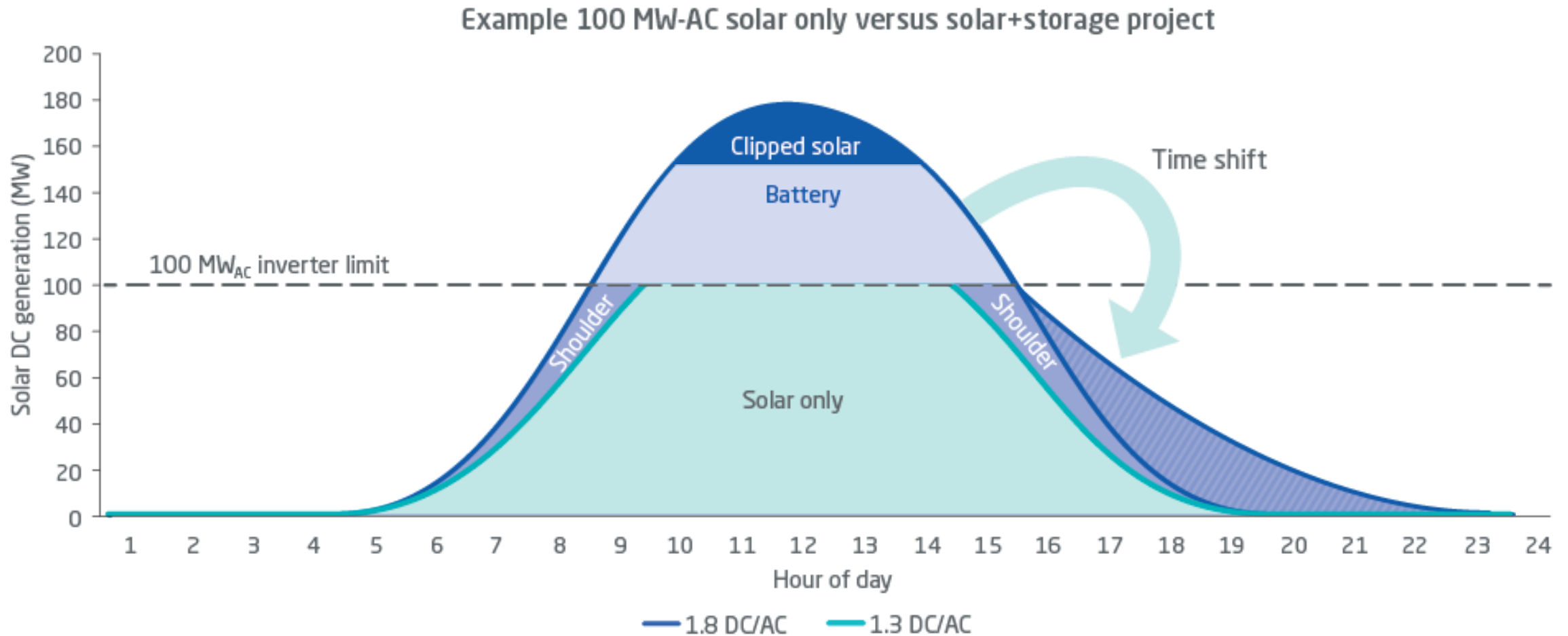# Examples: AC Coupled and DC Coupled Solar PV + Storage

AC Coupled

DC Coupled

Maximizing capabilities with DC-coupled energy storage

Example 100 MW-AC solar only versus solar+storage project

Benefits of Hybrid Resources

- Can emulate an existing resource model, but with more flexibility and control
  - A renewable plant that can provide not just "as available" energy, but also other services without needing to retain headroom (i.e., self-curtailing energy) to do it
  - A gas plant that can start instantly and ramp down to zero

- Directly managing batteries is complicated – hybrids simplify things for the customer
  - The Hybrid Owner/Operator manages battery state-of-charge (through their offers of services) and optimizes the operation of all the components in the hybrid
  - The customer sees a simpler interface that more directly matches their needs

- In markets, provides a simpler and "more ideal" offer to the market operator
  - The storage component of the hybrid can be charged from the renewable/generator component or from the grid—and that's an economic choice
  - Provides fully convex, one-part offers[*] without advance commitment requirements, startup costs, minimum generation levels or other constraints

[*] Monotonically increasing energy offers without startup or no-load fees. For a good explanation of convexity and offers, see:
https://www.iso-ne.com/static-assets/documents/2015/06/price_information_technical_session11.pdf
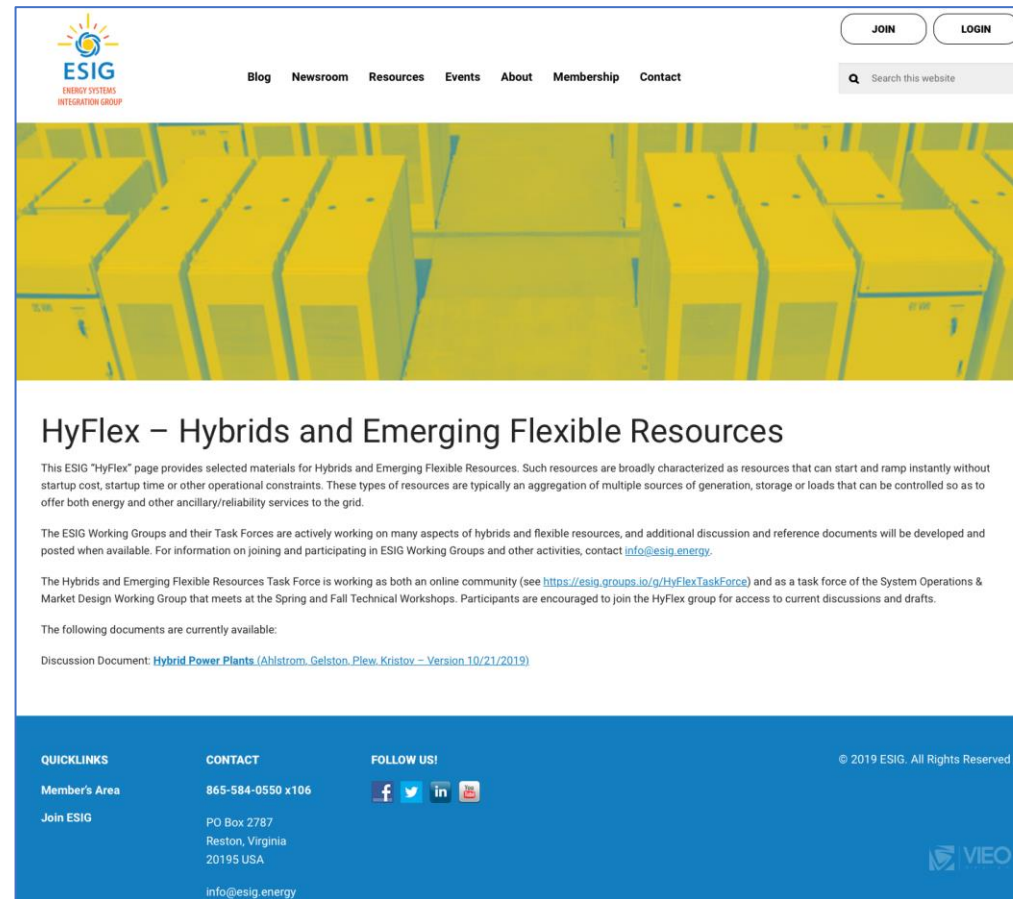
Motivates Beneficial Behavior

- Hybrids are motivated to use the best forecasting and optimization methods
  - Example: probabilistic PV forecasts backed by storage to firm variability and uncertainty

- Hybrids are motivated to use sophisticated analytics, controls and innovation
  - Deeply understanding battery degradation performance, opportunity costs and risks
  - Optimizing the power plant design to maximize the services that are most useful and valued, while minimizing the risk of delivering such services
  - Constantly working to improve, innovate and be better at providing value

- Never stop innovating!

Closing Thoughts

1) With generation, storage, electronics and software, we can emulate any desired electrical machine that we want to see at the point of interconnection (POI)

2) Intelligent Agent Model – internalizes the characteristics of the components behind the POI and offers energy and services at the POI like a conventional resource, but with more flexibility and fewer constraints

3) This is a Virtual Power Plant – focus on services at the margin, fix outdated rules

4) *"You focus on your job, we'll focus on our job"*
   - Don't worry about optimizing my factory for me, because I can do that better than you can
   - Pay for performance, encourage innovation and upgrades

5) Power systems and power markets aren't as unique as we think they are
   - Other industries (software, electronics, communications, music, photography…) have been using these methods for decades – the digital revolution is here!

Discussion paper is available

https://www.esig.energy/hyflex-hybrids-and-emerging-flexible-resources/

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