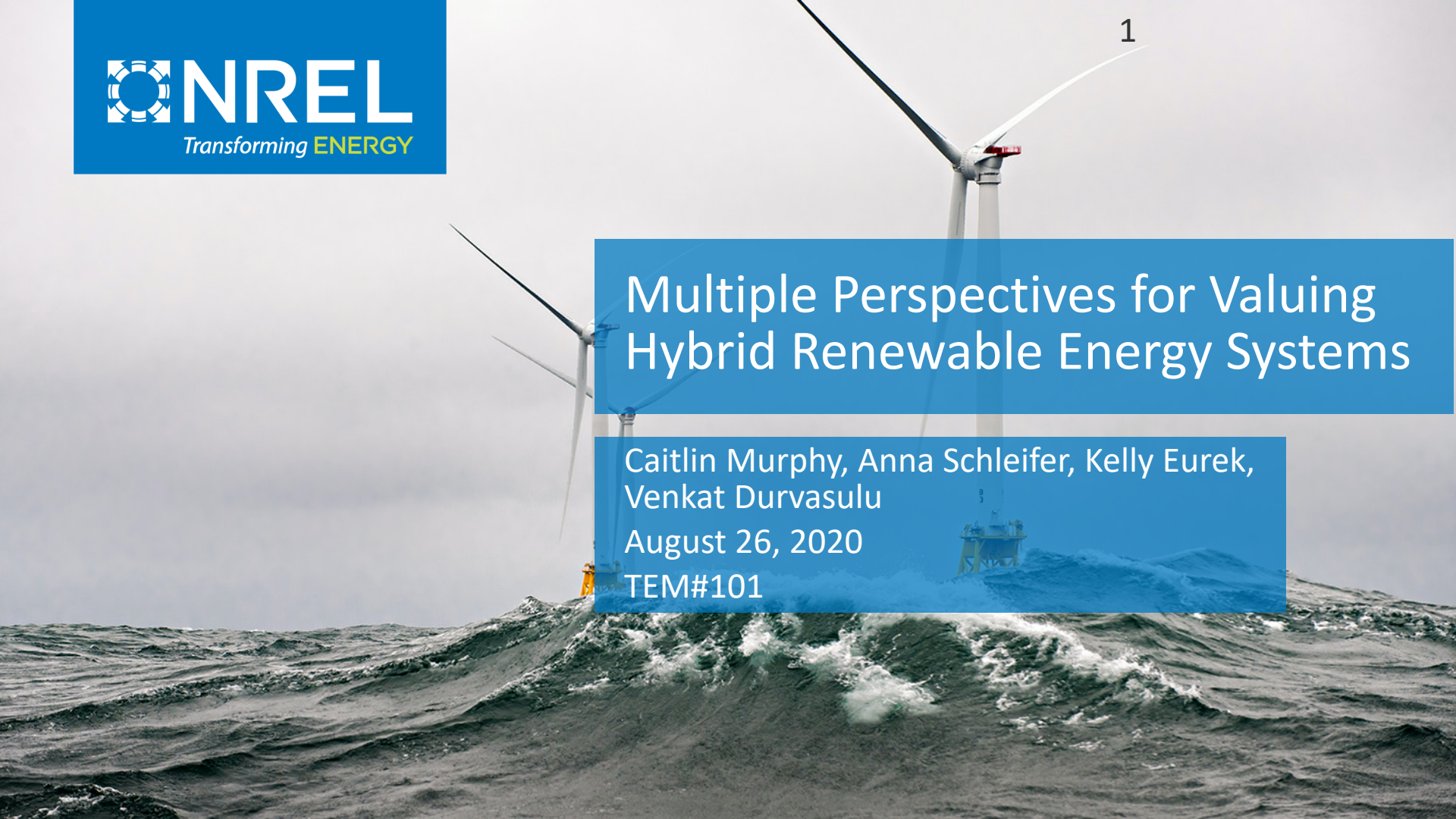

Multiple Perspectives for Valuing Hybrid Renewable Energy Systems

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TEM#101

A broad view of hybrid renewable energy systems (HRES)

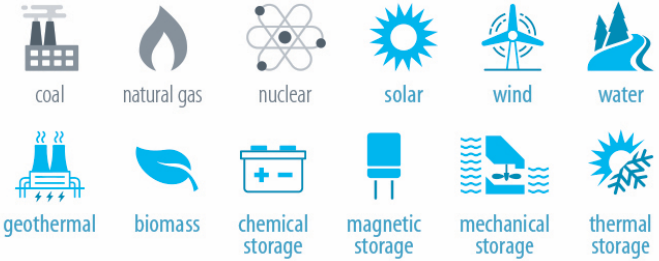
We began by surveying systems comprising multiple technologies that are locationally and/or operationally linked in order to realize net economic benefits, relative to comparable independent systems.

Hybrid Energy Systems

A broad universe that encompass...

A wide variety of energy generation and storage technologies

Our scope focuses on:
Systems that include commercially available renewable energy and/or energy storage technologies



Systems connected to the bulk grid, the distribution network, or remote microgrids

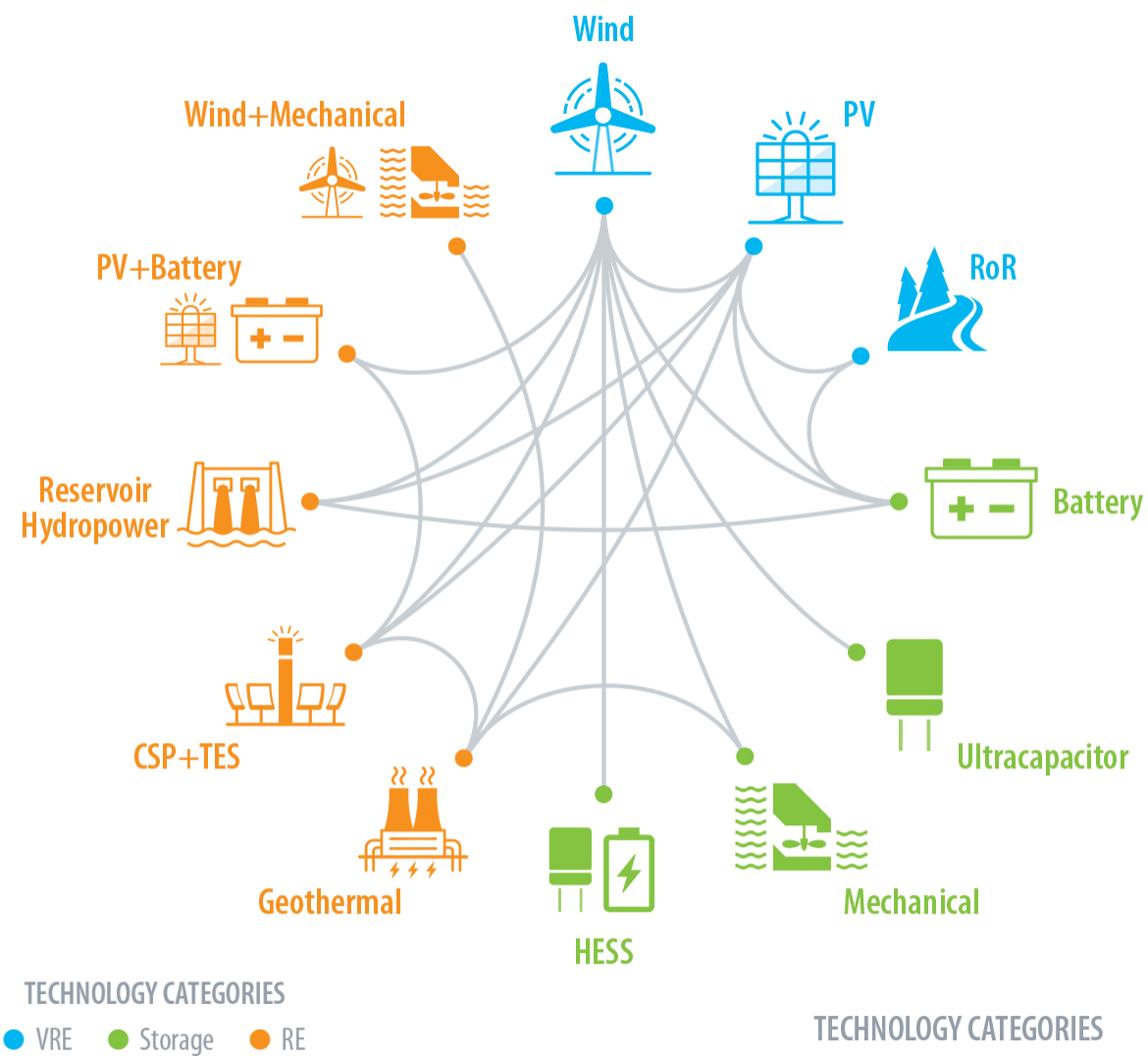
Our scope focuses on:
Systems connected to the bulk grid

Systems that provide a variety of energy services and products

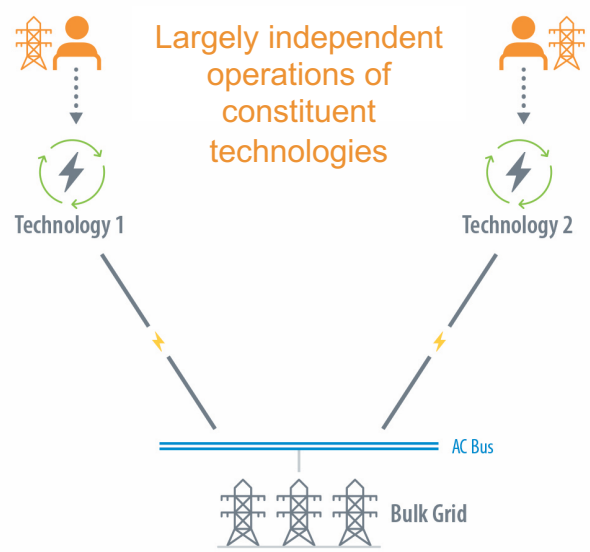
Our scope focuses on:
Systems for which electricity is the only output

HRES in the Literature

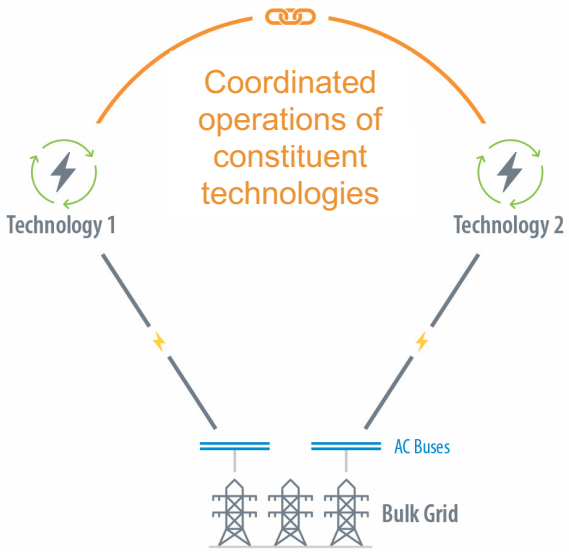
The literature indicates commonalities among diverse technology combinations, which are often motivated by complementary resource profiles or capabilities



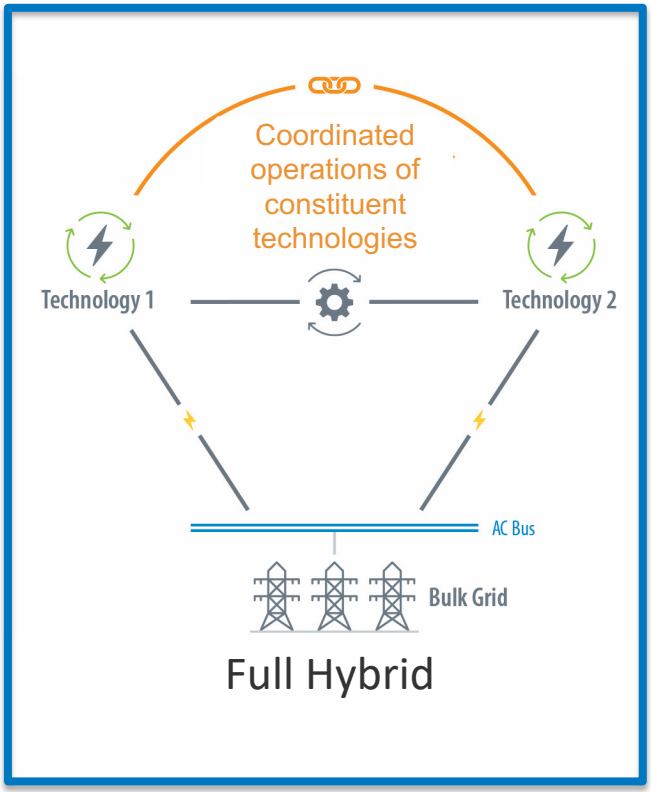
Proposed HRES Taxonomy



Co-Located Resources



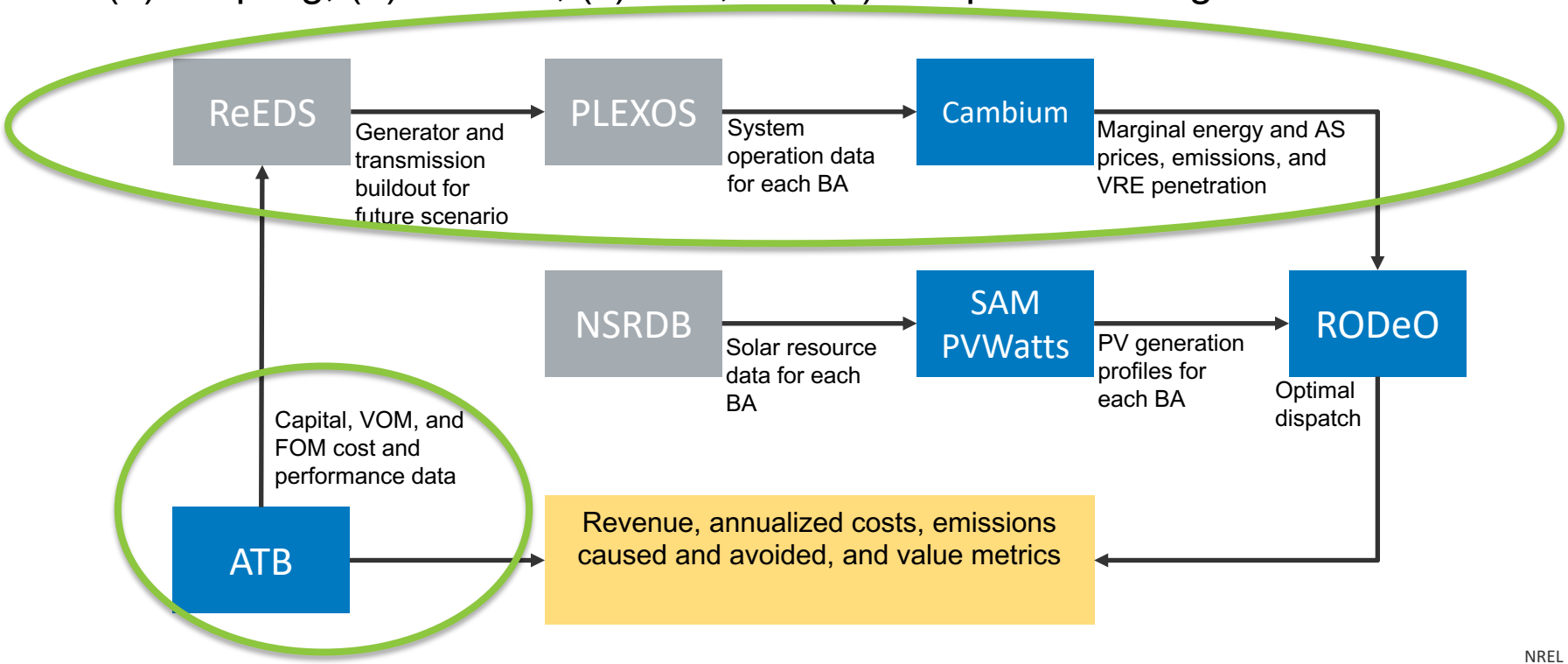
Virtual Power Plant



Full Hybrid

Valuing HRES from the Plant-Owner's Perspective

There is a need to understand how the value of HRES vary as a function of (a) coupling, (b) location, (c) time, and (d) component sizing

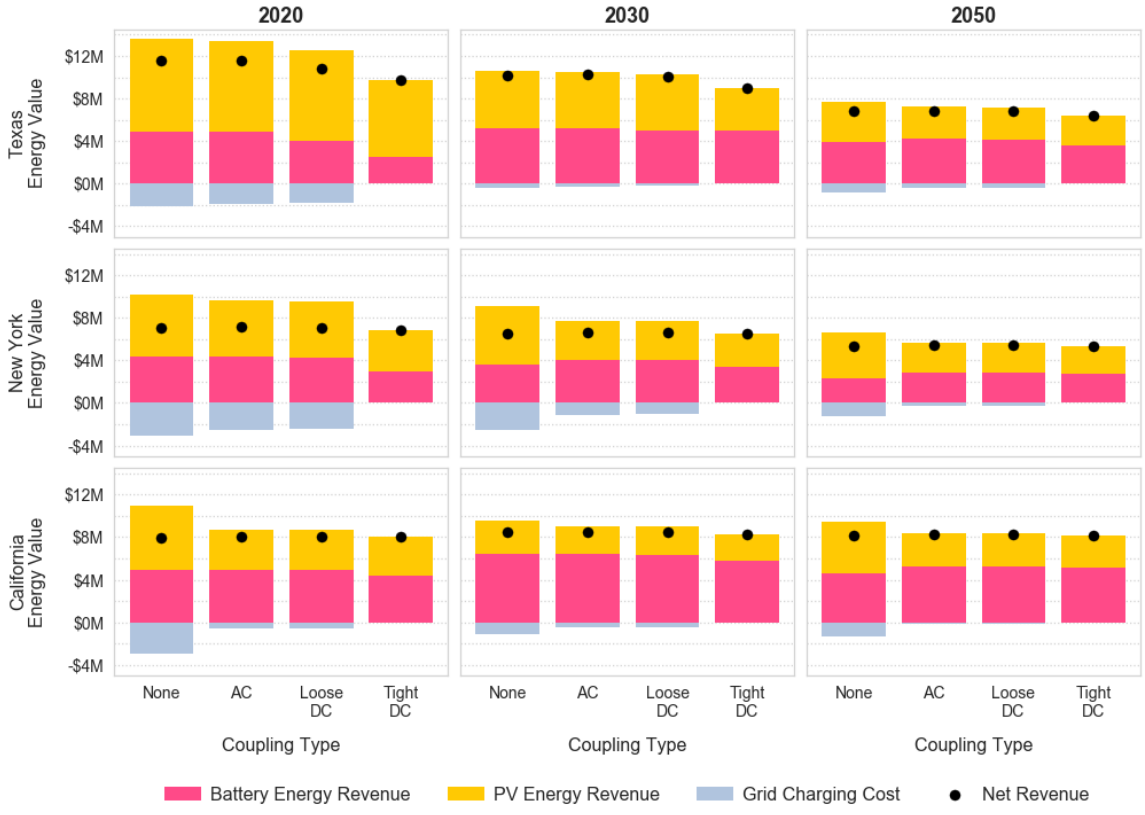


Valuing HRES from the Plant-Owner's Perspective

- Energy value varies by location (mostly based on PV penetration) and coupling type, but it ultimately converges to a similar value
- Capacity value favors AC-coupling at low-penetrations of PV and declines to the value of the storage component

Needs:

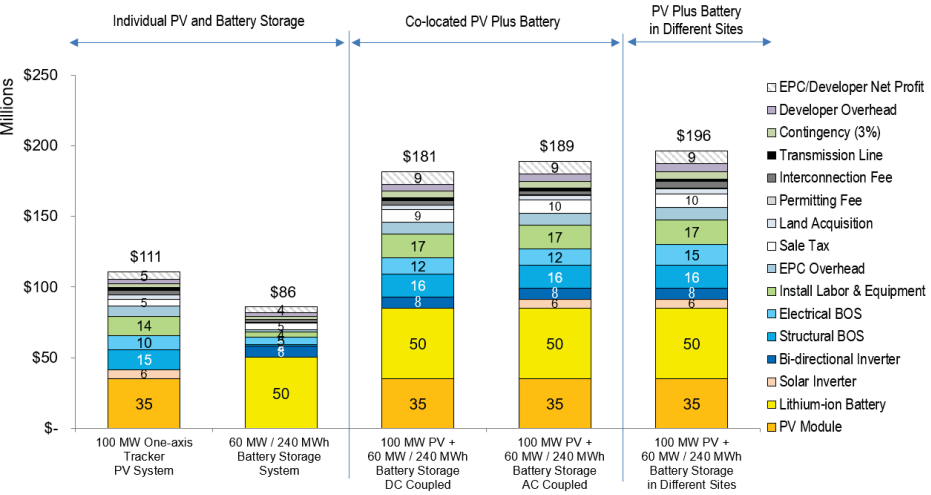
- Incorporate high-value (but likely shallow) value streams
- Explore higher ILRs
- Account for degradation effects



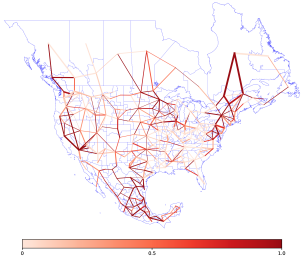
Preliminary results shown for a 100 MW_{DC} PV array, 77 MW_{AC} inverter, 60 MW_{AC} 4-hour battery, ILR 1.3

Valuing HRES from the Power System Perspective

Changes in Costs



https://ieeexplore.ieee.org/document/8547852



Changes in Value

- Peaking resource
- Energy Production
  - Curtailment recovery
  - Clipping recovery (clipping occurs when ILR > 1)
  - Low voltage harvesting
- Energy arbitrage
- Renewable Policy Requirements
  - State RPS; solar carveout
  - Storage mandates
- Ancillary services
  - Supply: Storage discharge; PV down ramp
  - Demand: PV capacity during day hours

Closing Thoughts: Research Needs

Hybrid-Owner Perspective	System-Level Perspective
Accounting for (but being realistic about the depth of) high-value services	Capturing technology interactions/synergies in system-level models (including policy)
Accounting for degradation effects (for storage-based hybrids)	Updating resource characterizations for hybrids with multiple generation sources
Exploring dramatically oversized systems	Flexible representations of *hybridization*
Standardized baselines for comparison	Endogenous hybrid system design
Understanding and quantifying potential discrepancies in the plant-level optimum vs. the system-level optimum (design and operation)	