Storage Plus: Exploring the Potential for Energy Storage and Generation Hybrids

April 20, 2021

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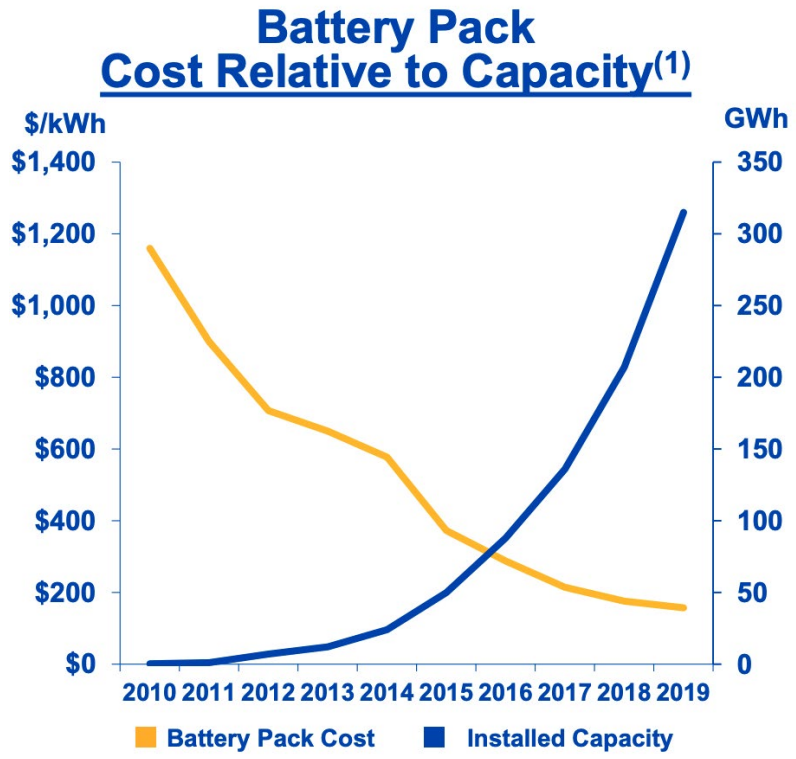
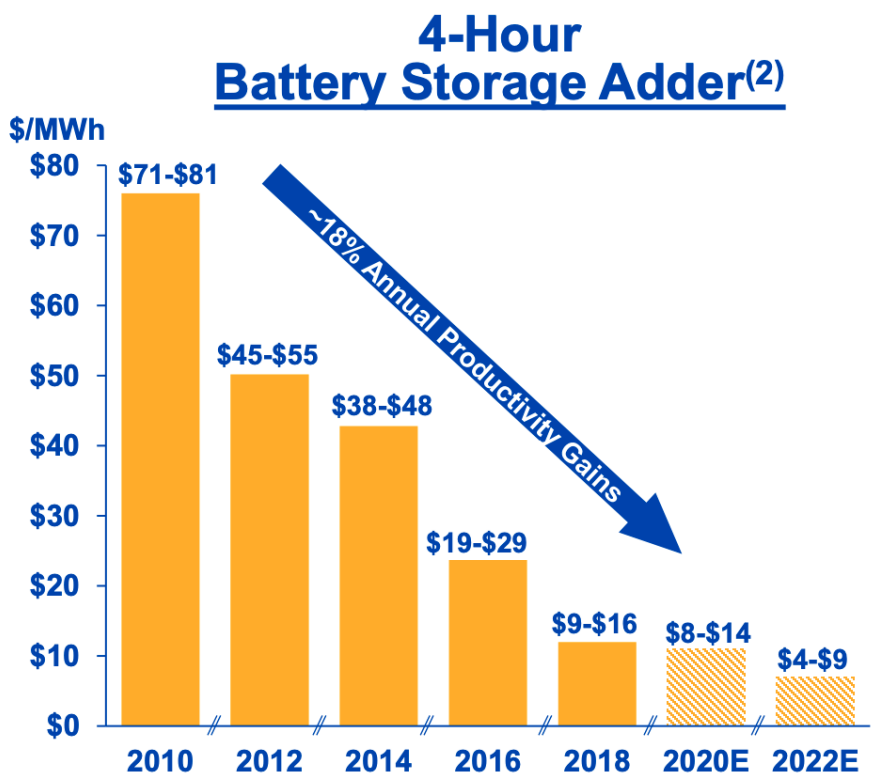
Exploring the Potential for Energy Storage and Generation Hybrids





Adding battery storage is becoming cheaper and cheaper as the industry's learning curve improves

Left Figure Source: Bloomberg NEF, Right Figure Source: Energy Resources' estimate based on Bloomberg NEF assumptions

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Exploring the Potential for Energy Storage and Generation Hybrids

- Hybrids can have several advantages over stand-alone projects, including cost savings and operational synergies.
- Hybrid co-location can provide **7-8% cost savings** by reducing costs related to site preparation, land acquisition, permitting, interconnection, etc.
- There may be trade-offs for the system performance and flexibility depending on the technical configuration

Source: https://www.nrel.gov/docs/fy19osti/71714.pdf

India: Researchers predict India's wind-solar hybrid capacity will soar from its current 148MW level to nearly 11.7GW by 2023. Recent Round the Clock Tenders have integrated storage.

Source: https://www.pv-tech.org/indias-wind-solar-hybrid-capacity-expected-to-reach-nearly-11-7gw-by-2023/

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Today's Speakers

Sarah Lawson

Senior Energy Analyst, USAID

Caitlin Murphy

Senior Energy Policy Analyst, NREL

Sika Gadzanku

Energy Technology and Policy Researcher, NREL

Poll Questions – Answer in Zoom

1. Is your country or organization currently considering integrating storage plus generation hybrid technologies?

2. What hybrid technology combinations are being considered now or may be considered in the near future?

3. What are the biggest barriers you see to deploying hybrid technologies?

Storage Plus

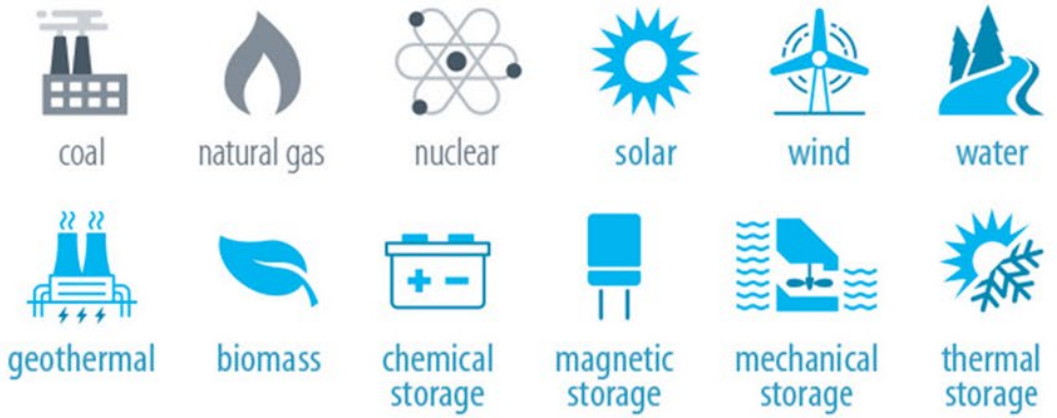
Exploring the Potential for Energy Storage and Generation Hybrids

Caitlin Murphy | Senior Energy Analyst, National Renewable Energy Laboratory | April 20, 2021

Hybrid Energy Systems: A Broad Universe Spanning Many Technologies, Scales, and Products

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

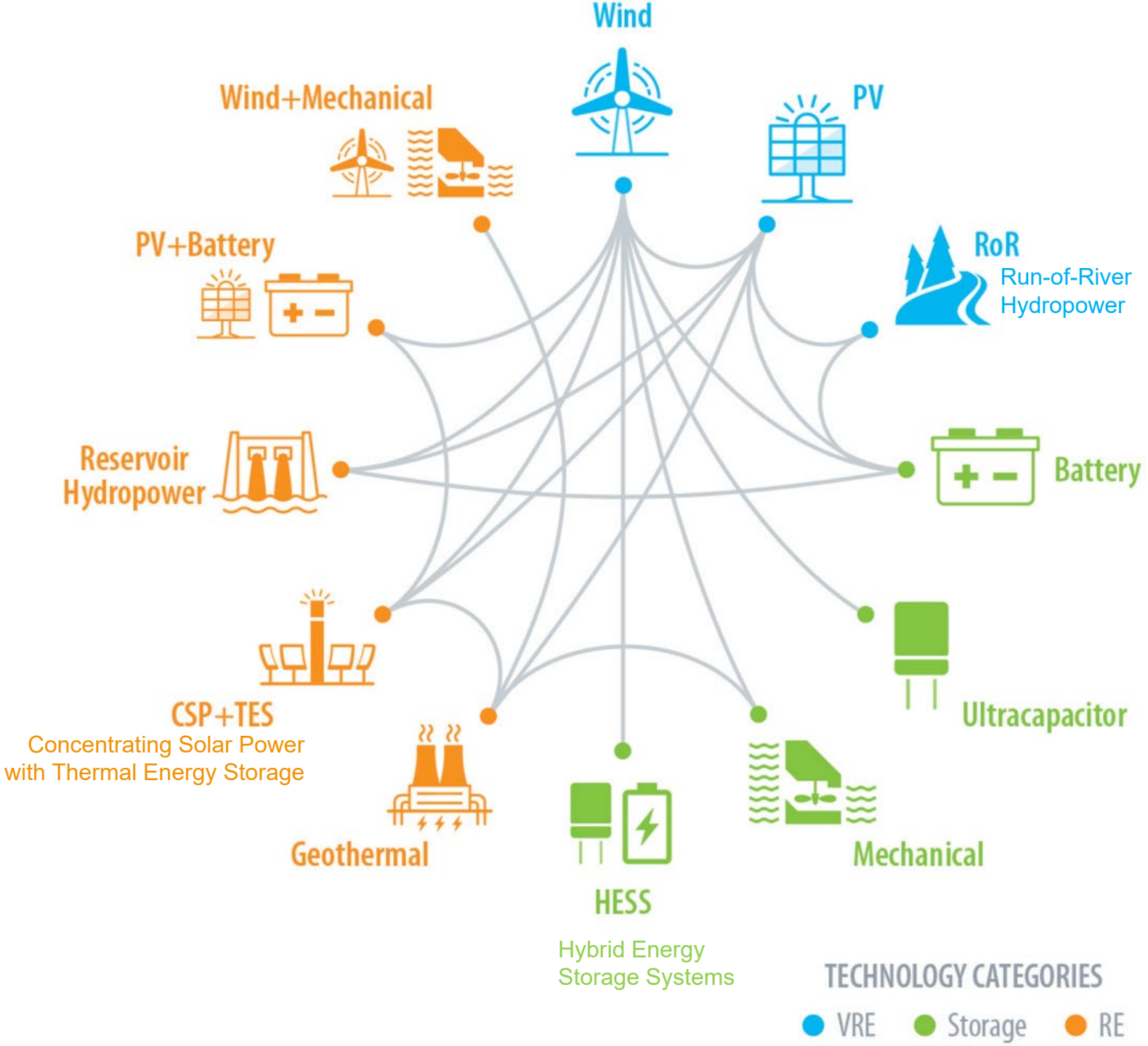
Our scope focuses on:
Systems connected to the bulk grid

Systems that provide a variety of energy services and products

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

Proposed Technology Combinations

There are commonalities among diverse technology combinations, which are often motivated by *complementary resource profiles* or *complementary capabilities.*



Key Questions Related to Hybridization

Interest in utility-scale generation-plus-storage projects is growing rapidly…

- What is the underlying motivation for such projects? Is industry interest driven by incentives or cost and value synergies?
- What are the most important aspects of hybridization that influence the competitiveness of hybrid vs. separate resources?
- Under what conditions does it make sense to combine multiple utility-scale generation and energy storage technologies?
- Does the optimal hybrid project vary based on perspective (e.g., plant-owner vs. system operator)?

Key Takeaways

- Hybrid projects combining PV-plus-battery, wind-plus-storage, and PV-plus-wind projects are commercially viable worldwide today, and a wider range of hybrid systems are likely viable in developing grids.
- Adding storage to variable renewable resources can facilitate many benefits:
  - **Renewable energy integration** by aligning the resource with load and mitigating short-term variability
  - **Increasing capacity factors** by utilizing generation that would otherwise be wasted
  - Localizing the provision of **high-value services**
  - **Cost savings** for cost categories that are applied once per project
- Many of the benefits attributed to hybrid systems can also be achieved through grid-level coordination of independent projects.

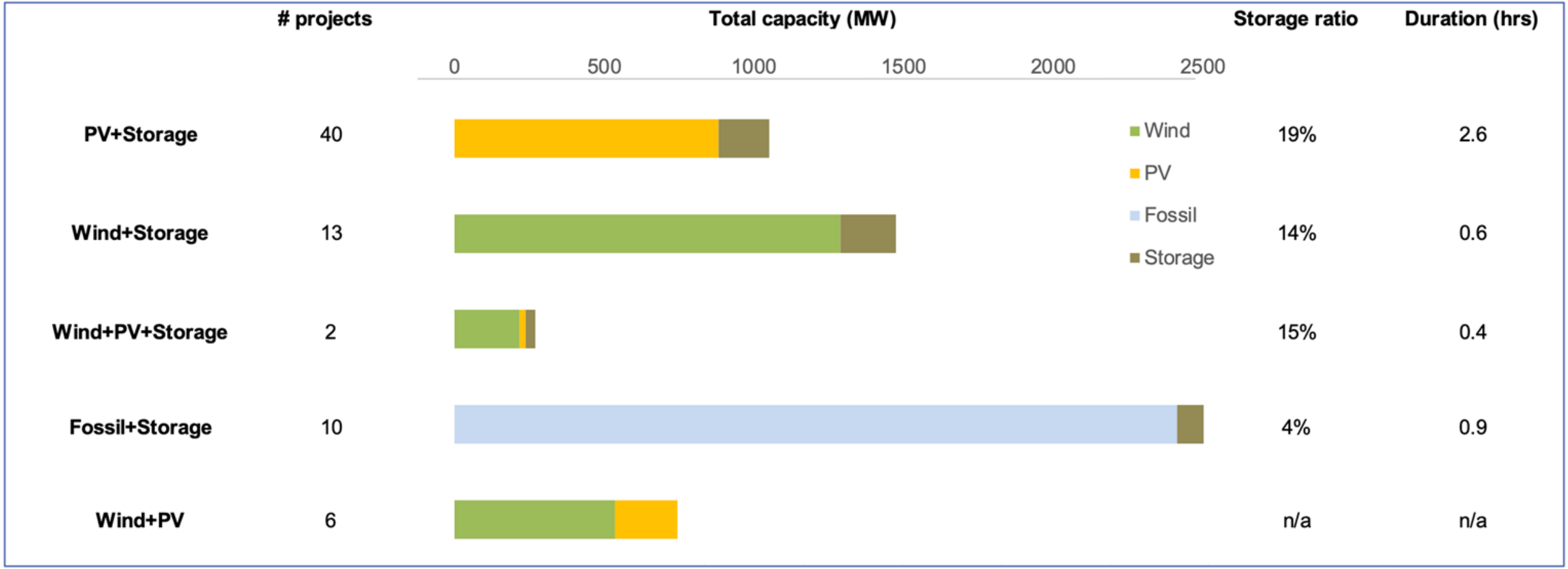
Online and Proposed Projects: A U.S. Example

Which technology combinations are commercially viable today?

What is a typical design, in terms of sizing and storage duration?

What is the expected role of storage-plus hybrids in the future?

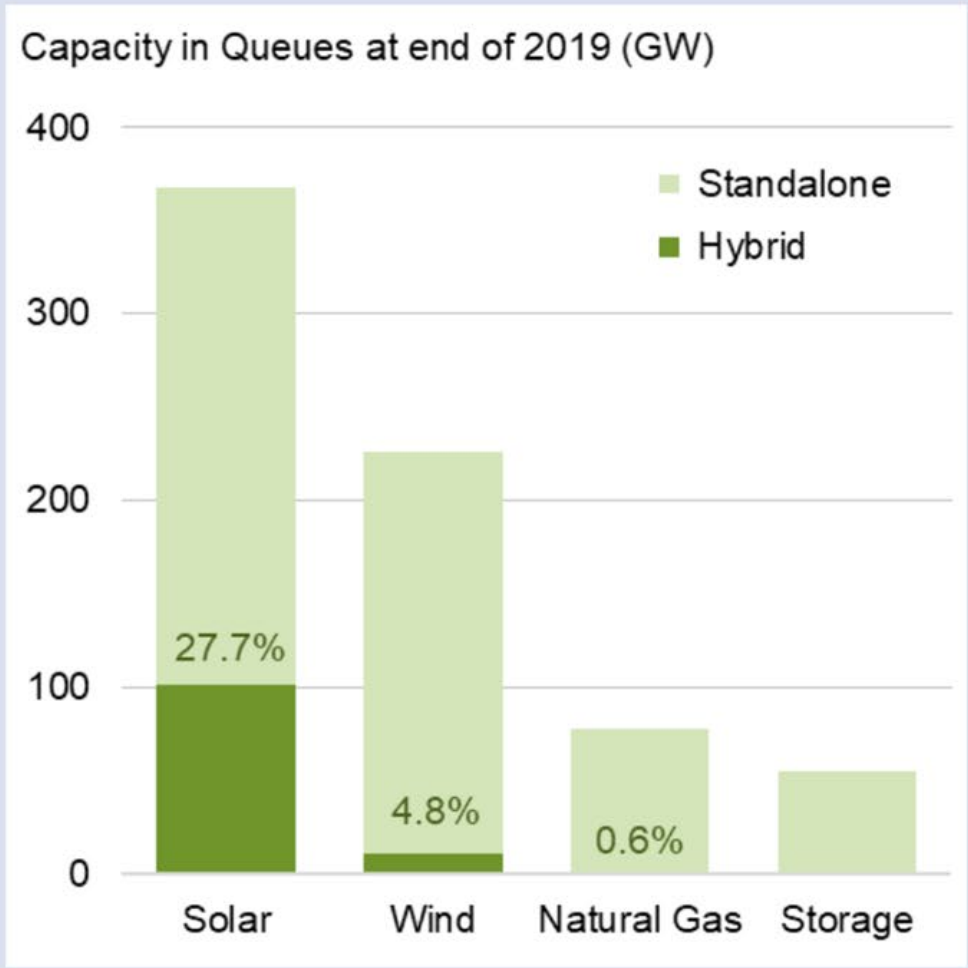
Hybrids and Co-Located Resources: Example from the U.S.



- Co-locating multiple generation and storage technologies
- Varying degrees of operational coordination (joint scheduling)

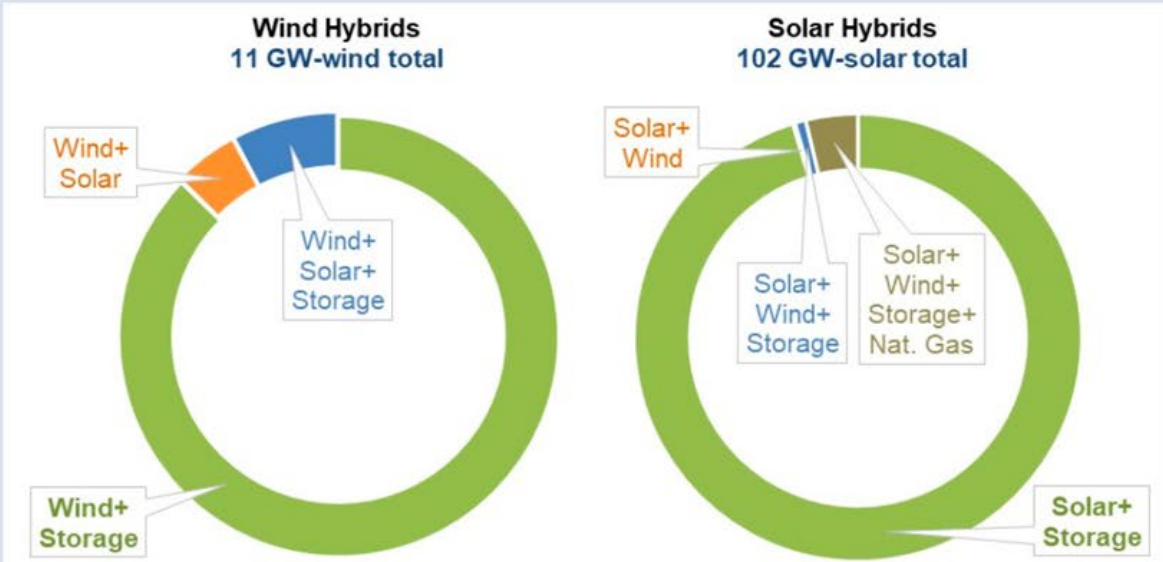
https://eta-publications.lbl.gov/sites/default/files/hybrid_plant_development_2020.pdf

Hybrids Represent a Significant Share of Proposed Projects



Source: Berkeley Lab review of interconnection queues

Solar+Storage and Wind+Storage configurations are more common than other hybrid types[1]

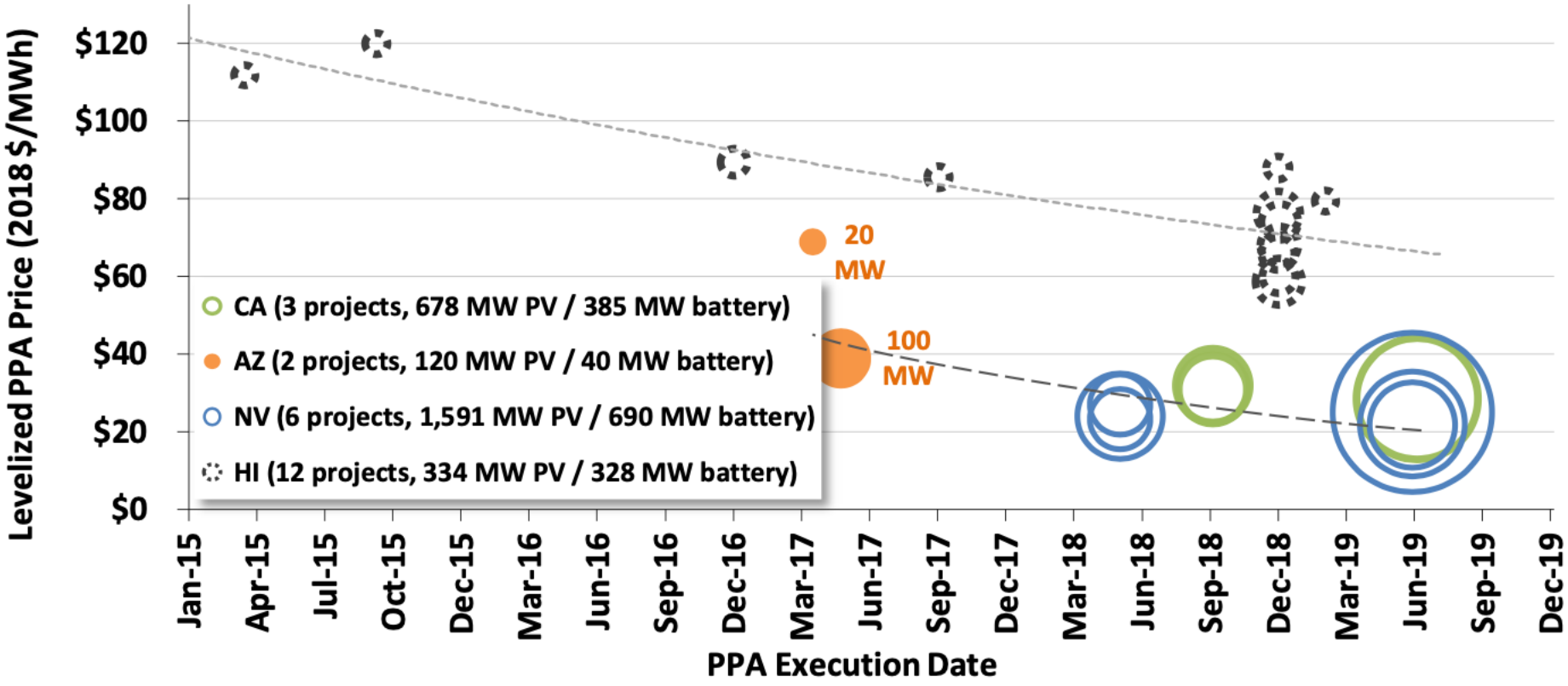


[1] Emphasis was placed on identification of wind+storage and solar+storage: other hybrid configurations are likely undercounted.

https://eta-publications.lbl.gov/sites/default/files/hybrid_plant_development_2020.pdf

Power Purchase Agreements for PV-plus-Storage

- Bundle storage cost into the overall energy price
- Compensate storage through a separate fixed capacity payment
- Compensate storage only for certain hours throughout the year
- "Renewable dispatchable generation" PPA (unique to Hawaii) pays projects through a lump sum for being able to be dispatched by the offtaker

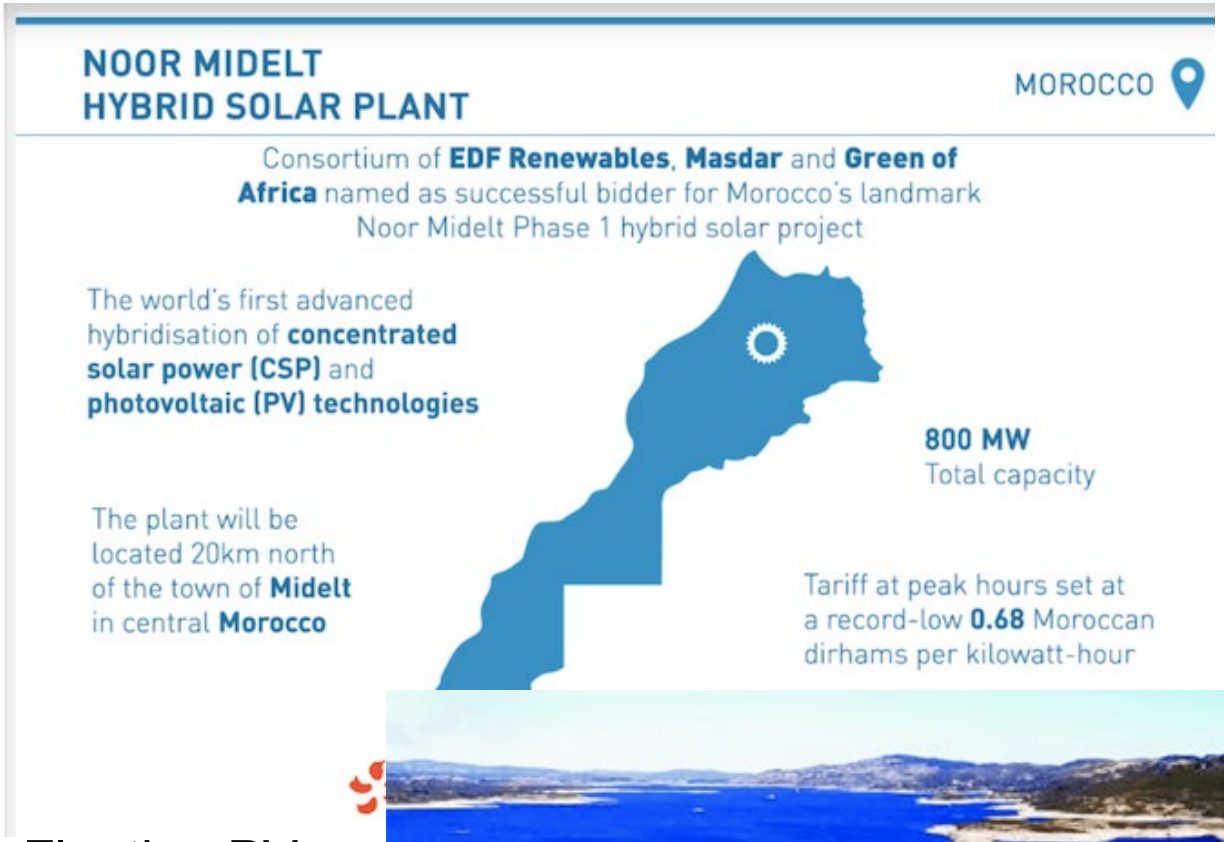


Hybrids Across the Globe: A Larger & Broader Mix

PV+Wind Hybrids in India

Recent research indicates “wind-solar hybrid capacity [in India] will soar from its current 148MW level to nearly 11.7GW by 2023.”

PV Tech Article, October 2020



Floating PV on hydropower reservoirs…

More to come!

Motivations for Solar-Plus: Cost and Value Synergies

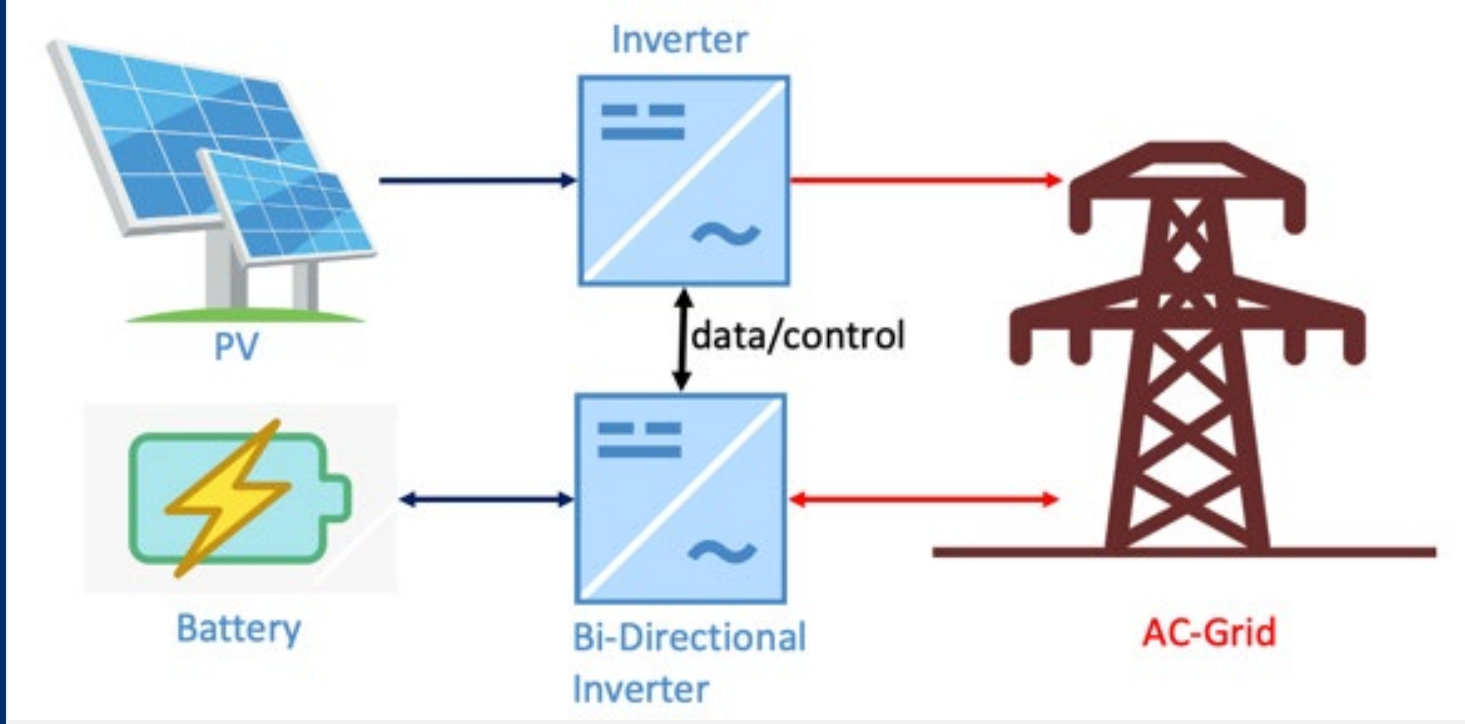
How do you decide if a hybrid project is cost effective?

What *value* factors influence this?

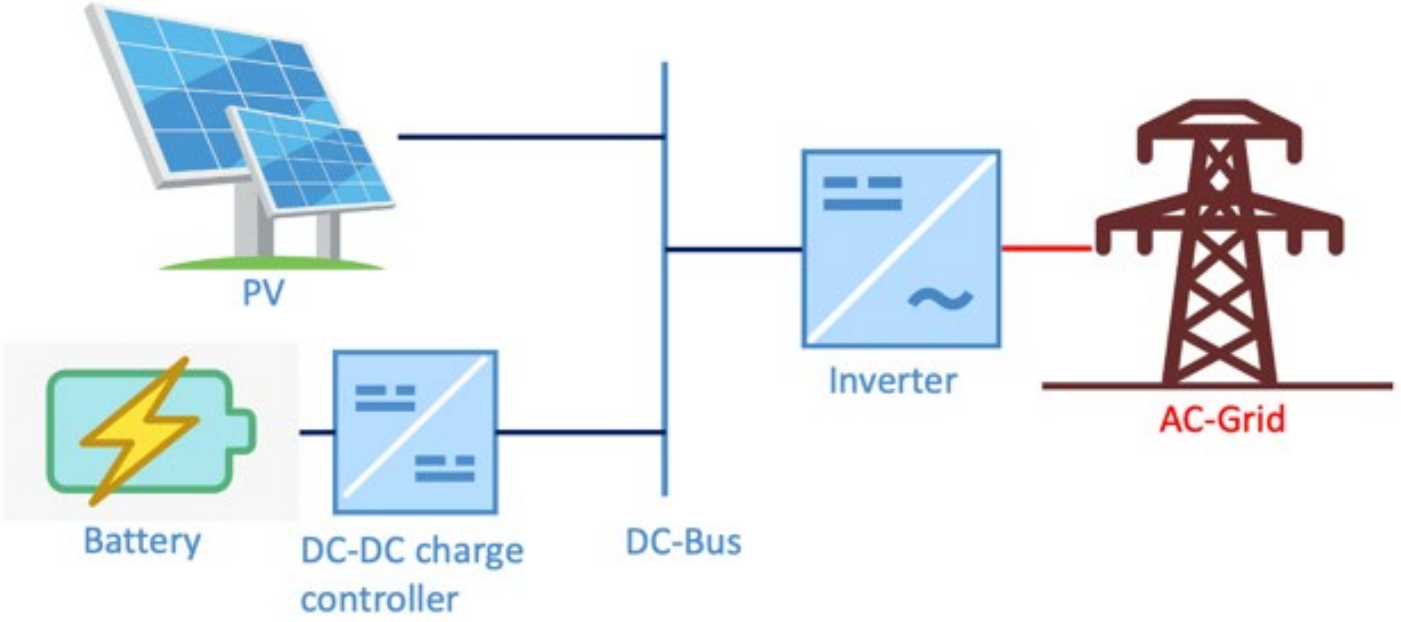
What is the future deployment potential?

How might such projects be compensated?

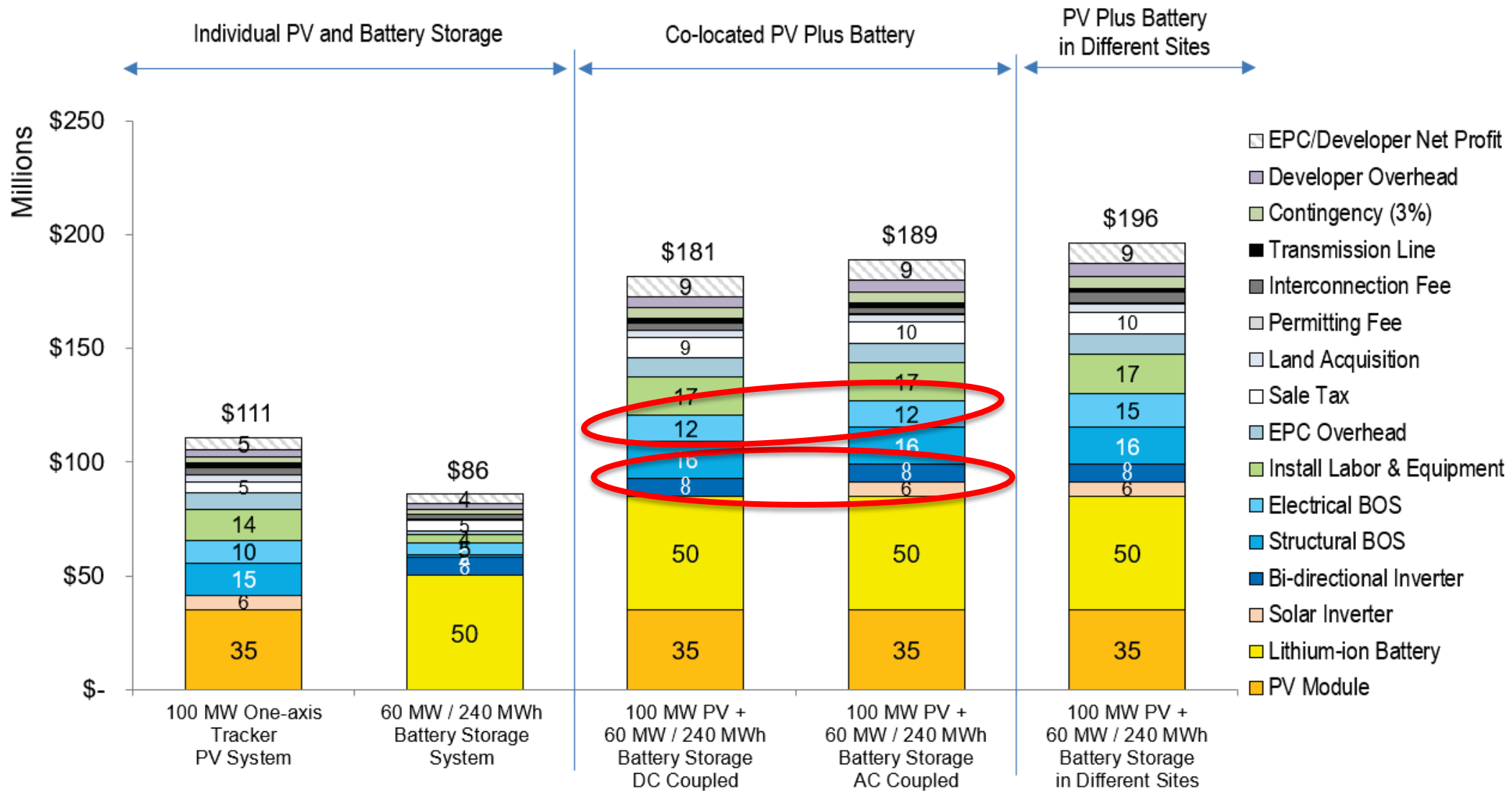
Separate Inverters: Value synergies may be limited in so-called “AC coupled” systems, but they also allow for more flexible operations and use of existing participation models



Shared Inverter: Using a single PV or battery inverter enables more value synergies in “DC coupled” systems, but it also introduces competition and potentially interconnection challenges

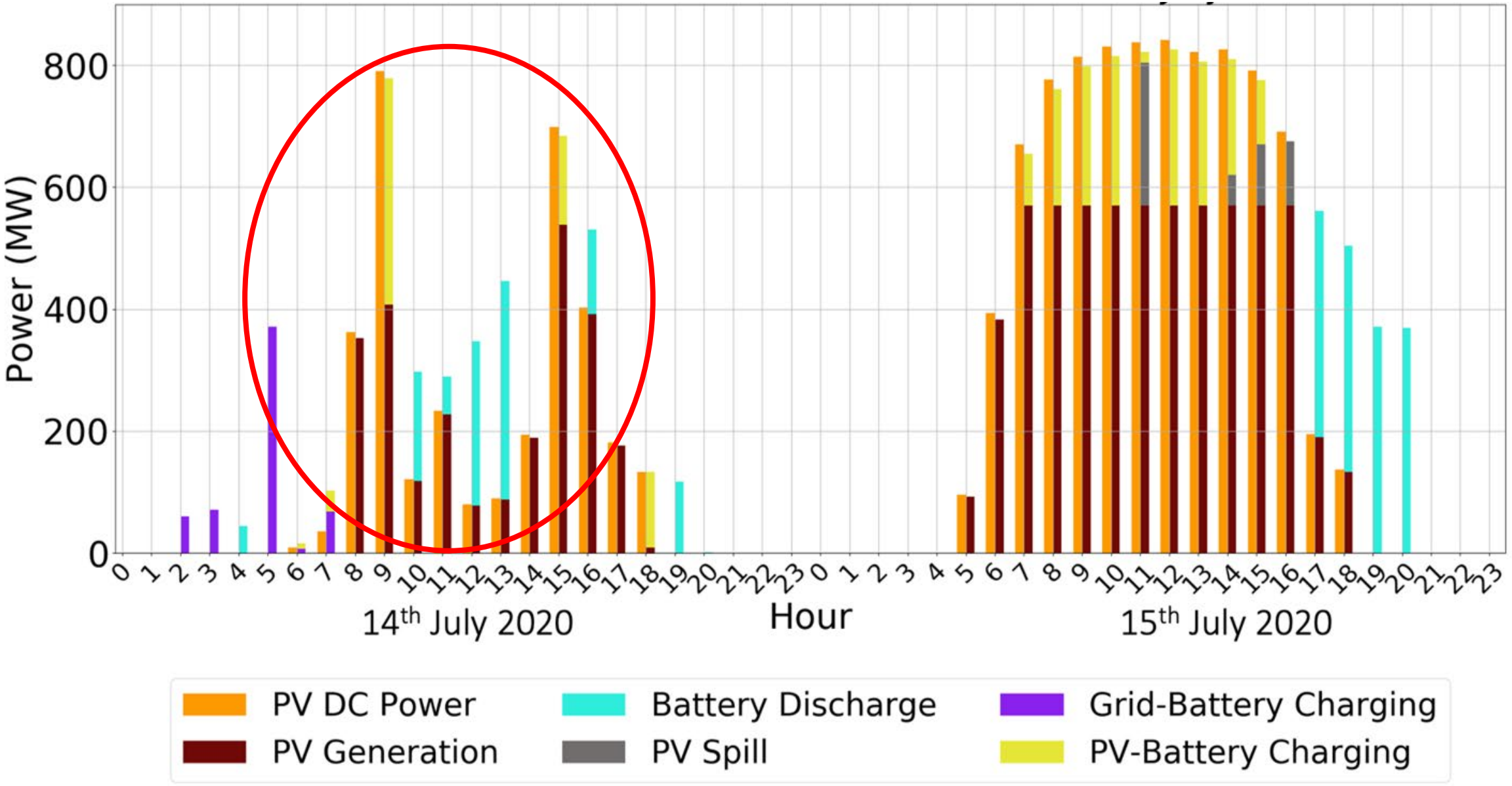


Sources of Value: Shared Costs

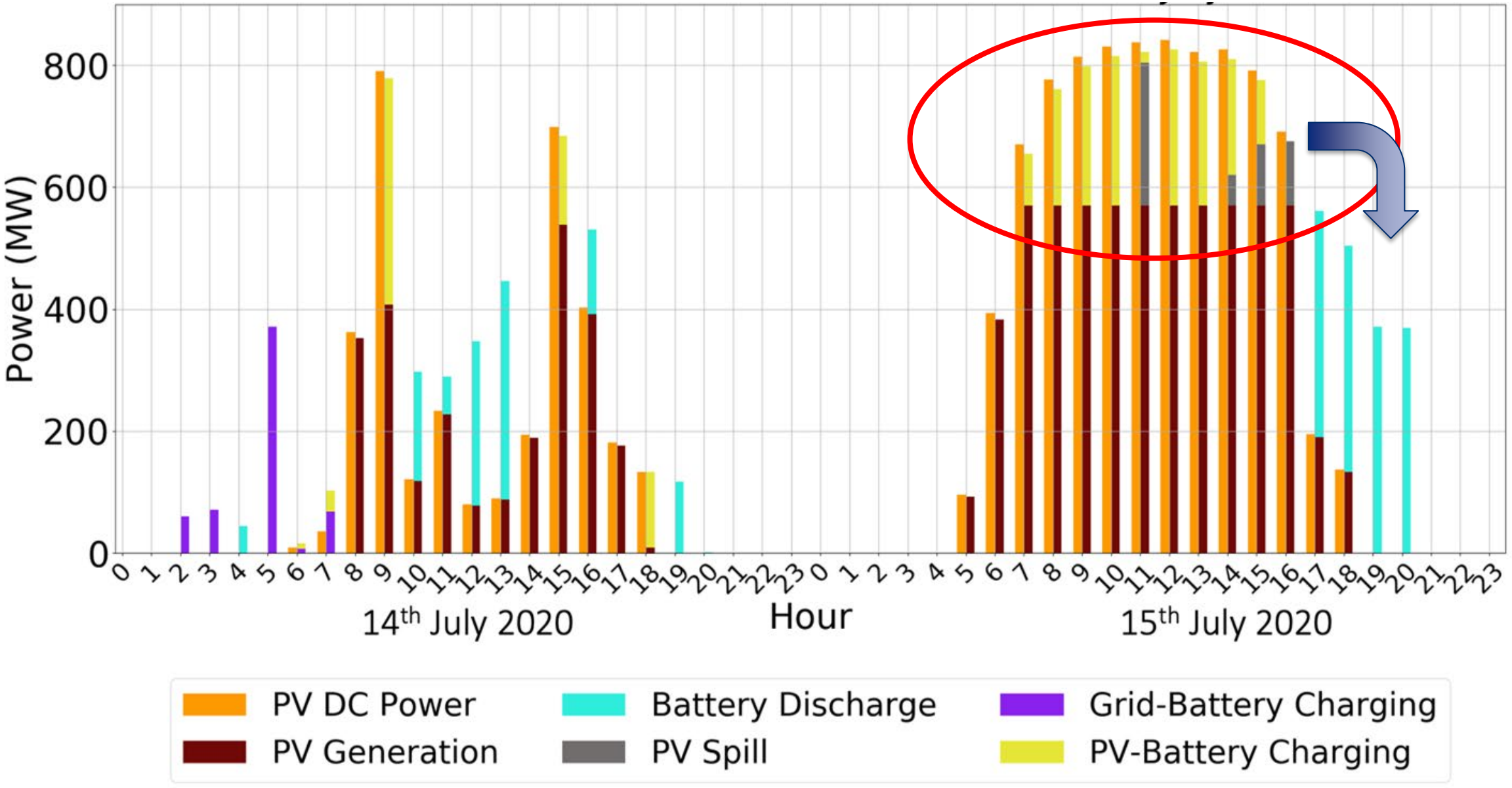


https://ieeexplore.ieee.org/document/8547852

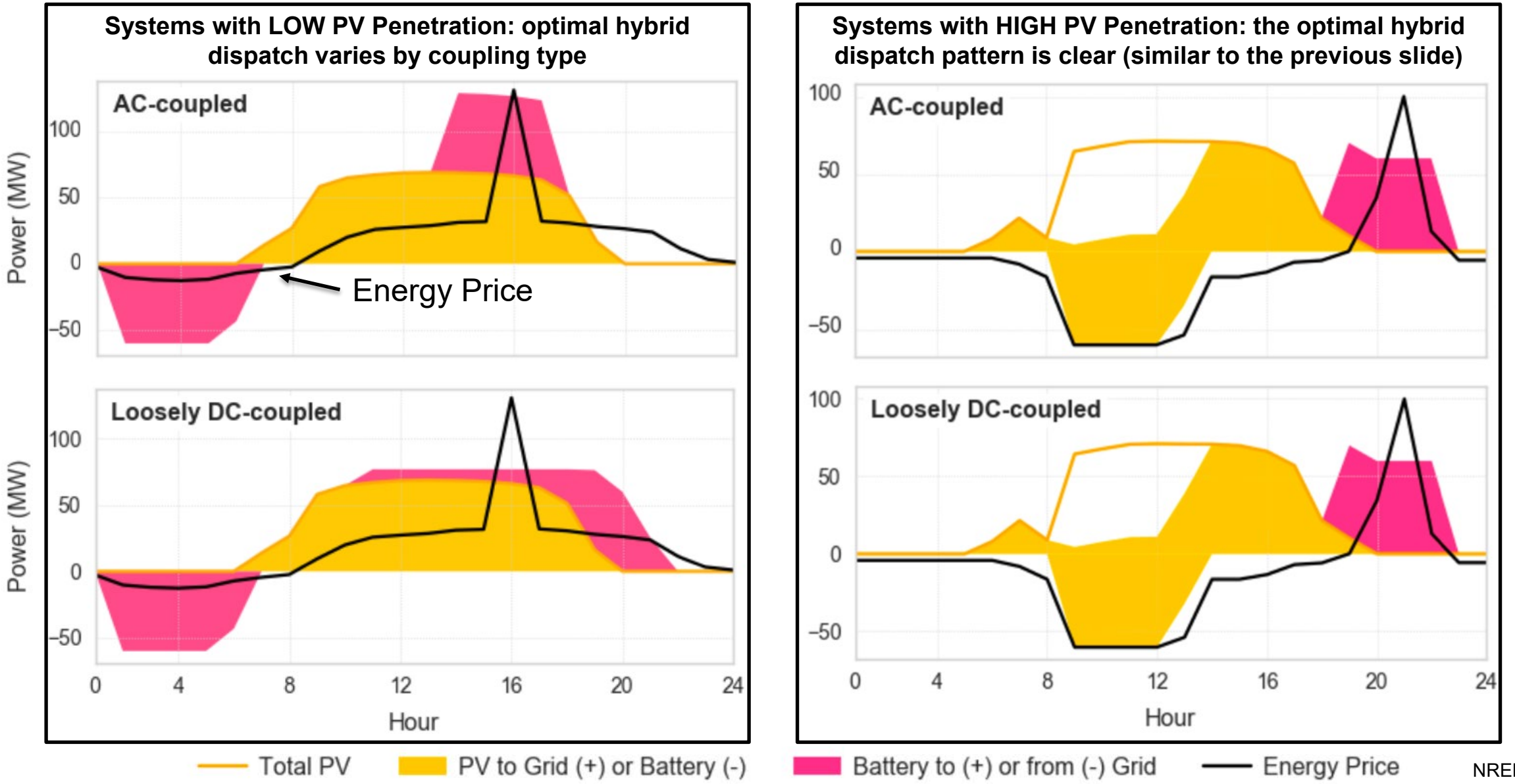
Sources of Value: Dispatchability Improvements



Sources of Value: Capacity Factor Improvements

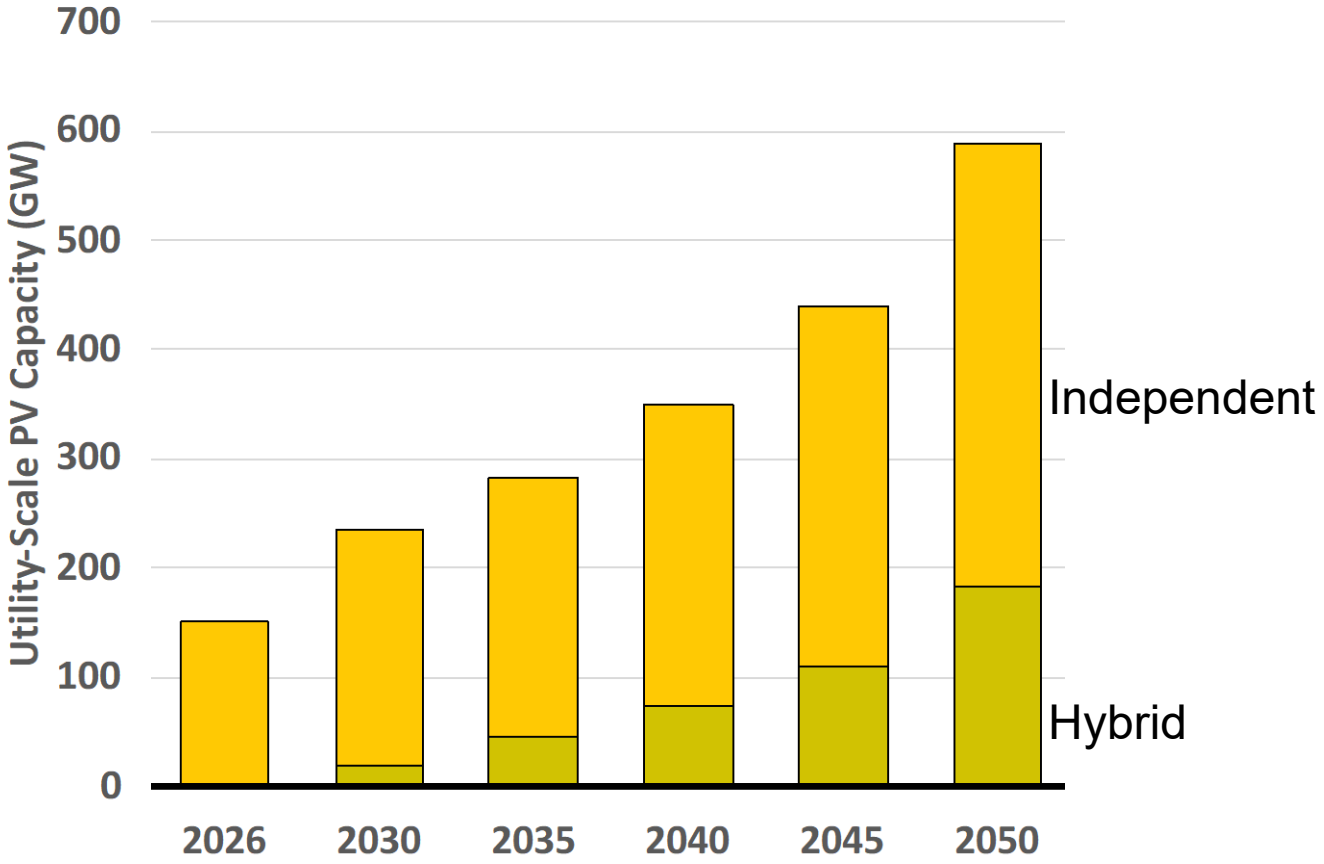


Sources of Value: Aligning Resource and Load



Deployment Potential: PV+Battery

- Cost and performance improvements drive significant deployment potential, based on resource planning modeling.
- Increasing PV+battery deployment primarily displaces independent PV and battery projects.
- Total deployment and the share of hybrid projects grows as:
  - PV and battery technology cost and performance improve more rapidly
  - PV and battery components share more costs



Key Takeaways

- A “hybrid” project should combine technologies with complementary generation profiles or capabilities, which results in cost savings and/or operational synergies.
- Hybrid projects combining PV-plus-battery, wind-plus-storage, and PV-plus-wind projects are commercially viable worldwide today, and a wider range of hybrid systems are likely viable in developing grids.
- Adding storage to variable renewable resources can facilitate renewable energy integration, increase capacity factors, localize the provision of high-value services, and enable cost savings.
- Many of the benefits attributed to hybrid systems can also be achieved through grid-level coordination of independent projects.

Thank you

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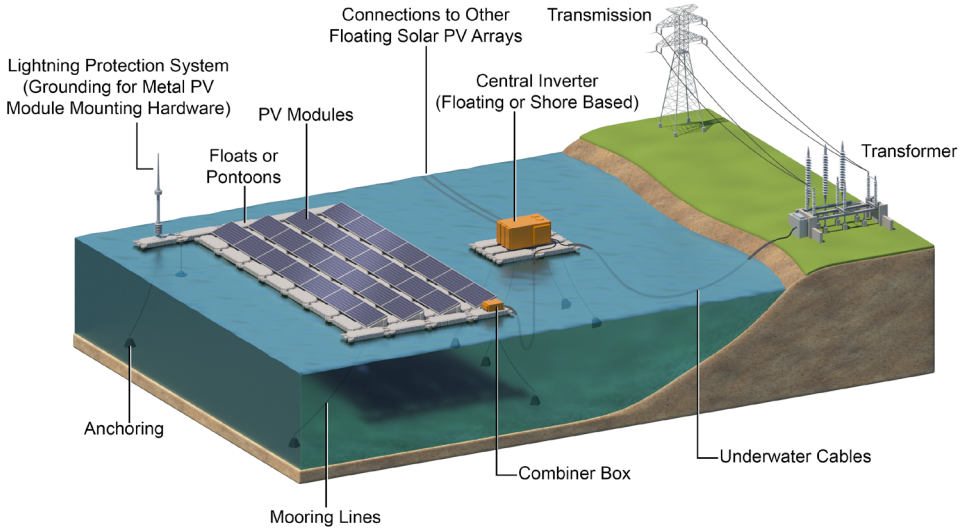
Case Study: Exploring the Operational Benefits of Floating Solar-Hydropower Hybrids

Sika Gadzanku | Researcher, National Renewable Energy Laboratory | April 20, 2021

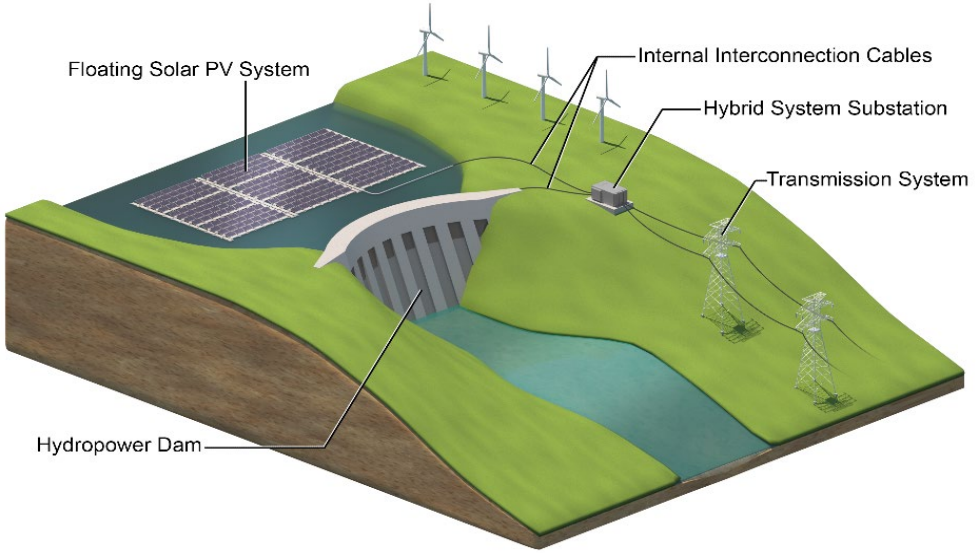
What is Floating Solar (FPV)?

Some Co-Benefits of FPV:

- Reduced land use
- Improved power plant operation
- Energy storage opportunities
- Transmission system benefits
- Reduced solar PV curtailment
- Water conservation



Stand-Alone FPV System



Hybrid FPV-Hydropower System

What is the current state of global FPV deployment?

- Total installed capacity at 2.6 GW, up from 6 MW in 2013
- Estimated technical potential of 7 TW
- Majority of installed capacity located in Asia
- FPV system costs vary widely ranging from $520-$3,000/kWdc (depends on a variety of factors)

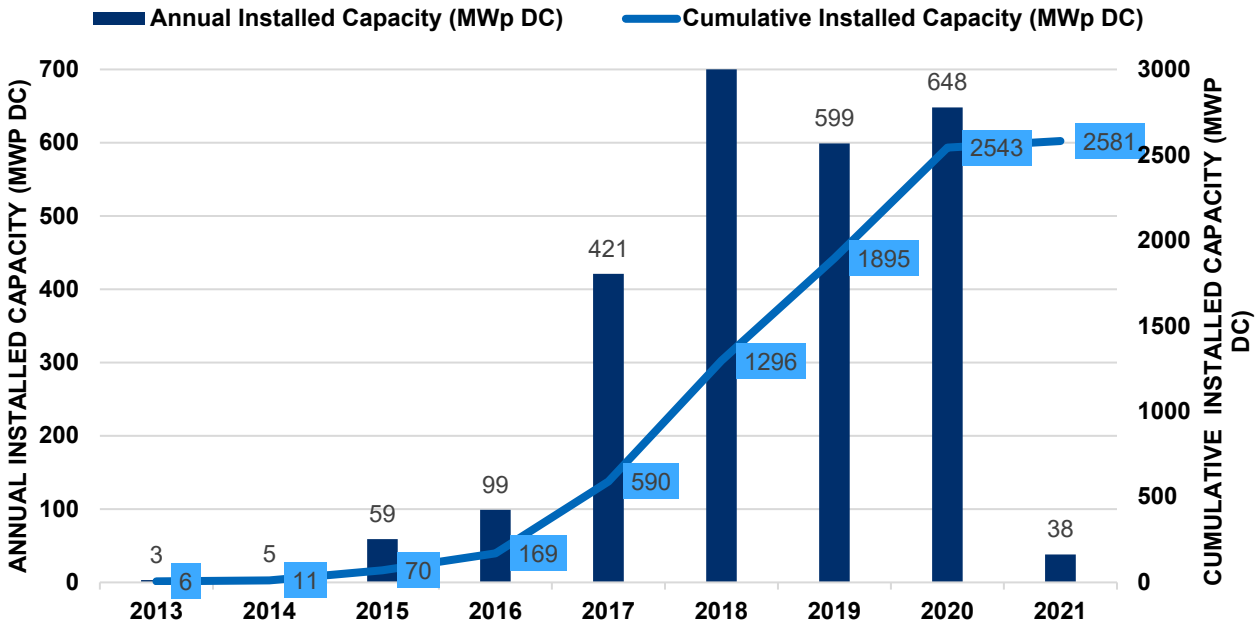


Fig. Annual FPV Deployment (2013 – present)

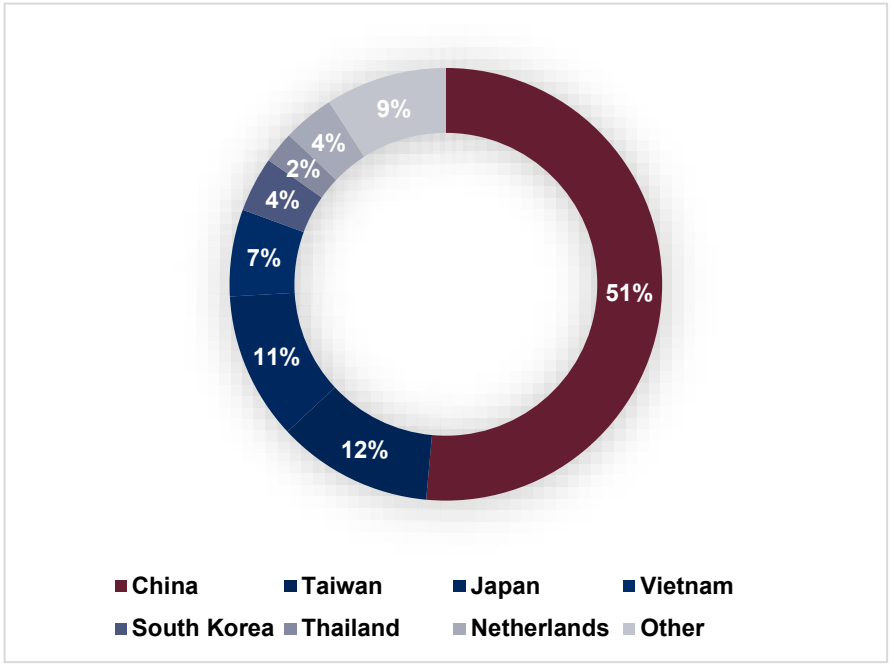


Fig. Installed Capacity

Sources: Floating Solar Landscape 2021, Wood Mackenzie (February 2021); Global Market Trends – Floating Solar, Solar Energy Research Institute of Singapore (March 2021)

Case Study:
What are the operational benefits of hybridizing FPV with hydropower?

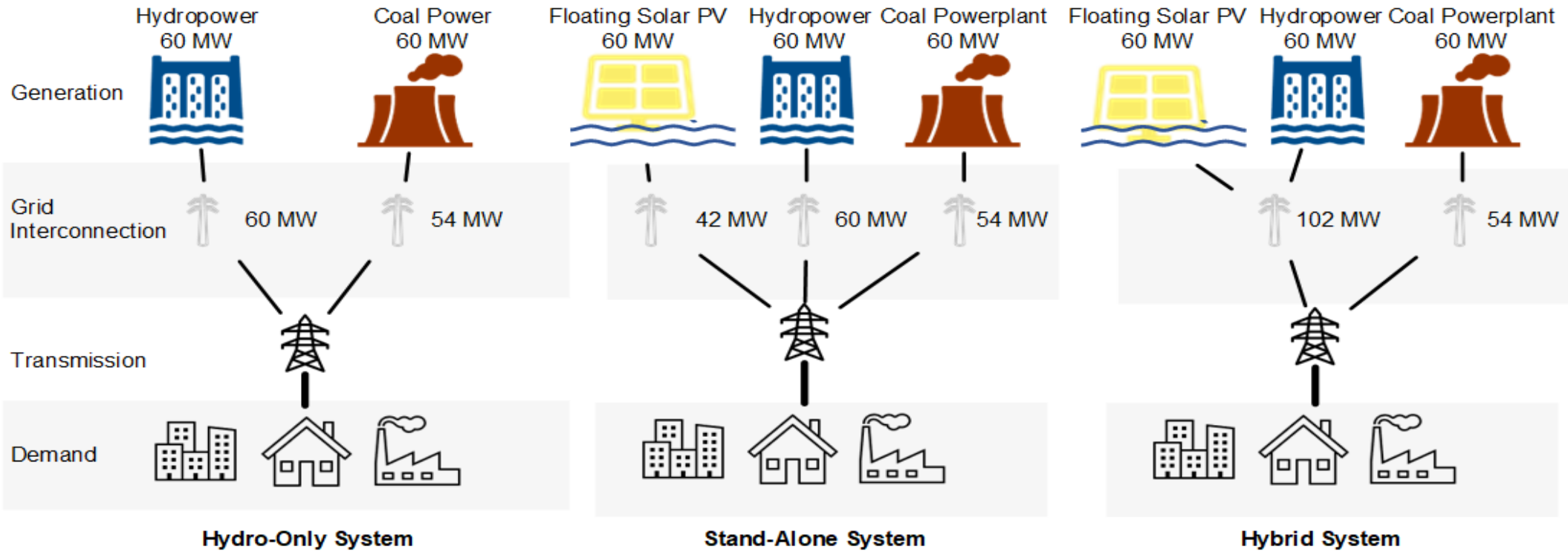
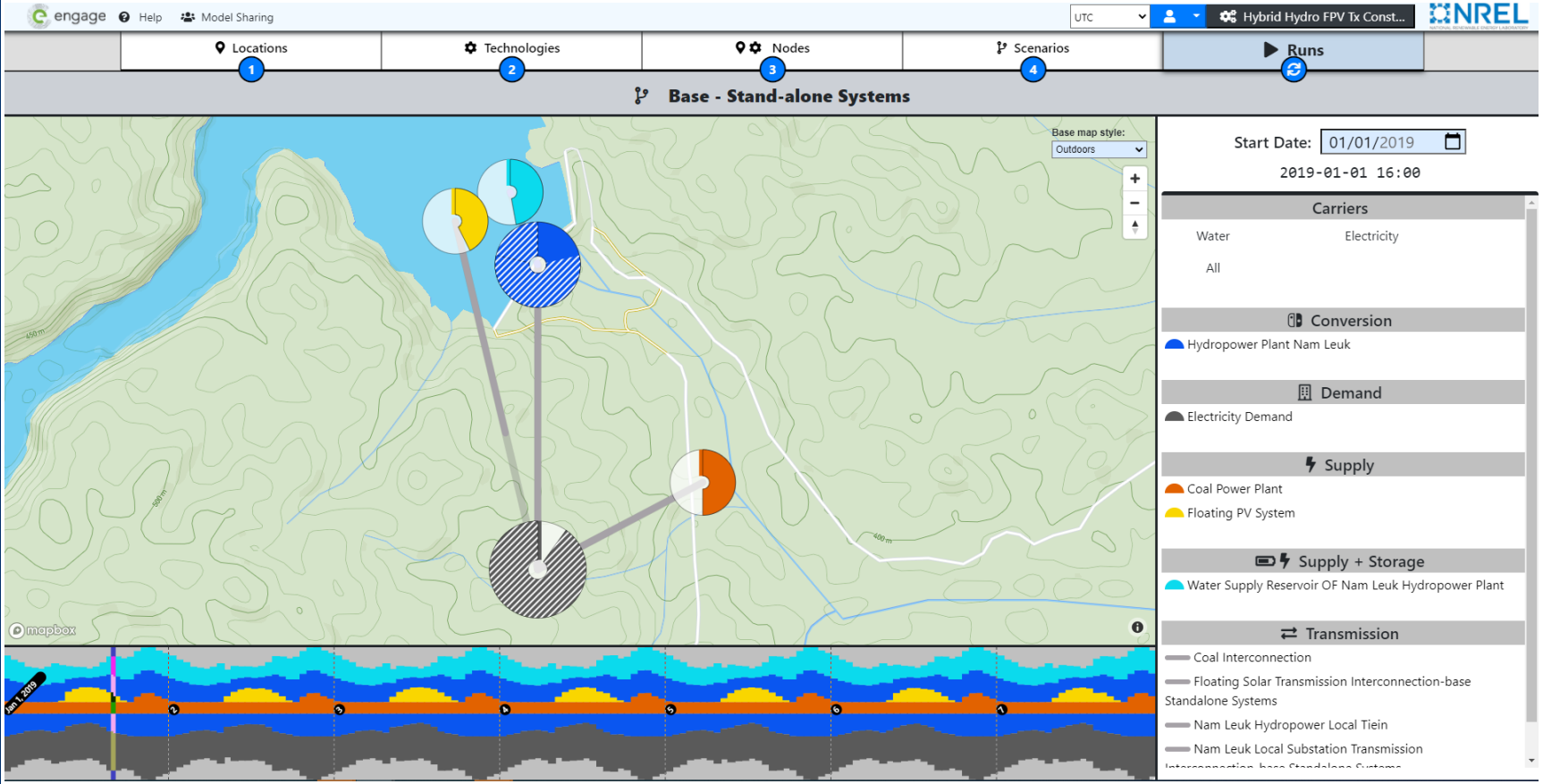


Fig. Example system configurations for the Hydro-Only (left), FPV Stand-Alone (middle), and Hybrid FPV-Hydropower (right) systems.

How did we explore this research question?

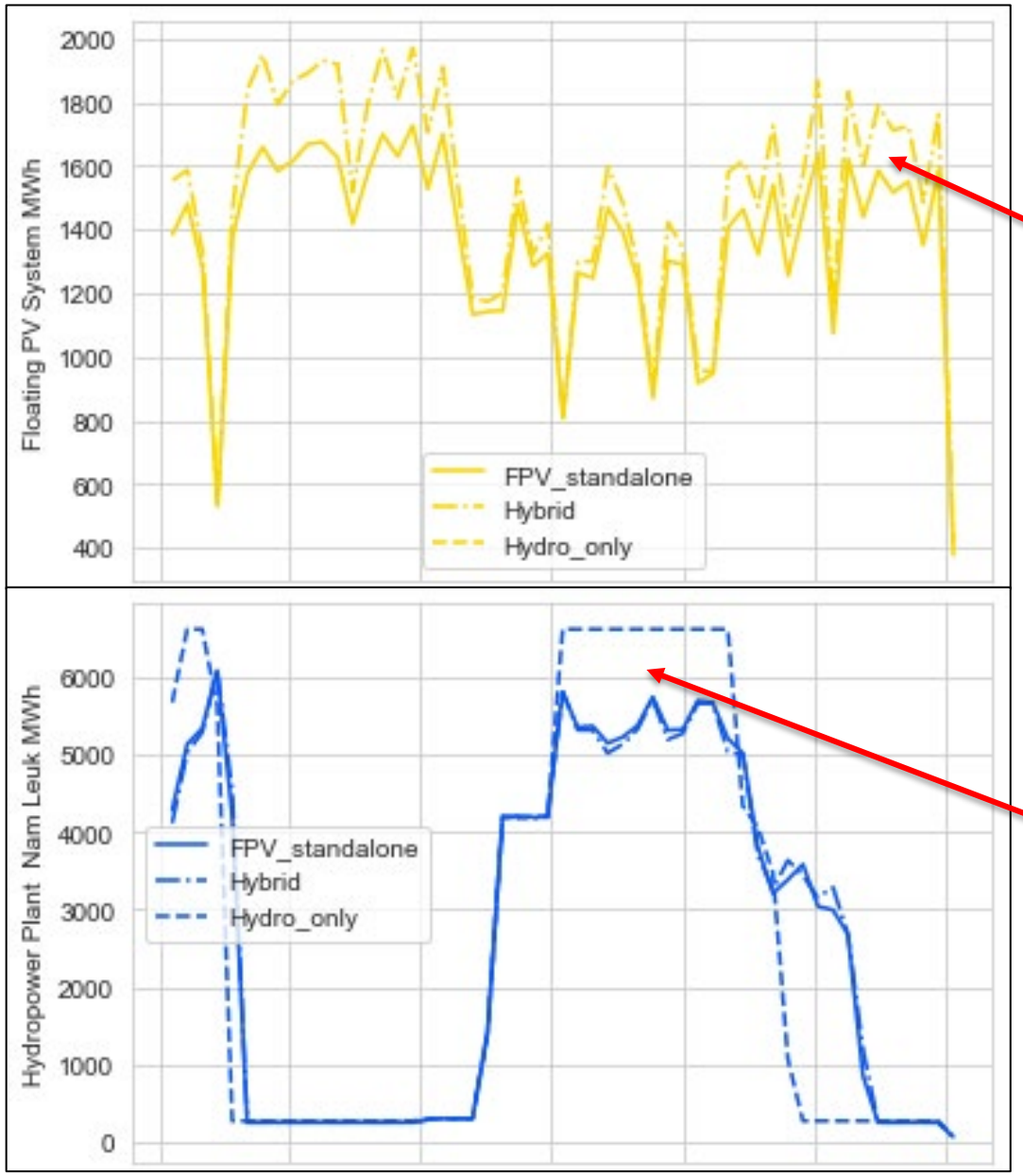
We used the Engage™ model, a web-based modeling platform that enables multi-energy-sectoral planning.

We quantified the differences in PV and hydropower generation.



For more information on Engage, visit: https://engage.nrel.gov/en/login/?next=/en/

What were some of our findings?



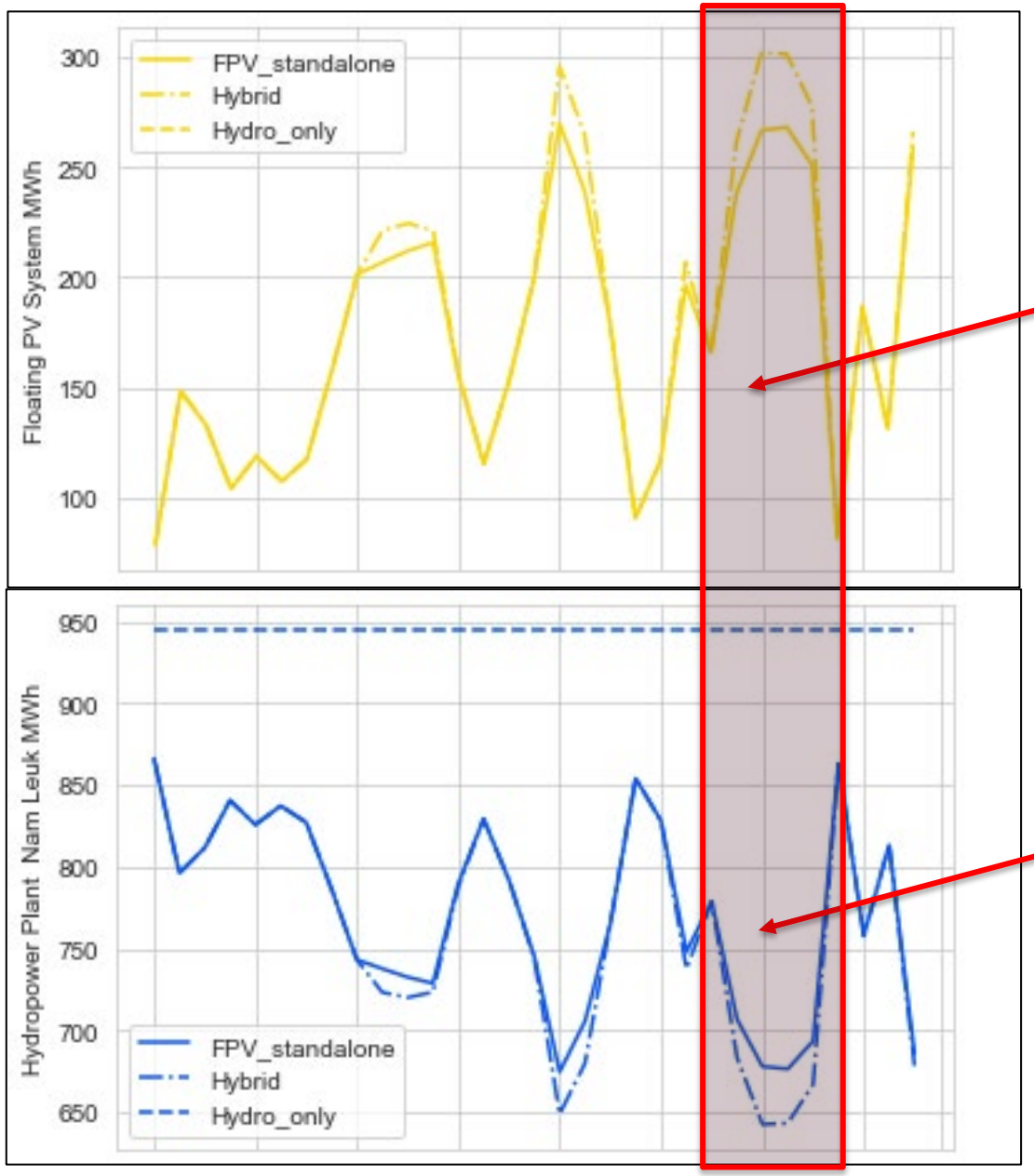
January – December 2019

Differences in PV generation

Differences in hydropower generation

What were some of our findings?

PV and hydropower generation complement each other



July 2019

PV generation increases

Hydropower generation decreases

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Where do we go from here?

Modeling results indicate that hybridizing FPV system with hydropower:

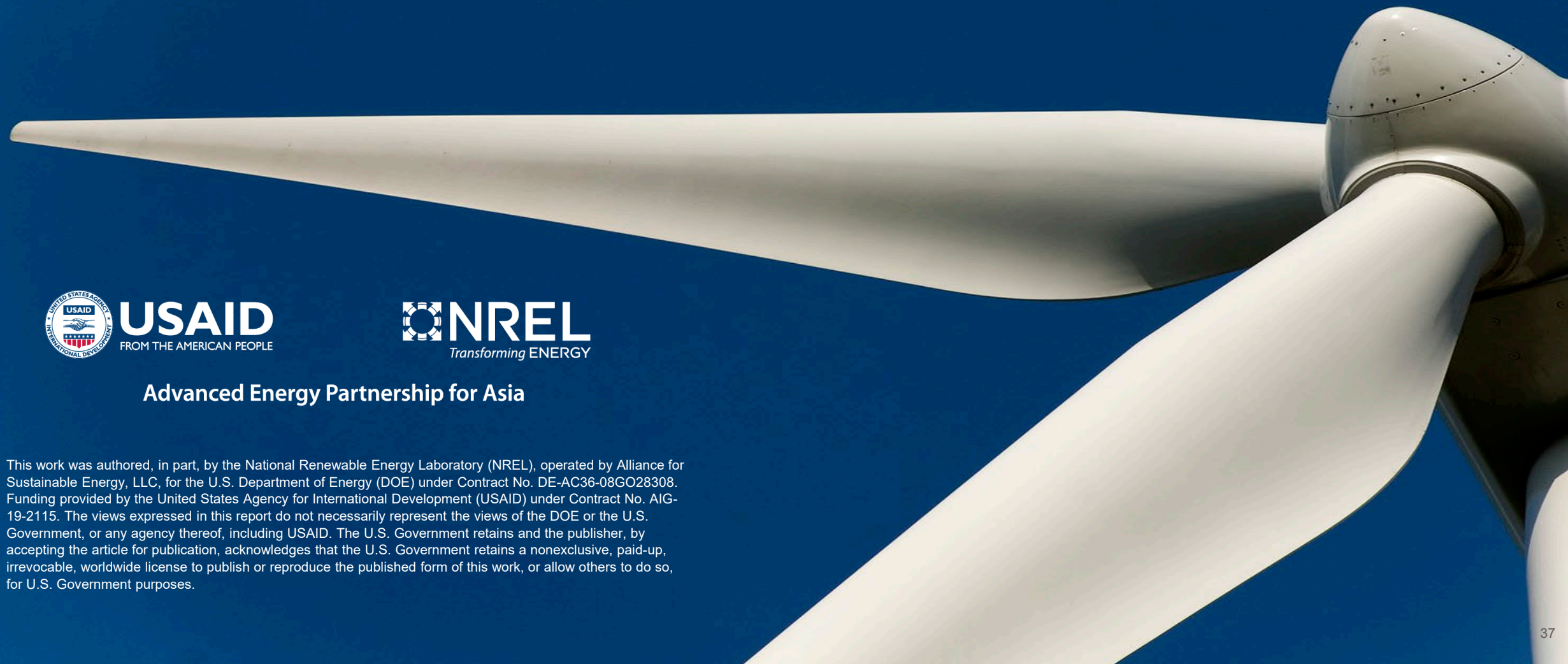
- Reduces PV curtailment.
- Conserves water resources by optimizing seasonal and daily electricity generation.

Overall:

- FPV is an emerging application of solar PV technology.
- FPV is especially of interest in Asia for several reasons including potential opportunity to hybridize with hydropower resources.
- Hybridizing FPV with hydropower could unlock several site-specific and grid-level benefits but additional research and development is needed to understand these well.

Thank you!

Sika.Gadzanku@nrel.gov



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Question and Answer

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