2024 Distributed Wind Energy Summit

Distributed Wind-Energy-Based Hybrids

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Kaitlin Brunik and Genevieve Starke
Hybrid Systems Research Engineers

Pacific Northwest NATIONAL LABORATORY

NREL Transforming ENERGY

What Are Distributed Wind-Energy-Based Hybrids?

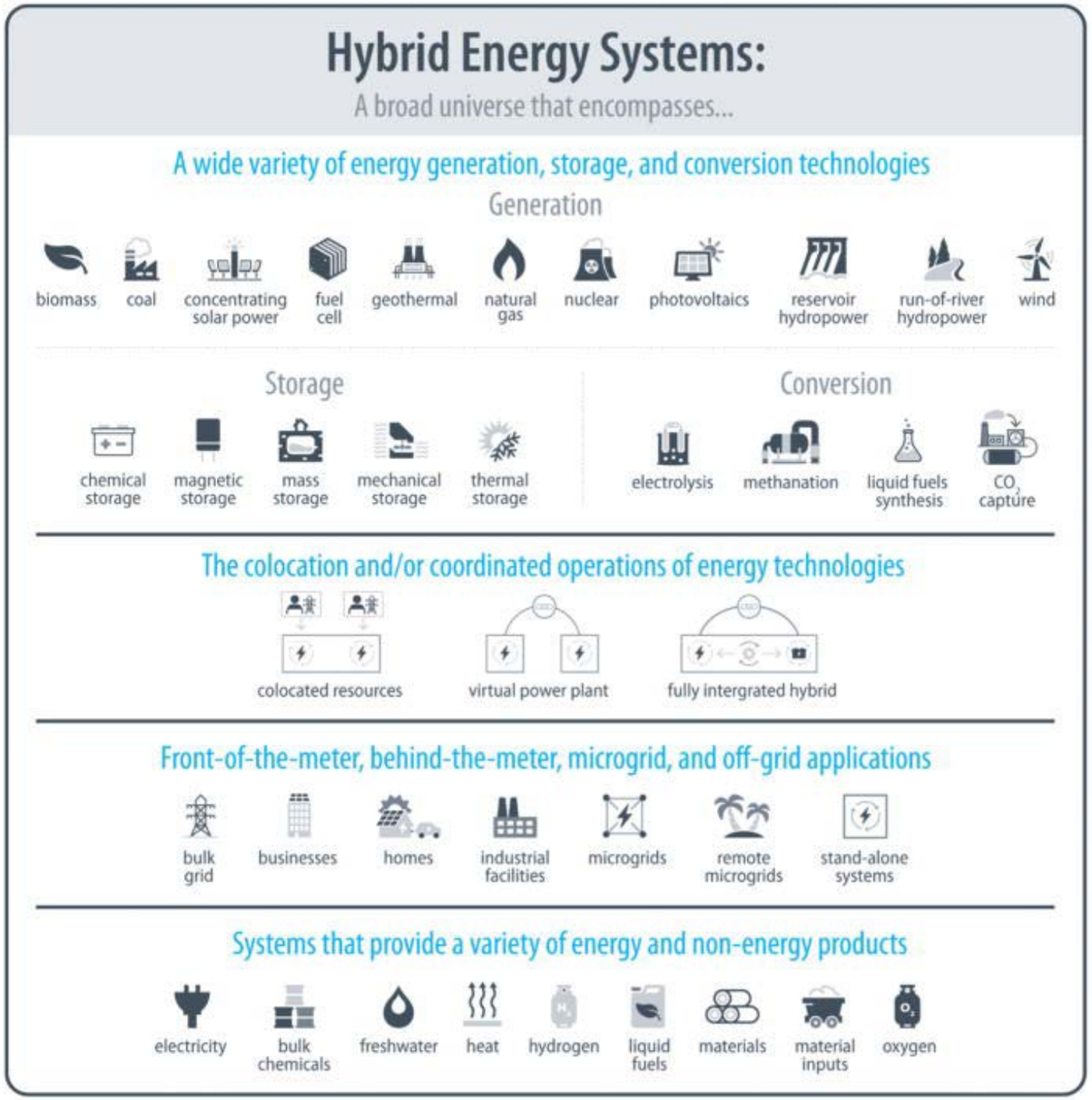
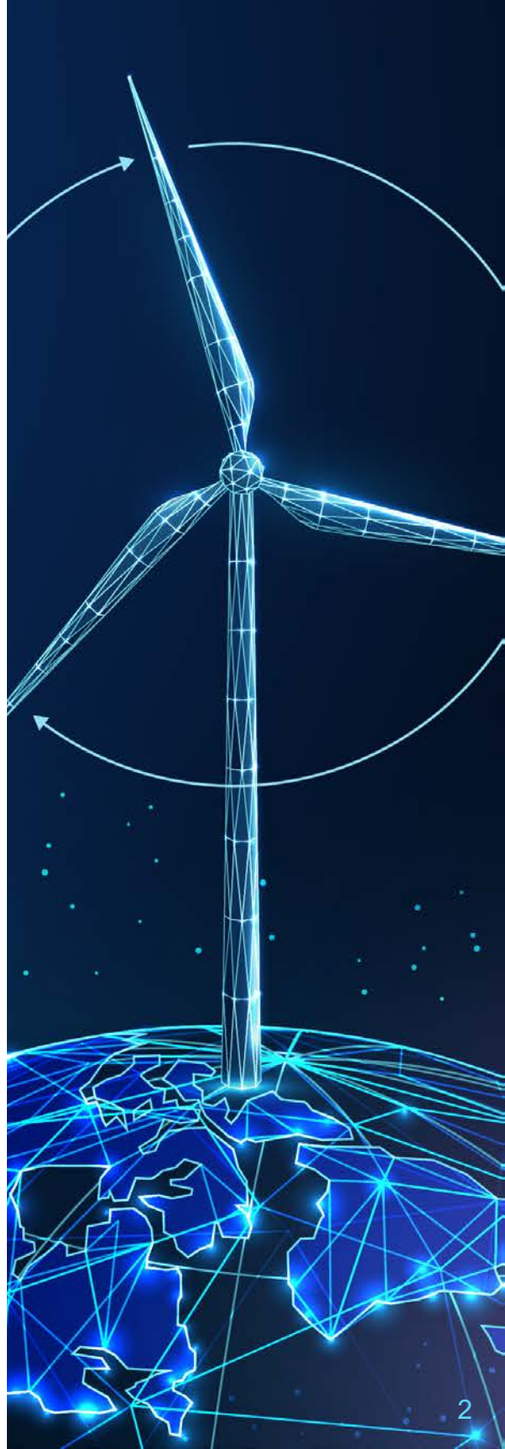


Figure from Murphy, C., and A. Mills. 2021. *Hybrid energy systems: Opportunities for coordinated research*. DOE/GO-102021-5447



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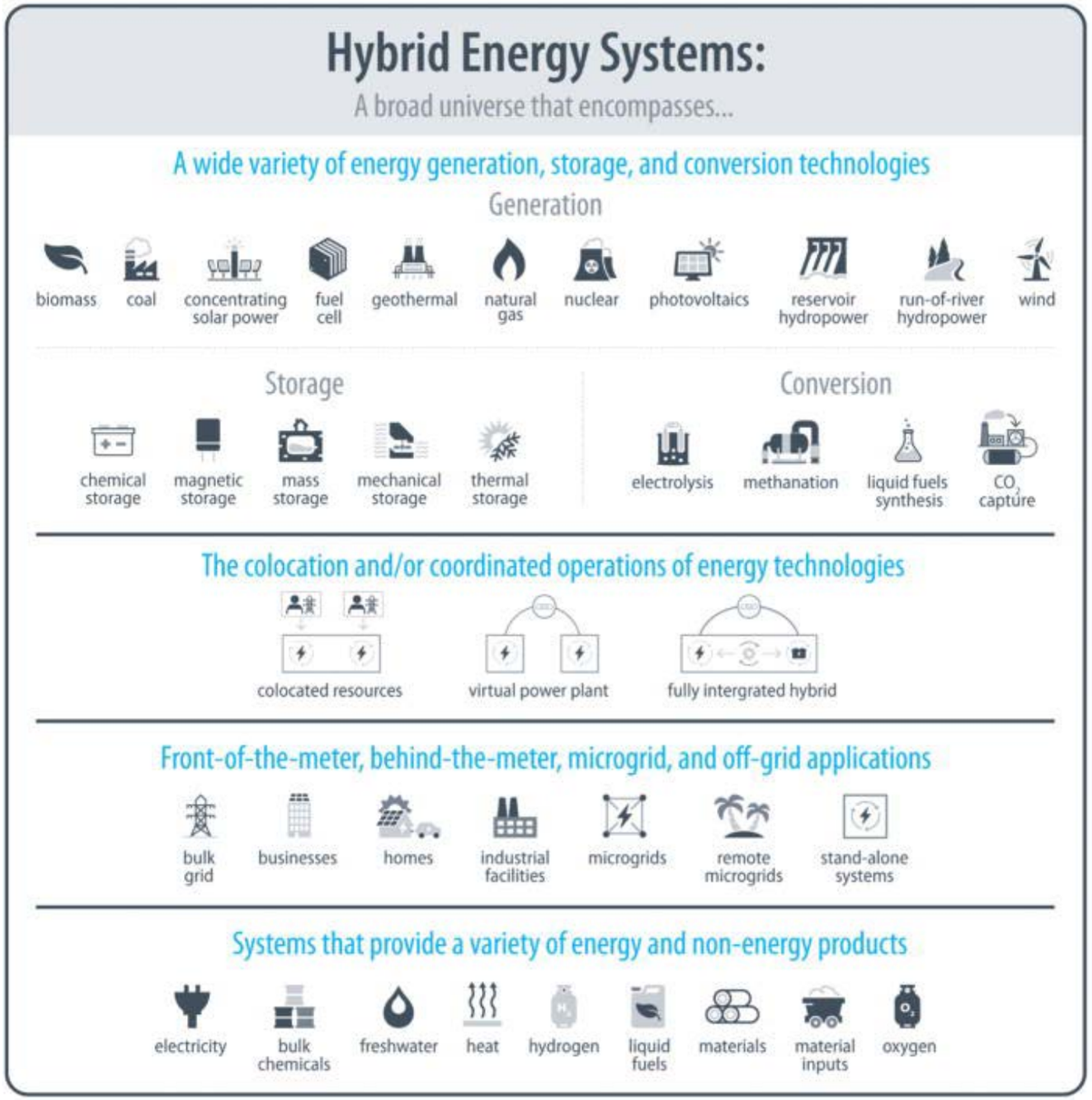

Possible connection configurations:

1. Customer's side of the meter to serve a local load
2. Connected to the distribution grid as a generation asset
3. Directly power an off-grid load.

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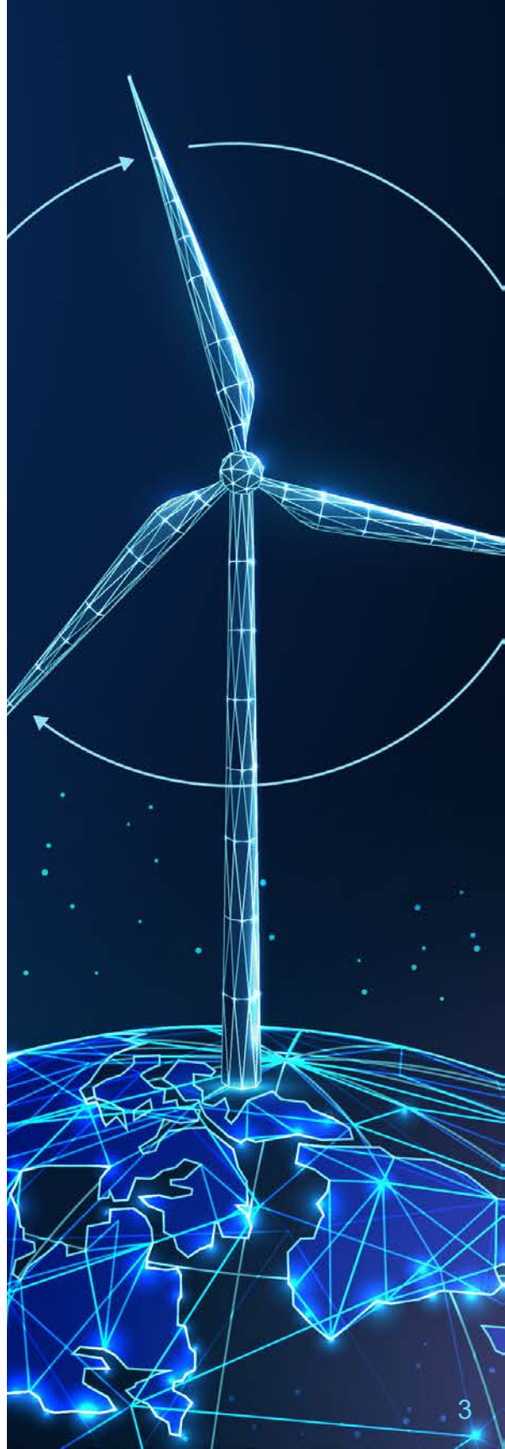
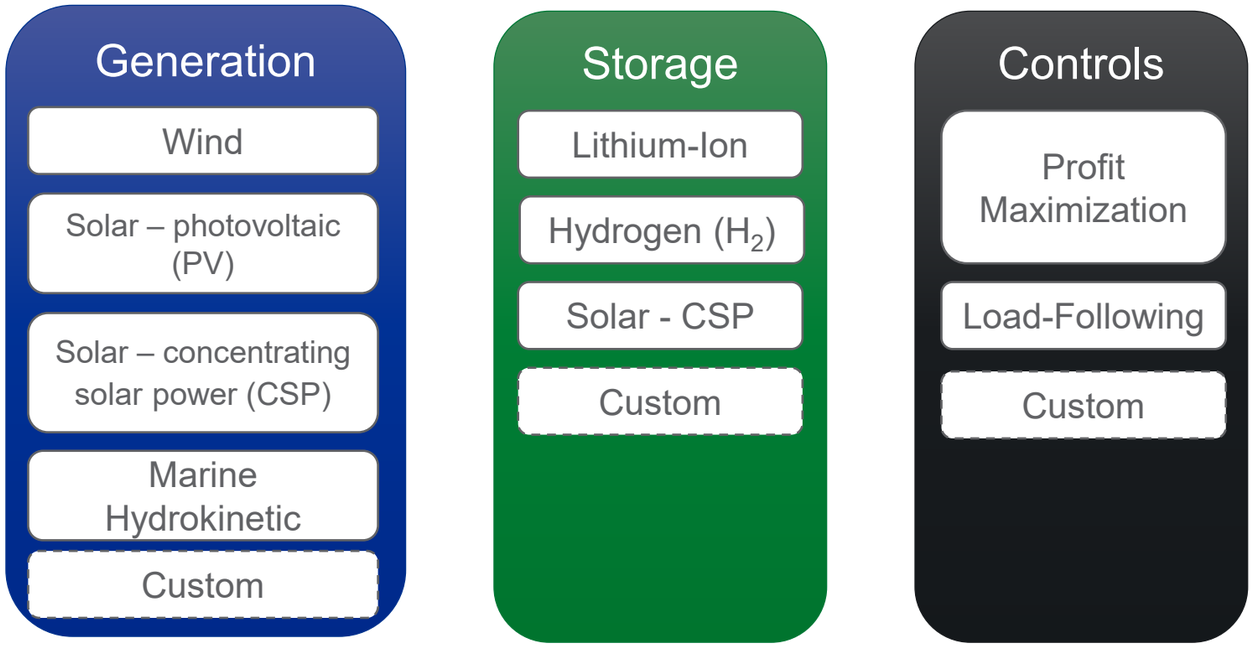
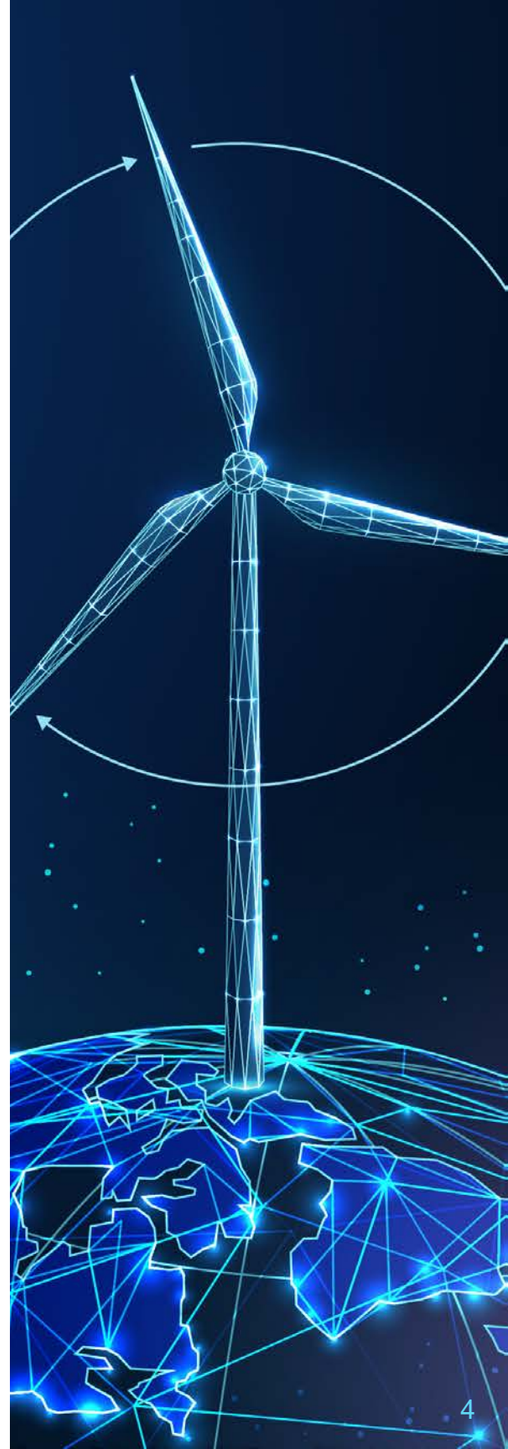


Hybrid Optimization Performance Platform (HOPP) Open-Source Tool

- Repository: https://github.com/NREL/HOPP
- Tool to design and optimize buildable hybrid power plants
  - Component-level design
  - Various combination of technologies
  - Layout
  - Costs (e.g., capital and operating costs).





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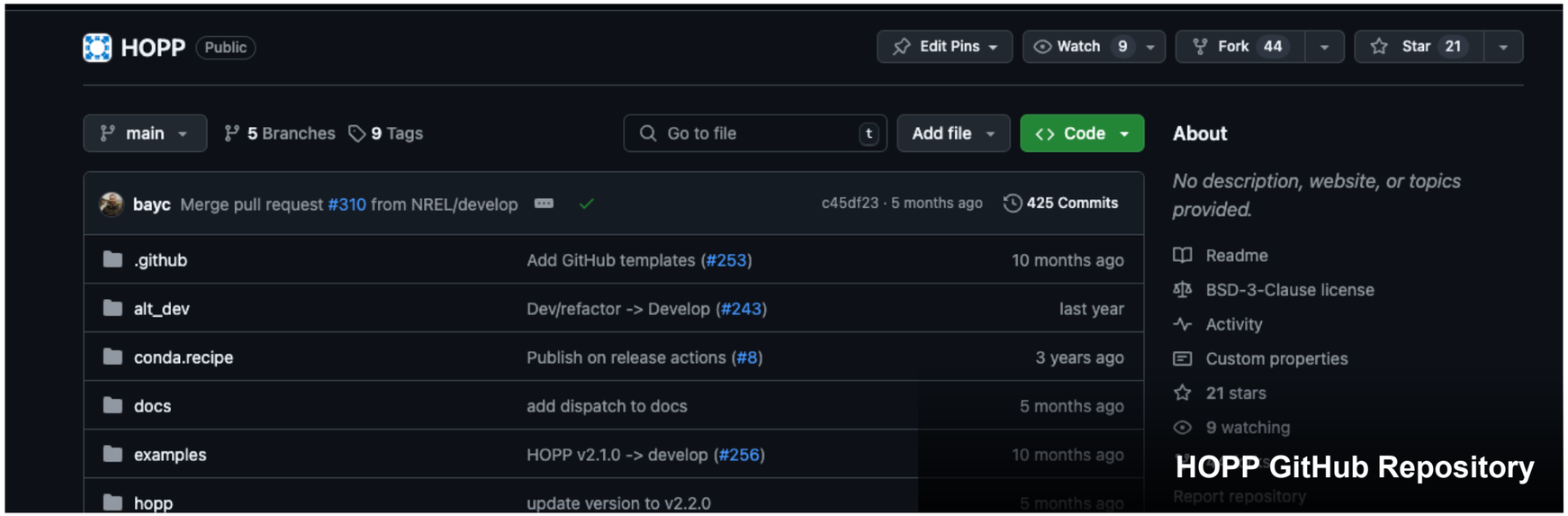
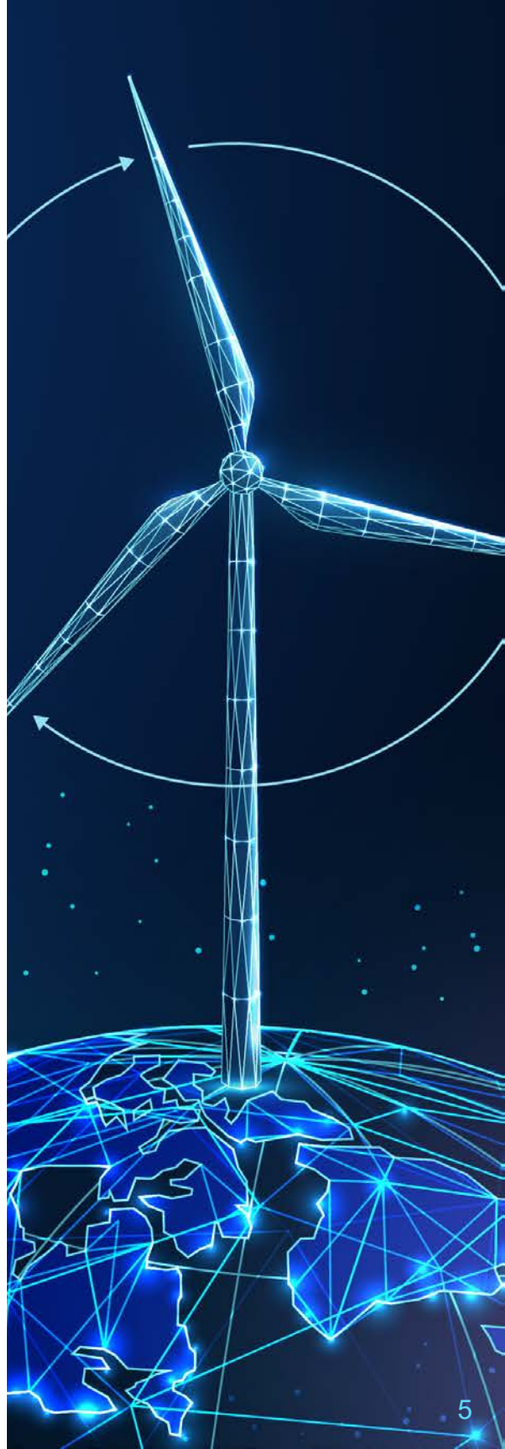


HOPP GitHub Repository



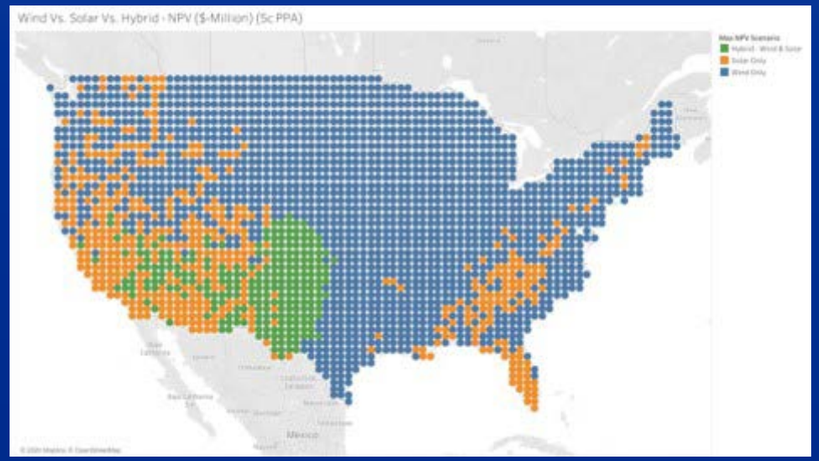
HOPP Capabilities

- Repository: https://github.com/NREL/HOPP

Analysis

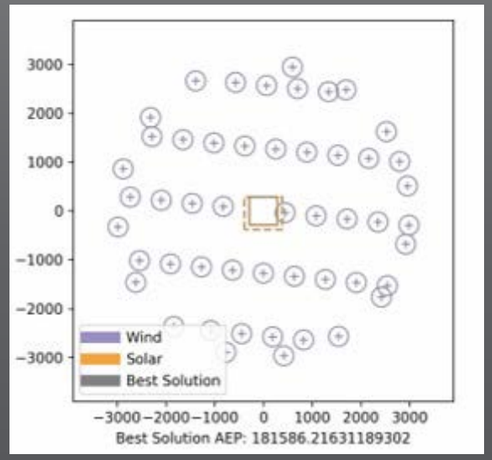
Where to build co-located hybrid plants?

- Resources are complementary
- Overbuild (Ex: 200-megawatt (MW) plant at 100-MW interconnect)
- Include storage.



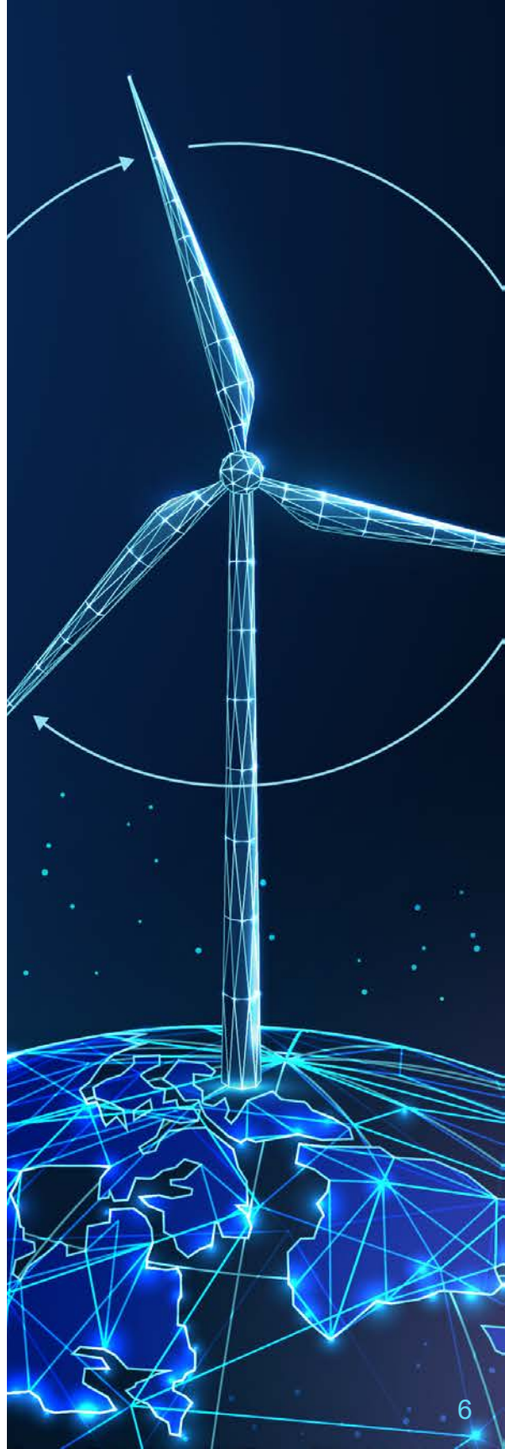
Optimization

Optimize hybrid plants down to the *component* levels



Control/Dispatch Algorithms

- **Wind-solar-storage** dispatch algorithms developed in HOPP
- Operation of plants down to the **10-minute timescale**
- Improve hybrid plant performance by > 5%.

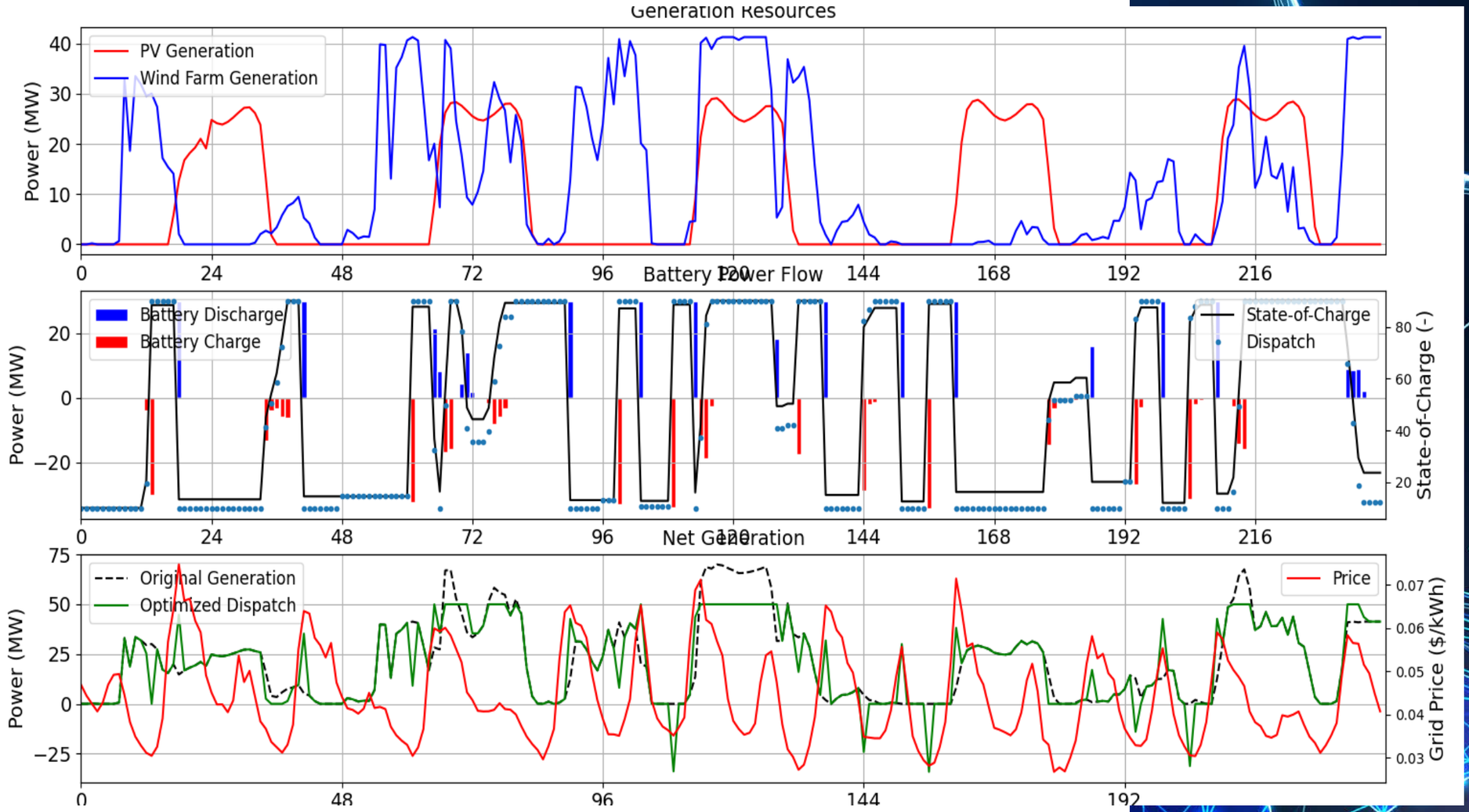


HOPP Example

Wind and solar power generation

Battery power and state of charge

Original and optimized power dispatch compared to the energy price



HOPP Examples Library

- 01-wind-solar.ipynb
- 02-wind-solar-api.ipynb
- 03-wind-solar-battery.ipynb
- 04-load-following-battery.ipynb
- 05-floris-wake-model.ipynb
- 06-wave-wind.ipynb
- 07-wind-solar-electrolyzer.ipynb

List of current examples in HOPP

[HOPP version 2.0.0 Tutorial]

Hybrid Plant with Battery Storage Example

In this example, we will explore how to simulate a hybrid renewable energy system that includes both wind and solar power sources, along with battery energy storage. The battery uses the default dispatch model,simple dispatch, which uses a profit maximization objective function.

The key aspects we will cover include setting up the simulation environment, configuring the system, running the simulation, and visualizing the results.

Import Required Modules

Begin by importing the necessary modules for the simulation.

In [1]:
```
from hopp.simulation import HoppInterface
from hopp.tools.dispatch.plot_tools import (
    plot_battery_output, plot_battery_dispatch_error, plot_generation_profile
)
```

```
/Users/cirmas/workspace/HOPP/examples/log/hybrid_systems_2023-11-22T11.23.47.243553.log
```

Create the Simulation Model

Instantiate the `HoppInterface` class by providing a YAML configuration.

In order to configure the battery dispatch model, ensure that you include a `grid_resource_file` within the `site` section, and incorporate the `battery` size and capacity into the `technologies` section of the YAML configuration.

In [2]:
```
hi = HoppInterface("./inputs/03-wind-solar-battery.yaml")
```

Run the Simulation

Simulate the hybrid renewable energy system for a specified number of years (in this case, 20 years).

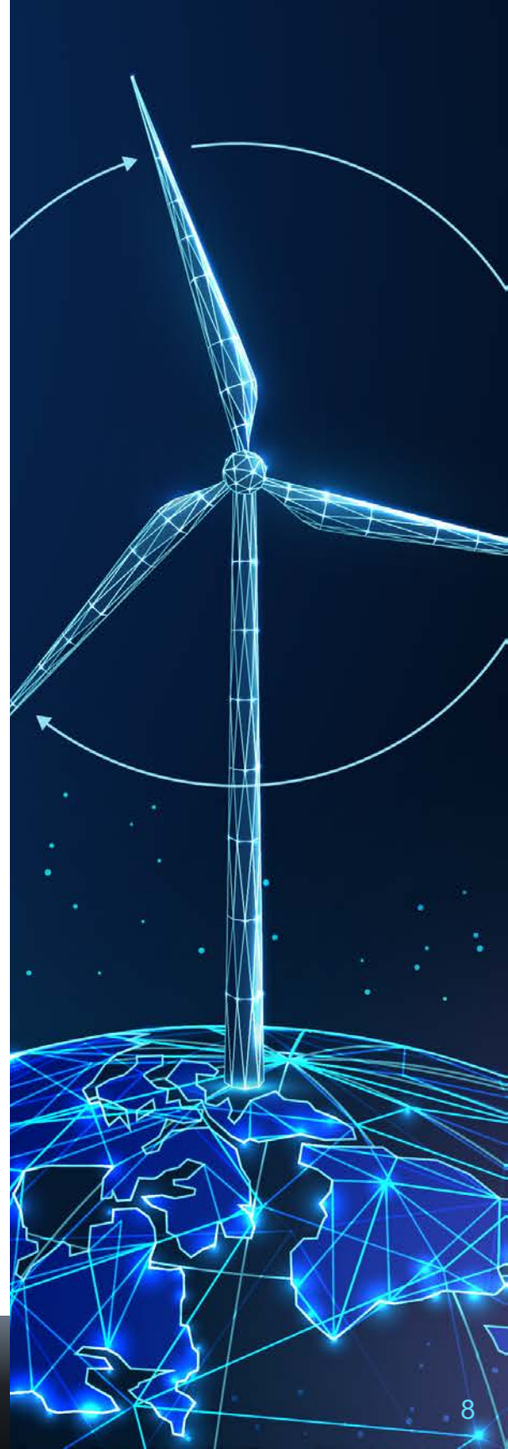
In [3]:
```
hi.simulate(project_life=20)
```

Print Simulation Results

Access and display various simulation results, including annual energies, net present values (NPVs), and total revenues.

In [4]:
```
hybrid_plant = hi.system

print("Output after losses over gross output:",
      hybrid_plant.wind.value("annual_energy") / hybrid_plant.wind.value("annual_gross_energy"))

# Save the outputs
annual_energies = hybrid_plant.annual_energies
npvs = hybrid_plant.net_present_values
revs = hybrid_plant.total_revenues

print("Annual Energies:")
print(annual_energies)

print("Net Present Values:")
print(npvs)

print("Total Revenues:")
```

Jupyter Notebook Hybrid Plant with Battery Storage Example in HOPP



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Thank you

Kaitlin Brunik and Genevieve Starke

HYBRID SYSTEM RESEARCH ENGINEERS

Kaitlin.Brunik@nrel.gov

Genevieve.Starke@nrel.gov

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401

www.nrel.gov

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