

HOPP – Hybrid Optimization and Performance Platform

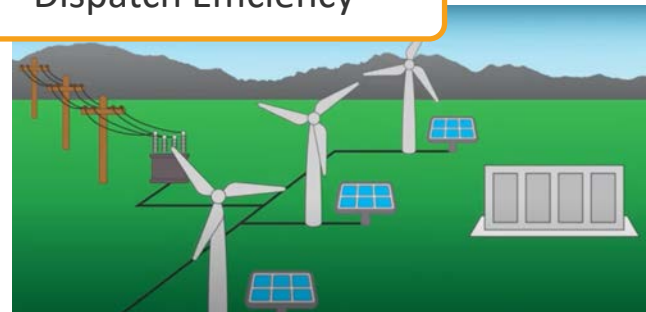
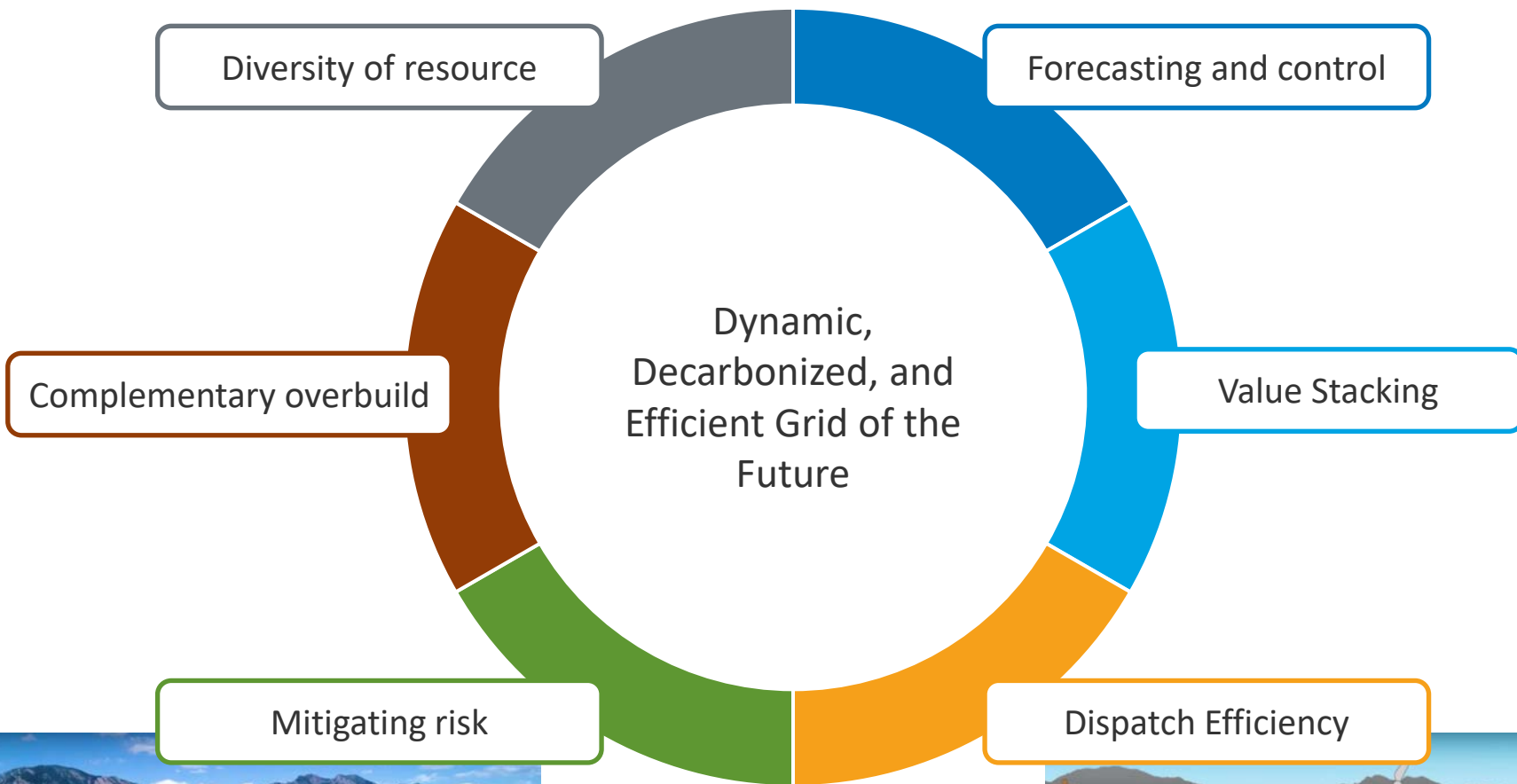
ASME Wind+ Digital, Nov 2021

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National Renewable Energy Lab

NREL/PR-7A40-81478

Hybrid Power Plants



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1 Hybrid Optimization and Performance Platform

2 Technology and Financial Modeling

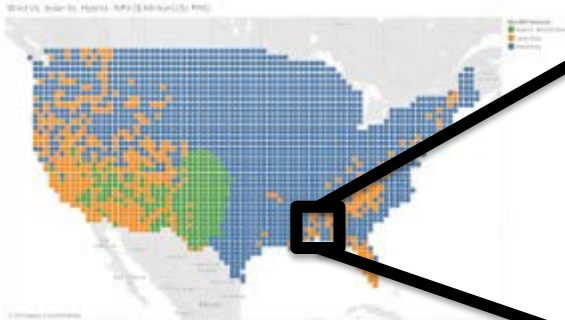
3 Optimal Sizing And Layout

Hybrid Optimization and Performance Platform

Optimize co-located, utility-scale hybrid plants down to the component level for different markets

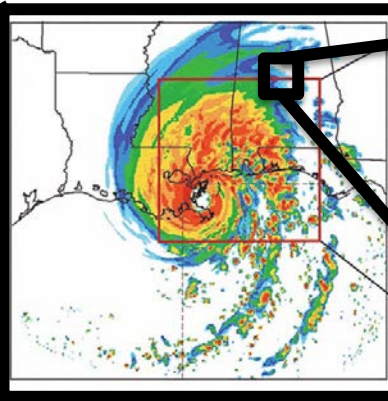
Facilitate Large-Scale Deployment of Hybrids

Techno-Economic Analysis



Investigation of resource mix and deployment. Balance between battery storage and alternative fuels.

System and Plant level design and control



Optimally design and operate plants to achieve different objectives

Hardware and Grid Strength

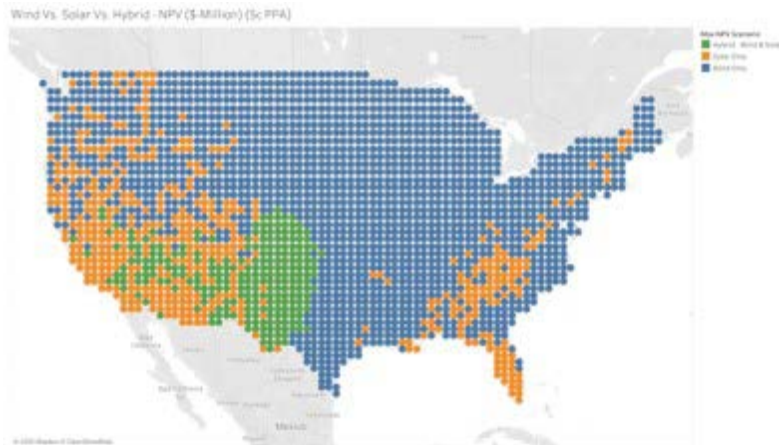


Support a grid that is 100% inverter-based. Need for inertia, blackstart capabilities.

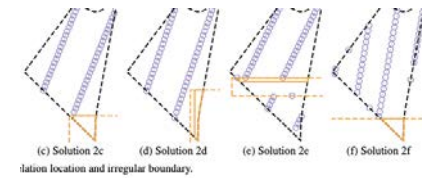
HOPP Capabilities

Analysis

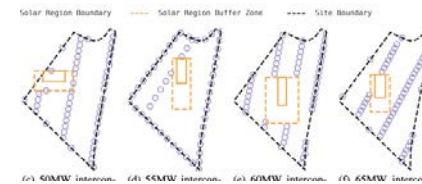
Where to build co-located hybrid plants?



Optimization

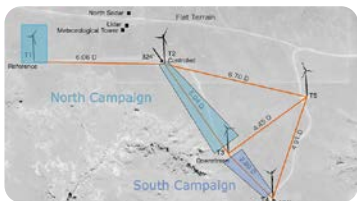


Optimize hybrid plants down to the *component* levels

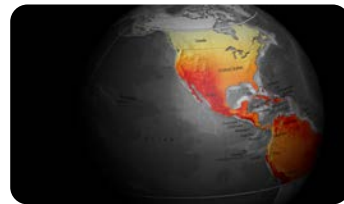


Control/Dispatch Algorithms

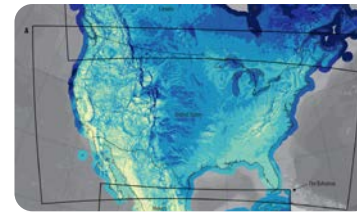
- **Wind-solar-storage** economic dispatch
- Operation of plants down to the **1-minute timescale**



FLORIS



National Solar Radiation Database



Wind Toolkit



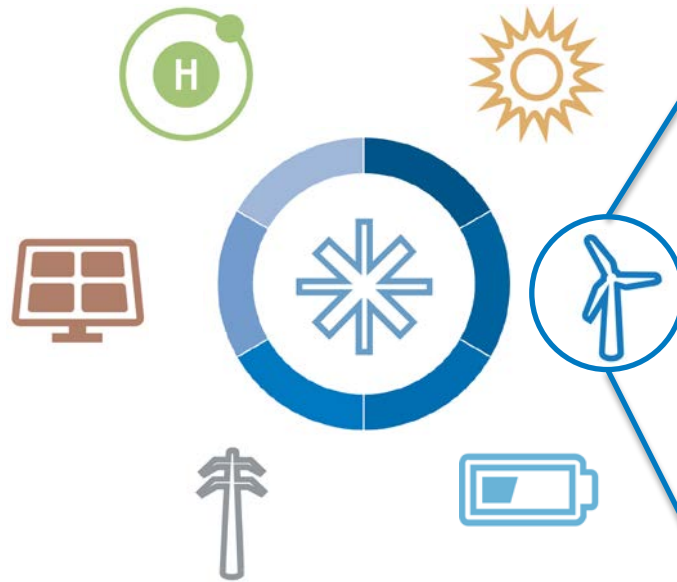
System Advisor Model

Technology and Financial Modeling

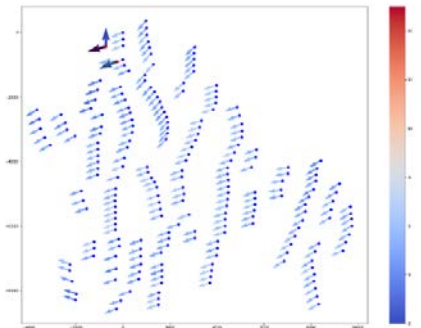
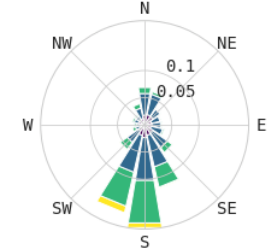
Key inputs to the HOPP model that inform the objective to be optimized

Layout and Performance: Wind

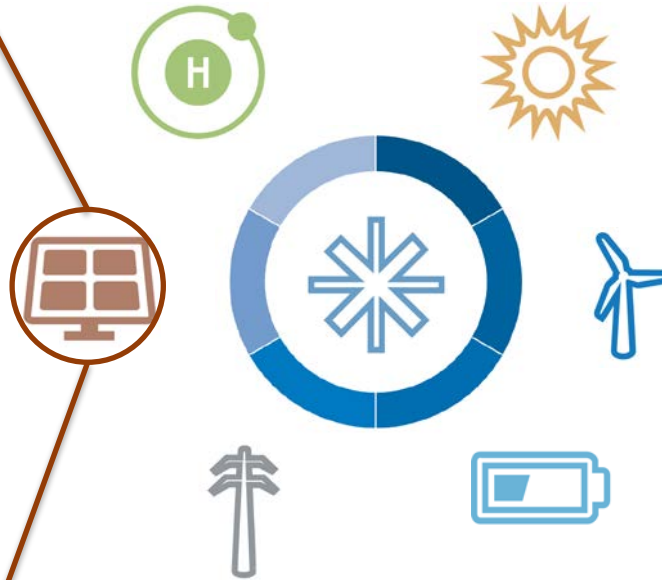
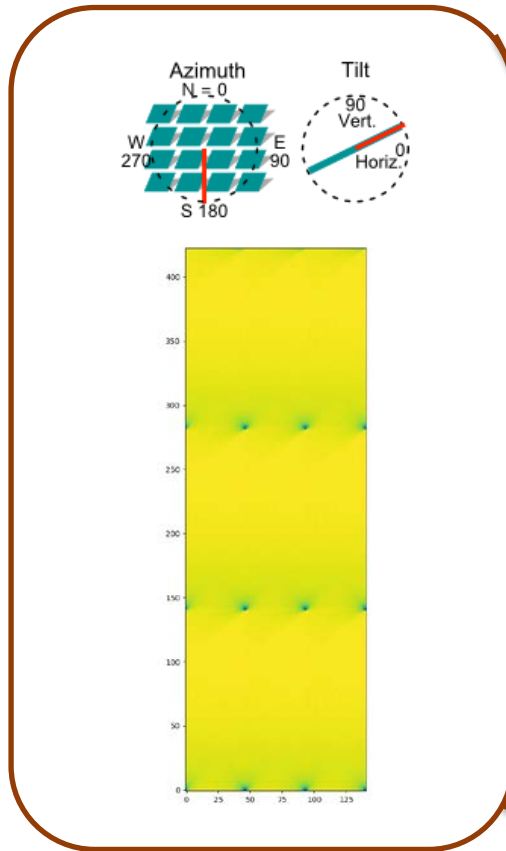
- Turbine placement
- Wake minimization
- Irregular boundaries
- Selection of turbines



West Texas (32.43, -99.73) 120m



Layout and Performance: PV

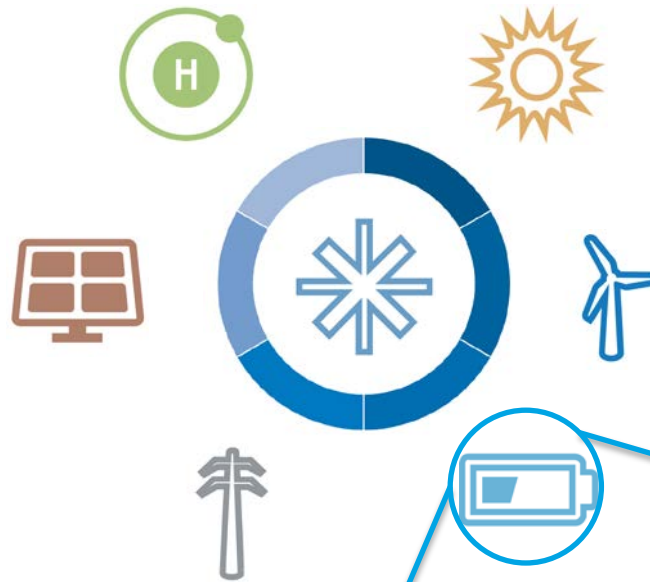


Array placement

Flicker and shadow
loss minimization

Spacing

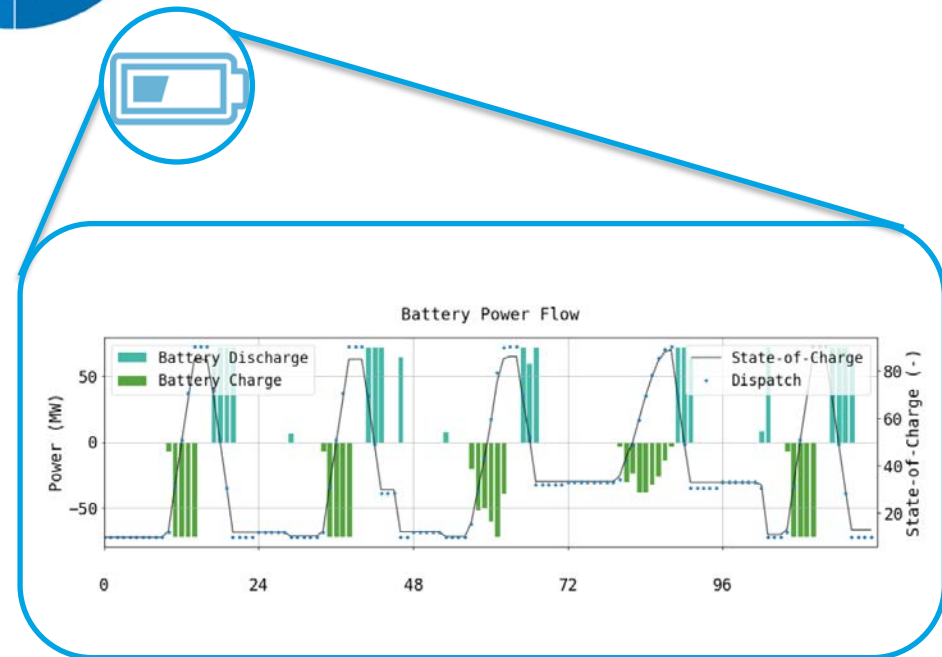
Battery Dispatch and Modeling



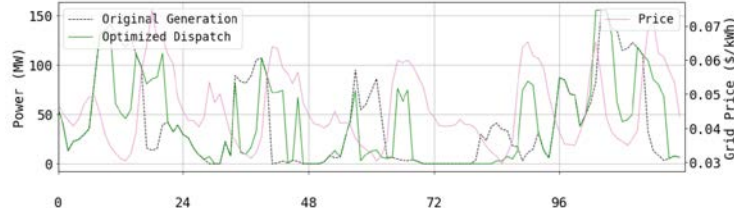
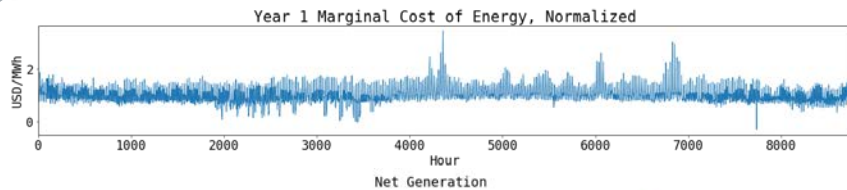
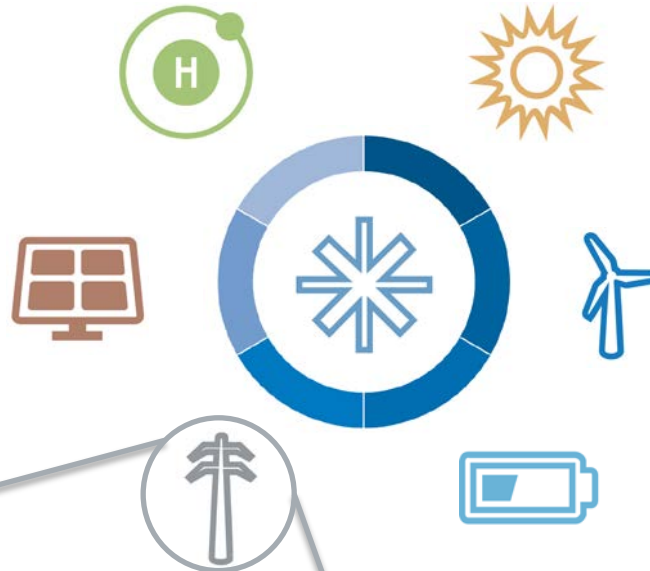
Optimal Predictive Dispatch

Augmentation & Replacements

Control over Charging Sources



Energy and Grid Services

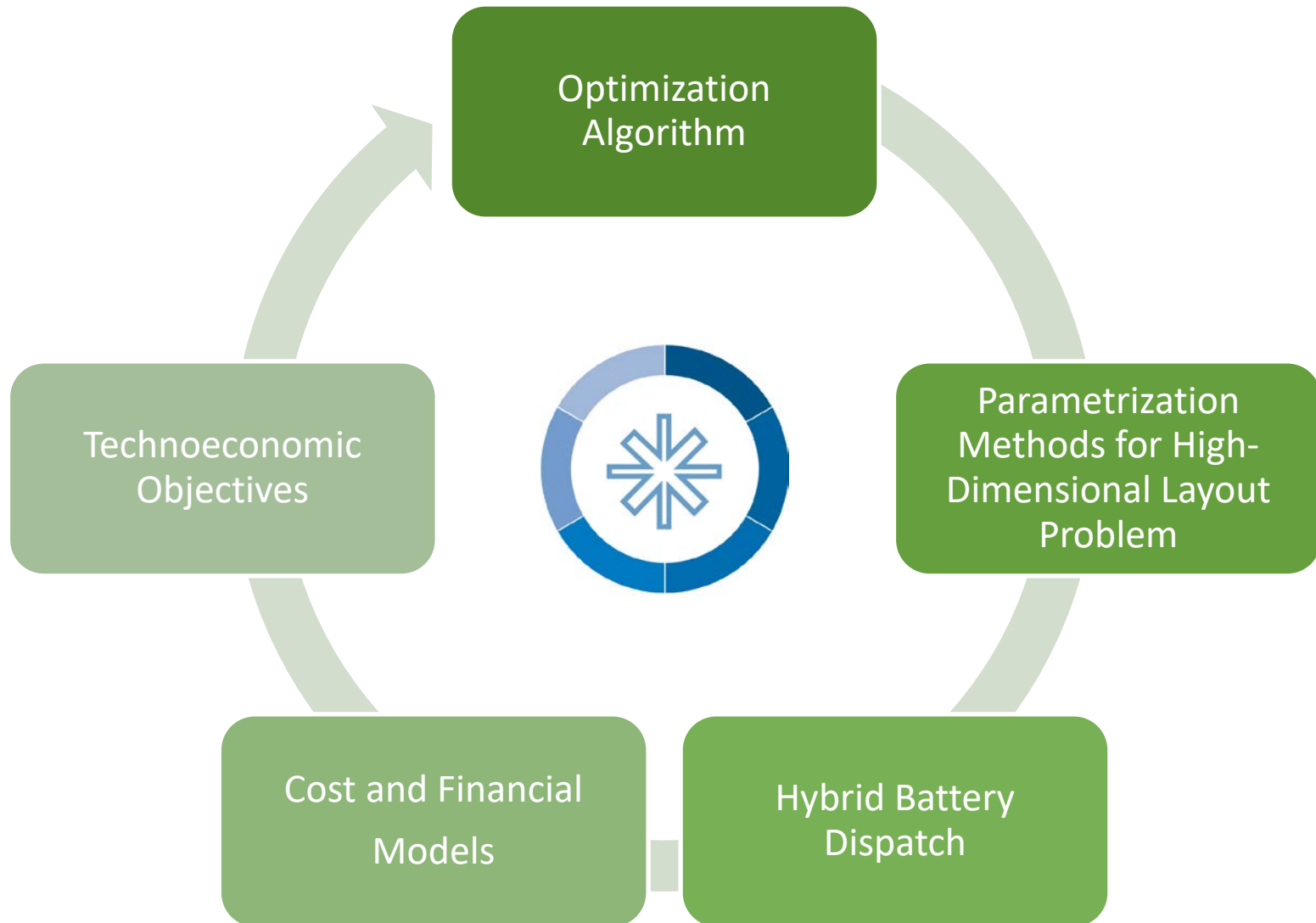


Energy Prices

Capacity Payments

Full financial model

Technoeconomic Design Optimization



Optimal Sizing And Layout

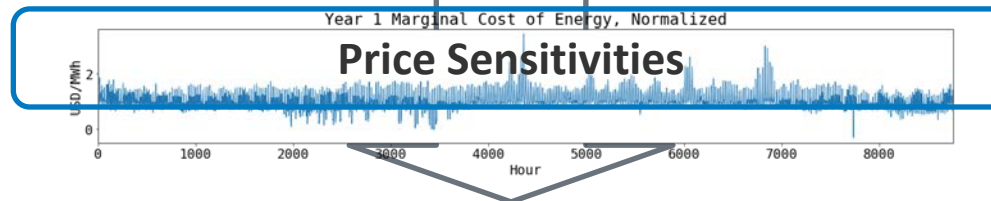
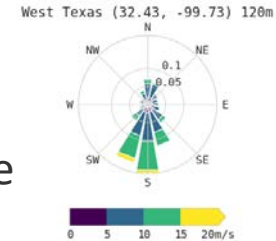
Sensitivity analysis of how optimal solution varies with input assumptions

<https://github.com/dguittet/HOPP-demos>

Example Wind + Solar + Battery Scenario

Scenario Set Up

- ATB Prices for Wind, Solar, and Battery
- Western Texas location with good resource
 - ~22% CF solar and ~39% CF wind
- Normalized Energy Dispatch Factors from CAISO
- Capacity Price and Accreditation Inspired from PJM



Open Loop 2021

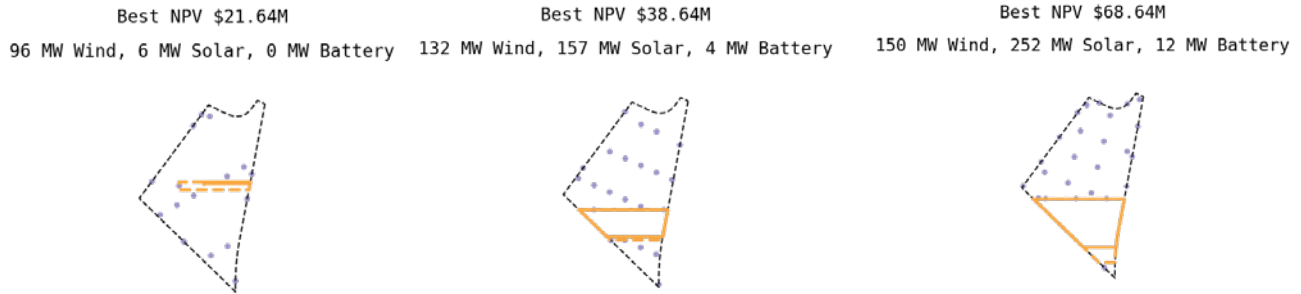
- Battery charges from PV, Wind and Grid
- PV receives ITC of 22%
- Battery receives no ITC
- Wind PTC of \$0.015/kWh

Closed Loop Solar 2022

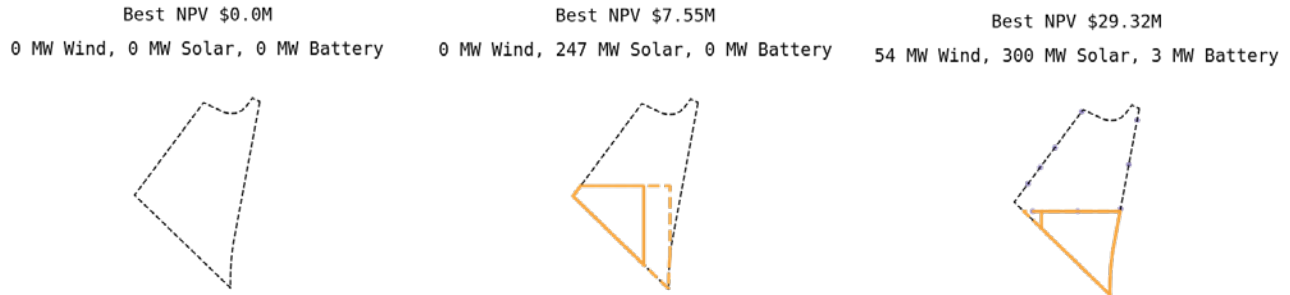
- Battery only charges from PV
- PV and Battery both receive ITC of 22%
- Wind does not receive PTC

Sizing and Layouts

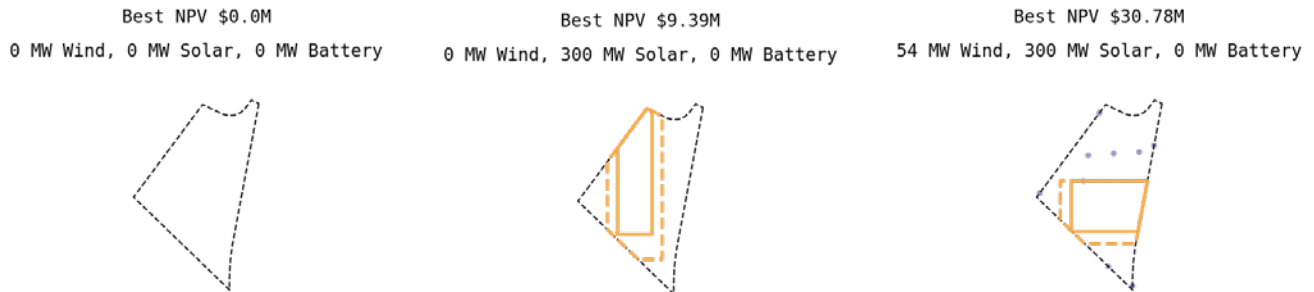
PTC +
ITC, Low
CP



ITC, Low
CP

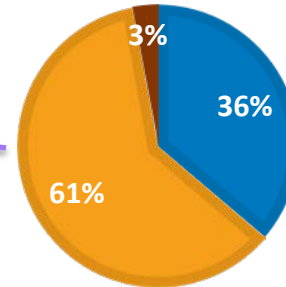
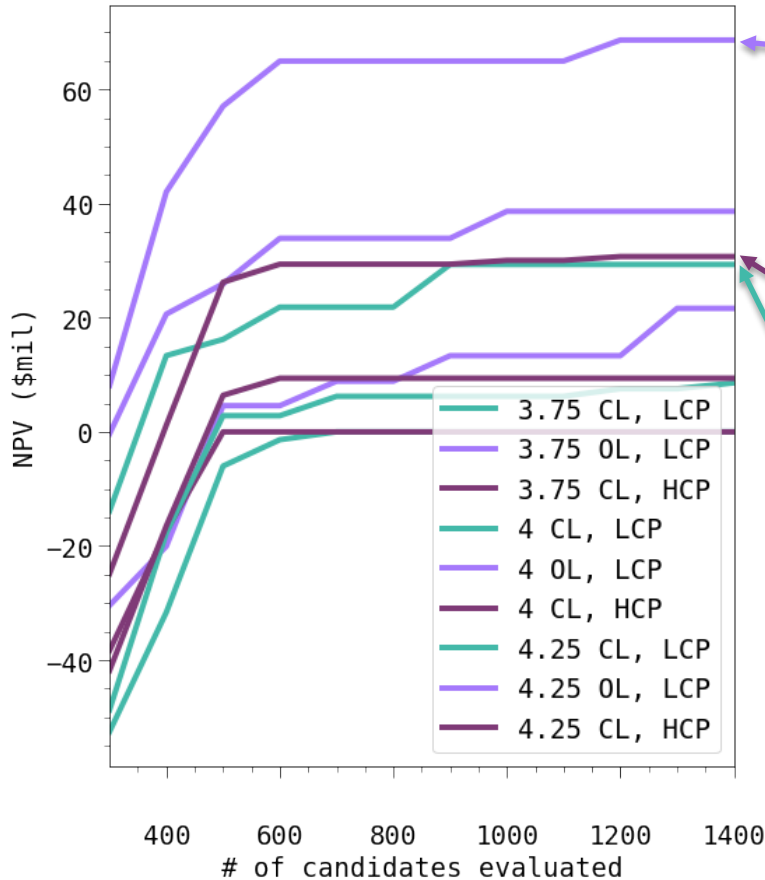


ITC,
High CP



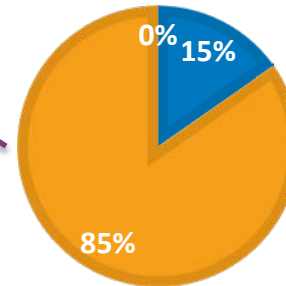
Optimal Hybrid NPV Results

Optimal NPV across All 3 Configurations



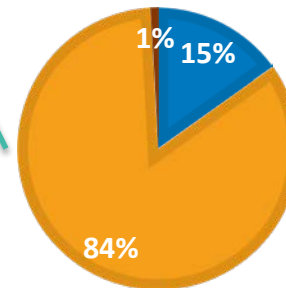
Open Loop 2021

- Battery charges from PV, Wind and Grid
- PV receives ITC of 22%
- Battery receives no ITC
- Wind PTC of \$0.015/kWh



Closed Loop Solar 2022

- Battery only charges from PV
- PV and Battery both receive ITC of 22%
- Wind does not receive PTC
- High vs Low Capacity Payment



■ Wind ■ Solar ■ Battery

Thank you!

Ongoing and Future Work

