

# Energy Transition Assessment of Solar Photovoltaics, Wind Turbines, and Energy Storage for the Pacific Northwest

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## Introduction

- Idaho/Oregon/Washington region is a strong candidate for decarbonization
  - Huge wind potential: ~63 GW total, only ~8.5 GW installed [1]
  - Underdeveloped solar photovoltaics (PV) capacity: <4.3 GW installed [2]
  - Coal generation nearly eliminated, natural gas ~20-40% of total generation (depending on state) [3]

## Research Questions

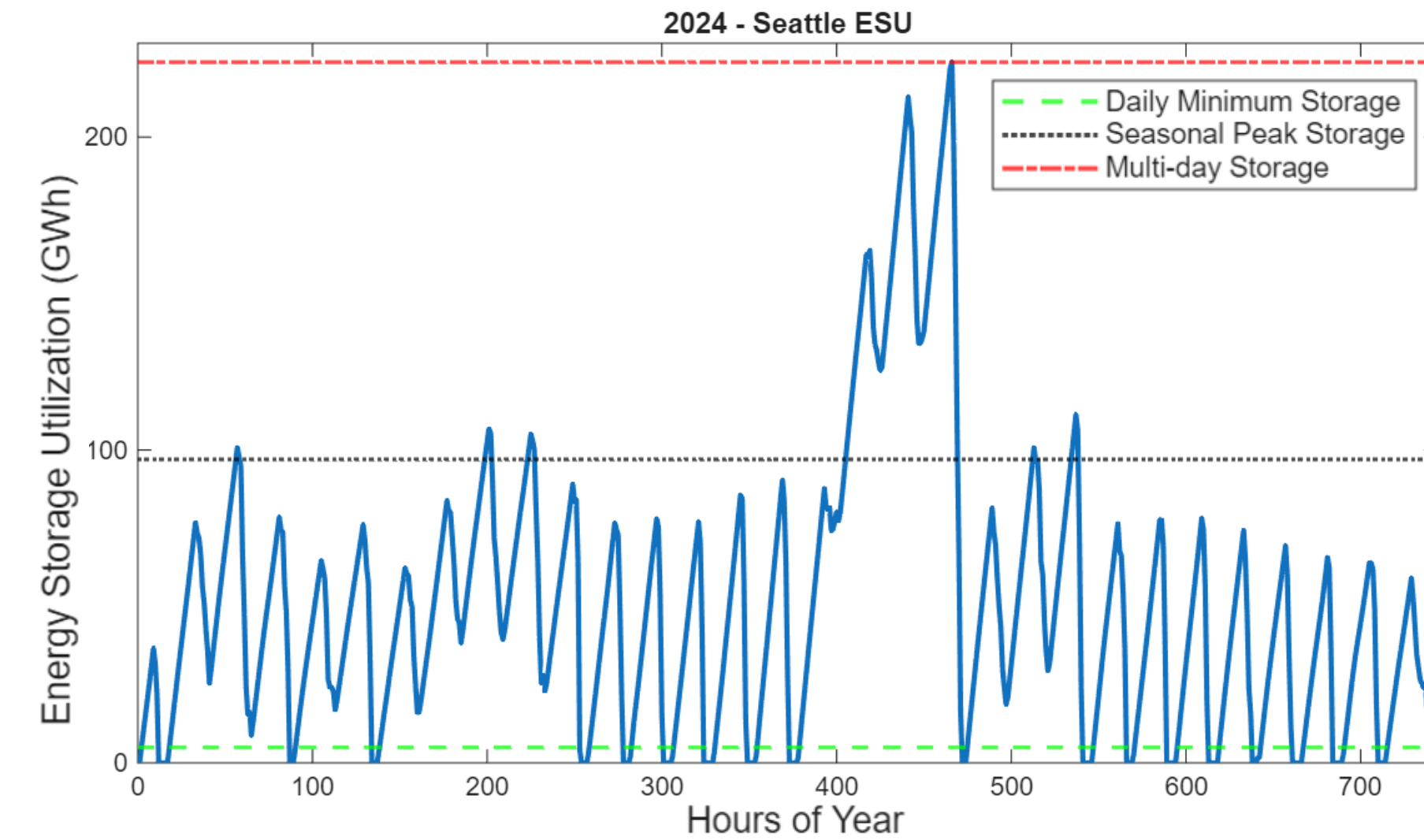
- Energy storage capacity requirements for decarbonized grid in the PNW:
  - With solar photovoltaics as sole replacement?
  - With optimized solar PV distribution?
  - With supplemental wind capacity?

## Data Sources

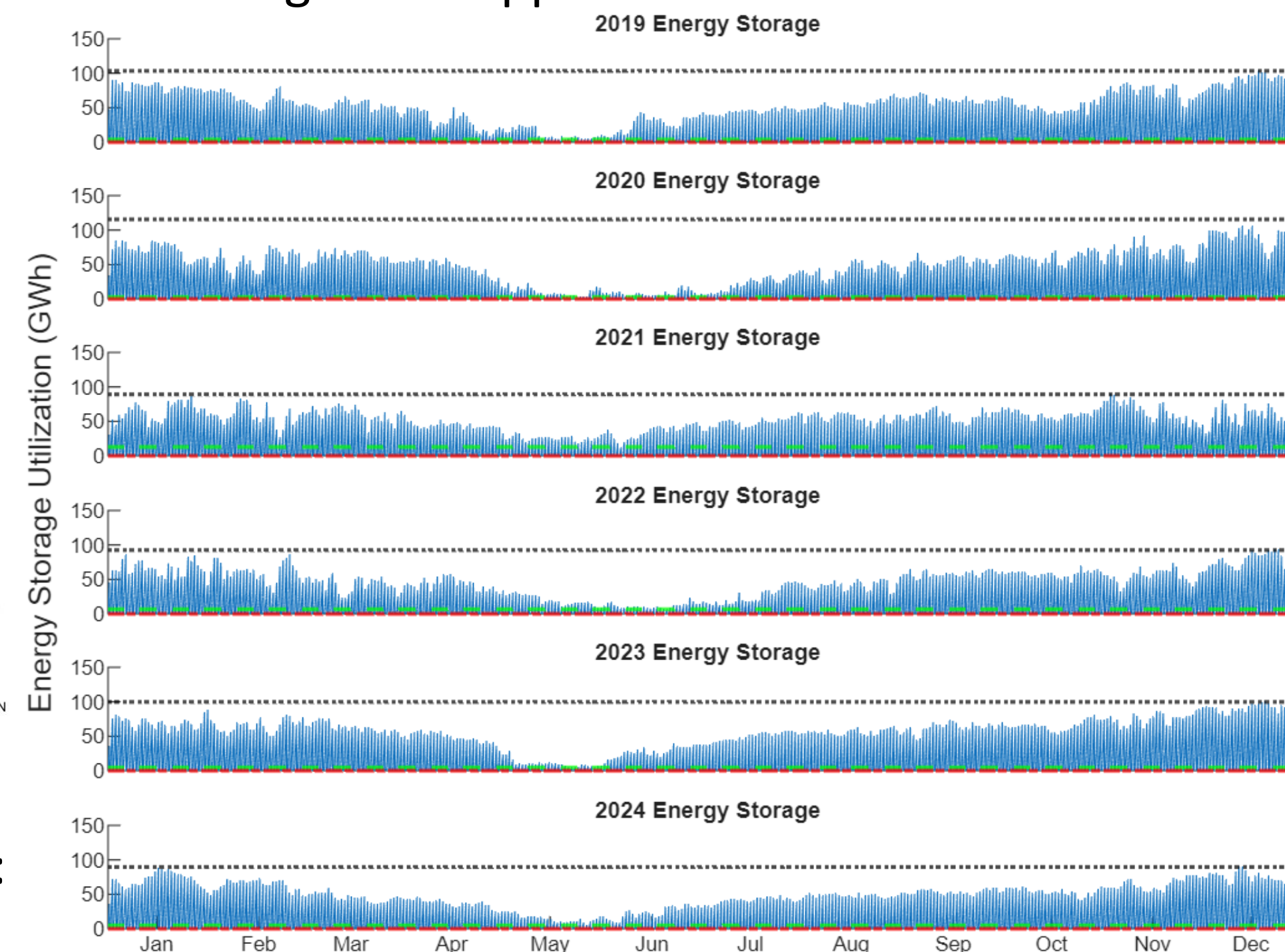
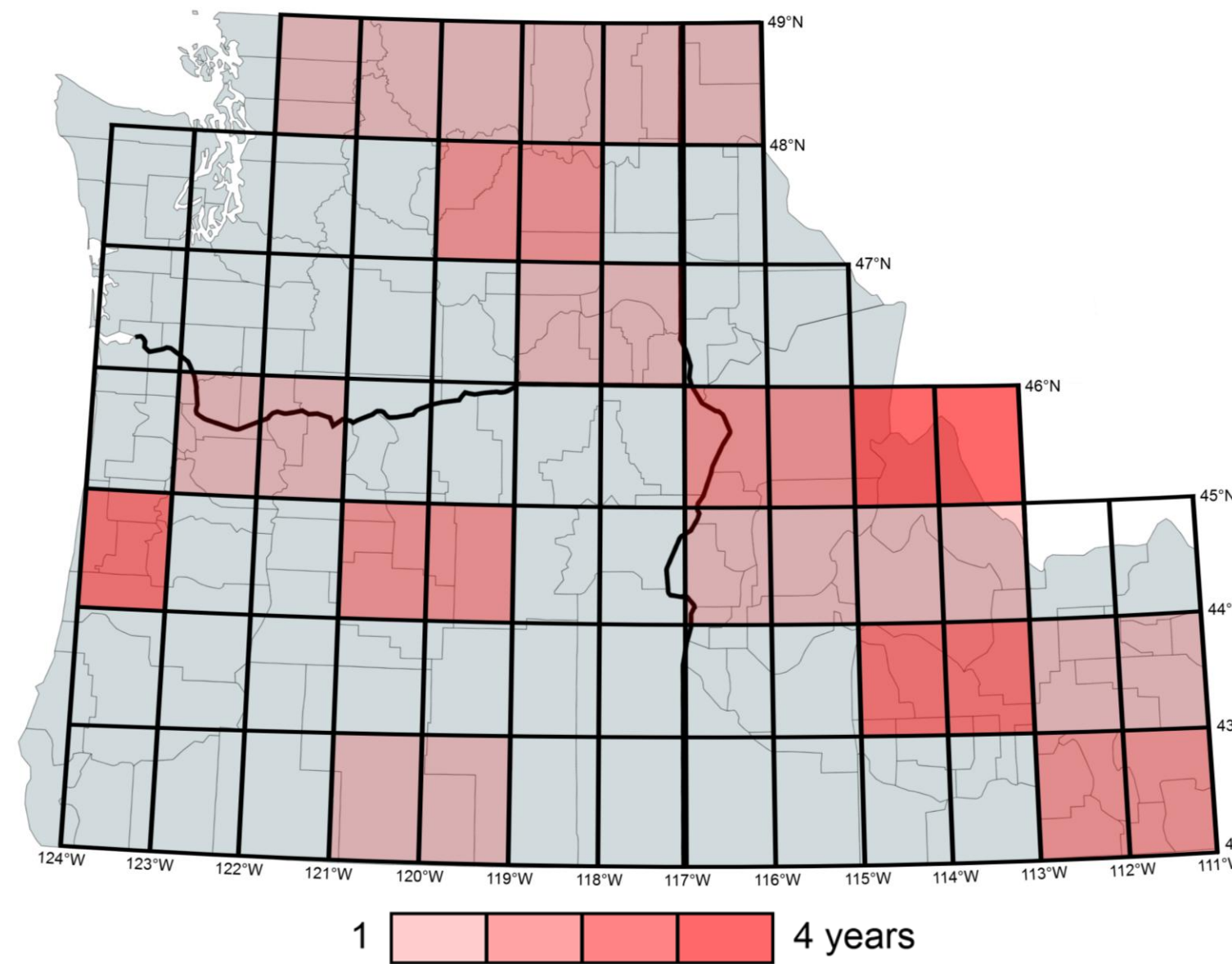
- Energy Information Administration (EIA):** hourly interval regional electric load split by generation source [3]
- National Solar Radiation Database (NSRDB):** global horizontal irradiance (GHI) [4]
- Wind Resource Database (WRDB):** 100-meter hub height wind speed [5]
- Energy storage and PV model developed in Nadeem et al., 2025 [6]

## Methods and Results

- Hourly **energy storage utilization (ESU)** defines battery's state in the charge-discharge cycle based on synchronous solar insolation and nonrenewable electric load
  - Daily minimum:** smallest discharge peak
  - Seasonal peak:** highest discharge peak from charge cycle <24 hours
  - Multi-day:** peak from charge cycle lasting >24 hours (extreme weather events)



- Select 40 locations, find individual locations' ESUs, and optimize to minimize multi-day peaks in hourly aggregate (2019-2024)
  - To achieve minimized peaks, determine area scaling factor applied to each chosen location



- Clustering observed in optimal locations: Central/southern ID, northern WA
- With sufficient panel area scaling at optimal locations, multi-day events can be eliminated
  - Seasonal peak becomes global maximum

## Results cont.

- Avg. wind speed across three best locations (2019-2023) used to simulate a representative wind farm
    - Power curve: Vensys 2,500 kW
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- Seasonal peak can be reduced by supplemental wind power, but high added capacities are needed

## Future Work

- Reduce error in determining area scaling factors → minimize total
- Optimization over multiple years: informative for real-world solar PV
- Explore impacts of optimizing wind resource distribution

**References:** [1] NLR, "Estimates of Windy Land Area," [www.nrc.gov/docs/ML1202/ML12026A745.pdf](http://www.nrc.gov/docs/ML1202/ML12026A745.pdf) [2] SEIA, "Solar State By State," [seia.org/solar-state-by-state/](http://seia.org/solar-state-by-state/) [3] EIA, U.S. Energy Information Database, [www.eia.gov/electricity/gridmonitor/dashboard/electric\\_overview/regional/REG-NW](http://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/regional/REG-NW) [4] NLR, NSRDB: National Solar Radiation Database, [nsrdb.nrl.gov/](http://nsrdb.nrl.gov/) [5] NLR, WRDB: Wind Resource Database, [wrdb.nrl.gov/](http://wrdb.nrl.gov/) [6] Nadeem et al., "Multi-Year Assessment of Energy Storage Capacity for a Carbon-Neutral Grid in Arizona and the Impact of Wind Energy Integration," (2025)