

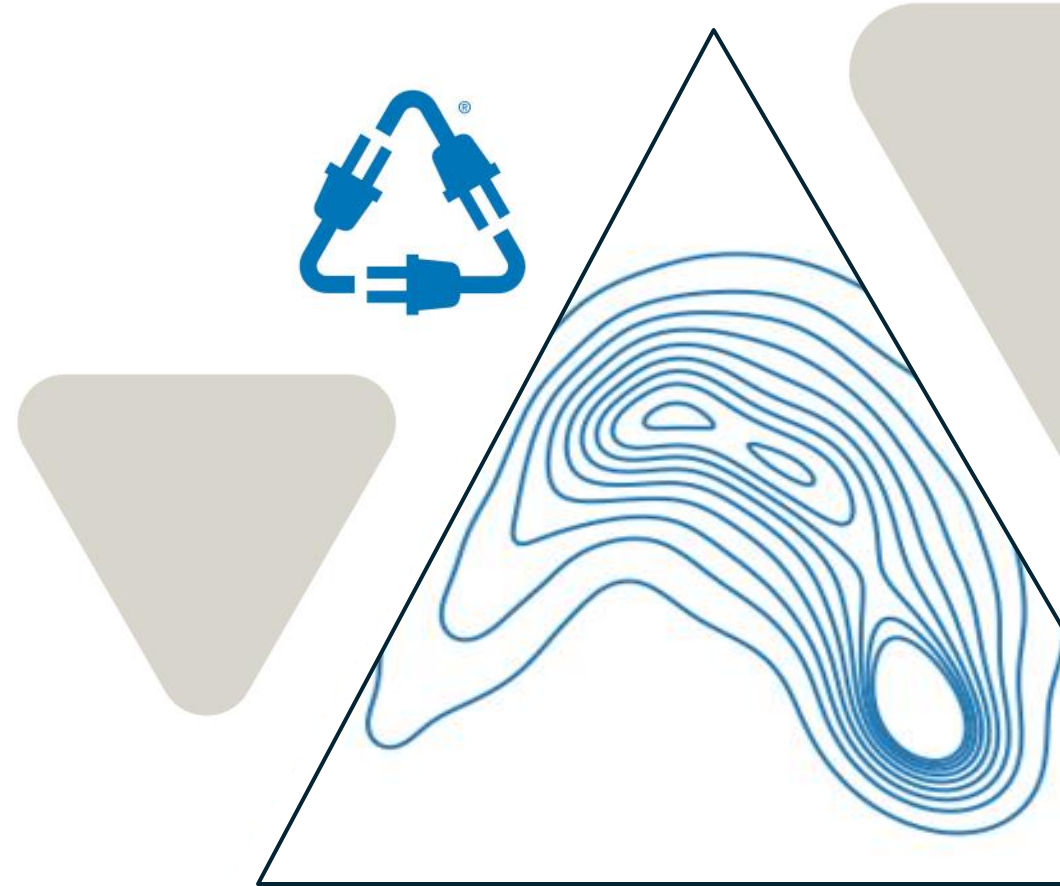
# Near-Term Probabilistic PV Power Forecasting

Thomas Haley

Lead Data Scientist

Clean Power Research

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# Agenda

1. GHI as a random variable
2. Irradiance as jointly distributed random variables
3. Monte Carlo modeling for PV power
  1. PV System Forecast
  2. Curtailed Forecast
4. Applications
  1. Non-Spinning Reserve Planning
  2. Minimized expected cost forecasts

# GHI Forecast: Possible Approaches

## Prediction + Uncertainty

- Hybrid Solution
- Hard to Iterate

## Quantile Regression

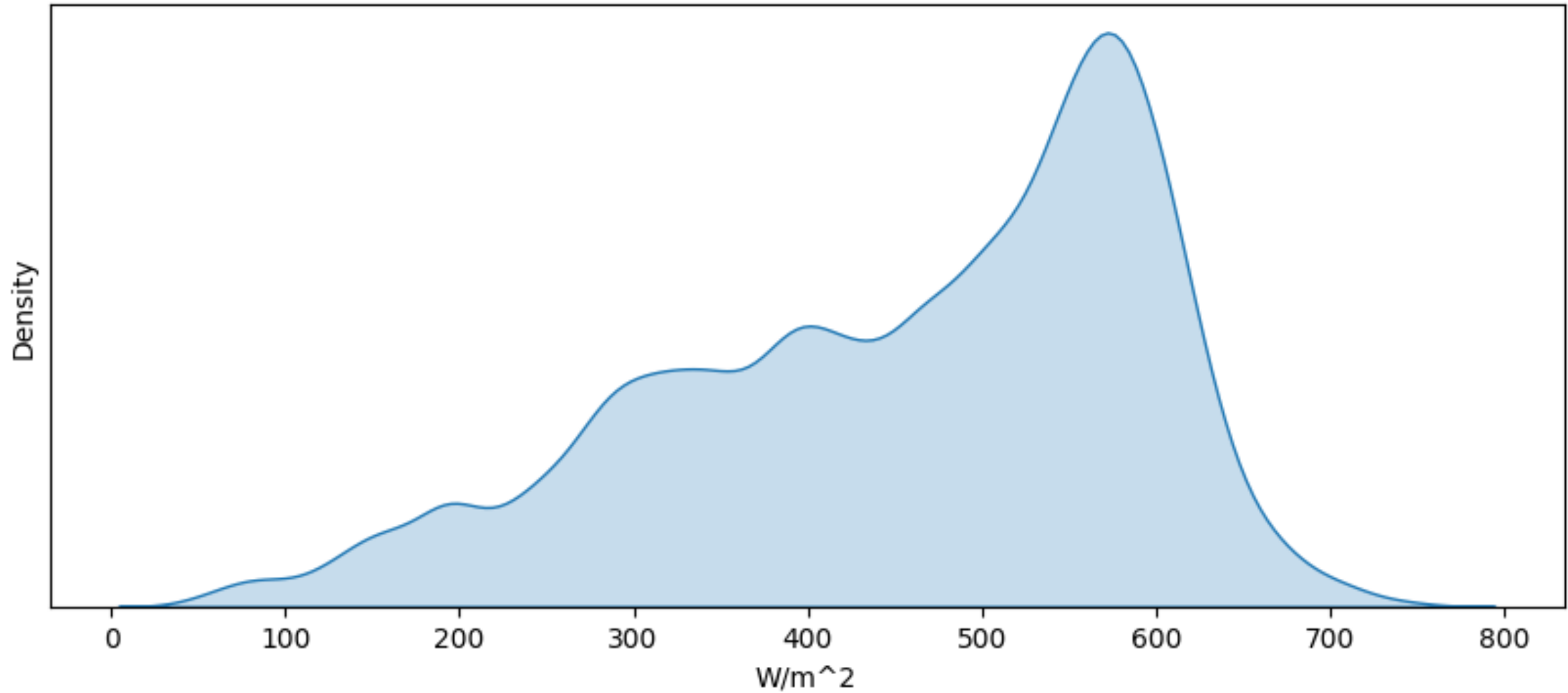
- Multiple Models to Maintain
- $f(\text{quantile}(\text{GHI}))$  almost equals  $\text{quantile}(f(\text{GHI}))$  - but not quite.

## Random Variable Regression

- Direct Regression of Irradiance

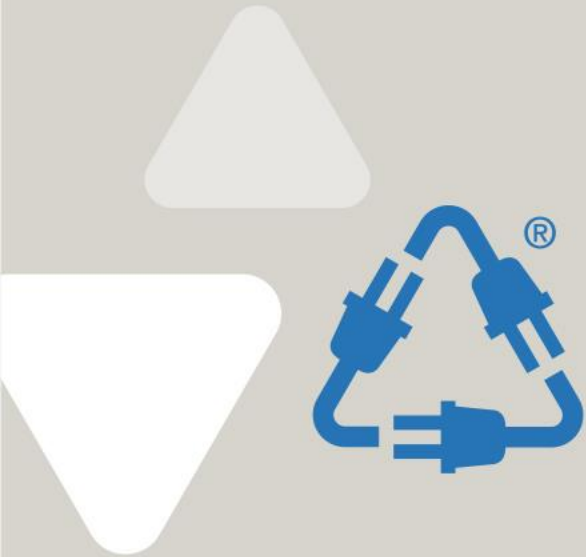
# GHI Forecast PDF

Forecasted GHI Distribution: Jul 18 09:00 to 09:15 AM



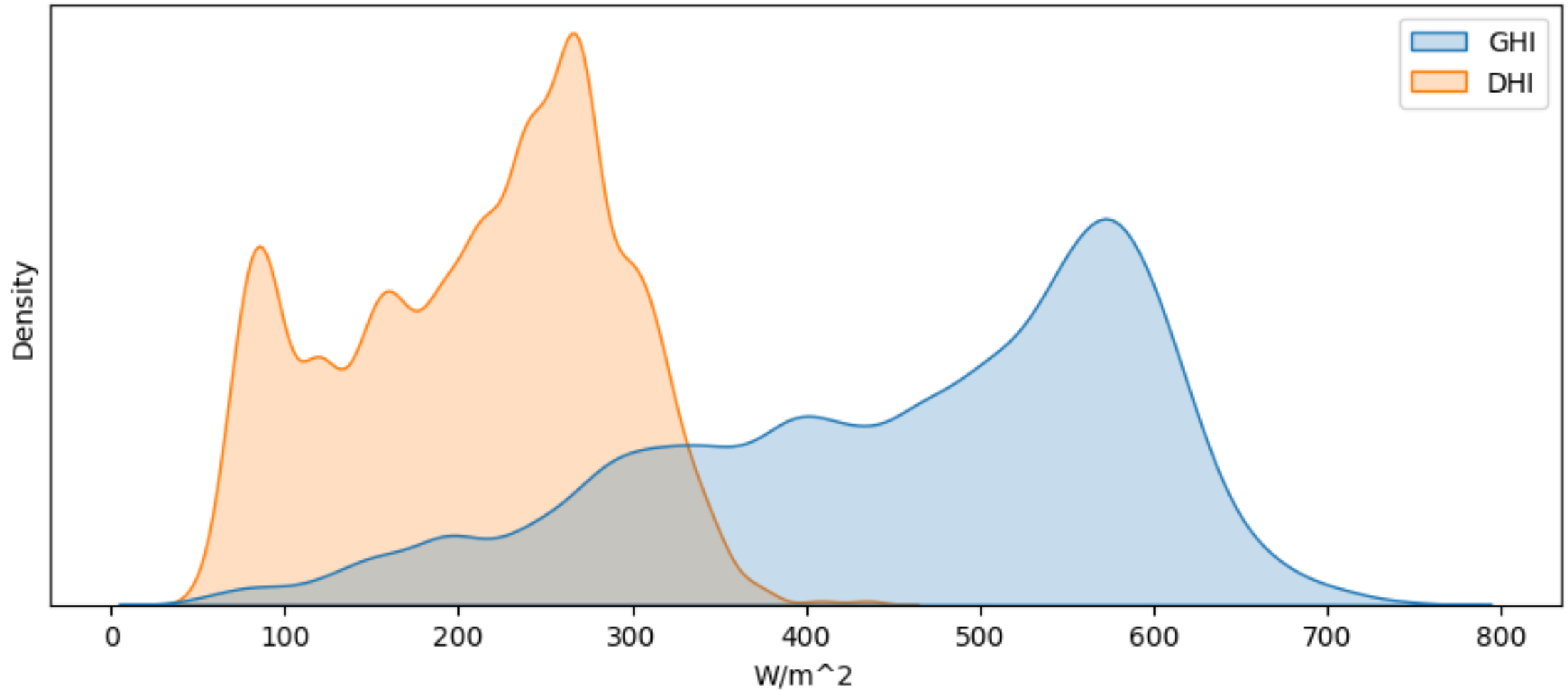
# Jointly Distributed Irradiance

- GHI is a random variable.
- DHI and DNI are also random variables.
- GHI, DHI, DNI are jointly distributed (dependent)



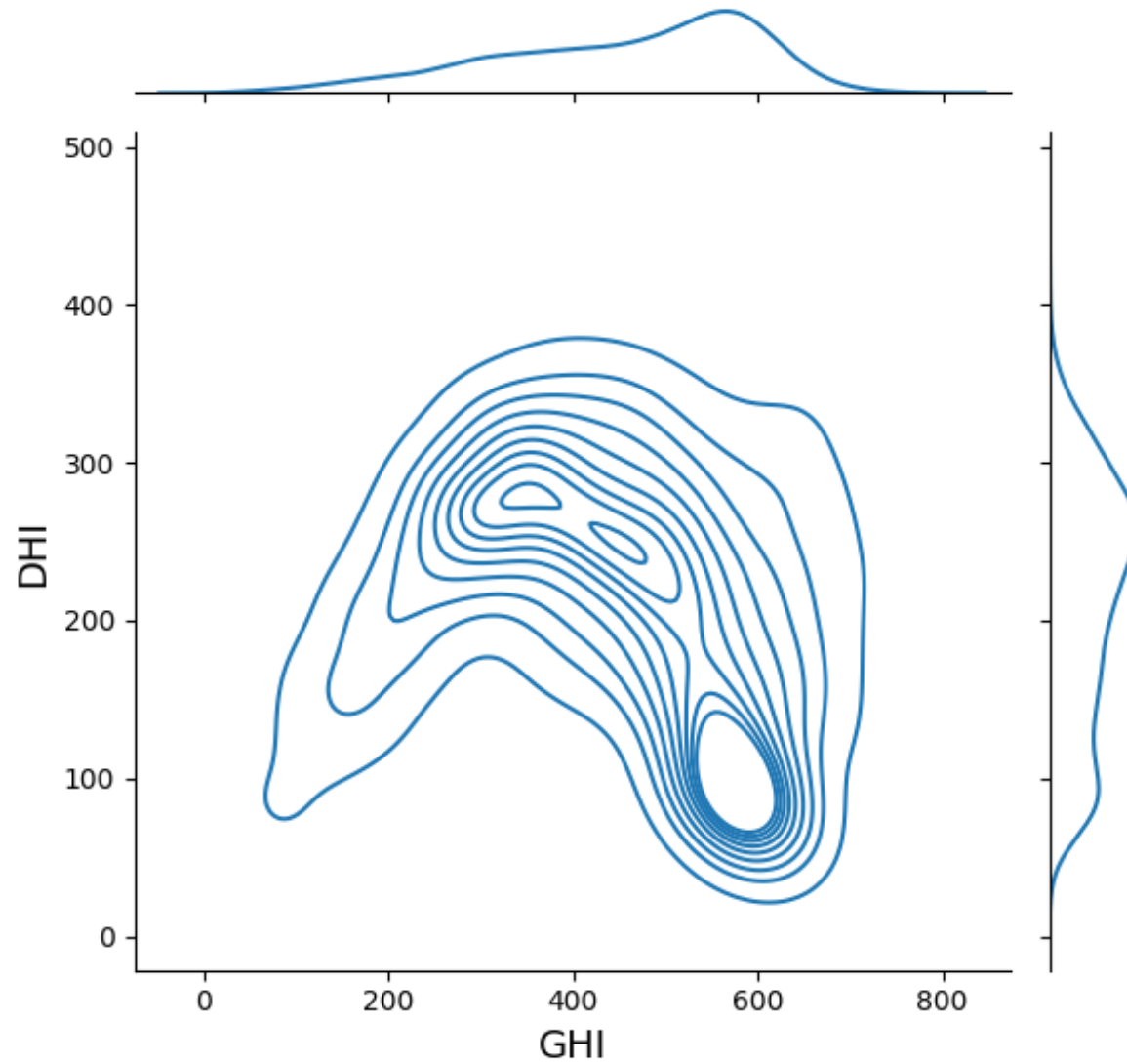
# GHI, DHI Forecast Marginal Distributions

Forecasted GHI and DHI Distribution: Jul 18 09:00 to 09:15 AM



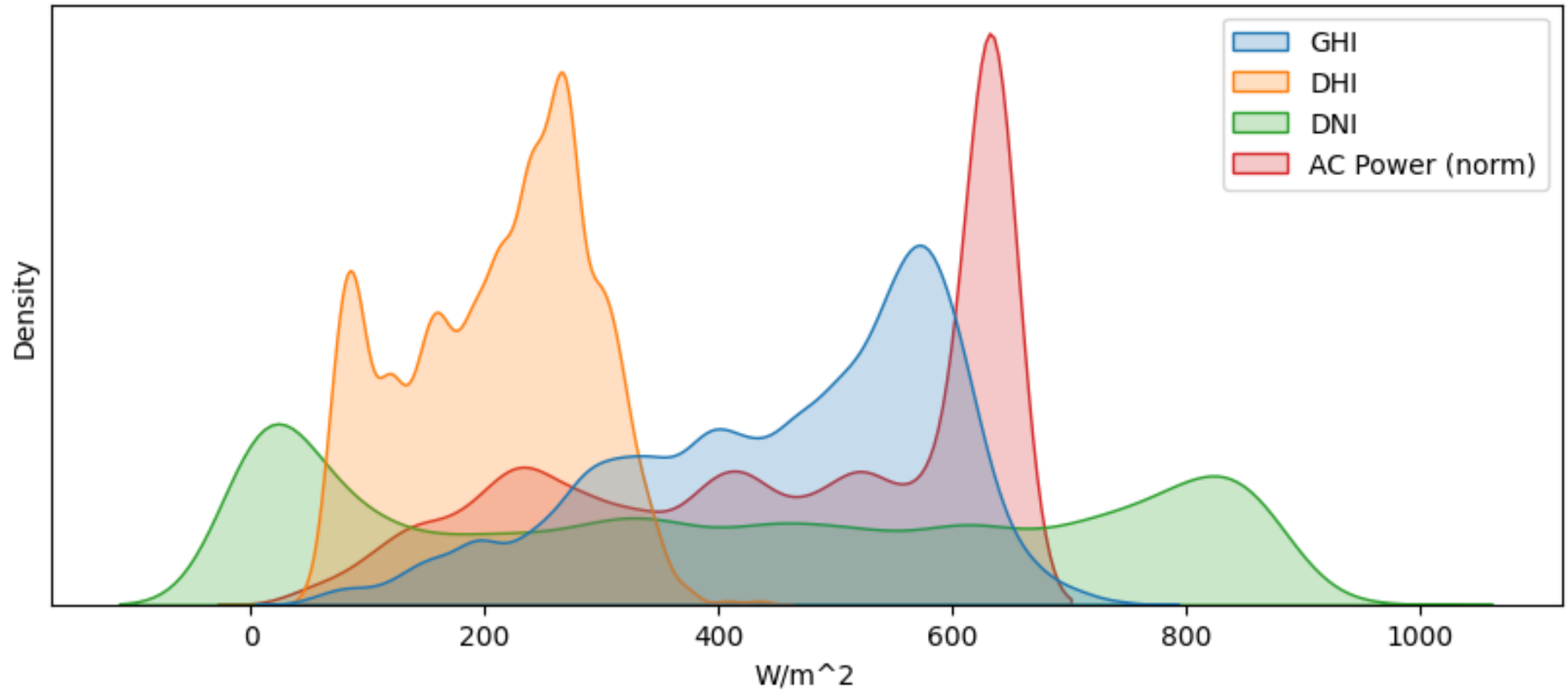
# Jointly Distributed Irradiance

Joint Distribution: GHI and DHI, Jul 18 09:00 - 09:15 AM



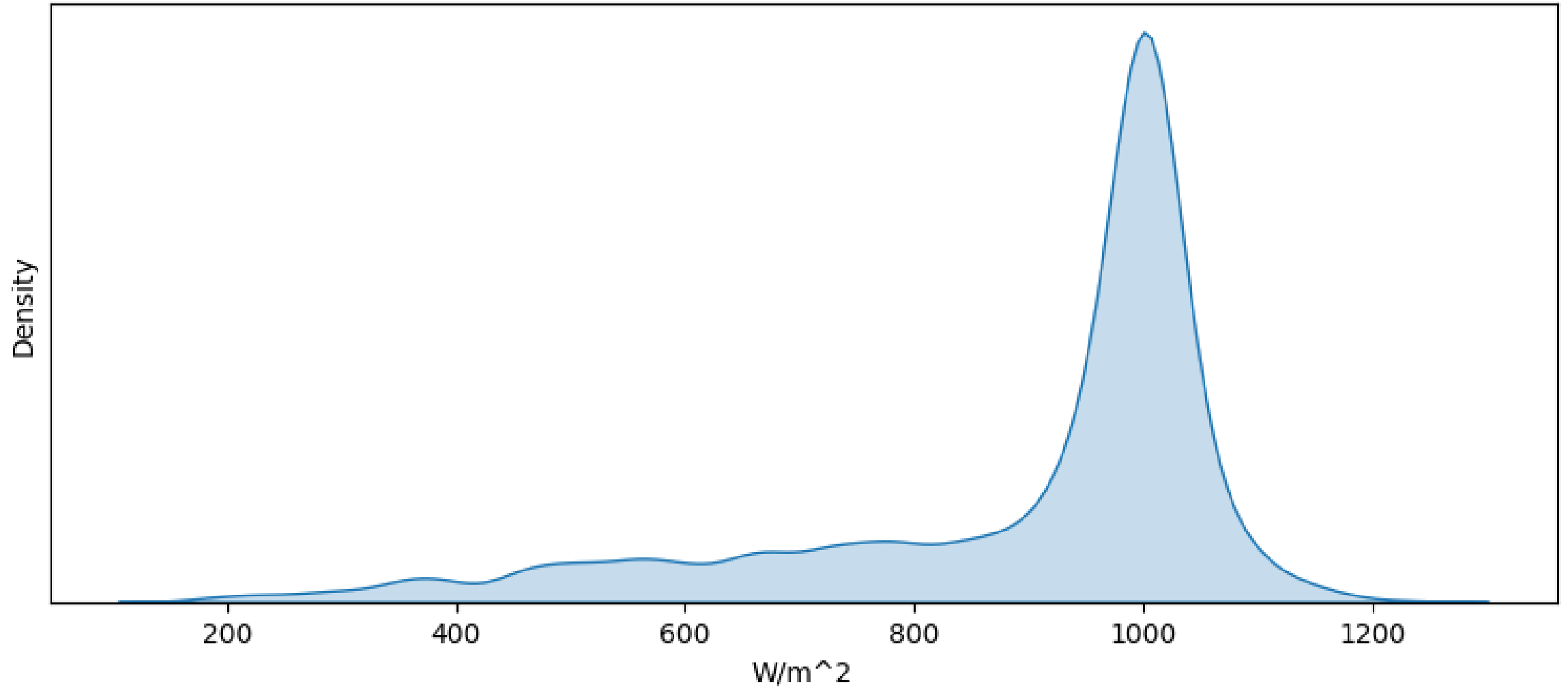
# Monte Carlo Evaluation of AC Power

Forecasted Marginal Distributions: Jul 18 09:00 to 09:15 AM



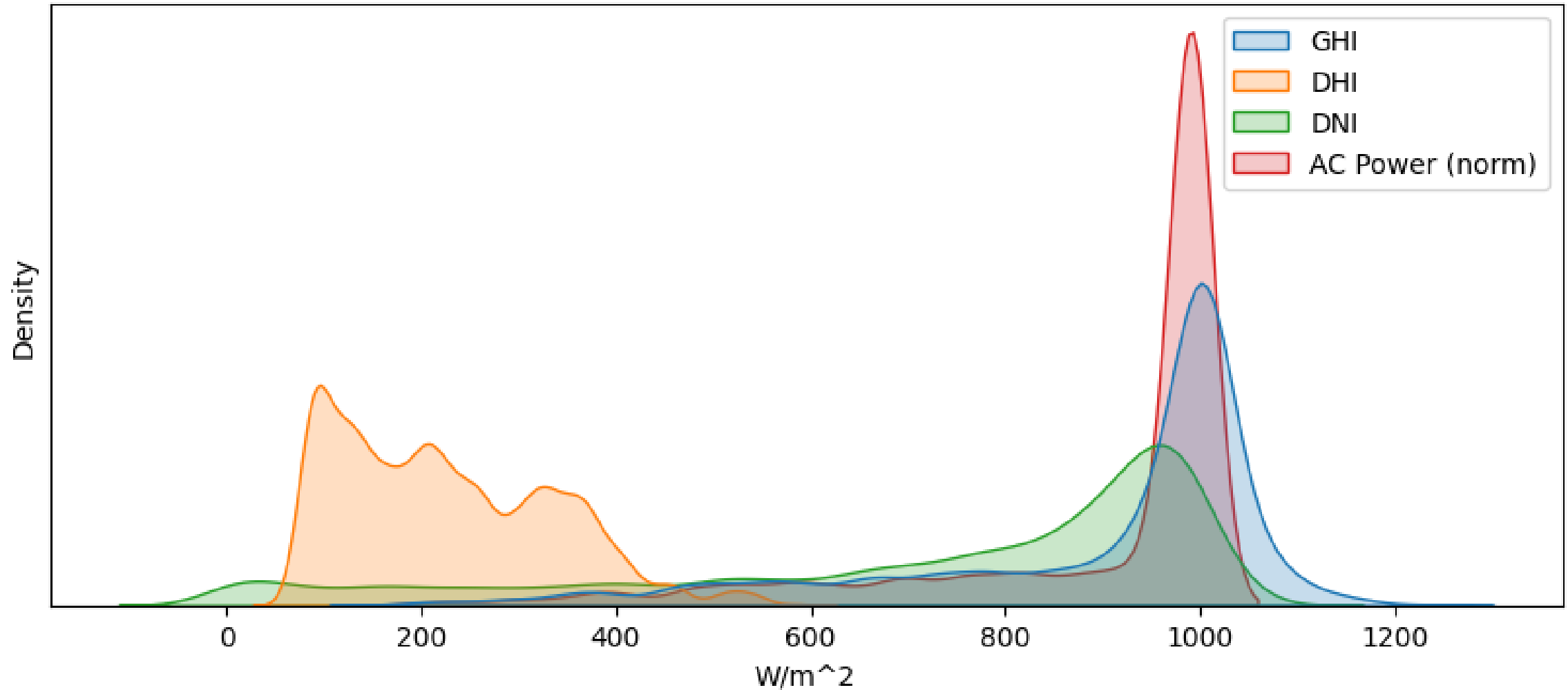
# Afternoon GHI

Forecasted GHI Distribution: Jul 18 01:00 to 01:15 PM



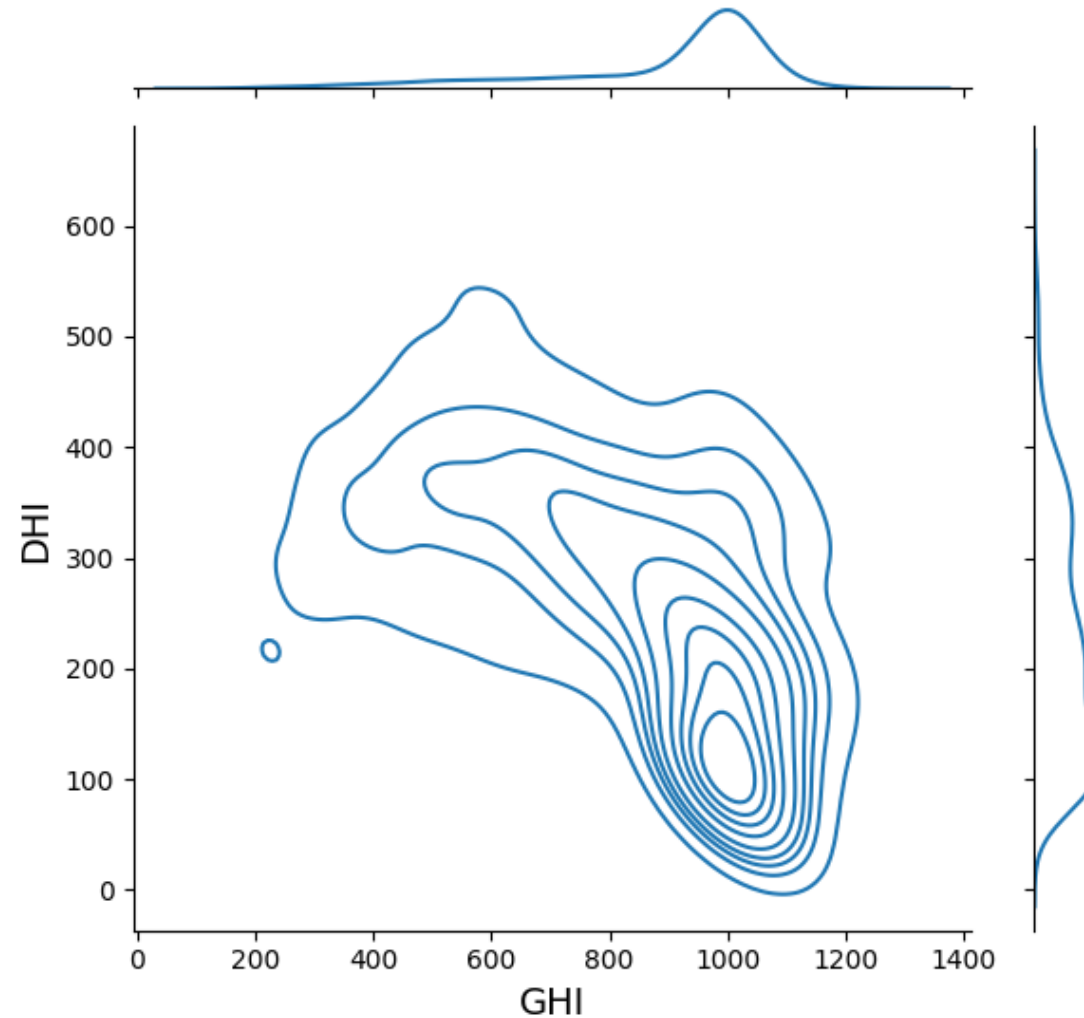
# Forecast Marginal Distributions

Forecasted Marginal Distributions: Jul 18 01:00 to 01:15 PM



# Jointly Distributed Irradiance: Afternoon

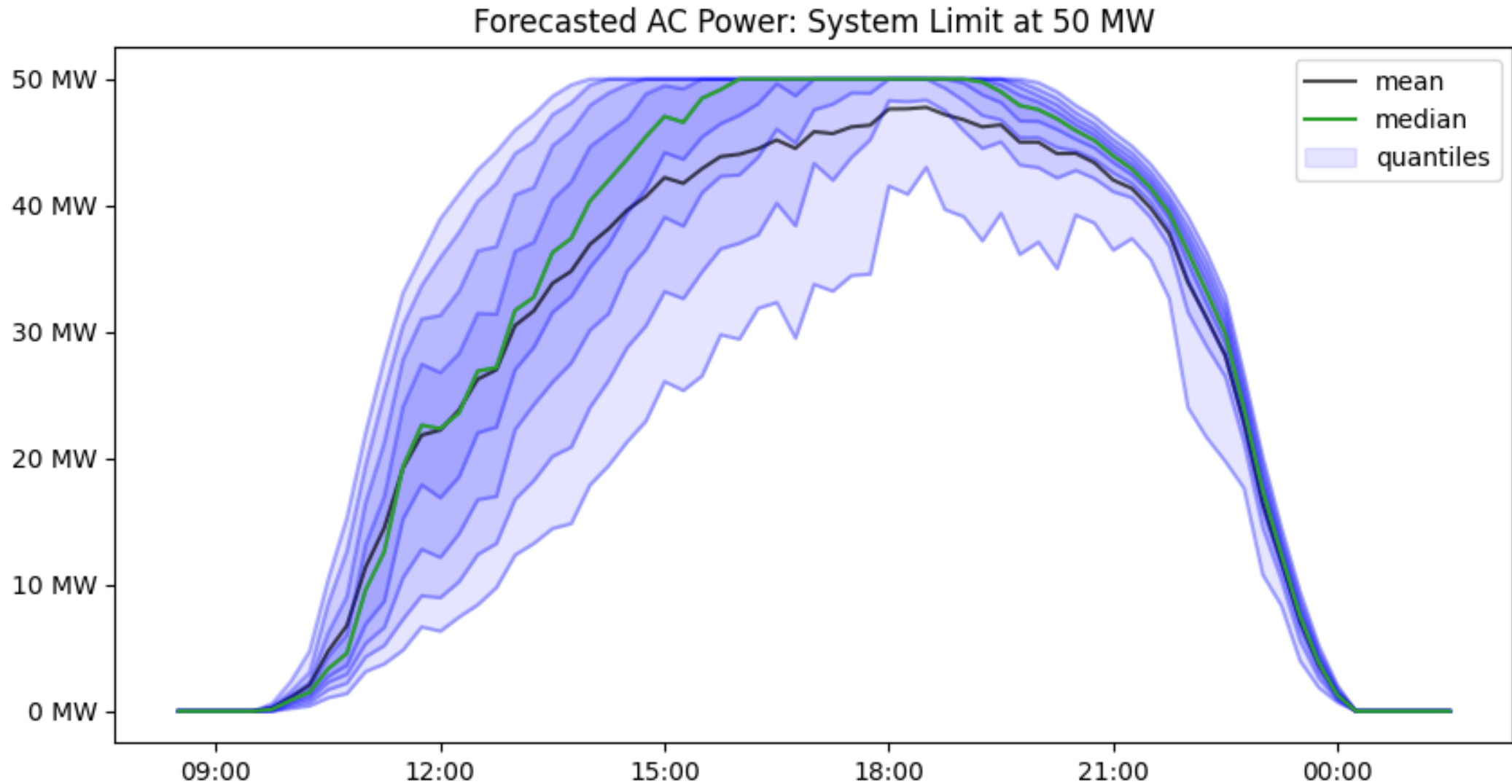
Joint Distribution: GHI and DHI, Jul 18 01:00 - 01:15 PM



# Applications



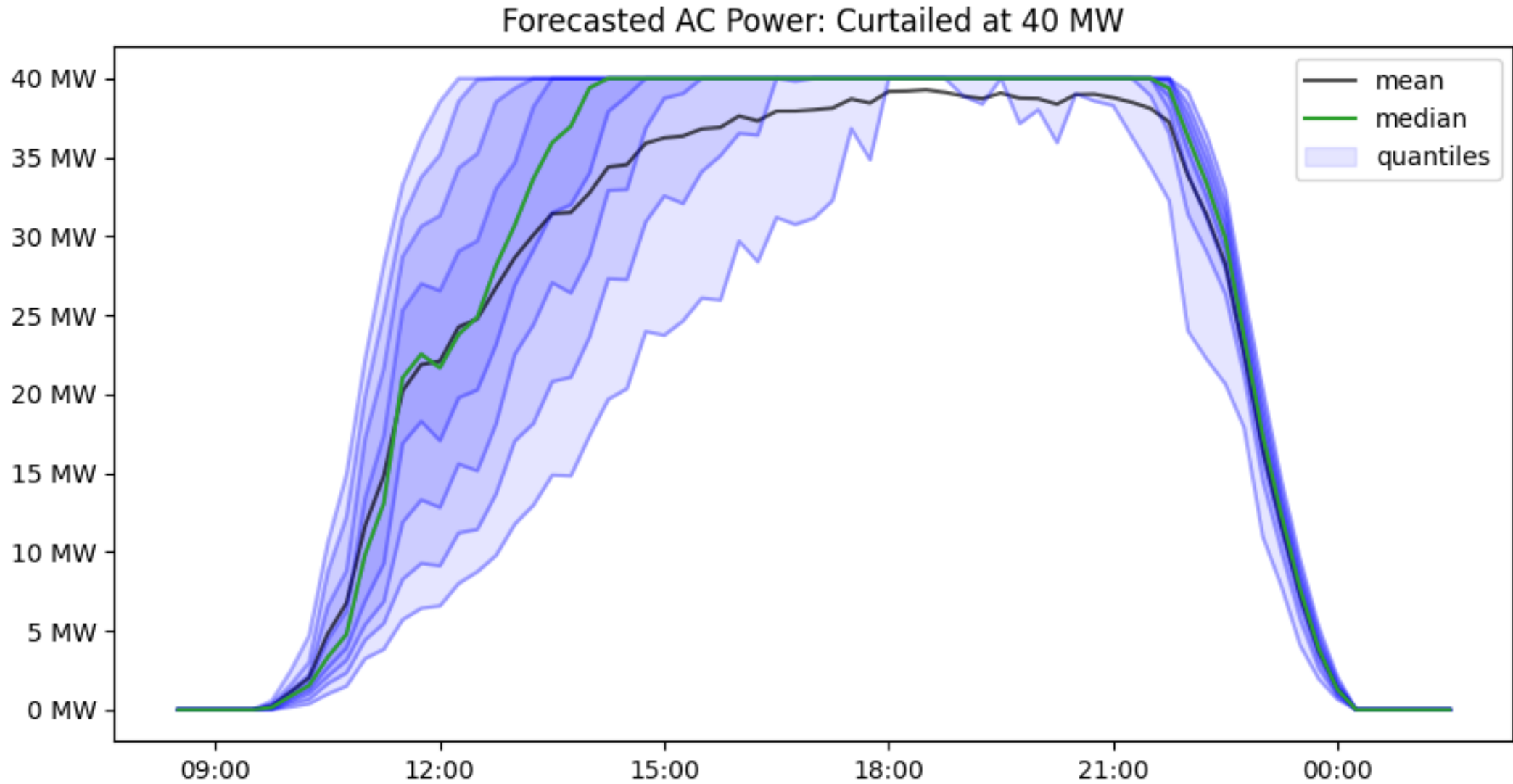
# Full Day Forecast: Full System Power



# Curtailed Forecasts



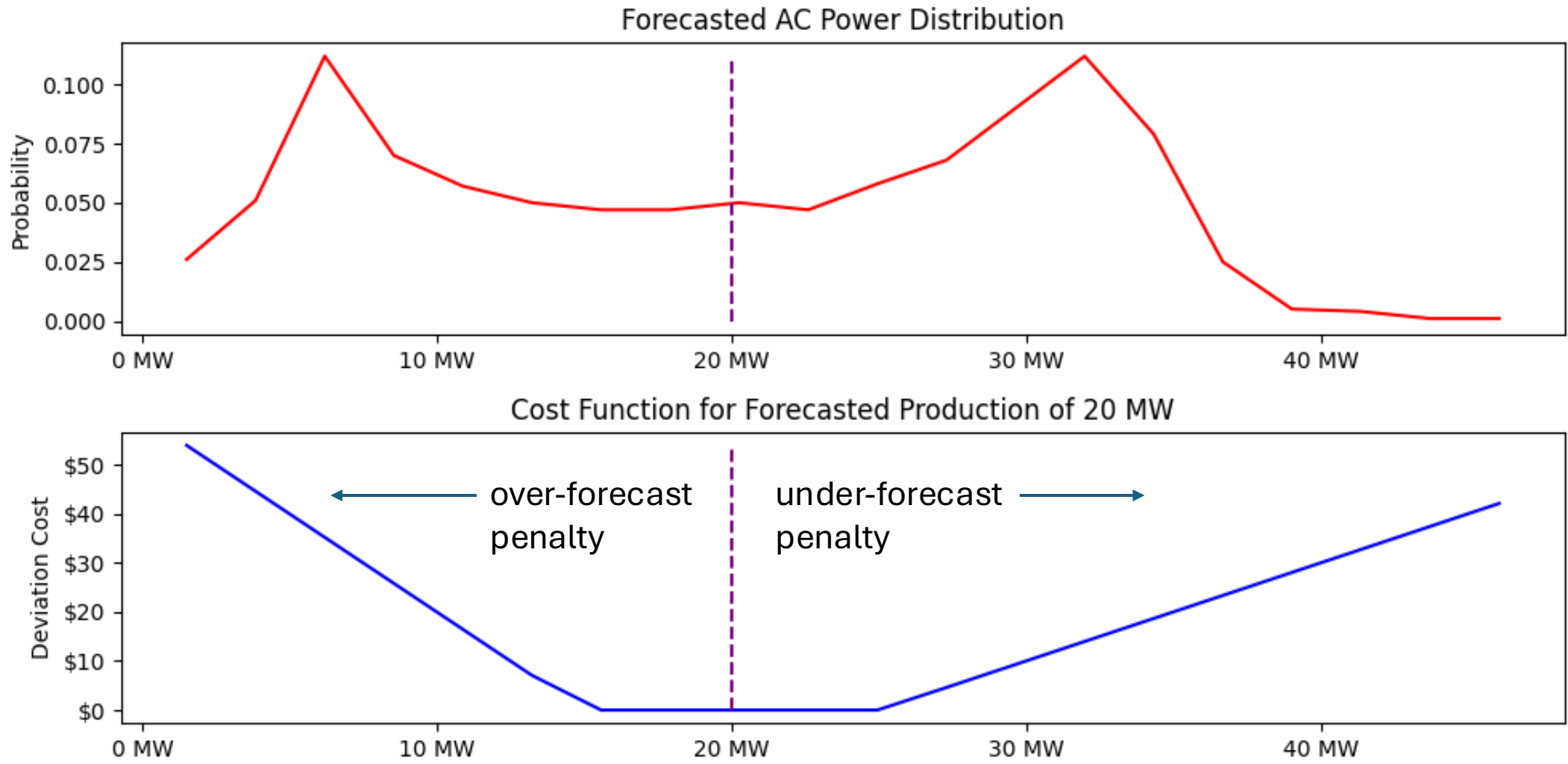
# Full Day Forecast: Curtailed



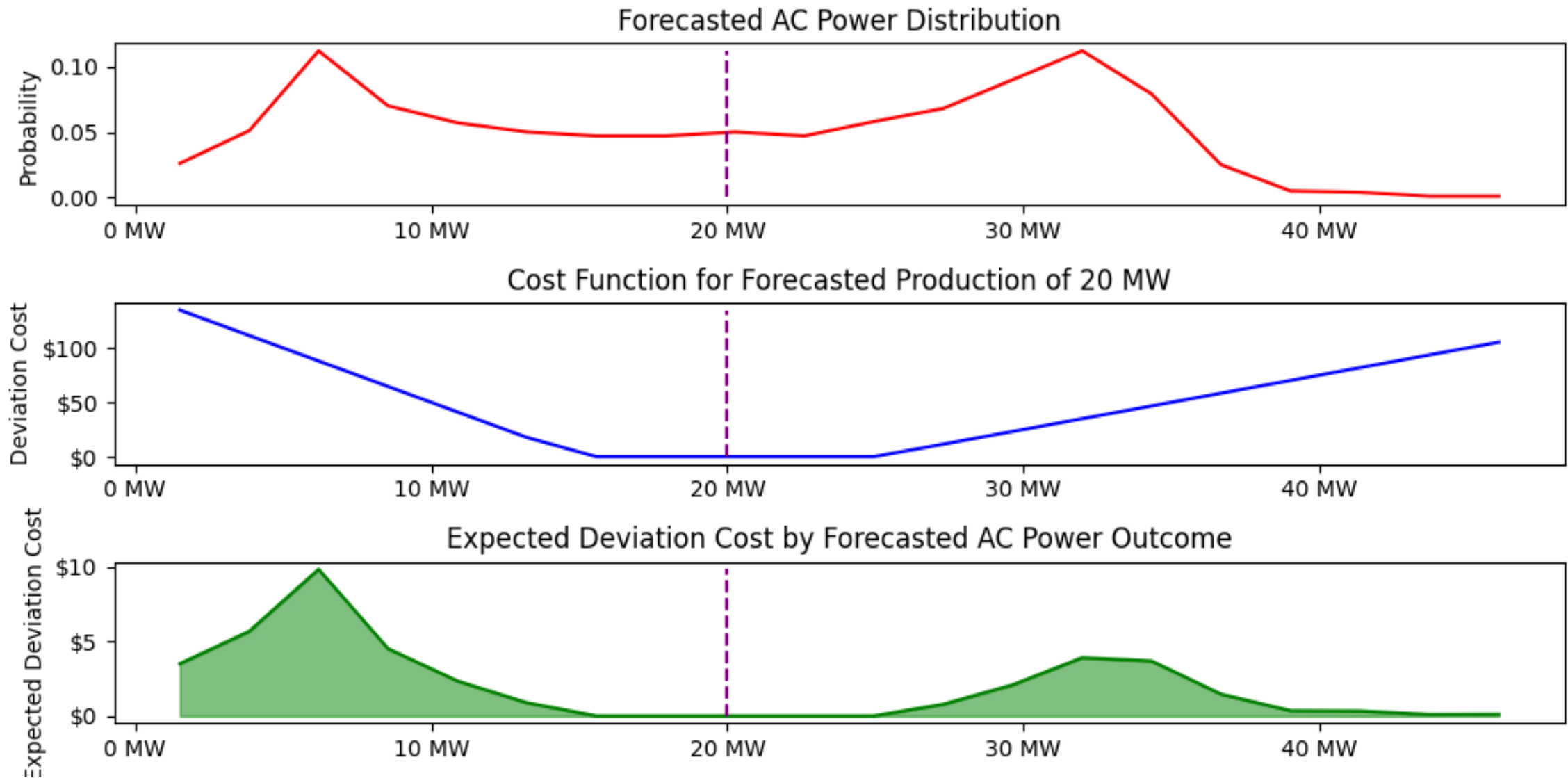
# Minimizing Expected Cost



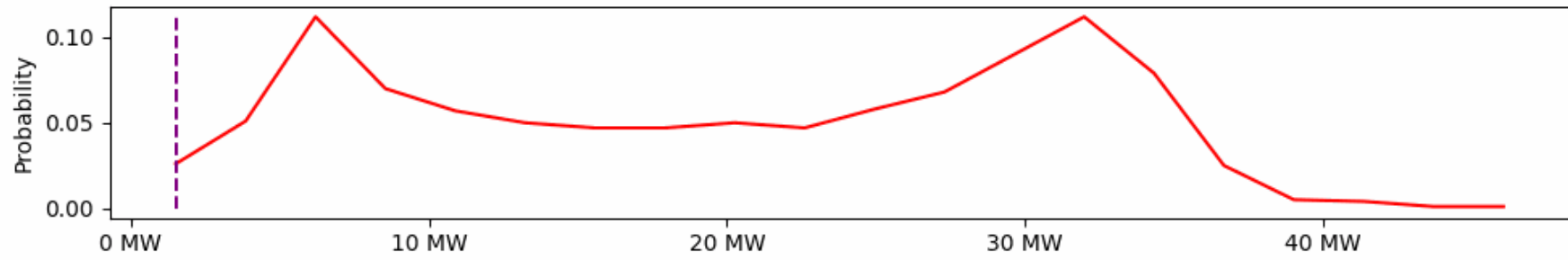
# Asymmetric Cost Function with 10 MW Dead Band



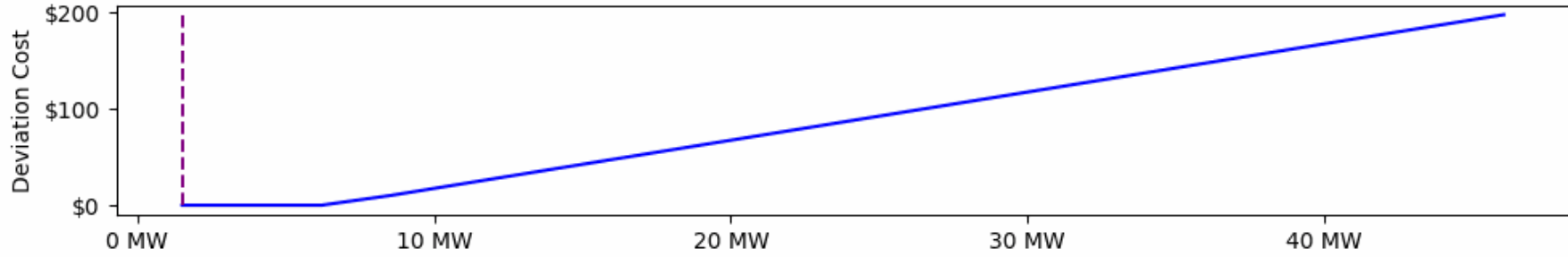
# Expected Deviation Cost: 20 MW Forecast



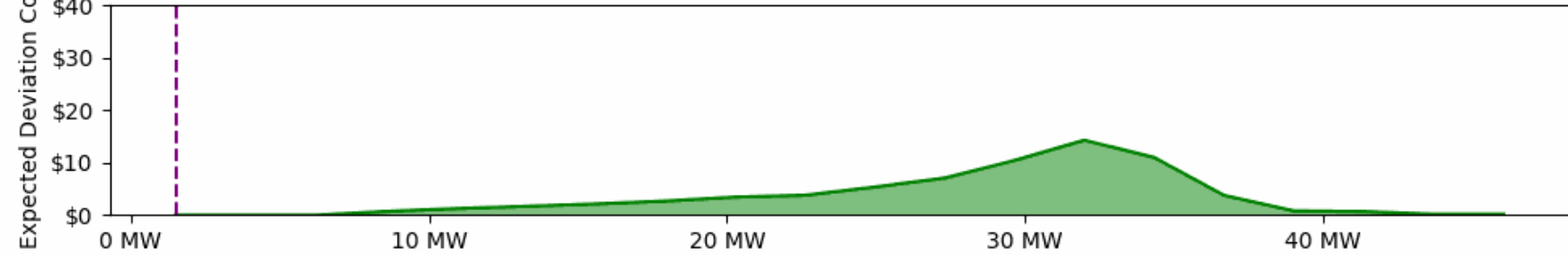
### Forecasted AC Power Distribution



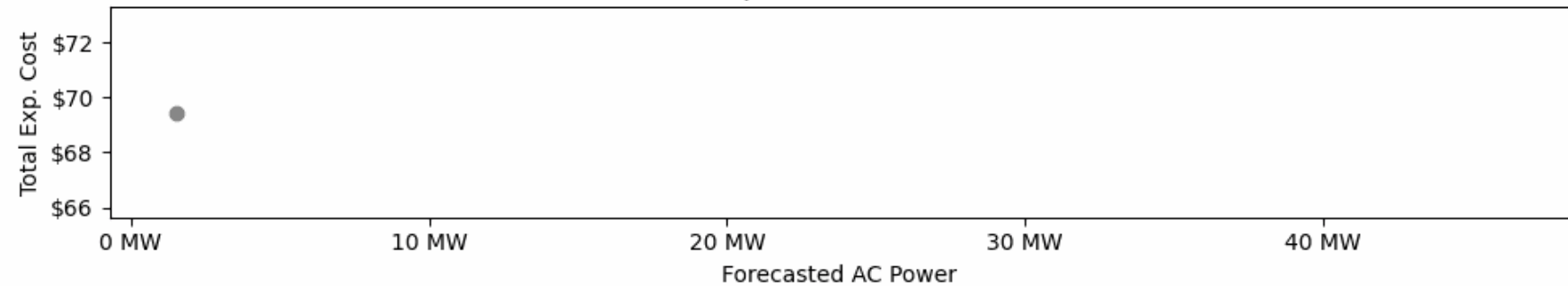
### Cost Function for Forecasted Production of 2 MW



### Expected Deviation Cost by Forecasted AC Power Outcome



### Total Expected Deviation Cost



Thank you

