# GRIDSHIELD – Stage 1 Load Forecast Risk Optimization Report

## Executive Summary

Objective: Minimize financial penalty under asymmetric ABT regulation. Under the current regulation, underforecasting incurs a penalty of ■4/kWh, while overforecasting costs ■2/kWh. Our cost-sensitive modeling approach aims to skew predictions slightly upward to leverage this asymmetry and reduce overall financial risk.

## Data Overview

The model uses 15-minute resolution load data (2013-2021), weather variables (Temperature, Humidity, Rain), and event/holiday indicators. Total training rows: 238,463.

## Feature Engineering

The feature matrix includes: Time features (hour, day, month), Weekend & peak flags, Lag features (1-step, 96, 672), and Rolling 24h & 7d averages.

## Model Design

A RandomForestRegressor model was trained using a time-based split with a cutoff of 2020-01-01 to ensure no data leakage and realistic validation metrics.

## Financial Penalty Function

Formula: Penalty = 4 * (Actual - Forecast) if Actual > Forecast else 2 * (Forecast - Actual). This asymmetric loss function penalizes shortages twice as heavily as surpluses.

## Results

| Metric | Value |
|---|---|
| Total Penalty | 1,137,673.05 |
| Peak Penalty | 267,063.59 |
| Off-Peak Penalty | 870,609.47 |
| Bias | 0.01% |
| P95 Abs Deviation | 24.13 |
| Naive Penalty | 7,682,043.79 |
| Optimized Penalty | 1,078,369.14 |

| | |
|---|---|
| % Reduction vs Naive | 85.96% |

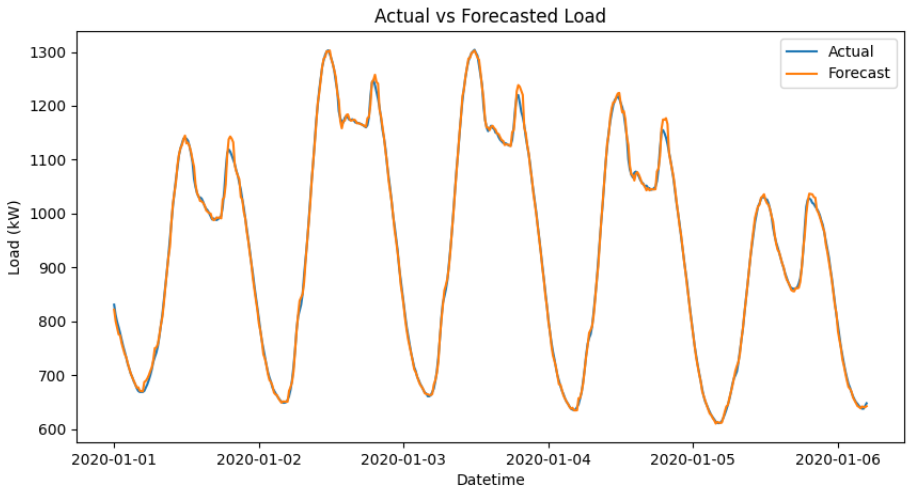
### *Multiplier Sweep Results*

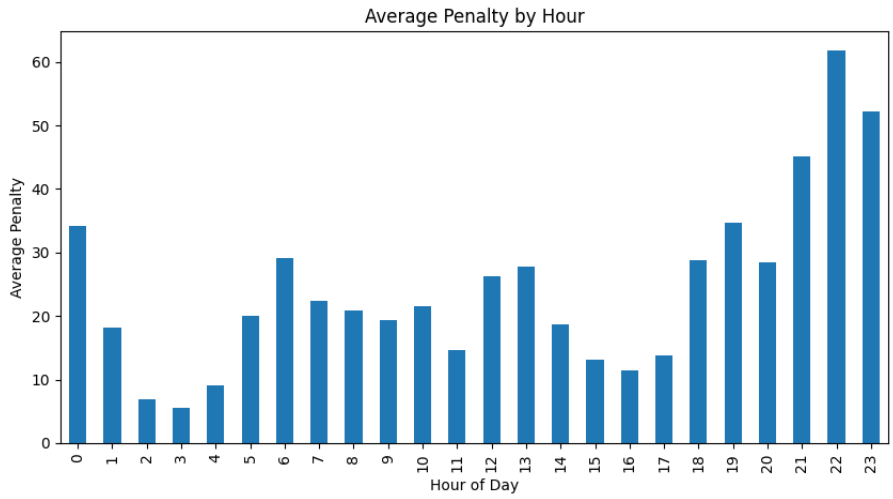
| Multiplier | Total Penalty |
|---|---|
| 0.995 | 1,613,915.61 |
| 1.0 | 1,137,673.05 |
| 1.005 | 1,078,369.14 |
| 1.01 | 1,313,184.85 |
| 1.015 | 1,695,223.70 |

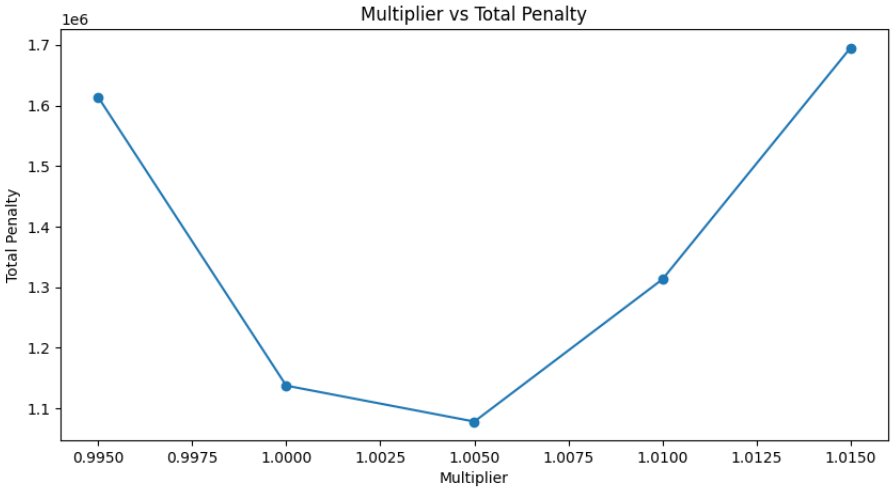
## Risk Strategy Explanation

A multiplier of 1.005 was found to be optimal because the model's inherent bias was slightly negative (-0.06%). By shifting the forecast upward, we reduce the frequency and magnitude of the ■4/kWh underforecast penalties. The theoretical optimal quantile for a 4:2 ratio is 0.67, which aligns with our findings that a slight upward shift (0.5%) yields a lower total penalty than a 2% shift which would over-adjust and increase overforecast costs.

## Visualizations






## Reproducibility Instructions

How to run: Execute 'python load_forecasting.py' in the working directory. Expected output includes initial metrics, multiplier sweep logs, and naive baseline comparison. The final PDF report is generated automatically.