DSC Final Project

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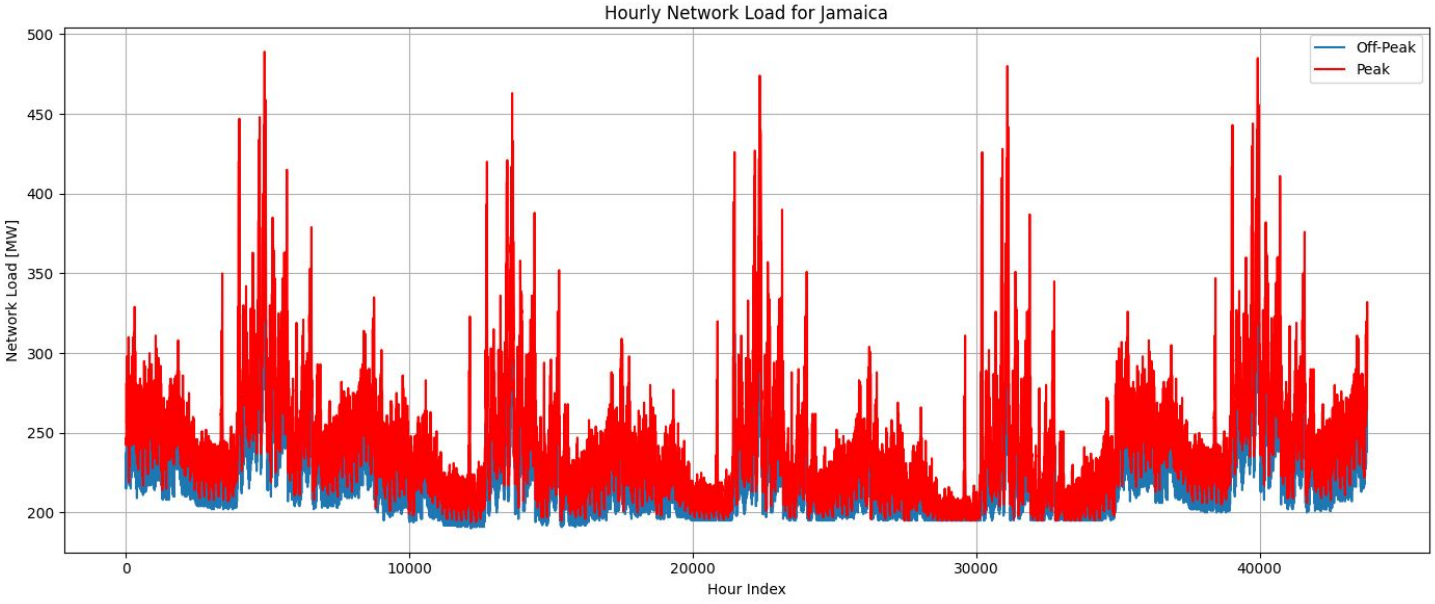
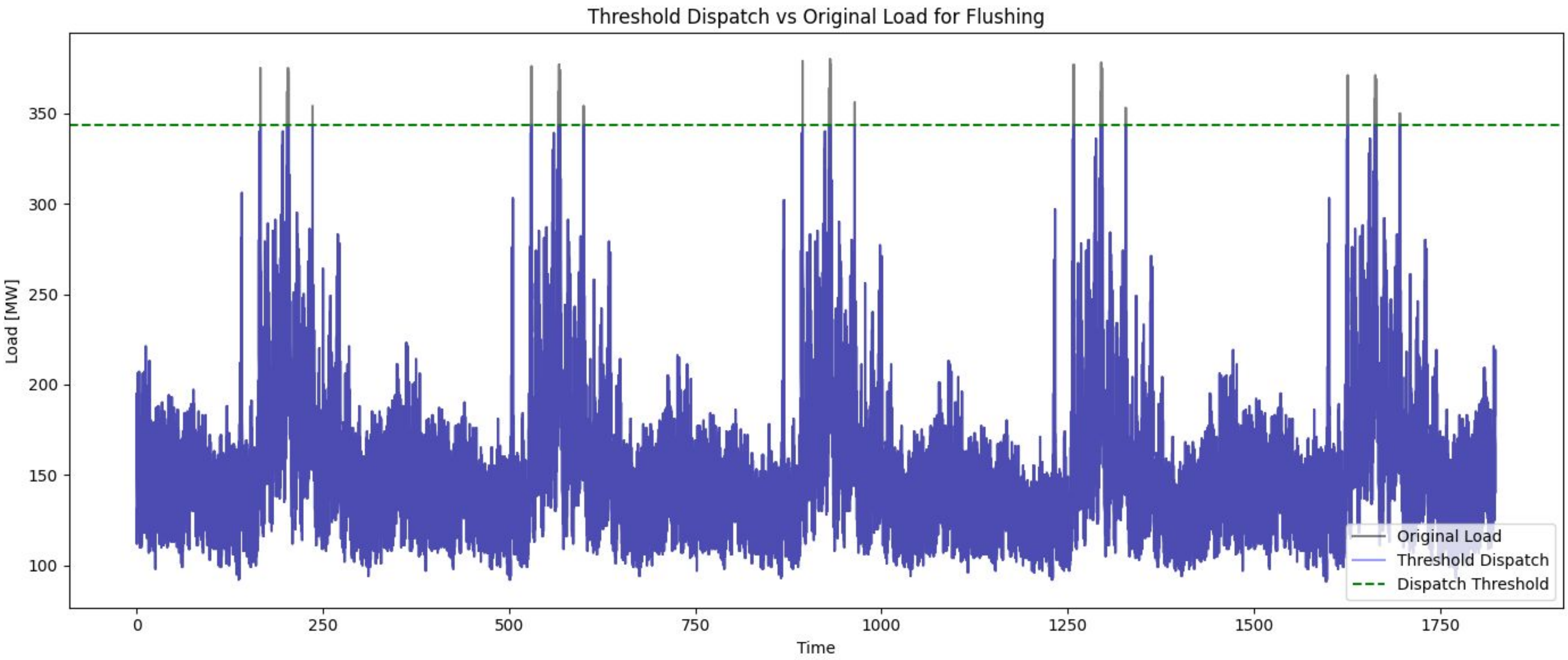
Problem

NYC's energy distribution system needs to be sized according to peak loads which is far greater than the average load.

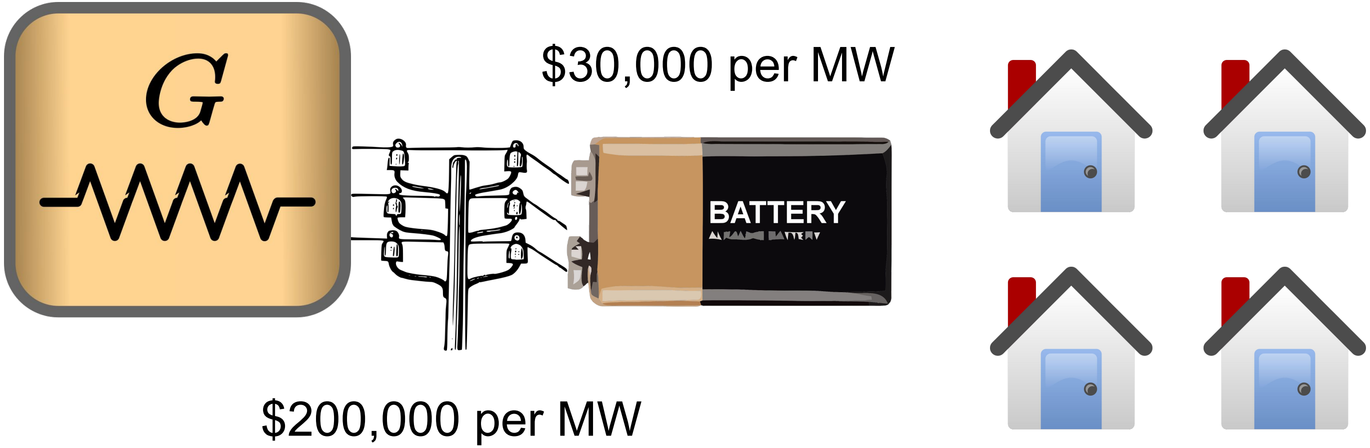




We can set the threshold of this controller according to our allowable failure rate.

Hypothesis

A battery system can save money by lowering peak loads and deferring upgrades.



My Dataset

https://coned.maps.arcgis.com/apps/MapSeries/index.html?appid=edce09020bba4f999c06c462e5458ac7

My Dataset 2

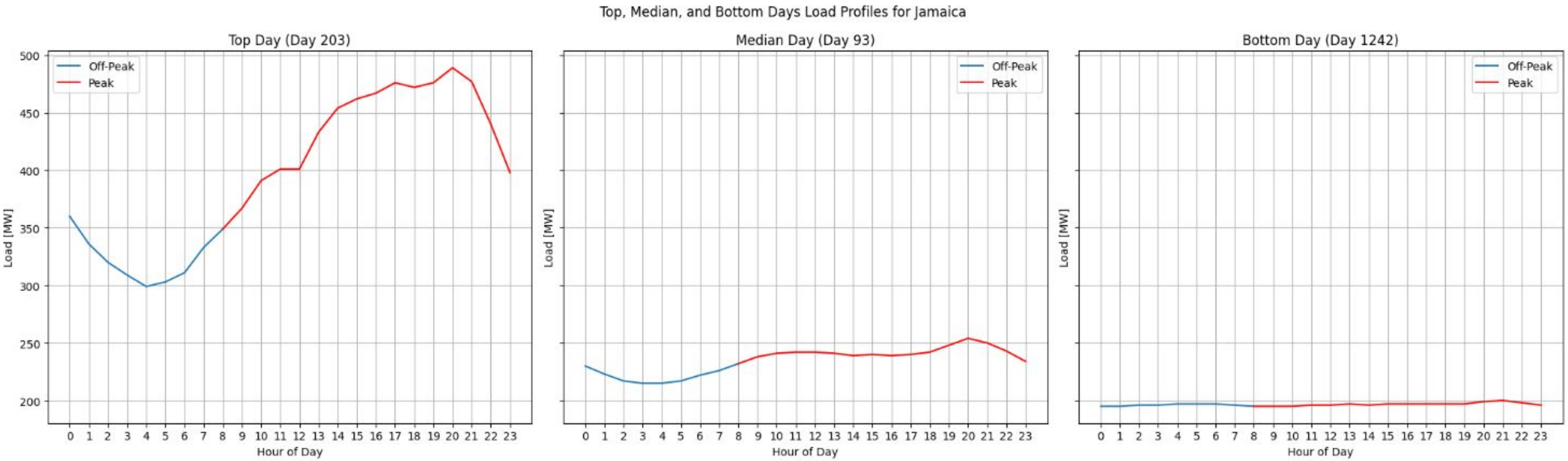
Time-of-Use Periods	PEAK RATES 8 A.M. TO MIDNIGHT	OFF-PEAK RATES ALL OTHER HOURS OF THE WEEK
JUNE 1 TO SEPT 30	**35.23 cents/kWh**	**2.49 cents/kWh**
ALL OTHER MONTHS	**13.05 cents/kWh**	**2.49 cents/kWh**

Super-peak Pricing

Electricity supply is an additional cost. Summer super-peak pricing is in effect from June through September on weekdays between 2 and 6 p.m. Super-peak charges are significantly higher than supply charges during the rest of the day. Save by opting to power down during super-peak periods.

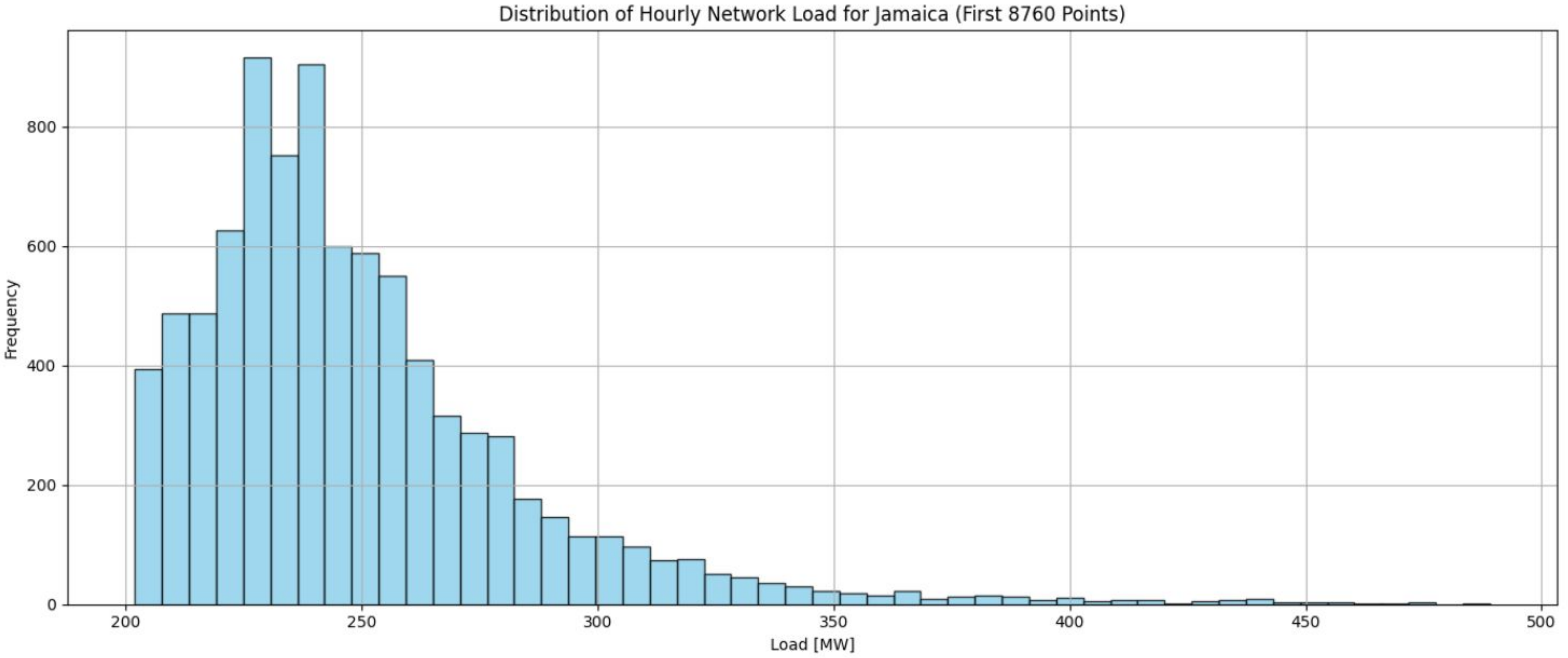
Standard Delivery Periods	RATES <250 KWH	RATES >250 KWH
JUNE 1 TO SEPT 30	**16.107 cents/kWh**	**18.518 cents/kWh**
ALL OTHER MONTHS	**16.107 cents/kWh**	**16.107 cents/kWh**

EDA



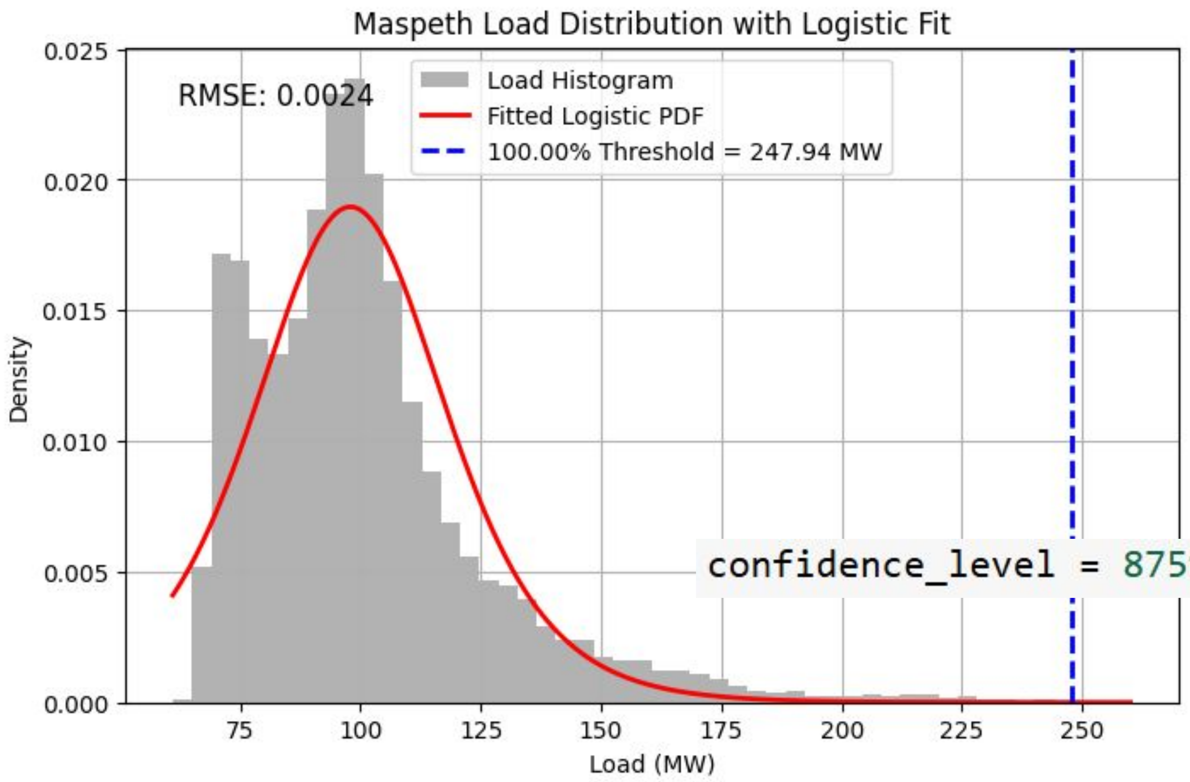
Top, Median, and Bottom Days Load Profiles for Jamaica
Top Day (Day 203)
Median Day (Day 93)
Bottom Day (Day 1242)
Off-Peak
Peak
Load [MW]
Hour of Day

EDA 2



Distribution of Hourly Network Load for Jamaica (First 8760 Points)
Frequency
0
200
400
600
800
200
250
300
350
400
450
500
Load [MW]

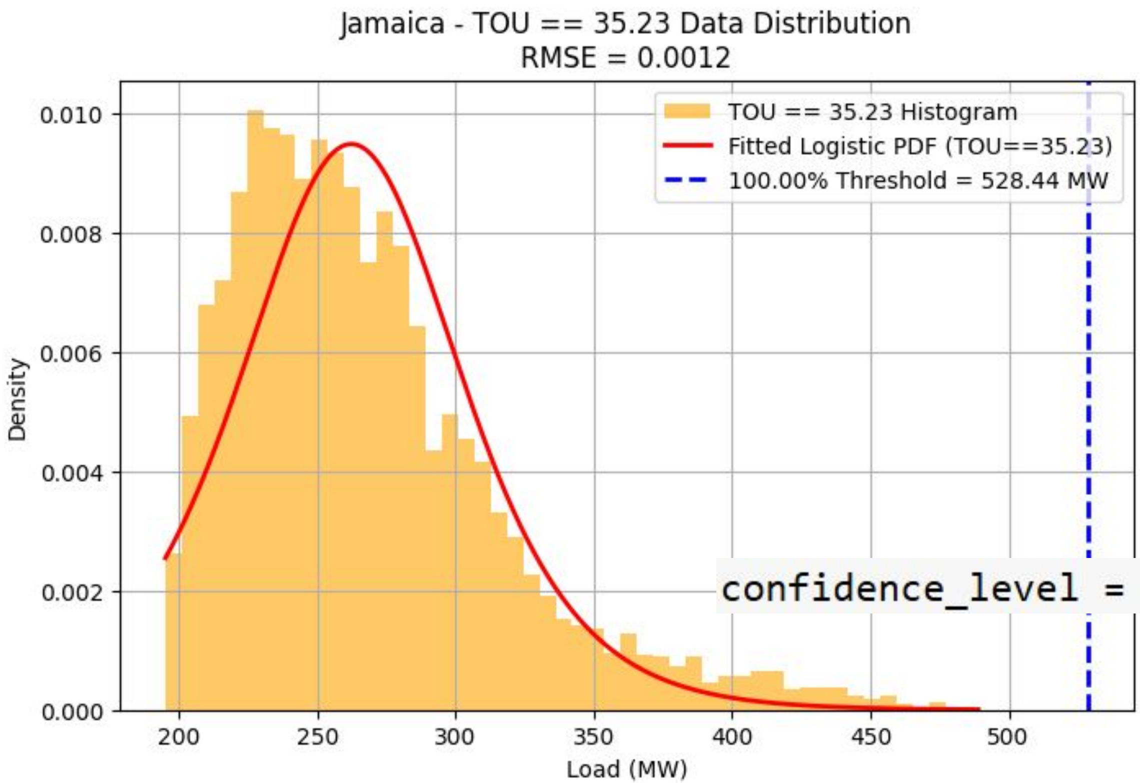
Peak Estimation Model 1




```
confidence_level = 87599 / 87600
```

Average RMSE
= 0.0049

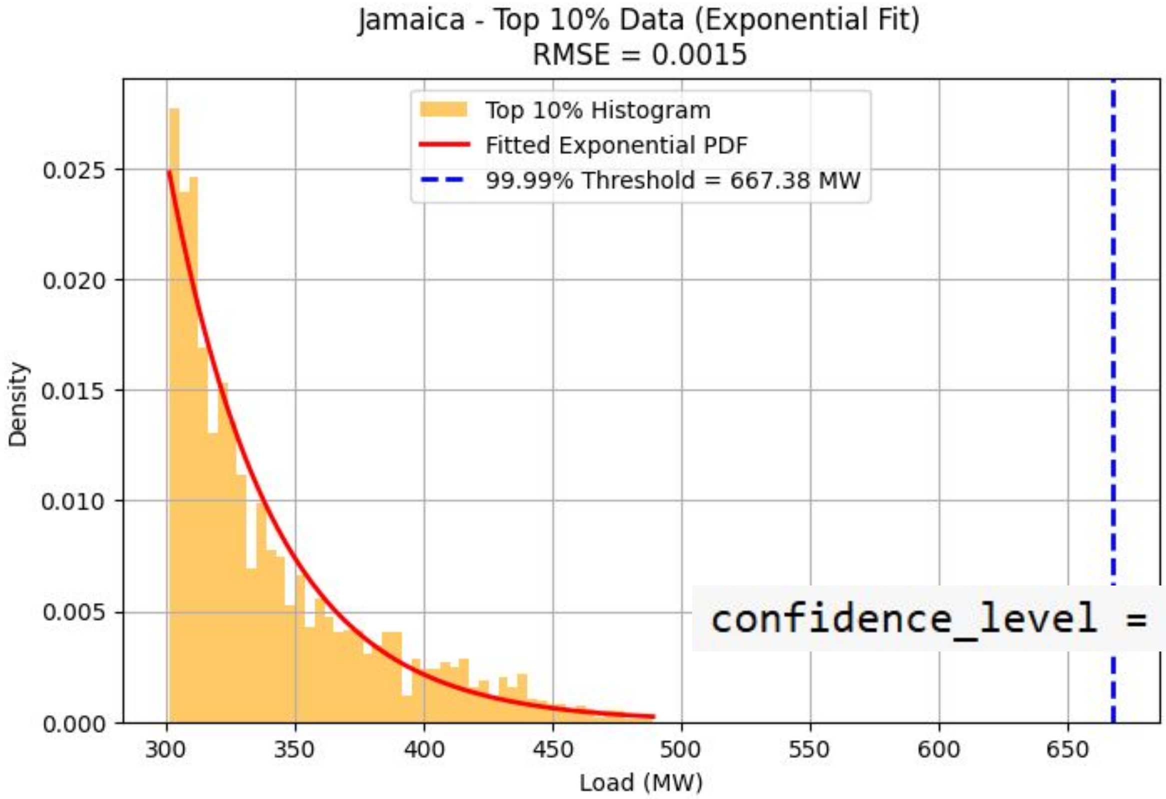
Peak Estimation Model 2




```
confidence_level = 24399 / 24400
```

Average RMSE = 0.0032

Another cool model I tried




```
confidence_level = 8759 / 8760
```

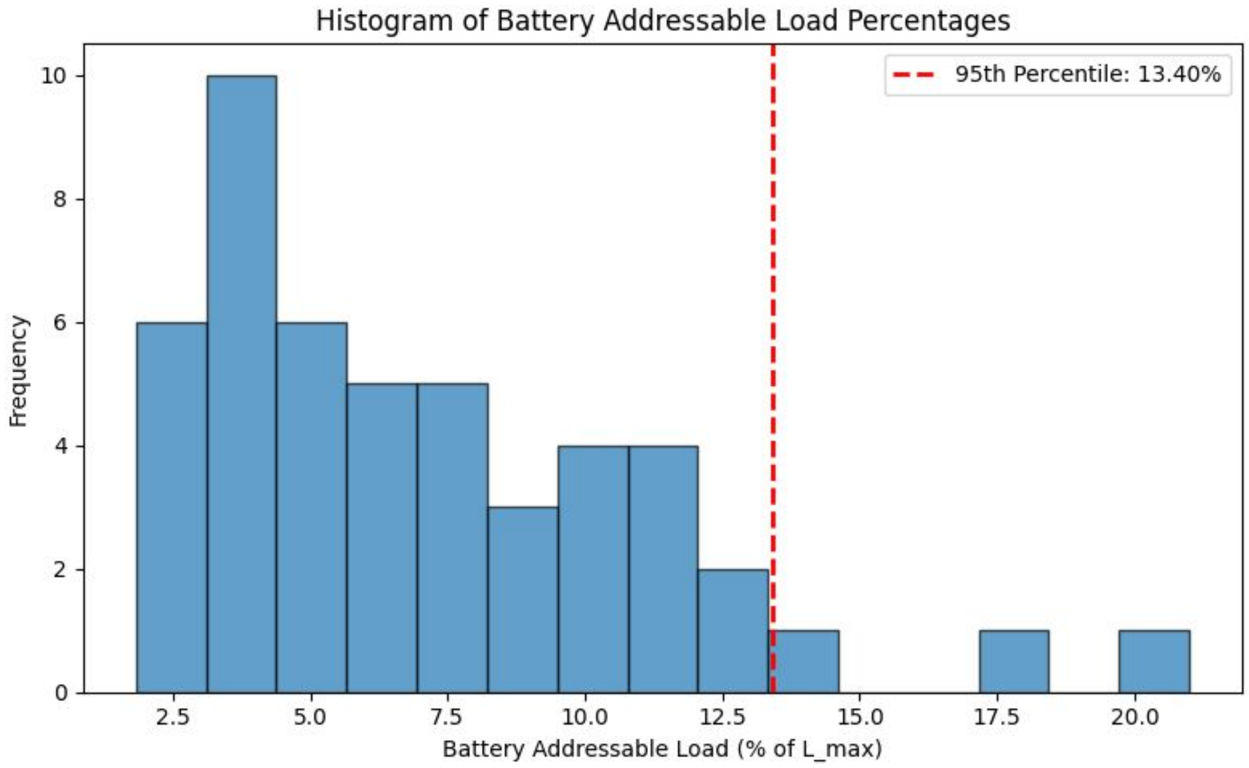
Average RMSE = 0.0070

Battery Addressable Load Model 1

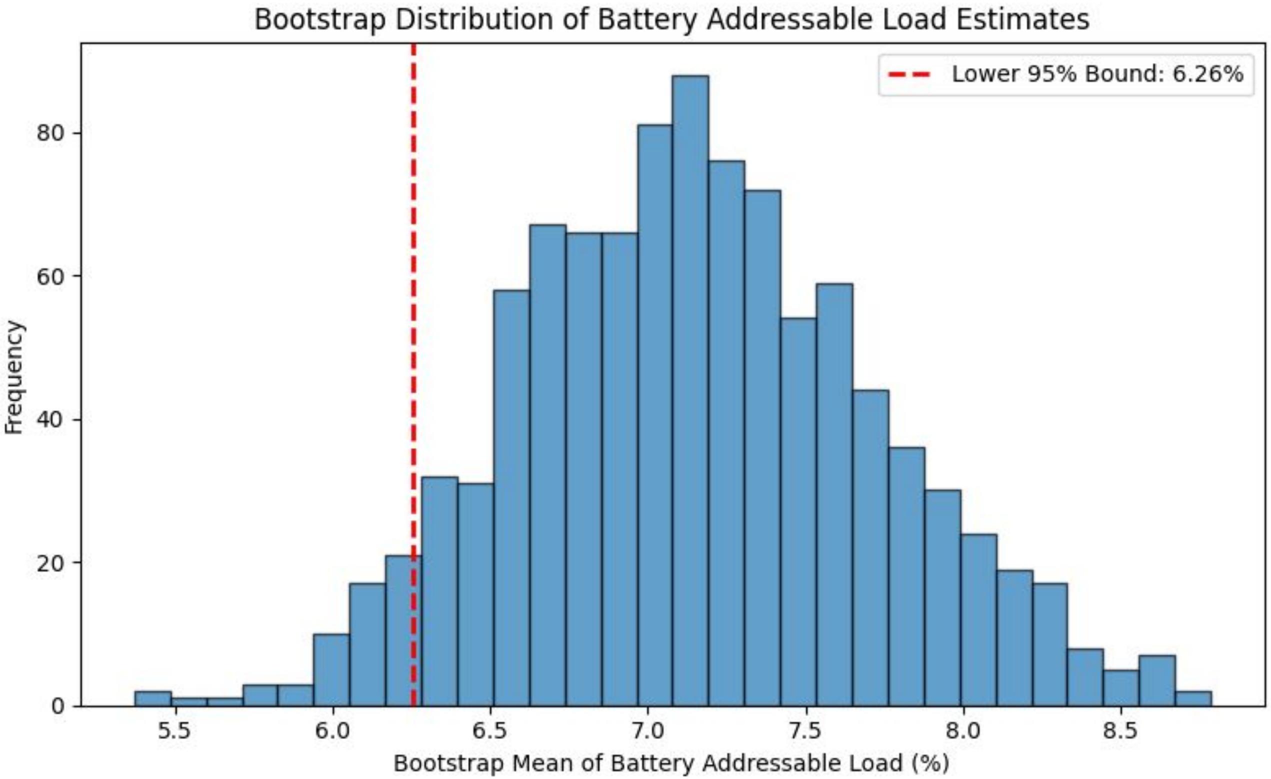
```python
L_max = load_series.max()

# Set lower bound to 90% of L_max and upper bound to L_max.
lb = 1e-6
ub = L_max

# Define g(x) = 4*x - max_daily_shaved_energy, where for each day,
# daily_shaved_energy = sum(max(0, load - (L_max - x)))
# and we use the maximum value across days.
def g(x):
    threshold = L_max - x
    # Compute the shaved energy for each day using the global loads_df day column.
    daily_shaved_sum = load_series.sub(threshold).clip(lower=0).groupby(loads_df['Day']).sum()
    max_daily_shaved = daily_shaved_sum.max()
    return 4 * x - max_daily_shaved
```

```python
# Binary search: find the largest x
for _ in range(max_iter):
    mid = (lb + ub) / 2
    if g(mid) >= 0:
        lb = mid
    else:
        ub = mid
    if abs(ub - lb) < tol:
        break

x = lb
pct = (x / L_max) * 100
dispatch_threshold = L_max - x
return dispatch_threshold, x, pct
```

Battery Addressable Load Model 2

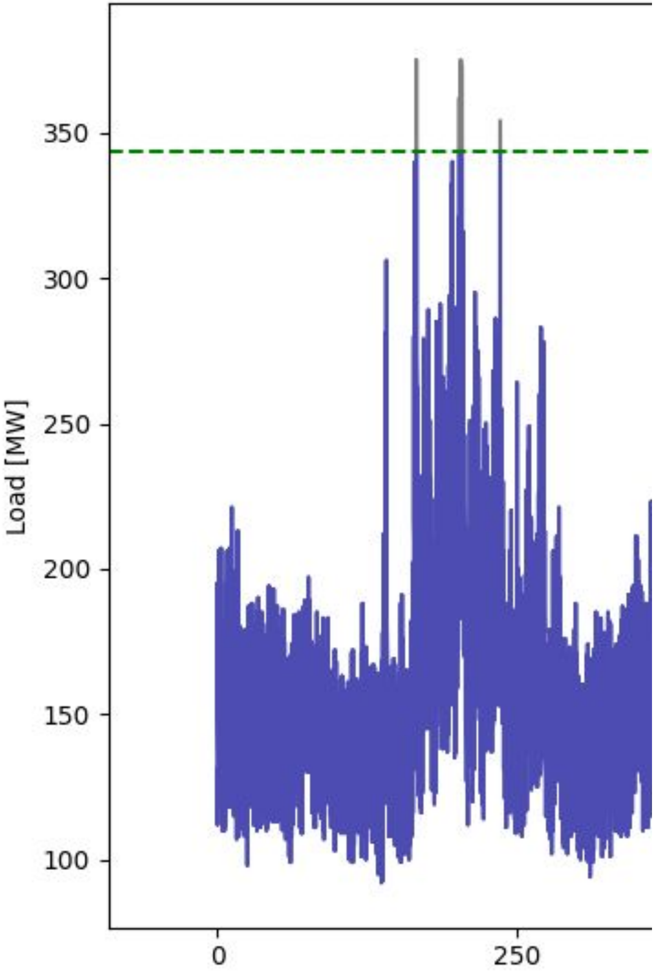


Battery Addressable Load Model 3



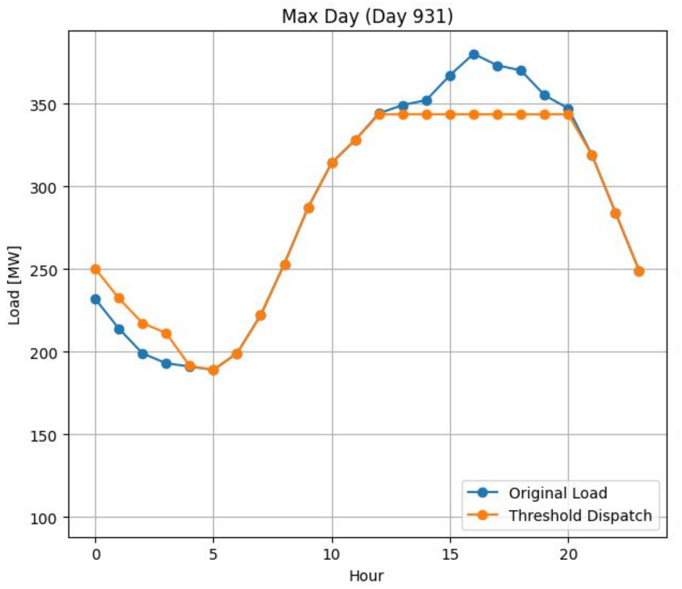
Threshold Controller Model

```python
if hour < 8:
    # Off-peak: charge at rate battery_power/2 (but do not exceed capacity).
    charge_rate = battery_power / 2.0
    charge = min(charge_rate, battery_capacity - SOC)
    SOC += charge
    effective_load = load + charge
    control_action = charge  # positive value indicates charging
else:
    # Peak: discharge if load exceeds dispatch threshold.
    if load > dispatch_threshold:
        desired_discharge = load - dispatch_threshold
        discharge = min(desired_discharge, battery_power, SOC)
        SOC -= discharge
        effective_load = load - discharge
        control_action = -discharge  # negative value indicates discharging
    else:
        effective_load = load
        control_action = 0.0
```

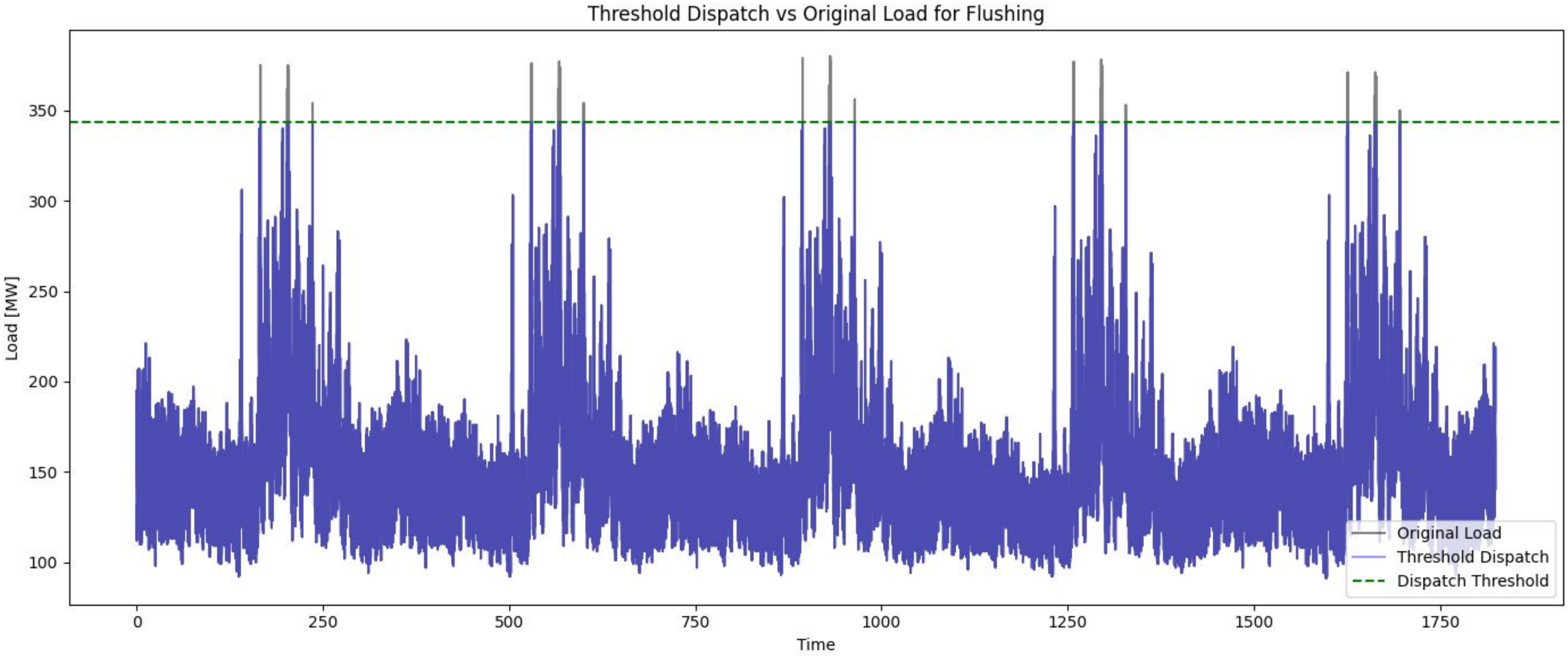


Failure Modes

- Peak exceeds threshold + battery power
- Energy required exceeds battery capacity

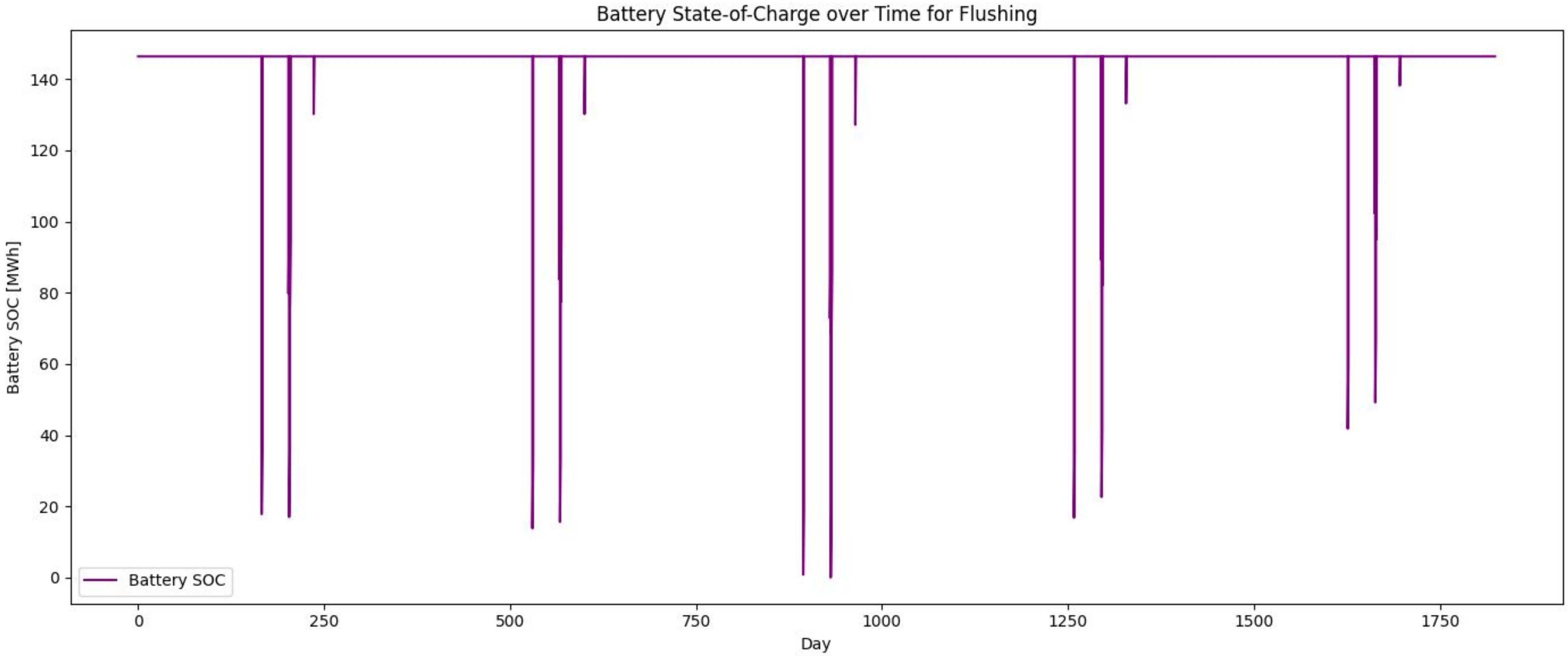


Visuals 1



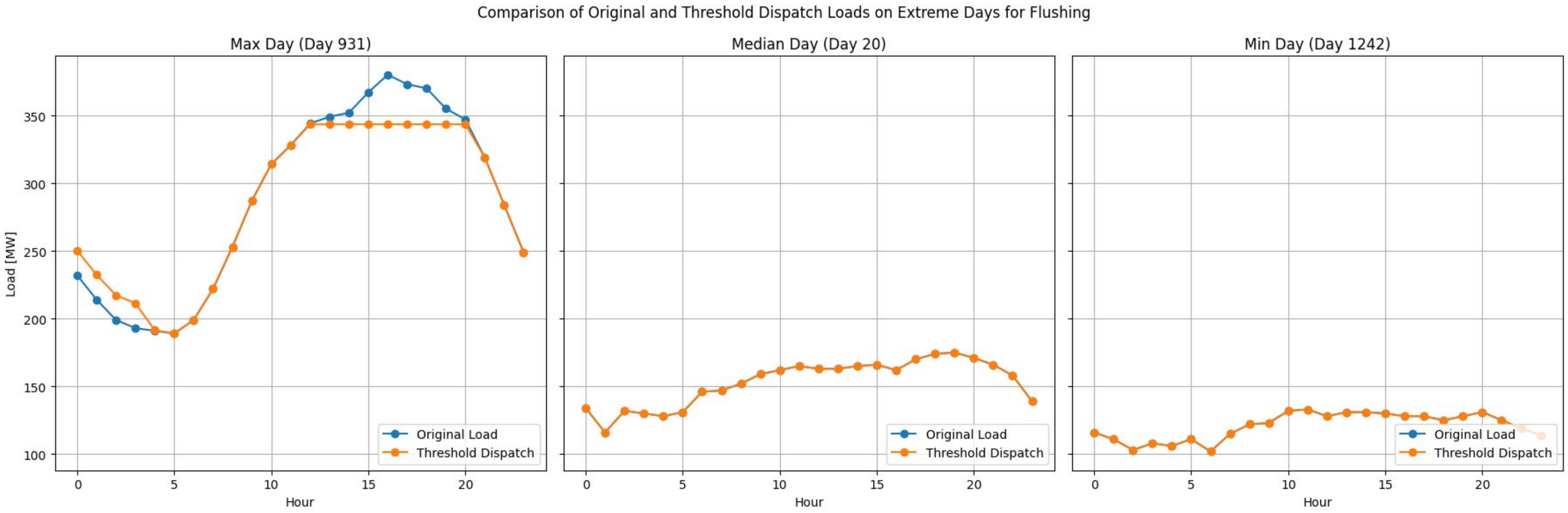
Threshold Dispatch vs Original Load for Flushing
Load [MW]
350
300
250
200
150
100
0
250
500
750
1000
1250
1500
1750
Time
Original Load
Threshold Dispatch
Dispatch Threshold

Visuals 2



Battery State-of-Charge over Time for Flushing
Battery SOC [MWh]
0
20
40
60
80
100
120
140
Day
0
250
500
750
1000
1250
1500
1750
Battery SOC

Visuals 3



Comparison of Original and Threshold Dispatch Loads on Extreme Days for Flushing
Max Day (Day 931)
Median Day (Day 20)
Min Day (Day 1242)
Load [MW]
350
300
250
200
150
100
0
5
10
15
20
Hour
Original Load
Threshold Dispatch

What I learned

Cleaning and manipulating time series data can be tricky but also very insightful.

Try lots of things when looking for patterns. Some times visuals are more enlightening than statistics.

I was able to connect what I learn as a mechanical engineer (controllers) to data science!