Energy Estimation of Spiking Neural Networks

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Content

- Research Introduction
- System architecture
- Research progress
  - Done
  - Doing
  - Todo
- Schedule

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Research introduction

- Estimation of energy consumption of SNNs.
- Estimation of solar energy.
- Part of carbon neutral E3STDP.
- Estimation provides energy requirements to achieve Net Zero.

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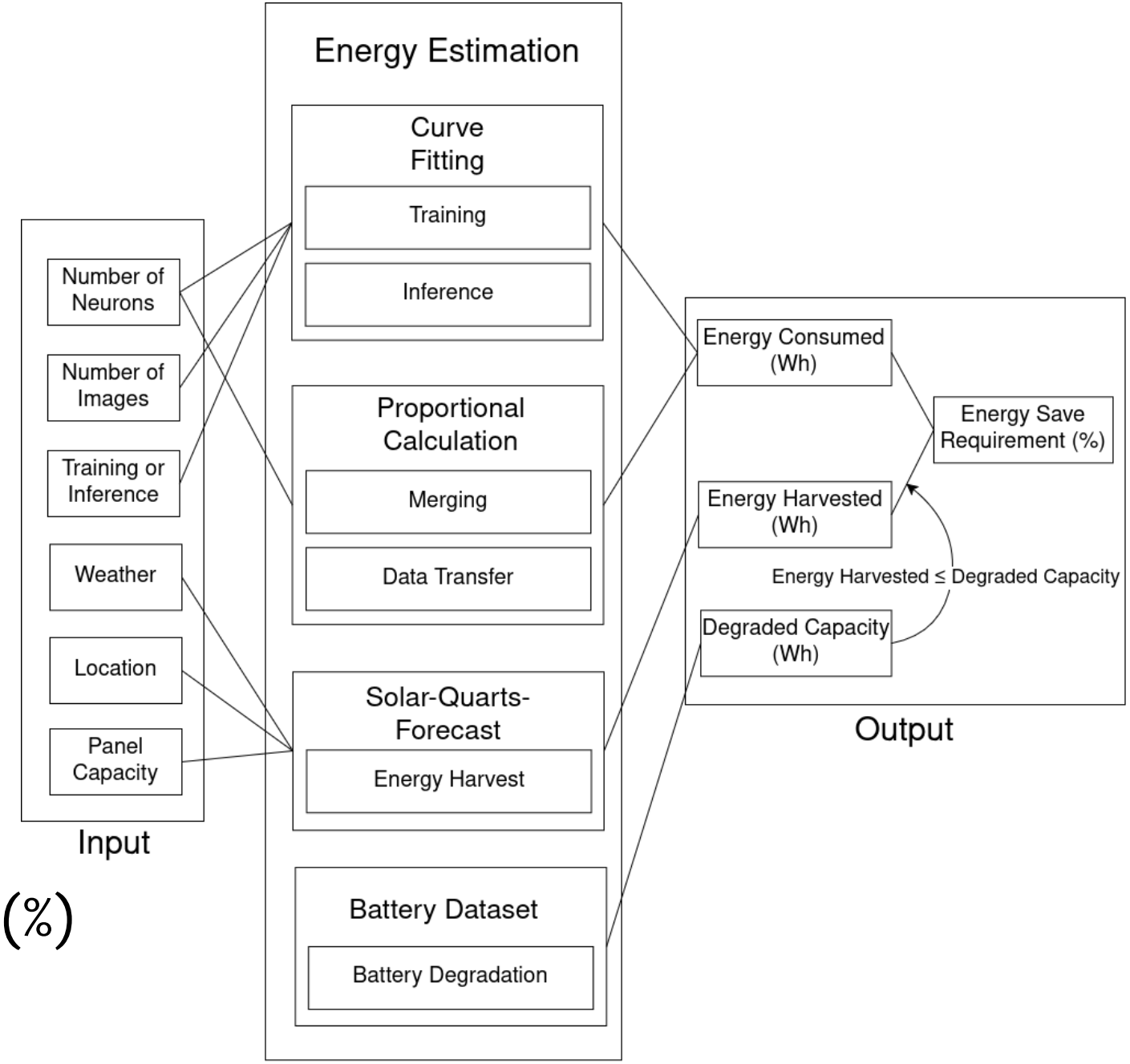
Framework

Estimation:

- SNN Training / Inference
- Data Transfer / Merging
- Solar energy harvested
- Battery degradation

Output -> Energy requirement(%)



1. SNN Training / Inference

1.1 Collect data points.

n_neurons	n_input	Wh
50	3000	0.56
100	6000	1.93
150	6000	2.92
200	12000	5.14

1.2 Apply curve fitting method (scipy.optimize library)

```
n_neurons:50
n_inputs:5000
Estimated energy consumption (Wh): 0.93
```

2. Data Transfer / Merge

2.1 Obtain data size of trained models.

10 Bindsnet models: 6.2 MB

2.2 Calculate transfer energy from device specs.

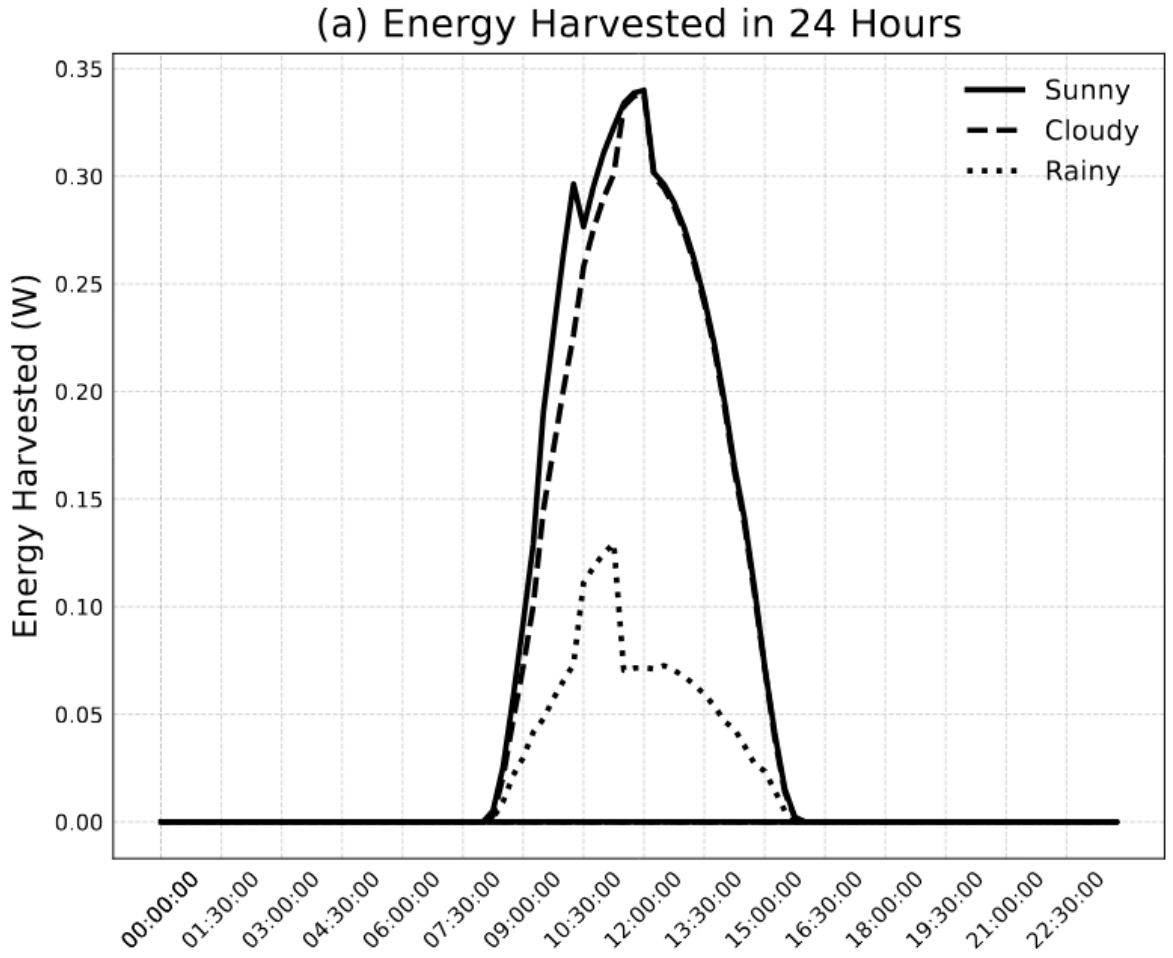
For Raspberry Pi Pico W:

3.3 (V) x 0.072(A) x 6.2 (MB) / 6 (Mbps) = 0.24 (J) = 0.00066 (Wh)

3. Solar Energy

open-sauce-quarts-solar-forecast
Input:
Location
Weather
Panel Capacity

1.53 Wh (Sunny)
1.43 Wh (Cloudy)
0.43 Wh (Rainy)

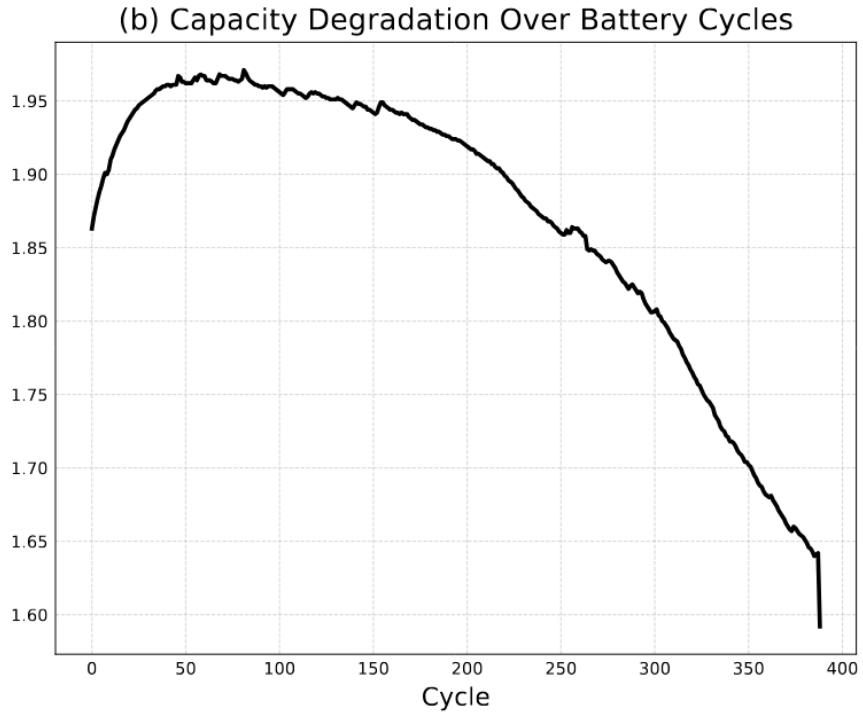


4. Battery Degradation (1)

4.1 Obtain capacity degradation data (battery dataset code library).

One battery cycle:
Charging to 100%, then discharging to 0%.

*In reality, battery does not follow perfect battery cycle.



4. Battery Degradation (2)

4.2 Take summation at each cycle

$$E_{\text{total}}(N) = \int_0^N E_{\text{cap}}(n), dn$$

Capacity Degradation: [1.0, 0.9, 0.8, 0.7…]

Total extracted energy at each cycle: [1.0, 1.9, 2.7, 3.4…]

4.3 Obtain current battery cycle N from total energy system used

4. Battery Degradation (3)

4.4 Capacity Degradation[N]: Degraded Capacity.

4.5 Set upper bound to the solar energy harvested.

(Solar Energy Harvested) <= (Degraded Capacity)

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Research Progress | Done

- Framework to provide energy requirement in (%)
- Evaluation for inference energy
- Evaluation for solar energy harvest
- Solar energy harvested under different weathers
- Battery degradation under different weathers

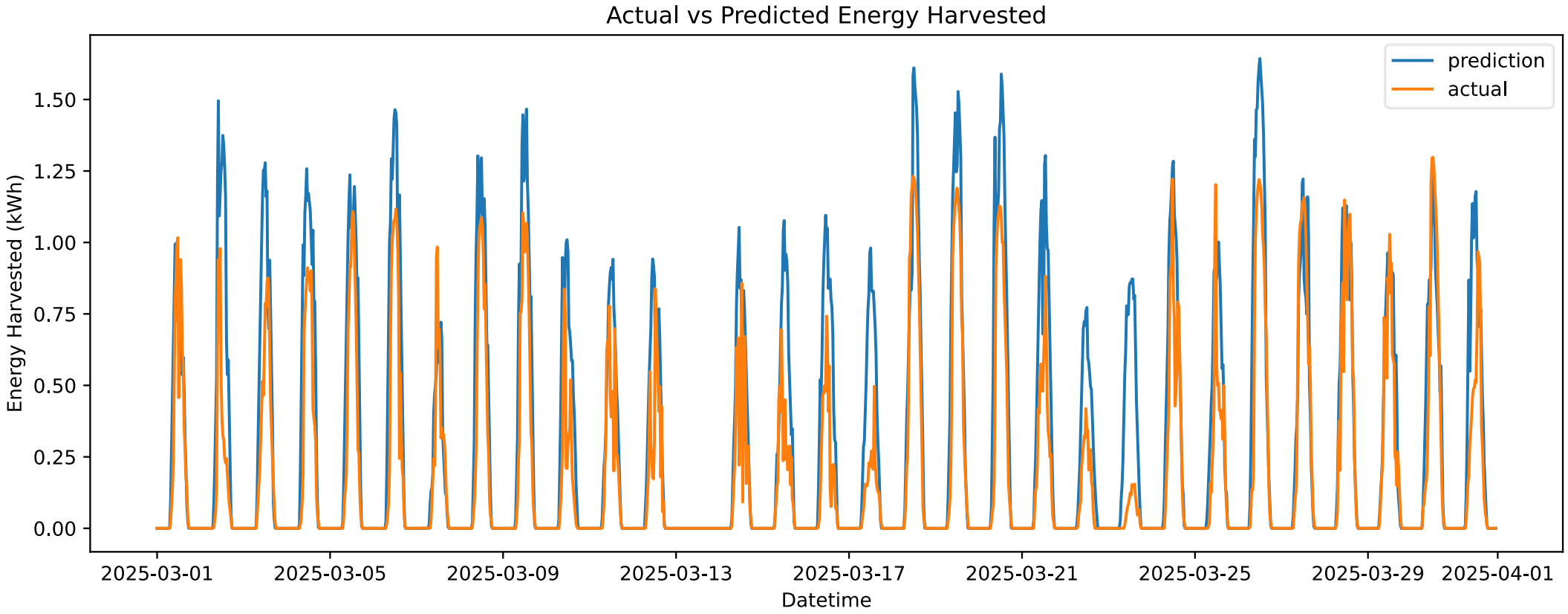
Research Progress | Done

Solar energy harvested under different weathers

1. Compare prediction vs actual of a month
2. Average of each weather
3. Calculate MAE, Error (%)

	Prediction (kWh)	**Actual (kWh)**	**MAE (kWh)**
Sunny	0.34	0.23	0.12 (3.5%)
Cloudy	0.31	0.20	0.13 (3.8%)
Rainy	0.04	0.02	0.02 (0.5%)

Research Progress | Done

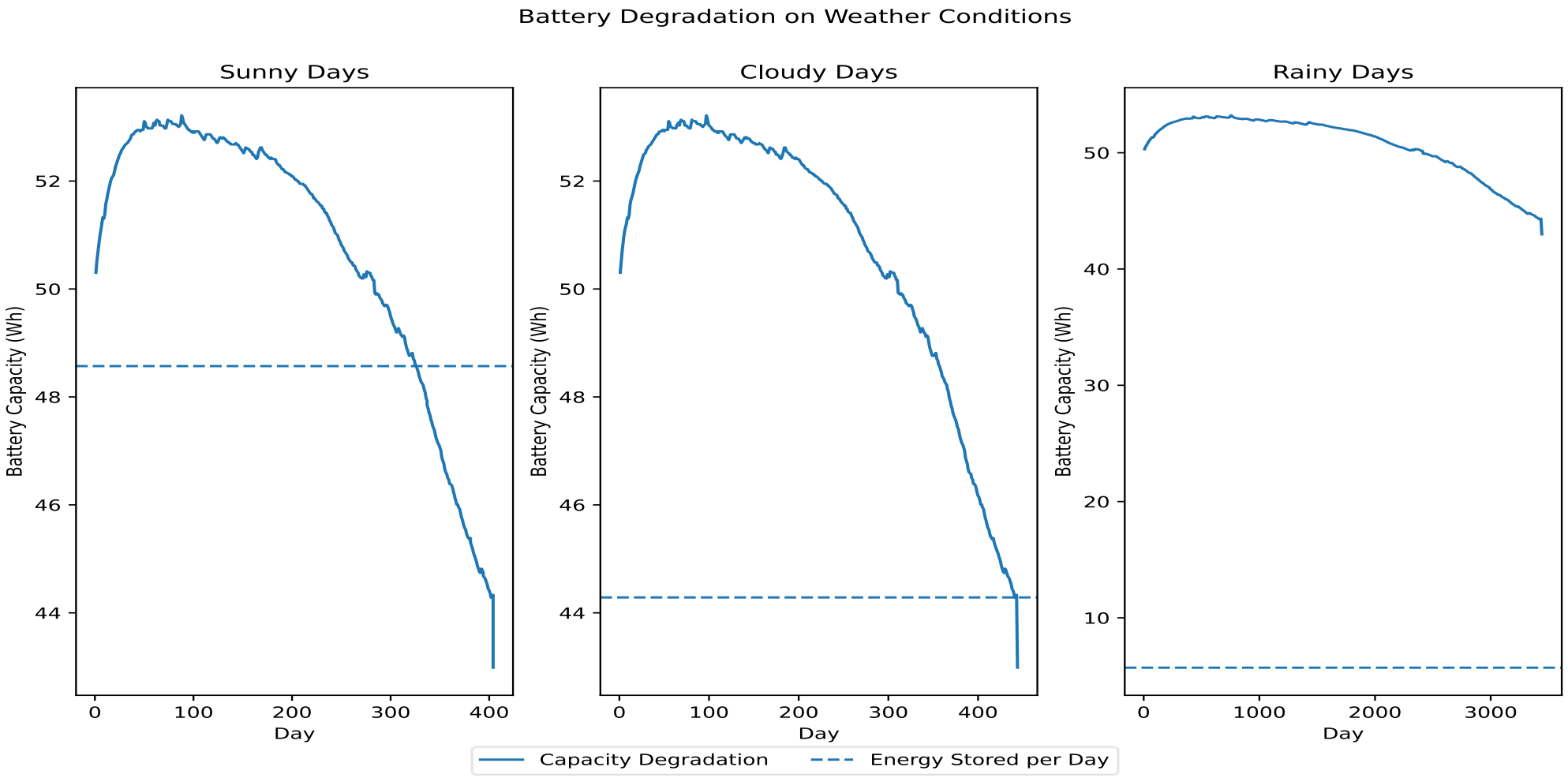


Research Progress | Done

Battery degradation under different weathers

1. Load a degradation data
2. Scale the degradation data
3. Calculate energy stored and used in 24 hours
4. Simulate battery degradation

Research Progress | Done



Research Progress | Doing

- Drafting the framework evaluation section
- Description of the framework diagram
- Predicted vs actual energy consumption (scatter plot)
- Predicted vs actual solar energy (time series plot)
- 5 sets of input and output (energy requirement)

-> 2 plots and 1 table

Research Progress | Todo

- Finish the framework evaluation section

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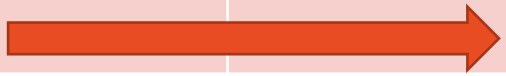
Schedule

Time	May. 27, 2025	Jun. 10, 2025
Task 1		

- Task 1: Finish the evaluation section of the paper

Thank you for your attention!