

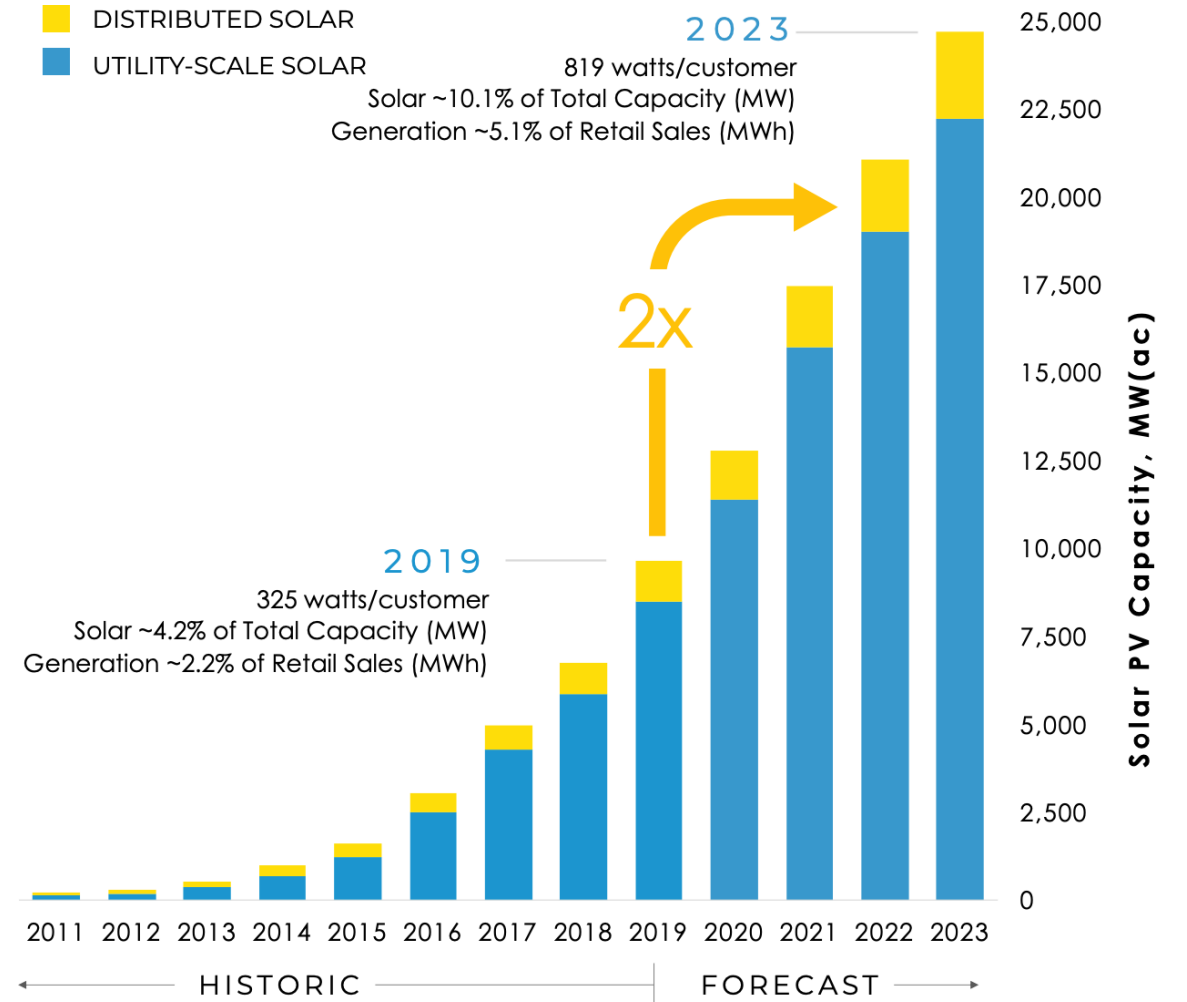
# Optimization Framework for Economic Operation of Solar Farm with Consideration of Variable Electricity Price

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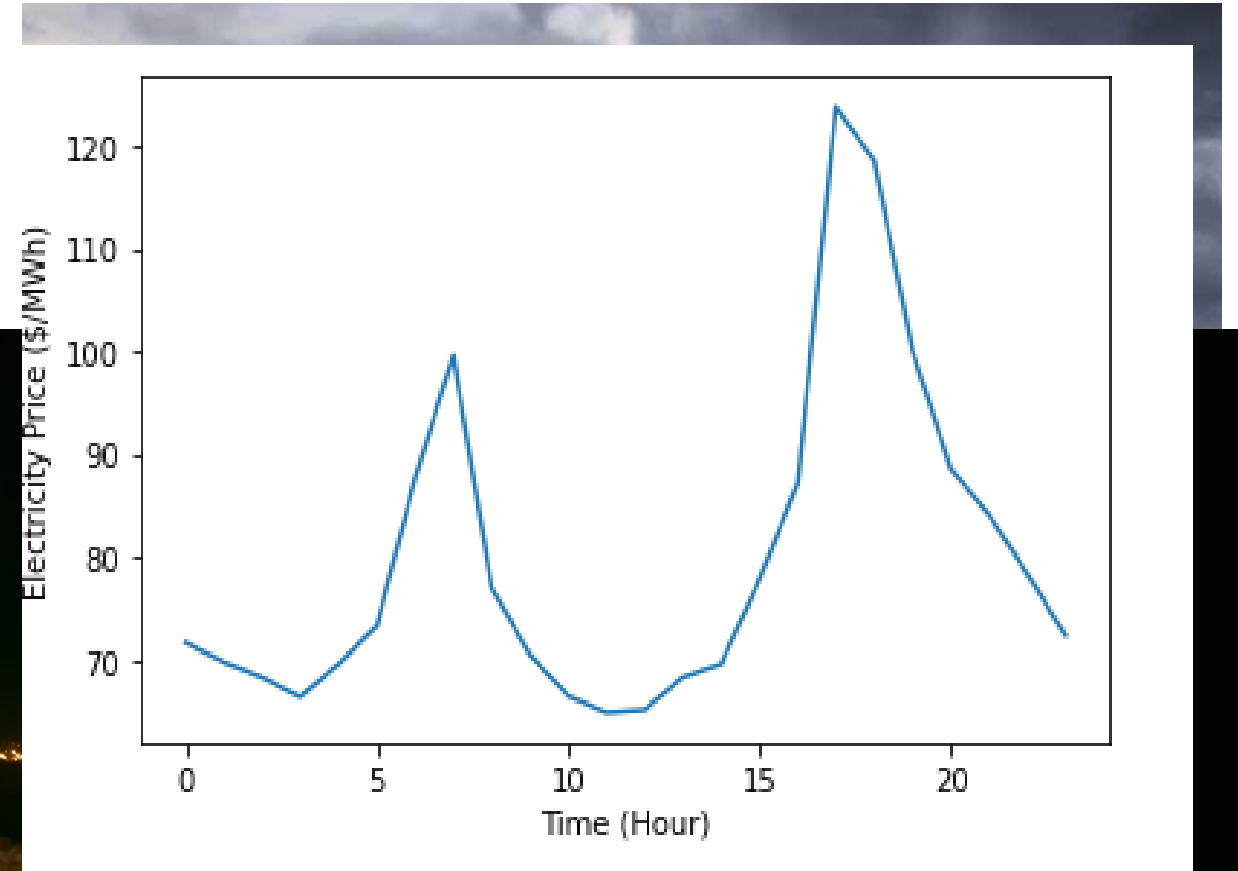
# Introduction

- Solar generation growth fast
  - Past decade, annual 40% growth
  - High growth rate due to the carbon neutral

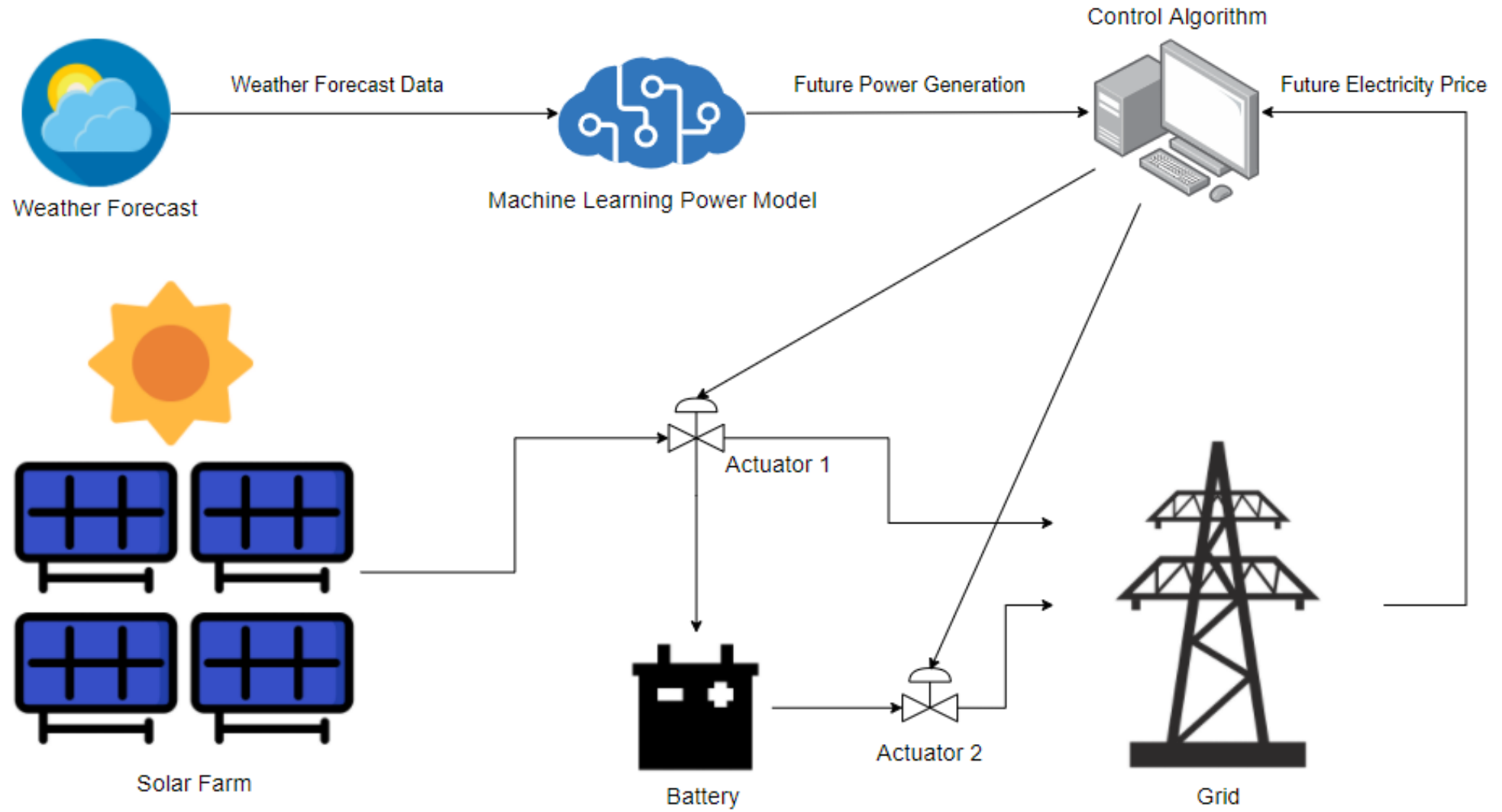


# Introduction

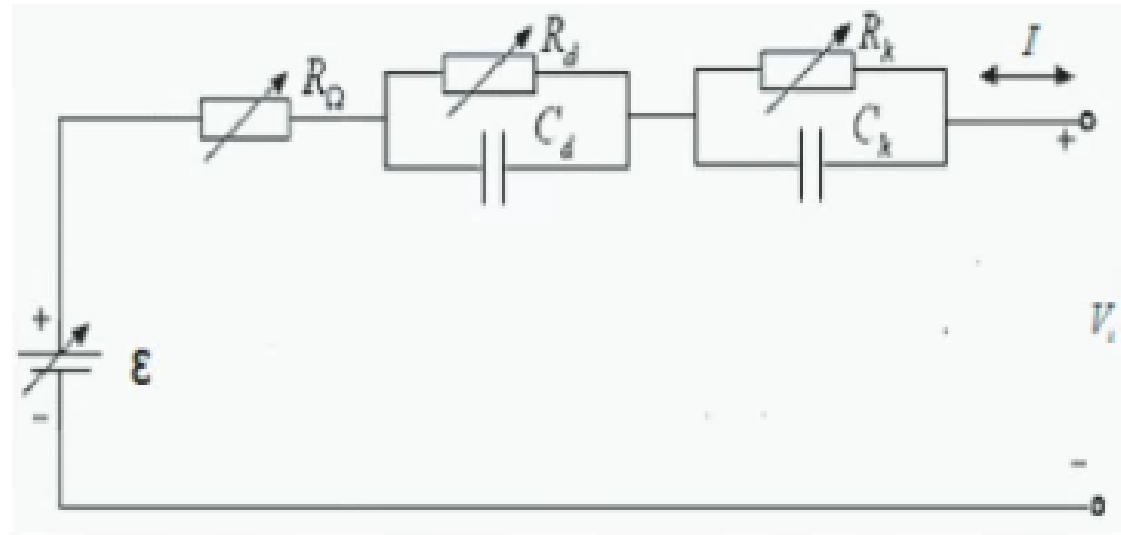
- Solar generation growth fast
  - Past decade, annual 40% growth
  - High growth rate due to the carbon neutral
- Solar Generation no stable
  - No baseline operation
  - Cloudy
  - No generation at night
- Electricity Price
  - Inverse relationship
- Need a battery storage system



# System Framework



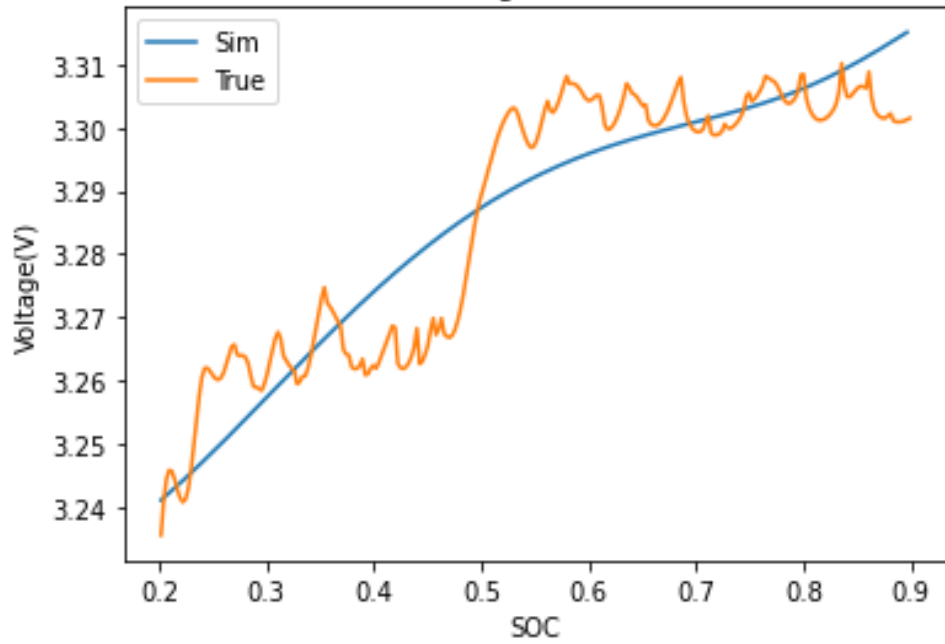
# Battery Model – Parameter Estimation



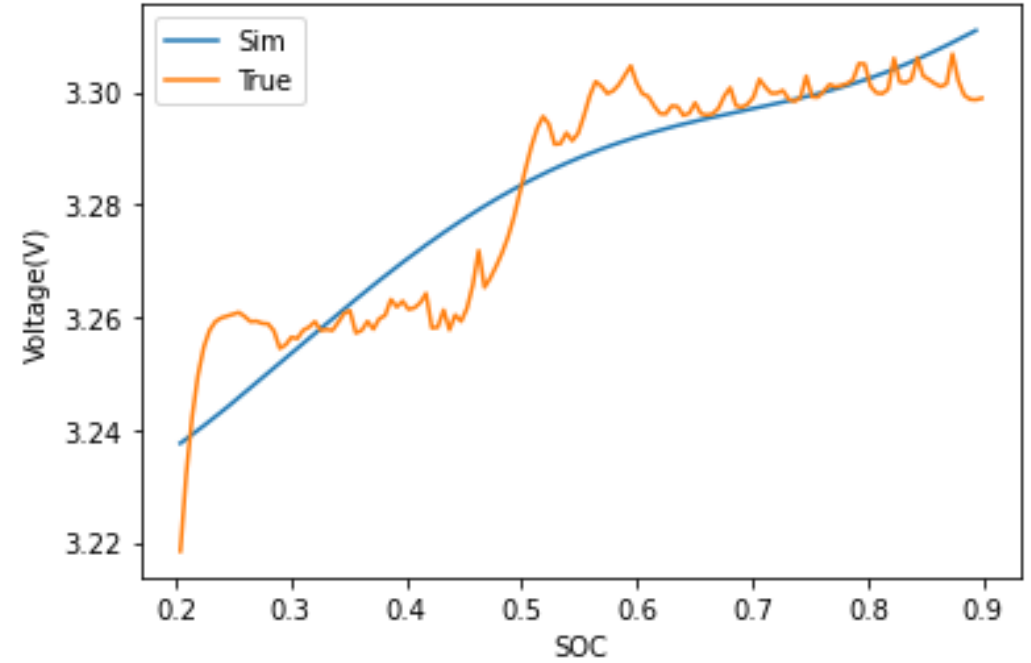
$$SOC = a \left( V_t + I(t) R_{\Omega} + I(t) R_d \left( 1 - e^{-t/\tau_d} \right) \right) + b + k \cdot e^{1-1/[SOC(1-SOC)]}$$

# Battery Model – Parameter Estimation

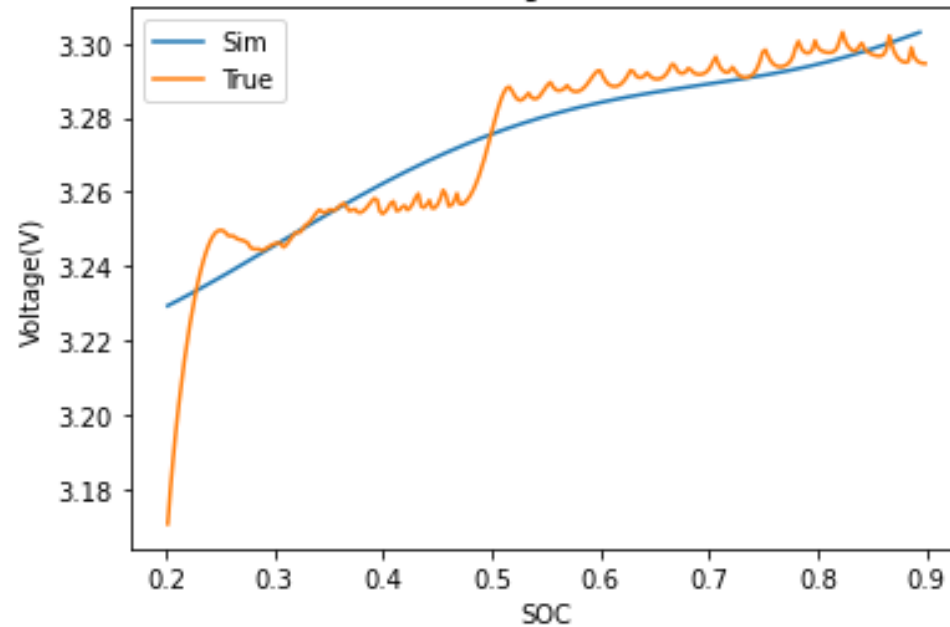
Discharge with 0.5C



Discharge with 1C

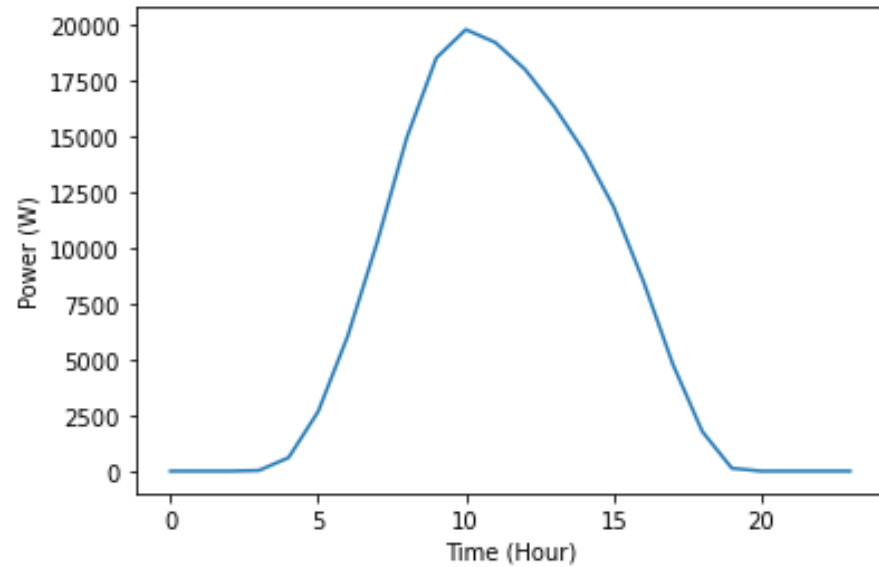


Discharge with 2C

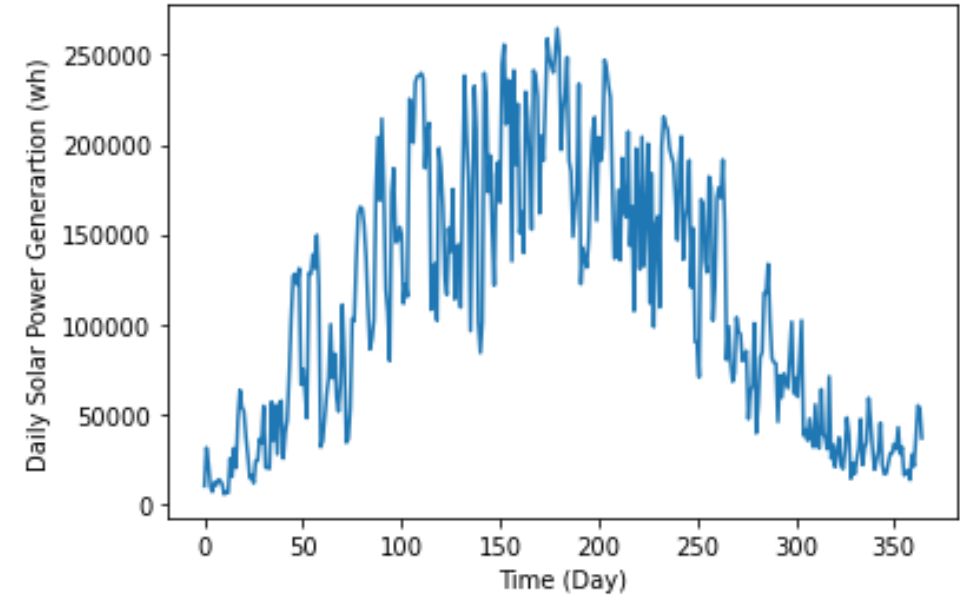


# Solar Farm Machine Learning Model

Solar generation vary within a day



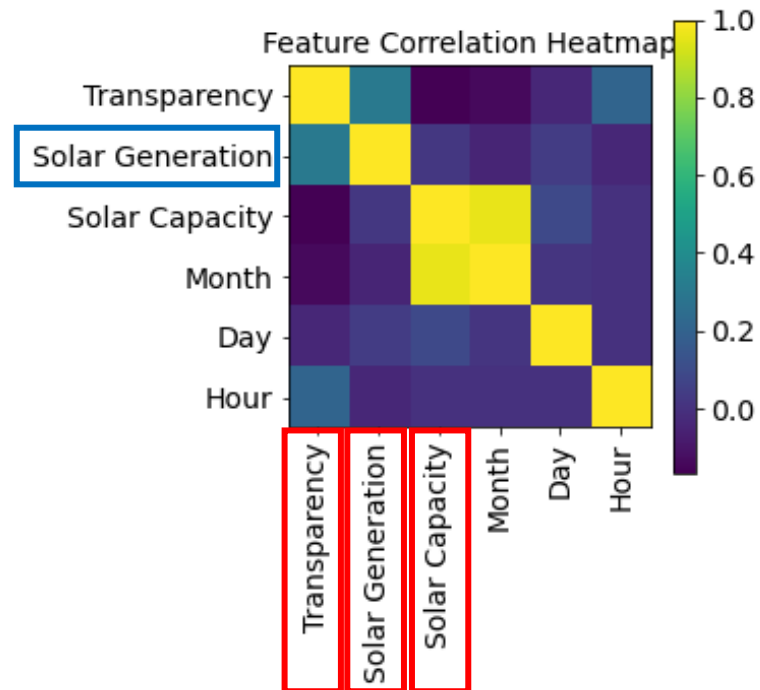
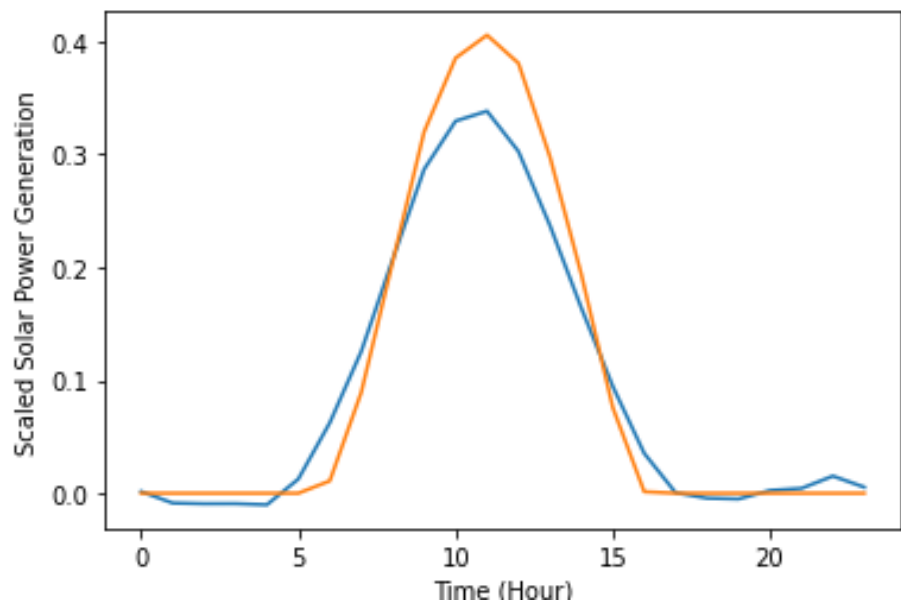
Solar generation vary within a year



Long Short-Term Memory Neural Network

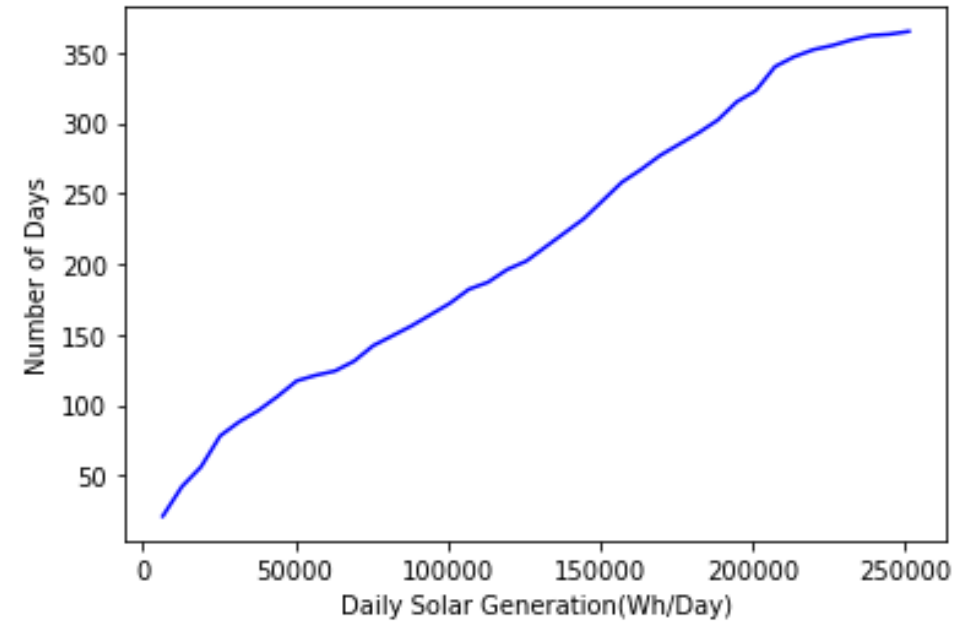
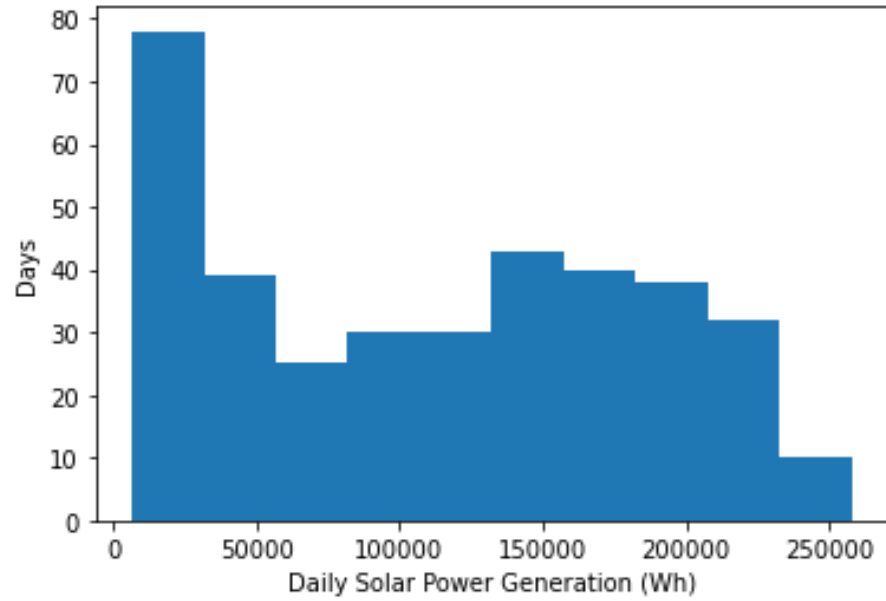
# Solar Farm Machine Learning Model

	Transparency	Solar Generation	Solar Capacity	Month	Day	Hour
0	42254.95	0.0	47480	1	1	0.0
4	40984.90	0.0	47480	1	1	1.0
8	39042.55	0.0	47480	1	1	2.0
12	38761.12	0.0	47480	1	1	3.0
16	38958.22	0.0	47480	1	1	4.0





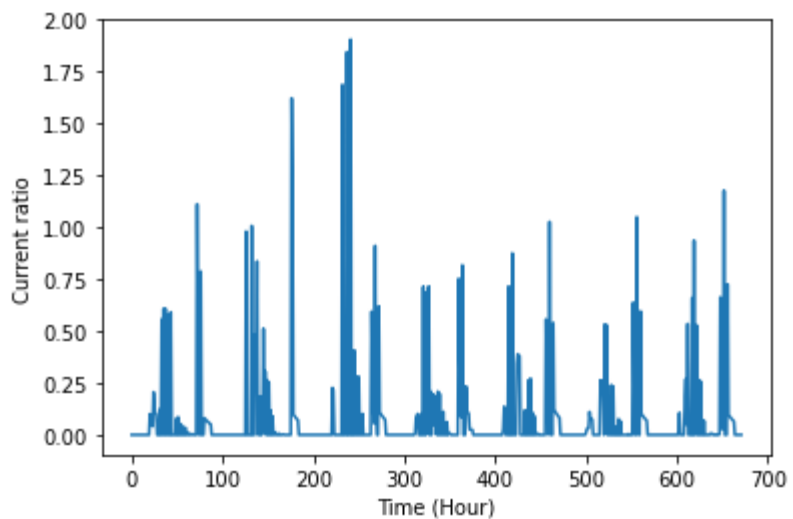
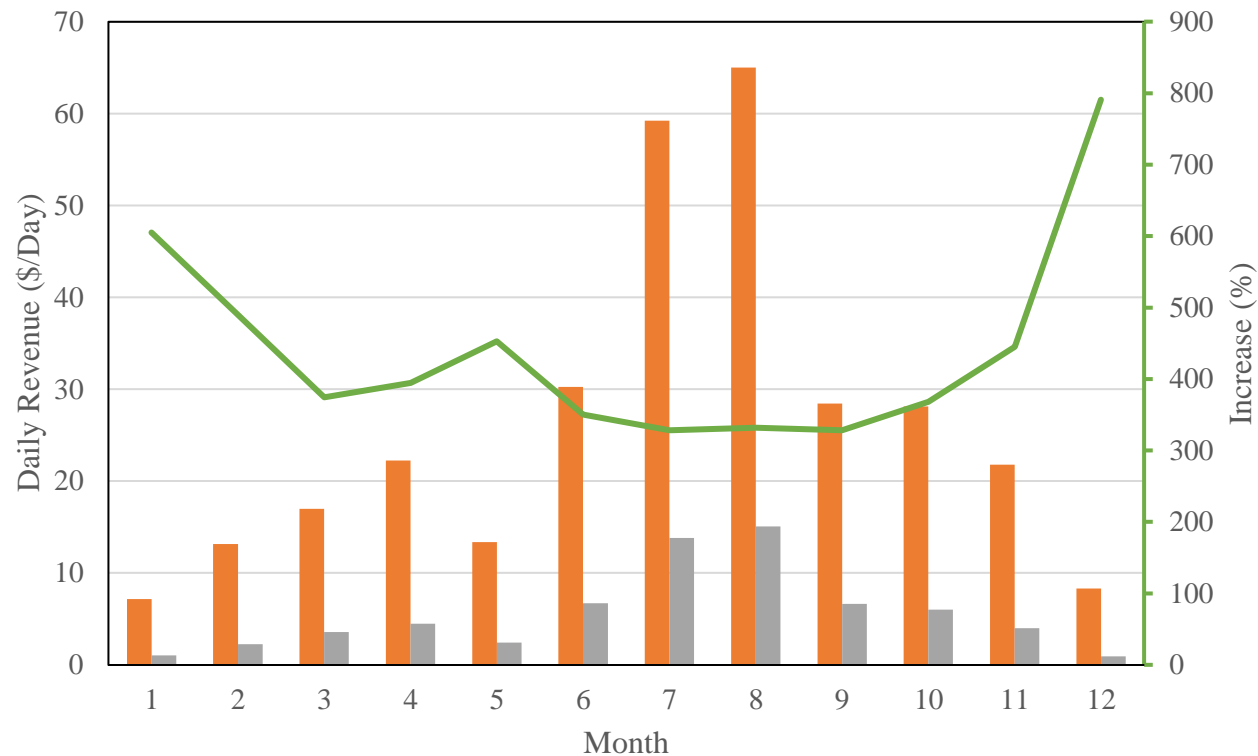
# Battery Sizing



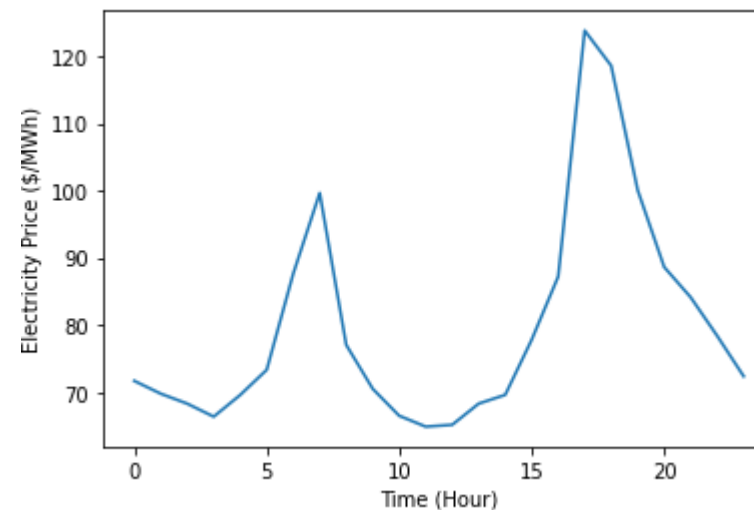
113774 Wh or 34900 Ah

# Result

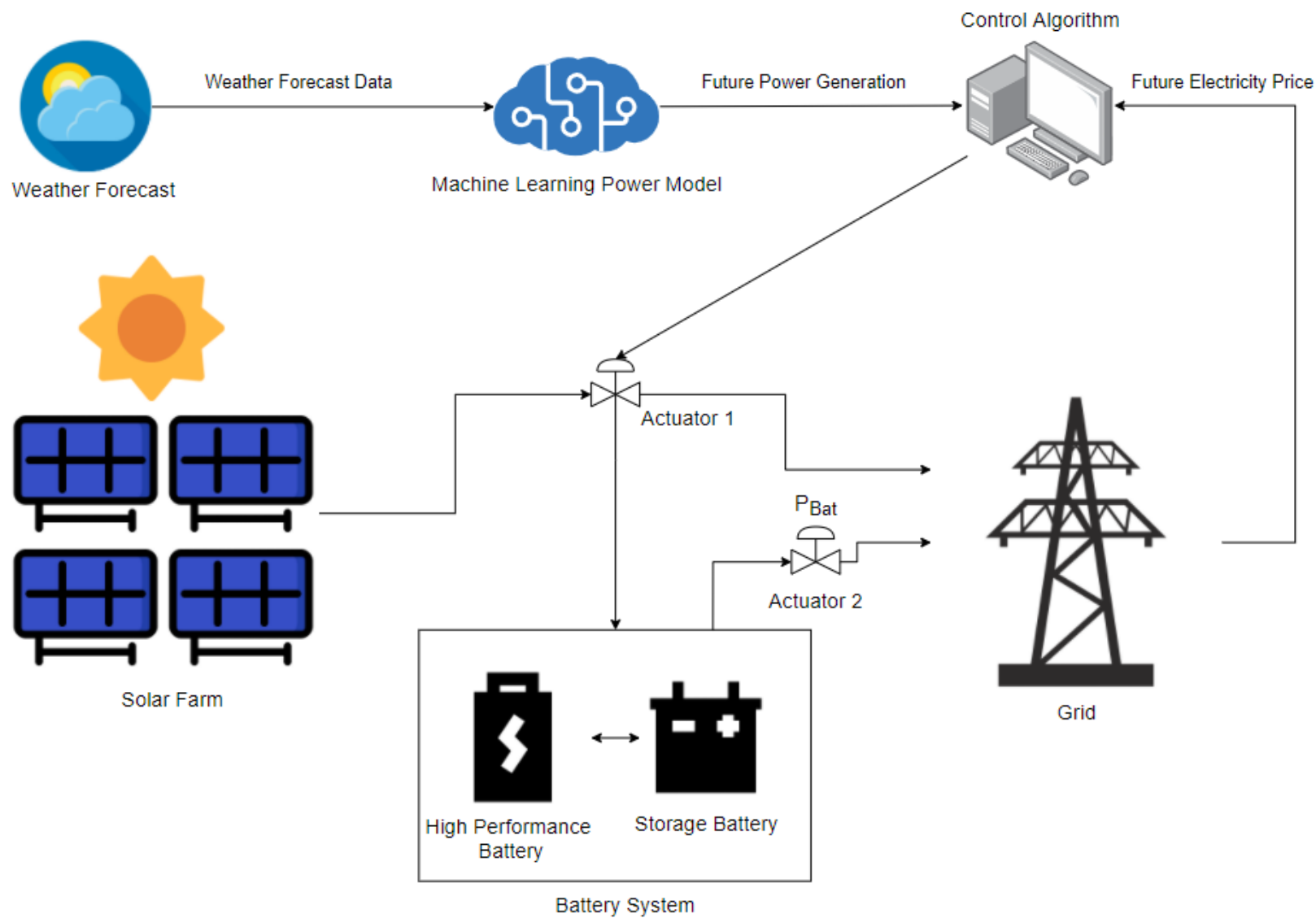
- Daily Revenue Increase
  - Highest 800%
  - Average 466%
  - Lowest 350%
- The increasement decrease as the generation increase
  - Battey is saturated
- Current Concern



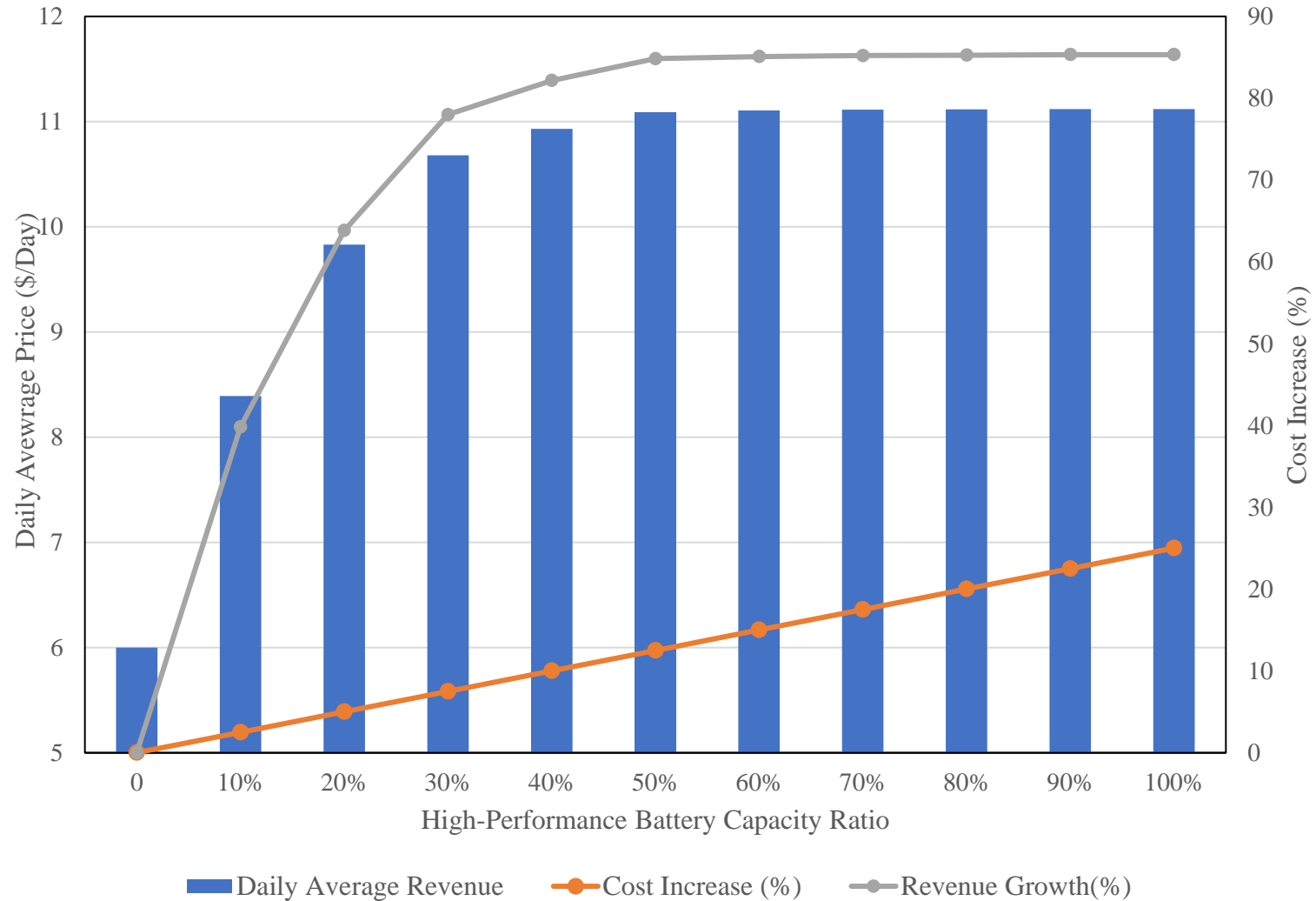
With MPC Daily Without MPC Daily Increase



# Heterogenous Battery Pack



# Heterogeneous Battery Pack



# Summary

- Combing battery storage with MPC can raise the solar farm daily revenue up to 800%
- With battery safety concern, a heterogenous pack is recommended
- With 50% high-performance battery, the average daily revenue can increase 83% from the homogenous battery pack with general battery, while the cost only increase 15%

*Thank  
you*