Neural Network Based Energy Storage Control For Wind Farms

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Introduction

Energy storage plays a crucial role in modern power systems, especially in renewable energy sources like wind and solar farms. Due to the intermittent nature of renewable generation, efficient energy storage management is necessary to balance supply and demand, optimize energy utilization, and improve grid stability. Traditional control strategies often struggle with the dynamic and uncertain nature of energy production and consumption. This project explores the use of Deep Q-Networks (DQN), a reinforcement learning technique, to develop an adaptive and intelligent approach to energy storage management.

Objectives

- ***Develop a Simulation Environment***
- ***Implement Deep Q-Networks for Energy Storage Control***
- ***Compare with Traditional Methods***
- ***Optimize Model for Real-Time Decision-Making***

Working Principle

The Deep Q-Network (DQN) approach works by modeling energy storage management as a reinforcement learning (RL) problem.

- ***System Components : The energy storage management system consists of the following key components :***

- ***Load Demand***
- ***Renewable Energy Generation***
- ***Electricity Price***
- ***Battery State of Charge***

The goal is to optimize the charging and discharging decisions to minimize electricity costs while maintaining battery operational constraints.

- ***Deep Q-Network (DQN) Based Control:***

- ***Step 1 : Observe the system state***
- ***Step 2 : Predict the best action (Charge, Discharge, Idle) using DQN.***
- ***Step 3 : Execute the action in the system***
- ***Step 4 : Reward Calculation***
- ***Step 5 : Training the DQN Model***
- ***Policy Implementation***

Methodology

1.Problem Identification & Data Collection :

→ Identify key factors affecting energy storage and collect data on wind energy, power demand, and battery levels and prices.

2.Build a Simulation Environment :

→ Create a virtual model of wind energy generation, battery operation, and fluctuating power demand to train the AI.

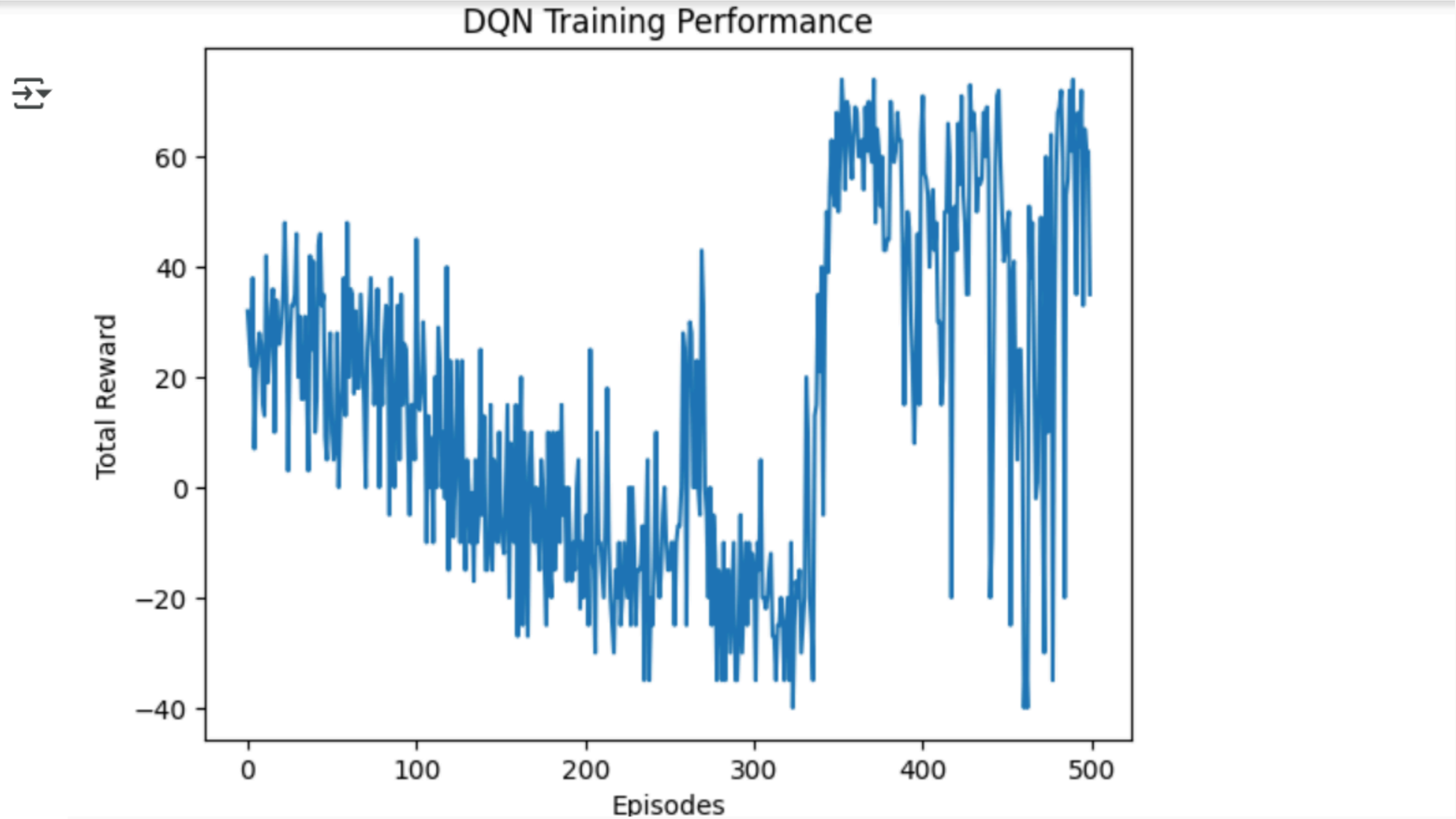
3.Implement Deep Q-Networks (DQN) :

→ Train an AI agent using reinforcement learning to optimize battery charging, discharging, and energy management decisions.

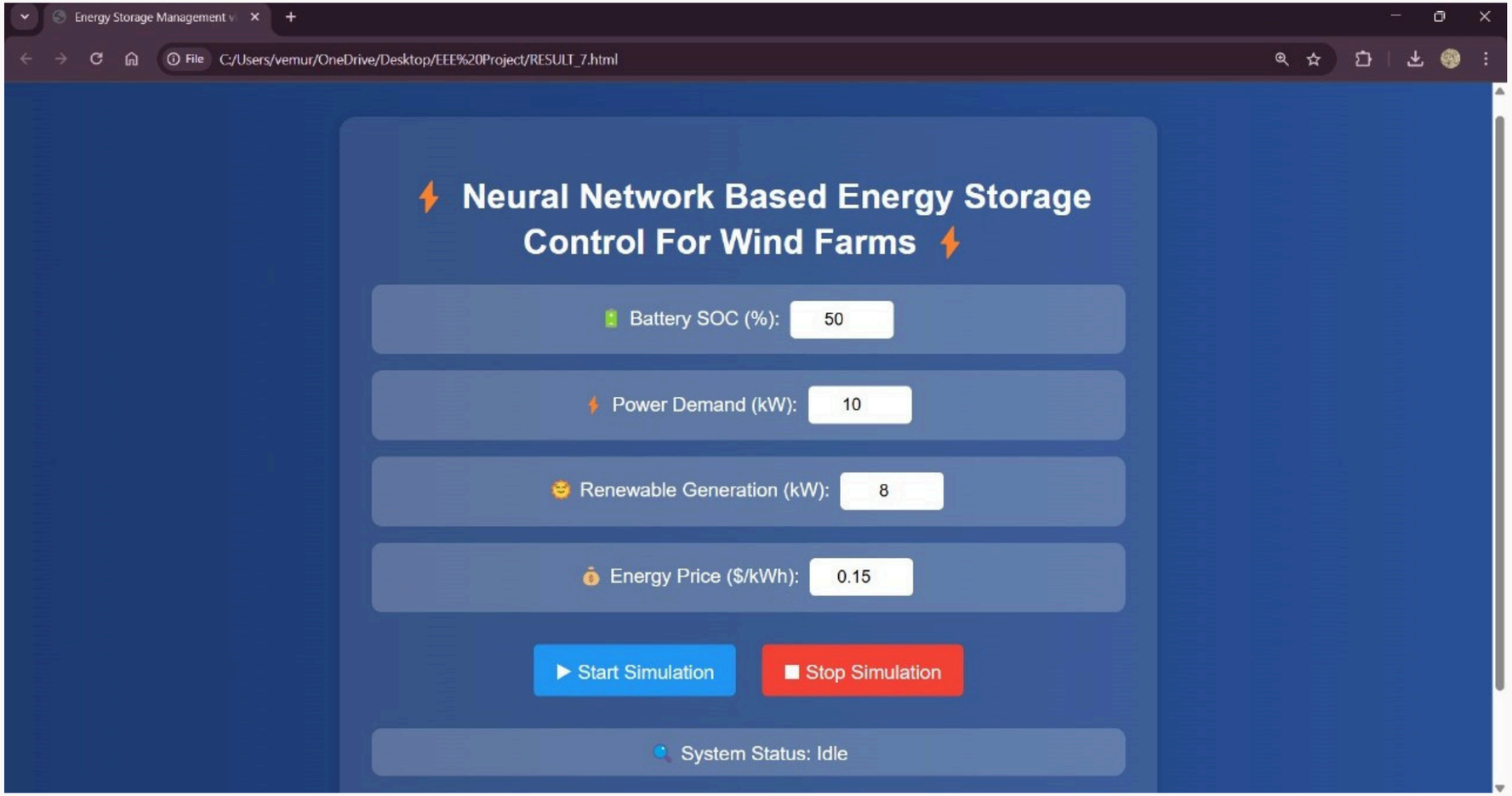
4.Train & Optimize the Model :

→ Run multiple simulations, apply a reward-based system for learning efficiency, and fine-tune hyperparameters for better performance.

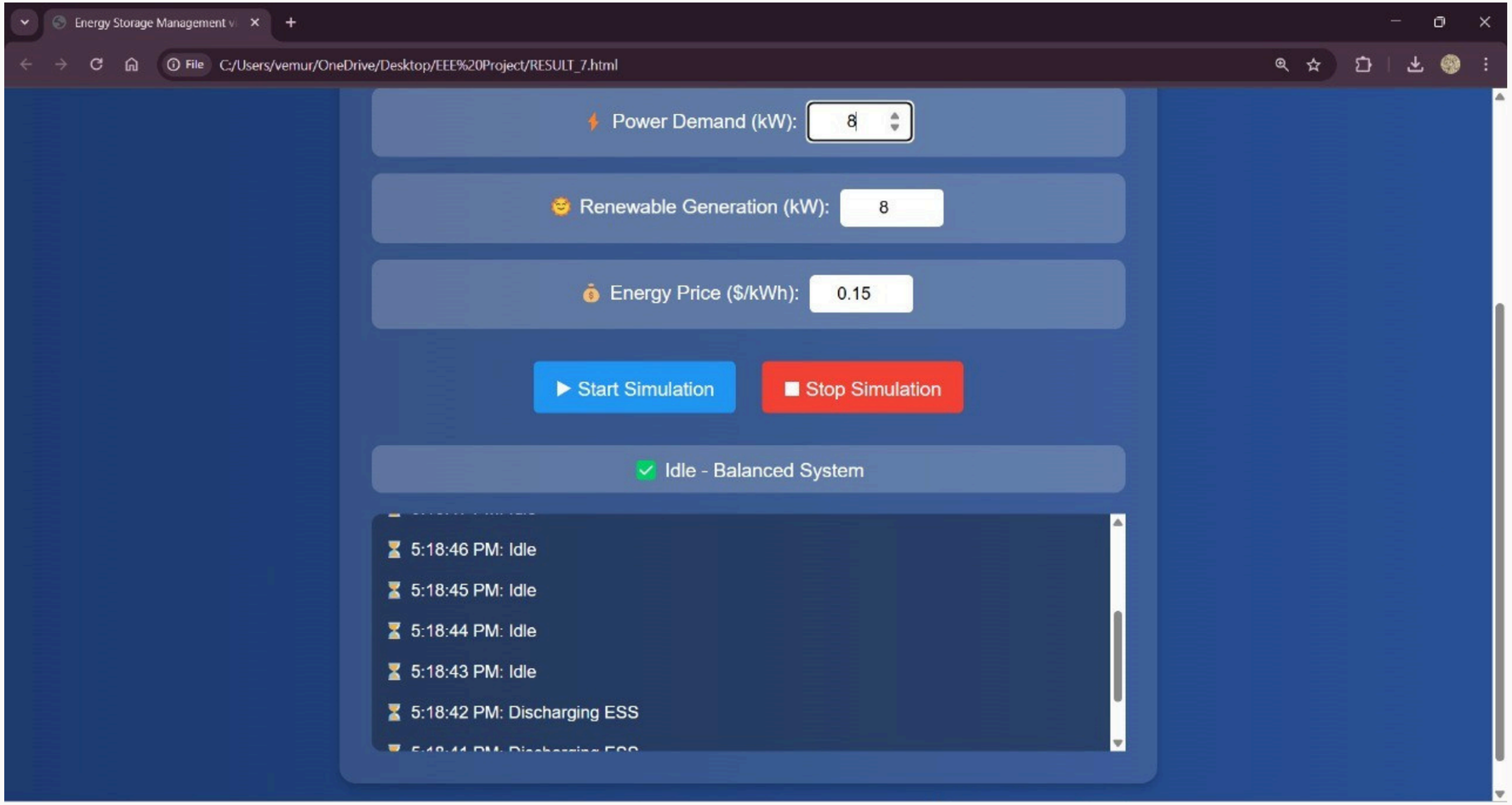
Result


DQN Training Performance
Total Reward
Episodes
60
40
20
0
−20
−40
0
100
200
300
400
500

UID


Energy Storage Management
File
C:/Users/vemur/OneDrive/Desktop/EEE%20Project/RESULT_7.html
Neural Network Based Energy Storage Control For Wind Farms
Battery SOC (%):
50
Power Demand (kW):
10
Renewable Generation (kW):
8
Energy Price ($/kWh):
0.15
Start Simulation
Stop Simulation
System Status: Idle

UID


Energy Storage Management v
File
C:/Users/vemur/OneDrive/Desktop/EEE%20Project/RESULT_7.html
Power Demand (kW):
8
Renewable Generation (kW):
8
Energy Price ($/kWh):
0.15
Start Simulation
Stop Simulation
Idle - Balanced System
5:18:46 PM: Idle
5:18:45 PM: Idle
5:18:44 PM: Idle
5:18:43 PM: Idle
5:18:42 PM: Discharging ESS

Thank You!