Solar Panel Power Simulation:

Introduction

This simulation models the power output of a solar panel throughout a typical day. The solar irradiance is approximated as a sine wave representing sunlight intensity from sunrise (6 AM) to sunset (6 PM). The program calculates the solar panel's power output given its area and efficiency and visualizes the output as a graph over 24 hours.

Key Concepts

- **Solar Irradiance (W/m^2):** Modeled as a sine wave, peaking at 1000 W/m^2 at noon (12 PM), zero before sunrise and after sunset.
- **Panel Area (m^2):** The surface area of the solar panel capturing sunlight.
- **Efficiency:** The conversion efficiency of solar energy into electrical energy (0–1).

How the Simulation Works

- Solar irradiance varies through the day, simulated by a sine wave between 6 AM and 6 PM.
- Outside these hours, irradiance is zero.
- Power output at each time step is calculated as:

*P=Irradiance×Area×EfficiencyP = \text{Irradiance} \times \text{Area} \times \text{Efficiency}*P=Irradiance×Area×Efficiency

- The power output is plotted against time (hour of day) to visualize daily performance.

Python Code

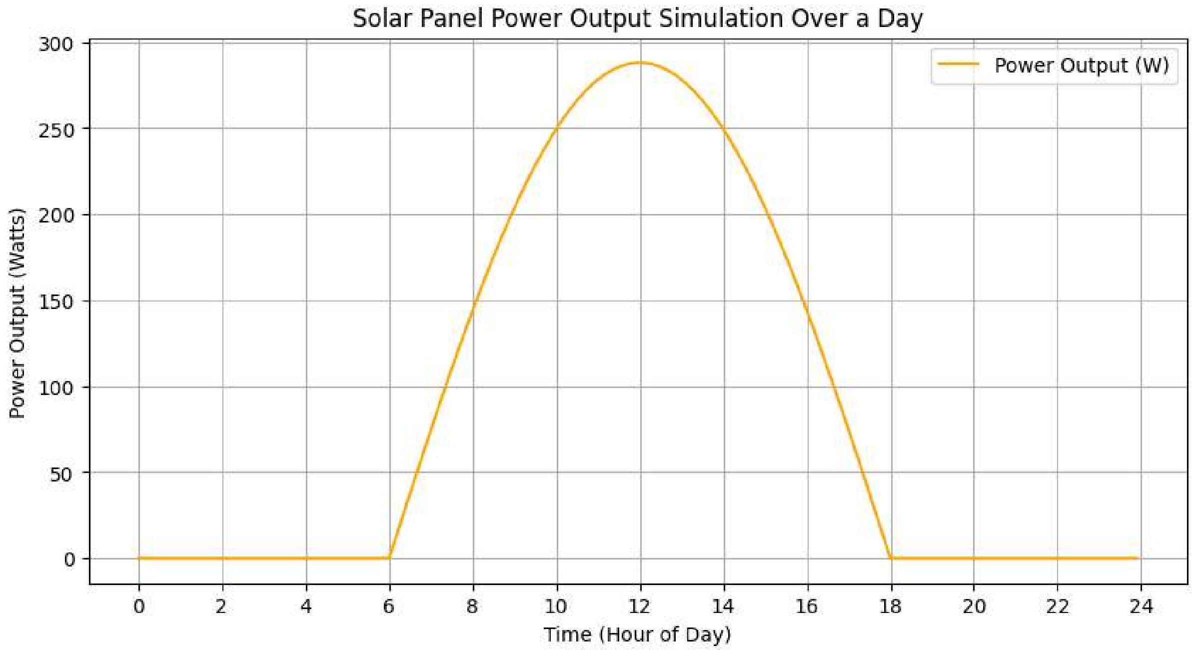
```
import numpy as np
import matplotlib.pyplot as plt

def solar_irradiance(hour):
    """
    Approximate solar irradiance over the day (6 AM to 6 PM)
    using a sine wave to simulate sunlight intensity.
```

```
    """
    if 6 <= hour <= 18:
        # Peak at noon (12 PM), irradiance max ~1000 W/m^2
        return 1000 * np.sin(np.pi * (hour - 6) / 12)
    else:
        return 0

def solar_power_output(irradiance, area, efficiency):
    """
    Calculate power output of a solar panel.
    """
    return irradiance * area * efficiency

def simulate_day(area, efficiency):
  hours = np.arange(0, 24, 0.1)  # simulate in 0.1 hour increments
    power_output = []

    for hour in hours:
        irradiance = solar_irradiance(hour)
        power = solar_power_output(irradiance, area, efficiency)
        power_output.append(power)

    return hours, power_output

def plot_power_output(hours, power_output):
    plt.figure(figsize=(10,5))
    plt.plot(hours, power_output, label='Power Output (W)',
color='orange')
    plt.title('Solar Panel Power Output Simulation Over a Day')
    plt.xlabel('Time (Hour of Day)')
    plt.ylabel('Power Output (Watts)')
    plt.xticks(range(0, 25, 2))
    plt.grid(True)
    plt.legend()
    plt.show()

def main():
    area = float(input("Enter solar panel area (m^2): "))          #
e.g., 1.6 m^2
    efficiency = float(input("Enter solar panel efficiency (0 to 1):
"))  # e.g., 0.18
```

```
    hours, power_output = simulate_day(area, efficiency)
    plot_power_output(hours, power_output)

if __name__ == "__main__":
    main()
```

Output:-

```
Enter solar panel area (m^2): 1.6
Enter solar panel efficiency (0 to 1): 0.18
```



How to Run the Program

1. **Prerequisites:** Make sure Python is installed on your system.
2. **Required Libraries:** Install the libraries numpy and `matplotlib` using pip if you haven't:

```
pip install numpy matplotlib
```

3. **Run the script:** Execute the Python script. When prompted:
   a. Enter the solar panel area in square meters.
   b. Enter the solar panel efficiency as a decimal between 0 and 1 (e.g., 0.18 for 18%).
4. The program will generate a graph showing the estimated power output of the solar panel throughout the day.

Interpretation of Results

The graph shows the power output rising from sunrise (6 AM), peaking at noon, and declining until sunset (6 PM). Hours outside this range have zero power output due to lack of sunlight.