Hybrid Renewable Energy System (Solar + Wind)

In [1]:

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

```
C:\Users\reshm\anaconda3\Lib\site-packages\pandas\core\arrays\masked.py:60: UserWarning: Pandas requires versio
n '1.3.6' or newer of 'bottleneck' (version '1.3.5' currently installed).
  from pandas.core import (
```

In [2]:

```
# Load the dataset
file_path = "D:/Capstone_2025/data/solardata_addis.xlsx"
df = pd.read_excel(file_path)
```

In [3]:

```
# Constants for Power Estimation
solar_efficiency = 0.2  # Assuming 20% efficiency for solar panels
wind_turbine_efficiency = 0.4  # Assuming 40% efficiency for wind turbines
air_density = 1.225  # kg/m^3 (standard air density)
turbine_area = 10  # m^2, assumed swept area of the wind turbine
```

In [4]:

```
# Estimate Solar Power Generation (kW)
df['Solar_Power_kW'] = df['GHI'] * solar_efficiency
```

In [5]:

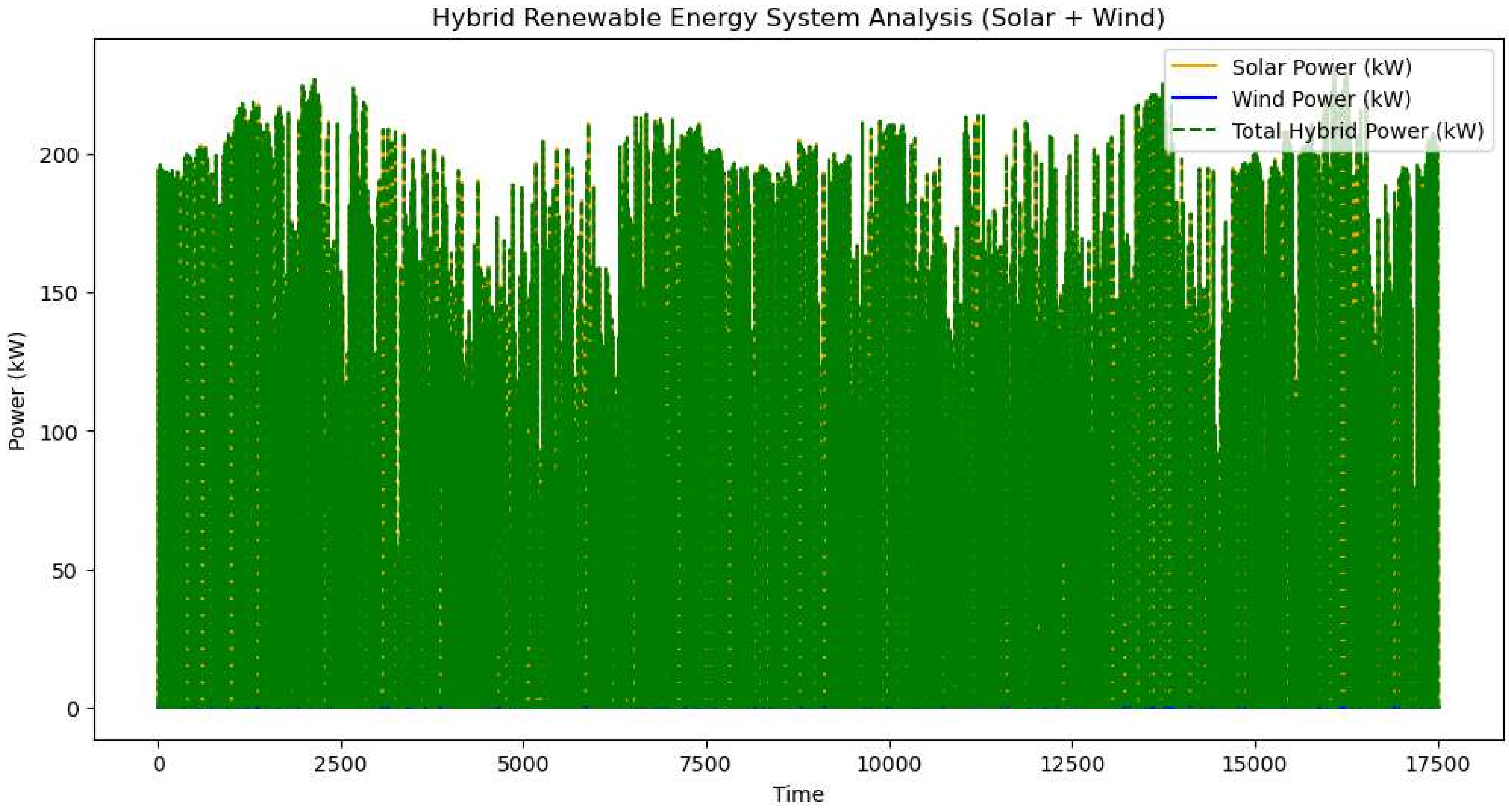
```
# Estimate Wind Power Generation (kW) using simplified wind power equation
df['Wind_Power_kW'] = 0.5 * air_density * turbine_area * wind_turbine_efficiency * (df['Wind Speed'] ** 3) / 100
```

In [6]:

```
# Calculate the total hybrid power generation
df['Total_Power_kW'] = df['Solar_Power_kW'] + df['Wind_Power_kW']
```

In [7]:

```python
# Plot the results
plt.figure(figsize=(12, 6))
plt.plot(df.index, df['Solar_Power_kW'], label="Solar Power (kW)", color='orange')
plt.plot(df.index, df['Wind_Power_kW'], label="Wind Power (kW)", color='blue')
plt.plot(df.index, df['Total_Power_kW'], label="Total Hybrid Power (kW)", color='green', linestyle='dashed')
plt.xlabel("Time")
plt.ylabel("Power (kW)")
plt.title("Hybrid Renewable Energy System Analysis (Solar + Wind)")
plt.legend()
plt.show()
```



In [8]:

```python
# Calculate the best solar-wind mix
solar_contribution = df['Solar_Power_kW'].sum()
wind_contribution = df['Wind_Power_kW'].sum()
total_power = solar_contribution + wind_contribution

solar_ratio = (solar_contribution / total_power) * 100
wind_ratio = (wind_contribution / total_power) * 100

print(f"Optimal Renewable Energy Mix: Solar {solar_ratio:.2f}% | Wind {wind_ratio:.2f}%")
```

```
Optimal Renewable Energy Mix: Solar 99.90% | Wind 0.10%
```

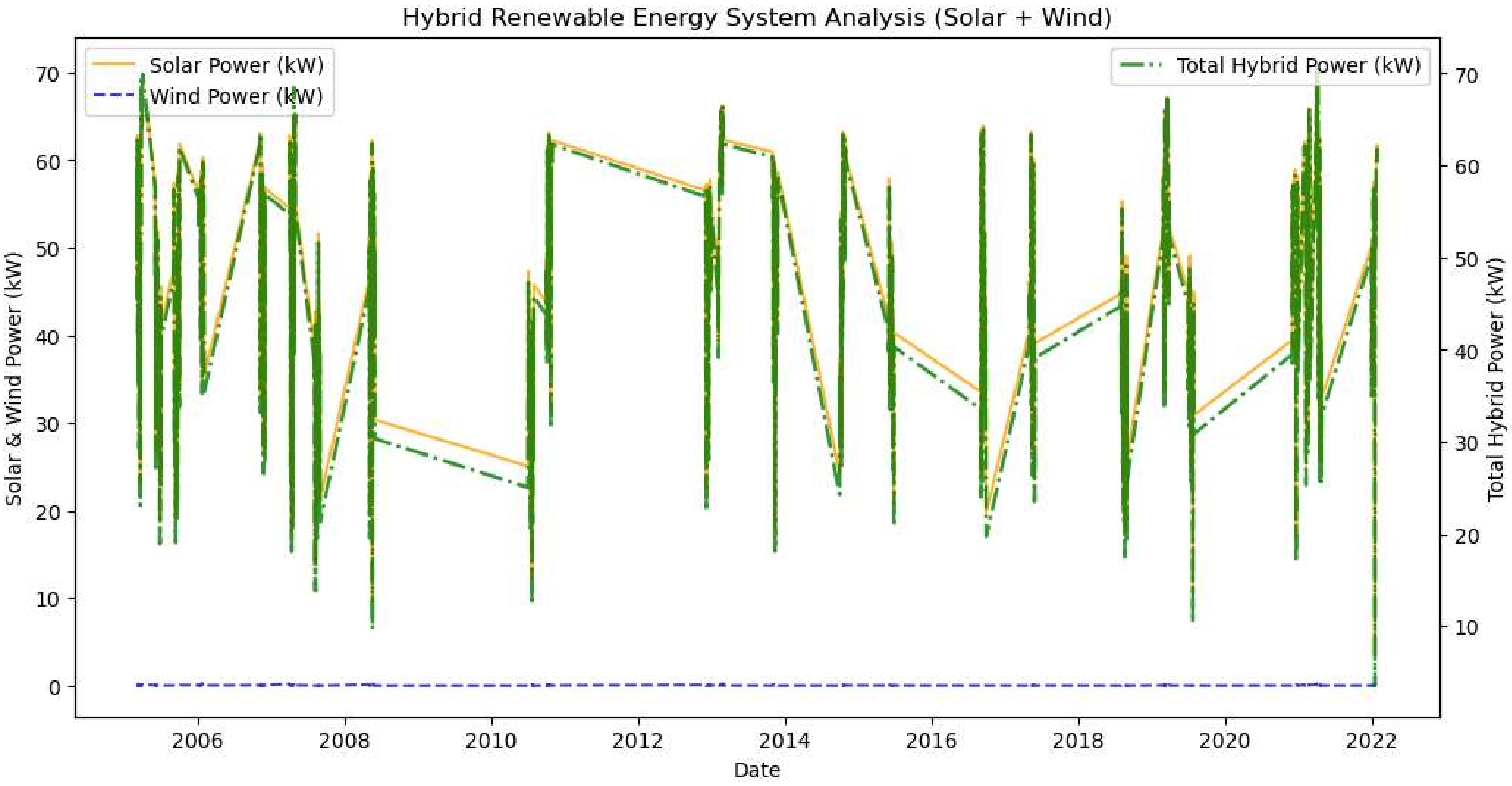
In [ ]:

improved model

In [9]:

```
# Constants for Power Estimation
solar_efficiency = 0.2  # Assuming 20% efficiency for solar panels
wind_turbine_efficiency = 0.4  # Assuming 40% efficiency for wind turbines
air_density = 1.225  # kg/m^3 (standard air density)
turbine_area = 10  # m^2, assumed swept area of the wind turbine

# Estimate Solar Power Generation (kW)
df['Solar_Power_kW'] = df['GHI'] * solar_efficiency

# Estimate Wind Power Generation (kW)
df['Wind_Power_kW'] = 0.5 * air_density * turbine_area * wind_turbine_efficiency * (df['Wind Speed'] ** 3) / 100

# Calculate the total hybrid power generation
df['Total_Power_kW'] = df['Solar_Power_kW'] + df['Wind_Power_kW']

# Resample data for better visualization (daily averages)
df['Date'] = pd.to_datetime(df[['Year', 'Month', 'Day']])
df_resampled = df.groupby('Date')[['Solar_Power_kW', 'Wind_Power_kW', 'Total_Power_kW']].mean()

# Plot with improved clarity
fig, ax1 = plt.subplots(figsize=(12, 6))

ax1.plot(df_resampled.index, df_resampled['Solar_Power_kW'], label="Solar Power (kW)", color='orange', linestyle
ax1.plot(df_resampled.index, df_resampled['Wind_Power_kW'], label="Wind Power (kW)", color='blue', linestyle='--

# Second Y-axis for Total Power
ax2 = ax1.twinx()
ax2.plot(df_resampled.index, df_resampled['Total_Power_kW'], label="Total Hybrid Power (kW)", color='green', lin

# Labels and Titles
ax1.set_xlabel("Date")
ax1.set_ylabel("Solar & Wind Power (kW)")
ax2.set_ylabel("Total Hybrid Power (kW)")
ax1.set_title("Hybrid Renewable Energy System Analysis (Solar + Wind)")

# Legends
ax1.legend(loc="upper left")
ax2.legend(loc="upper right")
```

```
plt.show()
```



In [ ]:

In [ ]: