ELECTRICITY MONITORING IN SMART CITIES

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WORK

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OBJECTIVE OF OUR PROJECT

- Monitoring electricity use within one certain community and how it changes with time.
- Understanding the electricity usage through the visualization of data
- Understand how a smart city may utilize an electricity monitoring system

METHODS OF VISUALIZATION AND DATA STRATEGY

- We will create a series of fake data on electricity consumption and generation to fit into our model.
- We will use tools to visualize our data, including its geographic coordinates and time.

CREATE LOCATIONS WITH RANDOMIZED COORDINATES

```python
import random
import pandas as pd

# 台北市の緯度と経度の範囲
latitude_range = (24.960, 25.200)
longitude_range = (121.440, 121.620)

# ランダムなポイントを生成する関数
def generate_random_coordinates(n):
    coordinates = []
    for _ in range(n):
        latitude = round(random.uniform(*latitude_range), 6)
        longitude = round(random.uniform(*longitude_range), 6)
        coordinates.append((latitude, longitude))
    return coordinates

# 30件分のランダムポイントを生成
random_coordinates = generate_random_coordinates(30)

# 緯度経度データをデータフレームに変換
coordinates_df = pd.DataFrame(random_coordinates, columns=["Latitude", "Longitude"])

# データフレームの確認
print(coordinates_df.head())
```

```
   Latitude   Longitude
0  25.171506  121.572323
1  25.011450  121.586835
2  25.107502  121.515934
3  25.007797  121.564123
4  24.993073  121.535000
```

HOURLY ELECTRICITY USAGE OF DIFFERENT USER CATEGORIES

```python
import time
import random
import datetime
import pandas as pd

# Set base consumption levels and peak times for each category
base_consumption = {
    "residential": 2,   # residential: base consumption (kW)
    "commercial": 10,   # commercial; base consumption (kW)
    "industrial": 50    # industrial: base consumption (kW)
}

peak_hours = {
    "residential": [18, 19, 20],  # residential:evening peak hours
    "commercial": [9, 10, 11],    # commercial: morning peak hours
    "industrial": [14, 15, 16]    # industrial: afternoon peak hours
}

# Generate data by residential, commercial and industrial
def generate_hourly_consumption(category, hour):
    """時間ごとの電力消費データを生成する関数"""
    base = base_consumption[category]
    peak_factor = 3 if hour in peak_hours[category] else 1  # Peak hours hav
    variation = random.uniform(0.8, 1.2)  # add random variation
    return round(base * peak_factor * variation, 2)

# generate real-time power consumption data
def simulate_realtime_consumption(interval=1):
    """simulate real-time power consumption data"""
    try:
        while True:
            current_time = datetime.datetime.now()
            hour = current_time.hour

            # Generate consumption data for each category
            data = {
                "Time": current_time,
                "Residential": generate_hourly_consumption("residential", ho
                "Commercial": generate_hourly_consumption("commercial", hour
                "Industrial": generate_hourly_consumption("industrial", hour
            }

            # Display in DataFrame
            df = pd.DataFrame([data])
            print(df)

            # インターバル
            time.sleep(interval)
    except KeyboardInterrupt:
        print("リアルタイムデータ生成を終了しました。")

# 1秒ごとにデータを生成するシミュレーションを開始
simulate_realtime_consumption(interval=1)
```

```
                        Time  Residential  Commercial  Industrial
8-14 09:10:55.178602                1.86       27.63       55.36
                        Time  Residential  Commercial  Industrial
8-14 09:10:56.183524                 1.7       24.58       51.25
                        Time  Residential  Commercial  Industrial
8-14 09:10:57.188113                2.29        32.1       55.83
                        Time  Residential  Commercial  Industrial
8-14 09:10:58.192279                1.94       29.98       46.16
                        Time  Residential  Commercial  Industrial
8-14 09:10:59.196626                2.32       30.39       45.18
                        Time  Residential  Commercial  Industrial
8-14 09:11:00.200849                2.22        30.7        52.9
                        Time  Residential  Commercial  Industrial
8-14 09:11:01.206749                1.92       30.25       48.55
                        Time  Residential  Commercial  Industrial
8-14 09:11:02.210997                1.79       35.73       44.29
                        Time  Residential  Commercial  Industrial
8-14 09:11:03.215426                1.77       29.43       55.44
                        Time  Residential  Commercial  Industrial
8-14 09:11:04.219952                2.27       31.01       48.99
                        Time  Residential  Commercial  Industrial
8-14 09:11:05.223558                1.84       25.27       46.78
                        Time  Residential  Commercial  Industrial
8-14 09:11:06.229439                1.67       31.82       46.11
                        Time  Residential  Commercial  Industrial
8-14 09:11:07.234312                1.71       29.08       52.57
                        Time  Residential  Commercial  Industrial
8-14 09:11:08.238545                2.35       32.31       57.64
                        Time  Residential  Commercial  Industrial
8-14 09:11:09.243236                2.34       26.56       49.05
                        Time  Residential  Commercial  Industrial
8-14 09:11:10.247657                2.37       29.64        51.9
                        Time  Residential  Commercial  Industrial
8-14 09:11:11.251545                1.71        28.6       57.16
                        Time  Residential  Commercial  Industrial
8-14 09:11:12.257524                2.04       32.96       48.27
                        Time  Residential  Commercial  Industrial
8-14 09:11:13.263593                1.63       26.38       53.57
                        Time  Residential  Commercial  Industrial
8-14 09:11:14.268513                 2.4       34.32       43.46
                        Time  Residential  Commercial  Industrial
8-14 09:11:15.272548                1.66       35.41       50.39
                        Time  Residential  Commercial  Industrial
8-14 09:11:16.276552                2.11       34.99        50.3
ムデータ生成を終了しました。
```

DAILY ELECTRICITY USAGE OF DIFFERENT USER CATEGORIES

```
    Datetime  Building_ID    Category Weekday_Weekend  Consumption_kW
0 2024-08-01  Building_01  commercial         Weekday            8.91
1 2024-08-01  Building_02  industrial         Weekday           59.58
2 2024-08-01  Building_03  commercial         Weekday           10.29
3 2024-08-01  Building_04  industrial         Weekday           56.98
4 2024-08-01  Building_05  commercial         Weekday            8.36
      Building_ID    Category Weekday_Weekend  Hour  Mean_Consumption_kW  \
1358  Building_29  industrial         Weekday    14             144.6900
736   Building_16  industrial         Weekday    16             153.5250
494   Building_11  industrial         Weekday    14             163.5175
975   Building_21  industrial         Weekday    15             167.6150
1360  Building_29  industrial         Weekday    16             149.3550
1070  Building_23  industrial         Weekday    14             161.2225
160   Building_04  industrial         Weekday    16             170.6550
543   Building_12  industrial         Weekday    15             158.2175
831   Building_18  industrial         Weekday    15             156.1550
350   Building_08  industrial         Weekday    14             155.6425

      Max_Consumption_kW
1358              179.99
736               179.69
494               179.40
975               179.38
1360              179.10
1070              178.95
160               178.35
543               177.99
831               177.92
350               177.36
```

The priod of the data: 2024/08/01~2024/08/14

- Categories: ①residential, ②commercial, and ③industrial

each with its own base consumption (e.g., 2 kW for residential, 10 kW for commercial, and 50 kW for industrial).

- Peak Hours: ①evening, ②morning, and ③afternoon

Each category has predefined peak hours during which electricity consumption increases (e.g., residential buildings peak during evening hours, while commercial buildings peak in the morning).

- Weekend Factors: ①increase and ②③ decrease

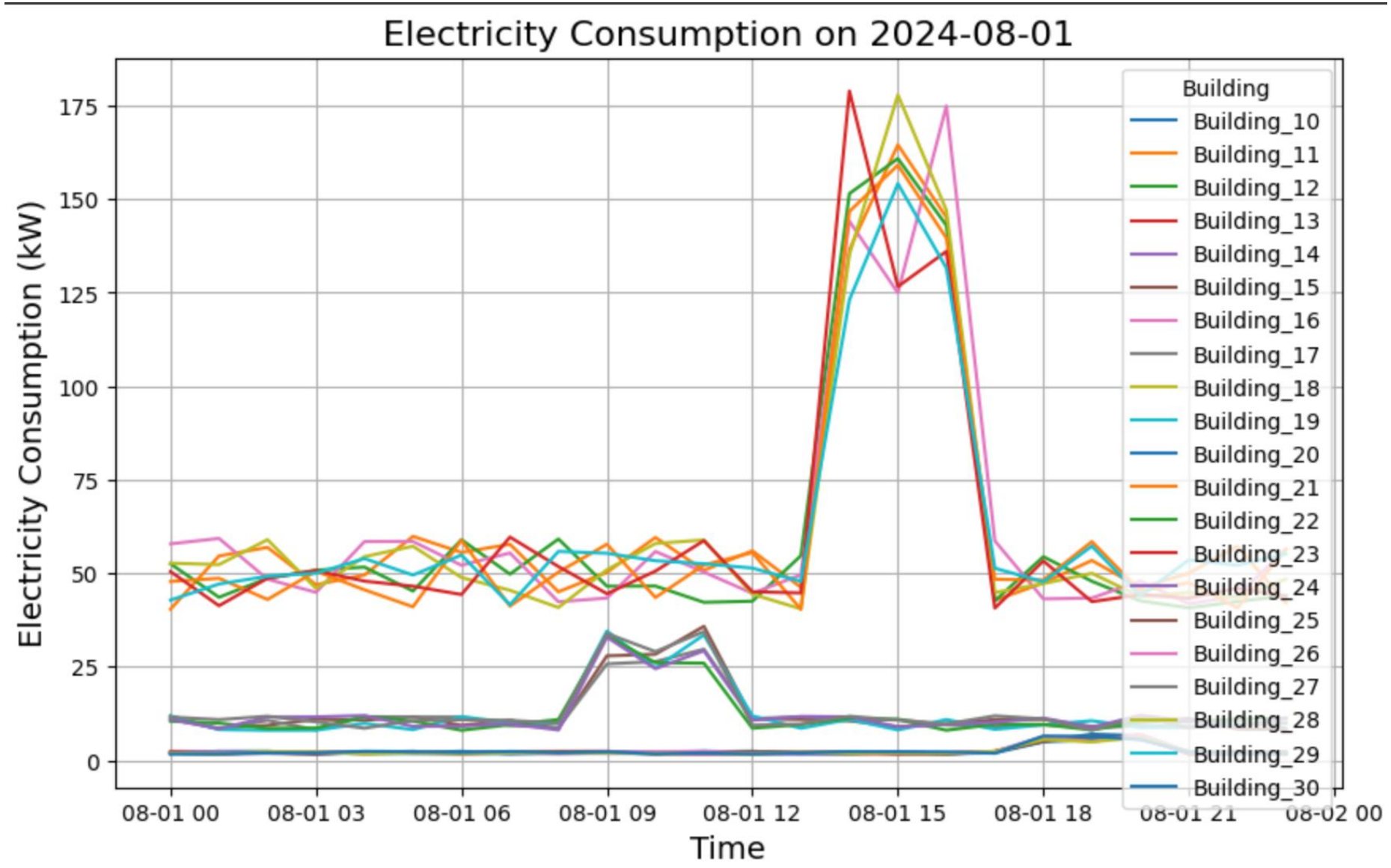
The dataset incorporates adjustments for weekends, where consumption for residential buildings increases, but decreases for commercial and industrial buildings.

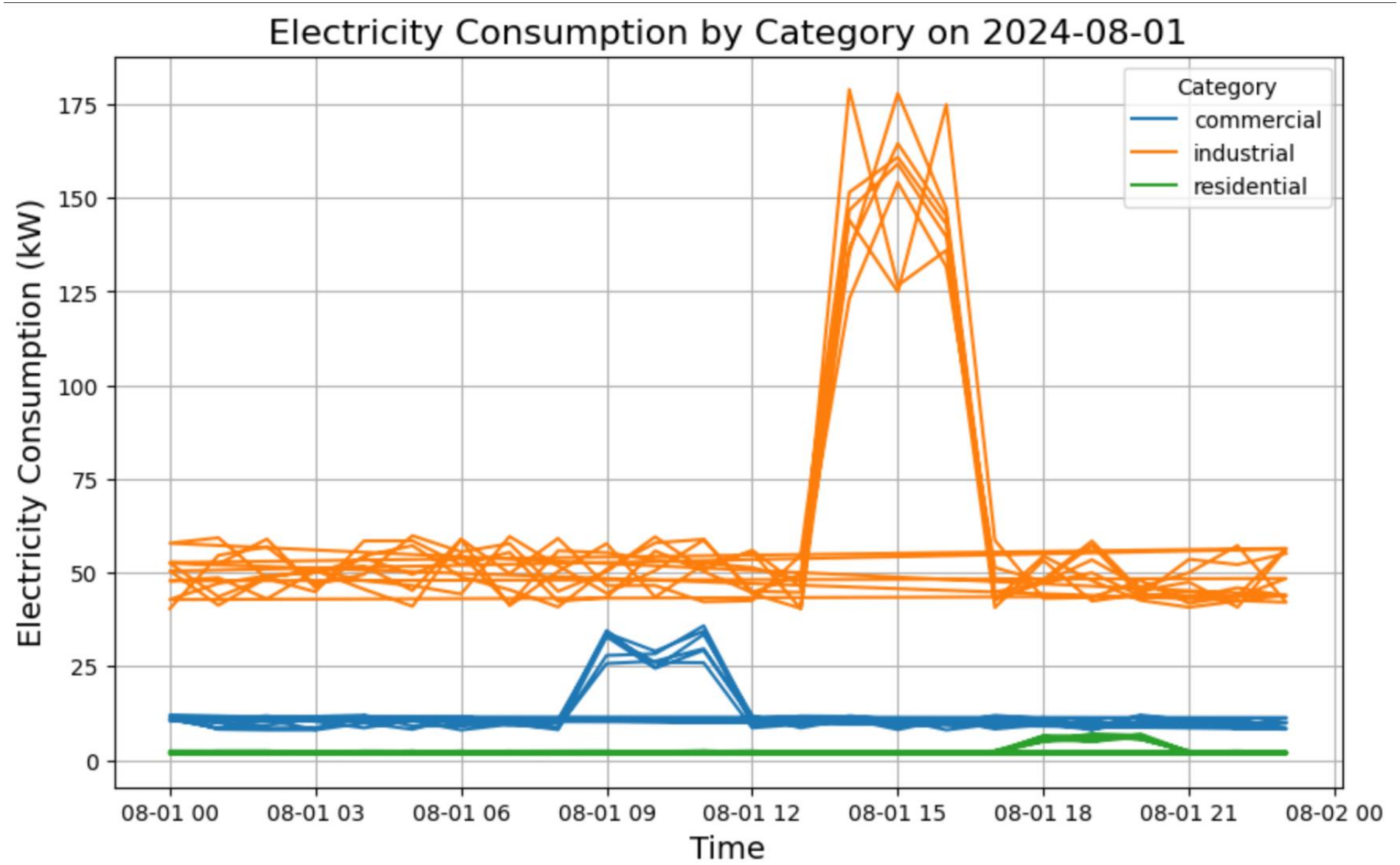
- Random Variation:

A random factor is applied to simulate fluctuations in electricity consumption.

The dataset covers a week-long period, and consumption values are recorded hourly. The data is also aggregated to analyze peak consumption by building, category, and time of day.


Electricity Consumption Over Time for Each Building
Electricity Consumption (kW)
0
25
50
75
100
125
150
175
Time
Building
Building_10
Building_11
Building_12
Building_13
Building_14
Building_15
Building_16
Building_17
Building_18
Building_19
Building_20
Building_21
Building_22
Building_23
Building_24
Building_25
Building_26
Building_27
Building_28
Building_29
Building_30


Electricity Consumption on 2024-08-01
Electricity Consumption (kW)
0
25
50
75
100
125
150
175
08-01 00
08-01 03
08-01 06
08-01 09
08-01 12
08-01 15
08-01 18
08-01 21
08-02 00
Time
Building
Building_10
Building_11
Building_12
Building_13
Building_14
Building_15
Building_16
Building_17
Building_18
Building_19
Building_20
Building_21
Building_22
Building_23
Building_24
Building_25
Building_26
Building_27
Building_28
Building_29
Building_30


Electricity Consumption by Category on 2024-08-01
Category
commercial
industrial
residential
Electricity Consumption (kW)
0
25
50
75
100
125
150
175
08-01 00
08-01 03
08-01 06
08-01 09
08-01 12
08-01 15
08-01 18
08-01 21
08-02 00
Time

ELECTRICITY GENERATED BY DIFFERENT SOURCES

```python
generation_sources = {
    "solar": {"base_output": 10, "variability": 0.2},  # 太陽光：基本出力と変動率
    "wind": {"base_output": 20, "variability": 0.3},   # 風力：基本出力と変動率
    "hydropower": {"base_output": 15, "variability": 0.1}, # 水力：基本出力と変動率
    "fossil_fuel": {"base_output": 100, "variability": 0.05}, # 化石燃料：基本出力と変動率
    "nuclear": {"base_output": 80, "variability": 0.02}, # 原子力：基本出力と変動率
    "rooftop_solar": {"base_output": 5, "variability": 0.3}, # 屋上ソーラー：基本出力と変動
    "microgrid": {"base_output": 2, "variability": 0.4}, # マイクログリッド：基本出力と変動
    "community_energy": {"base_output": 3, "variability": 0.25} # コミュニティエネルギー：
}

# 時間ごとの発電量を生成する関数
def generate_hourly_generation(source, hour, is_sunny, is_windy):
    base_output = generation_sources[source]["base_output"]
    variability = generation_sources[source]["variability"]

    # 太陽光発電は昼間のみに発電し、曇りで変動
    if source == "solar" or source == "rooftop_solar":
        if 6 <= hour <= 18:
            base_output *= 1 if is_sunny else 0.5  # 晴天で増加、曇りで減少
        else:
            return 0  # 夜間は発電しない

    # 風力発電は風が強いと出力が増加
    if source == "wind":
        base_output *= 1 if is_windy else 0.7  # 風が強ければ増加

    # 変動率を適用して発電量を決定
    variation = random.uniform(1 - variability, 1 + variability)
    return round(base_output * variation, 2)

# 時系列データを生成する関数
def generate_generation_timeseries(start_date, end_date):
    date_range = pd.date_range(start=start_date, end=end_date, freq='H')
    data = []

    for date_time in date_range:
        hour = date_time.hour
        is_sunny = random.choice([True, False])  # ランダムな晴天/曇り
        is_windy = random.choice([True, False])  # ランダムな風の強さ

        for source in generation_sources.keys():
            generation = generate_hourly_generation(source, hour, is_sunny, is_windy)
            data.append({
                "Datetime": date_time,
                "Source": source,
                "Generation_MW": generation
            })

    return pd.DataFrame(data)

# 1週間分のデータを生成
start_date = "2024-08-01"
end_date = "2024-08-07"
generation_df = generate_generation_timeseries(start_date, end_date)

# データフレームの先頭を表示
print(generation_df.head())

# 必要に応じてcsvファイルに保存
generation_df.to_csv("power_generation_data.csv", index=False)
```

	Datetime	Source	Generation_MW
0	2024-08-01	solar	0.00
1	2024-08-01	wind	15.18
2	2024-08-01	hydropower	14.28
3	2024-08-01	fossil_fuel	95.31
4	2024-08-01	nuclear	78.98

1. Time-Series Generation:

- The dataset is generated hourly, covering a two-week period from August 1 to August 14, 2024. For each hour, the power generation of each energy source is recorded.
- Weather conditions (sunny or cloudy for solar, windy or calm for wind) are randomized for each hour.

2. Energy Sources:

solar, wind, hydropower, fossil fuel, nuclear, rooftop solar, microgrids, and community energy.

- Each energy source has a defined base output (in MW) and a variability factor that introduces randomness into the generation levels.

3. Influence of Environmental Factors:

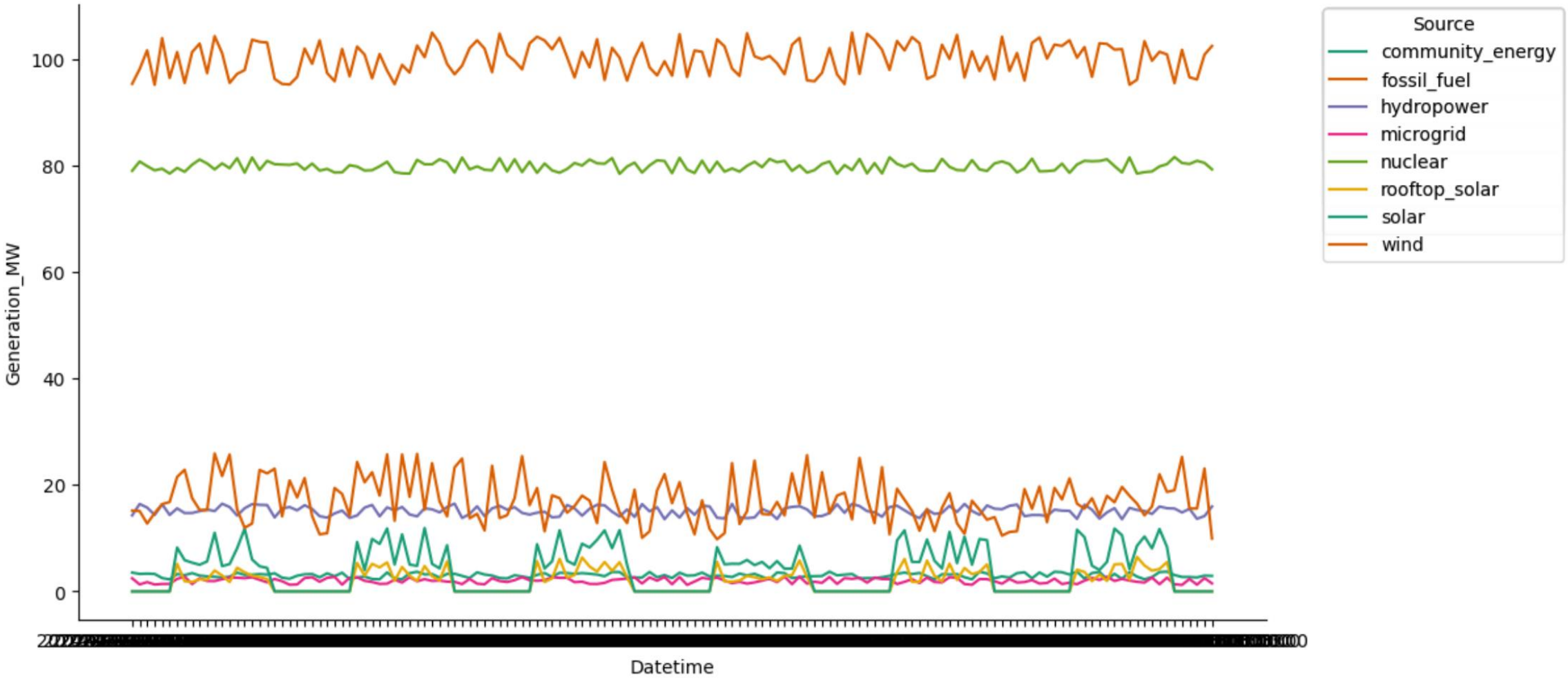
- **Solar** and **rooftop solar** generation are dependent on **daylight hours and weather conditions**
Solar generation occurs only between 6 AM and 6 PM, with reduced output on cloudy days.
- **Wind** generation is affected by **wind strength**.

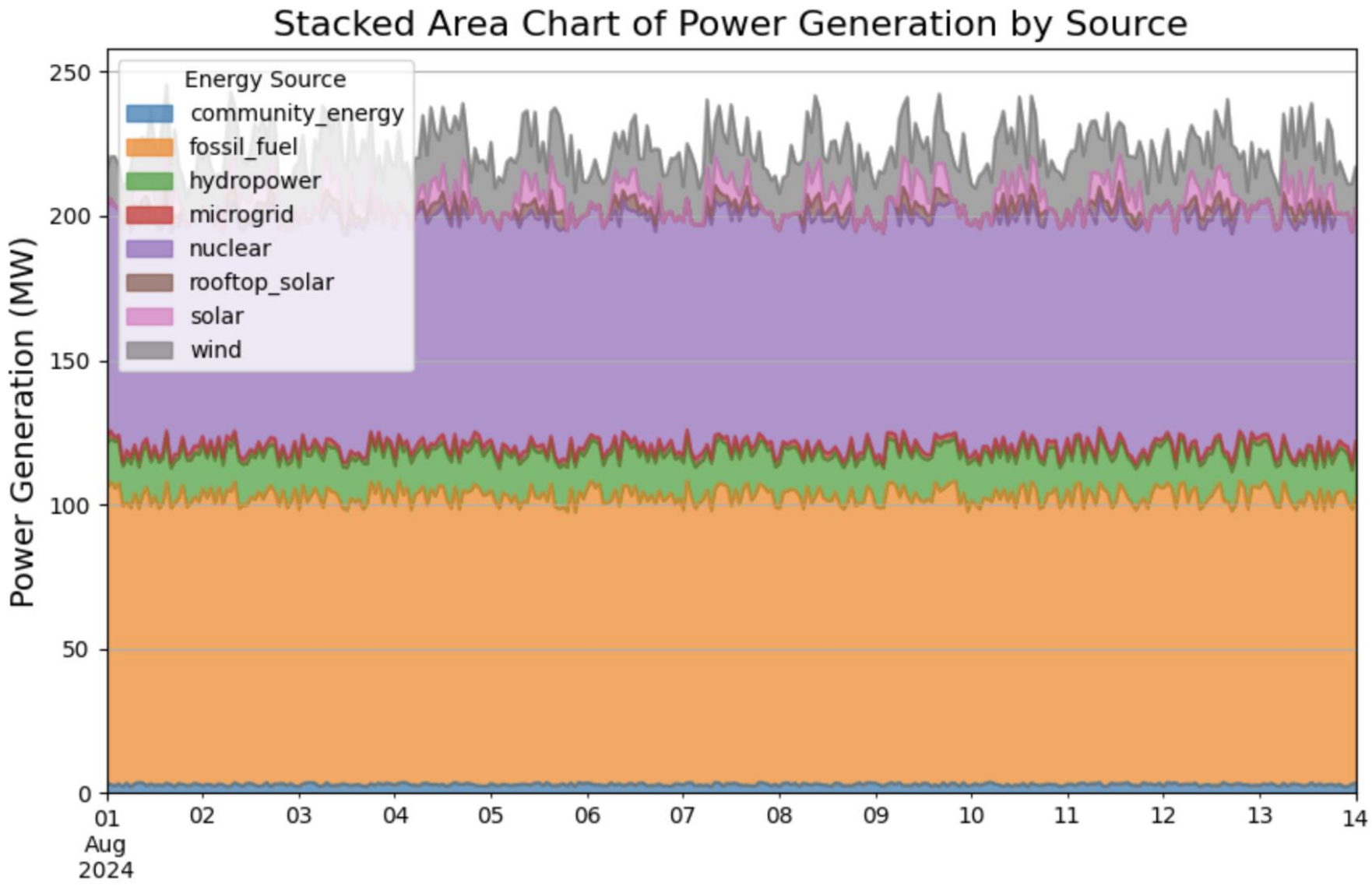
4. Generation Dynamics:

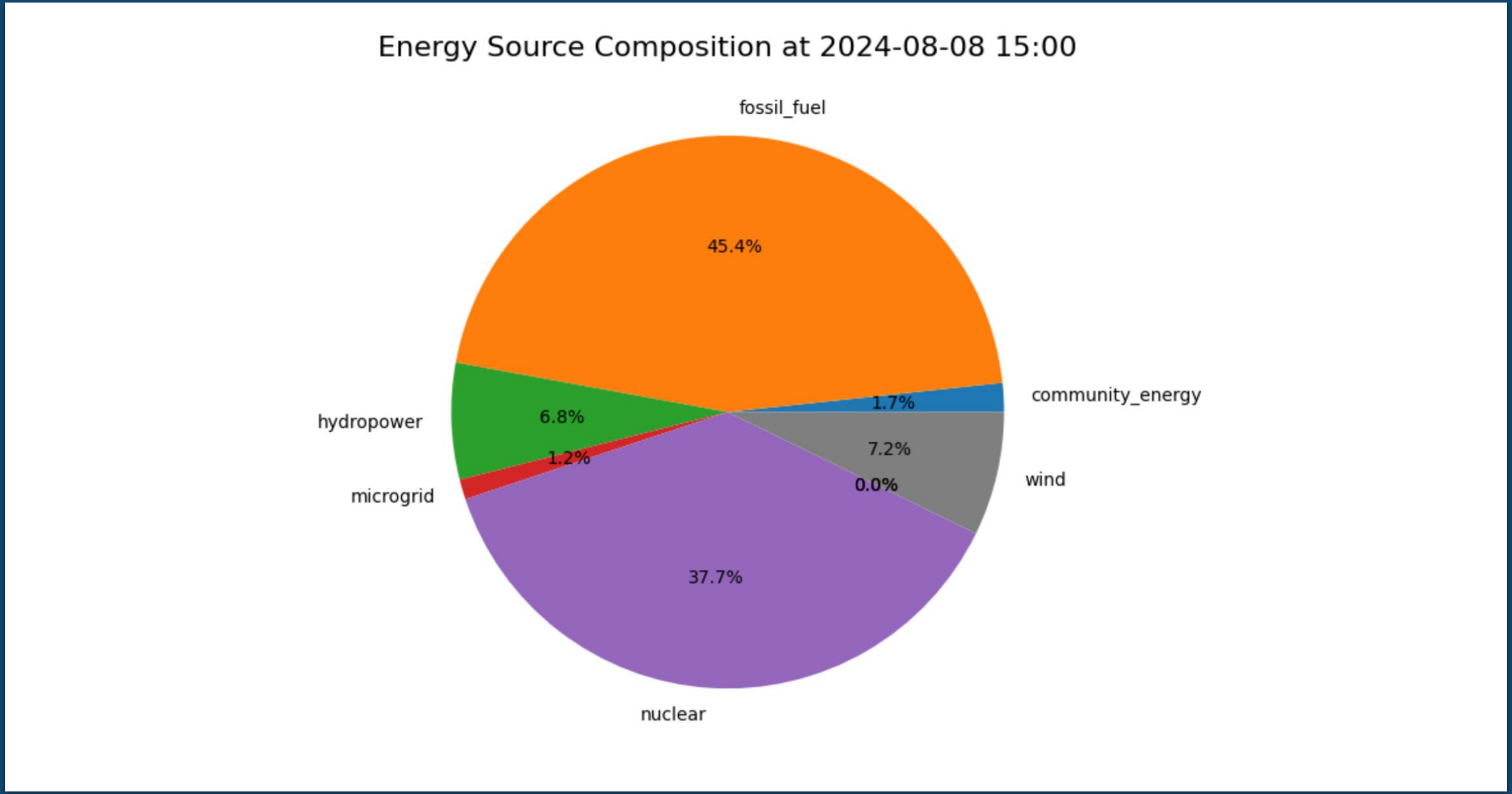
- *Fossil fuel* and *nuclear* generation have relatively stable outputs.
- *Hydropower*, *microgrids*, and *community energy* systems exhibit variability in generation but are not dependent on weather conditions.

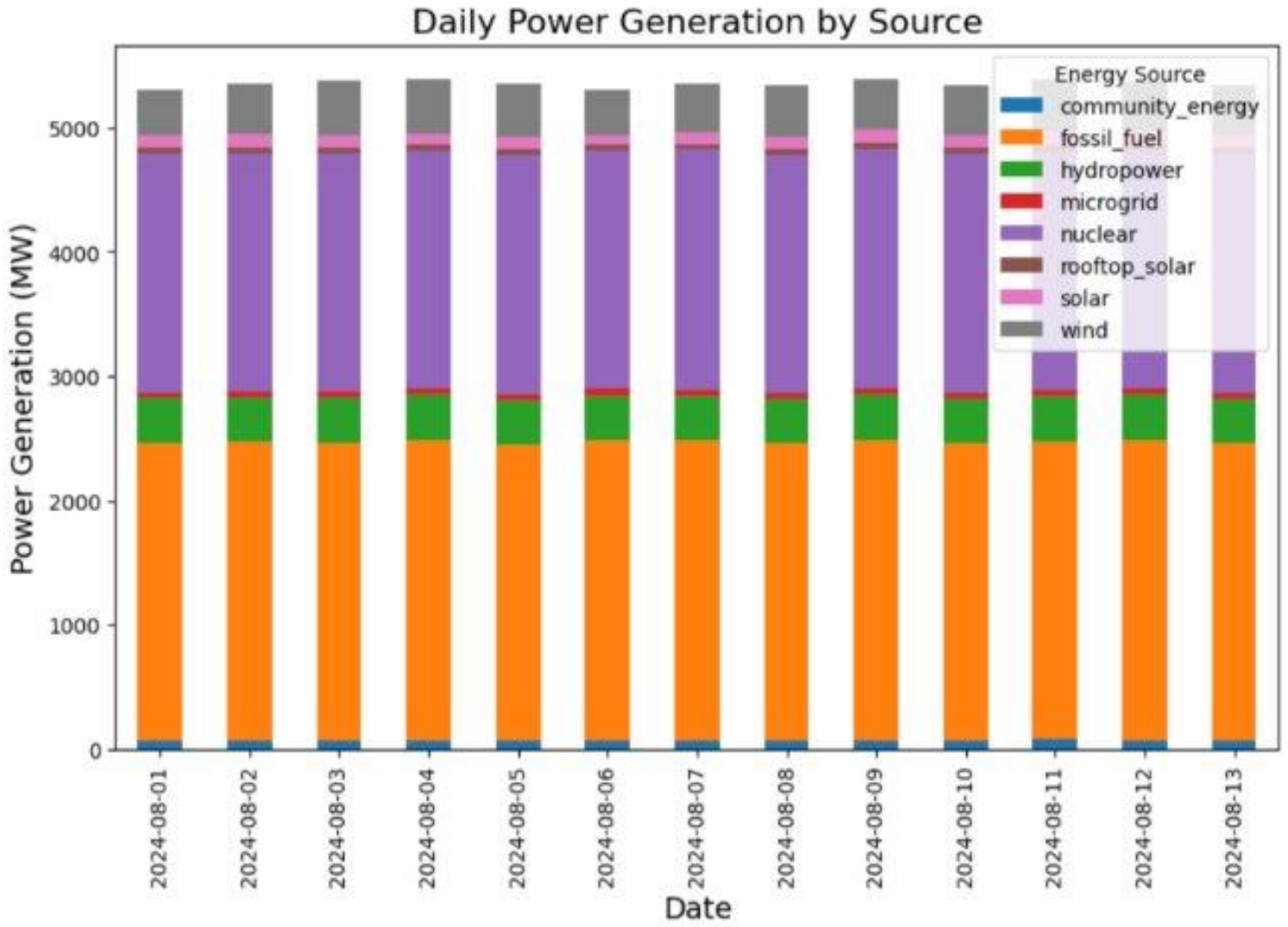
5. Data Fields:

- *Datetime*: Timestamp for the generation data.
- *Source*: The energy source responsible for the generation.
- *Generation_MW*: The generated power in megawatts (MW) for that specific hour and source.


Source
community_energy
fossil_fuel
hydropower
microgrid
nuclear
rooftop_solar
solar
wind
Generation_MW
0
20
40
60
80
100
Datetime


Stacked Area Chart of Power Generation by Source
Energy Source
community_energy
fossil_fuel
hydropower
microgrid
nuclear
rooftop_solar
solar
wind
Power Generation (MW)
250
200
150
100
50
0
01
Aug
2024
02
03
04
05
06
07
08
09
10
11
12
13
14


Energy Source Composition at 2024-08-08 15:00
fossil_fuel
45.4%
community_energy
1.7%
hydropower
6.8%
7.2%
wind
1.2%
microgrid
0.0%
37.7%
nuclear


Daily Power Generation by Source
Energy Source
community_energy
fossil_fuel
hydropower
microgrid
nuclear
rooftop_solar
solar
wind
Power Generation (MW)
0
1000
2000
3000
4000
5000
2024-08-01
2024-08-02
2024-08-03
2024-08-04
2024-08-05
2024-08-06
2024-08-07
2024-08-08
2024-08-09
2024-08-10
2024-08-11
2024-08-12
2024-08-13
Date

THANK YOU FOR LISTENING