**US Energy Market Dynamics Monitor**

**Group Composition:** Yussufkadir Syurmen

**Description of the Domain:**

The U.S. energy market involves complex interactions between electricity generation from various sources, the flow of power across the grid, and the resulting price signals. Understanding even a few key relationships within this system can provide valuable insights into its operation. This project will initially focus on a limited set of crucial dynamics and potentially expand its scope later.

**Project Scope:**

This project will initially concentrate on implementing the core functionalities for visualizing electricity generation mix and load for the entire Lower 48 United States using hourly data from the EIA. Then assess the feasibility of adding other layers like price and flow data based on the progress with these fundamental components.

* Initial Data Focus:
  + Hourly Electricity Generation by Source: Focusing on major categories like Fossil Fuels, Nuclear, Renewables (Wind, Solar, Hydro, Other) for the Lower 48 states. We'll use EIA Form-930 data accessible via the API.
  + Hourly Total Electricity Load: Aggregated load for the Lower 48 states, also available through EIA Form-930.
* Weather Integration (Phase 2 Consideration): Basic integration of nationwide average temperature as a potential future enhancement to explore its correlation with total load.
* Visualization Goals (for the initial stage can be expanded in the future): Creating interactive visualizations to show:
  + The hourly generation mix for the Lower 48 states.
  + The hourly trend of total electricity load for the Lower 48 states.
  + A combined view of generation mix and load over time.
* Analysis Focus:
  + What is the overall hourly electricity generation mix in the United States? How does it change throughout the day and week?
  + What is the typical hourly load profile for the U.S.? Are there predictable patterns?
  + How does the generation mix respond to changes in overall load?

**Initial Plan:**

1. EIA Form-930 Data Acquisition and Preprocessing:
   * Deep dive into the EIA Form-930 documentation and the EIA API to understand how to query hourly generation by fuel type and total load for the aggregated Lower 48 region.
   * Develop Python scripts to efficiently extract this data for a reasonable historical period (e.g., the last few months or a full recent year, depending on API limits and data volume).
   * Implement robust data cleaning and time series management (handling timestamps, potential missing data).
2. Basic Data Storage: It can change depending on the size of the data, but I think pandas will be enough but if the data volume gets so big maybe transferring them to a SQL would be a great idea.
3. Core Visualization Development:
   * Utilizing a suitable Python visualization library to create:
     + Stacked area charts showing the hourly contribution of different generation sources to the total.
     + Line charts showing the trend of total hourly load.
     + Potentially, overlaid or linked charts to compare generation mix and load patterns.
4. Basic Dashboard Interface (Optional): If possible, to do within the time scope, a simple dashboarding framework in Python (like Streamlit or Dash) to present these initial visualizations in an interactive web interface.
5. Phase 2 Assessment (Price and Flow): Once the generation and load visualization are stable and well-understood, feasibility of integrating will be assessed:
   * Wholesale Electricity Prices: Investigating EIA's Wholesale Electricity Market Portal or API access to LMP data at major US hubs and determine the complexity of integrating and visualizing this alongside generation and load.
   * Interstate Electricity Flows: Exploring data sources for interstate flows (e.g., EIA's Hourly Electric Grid Monitor) and evaluate the challenges of visualizing these flows on a national map in a meaningful way.
6. Iterative Expansion: Based on the assessment in Phase 2, I will decide which additional components (price, flow, weather) are feasible to integrate within the project timeframe. The focus will remain on building each component thoroughly before moving to the next.
7. Documentation: Maintain detailed documentation of the data sources, code, and design decisions throughout the project.

**Possible Data Sources:**

* EIA Open Data API (v2) - Primarily for Form EIA-930 Data: This will be the primary source for hourly generation by fuel and total load for the Lower 48.
  + Restrictions: Same as previously mentioned. Careful management of API calls and understanding the structure of Form-930 data in the API is crucial.
  + Data Description: Focus on the specific data series related to total generation by source category and total load for the "US" aggregate.
  + Data Cleaning: Standard time series cleaning will be important.
* (Phase 2) EIA Wholesale Electricity Market Portal/API: For price data at major hubs.
* (Phase 2) EIA Hourly Electric Grid Monitor: For interstate flow data.
* (Phase 2) NOAA APIs: For nationwide average temperature data.

Link for the EIA website: <https://www.eia.gov/>