Core Functional Modules of the Business Logic Layer (BLL)

The BLL in the EV Charging Station Recommendation System comprises five key modules:

1. **Analysis Engine**:
    - Calculates the **Electric Vehicle Potential Rating (EVPR)** using multi-criteria decision analysis (MCDA).
    - Applies weighted scoring and normalization for fair location comparisons.
    - Filters results based on thresholds (e.g., minimum traffic volume).
2. **Data Processing**:
    - Performs **ETL (Extract-Transform-Load)** for geospatial data.
    - Validates coordinates (e.g., latitude/longitude ranges) and merges datasets.
    - Filters incomplete or irrelevant data (e.g., exclusion zones).
3. **Map Visualization**:
    - Translates analysis results into **interactive maps** (e.g., markers, heatmaps).
    - Uses clustering algorithms to avoid visual clutter.
4. **User Management**:
    - Handles **authentication** (password hashing, email validation).

- Tracks search history and enforces **role-based access control (RBAC)**.

5. **Business Rules Integration**:
    - **Location rules**: Minimum distance between stations, proximity to POIs.
    - **Economic rules**: Population density thresholds, ROI calculations.
    - **User rules**: Organization-specific data access, preference-based filtering.

Implementation of Business Rules & Validation

1. **Business Rules**:
    - **User Module**: Ensures unique usernames, valid emails, and hashed passwords.
    - **ChargingStation/POI Modules**: Validates coordinates and status fields (e.g., "active/inactive").
    - **AnalysisEngine**: Enforces parameter ranges (e.g., positive EVPR weights).
    - **MapVisualization**: Checks coordinate validity before rendering markers.
2. **Validation Logic**:
    - **User Inputs**: Email format, password complexity, and session checks.

- **Data Integrity**: Filters null values, validates coordinate ranges (-90 to 90 for latitude).
- **API Requests**: Validates inputs (e.g., EVPR thresholds) before processing.

3. **Data Transformation**:
    - **DataProcessor**: Standardizes coordinates, merges datasets, and cleans raw data.
    - **AnalysisEngine**: Converts raw data into scores (e.g., EVPR) and JSON for UI.
    - **MapVisualization**: Transforms coordinates into Folium markers/heatmaps.
    - **FlaskApp**: Formats backend results into JSON/HTML for frontend rendering.

Conclusion:
The BLL integrates **validation, transformation, and business rules** to ensure data accuracy, security, and usability. Modules like AnalysisEngine and DataProcessor handle core logic, while User Management and Map Visualization tailor outputs to user needs. This structured approach maintains separation of concerns while delivering actionable insights.