### **Entities and Their Attributes**

1. **User**
   * **Attributes**:  
     + user\_id (Primary key, unique identifier for each user)
     + name
     + email
     + phone\_number
     + address
     + account\_type (Residential/Commercial)
   * **Participation**: Mandatory in the system as every interaction (e.g., usage tracking, billing) involves a user.
   * **Description**: Represents electricity consumers (either residential or commercial).
2. **Electric Meter**
   * **Attributes**:
     + meter\_id (Primary key, unique identifier for each meter)
     + user\_id (Foreign key, linking the meter to a user)
     + installation\_date
     + Location
   * **Participation**: Mandatory because users need a meter to track their consumption.
   * **Description**: Represents the device that tracks electricity usage for each user.
3. **Electricity Usage**
   * **Attributes**:
     + usage\_id (Primary key)
     + meter\_id (Foreign key, linking usage to a specific meter)
     + start\_time (When usage started)
     + end\_time (When usage ended)
     + total\_usage (Amount of electricity used, in kWh)
   * **Participation**: Optional for new users, but mandatory for tracking active users' consumption.
   * **Description**: Tracks the electricity consumed during a specific period.
4. **Bill**
   * **Attributes**:  
     + bill\_id (Primary key)
     + meter\_id (Foreign key)
     + amount\_due
     + due\_date
     + status (Paid/Unpaid)
     + Issue\_date
   * **Participation**: Mandatory for all users, as every user is billed for their electricity   
     Usage.
   * **Description**: Represents billing information based on usage data.
5. **Notification**
   * **Attributes**:  
     + notification\_id (Primary key)
     + user\_id (Foreign key, identifying the user receiving the notification)
     + message
     + sent\_date
     + status (Read/Unread)
   * **Participation**: Optional for users, as notifications are sent based on specific events (e.g., overdue bills, high usage alerts).
   * **Description**: Represents notifications sent to users regarding bill payments, usage thresholds, etc.
6. **Appliance**
   * **Attributes**:
     + appliance\_id (Primary key)
     + name
     + power\_rating (In watts)
     + usage\_rate (Cost per kWh)
   * **Participation**: Optional for users who want to estimate the cost of appliance usage.
   * **Description**: Represents appliances that users can estimate electricity costs for.
7. **Usage Estimation**
   * **Attributes**:
     + estimation\_id (Primary key)
     + user\_id (Foreign key)
     + appliance\_id (Foreign key)
     + usage\_duration (Time the appliance was used, in hours)
     + estimated\_cost (Cost calculated for the given usage)
   * **Participation**: Optional, only when a user chooses to estimate the cost of specific appliance usage.
   * **Description**: Represents the feature allowing users to estimate electricity costs for individual appliances.

### **Relationships**

1. **User–Electric Meter**
   * **Relationship Name**: "Assigned"
   * **Cardinality**: One user can have one or more electric meters, but each meter is assigned to only one user.
   * **Type**: 1  
     (One-to-Many)
   * **Participation**: Mandatory for both. Every user must have at least one meter, and every meter must be assigned to a user.
2. **Electric Meter–Electricity Usage**
   * **Relationship Name**: "Records"
   * **Cardinality**: One meter can record multiple usage sessions, but each session is recorded by one meter.
   * **Type**: 1  
     (One-to-Many)
   * **Participation**: Mandatory for the meter, optional for usage (new users may not have usage records yet).
3. **Electric Meter–Bill**
   * **Relationship Name**: "Generates"
   * **Cardinality**: One meter generates many bills over time, but each bill is associated with one meter.
   * **Type**: 1  
     (One-to-Many)
   * **Participation**: Mandatory for both. Each user must receive bills based on their meter’s readings.
4. **User–Notification**
   * **Relationship Name**: "Receives"
   * **Cardinality**: One user can receive multiple notifications, but each notification is sent to only one user.
   * **Type**: 1  
     (One-to-Many)
   * **Participation**: Optional for the user (notifications are event-driven).
5. **User–Usage Estimation**
   * **Relationship Name**: "Requests"
   * **Cardinality**: One user can request many usage estimations, but each estimation belongs to one user.
   * **Type**: 1  
     (One-to-Many)
   * **Participation**: Optional, as not all users will use this feature.
6. **Appliance–Usage Estimation**
   * **Relationship Name**: "Estimates"
   * **Cardinality**: One appliance can be used in many usage estimations, but each estimation involves one appliance.
   * **Type**: 1  
     (One-to-Many)
   * **Participation**: Optional for both entities (only involved when users estimate appliance costs).

### 

| **Entity Relationship** | **Cardinality** | **Participation** |
| --- | --- | --- |
| User–Electric Meter | 1 | Mandatory for both |
| Electric Meter–Electricity Usage | 1 | Mandatory for meter, optional for usage |
| Electric Meter–Bill | 1 | Mandatory for both |
| User–Notification | 1 | Optional for user |
| User–Usage Estimation | 1 | Optional for both |
| Appliance–Usage Estimation | 1 | Optional for both |

### **Cardinality and Participation Summary**

### **Diagram Notes**

* **Weak Entity**: The Usage Estimation entity can be a weak entity, dependent on the User and Appliance.
* **Primary Keys (PK)**: Ensure each entity has a unique identifier (user\_id, meter\_id, etc.).
* **Foreign Keys (FK)**: Relationships are established using foreign keys (user\_id, meter\_id, etc.) to connect related entities.
* **Participation**: Denote mandatory participation with a double line (||) and optional participation with a single line (|) when drawing the relationships.