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Project Assignment

Database Systems

## Database Design and Implementation

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# 1 Conceptual Design

## 1.1 Requirements

The requirements for the database are the following:

"GreenWorld Energy"
<p>The company "GreenWorld Energy" operates decentralized renewable energy production facilities distributed across regions. Each facility is characterized by a name, location, type of energy produced (e.g., solar, wind, hydro), and maximum energy output capacity. The company also manages contracts with customers for energy supply, categorized as residential or commercial, and offers flexible pricing models based on consumption. Each customer has one or more accounts, each identified by a unique code. Every energy contract is linked to a single customer account and includes details such as start date, duration, energy plan, and cost. Facilities are overseen by management teams, each identified by a unique code, team name, and the number of projects managed. Teams are evaluated based on performance metrics such as energy efficiency, uptime, and customer satisfaction. Each team is represented by the main responsible employee and other employees identified by fiscal code, name, surname, date of birth and date of hiring. Additionally, the company supports a feedback system allowing customers to submit ratings and comments regarding service quality. Customers are classified into residential and commercial types, each identified by a unique alphanumeric code, with associated contact details and energy consumption history.</p>

Table 1: Requirements



## 1.2 Analysis

### 1.2.1 Glossary of Terms

Term	Description	Connections	Synonyms
Region	Area where the facilities are located.	Facility	Location
Facility	Energy production facility. It emits energy for customers	Contract, Teams, Region	Projects
Contract	Energy supply contract. It describes the energy plan. It can be residential or commercial	Account, Facility	
Customer	Customer of GreenWorld Energy. It can be residential or commercial	Account	
Account	Customer account. It associated with only one account and one contract	Contract, Customer, Feedback	
Feedback	Customer feedback. Used to give a score to each team	Account, Team	Ratings, customer satisfaction
Team	Groups of employees that oversees a facility. Each team has a manager	Facility, Employee, Feedback	
Employee	Employee of a GreenWorld Energy's team.	Team	

Table 2: Glossary of Terms

### 1.2.2 Level of Abstraction

By considering the synonyms of the terms, we can identify the level of abstraction of the terms. The terms can be classified as follows:

- **Region** as Location
- **Facility** as Facility
- **Contract** as Contract
- **Customer** as Customer
- **Account** as Account
- **Feedback** as Feedback
- **Team** as Team
- **Employee** as Employee

### 1.2.3 Reorganization of Concepts

The concepts can be reorganized as follows:

Facility
Each facility is characterized by a name, location, type of energy produced (e.g., solar, wind, hydro), and maximum energy output capacity. The company also manages contracts with customers for energy supply, categorized as residential or commercial, and offers flexible pricing models based on consumption. Facilities are overseen by management teams

Table 3: Facility’s Concepts

Contract
The company also manages contracts with customers for energy supply, categorized as residential or commercial, and offers flexible pricing models based on consumption. Every enegy contract is linked to a single customer account and includes details such as start date, duration, energy plan, and cost.

Table 4: Contract’s Concepts

<b>Customer</b>
Each customer has one or more accounts, each identified by a unique code. Customers are classified into residential and commercial types, each identified by a unique alphanumeric code, with associated contact details and energy consumption history. Additionally, the company supports a feedback system allowing customers to submit ratings and comments regarding service quality.

Table 5: Customer’s Concepts

<b>Account</b>
Each customer has one or more accounts, each identified by a unique code. Every energy contract is linked to a single customer account and includes details such as start date, duration, energy plan, and cost.

Table 6: Account’s Concepts

<b>Feedback</b>
The company supports a feedback system allowing customers to submit ratings and comments regarding service quality.

Table 7: Feedback’s Concepts

<b>Team</b>
Facilities are overseen by management teams, each identified by a unique code, team name, and the number of projects managed. Teams are evaluated based on performance metrics such as energy efficiency, uptime, and customer satisfaction. Each team is represented by the main responsible employee

Table 8: Team’s Concepts

<b>Employee</b>
Each team is represented by the main responsible employee and other employees identified by fiscal code, name, surname, date of birth and date of hiring.

Table 9: Employee’s Concepts

### 1.2.4 Entity-Relationship Diagram

#### SKELETON SCHEMA

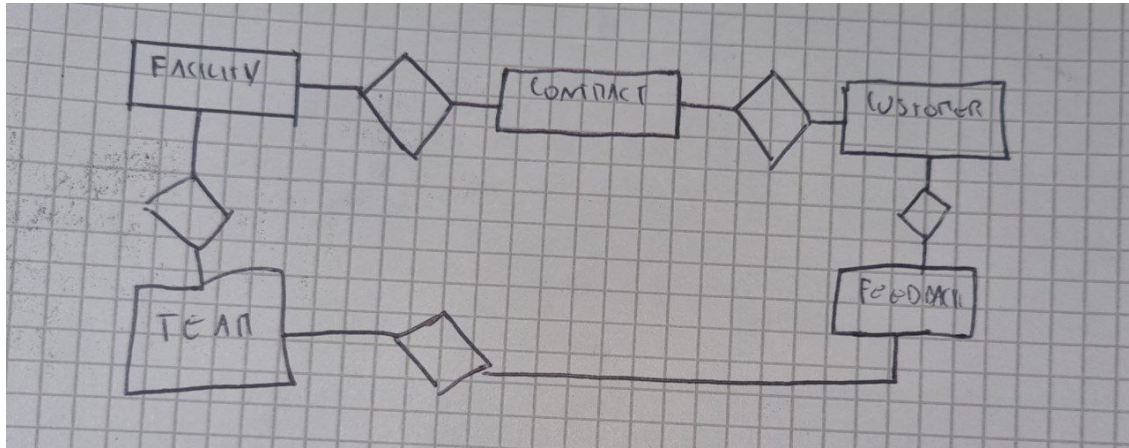


Figure 1: Skeleton Schema

This schema represents the main entities and their relationships. The entities are the following:

- **Facility**
- **Contract**
- **Customer**
- **Feedback**
- **Team**

The purpose of this schema is to have a general idea of the entities and their relationships. The attributes of the entities and the cardinality of the relationships are not included in this schema. Also, some entities are not included in this schema, such as Account and Employee. These entities will be included in the final schema with all the other details.

#### FINAL SCHEMA



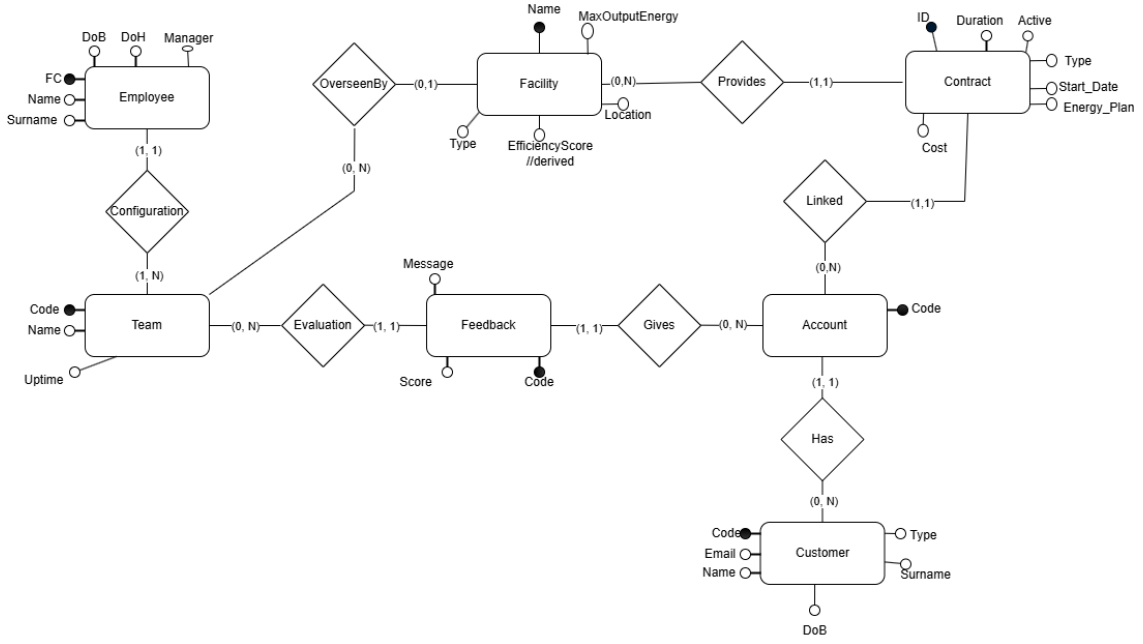


Figure 2: Final Schema

Note: Duration is expressed in months

### 1.2.5 Business Rules

The business rules are the following:

- A customer can't be a minor
- An employee can't be a minor
- Each team has got only one main responsible employee
- The sum of energy plan of all contracts related to a facility can't exceed the maximum energy output capacity of the facility
- If an account needs to activate a new contract with the same facility, the old contract must be deactivated before the new one is activated
- A customer of a specific type can't have a contract of the other type
- The score of a feedback can be between 0 and 5
- Uptime is the number of hours the facility is active in a day. Between 6 and 8

- Energy efficiency is the percentage of energy produced compared to the maximum energy output capacity of the facility. Between 0 and 100
- EnergyPlan can be; 2.500 kWh, 4.500 kWh or 10.000 kWh
- Cost: 500 if EnergyPlan=2.500, 750 if EnergyPlan=4.500, 1000 if EnergyPlan=10.000

## 2 Logical Design

### 2.1 Volume Table

Lets consider the volumes for a year

Concept	Type	Volume	Description
Facility	E	100	Number of facilities (Given)
Contract	E	900.000	Number of contracts. 100 facilities * 500 contracts per facility * 12 months * 1.5 contracts per account
Customer	E	300.000	Number of customers.(ASSUMPTION)
Account	E	600.000	Number of accounts. 300.000 customers * 2 accounts per customer on average
Team	E	50	Number of teams. (ASSUMPTION)
Employee	E	250	Number of employees. 5 employees per team * 50 teams (ASSUMPTION)
Feedback	E	600.000	Number of feedbacks.
Provides	R	900.000	Each contract is provided by a single facility
Linked	R	900.000	On average each account has 1.5 contracts
Has	R	600.000	Each customer 2 accounts on average
OverseenBy	R	100	Each facility is overseen by a single team. Each team oversees 2 facilities, on average
Configuration	R	500	Each team consists of 5 employees on average
Gives	R	500.000	Each feedback is given by a single account. Not all accounts give feedback
Evaluation	R	500.000	Each feedback is linked to a single team

Table 10: Volume Table

### 2.2 Access Table

**Operation1:** Register a new customer (50 times per day)

Concept	Type	Access	Type
Customer	E	1	W

Table 11: Access Table for Operation1

Total Cost:  $2 * 50 = 100$  per day

**Operation2:** Register a new energy contract (50 times per day)

Concept	Type	Access	Type
Contract	E	1	W
Provides	R	1	W
Facility	E	1	R
Linked	R	1	W
Account	E	1	R
Facility	E	1	W
Provides	R	9000	R
Contract	E	9000	R

Table 12: Access Table for Operation2

Total Cost:  $(2+2+1+2+1+2+9000+9000)*200=3.602.000$  per day

Every time we need to update the efficiency score of the facility related to the contracts.

**Operation3:** Assign a facility to a management team (50 times per day)

Concept	Type	Access	Type
Team	E	1	R
OverseenBy	R	1	W
Facility	E	1	R

Table 13: Access Table for Operation3

Total Cost:  $(1+2+1)*50=200$  per day

**Operation4:** View the total energy output of a specific facility managed by the

eldest employee (1 per month = 0.03 per day)

Concept	Type	Access	Type
Employee	E	250	R
Configuration	R	1	R
Team	E	1	R
OverseenBy	R	2	R
Facility	E	2	R
Provides	R	9000	R
Contract	E	9000	R

Table 14: Access Table for Operation4

Total Cost:  $(250+1+1+1+2+9000+9000)*0.03=547.65$  per day

Each team oversees, on average, two facilities. We need to choose only one of them, which provides on average 9000 contracts. In this case we don't have sumEnergyOutput in the schema as attribute of the facility, so we need to compute it every time. If we introduce it, the cost will be

Concept	Type	Access	Type
Employee	E	250	R
Configuration	R	1	R
Team	E	1	R
OverseenBy	R	2	R
Facility	E	2	R

Table 15: Access Table for Operation4 with redundancy

Total Cost:  $(250+1+1+2+2)*0.03=7.68$  per day

But in this case we need to update it every time we add a new contract, so the total cost of **Operation2** will be:

Concept	Type	Access	Type
Contract	E	1	W
Provides	R	1	W
Facility	E	1	R
Facility	E	1	W
Linked	R	1	W
Account	E	1	R
Facility	E	1	W
Provides	R	9000	R
Contract	E	9000	R

Table 16: Access Table for Operation2 with redundancy

Total Cost:  $(2+2+1+2+2+1+2+9000+9000)*200=3.602.400$  per day  
So the total cost without redundancy is  $3.602.000 + 547.65 = 3.602.547.65$ , while the total cost with redundancy is  $3.602.400 + 7.68 = 3.602.407.68$  per day. So we should keep the redundancy in this case.

**Operation5:** Print a ranked list of facilities based on their efficiency scores (10 per day)

Concept	Type	Access	Type
Facility	E	100	R

Table 17: Access Table for Operation5

Total Cost:  $100*10 = 1000$  per day

We can try to remove the redundancy of the efficiencyScore in facilities

Concept	Type	Access	Type
Facility	E	100	R
Provides	R	900.000	R
Contract	E	900.000	R

Table 18: Access Table for Operation5 without redundancy

Total Cost:  $(100+900.000+900.000)*10 = 18.001.000$  per day

Concept	Type	Access	Type
Contract	E	1	W
Provides	R	1	W
Facility	E	1	R
Linked	R	1	W
Account	E	1	R

Table 19: Access Table for Operation2 without redundancy

Total Cost:  $(2+2+1+2+1)*200=1.600$  per day

Now we don't need to update the the efficiency score everytime we register a new contract.

So the total cost without redundancy is 18.002.600, while the total cost with redundancy is  $2.402.000 + 1000 = 2.403.000$  per day.

We should keep the redundancy in this case.

### 2.2.1 Redundancies and Generalization

- **Redundancies:** The number of facilities managed by a team is not stored in the schema, as it can be calculated by counting the number of facilities managed by the team. The score of the team can be derived by the following formula:  $score = \frac{energy\_efficiency + uptime + AVG(customer\_score)}{3}$  and is not stored in the schema to avoid redundancy. Due to the previous analysis, the redundancy of the efficiency score and sumEnergyOutput in the facility are kept in the schema
- **Generalization:** The schema doesn't contain any generalization since there aren't different operations for them. There is a **type** attribute in the **Customer** and **Contract** entities so that the business rule related to the type of contract can be enforced.

## 2.3 UML Schema

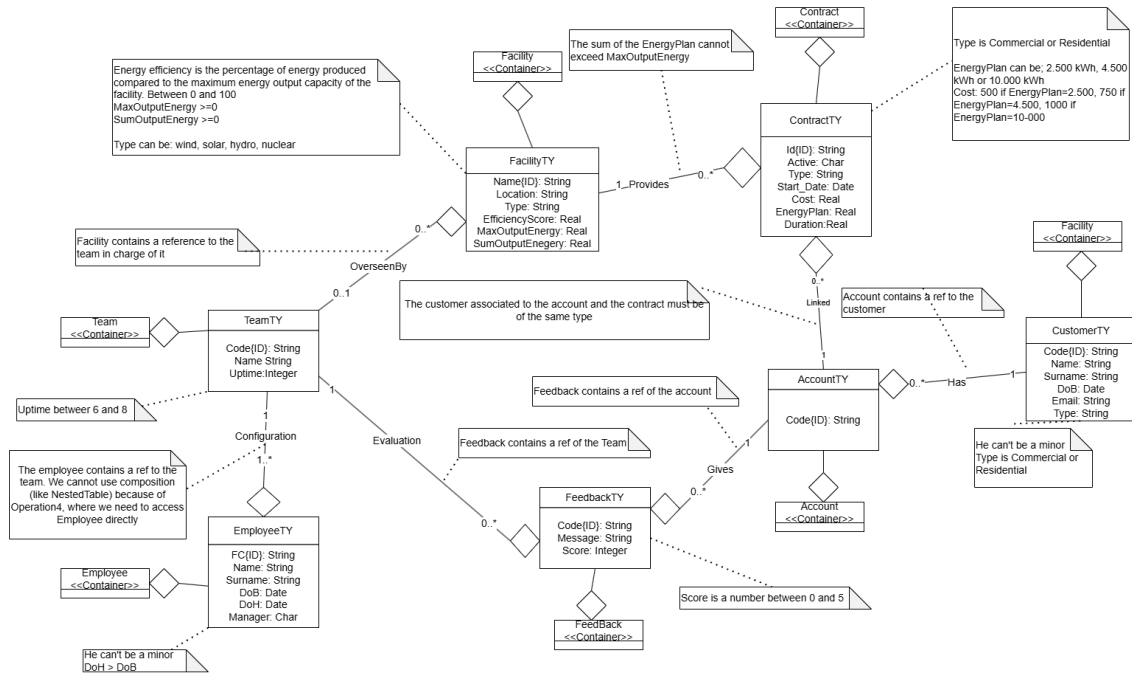


Figure 3: UML Schema



## 3 Implementation

### 3.1 Types Definition

---

```
CREATE OR REPLACE TYPE TeamTY AS OBJECT (  
    Code VARCHAR2(20) ,  
    Name VARCHAR2(50) ,  
    Uptime INTEGER  
)
```

---

---

```
CREATE OR REPLACE TYPE FacilityTY AS OBJECT (  
    Name VARCHAR2(50) ,  
    Location VARCHAR2(100) ,  
    Type VARCHAR2(20) ,  
    EfficiencyScore NUMBER,  
    MaxOutputEnergy NUMBER,  
    SumOutputEnergy NUMBER,  
    Team REF TeamTY)
```

---

---

```
CREATE OR REPLACE TYPE EmployeeTY AS OBJECT (  
    FC VARCHAR2(20) ,  
    Name VARCHAR2(50) ,  
    Surname VARCHAR2(50) ,  
    DoB DATE,  
    DoH DATE,  
    Manager CHAR(1) ,  
    Team REF TeamTY  
)
```

---

---

```
CREATE OR REPLACE TYPE CustomerTY AS OBJECT (  
    Code VARCHAR2(20) ,  
    Name VARCHAR2(50) ,  
    Surname VARCHAR2(50) ,  
    Email VARCHAR2(100) ,  
    Type VARCHAR2(20) ,  
    DoB DATE  
)
```

---

---

```
CREATE OR REPLACE TYPE AccountTY AS OBJECT (  
    Code VARCHAR2(20) ,  
    Customer REF CustomerTY
```

---

```

)
CREATE OR REPLACE TYPE ContractTY AS OBJECT (
    ID VARCHAR2(20) ,
    Active CHAR(1) ,
    Type VARCHAR2(20) ,
    Start_Date DATE,
    Cost NUMBER,
    EnergyPlan NUMBER,
    Duration NUMBER,
    Account REF AccountTY,
    Facility REF FacilityTY
)

```

---

```

CREATE OR REPLACE TYPE FeedbackTY AS OBJECT (
    Code VARCHAR2(20) ,
    Message VARCHAR2(200) ,
    Score INTEGER,
    Account REF AccountTY ,
    Team REF TeamTY
)

```

---

### 3.2 Tables Definition

---

```

CREATE TABLE Team OF TeamTY (
    Code PRIMARY KEY,
    CONSTRAINT chk_uptime CHECK (Uptime BETWEEN 6 AND 8)
    ,
    Name NOT NULL,
    Uptime NOT NULL
)

```

---

We can see that simple constraints are handled with **check**

---

```

CREATE TABLE Facility OF FacilityTY (
    Name PRIMARY KEY,
    CONSTRAINT chk_facility_type CHECK (Type IN ( 'wind'
    , 'solar' , 'hydro' , 'nuclear' )),
    CONSTRAINT chk_max_output_energy CHECK (
        MaxOutputEnergy >= 0) ,

```

```

CONSTRAINT chk_sum_output_energy CHECK (
    SumOutputEnergy >= 0),
Location NOT NULL,
Type NOT NULL,
MaxOutputEnergy NOT NULL,
EfficiencyScore NOT NULL,
Team REFERENCES Team ON DELETE SET NULL
)

```

---

```

CREATE TABLE Employee OF EmployeeTY (
    FC PRIMARY KEY,
    CONSTRAINT chk_manager CHECK (Manager IN ( 'Y' , 'N'
        ' ')),
    Name NOT NULL,
    Surname NOT NULL,
    DoB NOT NULL,
    DoH NOT NULL,
    Manager NOT NULL,
    CONSTRAINT chk_doh_after_dob CHECK (DoH > DoB),
    Team REFERENCES Team ON DELETE SET NULL
)

```

---

```

CREATE TABLE Customer OF CustomerTY (
    Code PRIMARY KEY,
    CONSTRAINT chk_customer_type CHECK (Type IN ( '
        Commercial' , 'Residential' )),
    Name NOT NULL,
    Surname NOT NULL,
    Email NOT NULL,
    Type NOT NULL,
    DoB NOT NULL
)

```

---

```

CREATE TABLE Account OF AccountTY (
    Code PRIMARY KEY,
    Customer NOT NULL REFERENCES Customer ON DELETE
        CASCADE
)

```

---

```

CREATE TABLE Contract OF ContractTY (
    ID PRIMARY KEY,

```

```

CONSTRAINT chk_contract_type CHECK (Type IN ( '
    Commercial' , 'Residential' )),
CONSTRAINT chk_energy_plan CHECK (EnergyPlan IN
    (2500, 4500, 10000)),
CONSTRAINT chk_cost CHECK (Cost IN (2500,4500,10000)
    ),
CONSTRAINT chk_active CHECK (Active IN ( 'Y' , 'N'
    )),
CONSTRAINT chk_cost CHECK (Cost >= 0),
CONSTRAINT chk_duration CHECK (Duration >= 1),
Start_Date NOT NULL,
Cost NOT NULL,
EnergyPlan NOT NULL,
Duration NOT NULL,
Active NOT NULL,
Account NOT NULL REFERENCES Account ON DELETE
    CASCADE,
Facility NOT NULL REFERENCES Facility ON DELETE
    CASCADE,
Type NOT NULL
)

```

---

```

CREATE TABLE Feedback OF FeedbackTY (
    Code PRIMARY KEY,
CONSTRAINT chk_feedback_score CHECK (Score BETWEEN 1
    AND 5),
Message NOT NULL,
Score NOT NULL,
Account REFERENCES Account ON DELETE SET NULL,
Team NOT NULL REFERENCES Team ON DELETE CASCADE
)

```

---

### 3.3 Population procedure

```

CREATE OR REPLACE PROCEDURE PopulateDatabase(
    p_num_customers IN NUMBER,
    p_num_accounts IN NUMBER,
    p_num_contracts IN NUMBER,
    p_num_feedbacks IN NUMBER
) IS

```

```
BEGIN
```

```
FOR i IN 1..50 LOOP
    INSERT INTO Team VALUES (
        TeamTY(
            'Team' || TO_CHAR(i),
            'TeamName' || TO_CHAR(i),
            ROUND(DBMS_RANDOM.VALUE(6, 8))
        )
    );
END LOOP;
```

```
FOR team_id IN 1..50 LOOP
    FOR i IN 1..5 LOOP
        DECLARE
            v_employee_code VARCHAR2(20);
            v_team_code      VARCHAR2(20) := 'Team'
                || TO_CHAR(team_id);
            v_dob             DATE;
            v_doh             DATE;
            v_manager         CHAR(1);
        BEGIN

            IF i = 1 THEN
                v_manager := 'Y';
            ELSE
                v_manager := 'N';
            END IF;

            v_employee_code := 'FC' || TO_CHAR((
                team_id - 1) * 5 + i);

            v_dob := ADD_MONTHS(SYSDATE, -ROUND(
                DBMS_RANDOM.VALUE(18*12, 60*12)));
        END LOOP;
    END LOOP;
```

```

v_doh := v_dob + ROUND(DBMS_RANDOM.VALUE
(18*365, 60*365));

INSERT INTO Employee VALUES (
    EmployeeTY(
        v_employee_code ,
        'Name' || v_employee_code ,
        'Surname' || v_employee_code ,
        v_dob ,
        v_doh ,
        v_manager ,
        (SELECT REF(t) FROM Team t WHERE
            t.Code = v_team_code)
    )
);
END;
END LOOP;
END LOOP;

FOR i IN 1..100 LOOP
    INSERT INTO Facility VALUES (
        FacilityTY(
            'Facility' || TO_CHAR(i) ,
            'Location' || TO_CHAR(i) ,
            CASE MOD(i, 4)
                WHEN 0 THEN 'wind'
                WHEN 1 THEN 'solar'
                WHEN 2 THEN 'hydro'
                WHEN 3 THEN 'nuclear'
            END,
            100,
            9000000000,
            0,
            (SELECT REF(t) FROM Team t WHERE t.Code
                = 'Team' || TO_CHAR(CEIL(i/2)))
        )
    );
END LOOP;

```

```

FOR i IN 1..p_num_customers LOOP
    DECLARE
        v_dob DATE;
    BEGIN

        v_dob := ADDMONTHS(SYSDATE, -ROUND(
            DBMS_RANDOM.VALUE(18*12, 60*12)));

        INSERT INTO Customer VALUES (
            CustomerTY(
                'Customer' || TO_CHAR(i),
                'Name' || TO_CHAR(i),
                'Surname' || TO_CHAR(i),
                'email' || TO_CHAR(i) || '@example.
                    com',
                CASE WHEN MOD(i, 2) = 0 THEN '
                    Commercial' ELSE 'Residential'
                END,
                v_dob
            )
        );
    END;
END LOOP;

FOR i IN 1..p_num_accounts LOOP
    INSERT INTO Account VALUES (
        AccountTY(
            'Account' || TO_CHAR(i),
            (SELECT REF(c) FROM Customer c WHERE c.
                Code = 'Customer' || TO_CHAR(ROUND(
                    DBMS_RANDOM.VALUE(1, p_num_customers)
                )))
        )
    );
END LOOP;

```

```

FOR i IN 1..p_num_contracts LOOP
  DECLARE
    v_account_code VARCHAR2(20);
    v_customer_type VARCHAR2(20);
    v_start_date DATE;
    v_duration NUMBER;
    v_end_date DATE;
    v_active CHAR(1);
    v_energy_plan NUMBER;
    v_cost NUMBER;
  BEGIN
    v_account_code := 'Account' || TO_CHAR(ROUND
      (DBMS_RANDOM.VALUE(1, p_num_accounts)));

    SELECT c.Type
    INTO v_customer_type
    FROM Account a
    JOIN Customer c ON Deref(a.Customer).Code =
      c.Code
    WHERE a.Code = v_account_code;
    v_start_date := SYSDATE;
    v_duration := ROUND(DBMS_RANDOM.VALUE(1, 12)
      );
    v_end_date := ADD_MONTHS(v_start_date,
      v_duration);
    IF v_end_date >= SYSDATE THEN
      v_active := 'Y';
    ELSE
      v_active := 'N';
    END IF;

    v_energy_plan := CASE MOD(i, 3)
      WHEN 0 THEN 2500
      WHEN 1 THEN 4500
      WHEN 2 THEN 10000
    END;
    IF v_energy_plan = 2500 THEN
      v_cost := 500;
    ELSIF v_energy_plan = 4500 THEN
      v_cost := 750;

```



```

ELSE
    v_cost := 1000;
END IF;

INSERT INTO Contract VALUES (
    ContractTY(
        'Contract' || TO_CHAR(i),
        v_active,
        v_customer_type,
        v_start_date,
        v_cost,
        v_energy_plan,
        v_duration,
        (SELECT REF(a) FROM Account a WHERE
            a.Code = v_account_code),
        (SELECT REF(f) FROM Facility f WHERE
            f.Name = 'Facility' || TO_CHAR(
                ROUND(DBMSRANDOM.VALUE(1, 100)))
            )
        )
    );
END;
END LOOP;

FOR i IN 1..p_num_feedbacks LOOP
    INSERT INTO Feedback VALUES (
        FeedbackTY(
            'Feedback' || TO_CHAR(i),
            'Message' || TO_CHAR(i),
            ROUND(DBMSRANDOM.VALUE(1, 5)),
            (SELECT REF(a) FROM Account a WHERE a.
                Code = 'Account' || TO_CHAR(ROUND(
                    DBMSRANDOM.VALUE(1, p_num_accounts))
                )),
            (SELECT REF(t) FROM Team t WHERE t.Code
                = 'Team' || TO_CHAR(ROUND(DBMSRANDOM
                    .VALUE(1, 50))))
            )
        );

```

```
END LOOP;  
END;
```

---

### 3.4 Trigger

---

```
CREATE OR REPLACE TRIGGER trg_employee_manager  
FOR INSERT OR UPDATE ON Employee  
COMPOUND TRIGGER  
    v_team REF TeamTY;  
    v_count NUMBER;  
    status CHAR(1);  
BEFORE EACH ROW IS  
BEGIN  
    v_team := :new.Team;  
    status := :new.Manager;  
END BEFORE EACH ROW;  
AFTER STATEMENT IS  
BEGIN  
    IF status = 'Y' THEN  
        SELECT COUNT(*) INTO v_count  
        FROM Employee  
        WHERE (DEREF(Team)).Code = (DEREF(v_team)).Code  
        AND Manager = 'Y';  
  
        IF v_count > 1 THEN  
            RAISE_APPLICATION_ERROR(-20001, 'Errore:  
                Esiste già un manager per il team');  
        ELSE  
            DBMS_OUTPUT.PUT_LINE('Operazione eseguita  
                con successo');  
        END IF;  
    END IF;  
END AFTER STATEMENT;  
END trg_employee_manager;
```

---

This trigger is used to check if there is already a manager in the team. If the new employee is a manager, the trigger checks if there is already a manager in the team. If there is, it raises an error, otherwise it allows the operation.

---

```
CREATE OR REPLACE TRIGGER trg_contract_type  
BEFORE INSERT OR UPDATE ON Contract
```

```

FOR EACH ROW
DECLARE
    v_customer_type VARCHAR2(20);
BEGIN
    SELECT Deref(a.Customer).Type
        INTO v_customer_type
        FROM Account a
        WHERE a.Code = (Deref(:NEW.Account)).Code;

    IF :NEW.Type = v_customer_type THEN
        DBMS_OUTPUT.PUT_LINE('Operation Completed');
    ELSE
        RAISE_APPLICATION_ERROR(-20003, 'Error: Contract
            type and customer type mismatch');
    END IF;
END;

```

---

This trigger is used to check if the type of the contract is the same as the type of the customer. If they are different, it raises an error, otherwise it allows the operation.

---

```

CREATE OR REPLACE TRIGGER trg_deactivate_old_contracts
FOR INSERT ON Contract
FOLLOWS trg_contract_type
COMPOUND TRIGGER
    v_account REF AccountTY;
    v_facility REF FacilityTY;
    v_contract_id VARCHAR2(20);
    v_status CHAR(1);
    BEFORE EACH ROW IS
    BEGIN
        v_account := :NEW.Account;
        v_facility := :NEW.Facility;
        v_contract_id := :NEW.ID;
        IF :NEW.Active = 'N' THEN
            — Check if contract's end date is in the
            past
            IF ADDMONTHS(:NEW.Start_Date, :NEW.Duration
                ) < SYSDATE THEN
                DBMS_OUTPUT.PUT_LINE('You are inserting
                    an expired contract');
            ELSE

```

```

        DBMS_OUTPUT.PUT_LINE('Error: Contract is
                               not active');
        :NEW.Active := 'Y';
    END IF;
END IF;
v_status := :NEW.Active;
END BEFORE EACH ROW;
AFTER STATEMENT IS
BEGIN
    IF v_status='Y' THEN
        FOR rec IN (
            SELECT ID
            FROM Contract
            WHERE Active = 'Y'
            AND Account = v_account
            AND Facility = v_facility
            AND ID <> v_contract_id
        ) LOOP
            UPDATE Contract
            SET Active = 'N'
            WHERE ID = rec.ID;

            DBMS_OUTPUT.PUT_LINE('Contract
                                   deactivated');
        END LOOP;

        DBMS_OUTPUT.PUT_LINE('Trigger
                               trg_deactivate_old_contracts executed');
    END IF;
END AFTER STATEMENT;

END trg_deactivate_old_contracts;
/

```

---

This trigger is used to deactivate old contracts when a new contract is inserted. It checks if the new contract is active and if the end date is in the past. If the end date is in the past, the new contract is inserted as inactive. Then, it deactivates all the other contracts of the same account and facility.

---

```

CREATE OR REPLACE TRIGGER trg_energy_plan
BEFORE INSERT OR DELETE OR UPDATE OF Active ON Contract
FOR EACH ROW

```

```

DECLARE
    v_facility_name Facility.Name%TYPE;
    v_current_sum NUMBER;
    v_max_output NUMBER;
BEGIN
    IF INSERTING OR UPDATING THEN
        SELECT f.Name INTO v_facility_name FROM Facility f
            WHERE REF(f) = :NEW.Facility;
    ELSE
        SELECT f.Name INTO v_facility_name FROM Facility f
            WHERE REF(f) = :OLD.Facility;
    END IF;
    SELECT SumOutputEnergy, MaxOutputEnergy
    INTO v_current_sum, v_max_output
    FROM Facility
    WHERE Name = v_facility_name
    FOR UPDATE;
    IF INSERTING THEN
        IF v_current_sum + :NEW.EnergyPlan > v_max_output
        THEN
            RAISE_APPLICATION_ERROR(-20001, 'SumOutputEnergy
            supera MaxOutputEnergy per la Facility ' ||
            v_facility_name);
        ELSE
            UPDATE Facility
            SET SumOutputEnergy = v_current_sum + :NEW.
            EnergyPlan
            WHERE Name = v_facility_name;
        END IF;
    ELSIF DELETING THEN
        UPDATE Facility
        SET SumOutputEnergy = v_current_sum - :OLD.
        EnergyPlan
        WHERE Name = v_facility_name;
    ELSIF UPDATING THEN
        IF :OLD.Active = 'Y' AND :NEW.Active = 'N' THEN
            UPDATE Facility
            SET SumOutputEnergy = v_current_sum - :OLD.
            EnergyPlan
            WHERE Name = v_facility_name;
        END IF;
    END IF;
END;

```

```

        END IF ;
    END IF ;
END trg_energy_plan ;

```

---

This trigger is used to update the sum of the output energy of the facility when a contract is inserted, deleted or updated. It checks if the sum of the output energy exceeds the maximum output energy of the facility. If it does, it raises an error, otherwise it allows the operation.

---

```

CREATE OR REPLACE TRIGGER trg_efficiency_score
BEFORE UPDATE ON Facility
FOR EACH ROW
BEGIN
    IF :NEW.SumOutputEnergy = 0 THEN
        :NEW.EfficiencyScore := 100;
    ELSE
        :NEW.EfficiencyScore := 100 * :NEW.SumOutputEnergy /
            :NEW.MaxOutputEnergy;
    END IF ;
END trg_efficiency_score ;

```

---

This trigger is used to update the efficiency score of the facility when the sum of the output energy is updated. It calculates the efficiency score as the ratio between the sum of the output energy and the maximum output energy.

---

```

CREATE OR REPLACE TRIGGER trg_customer_age
AFTER INSERT OR UPDATE ON Customer
FOR EACH ROW
BEGIN
    IF MONTHS.BETWEEN(SYSDATE, :NEW.DoB) < 18*12 THEN
        RAISE_APPLICATION_ERROR(-20001, 'Error: Customer is
            a minor');
    END IF ;
END;

```

---

```

CREATE OR REPLACE TRIGGER trg_employee_age
AFTER INSERT OR UPDATE ON Employee
FOR EACH ROW
BEGIN
    IF MONTHS.BETWEEN(SYSDATE, :NEW.DoB) < 18*12 THEN
        RAISE_APPLICATION_ERROR(-20002, 'Error: Employee is
            a minor');
    END IF ;

```

END;

---

These two triggers are used to check if the age of the customer or the employee is less than 18 years old. If it is, it raises an error, otherwise it allows the operation.

---

```
CREATE OR REPLACE TRIGGER trg_contract_cost
BEFORE INSERT OR UPDATE ON Contract
FOR EACH ROW
BEGIN
    IF UPDATING THEN
        IF (:NEW.EnergyPlan <> :OLD.EnergyPlan) OR (:NEW.
            Cost <> :OLD.Cost) THEN
            RAISE_APPLICATION_ERROR(-20003, 'Error: Energy
                plan and cost cannot be changed');
        END IF;
    END IF;

    IF INSERTING THEN
        IF :NEW.EnergyPlan = 2500 THEN
            :NEW.Cost := 500;
        ELSIF :NEW.EnergyPlan = 4500 THEN
            :NEW.Cost := 750;
        ELSE
            :NEW.Cost := 1000;
        END IF;
    END IF;
END;
```

---

This trigger is used to check if the energy plan and the cost of the contract are changed. If they are, it raises an error, otherwise it allows the operation. It also sets the cost of the contract based on the energy plan when a new contract is inserted.

## 3.5 Operations

---

---

— Procedure 1: Add a new customer to the database

---

```

CREATE OR REPLACE PROCEDURE proc_register_customer (
    p_code      IN VARCHAR2,
    p_name      IN VARCHAR2,
    p_surname   IN VARCHAR2,
    p_email     IN VARCHAR2,
    p_type      IN VARCHAR2,  — 'Commercial' o '
    Residential'
    p_dob       IN DATE
) AS
BEGIN
    INSERT INTO Customer
    VALUES (
        CustomerTY(p_code , p_name , p_surname , p_email ,
        p_type , p_dob)
    );
    COMMIT;
END;
/

```

---

— Procedure 2: Add a new contract to the database

---

```

CREATE OR REPLACE PROCEDURE proc_add_contract (
    p_contract_id  IN VARCHAR2,
    p_contract_type IN VARCHAR2,  — 'Commercial' o '
    Residential'
    p_start_date   IN DATE,
    p_energy_plan  IN NUMBER,      — 2500, 4500 o 10000
    p_duration     IN NUMBER,
    p_account_code IN VARCHAR2,
    p_facility_name IN VARCHAR2
) AS
    p_cost NUMBER;
BEGIN
    IF p_energy_plan = 2500 THEN
        p_cost := 500;
    
```



```

ELSIF p-energy_plan = 4500 THEN
    p-cost := 750;
ELSE
    p-cost := 1000;
END IF;
INSERT INTO Contract
VALUES (
    ContractTY(
        p-contract_id ,
        'N',
        p-contract_type ,
        p-start_date ,
        p-cost ,
        p-energy_plan ,
        p-duration ,
        (SELECT REF(a) FROM Account a WHERE a.Code =
            p-account_code) ,
        (SELECT REF(f) FROM Facility f WHERE f.Name
            = p-facility_name)
    )
);
COMMIT;
EXCEPTION
    WHEN OTHERS THEN
        RAISE_APPLICATION_ERROR(-20011, 'Errore in
            proc_add_contract: ' || SQLERRM);
END;

```

/

---



---

— Procedure 3: Assign a facility to a team

---

```

CREATE OR REPLACE PROCEDURE proc_assign_facility (
    p-facility_name IN VARCHAR2,
    p-team_code     IN VARCHAR2

```

```

) AS
    v_count_team NUMBER;
    v_count_facility NUMBER;
BEGIN
    — Check if the facility exists
    SELECT COUNT(*) INTO v_count_facility
    FROM Facility
    WHERE Name = p_facility_name;

    IF v_count_facility = 0 THEN
        RAISE_APPLICATION_ERROR(−20013, 'Error: Facility
            not found!');
    END IF;

    — Check if the team exists
    SELECT COUNT(*) INTO v_count_team
    FROM Team
    WHERE Code = p_team_code;

    IF v_count_team = 0 THEN
        RAISE_APPLICATION_ERROR(−20014, 'Error: Team not
            found!');
    END IF;
    UPDATE Facility
    SET Team = (SELECT REF(t) FROM Team t WHERE t.Code =
        p_team_code)
    WHERE Name = p_facility_name;

    COMMIT;
EXCEPTION
    WHEN OTHERS THEN
        RAISE_APPLICATION_ERROR(−20012, 'Errore in
            proc_assign_facility: ' || SQLERRM);
END;
/

```

---

— Function 4: Return the total energy output of a facility

---

```

CREATE OR REPLACE FUNCTION func_get_facility_energy (
    p_facility_name IN VARCHAR2
) RETURN NUMBER AS
    v_total_energy NUMBER;
BEGIN
    — Return the total energy output of the facility
    SELECT f.SumOutputEnergy
        INTO v_total_energy
        FROM Facility f
        WHERE f.Name = p_facility_name;
    RETURN v_total_energy;
EXCEPTION
    WHEN OTHERS THEN
        RAISE_APPLICATION_ERROR(-20013, 'Errore in
            func_get_facility_energy: ');
END;
/

```

---

— Procedure 5: Get the ranked facilities by efficiency score

---

```

CREATE OR REPLACE PROCEDURE proc_get_ranked_facilities (
    p_cursor OUT SYS_REFCURSOR
) AS
BEGIN
    OPEN p_cursor FOR
        SELECT Name, EfficiencyScore
        FROM Facility
        ORDER BY EfficiencyScore DESC;
END;
/

```

---

## 4 Physical Design

Here we will discuss the physical design of the system, so the creation of indexes

### 4.1 Indexes for operations

#### Operation1

OPERATION	OBJECT_NAME	OPTIONS	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
INSERT STATEMENT				1	1139
LOAD TABLE CONVENTIONAL	CUSTOMER			1	1139

Figure 4: Operation1

Since the operation is a simple insert, it doesn't require any indexes to be created. The data will be inserted into the table as it is.

#### Operation2

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
INSERT STATEMENT					1	565
LOAD TABLE CONVENTIONAL	CONTRACT					23625
TABLE ACCESS	FACILITY	BY INDEX ROWID	1	1	2	7
INDEX	SYS_C008574	UNIQUE SCAN	1	0	1	2
Access Predicates	F.NAME=FacilityTest7					
TABLE ACCESS	ACCOUNT	BY INDEX ROWID	1	2	3	16
INDEX	SYS_C008596	UNIQUE SCAN	1	1	2	11
Access Predicates	A.CODE=AccountTest					

Figure 5: Operation2

Since the operation is a simple insert, it doesn't require any indexes to be created. The data will be inserted into the table as it is.

#### Operation3

The operation is an update, so the creation of an index is not required. However, we check for the existence of the Facility and of the Team but they are primary keys, so they are already indexed.

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
SELECT STATEMENT					1	141
AGGREGATE			1	1	1	141
INDEX	SYS_C008574	UNIQUE SCAN	1	0	1	134
Access Predicates	NAME=Facility1					

Figure 6: Facility Name Index

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
SELECT STATEMENT					1	109
SORT				1		109
INDEX	SYS_C008565	UNIQUE SCAN		1	0	103
Access Predicates						
CODE='Team1'						

Figure 7: Team Code Index

## Operation4

The first part is the selection of the oldest employee who is a manager. We can create an index on the Date of Birth (DoB) attribute of the Employee table, so that they will be ordered by DoB and we can fetch the first row.

```
SELECT Deref(e.Team).Code AS team_code
FROM Employee e
WHERE e.Manager = 'Y'
ORDER BY e.DoB ASC
FETCH FIRST 1 ROWS ONLY;
```

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
SELECT STATEMENT					6	198
VIEW				1	6	198
Filter Predicates						
from\$_subquery\$_002.rowlimit\$_\$_.rownumber <= 1						
WINDOW		Sort Pushed Rank		50	6	189
Filter Predicates						
ROW_NUMBER() OVER (ORDER BY E.DOB) <= 1						
HASH JOIN		OUTER		50	5	161
Access Predicates						
P0000046.SYS_NC_010\$=E.SYS_NC00010\$						
TABLE ACCESS	EMPLOYEE	FULL		50	3	46
Filter Predicates						
E.MANAGER='Y'						
TABLE ACCESS	TEAM	FULL		52	2	19

Figure 8: Autotrace without Index

By using the autotrace we can see that here we are not using any index. Let's create the index

```
CREATE INDEX Employee_DoB_Index ON Employee (DoB) ;
```

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
SELECT STATEMENT					6	87
VIEW				1	6	87
Filter Predicates						
from\$_subquery\$_002.rowlimit\$_\$_.rownumber <= 1						
WINDOW		NOSORT STOPKEY		1	6	84
Filter Predicates						
ROW_NUMBER() OVER (ORDER BY E.DOB) <= 1						
NESTED LOOPS		OUTER		1	6	77
TABLE ACCESS	EMPLOYEE	BY INDEX ROWID		50	5	31
Filter Predicates						
E.MANAGER='Y'						
INDEX	EMPLOYEE_DOB_INDEX	FULL SCAN		6	1	14
TABLE ACCESS	TEAM	BY INDEX ROWID		1	1	42
INDEX	SYS_C008566	UNIQUE SCAN		1	0	4
Access Predicates						
P0000046.SYS_NC_010\$=E.SYS_NC00010\$						

Figure 9: Autotrace with Index

We can see that now we are using the Employee\_DoB\_Index index to fetch the first row (the Autotrace shows UNIQUE SCAN). The second part of the operation is a simple sselection. It uses Facility.Name with is already indexed.

# Operation5

Operation five is a selection sorted by FacilityEfficiency. However, even with an index on that attribute, the Autotrace shows that the index is not used.

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED_TIME
SELECT STATEMENT					3	296
SORT		ORDER BY	105	105	3	296
TABLE ACCESS	FACILITY	FULL	105	105	2	292

Figure 10: Autotrace

## 5 Web Interface

The web interface is a simple web application that allows users to interact with the system. It allows users to execute the 5 operations previously described.

### 5.1 Backend

It is implemented using the Flask web framework of Python.

---

```
# app.py
from flask import Flask, render_template, request, redirect,
    url_for, flash
import oracledb
import datetime

app = Flask(__name__)
app.secret_key = 'supersecretkey' # per flash messages

# Configurations parameters for the Oracle DB
DB_USER = 'System'
DB_PASSWORD = 'password123'
DB_SID = 'localhost:1521/xe'

def get_db_connection():
    try:
        connection = oracledb.connect(user=DB_USER, password
            =DB_PASSWORD, dsn=DB_SID)
        return connection
    except Exception as e:
        print("Errore nella connessione al DB:", e)
        return None

# Homepage
@app.route('/')
def index():
    return render_template('index.html')

# Operation 1: Register a new customer
@app.route('/register_customer', methods=['GET', 'POST'])
def register_customer():
    if request.method == 'POST':
```

```

code = request.form.get('code')
name = request.form.get('name')
surname = request.form.get('surname')
email = request.form.get('email')
cust_type = request.form.get('cust_type')
dob_str = request.form.get('dob')
try:
    dob = datetime.datetime.strptime(dob_str, '%Y-%m
    -%d').date()
except Exception as e:
    flash("Birth date non valida", "danger")
    return redirect(url_for('register_customer'))

conn = get_db_connection()
if conn is None:
    flash("Connection error", "danger")
    return redirect(url_for('register_customer'))
try:
    cur = conn.cursor()
    cur.callproc("proc_register_customer", [code,
        name, surname, email, cust_type, dob])
    conn.commit()
    flash("Customer added successfully", "success")
except oracledb.DatabaseError as e:
    flash(f"Error during customer registration: {e}"
        , "danger")
finally:
    cur.close()
    conn.close()
    return redirect(url_for('index'))
return render_template('register_customer.html')

```

# Operation 2: Add a new energy contract

```
@app.route('/add_contract', methods=['GET', 'POST'])
```

```
def add_contract():
```

```
    if request.method == 'POST':
```

```
        contract_id = request.form.get('contract_id')
```

```
        contract_type = request.form.get('contract_type')
```

```
        start_date_str = request.form.get('start_date')
```

```
        energy_plan = float(request.form.get('energy_plan'))
```



```

duration = float(request.form.get('duration'))
account_code = request.form.get('account_code')
facility_name = request.form.get('facility_name')
try:
    start_date = datetime.datetime.strptime(
        start_date_str, '%Y-%m-%d').date()
except Exception as e:
    flash("Not a valid date", "danger")
    return redirect(url_for('add_contract'))

conn = get_db_connection()
if conn is None:
    flash("Error during connection to the database",
        "danger")
    return redirect(url_for('add_contract'))
try:
    cur = conn.cursor()

    cur.callproc("proc_add_contract", [contract_id,
        contract_type,
                                start_date,
                                energy_plan,
                                duration,
                                account_code,
                                facility_name
                                ])

    conn.commit()
    flash("Contract added successfully", "success")
except Exception as e:
    flash(f"Error during contract addition: {e}", "
        danger")
finally:
    cur.close()
    conn.close()
    return redirect(url_for('index'))
return render_template('add_contract.html')

```

```

# Operation 3: Assign a facility to a management team
@app.route('/assign_facility', methods=['GET', 'POST'])
def assign_facility():
    if request.method == 'POST':
        facility_name = request.form.get('facility_name')
        team_code = request.form.get('team_code')
        conn = get_db_connection()
        if conn is None:
            flash("Error during connection to the database",
                  "danger")
            return redirect(url_for('assign_facility'))
        try:
            cur = conn.cursor()
            cur.callproc("proc_assign_facility", [
                facility_name, team_code])
            conn.commit()
            flash("Facility assigned successfully", "success")
        except Exception as e:
            flash(f"Error during facility assignment: {e}",
                  "danger")
        finally:
            cur.close()
            conn.close()
        return redirect(url_for('index'))
    return render_template('assign_facility.html')

# Operation 4: View the total energy output of a facility
# managed by the eldest employee
@app.route('/view_facility_energy', methods=['GET', 'POST'])
def view_facility_energy():
    facilities = []
    energy_output = None

    # 1. Query to retrieve the oldest manager's team code
    conn = get_db_connection()
    if conn is None:
        flash("Error during connection to the database", "
            danger")

```

```

        return redirect(url_for('index'))
try:
    cur = conn.cursor()
    query_oldest_manager = """
        SELECT Deref(e.Team).Code AS team_code
        FROM Employee e
        WHERE e.Manager = 'Y'
        ORDER BY e.DoB ASC
        FETCH FIRST 1 ROWS ONLY
    """
    cur.execute(query_oldest_manager)
    result = cur.fetchone()
    if result is None:
        flash("No manager found", "danger")
    else:
        team_code = result[0]
        # 2. Query to retrieve the facilities managed by
        # the oldest manager
        query_facilities = """
            SELECT f.Name
            FROM Facility f
            WHERE Deref(f.Team).Code = :team_code
        """
        cur.execute(query_facilities, {'team_code':
            team_code})
        facilities = [row[0] for row in cur.fetchall()]
except Exception as e:
    flash(f"Error during data retrieval: {e}", "danger")
finally:
    cur.close()
    conn.close()

# 3. Retrieve the total energy output of the selected
# facility
if request.method == 'POST':
    selected_facility = request.form.get('facility')
    conn = get_db_connection()
    if conn is None:
        flash("Error during connection to the database",
            "danger")

```

```

        return redirect(url_for('view_facility_energy'))
    try:
        cur = conn.cursor()
        # Chiamata alla funzione SQL per ottenere il
        # totale dell'energia in output
        energy_output = cur.callfunc("
            func_get_facility_energy", oracledb.NUMBER, [
                selected_facility])
        flash(f"Total Energy Output for {
            selected_facility}: {energy_output}", "
            success")
    except Exception as e:
        flash(f"Error during data retrieval: {e}", "
            danger")
    finally:
        cur.close()
        conn.close()

    return render_template("view_facility_energy.html",
        facilities=facilities, energy_output=energy_output)

# Operation 5: Print a ranked list of facilities based on
# their efficiency scores
@app.route('/ranked_facilities')
def ranked_facilities():
    facilities = []
    conn = get_db_connection()
    if conn is None:
        flash("Errore di connessione al database", "danger")
        return redirect(url_for('index'))
    try:
        cur = conn.cursor()
        out_cursor = cur.var(oracledb.CURSOR)
        cur.callproc("proc_get_ranked_facilities", [
            out_cursor])
        result_cursor = out_cursor.getvalue()
        facilities = result_cursor.fetchall()
    except Exception as e:
        flash(f"Errore durante il recupero dei dati: {e}", "
            danger")

```

```

finally:
    cur.close()
    conn.close()
return render_template('ranked_facilities.html',
    facilities=facilities)

if __name__ == '__main__':
    app.run(debug=True)

```

---

## 5.2 Frontend

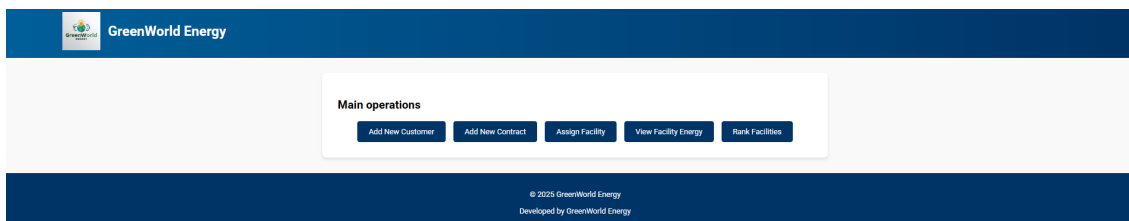


Figure 11: Homepage

Figure 12: Register a new customer

**GreenWorld Energy**

### Add New Contract

Contract ID:

Contract Type:

Start Date:

Energy Plan:

Duration (months):

Account Code:

Facility Name:

**Add Contract**

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Figure 13: Add a new energy contract

**GreenWorld Energy**

### Assign Facility to Team

Facility Name:

Team Code:

**Assign**

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Developed by GreenWorld Energy

Figure 14: Assign a facility to a management team

**GreenWorld Energy**

Total Energy Output for Facility59: 1795500.0

### Visualization of Facility Energy

Facility:

**Visualize**

Energy Output  
1795500.0

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Developed by GreenWorld Energy

Figure 15: View the total energy output of a facility managed by the eldest employee

GreenWorld Energy	
Ranks of Facilities	
Facility Name	Efficiency Score
FacilityWeb	100
FacilityTest3	100
FacilityTest	100
FacilityWeb2	100
Facility23	0.22455555555555556
Facility22	0.22205555555555556
Facility97	0.22111111111111112
Facility19	0.21677777777777778
Facility92	0.21383333333333332
Facility77	0.21277777777777778
Facility48	0.21027777777777779
Facility99	0.2085
Facility65	0.20844444444444443
Facility62	0.20633333333333334
Facility80	0.20405555555555555
Facility68	0.20366666666666666
Facility90	0.20327777777777778
Facility21	0.202
Facility18	0.2005

Figure 16: Print a ranked list of facilities based on their efficiency scores