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Project Assignment

Database Systems

Database Design and Implementation

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Indice

1	Conceptual Design	2
1.1	Requirements	2
1.2	Analysis	4
1.2.1	Glossary of Terms	4
1.2.2	Level of Abstraction	5
1.2.3	Reorganization of Concepts	5
1.2.4	Entity-Relationship Diagram	7
1.2.5	Business Rules	8
2	Logical Design	10
2.1	Volume Table	10
2.2	Access Table	10
2.2.1	Redundancies and Generalization	14
2.3	UML Schema	15
3	Implementation	16
3.1	Types Definition	16
3.2	Tables Definition	17
3.3	Population procedure	19
3.4	Trigger	24
3.5	Operations	29
4	Physical Design	34
4.1	Indexes for operations	34
5	Web Interface	36
5.1	Backend	36
5.2	Frontend	42

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	
Contract	Energy supply contract. It describes the energy plan. It can be residential or commercial	Account, Facility	Projects
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

Customer
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

Account
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

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

Table 7: Feedback’s Concepts

Team
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

Employee
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

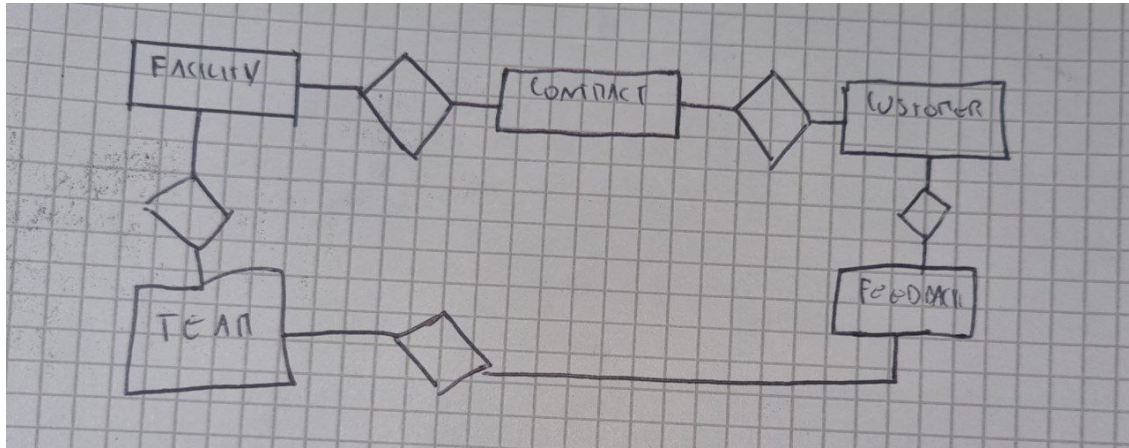


Figure 1: Skeleton Schema

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

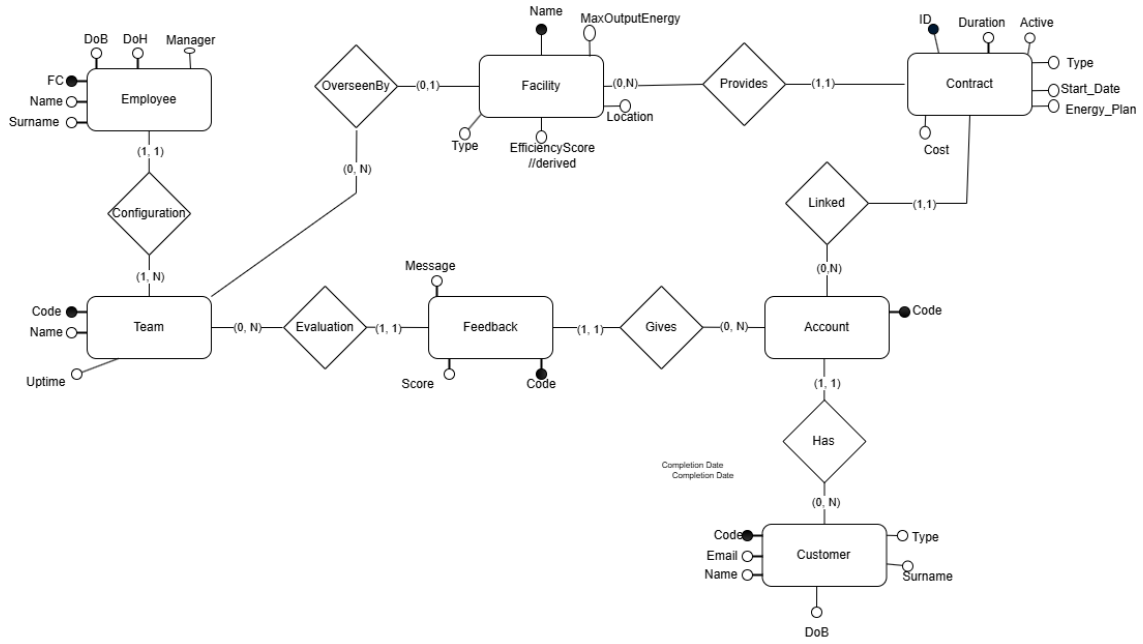


Figure 2: Final Schema

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

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. (Given)
Employee	E	250	Number of employees. 5 employees per team * 100 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 constists 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 contracts handled by a team is not stored in the schema, as it can be calculated by counting the number of contracts related to the facility 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 theme. 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

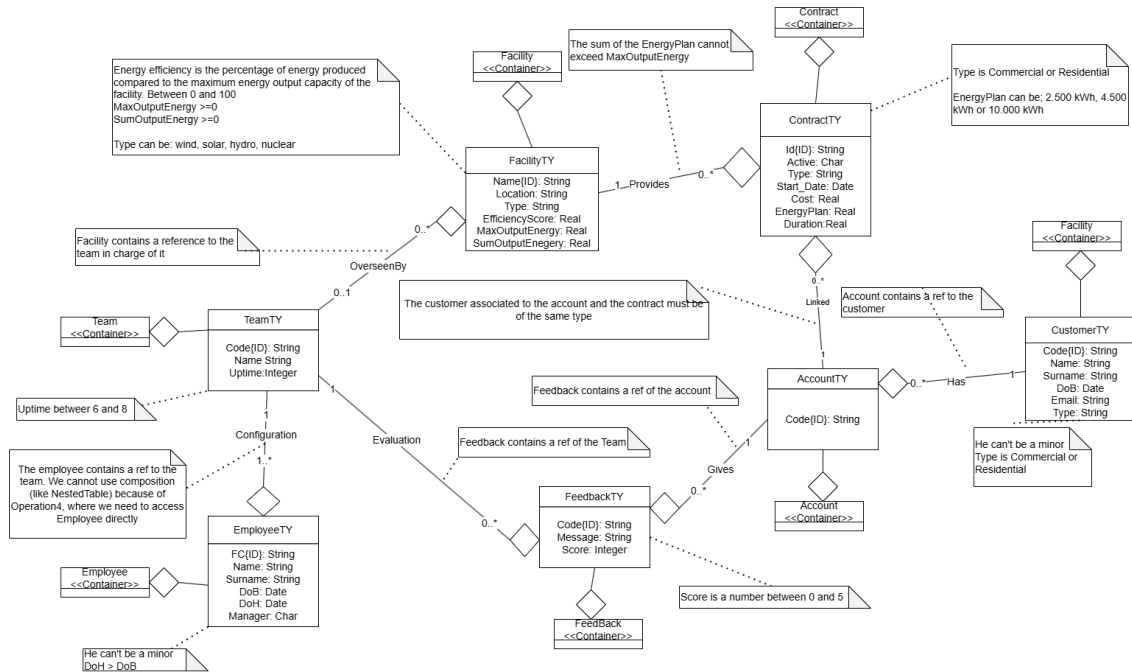


Figure 3: UML Schema

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_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(DBMSRANDOM.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(
                DBMSRANDOM.VALUE(18*12, 60*12)));

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

```

```

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);
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 := ADDMONTHS(v_start_date ,
v_duration);
IF v_end_date >= SYSDATE THEN
v_active := 'Y';
ELSE
v_active := 'N';
END IF;
INSERT INTO Contract VALUES (
ContractTY(
'Contract' || TO_CHAR(i) ,
v_active ,
v_customer_type ,
v_start_date ,
DBMS_RANDOM.VALUE(100, 1000) ,
CASE MOD(i, 3)
WHEN 0 THEN 2500
WHEN 1 THEN 4500
WHEN 2 THEN 10000
END,
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 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;

```

```

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.

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_cost             IN NUMBER,
    p_energy_plan      IN NUMBER,    — 2500, 4500 o 10000
    p_duration         IN NUMBER,
    p_account_code     IN VARCHAR2,
    p_facility_name    IN VARCHAR2
) AS
BEGIN
    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, 'Error: 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

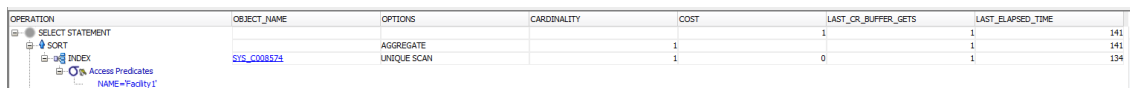
Since the operation is a simple insert, it doesn't require any indexes to be created. The data will be inserted into the table as it is.

Operation2

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.



The image shows an Oracle SQL Developer execution plan for a query. The plan is displayed in a tree view on the left and a table on the right. The tree view shows a SELECT STATEMENT, followed by a SORT, then an INDEX, and finally an Access Predicates node with the predicate NAME='Facility1'. The table on the right has columns: OPERATION, OBJECT_NAME, OPTIONS, CARDINALITY, COST, LAST_CR_BUFFER_GETS, and LAST_ELAPSED_TIME. The rows are: SELECT STATEMENT (1, 1, 1, 141), SORT (1, 1, 1, 141), INDEX (SYS_C008574, AGGREGATE, 1, 1, 141), and Access Predicates (SYS_C008574, UNIQUE SCAN, 1, 0, 1, 134).

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

Figure 4: Facility Name Index



The image shows an Oracle SQL Developer execution plan for a query. The plan is displayed in a tree view on the left and a table on the right. The tree view shows a SELECT STATEMENT, followed by a SORT, then an INDEX, and finally an Access Predicates node with the predicate CODE='Team1'. The table on the right has columns: OPERATION, OBJECT_NAME, OPTIONS, CARDINALITY, COST, LAST_CR_BUFFER_GETS, and LAST_ELAPSED_TIME. The rows are: SELECT STATEMENT (1, 1, 1, 109), SORT (1, 1, 1, 109), INDEX (SYS_C008565, AGGREGATE, 1, 1, 109), and Access Predicates (SYS_C008565, UNIQUE SCAN, 1, 0, 1, 103).

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

Figure 5: 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	6
VIEW				1	6	6
Filter Predicates						
from\$_subquery\$_002.rownum\$<=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						
P000004\$.SYS_NC_OID\$=E.SYS_NC00010\$						
TABLE ACCESS	EMPLOYEE	FULL		50	3	46
Filter Predicates						
E.MANAGER='Y'						
TABLE ACCESS	TEAM	FULL		52	2	19

Figure 6: 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	6
VIEW				1	6	87
Filter Predicates						
from\$_subquery\$_002.rownum\$<=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_C008366	UNIQUE SCAN		1	0	4
Access Predicates						
P000004\$.SYS_NC_OID\$=E.SYS_NC00010\$						

Figure 7: 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	3
ORDER BY			105		3	256
TABLE ACCESS	FACILITY	FULL		105	2	262

Figure 8: 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')
        cost = float(request.form.get('cost'))

```

```

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,
                                                    cost,
                                                    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

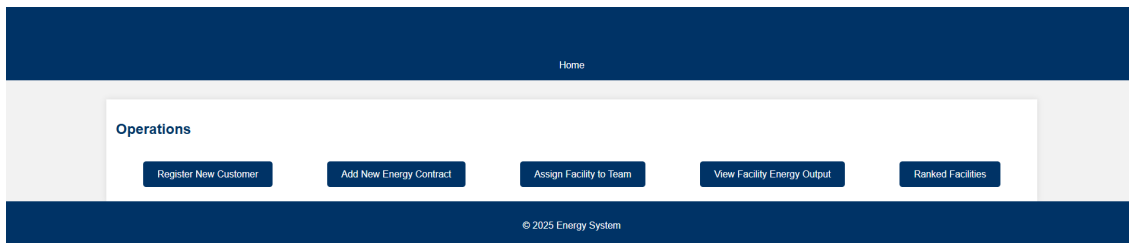


Figure 9: Homepage

The screenshot shows the 'Register New Customer' form. It has a dark blue header with 'Home' and a light gray sidebar with 'Register New Customer' as the title. The form contains the following fields: 'Customer Code' (text input), 'Name' (text input), 'Surname' (text input), 'Email' (text input), 'Type' (dropdown menu with 'Commercial' selected), and 'Date of Birth' (text input with a date picker icon). A dark blue 'Register' button is at the bottom of the form. The footer is dark blue with '© 2025 Energy System'.

Figure 10: Register a new customer

The screenshot shows a web application interface with a dark blue header bar containing a 'Home' link. The main content area is white and features a form titled 'Add New Energy Contract'. The form includes the following fields: 'Contract ID:' (text input), 'Contract Type:' (dropdown menu with 'Commercial' selected), 'Start Date:' (date picker showing 'gg/mm/aaaa'), 'Cost:' (text input), 'Energy Plan:' (dropdown menu with '2500' selected), 'Duration (in months):' (text input), 'Account Code:' (text input), and 'Facility Name:' (text input). A dark blue 'Add Contract' button is located at the bottom of the form.

Figure 11: Add a new energy contract

The screenshot shows a web application interface with a dark blue header bar containing a 'Home' link. The main content area is white and features a form titled 'Assign Facility to Management Team'. The form includes the following fields: 'Facility Name:' (text input) and 'Team Code:' (text input). A dark blue 'Assign' button is located at the bottom of the form. The footer of the page is dark blue and contains the text '© 2025 Energy System'.

Figure 12: Assign a facility to a management team

The screenshot shows a web application interface with a dark blue header bar containing a 'Home' link. A green banner at the top of the main content area displays the text 'Total Energy Output for Facility59: 1795500.0'. Below this is a form titled 'View Facility Energy Output'. The form includes a 'Select Facility:' dropdown menu with 'Facility59' selected and a dark blue 'Calculate Energy Output' button. Below the button, the text 'Facility Energy Output' is displayed, followed by 'Total Energy Output: 1795500.0'. The footer of the page is dark blue and contains the text '© 2025 Energy System'.

Figure 13: View the total energy output of a facility managed by the eldest employee

Facility Name	Efficiency Score
FacilityWeb	100
FacilityTest3	100
FacilityTest	100
FacilityWeb2	100
Facility23	0.22465656565656565656
Facility32	0.22295656565656565656
Facility97	0.221111111111111112
Facility19	0.2167777777777778
Facility62	0.21383333333333332
Facility77	0.2127777777777778
Facility48	0.2102777777777778
Facility99	0.2085
Facility65	0.20844444444444443
Facility62	0.20633333333333334
Facility80	0.204956565656565655
Facility68	0.203666666666666666
Facility30	0.2032777777777778
Facility21	0.202
Facility18	0.2005

Figure 14: Print a ranked list of facilities based on their efficiency scores