CE 49X: Introduction to Computational Thinking and Data Science

Laboratory Assignment 1

Building Energy Calculator

Fall 2025

Dr. Eyuphan Koc
Department of Civil Engineering, Bogazici University

Overview

Energy efficiency is a critical concern in modern civil engineering. Buildings consume approximately 40% of global energy, and as civil engineers, understanding how to analyze and optimize building energy consumption is essential for sustainable design. In this lab, you will develop a Python-based energy calculator that analyzes building energy consumption, classifies buildings by efficiency, and provides cost analysis.

Learning Objectives

By completing this lab, you will be able to:

- Apply Python variables, data types, and operators to solve engineering problems
- Use lists and dictionaries to organize and process building energy data
- Implement control flow (if/elif/else, for loops) for data analysis
- Write functions to perform energy calculations and unit conversions
- Format output using f-strings for clear presentation of results
- Handle basic errors in your code using try/except blocks

Submission Requirements

Instructions

- **Due Date:** October 9, Thursday, before class (15:00)
- **Submission Method:** Via Moodle only
- **What to Submit:**
  - Completed Jupyter notebook: `lab01_energy_calculator.ipynb`
  - All code cells must be executed showing outputs
  - Include comments explaining your logic
- **Grading:** Total 100 points
  - Exercise 1: 20 points
  - Exercise 2: 25 points
  - Exercise 3: 25 points
  - Exercise 4: 20 points
  - Exercise 5: 10 points
- **Presentation:** 3 students will be randomly selected to present their solutions

1 Background: Energy Units and Building Efficiency

1.1 Energy Units

- **kWh (Kilowatt-hour):** Standard unit for electrical energy consumption. 1 kWh = energy consumed by a 1 kW device running for 1 hour.
- **MJ (Megajoule):** SI unit for energy. 1 kWh = 3.6 MJ.
- **Conversion:** Energy (MJ) = Energy (kWh) $\times$ 3.6

1.2 Energy Efficiency Ratings

Buildings are classified by their annual energy consumption per square meter:

Rating	Energy Use (kWh/m²/year)	Classification
A	< 50	Excellent
B	50–100	Good
C	100–150	Average
D	150–200	Poor
F	> 200	Very Poor

1.3 Typical Energy Costs

- Standard rate: 0.12 USD/kWh
- Peak hours (08:00–20:00): 0.15 USD/kWh

- Off-peak hours (20:00–08:00): 0.08 USD/kWh

2 Exercise 1: Energy Consumption Basics (20 points)

In this exercise, you'll work with basic energy calculations for a single building.

2.1 Part A: Daily Energy Calculation (8 points)

A commercial building has the following daily energy consumption:

- Lighting: 450 kWh
- HVAC (Heating, Ventilation, Air Conditioning): 1200 kWh
- Equipment: 350 kWh
- Other: 180 kWh

Tasks:

1. Create variables for each energy component
2. Calculate the total daily energy consumption
3. Calculate the monthly energy consumption (assume 30 days)
4. Print results using f-strings with appropriate formatting

```
# Example output format:
# Daily Energy Consumption:
#   Lighting: 450.00 kWh
#   HVAC: 1200.00 kWh
#   Equipment: 350.00 kWh
#   Other: 180.00 kWh
#   Total: 2180.00 kWh
#
# Monthly Consumption: 65400.00 kWh
```

2.2 Part B: Unit Conversion (6 points)

Convert the monthly energy consumption from kWh to MJ and GJ (Gigajoules).

Given:

- 1 kWh = 3.6 MJ
- 1 GJ = 1000 MJ

Tasks:

1. Convert monthly consumption to MJ
2. Convert monthly consumption to GJ
3. Print results with 2 decimal places

2.3 Part C: Cost Calculation (6 points)

Calculate the monthly energy cost using the standard rate of 0.12 USD/kWh.

Tasks:

1. Calculate monthly cost
2. Calculate annual cost (12 months)
3. Print results formatted as currency (e.g., $7,848.00)

Hint

Use the comma formatting option in f-strings: `f"$cost:,.2f"`

3 Exercise 2: Building Energy Analysis (25 points)

Now you'll analyze energy data for multiple buildings using lists and loops.

3.1 Given Data

```
# Building names
buildings = ['Office A', 'Retail B', 'School C', 'Hospital D',
    'Apartment E']

# Monthly energy consumption (kWh)
monthly_consumption = [85000, 62000, 48000, 125000, 71000]

# Building floor area (m^2)
floor_area = [2500, 1800, 3200, 4000, 2800]
```

3.2 Part A: Energy Intensity Calculation (10 points)

Energy intensity is defined as energy consumption per unit area: **Energy Intensity** = **Monthly Consumption** / **Floor Area** (kWh/m^2/month)

Tasks:

1. Use a for loop with `enumerate()` to iterate through buildings
2. Calculate energy intensity for each building
3. Store results in a new list called `energy_intensity`
4. Print each building's name, consumption, area, and intensity

```
# Example output:
# Office A: 85000 kWh / 2500 m^2 = 34.00 kWh/m^2/month
# Retail B: 62000 kWh / 1800 m^2 = 34.44 kWh/m^2/month
# ...
```

3.3 Part B: Statistical Analysis (8 points)

Tasks:

1. Calculate total monthly consumption across all buildings
2. Calculate average monthly consumption
3. Find the maximum and minimum consumption
4. Print a summary report

Hint

Use built-in functions: `sum()`, `len()`, `max()`, `min()`

3.4 Part C: Find Buildings Above Average (7 points)

Tasks:

1. Create a new list containing names of buildings with above-average consumption
2. Use a for loop with conditional statements
3. Print the list of buildings above average
4. Count how many buildings are above average

4 Exercise 3: Energy Efficiency Classifier (25 points)

Classify buildings based on their annual energy consumption per square meter.

4.1 Part A: Annual Energy Calculation (8 points)

Tasks:

1. Convert monthly energy intensity to annual (multiply by 12)
2. Create a list `annual_intensity` containing annual values
3. Print each building with its annual energy intensity

4.2 Part B: Efficiency Classification (12 points)

Using the efficiency ratings from the background section, classify each building.

Tasks:

1. Write a for loop to classify each building
2. Use if/elif/else statements to assign ratings (A, B, C, D, F)
3. Store ratings in a list
4. Print a formatted report showing building name, annual intensity, and rating

```
# Example output:
# === Energy Efficiency Report ===
# Office A: 408.00 kWh/m^2/year - Rating: F
# Retail B: 413.33 kWh/m^2/year - Rating: F
# School C: 180.00 kWh/m^2/year - Rating: D
# ...
```

4.3 Part C: Rating Summary (5 points)

Tasks:

1. Count how many buildings have each rating (A, B, C, D, F)
2. Print a summary showing the count for each rating category
3. Identify which rating is most common

Hint

You can use the `count()` method on lists: `ratings.count('A')`

5 Exercise 4: Energy Cost Calculator (20 points)

Write functions to calculate energy costs under different pricing scenarios.

5.1 Part A: Simple Cost Function (8 points)

Write a function that calculates monthly energy cost.

```
def calculate_monthly_cost(consumption_kwh, rate_per_kwh):
    """
    Calculate monthly energy cost.

    Parameters:
        consumption_kwh (float): Monthly energy consumption in kWh
        rate_per_kwh (float): Energy rate in USD/kWh

    Returns:
        float: Monthly cost in USD
    """
    # YOUR CODE HERE
    pass
```

Tasks:

1. Implement the function
2. Test with: consumption = 50000 kWh, rate = 0.12 USD/kWh
3. Print the result

5.2 Part B: Peak/Off-Peak Cost Function (12 points)

Write a function that calculates cost considering peak and off-peak hours.

```
def calculate_tiered_cost(total_consumption, peak_percentage=0.6):
    """
    Calculate cost with peak/off-peak pricing.

    Parameters:
        total_consumption (float): Total monthly consumption in kWh
        peak_percentage (float): Fraction of consumption during peak
           hours

    Returns:
        tuple: (peak_cost, off_peak_cost, total_cost)
    """
    peak_rate = 0.15  # USD/kWh
    off_peak_rate = 0.08  # USD/kWh

    # YOUR CODE HERE
    pass
```

Tasks:

1. Implement the function
2. Calculate peak consumption = `total_consumption * peak_percentage`
3. Calculate off-peak consumption = `total_consumption * (1 - peak_percentage)`

4. Return all three cost values
5. Test the function with consumption = 85000 kWh, peak percentage = 60%
6. Print results showing peak cost, off-peak cost, and total cost

6 Exercise 5: Challenge - Energy Optimization (10 points)

Apply your knowledge to identify optimization opportunities.

6.1 Part A: Find Most and Least Efficient Buildings (5 points)

Tasks:

1. Find the building with the lowest annual energy intensity (most efficient)
2. Find the building with the highest annual energy intensity (least efficient)
3. Print both buildings with their intensities and ratings
4. Calculate the percentage difference between them

Hint

Use `min()` and `max()` with the energy intensity list, then use `index()` to find which building it corresponds to.

6.2 Part B: Energy Savings Potential (5 points)

Calculate the potential energy and cost savings if all buildings could achieve rating B (100 kWh/m²/year).

Tasks:

1. For each building with rating worse than B (C, D, or F):
   - Calculate current annual consumption: `annual_intensity * floor_area`
   - Calculate target consumption: `100 * floor_area`
   - Calculate potential savings in kWh
2. Sum total potential savings across all buildings
3. Calculate annual cost savings using standard rate (0.12 USD/kWh)
4. Print a summary report

```
# Example output:
# === Energy Savings Potential ===
# If all buildings achieved Rating B (100 kWh/m^2/year):
# Office A: Could save 770000 kWh/year
# Retail B: Could save 672000 kWh/year
# ...
# Total Potential Savings: 2500000 kWh/year
# Annual Cost Savings: $300,000.00
```

7 Bonus Challenge (Optional, +5 points)

7.1 Interactive Energy Calculator

Create an interactive program that asks the user to input building data and provides analysis.

Requirements:

1. Use `input()` to get building name, monthly consumption, and floor area
2. Use `try/except` to handle invalid inputs (non-numeric values)
3. Calculate energy intensity and efficiency rating
4. Calculate monthly cost using the tiered pricing function
5. Print a formatted report
6. Allow the user to analyze multiple buildings (use a while loop)

```
# Example interaction:
# Enter building name (or 'quit' to exit): Tech Center
# Enter monthly consumption (kWh): 95000
# Enter floor area (m^2): 3000
#
# === Analysis for Tech Center ===
# Monthly Consumption: 95000 kWh
# Floor Area: 3000 m^2
# Energy Intensity: 380.00 kWh/m^2/year
# Efficiency Rating: F
# Monthly Cost (tiered): $10,260.00
```

General Tips

Important

- **Test incrementally:** Don't write all code at once. Test each part as you go.
- **Use meaningful variable names:** Use `monthly_consumption` instead of `x`
- **Comment your code:** Explain what each section does
- **Check units:** Make sure your calculations use consistent units
- **Format output clearly:** Use f-strings with appropriate decimal places
- **Start early:** Don't wait until the last day!

Resources

- Week 1 Lecture Notes: Python Fundamentals
- Week 2 Lecture Notes: Control Flow and Functions
- Python Documentation: `https://docs.python.org/3/`

- Teaching Assistant: Eren Özçetin - mustafa.ozcetin@std.bogazici.edu.tr

---