Objective

This exercise aims to test your understanding of linear algebra concepts using the NumPy library. You will analyze and optimize the distribution of renewable energy in a simplified grid system. This exercise will involve matrix operations, solving systems of linear equations, and practical application of these concepts. Each of the tasks will be marked based on unit/assertion testing.

Problem Statement

You are tasked with analyzing a renewable energy grid that distributes electricity from three renewable energy sources (solar, wind, and hydro) to three different regions (A, B, and C). You need to determine the optimal distribution of energy and analyze the system's efficiency.

Tasks

1. Energy Distribution Matrix

Given the energy production from three sources in the form of a vector:

$$\mathbf{P} = \begin{bmatrix} 50 \\ 40 \\ 60 \end{bmatrix} \quad \text{(in MW)}$$

where 50 MW is from solar, 40 MW from wind, and 60 MW from hydro. The distribution matrix D shows the proportion of energy each source supplies to each region:

$$D = \begin{bmatrix} 0.6 & 0.2 & 0.2 \\ 0.3 & 0.5 & 0.2 \\ 0.1 & 0.3 & 0.6 \end{bmatrix}$$

Compute the energy distribution vector $\mathbf{E}$ for each region.

2. Solving System of Linear Equations

Suppose there is a sudden change in demand, and you need to adjust the production levels. The new energy requirements for the regions are given by:

$$\mathbf{R} = \begin{bmatrix} 70 \\ 60 \\ 80 \end{bmatrix} \quad \text{(in MW)}$$

Solve for the new production levels $\mathbf{P_{new}}$ required from each source to meet this demand, assuming the distribution matrix remains the same.

3. Efficiency Analysis

Given the efficiency matrix E which shows the efficiency of energy transfer from each source to each region:

$$E = \begin{bmatrix} 0.9 & 0.85 & 0.8 \\ 0.95 & 0.9 & 0.85 \\ 0.9 & 0.95 & 0.9 \end{bmatrix}$$

Compute the effective energy received by each region considering the efficiency losses. Determine which source-region pairs are the most and least efficient.

Additional Resources

- NumPy Documentation

- Linear Algebra in NumPy