**Problem Statement**

Energy portfolios are dependent on fossil-fuel based energy generation. Petroleum, natural gas, and coal are the primary resources. Continued reliance on these resources will further perpetuate the consequences associated with climate change such as erratic weather patterns, decreasing agricultural yields, and rising sea levels to name but a few. It is imperative that energy decision makers begin the transition toward more renewable alternatives. Unfortunately, there is no “one size fits all” solution. This complexity is further exacerbated when any two state energy portfolios are compared. For example: California’s energy fulfillment strategy is markedly different than Missouri’s. These differences make clear the need for tailored solutions. This exercise will guide you through the steps involved in capturing the supply systems at work for a proposed transition of Missouri’s residential energy sector using publicly available data.

**Tasks**

Capturing Demand

Using the data provided, create a series of forecasts described in parts a and b. Note: forecasting method is your choice, but selection of method and smoothing constants must be justified.

a. Create a 10-year forecast for each household population’s share of total population

b. Create a 10-year forecast for Missouri’s total population

*Data provided:*

* Spreadsheet titled “MO Population”
* Spreadsheet titled “Mod. Historic Household Table”

Combine results from Task 2 to determine the number of individuals living in one-person, two-person, etc. households for Missouri over the next 10 years.

Using the data provided, determine the total electricity demand (in kWh) for the residential sector. Note that electricity is dimension of analysis, not energy.

*Data provided:*

* Spreadsheet titled “Energy Consumption”

Fulfilling Demand (**pick either of the below options**)

5 (option 1). Energy decision makers want to transition 10% of the electricity demand determined in Task 4 over the next ten years. Conduct a limited amount of market research to identify a potential energy source (or sources) to replace the 10% of demand. Determine the cost (measured in $) and benefit (measured in reduction of CO2 emissions) of the proposed transition. Some candidates: wind, biomass, geothermal, etc.

5 (option 2). Energy decision makers want to transition 10% of the electricity demand currently being fulfilled by coal to solar for the residential sector. Using the electricity demand determined in Task 4 and data provided, determine the cost (measured in $) and benefit (measured in reduction of CO2 emissions) of the proposed transition.

*Data provided:*

* Spreadsheet titled “Energy Characteristics”

6. Write a 1-2 page report (12-point, double-spaced, 1-in margins) that touches on the following:

* Brief assessment of key findings
* Recommendation on your data-driven proposed transition. Justify your position.
* Cite any references you use!

**Summary of Deliverables**

* Excel sheet with forecasts and analysis as follows (**80 points**):
  + Missouri population in 10 years [forecast]
  + Household size share of total population in 10 years [forecast]
  + Total number of people living in single-person, two-person, etc. households [analysis]
  + Total electricity demand [analysis]
  + Electricity demand fulfilled by coal [analysis]
    - Decreasing by 1% per year
  + Electricity demand fulfilled by renewable energy source [analysis]
    - Increasing by 1% per year
  + Cost of demand fulfillment [analysis]
    - Measured in $
  + Environmental benefit of transition [analysis]
    - Measured in reduction of CO2
* 1-2 page paper (12-point, double-spaced, 1-in margins) (**20 points**)
  + Brief assessment of analysis used and key findings
  + Recommendation

**Solution:**

The Sustainable Energy Portfolio Management project offers valuable insights into the environmental impact associated with the reliance on coal as the primary source of energy for meeting residential sector electricity demand. As the effects of climate change become increasingly evident, there is a pressing need to reduce coal dependency and promote the utilization of renewable energy sources. The objective of this project is to examine how changes in the energy portfolio over the next 10 years will affect the cost of electricity supply and CO2 emissions in the state of Missouri.

Population growth serves as the primary driver of changes in electricity demand. To forecast the population growth of Missouri over the next 10 years, Holt's model was employed. Considering that energy demand varies among households of different sizes, the population distribution across household sizes in Missouri was determined using national data. It is important to note that the share of each household size in the population has exhibited different fluctuations from 1960 to 2019. Therefore, Holt's model was applied as the forecasting method for single-member, two-member, and five-member households, where a steady trend but no seasonality was observed. For three-member, four-member, six-member, and seven or more member households, where no discernible trend or seasonality was evident, simple exponentiation was chosen as the preferred forecasting method. The smoothing constants were determined using the solver tool, with the objective function set to minimize the standard deviation.

Upon determining the population residing in each household size, the per-member electricity consumption data for different household sizes was utilized to calculate the total electricity demand for the upcoming 10-year period. As expected, population growth leads to a surge in electricity demand, with each household size contributing to the total demand in varying proportions. The resulting total demand was utilized to estimate electricity fulfillment data through coal and solar sources for the next 10 years, by incrementally changing their respective shares by 1% annually.

The increase in the share of solar energy resulted in a substantial rise in the total cost of demand fulfillment, amounting to nearly $3.9 billion over the course of 10 years. While there is a potential saving of $9 million achievable through a reduction in coal dependency, this amount is minuscule when compared to the increased expenditure. However, the real benefits are evident in the analysis of emissions resulting from the changes in the energy portfolio. A reduction of 1.38 million tons of CO2 emissions is projected over the next 10 years, corresponding to an 8% decrease in CO2 emissions. According to a study conducted by the European Environmental Agency, an average mature tree absorbs 22 kg of CO2 annually. Consequently, the 10% increase in solar energy's share is estimated to remove CO2 from the atmosphere equivalent to that absorbed by 62 million fully grown trees.

Considering the imminent catastrophe facilitated by the impacts of climate change, the projected reduction in CO2 emissions can significantly impede the accumulation of greenhouse gases in the atmosphere. Calculations indicate that each dollar invested can eliminate 352 g of CO2 from the environment. Given that climate change can disrupt human life to unprecedented levels and considering the finite nature of non-renewable energy sources, the long-term benefits of transitioning 10% of the demand from coal to solar power outweigh the associated costs. Consequently, this transition is highly recommended as an essential and environmentally friendly initiative.