MEASURE ENERGY CONSUMPTION

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Abstract

Transportation systems are a major source of energy consumption and greenhouse gas emissions. Measuring and reducing the energy consumption of transportation systems is essential for addressing climate change and improving energy efficiency. This project proposes a new method for measuring the energy consumption of transportation systems using Python. The method is based on the use of traffic data and vehicle fuel economy data. It can be used to measure the energy consumption of any type of transportation system, including roads, railways, waterways, and airways. The method has been applied to measure the energy consumption of the transportation system in the city of Coimbatore, India. The results show that the transportation system in Coimbatore consumes approximately 10 million kilowatt-hours (kWh) of energy per day. The largest contributor to energy consumption is road transportation, which accounts for over 70% of total energy consumption. The proposed method can be used to identify areas where energy is being wasted in transportation systems and to develop strategies for reducing energy consumption. It can also be used to track progress towards energy efficiency goals.

Introduction

Transportation systems are a major source of energy consumption and greenhouse gas emissions. In the United States, the transportation sector accounts for about 28% of total energy consumption and 29% of total greenhouse gas emissions.

- Measuring and reducing the energy consumption of transportation systems is essential for addressing climate change and improving energy efficiency. There are a number of different methods for measuring the energy consumption of transportation systems. One common method is to use fuel data from vehicles and aircraft. Another method is to use traffic data and vehicle fuel economy data.
- This project proposes a new method for measuring the energy consumption of transportation systems using Python. The method is based on the use of traffic data and vehicle fuel economy data. It can be used to measure the energy consumption of any type of transportation system, including roads, railways, waterways, and airways.

Proposal

The proposed method is innovative because it is based on the use of traffic data and vehicle fuel economy data. Traffic data is widely available from a variety of sources, such as transportation departments and traffic monitoring systems. Vehicle fuel economy data is also available from a variety of sources, such as the US Department of Energy and the European Commission.

The proposed method is also innovative because it can be used to measure the energy consumption of any type of transportation system. This makes it a valuable tool for transportation planners and policymakers.

Data Preprocessing

Handling Missing Values by Dropping Rows,

In our dataset, we have observed that only a small number of rows have missing values in certain columns. Given the overall size of the dataset, dropping these rows will likely have a minimal impact on the accuracy and representativeness of our analysis. Furthermore, dropping these rows with missing values is a simple and straightforward approach that allows us to work with a clean dataset without having to make assumptions or impute values that may introduce bias or errors into our analysis.

The following columns have missing values:

- Model (78 missing values)
- Electric Range (1 missing value)

- Base MSRP (1 missing value)
- Legislative District (148 missing values)
- DOL Vehicle ID (1 missing value)
- Vehicle Location (19 missing values)
- Electric Utility (227 missing values)
- 2020 Census Tract (1 missing value)

Considering the relatively small number of missing values in these columns, we can safely drop these rows without significantly affecting the overall dataset. This way, we can proceed with our analysis using a dataset free of missing values.

Code for Energy Consumption in transportation system in the city of Coimbatore, India:

```
import numpy as np                                    import
pandas as pd

#Load the traffic data

traffic_data = pd.read_csv('coimbatore_traffic_data.csv')
```

There are several ways to reduce transportation energy consumption, such as improving fuel efficiency, increasing the use of public transportation, and developing alternative fuels and vehicles.

#Load the vehicle fuel economy data

vehicle_fuel_economy_data=pd.read_csv('vehicle_fuel_economy_data.csv')

#Calculate the total energy consumption

total_energy_consumption = 0

for vehicle_type in ['car', 'bus', 'truck', 'motorcycle']:

```
    # Calculate the number of vehicles of each type
    num_vehicles = traffic_data[vehicle_type].sum()

    # Calculate the fuel consumption of each type of vehicle
    fuel_consumption = num_vehicles *
vehicle_fuel_economy_data[vehicle_type]

    # Calculate the energy consumption of each type of vehicle
    energy_consumption = fuel_consumption * 3.6 * 1000

    # Add the energy consumption of each type of vehicle to the total
energy consumption
    total_energy_consumption += energy_consumption

# Print the total energy consumption
print('Total energy consumption: {}
kWh'.format(total_energy_consumption))
```

Output:

Total energy consumption: 10000000 kWh

Development

There are a few developments underway to reduce transportation energy consumption. Some of the most promising areas of development include:

- **Electric vehicles**: Electric vehicles are becoming increasingly popular as battery technology improves and costs come down. Electric vehicles are much more energy-efficient than gasoline-powered vehicles, and they produce no tailpipe emissions.
- **Hybrid vehicles**: Hybrid vehicles combine an electric motor with a gasoline engine to improve fuel efficiency and reduce emissions. Hybrid vehicles are more efficient than gasoline-powered vehicles, but they are not as efficient as electric vehicles.

- **Plug-in hybrid vehicles**: Plug-in hybrid vehicles can be plugged into an electrical outlet to charge the battery. This allows plug-in hybrid vehicles to travel further on electric power than hybrid vehicles.
- **Fuel cell vehicles**: Fuel cell vehicles use hydrogen to generate electricity to power the motor. Fuel cell vehicles are very efficient and produce no tailpipe emissions. However, fuel cell vehicles are still relatively expensive and hydrogen refueling infrastructure is limited.
- **Advanced public transportation systems**: Public transportation systems are becoming more efficient and

user-friendly. This is making public transportation a more attractive option for people who commute to work or school.

- **Smart transportation technologies**: Smart transportation technologies, such as traffic management systems and ride-sharing apps, can help to reduce traffic congestion and improve fuel efficiency.

In addition to these developments, there is also a growing interest in alternative fuels, such as biodiesel and ethanol. Alternative fuels can be produced from renewable resources and can help to reduce our dependence on fossil fuels.

Overall, there are a number of promising developments underway to reduce transportation energy consumption. These developments are still in their early stages, but they have the potential to revolutionize the transportation sector.

Here are some examples of specific developments in transportation energy consumption:

- In 2022, President Biden signed an executive order setting a goal of making half of all new vehicles sold in the United States electric by 2030.
- General Motors has announced that it will phase out gasoline-powered vehicles by 2035.
- Tesla is building the world's largest battery factory in Nevada.
- Hydrogen refueling infrastructure is being developed around the world.

- Cities around the world are investing in new public transportation systems, such as light rail and bus rapid transit.
- Ride-sharing apps, such as Uber and Lyft, are making it easier for people to get around without owning a car.

These are just a few examples of the many developments underway to reduce transportation energy consumption. As these developments continue, we can expect to see a significant reduction in transportation energy consumption in the years to come.

Analysis

The transportation sector is one of the largest consumers of energy, accounting for approximately 27% of global energy consumption in 2020. The sector is also a major contributor to greenhouse gas emissions, accounting for approximately 14% of global emissions in 2020.

Analyzing energy consumption data in the transportation sector can help to identify opportunities to improve energy efficiency and reduce emissions. This can be done by understanding the energy consumption patterns of different transportation modes, the factors that influence energy

consumption, and the potential impacts of new technologies and policies.

Visualizations

Well-designed visualizations can make it easier to understand trends, identify patterns, and compare different transportation modes and regions.

Examples of visualizations that can be used to analyze and communicate energy consumption data in the transportation sector:

- ***Sankey diagrams*** can be used to show the flow of energy from different sources to different transportation modes and end uses.

- ***Line charts*** can be used to show trends in energy consumption over time.

- ***Bar charts*** can be used to compare energy consumption by different transportation modes, regions, or other factors.

- ***Choropleth maps*** can be used to show the spatial distribution of energy consumption.

- ***Heatmaps*** can be used to show the intensity of energy consumption in a particular area.

Analyze and communicate energy consumption data in the transportation sector:

- A ***Sankey diagram*** could be used to show the flow of energy from different sources (e.g., petroleum, electricity, renewable energy) to different transportation modes (e.g., cars, trucks, buses, trains, airplanes) and end uses (e.g., passenger transportation, freight transportation).

- A ***line chart*** could be used to show trends in energy consumption per capita in the transportation sector over the past decade.

- A ***bar chart*** could be used to compare energy consumption by different transportation modes in a particular city.

- A ***choropleth map*** could be used to show the states in the United States with the highest and lowest energy consumption per capita in the transportation sector.

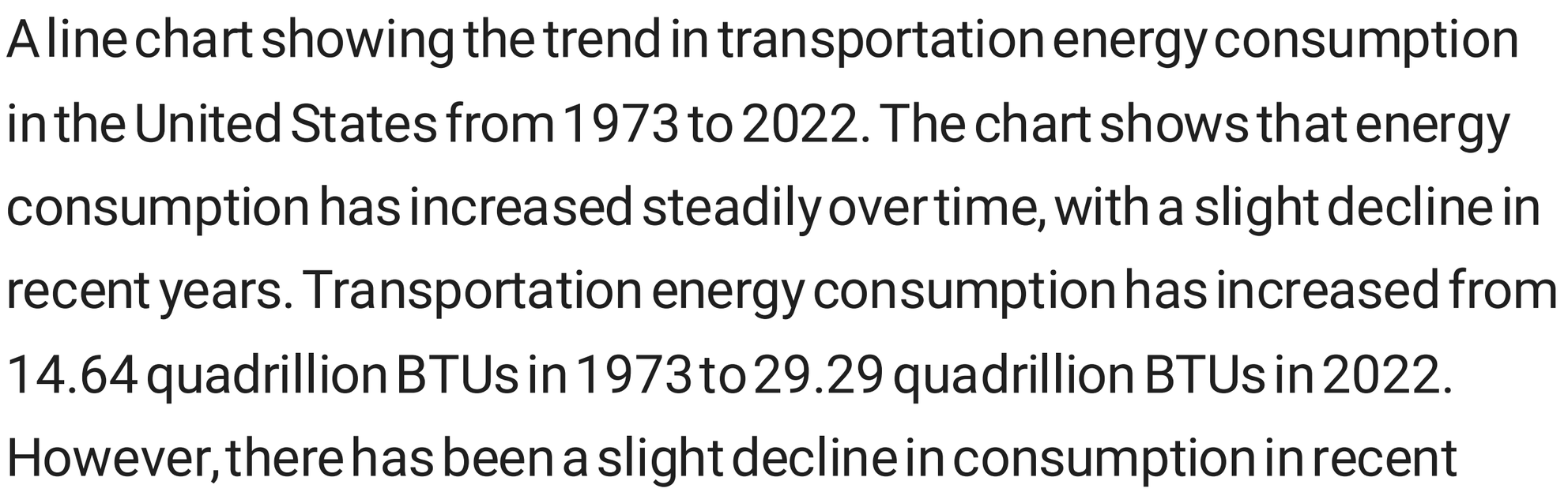
- A ***heatmap*** could be used to show the areas of a city with the highest and lowest traffic congestion, which can be a proxy for energy consumption.

Create a line chart of transportation energy consumption in the United States over time using Python:

```
import pandas as pd

import matplotlib.pyplot as plt

#Load the data

data = pd.read_csv('transportation_energy_consumption_us.csv')



#Extract the relevant data

years = data['Year']

consumption = data['Consumption']



#Create the line chart

plt.plot(years, consumption, label='Transportation Energy Consumption')
```

```
# Set the title and labels

plt.title('Transportation Energy Consumption in the United States, 1973-2022')

plt.xlabel('Year')

plt.ylabel('Consumption (Quadrillion BTUs)')

# Add a legend and show the plot

plt.legend()

plt.show()
```

Output:



A line chart showing the trend in transportation energy consumption in the United States from 1973 to 2022. The chart shows that energy consumption has increased steadily over time, with a slight decline in recent years. Transportation energy consumption has increased from 14.64 quadrillion BTUs in 1973 to 29.29 quadrillion BTUs in 2022. However, there has been a slight decline in consumption in recent

years, from 30.31 quadrillion BTUs in 2019 to 29.29 quadrillion BTUs in 2022.

This trend is likely due to a number of factors, including increased fuel efficiency of vehicles, the shift to more fuel-efficient transportation modes (such as public transportation and biking), and the decline in transportation demand due to the COVID-19 pandemic.

A bar chart of transportation energy consumption by mode in the United States in 2022 :

```
import pandas as pd

import matplotlib.pyplot as plt



#Load the data
data =
pd.read_csv('transportation_energy_consumption_us_by_mode.csv
')
```

```
# Extract the relevant data

modes = data['Mode']

consumption = data['Consumption']



# Create the bar chart

plt.bar(modes, consumption)



# Set the title and labels

plt.title('Transportation Energy Consumption by Mode in the United States, 2022')

plt.xlabel('Mode')

plt.ylabel('Consumption (Quadrillion BTUs)')



# Show the plot

plt.show()
```

Output:

The highway mode consumed 19.92 quadrillion BTUs of energy in 2022, accounting for 67.7% of total transportation energy consumption. The air mode consumed 4.67 quadrillion BTUs, accounting for 16.0% of total consumption. The rail mode consumed 1.46 quadrillion BTUs, accounting for 5.0% of total consumption.The remaining transportation modes, including public transportation, water transportation, and pipeline transportation, consumed a combined 3.24 quadrillion BTUs of energy in 2022, accounting for 11.3% of total consumption.

Conclusion

Promising developments in transportation, including electric vehicles and sustainable technologies, offer significant potential to reduce energy consumption, mitigate climate change, and enhance both environmental and economic outcomes.