

Statistical Analysis of Renewable and Non-Renewable Energy Consumption under the Epidemic Situation

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ABSTRACT

Energy consumption not only reflects the level of energy utilizing technology, but also reflects the level of economic development. Since the sudden outbreak of COVID-19 in 2020, world energy consumption dropped drastically. Therefore, the effective energy management is particularly important. In this paper, long short-term memory (LSTM) time series prediction model is used to conduct statistical analysis on the consumption of coal, petroleum, natural gas and renewable energy in the United States. The goal is to analyze the impact of the epidemic based on the consumption statistics from different energy types and predict the trend of energy consumption in the United States. Based on the historical data and LSTM model, it can be concluded that coal and natural gas consumption have obvious jump in the epidemic, while petroleum and renewable energy consumption are relatively stable.

Keywords: energy consumption statistics, energy consumption prediction, LSTM prediction model, energy management

1. INTRODUCTION

Energy usage can be found everywhere, including embedded systems [1], smart home system, green buildings energy consumption and so on. More and more researchers are interested in the relationship between energy consumption and the Gross Domestic Product.

As the main non-renewable energy, coal, petroleum and natural gas are used in industrial manufacturing, transportation and other aspects. With the improvement of mining capacity, the application of renewable energy such as hydro, wind and solar energy is more extensive [2]. Renewable energy increases the

production and reduces pollution. In this paper, only the past gross data of renewable energy consumption have been retrieved, so that it can only study the consumption of gross renewable energy, but not the consumption of specific types of renewable energy in details. Affected by the outbreak of COVID-19, the energy consumption was at a low point. In order to lower down the impact on energy industry and help the government take timely correct actions on energy management. Energy consumption statistical analysis and prediction are particularly necessary.

2. RELATED WORK

In literatures, there are many past studies on energy consumption prediction and analysis. For example, CNN network and multi-layer bi-directional LSTM network were used to predict residents' short-term electricity consumption, which overcame the interference of weather conditions and achieved high prediction accuracy [3]. Jae-min Lee also used LSTM neural network model to analyze and predict the electric energy consumption per hour [4]. A CNC machining process was also tried by using the incomplete data to predict energy consumption [5]. Effective management of energy resources created greater value [6]. A federated learning approach was used to predict short-term energy consumption [7].

Different from the above researches, this paper studies the gross energy consumption in the United States, rather than the energy conversion into electricity, heat and other forms. And the forecast is based on the analysis of the statistical trend of energy consumption. As a comparison, the impact of the SARS on energy consumption in 2002-2003 is also studied. As we can see from the studies, the energy consumption is not only affected by the epidemic, but also by energy

development technology, season, energy utilization level. In this paper, the LSTM model is chosen as the main tool. It can be used to solve the long-term dependency problem and strengthen the prediction ability of RNN. Generally, it is simpler and can reach smaller mean square error with good prediction performances, especially when processing time series. LSTM model is composed of forgetting gate, input layer gate and output layer gate, which can remove invalid information and add effective information for the forecast content. The LSTM model structure is shown in Figure 1.

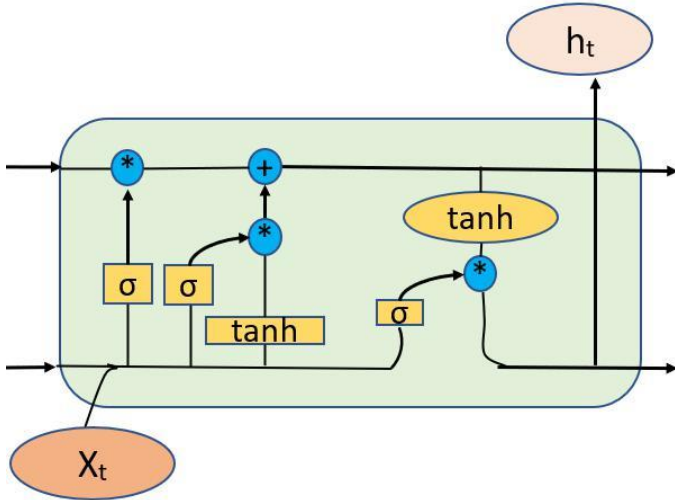


Fig. 1. LSTM model structure

In this paper, the monthly consumption data of coal, petroleum, natural gas and renewable energy in the United States from January 1973 to May 2021 are used to analyze the impact of COVID-19 on energy consumption.

3. CONSUMPTION STATISTICS AND PREDICTION

3.1 Energy consumption statistics

The arrival of COVID-19 had affected not only the import and export of energy, but also the amount of energy consumption. Energy supply is a favorable support for economic growth, so predicting energy consumption is helpful to estimate economy.

The COVID-19 pandemic is a current crisis in the energy market. Figures 2, 3, 4 and 5 respectively represent the consumption of coal, petroleum, natural gas and renewable resources in the United States from June 2019 to May 2021.

In Figure 2, coal consumption reached the lowest point in April 2020. It fell by the most, with a maximum drop of 33097.83 thousand short tons. Although the coal consumption data dropped rapidly, the speed of recovery was relatively fast, and it recovered to the

highest consumption level in 3-4 months. In Figure 3, petroleum consumption also reached the lowest point in April 2020. And the petroleum consumption was relatively stable.

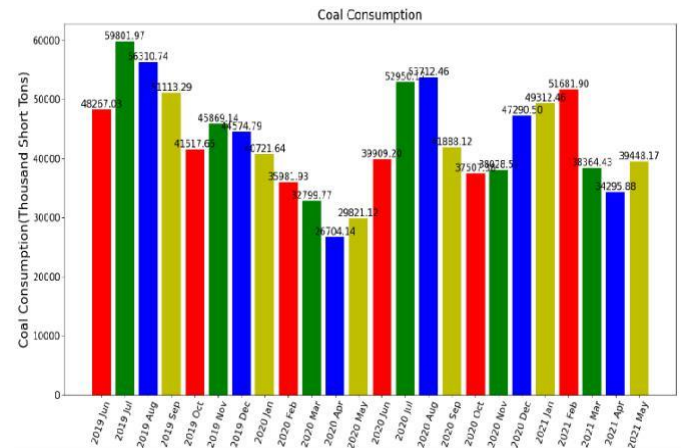


Fig. 2. Coal consumption

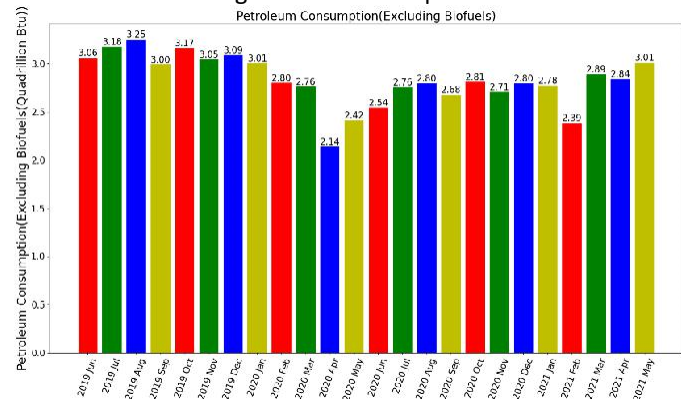


Fig. 3. Petroleum consumption

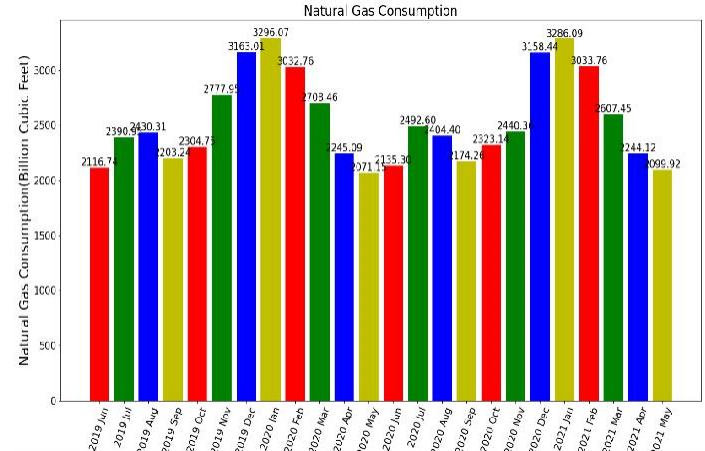


Fig. 4. Natural gas consumption

In Figure 4, natural gas consumption fell. It reached the lowest point in May 2020. The maximum drop of 1224.92 billion cubic feet. In Figure 5, renewable energy consumption did not decline sharply. Therefore, the epidemic had little impact on renewable energy and the economic dependence on renewable energy was stable.

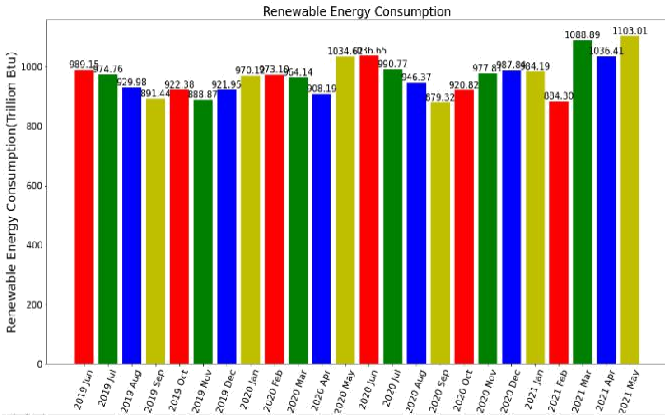


Fig. 5. Renewable energy consumption

In the first six months of the outbreak, the whole energy consumption in the United States declined. Coal consumption declined the most, followed by natural gas. Petroleum consumption rose slowly in the early stage of the outbreak, then declined slowly. Renewable energy consumption had not been affected.

3.2 Energy consumption trend prediction

Energy is used in all aspects of our lives, including heating, lighting, transportation and running factories. Forecasting energy consumption data in the post-pandemic period will benefit to manage energy. Figures 6, 7, 8 and 9 respectively represent the predicted consumption of coal, petroleum, natural gas and renewable resources in the United States from June 2021 to January 2023.

In Figure 6, coal consumption still fluctuates greatly. In the later period of the epidemic, it remains above 44000 thousand short tons. In the first quarter and the third quarter of the year, it shows a downward trend. In the second quarter and the fourth quarter, it starts to rise rapidly.

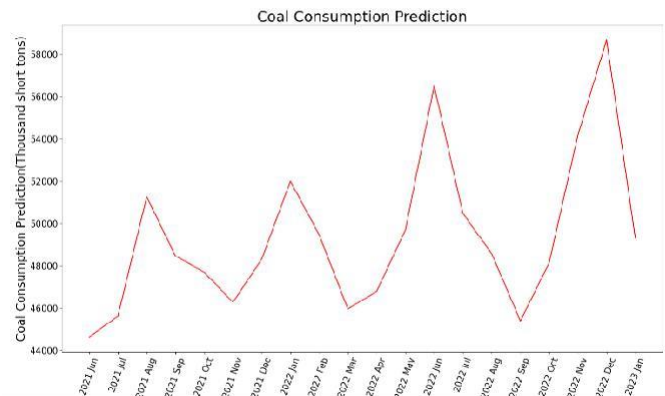


Fig. 6. Coal consumption prediction

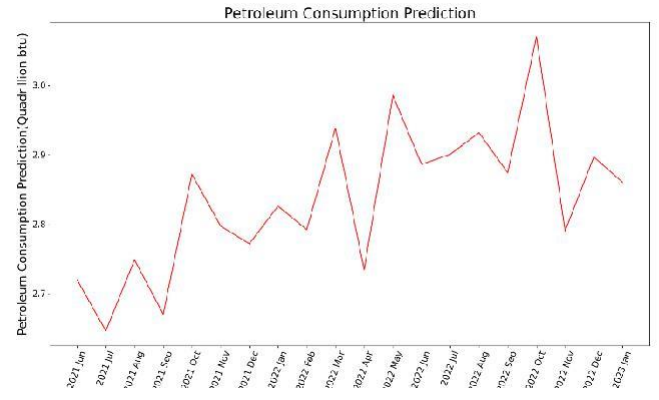


Fig. 7. Petroleum consumption prediction

In Figure 7, petroleum consumption will rise. Petroleum consumption varies frequently, but it doesn't change much. The maximum predicted consumption will not exceed 3.2 quadrillion btu.

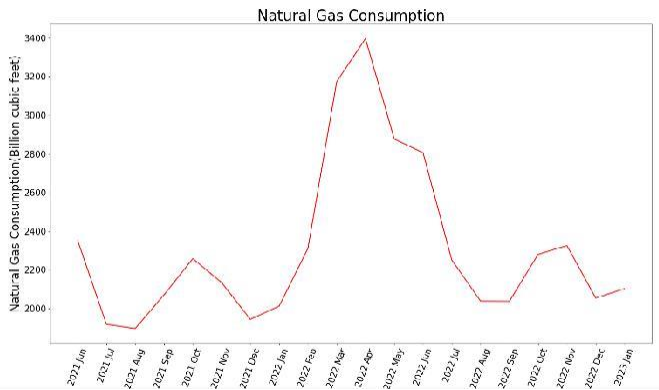


Fig. 8. Natural gas consumption prediction

In Figure 8, the variation of natural gas consumption will increase rapidly in April 2022. The maximum drop is around 1400 billion cubic feet, and natural consumption will be around 1800-2400 billion cubic feet in most instances.

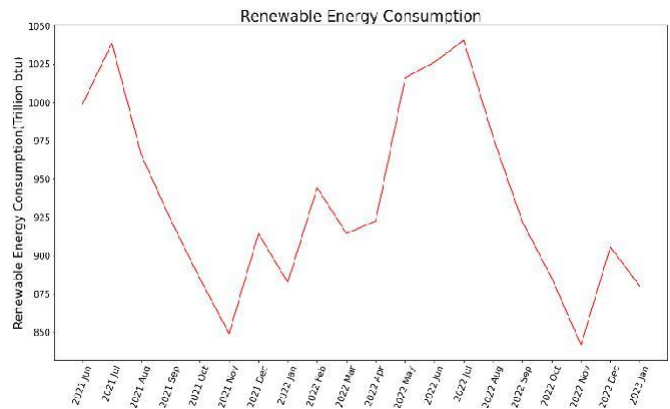


Fig. 9. Renewable energy consumption prediction

In May 2021, the monthly consumption of renewable energy is 1103.013 trillion btu. In Figure 9, it

has fallen sharply. The minimum consumption is about 850 trillion btu. The consumption of renewable energy will drop significantly from August to November, with a drop of about 190 trillion btu.

According to energy data statistics and forecasts, energy market was impacted and economic development slowed down during the epidemic period. In the post-epidemic period, the monthly energy consumption was not very stable, and the overall energy consumption rose gradually. The outbreak of the epidemic is uncertain. When the prevention and control efforts are strengthened, the possibility of the outbreak turns less, as well as the impact on normal life, and the data of energy consumption recover quickly.

TABLE 1 Energy consumption prediction

	Coal	Petroleum	Natural gas	Renewable
2021.Oct	47709.48	2.871656	2257.851	885.1556
2021.Nov	46291.04	2.796854	2134.449	849.0206
2021.Dec	48318.70	2.771404	1943.511	914.3757
2022.Jan	52009.91	2.825668	2011.934	882.4976
2022.Feb	49476.84	2.791714	2310.410	944.3539

Table 1 shows energy consumption for the coming months, in which the units are, coal: thousand short tons, petroleum: quadrillion btu (excluding biofuels), natural gas: billion cubic feet, renewable: trillion btu, and the predicted results remained the same units.

4. CONCLUSION

This paper analyzed the impact of COVID-19 on the monthly consumption of coal, petroleum, natural gas and renewable energy in the United States. And it predicted the consumption of energy in the later period of the epidemic by using LSTM model. During the epidemic period, coal consumption fell by the most, and natural gas consumption fell by the second, while the consumption of petroleum and renewable energy was relatively stable. In the future, it can be seen that the reserves of coal, petroleum, natural gas and renewable resources are maintained at 45000-52000 thousand short tons, 2.7-3.0 quadrillion btu (excluding biofuels), 2100-2600 billion cubic feet and 850-1050 trillion btu, respectively, which are suitable for future economic development. However, the influence of seasonal change on energy consumption are not considered yet, so the accuracy of prediction results will be improved. In this paper, the statistical data will be available at

<https://www.eia.gov/totalenergy/data/monthly/index.php>.

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