Research on the Impact of Energy on Emission Reduction and Environmental Protection

Zhipeng Jia [1], Heyuan Liu [2, *] and Yuanze Lu [3]

[1] Admiral Farragut Academy Tianjin, Tianjin, 300143, China

[2] Xi Guang Middle School, Xi'an, 410006, China

[3] Cao Yang Middle School, Shanghai, 200333, China

* Corresponding author: 2016121571@jou.edu.cn

Abstract. All nations are concerned about how to deal with the problem of the increasing carbon dioxide emissions in the globe today. By replacing traditional non-renewable energy with clean energy, greenhouse gas emissions can be reduced, thus helping to tackle climate change. Since the industrial revolution, global greenhouse gas emissions and the amount of energy generated from fossil fuels have increased dramatically, resulting in the highest levels of atmospheric carbon dioxide in 400,000 years. Therefore, this article aims to analyze the data on various energy consumption and carbon dioxide emissions by incorporating them into a multiple linear model, in order to identify the impact of different energy sources on carbon dioxide emissions. The results show that only oil, coal, and hydropower have a significant positive correlation with carbon dioxide emissions, while other energy sources do not have a significant relationship. Based on the above analysis, it is hoped to provide some meaningful recommendations.

Keywords: Carbon dioxide emission, new energy, renewable resource, multiple linear regression model.

1. Introduction

Utilizing alternative energy sources can help to fight climate change by lowering glasshouse gas emissions. Fossil fuel combustion continues to be the world's main source of energy, and as a result, it produces a significant quantity of emissions that contribute to global warming. It is possible to dramatically reduce emissions from human activity, particularly burning coal, oil, and natural gas produces carbon dioxide. This can be done by switching to clean, renewable energy sources. It may be possible to lower overall emissions and lessen environmental harm by widely utilizing new energy sources including solar, wind, hydroelectric, geothermal, and nuclear power [1, 2]. This thesis investigates how the use of new energy affects emission levels and what it means for environmental preservation.

Since the Industrial Revolution, both global glasshouse gas emissions and the amount of energy produced from fossil fuels have drastically expanded. Since more than 400,000 years, the amount of carbon dioxide in the atmosphere is at its highest level [3, 4]. An increase in greenhouse gases is directly linked to a rise in global temperatures, sea level rise, ocean acidification, biodiversity loss, and altered ecosystems. The faster adoption of new energy sources has been identified by the Intergovernmental Panel on Climate Change as a crucial mitigation approach to keep global warming to 1.5°C and prevent catastrophic climate change effects [5]. The use of renewable or extremely low-carbon energy sources can dramatically reduce emissions in the production of electricity, transportation, buildings, industry, and other sectors [6, 7].

As more nations go through an energy transition, the results show in concrete terms the potential for new energy to reduce emissions [8]. To fully fulfil this potential, they emphasize the need for further legislative backing and adoption objectives. Maintaining the rapid adoption of renewable energy that has been seen over the preceding ten years is essential for cutting emissions from the power sector globally. Increased grid flexibility, transmission, and storage will enable the integration of more variable sources, enabling future growth in the share of wind and solar power [9, 10]. The

environmental benefits of achieving zero-carbon electrical systems with new energy are immense, ranging from local air pollution reduction to global climate stabilization [11].

In this thesis, the potential for new energy adoption to reduce emissions is quantitatively analyzed. It puts a lot of emphasis on important new energy sources such solar photovoltaics, wind turbines, hydropower, geothermal, and nuclear energy. These new energy methods' emission levels will be contrasted with those of conventional fossil fuel electricity generation. Along with records of emissions, information will be gathered on the varying rates of nuclear and renewable energy adoption during the last ten years. Based on its expansion, the investigation will try to ascertain new energy's concrete contributions to decreasing emissions. The findings of this thesis will shed light on how increased use of new energy might reduce emissions and support efforts to combat climate change. They will aid in directing energy strategy that aims to hasten the adoption of low-carbon energy in order to achieve significant emission reductions.

2. Methods

2.1. Data Sources

The data for this literature is collected from two reports on "Our World in Data" website, namely "Global primary energy consumption by Source" and "Per capita CO_2 emissions".

2.2. Variable Selection

The data used in this paper count 10 types of consumption, including natural gas, oil, coal, Wind energy, Solar energy, biofuels energy, hydropower, nuclear energy, traditional biomass energy, other renewables energy and carbon dioxide emissions, as Table 1 shows.

Table 1. Logogram and numbers of the 11 factors (x unit: Twh, y unit: T)

Elements	Logogram	Number1	Number2
Natural Gas consumption	x_1	657923.367	31329.684
Oil consumption	x_2	1013590.408	48266.209
Coal consumption	x_3	823324.886	39205.946
Wind energy consumption	x_4	29766.728	1417.463
Solar energy consumption	x_5	10018.592	477.0758
Biofuels energy consumption	x_6	12905.485	614.546
Hydropower energy consumption	x_7	198367.391	9446.066
Nuclear energy consumption	x_8	149487.841	7118.468
Traditional biomass consumption	x_9	245392	11685.333
Other renewable consumption	x_{10}	25981.960	1237.236
Carbon dioxide equivalents	y_1	1.03E+12	4.93E+10

2.3. Method Introduction

This article uses a multivariable regression model, with global carbon dioxide emissions as the dependent variable (Y), and a total of 10 types of clean energy and traditional non-renewable energy as independent variables (X). Next, this paper uses SPSS to analyze the relationship between the influence of X on Y, that is, the relationship between 10 factors and lung cancer.

2.4. Model Principle

Two or more independent variables and one dependent variable constitute a multiple linear regression study under the assumption of linear connection correlation, and the mathematical formula that captures this quantitative relationship is known as a multiple linear regression model. The multiple linear regression model is a development of the unary linear regression model, and both models share a common fundamental idea.

Let this model of random y and general variables $x_1, x_2, x_3, \ldots x_k$ as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon \tag{1}$$

Among them, β_0, $\beta_1, \ldots \beta_k$ are k+1 unknown parameters, β_0 is called the regression constant, $\beta_1, \ldots \beta_k$ is called the regression coefficient; y is called the explained variable; x_1, $x_2, \ldots x_k$ are k that can be accurately controlled. The general variables of are called explanatory variables.

When $P = 1$, the above formula is a one-variable linear regression model, and when K≥2, the above formula is named a multivariate multiple regression model. ε is the random error, as in unary linear regression, it is typically believed that:

$$\begin{cases} E_{(\varepsilon)} \\ var(\varepsilon) = \sigma^2 \end{cases} \tag{2}$$

Similarly, this model equation is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k \tag{3}$$

The coefficient β_1 represents the mean unit of the dependent variable y caused when the independent variable x_1 changes to one unit when the other independent variables remain unchanged. The meanings of other regression coefficients are similar. In the collective sense, multiple regression is a plane on a multidimensional space. The multiple linear sample regression equation is:

$$\hat{y} = \widehat{\beta_0} + \widehat{\beta_1} x_1 + \widehat{\beta_2} x_2 + \quad + \widehat{\beta_k} x_k \tag{4}$$

3. Results and Discussion

3.1. Visual Descriptive Analysis

It is clearly demonstrated in Figure 1. Traditional non-renewable energy still makes up the majority of the world's energy consumption above that, and even while new clean energy is rapidly growing, its share is still very tiny.

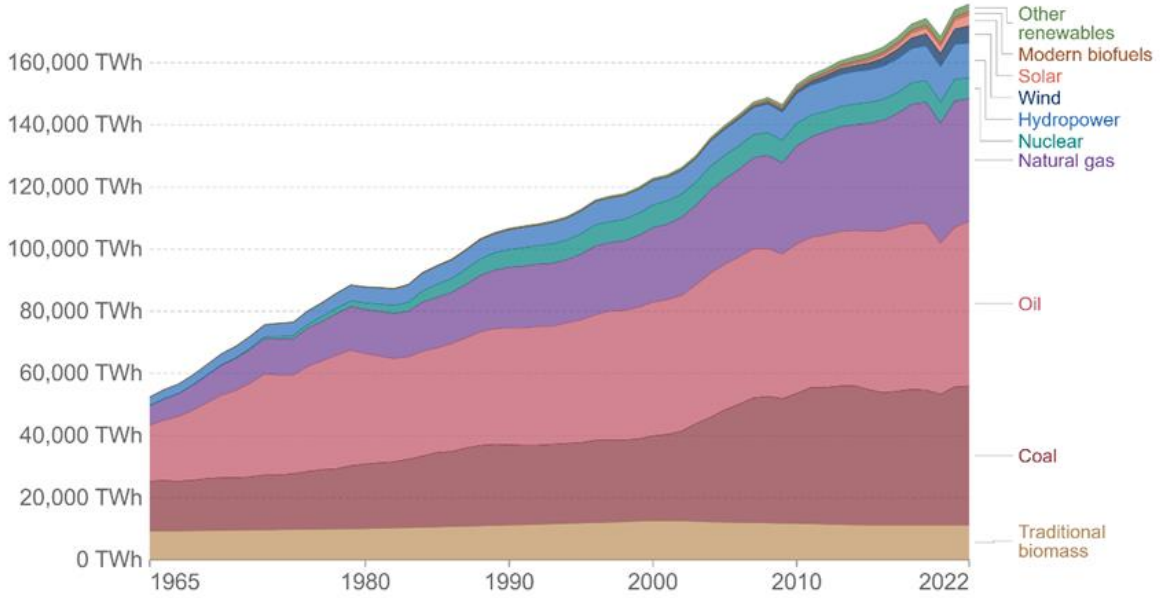


Figure 1. Area chart of various energy usage

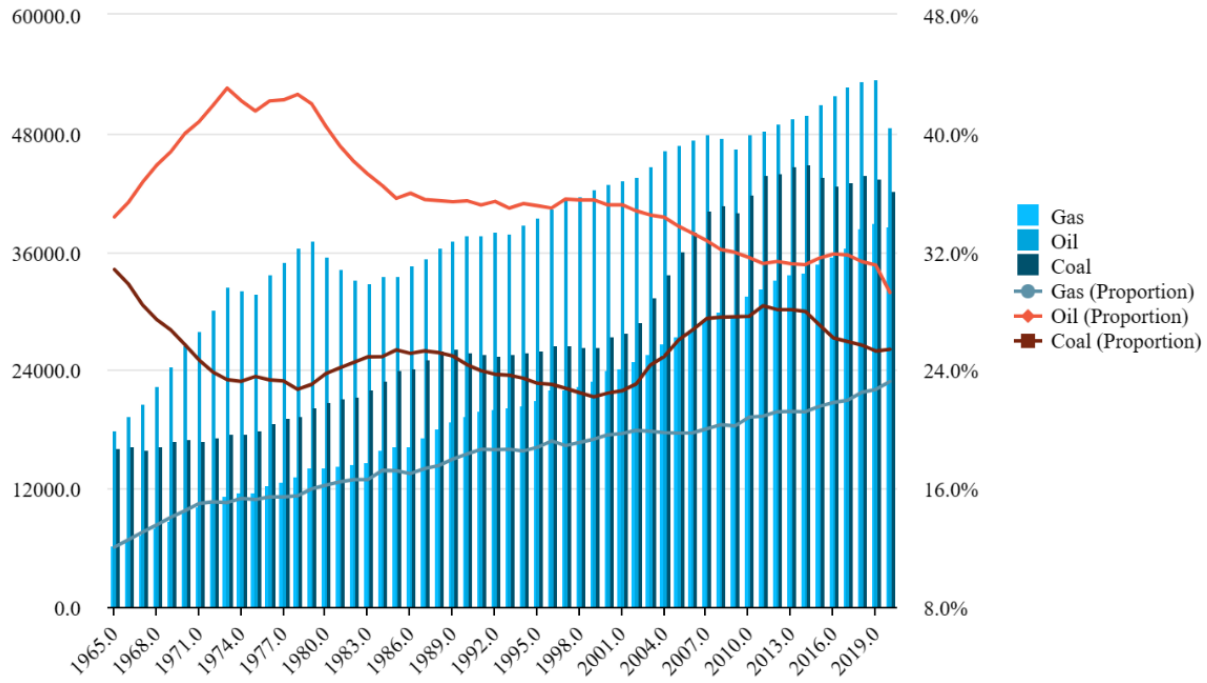


Figure 2. Proportion and total consumption of non-renewable resources

From Figure 2 above, it can be clearly seen that the consumption of non-renewable energy in the world is constantly increasing, but the proportion of oil and coal is declining as a whole. The utilization of natural gas in overall resources is steadily increasing.

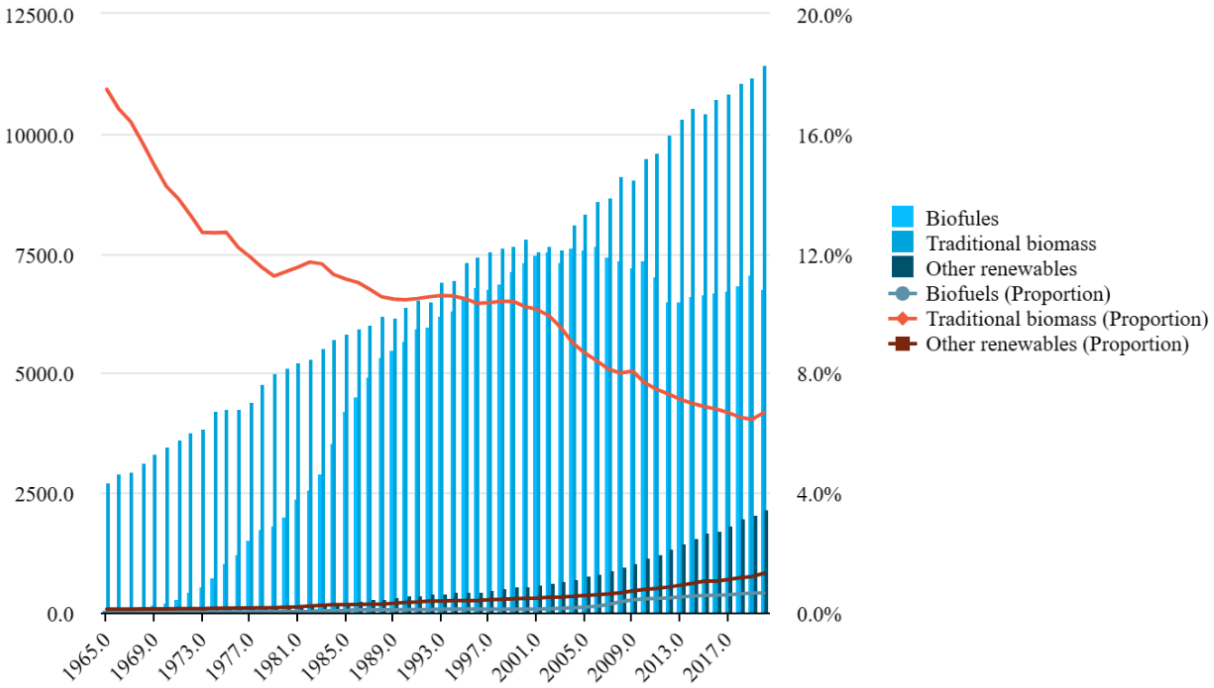


Figure 3. Proportion and total consumption of biofuels and other renewable energy sources

In Figure 3 above, it can be seen that the growth of traditional biomass reached its peak in 2005, and there was a slight increase in the next 10 years, but the downward trend was obvious in the past 60 years. The total amount of biofuels and other clean energy sources continues to rise, but the proportion is very small.

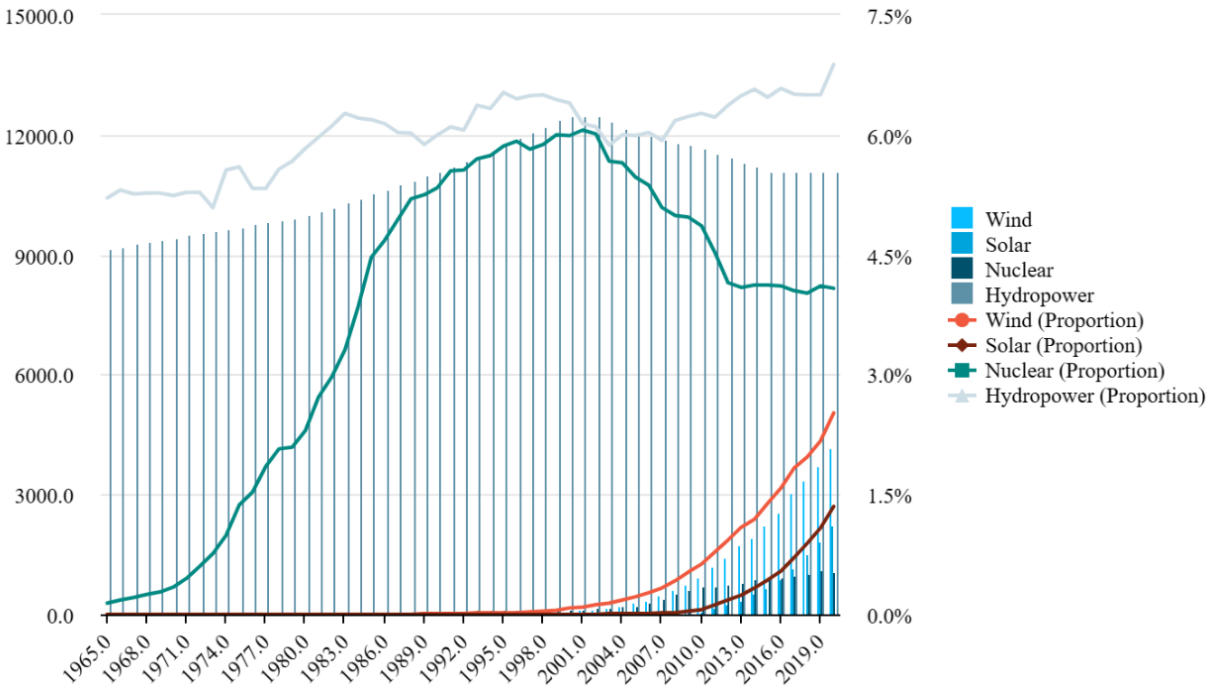


Figure 4. Consumption and proportion of mainstream clean energy

As can be seen from Figure 4 above, the consumption and proportion of wind energy and solar energy have only begun to increase slowly in the past 20 years, and the proportion is still very low. Hydropower is rising in twists and turns, and it is significantly higher than other new clean energy sources. Nuclear power was abruptly interrupted in its rapid growth.

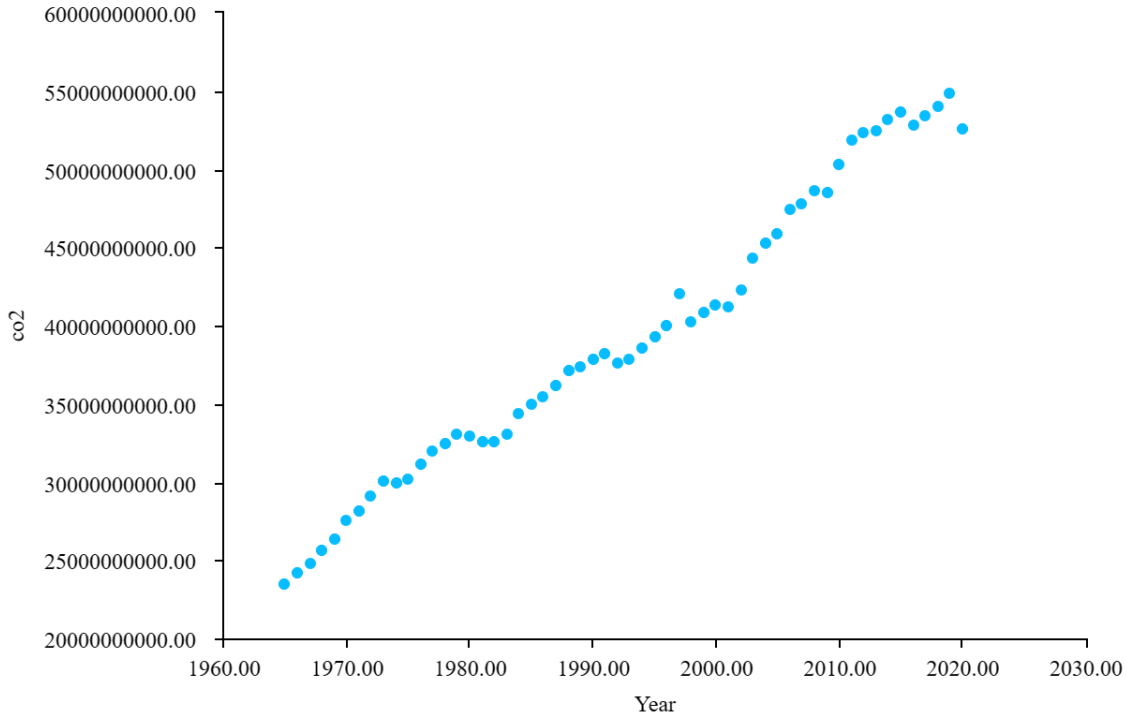


Figure 5. Scatterplot of global carbon dioxide emissions

From Figure 5 above, it can be clearly seen that the emission of carbon dioxide is continuously increasing, and the growth trend is stable first, and there will be a relatively large decline in 2020.

After visual analysis of the raw data, it can be concluded that the world's demand for energy is continuously increasing, with traditional non-renewable energy sources still accounting for a large proportion of energy consumption. Although new types of clean energy have not been in development

for long, their total quantity and percentage are steadily increasing. Oil and coal continue to dominate global energy production and consumption, but their share is constantly decreasing with the continuous development of new energy sources. Solar power, wind energy, and hydroelectric power are experiencing rapid development worldwide. The use and production of natural gas have significantly increased, and since natural gas emits less carbon dioxide when burned compared to coal, it is sometimes considered a "transition fuel" as society moves from heavily polluting fossil fuels to clean renewable energy. Global carbon dioxide emissions overall continue to rise, reaching a record 36.7 billion tons in 2019. However, the growth rate has slowed down in recent years due to COVID-19, and the decline will be relatively large in 2020.

3.2. Multiple Linear Regression Analysis

This paper established a multiple linear regression model and analyzed our data in detail. Firstly, the model diagram is established to visually see several independent factors' effects on those variables (Figure 6).

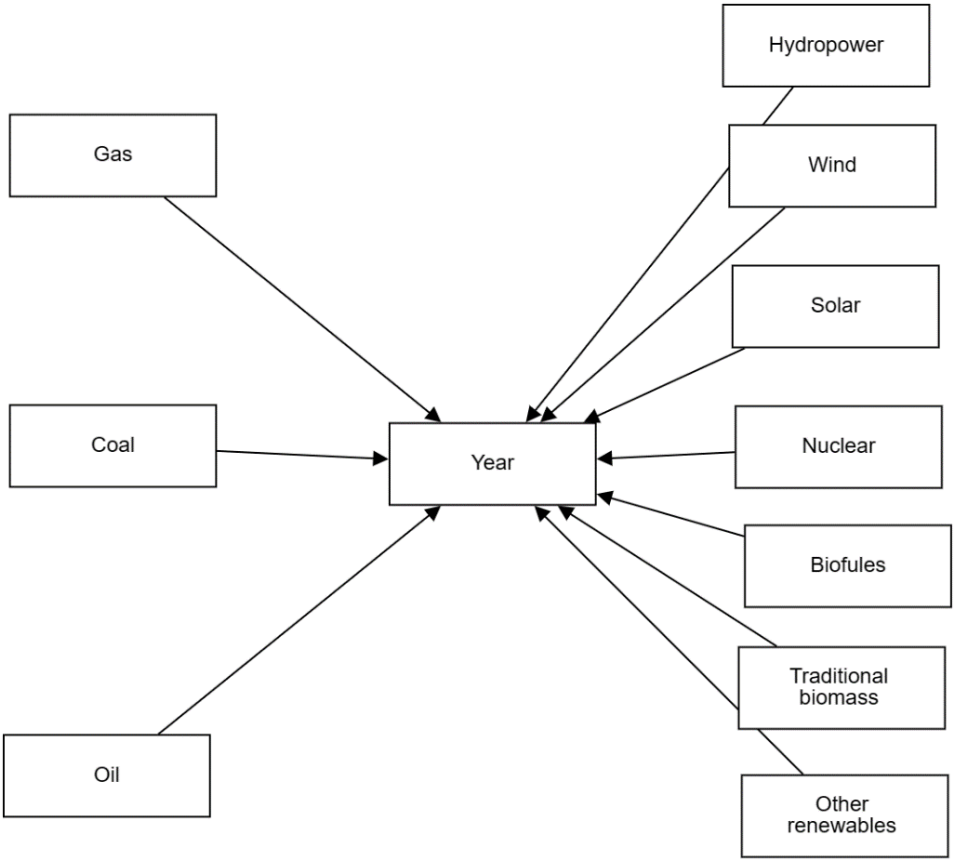


Figure 6. Model Plot for Multiple Independent and Dependent Variables

Next, we brought the data into the model for specific analysis. Table 2 below shows the specific results of the analysis.

Table 2. Linear regression analysis results

	Unstandardized Coefficient		Standardize Coefficient	t	p	collinearity diagnosis	
	B	standard error	Beta			VIF	tolerance
constant	15432075688.125	7078412881.334	-	2.180	0.035*	-	-
Other	1530197.060	2892326.977	0.099	0.529	0.599	875.697	0.001
Biofuels	2535638.275	2312882.402	0.096	1.096	0.279	190.253	0.005
Solar	-575124.200	1496597.833	-0.030	-0.384	0.703	147.671	0.007
Wind	-757223.405	1789263.324	-0.087	-0.423	0.674	1042.688	0.001
Hydropower	610936.094	296414.864	0.166	2.061	0.045*	161.265	0.006
Nuclear	251601.361	193441.105	0.077	1.301	0.200	86.462	0.012
Gas	226088.153	245828.449	0.230	0.920	0.363	1554.829	0.001
Oil	272111.782	63602.041	0.267	4.278	0.000**	96.718	0.010
Coal	202780.628	91438.457	0.217	2.218	0.032*	237.137	0.004
Traditional biomass	-340571.601	700800.903	-0.038	-0.486	0.629	152.519	0.007
R^2	0.998						
F	F (10,45)=2480.549, p=0.000						
D-W	1.687						

Dependent variable: CO2 consumption, $p<0.05$ ** $p<0.01$.

The conclusive study reveals that: Hydropower, Oil, and Coal will have a significant positive impact on carbon dioxide. But Other renewables will not affect carbon dioxide.

Table 3. ANOVA table

	sum of squares	df	mean square	F	p
return	4.59e+21	10	4.6e+21	2480.549	0.000
residual	8.3e+19	45	1.8e+17		
total	4.6e+21	55			

Finally, this paper conducted an F test on the data. From the table 3 above, we found that the model passed the F test ($F = 5549.273,\ P = 0.000 < 0.05$), which means that the model construction is meaningful.

Based on the statistical analysis of the data using the multiple linear regression model, it is found that only coal, oil, and hydroelectricity have a significant positive correlation with carbon dioxide emissions among various energy consumption quantities. The carbon dioxide emissions are not significantly impacted by other energy sources. In light of this, it can be said that oil and coal continue to dominate the global energy system, with the use of new energy sources being relatively low. Consequently, the model cannot analyze the relationship between the utilization of various new energy sources and carbon dioxide emissions. On the other hand, hydroelectric consumption exhibits a significant positive correlation with carbon dioxide emissions. This may be due to the high carbon emission cost during the initial construction phase of hydroelectric power plants and the relatively short time period of their operation, resulting in a significant positive correlation between hydroelectric consumption and carbon dioxide emissions. Moreover, the lack of a significant correlation between natural gas, as a traditional nonrenewable resource, and carbon dioxide emissions suggests that natural gas serves as a transitional energy source in switching to renewable energy sources from non-renewable ones.

4. Conclusion

The research shows that coal, oil, and hydroelectricity are the most important factors that affect carbon emissions, which means that traditional unrenewable resources take up the majority of global energy consumption. The reason that renewable resources take a relatively low portion of global energy consumption is that new energy is not widespread used. That is probably due to the high construction and maintenance costs that most developing countries cannot afford. Significantly, hydroelectricity reveals a close connection to carbon emission. That phenomenon could explain by the high carbon cost during the construction of hydroelectric power stations and the carbon emission when the facilities are operated. Surprisingly, another unrenewable resource, natural gas, does not have a strong relationship to carbon emission, meaning that natural gas plays an intermediate role between renewable resources and unrenewable resources. Based on the result of this research, some new research directions occur such as the comparison of renewable resource consumption in developed countries and developing countries and factors that lead to countries' different tendencies to energy consumption. There are some suggestions that are helpful to lower carbon emissions. Firstly, conserving energy and reducing emissions. This measure has already been carried out in China. The government of China supports the replacement of fuel vehicle with new energy automobile and building electric networks that covers almost all regions of China. The second method is to make an energy transition, which aims to decrease dependence on traditional unrenewable resources such as coal and oil. The third way is to tax carbon emissions. By encouraging lower carbon emissions, the situation of enormous carbon emissions could be strongly improved.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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