Analysis and Prediction of Energy Utilization in California (CA), Arizona (AZ), New Mexico (NM), and Texas (TX)

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Abstract: To describe the energy profiles of CA. AZ. NM. TX over 50 years, a classification statistics mode was established, which extracted 12 variables. To establish a comprehensive evaluation model of principal components for each state's energy situation, five most representative indicator variables based on 50 years' time series were selected. By comparing the weight of the five indicators for each state, we get the conclusion that AZ was the optimal use of renewable energy, and the industry prospects of CA and TX were higher than those in AZ and NM. In line with the analysis given by the government website, the model was valid. Considering the use of renewable energy as the main objectives, we substituted the data of 2009 to calculate the score. The score showed that CA was the best use of clean renewable energy. As the changing law of energy use was an uncertain system, the GM (1, 1) model was used to predict future energy utilization trends in the four states. In terms of goals for energy compact, we consider the best predictive value of CA for renewable energy use, which is 12.14% and 13.68% of the total renewable energy consumption for each state in 2025 and 2050. However, in a forecast point of view, it is harder to achieve the goal without policy intervention.

1. Introduction

As the major portion of any economy, energy production and usage interacted with the varying geographies and industries of different states. The Problem was to form a realistic new energy compact focused on increased usage of cleaner, renewable energy sources between four states – California (CA), Arizona (AZ), New Mexico (NM), and Texas (TX). To simplify and describe the problem more accurately, valid data must be filtered from 605 variables. Picking the representative factors was required to establish a model which can describe the energy profile for the entire 50 years. Then gave an index to evaluate the energy profile of each state. Based on this model, a gray forecasting model was built to simulate the energy profile of the four states in 2025 and 2050. Finally, the similarities and differences between clean and renewable energy states in each state can be drawn.

2. Principal Component Analysis

Based on the 50-year energy statistics made in A and the state energy reviews given by the government energy website on oil reserves, renewable energy use, energy-intensive industrial distribution and per capita energy consumption, we selected the most representative 5 Indicator Variables Principal component analysis of the state of energy over the past 50 years: x_1 was the total renewable energy consumption; x_2 was the total energy consumption; x_3 was the energy consumption of the industrial sector; x_4 was the energy consumption of the commercial sector; x_5 was the total energy consumption per capita.

Calculated the eigenvalues of the correlation coefficient matrix R, and the corresponding eigenvectors, then used the MATLAB software to make principal component analysis of the five evaluation indexes.

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Table 1. Arizona

	$\widetilde{x_1}$	$\widetilde{x_2}$	$\widetilde{x_3}$	$\widetilde{x_4}$	$\widetilde{x_5}$
The first eigenvector	0.0916	0.5452	0.8323	-0.0402	0.0001
The second eigenvector	0.9556	-0.1195	-0.0398	-0.2663	-0.0007

We could get a comprehensive score model:

$$Z_1 = 0.1381\widetilde{x_1} + 0.0509\widetilde{x_2} + 0.7855\widetilde{x_3} - 0.0237\widetilde{x_4} + 0.00005\widetilde{x_5}$$

Table 2. California

	$\widetilde{x_1}$	$\widetilde{x_2}$	$\widetilde{x_3}$	$\widetilde{x_4}$	$\widetilde{x_5}$
The first eigenvector	0.0876	-0.0863	0.9886	0.0864	0.00003
The second eigenvector	0.9479	-0.1485	-0.0732	-0.2723	0.00006

We could get the comprehensive score model of CA:

$$Z_2 = 0.1167\widetilde{x_1} - 0.0884\widetilde{x_2} + 0.9527\widetilde{x_3} + 0.0927\widetilde{x_4} + 0.00003\widetilde{x_5}$$

Table 3. New Mexico

	$\widetilde{x_1}$	$\widetilde{x_2}$	$\widetilde{x_3}$	$\widetilde{x_4}$	$\widetilde{x_5}$
The first eigenvector	0.0189	-0.0478	0.7605	-0.6472	0.0032
The second eigenvector	0.9317	-0.2122	-0.2114	--0.2056	-0.0010

We could get the comprehensive score model of NM:

$$Z_3 = 0.0609\widetilde{x_1} + 0.0554\widetilde{x_2} + 0.7158\widetilde{x_3} - 0.6079\widetilde{x_4} + 0.0031\widetilde{x_5}$$

Table 4. Texas

	$\widetilde{x_1}$	$\widetilde{x_2}$	$\widetilde{x_3}$	$\widetilde{x_4}$	$\widetilde{x_5}$
The first eigenvector	0.0104	-0.0683	0.9228	0.3791	-0.0002
The second eigenvector	0.8666	-0.4136	0.0705	-0.2701	-0.0002

We could get the comprehensive score model of TX:

$$Z_4 = 0.0428\widetilde{x_1} - 0.0814\widetilde{x_2} + 0.8906\widetilde{x_3} + 0.3546\widetilde{x_4} - 0.0002\widetilde{x_5}$$

From the above process, we extracted the same principal components from all the energy data of the four states and calculate the comprehensive score model for each state by a reasonable calculation. We knew the weight of every indicator in the composite score model, that was, the weight of each indicator. Therefore, we analyzed the energy profiles of the 50 years from 1960 to 2009 by comparing the magnitudes of the coefficients.

Table 5. The overall information of four states

	Renewable Energy	Total energy	Industry	Business	Per capita
AZ	0.138065	0.509491	0.785456	-0.02372	5.7E-05
CA	0.116707	-0.0884	0.952676	0.09269	3.1E-05
NM	0.060871	-0.05536	0.715811	-0.60799	0.003007
TX	0.042763	-0.08135	0.890584	0.354561	-0.0002

In terms of renewable energy use, AZ was the best, and AZ and CA were significantly better than NM and TX. Industrial sector energy use, CA and TX were higher than AZ and NM. Per capita energy consumption, NM was higher than all other states. The conclusions of the PCA model were consistent with the state energy statistics we had created and the analysis given by the government websites, so we thought this model worked.

3. The consumption of renewable energy

Based on the above model, we continued to select x_1 as the total renewable energy consumption, x_2 as the total energy consumption, x_3 as the energy consumption of the industrial sector, x_4 as

the energy consumption of the commercial sector, x_5 as the total energy consumption per capita Volume, a total of five indicators. On the four states in 2009, the main components of energy analysis established a unified evaluation model.

Table 6. The results of the standardization of the raw data

	RETCB	TETCB	TEICB	TECCB	TETPB
AZ	-0.6478	-0.7581	-0.6894	-0.7037	-0.7609
CA	1.3391	0.5145	0.0629	0.9369	0.7938
NM	-0.8691	-0.9104	-0.6816	-1.0109	0.2375
TX	0.1778	1.1539	1.4339	0.7778	1.3171

Using MATLAB software to make principal component analysis on five evaluation indexes, the first few characteristic roots and the contribution rate of the correlation coefficient matrix were as follows:

Table 7. Comprehensive evaluation

Serial number	Eigenvalues	Contribution rate	Cumulative contribution rate
1	3.2495	56.7167	56.7167
2	2.0663	36.0645	92.7812
3	0.4136	7.2188	99.9999
4	0.0015	0.0002	99.9999

It could be seen that the correlation between these indexes is high, the cumulative contribution rate of the first two eigenvalues reaches more than 90%, and the principal component analysis was very effective. The first two selected below the main components (cumulative contribution rate of 92%) for a comprehensive evaluation.

Table 8. The first two eigenvectors corresponding to the eigenvector table

	$\widetilde{x_1}$	$\widetilde{x_2}$	$\widetilde{x_3}$	$\widetilde{x_4}$	$\widetilde{x_5}$
The first eigenvector	0.3947	-0.552	0.5609	-0.4709	0.0543
The second eigenvector	0.5322	0.0081	-0.2320	0.2494	0.7750

Thus we could get the two main components respectively

$$y_1 = 0.3947\widetilde{x_1} - 0.552\widetilde{x_2} + \cdots + 0.0543\widetilde{x_5}$$
$$y_2 = 0.5322\widetilde{x_1} + 0.0081\widetilde{x_2} + \cdots + 0.775\widetilde{x_5}$$

Taking the contributions of the two principal components as the weights respectively, the following formula was obtained:

$$\mathrm{Z} = 0.5672y_1 + 0.3606y_2$$

The first principal component reflected the use of renewable energy in each state, the second principal component reflected the total energy consumption in each state, and the two principal components of each state were substituted into the above formula to obtain the energy status of each state in 2009 (based on renewable energy The use of the situation as the main objective of the evaluation) and the results of the sort as shown in the table

With the above ranking, we thought CA had the best use of clean renewable energy.

Table 9. Comprehensive evaluation value rank

Region	CA	TX	NM	AZ
Rank	1	2	3	4
Comprehensive evaluation value	0.4922	0.3231	0.0139	-0.30727

4. The energy profile in 2025 and 2050

The energy use situation in the four states was a very complex system. Considering that the law of change of energy usage was an uncertain system and gave more data samples and needs to make prediction up to 16 years or even 25 years, we used GM (1, 1) model to predict four more accurately important data from the energy use data of the past 50 years and provided more data for forecasting the energy use of the four states in 2050.

According to the Gray prediction model, the parameters a, u were obtained by using MATLAB software (see appendix in the program), and then the parameters were brought back to the differential equation to get the gray forecasting model of energy consumption, so as to find out the future value of energy consumption appendix). Based on the data from 1960 to 2009, the data for 2010-2025 were projected as shown in the figure below.

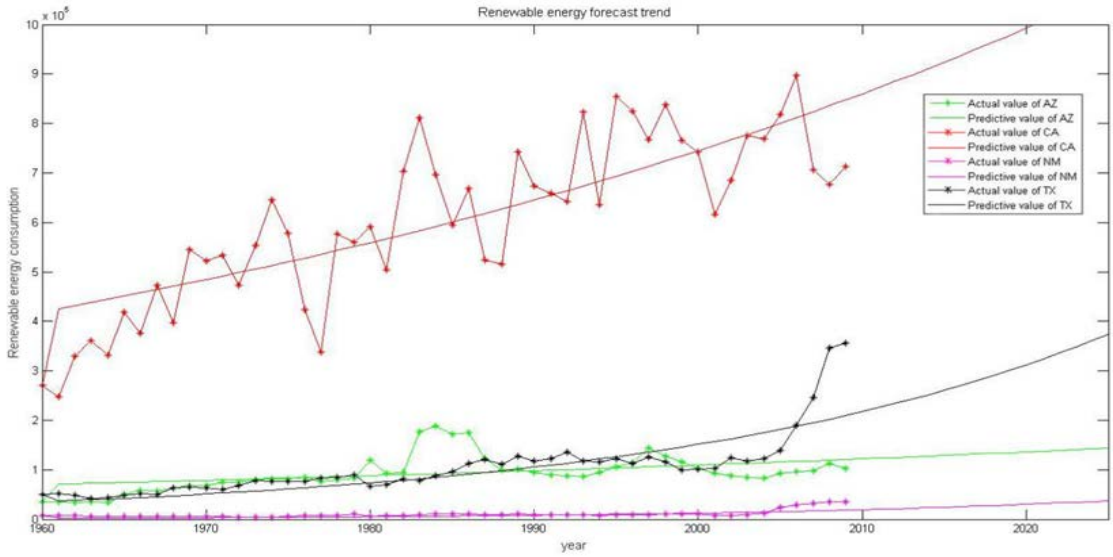

Figure 1. Forecast of the trend of renewable energy consumption in 1960-2025

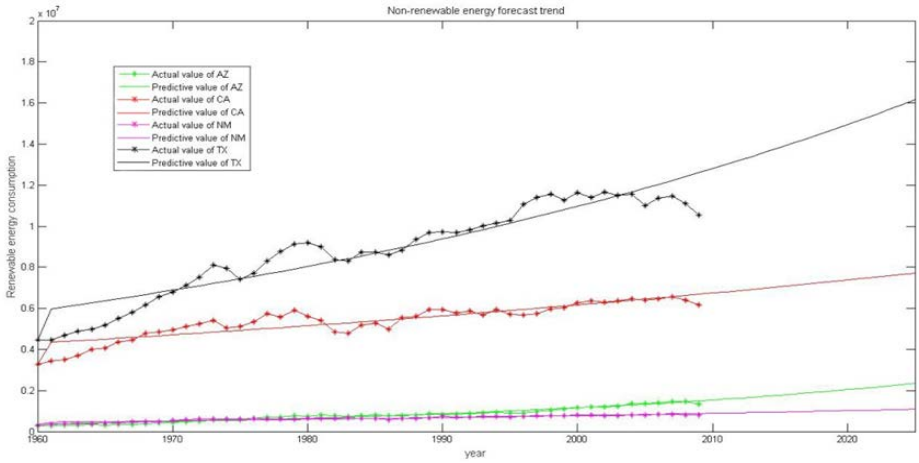

Figure 2. Forecast trends of consumption of non-renewable energy in 1960-2025

It could be seen from the figure that although states had many differences in the specific policies of renewable energy, these states paid close attention to renewable energy very early, of which CA was one of the states with the largest consumption of renewable energy, and CA was non-renewable Energy consumption is not growing as much as renewable energy, so CA was a fast-growing renewable energy state.

Through the simulation data obtained from the above figure and the use of MATLAB software, the 2010-2025 renewable energy consumption and non-renewable energy consumption data could be simulated. Combined with the predicted 2010-2025 data, the trend of renewable energy consumption and non-renewable energy consumption from 2026 to 2025 was predicted again by the gray prediction model as shown in the figure below.

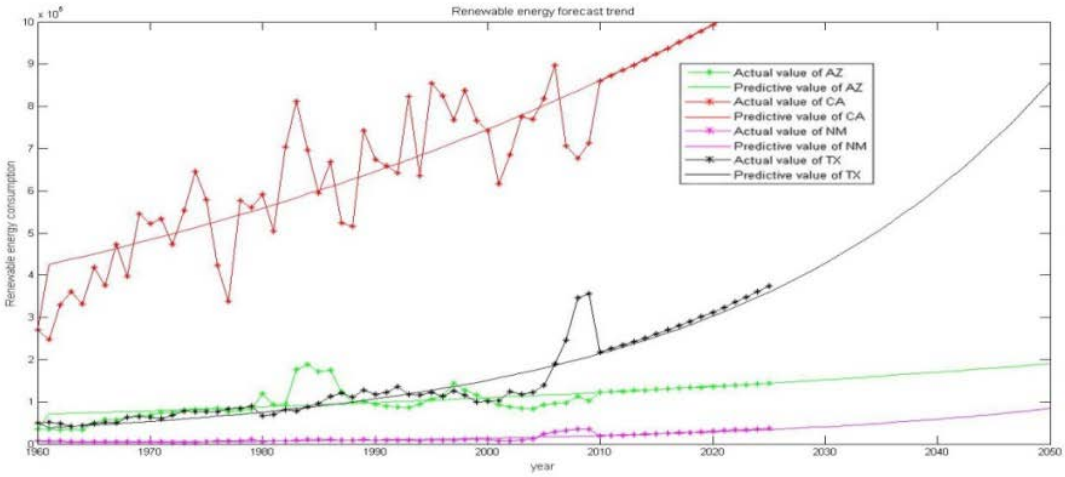

Figure 3. Forecast trends of renewable energy consumption from 1960 to 2050

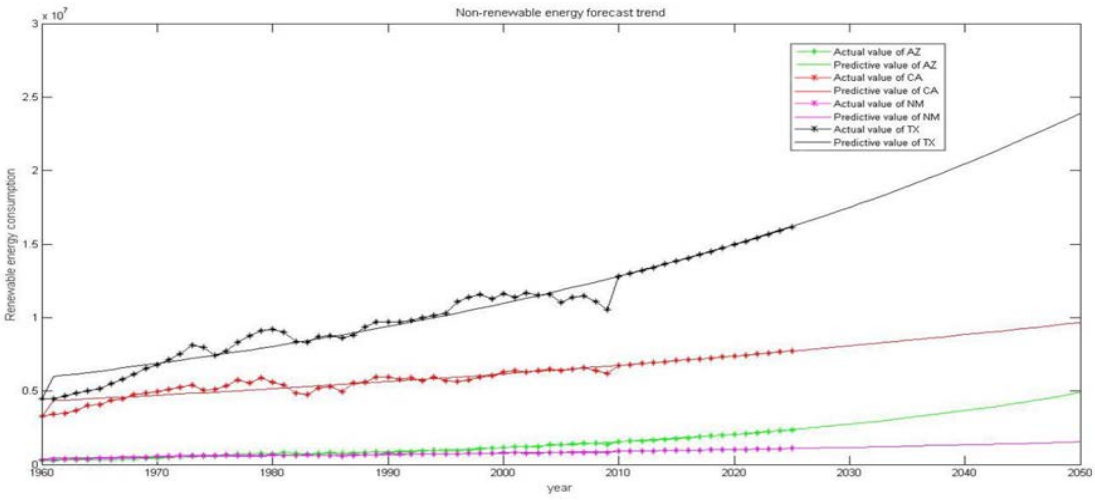

Figure 4. Forecast trends of non-renewable energy consumption in1960-2050

As could be seen from the figure, the trend of the curve in 2050 generally extended the forecast trend in 2025. Therefore, with the same policy, we could draw an overview of the energy of each state in 2025 and 2050 as shown in the following table:

Table 10. Overview of the energy of each state in 2025 and 2050

	AZ	CA	NM	TX
2025(Renewable)	143997.9	1066529.693	37718.71	374339.4
2050(Renewable)	190139.3	1531667.318	84713.96	857278.5
2025(Non-renew)	2357215	7719177	1090884	16157114
2050(Non-renew)	4885542	9665758	1530410	23897039

As could be seen from the figure, with the exception of AZ, each of CA、NM and TX increased the percentage of total renewable energy consumption as a percentage of total energy consumption while policy remained unchanged; and AZ, due to the historical evolution of its energy use In the process, renewable energy consumption appeared to increase first and then decrease. Therefore, the

model predicted that the consumption of renewable energy in Arizona would be reduced in several decades and the predicted result was in line with the historical evolution.

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