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T1 ________	**81166**	F1 ________
T2 ________		F2 ________
T3 ________	Problem Chosen	F3 ________
T4 ________	**C**	F4 ________

2018

Mathematical Contest in Modeling (MCM/ICM) Summary Sheet

Energy Profile Prediction And Evaluation Based On GM Model and ETP Criteria

Summary

In order to solve the problem of the four states energy contract of goal setting, this paper first analyses the data provided, and then analyzes the situation of the four states from 1960 to 2009 for the three aspects of total energy production, consumption and production consumption ratio, production and consumption of renewable energy.

In order to state the difference between each state, we use multiple regression methods to explore the relationship between total/renewable energy consumption and the four factors of industrial, geographical, demographic and climatic. We use known data to quantify the four factors and establish multiple regression models with dependent variables. The main influencing factors of each state can be obtained from the model. The reasons for the formation of the same factors and different factors are analyzed in combination with the data.

In order to rationally choose the optimal state for clean energy use, we set up an ETP model to evaluate the energy profile of the four states in 2009. The evaluation contains six evaluation indicators, using the EM,TOPSIS ,PROMETHEE methods to calculate the overall predominance C, and concludes by the C with the largest selection: California is the best state for clean energy use.

Based on the analysis of the problem B, the GM (1,1) prediction model is established by considering four factors. In order to make the prediction more accurate, the GM (1, 1) envelope curve model is optimized by using the exponential smoothing method. The variation range of total energy production/consumption and renewable energy production/consumption is estimated by the prediction model. After screening and linearizing the annual data, the GM (1,1) model is used to determine the more reasonable prediction values in 2025 and 2050.

In order to determine the policy recommendations, the ETP evaluation model is still adopted to evaluate the energy profile predicted by the GM (1,1) envelope curve model. It is concluded that the more the production of renewable resources is, the better the energy situation is. Therefore, in order to improve the production of renewable energy, the multiple regression model of it and four factors is set up, and the policy suggestions are put forward according to the regression model.

Keywords: Renewable Energy; Multiple linear Regression; GM Model;ETP Model

Contents

1 Introduction

1.1 Context of the Problem

Energy production and use is an important part of the national economy. However, in recent years, non-renewable energy resources are scarce and non-renewable energy causes climate problems such as greenhouse effect. Therefore, the development of clean energy is necessary. Clean energy is conducive to sustainable development, energy diversification and environmental improvement. With the common goal of saving energy and developing new energy sources, the Western Interstate Energy Compact came into being. WIEC promotes cooperation between states to achieve the goal of developing and managing energy. Before agreement is reached, there must be an understanding of the conditions within each state in order to formulate policies and targets that are tailored to local conditions.

1.2 Problem Analysis

- **Part1**

  First, by analyzing the energy consumption and production data of the four states over the past 50 years, the comparison results have been made to find the similarities and differences of energy consumption between four states in different industries. Second, find enough industry, traffic, climate, geography, and population data. The multiple regression model between the factors above total energy consumption and the multiple regression model between the factors of renewable energy consumption are set up. The analysis of the impact factors in the regression model results in the difference. Using the ETP evaluation system, the three methods are used to determine the weight, and the overall advantage value is finally obtained. The best state is selected by the standard of four states using the established standards. In the case of government policy, the improved GM model is used to predict.

- **Part2**

  According to the model and evaluation criteria, the production and consumption of renewable energy and the production and consumption of total energy for 2025 and 2050 are predicted. According to the forecast data, the control variable prediction method is used to predict the influence factors of industry, geography and population. According to the results, a reasonable and feasible goal is put forward.

2 Symbol Description

Table 1: Symbol Description

Symbols	Definitions
T	Total Energy Consumption.
C	Renewable Energy Consumption.
EP	Renewable Energy Production.
I	Industrial Factors.
G	Geographical Factors.
P	Demographic Factors.
W	Climatic Factors.
W_1	Fuel Ethanol, excluding denaturant, total consumption
W_2	Geothermal energy total consumption.
W_3	Hydroelectricity Total Production.
W_4	Photovoltaic and Solar Thermal Energy Total Consumption.
W_5	Electricity Produced From Wind Energy.

[1] The variable name given in ProblemCData is no longer listed.

- If there is no special instructions, the text unit of energy are Billion Btu.

3 Part1 A:Energy profiles for four states

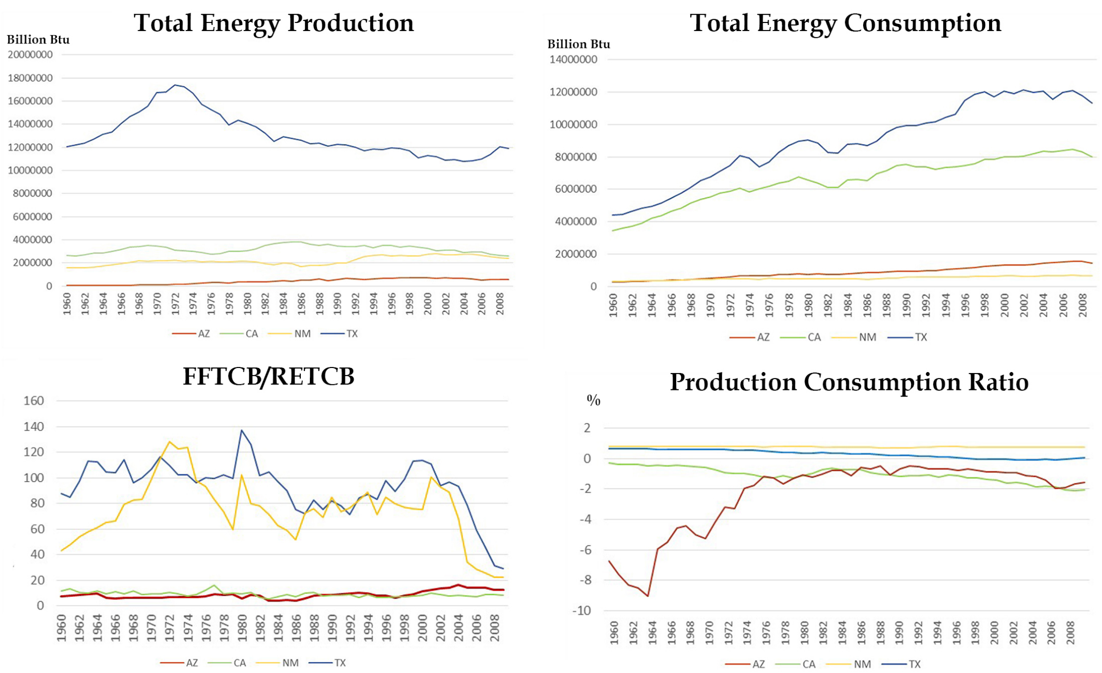

Figure 1: Energy profiles for four states

From the perspective of total energy consumption, the expenditure and consumption of the four states basically showed an increasing trend year by year. We can easily find that the Texas and California were obviously ahead of the remaining two states in terms of the four indicators we use. According to the relevant statistics, this is due to the abundance of natural resources in California and Texas. **From the perspective of total energy production**, the other three states basically maintained a steady trend in a certain range of fluctuations except Texas showed a trend of first rising and then declining. The reason for the phenomenon may be the emergence of clean energy such as wind and gradual replacement of fossil energy in the early 1970s. We use **Production Consumption Ratio** to compare the consumption and production status in each states.

Definition 1. *Production Consumption Ratio*

$$Production\ Consumption\ Ratio = \frac{production - consumption}{production}$$

In Arizona, though less than Texas and California in total energy consumption, has long been in an energy deficit with annual consumption exceeding production. **In New Mexico** ,Energy situation was very steady, less production, less consumption, could meet self-sufficiency and energy surpluses. **In Texas**, Energy production and consumption was very impressive. From the point of view of the ratio of production to consumption, the level of energy surpluses in Texas was similar to New Mexico. **In California**, The production and consumption level were very leading. However, from the perspective of the ratio of production to consumption, the state was experiencing an increasingly serious energy deficit situation.

Definition 2. *Energy Ratio Index*

$$The\ Energy\ Ratio\ Index = \frac{Fossil\ fuel\ total\ consumption}{Renewable\ energy\ total\ consumption}$$

The Energy Ratio Index in **Arizona and California** was stable around 10, showing a similar trend. So it can be seen that in long-term use of energy, the application amount of fossil and renewable energy increased together. The Energy Ratio Index of **New Mexico and Texas** had very large fluctuations. Specific data analysis shows that renewable energy in the two states showed a gradual increasing trend. The violent fluctuation was mainly due to the large changes in the use of fossil energy the tendency of fluctuations to rise, which had changed greatly between two years.

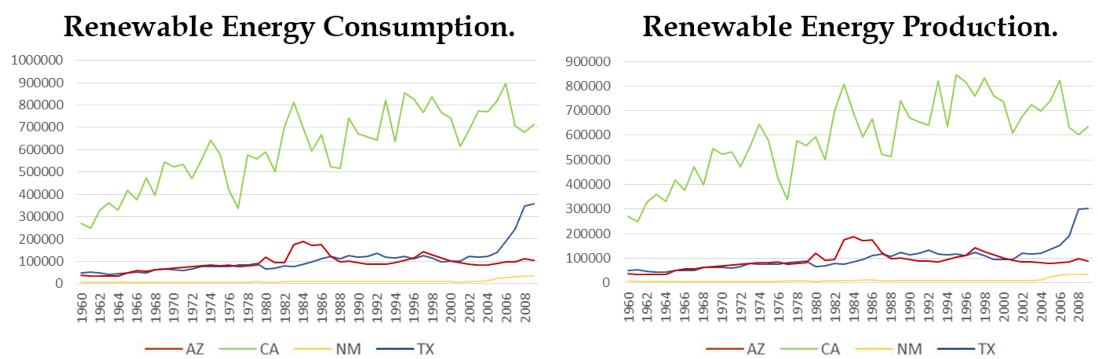

Figure 2: Renewable Energy profiles for four states

The production and consumption of renewable energy were barely the same and it means the four states made full use of renewable energy produced. It is obvious that California was always at a high level and there did exist a growth trend in the fluctuating process. The other three states grew steadily and slowly but when it was near to 1990 Texas did a big jump relatively to itself.

4 Part1 B:Basic Model

For the factors affecting the energy profile, we first consider the geographical, demographic, climatic and industrial factors. According to the relevant documents[2][3],we can know that climate factors, such as sunlight and precipitation, can be transformed into climatic resources under certain conditions, such as solar energy resources, precipitation resources and so on. Therefore, we can use solar energy resources, heat resources, precipitation resources and wind energy consumption (or energy production, in this case, the meaning of the two can be considered as the same) to quantify climate factors. As for the population data, we can calculate it by the ratio of the total energy consumption to the per capita energy consumption. As for the geographical factors, we use the total energy consumption of transportation to quantify geographical factors because of their great impact on traffic and transportation.

Taking these data as independent variables, dimensionless total energy consumption and renewable energy consumption as dependent variables, we can establish the multiple regression models respectively.

4.1 Assumptions

- **Quantify climatic factors into total energy consumption(or production) of climatic resources.**This is reasonable from reference [2][3]
- **Quantify geography into total energy consumed by the transportation sector.** Geography does too much impact on transportion hence we make this quantifying way.
- **Quantify industry into total energy consumed by the industrail sector.**

4.2 Multiple Regression of Total Energy Consumption

$$T_{AZ} = 0.121I + 0.569G + 0.294P + 0.005W_1 + 0.071W_2 + 0.009W_3 - 0.035W_4 + 0.002W_5$$

$$T_{CA} = 0.258I + 0.668G + 0.141P + 0.065W_1 + 0.009W_2 + 0.006W_3 + 0.088W_4 - 0.160W_5$$

$$T_{NM} = 0.337I + 0.556G + 0.245P + 0.037W_1 + 0.024W_2 + 0.033W_3 - 0.103W_4 - 0.021W_5$$

$$T_{TX} = 0.470I + 0.408G + 0.155P - 0.028W_1 - 0.051W_2 - 0.003W_3 + 0.031W_4 + 0.042W_5$$

Where:

- T:Total Energy Consumption.
- I:Industrial Factors.
- G:Geographical Factors.
- P:Demographic Factors.

- W:Climatic Factors.
- W_1:Fuel Ethanol, excluding denaturant, total consumption
- W_2: Geothermal energy total consumption.
- W_3:Hydroelectricity Total Production.
- W_4:Photovoltaic and Solar Thermal Energy Total Consumption.
- W_5:Electricity Produced From Wind Energy.

The whole model can pass the F test, and the several adjusted R^2 of the model are 0.9989, 0.9958, 0.9931 and 0.9996. Measured by this standard, the several equations are pretty to explain the characteristics of the data. The residual can be tested by the normality of Shapiro-Wilk under the condition of 0.05. It can be seen from the residual graph that the residuals fit the homogeneity of variance, indicating that the regression equation can accurately describe the total energy consumption in the four states from 1960 to 2009. It can be seen from the coefficient of variance expansion that there is a collinearity between the independent variables. But because of its actual meaning in the model, it is not appropriate to delete these independent variables.

We can find the similarities and differences from the parameters of the model:

The Similarities: The geographical factors have relatively large coefficients in each states' equation, indicating these factors play an important role in the four states' energy consumption condition. Besides, there is a clear and positive correlation between industrial and demographic factors and the total energy consumption.

The Differences: The effects of climatic factors vary widely in each state. In Arizona, geothermal factors play a major role in all climatic factors. And the solar factor is negatively correlated with total energy consumption. In California, the amount of vegetation and solar energy have a more significant impact, while the wind energy can reduce the total consumption. California is located on the coast and has a mild climate, contributing to the fuel efficiency. So the climate factors in California have an effect of reducing the total energy consumption. In New Mexico, the overall climate factor is negatively correlated with the total energy consumption. Especially, the solar energy factors can reduce the total energy consumption.

4.3 Multiple Regression of Renewable Energy

$$C_{AZ} = 0.044I - 0.569G + 0.724P + 0.130W_1 - 0.186W_2 + 0.931W_3 + 0.103W_4 - 0.027W_5$$

$$C_{CA} = 0.052I + 0.295G - 0.523P + 0.160W_1 + 0.647W_2 + 0.603W_3 + 0.207W_4 + 0.044W_5$$

$$C_{NM} = -0.111I - 0.077G + 0.182P + 0.114W_1 - 0.035W_2 + 0.124W_3 - 0.042W_4 + 0.865W_5$$

$$C_{TX} = -0.004I + 0.239G + 0.088P + 0.316W_1 - 0.569W_2 + 0.150W_3 + 0.275W_4 + 0.807W_5$$

Where:

- C:Renewable Energy Consumption.

Similar to the model 1, the model 2 also pass the F test, its adjusted R^2 of the model are 0.9896, 0.9934, 0.9725 and 0.9815. Measured by this standard, the several equations are pretty to explain the characteristics of the data. The residual can be tested by the normality of Shapiro-Wilk under the condition of 0.05. It can be seen from the residual graph that the residuals fit the homogeneity of variance, indicating that the regression equation can accurately describe the renewable energy consumption in the four states from 1960 to 2009. It can be seen from the coefficient of variance expansion that there is a collinearity between the population and transportation. But because of its actual meaning in the model, it is not appropriate to delete the two variables.

In terms of the consumption of renewable energy, the similarity among the four states is that the industrial factors affected less. In other ways, the situation in several states is very different.

In Arizona, population plays an important role in the consumption of renewable energy while the geographical factors play a negative role. From the climatic factors, we can see that the consumption of renewable energy is mainly related to hydropower. Arizona should encourage the development of geothermal and wind energy to reduce the energy dependence on hydropower because the geographical and wind factors can reduce the renewable energy consumption.

In California, the factors of population will reduces the consumption of renewable energy while the geographical can increase it. The influence of climate factors is not as obvious as that of Arizona. But the influence of geothermal and hydropower is greater and the two factors can increase the renewable energy consumption. This is consistent with the statistics, the per capita energy consumption is smaller because of the pretty climate can make the energy efficient.

In New Mexico, the geographical and demographic factors influence less while the climatic factors influence more. Meanwhile, the wind energy plays the major part in all climatic factors. So the government of New Mexico should encourage the development of wind energy.

In Texas, demographic factors influence less, geographical factors make the renewable energy consumption increase and the climatic factors influence most especially the plant and wind energy. The geothermal factors can greatly reduce the consumption of renewable energy, so the development of geothermal energy, the vegetation construction and the use of wind power should be paid attention to.

5 Part1 C:The "Best" Profile

5.1 The Evaluation Index

- **Assumptions: Total electricity production is regarded as much as total electricity consumption minus net imports of electricity into the United States.**

To select the best state for clean energy use, we evaluate the four states in 2009. According to relevant document, the evaluation indicators of the development and utilization of renewable energy are as follows[4]:

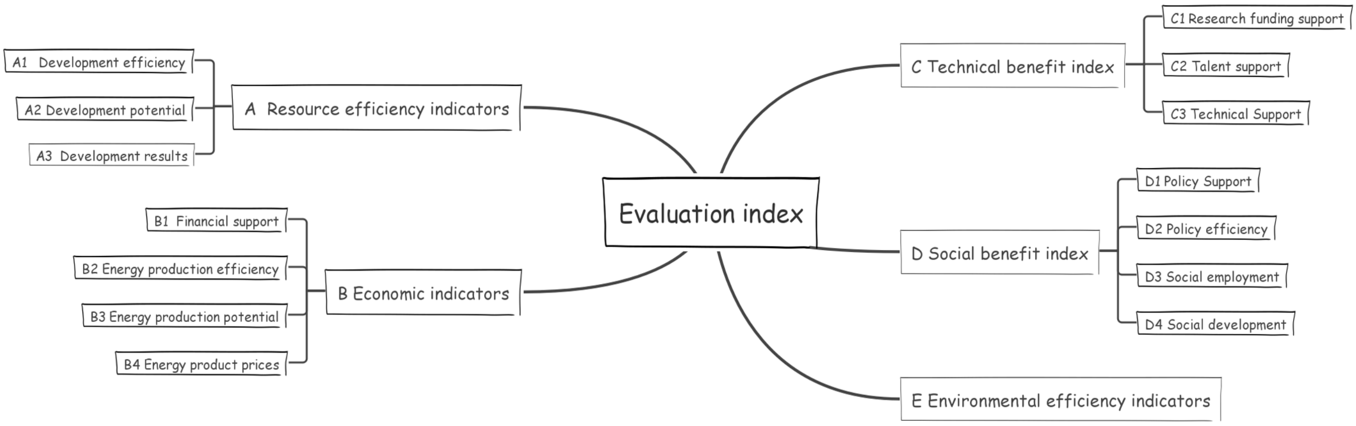

Figure 3: Evaluation Index

We make amendments to the above indicators to make it applicable to our subject:

- Regard the development efficiency A1 in A equivalently as the energy production efficiency B2 in B, which is equal to the ratio of the electricity production generated from renewable energy to the total electricity production.
- Regard the development potential A2 equivalent as the energy production potential B3, which is equal to the growth rate of electricity production generated from renewable energy.
- Regard the development results A3 as the ratio of renewable energy consumption to total energy consumption.
- Energy product prices B4 in B has been listed.
- Consider only one element C1 in C, which can be considered as the ratio of total energy expenditure in industry to GDP.
- Consider only social employment D3 in social benefit D, which can be considered to be equal to the ratio of renewable energy production to total energy production.

In most cases, there are mainly three kinds of index of the comparison: the first is benefit index, the bigger data represent the better situation, the second is cost index, the smaller data represent the better situation, the third is intermediate index, the better data is closer to the intermediate value. In summary, the final indicators are as below:

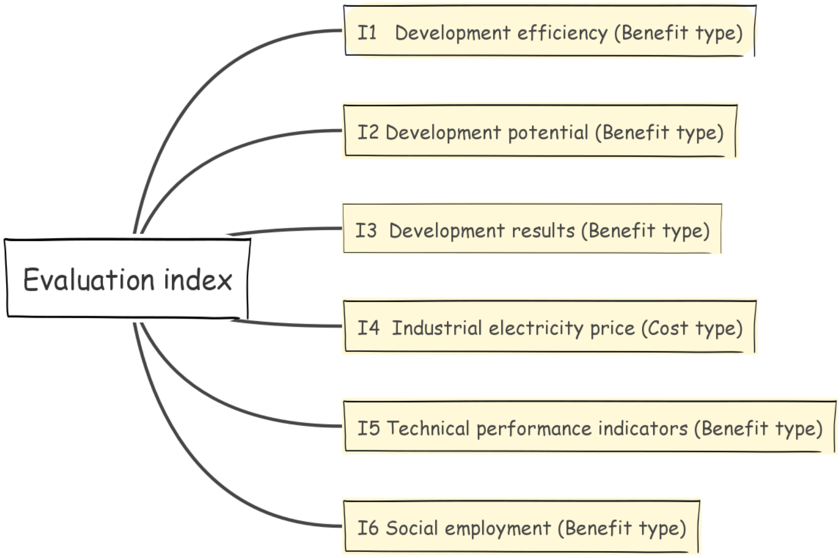

Figure 4: ETP Evaluation Index

5.2 EM-TOPSIS-PROMETHEE Model

In response to the above set of indicators, we need to establish a model to evaluate the states' consumption of renewable energy.

We use the integrated evaluation model of AGA-EAHP-EM-TOPSIS-PROMETHEE[4]. The model mainly includes two modules, one is the weight determination module, the other is the module of program evaluation. The weight determination module is mainly composed of extended analytic hierarchy process (AGA-EAHP) and an entropy method (EM) based on accelerated genetic algorithm. And the program evaluation module mainly consists of the technique for order preference by similarity to an ideal solution (TOPSIS) and the preference ranking organization methods for enrichment evaluations (PROMETHEE).

According to this model mentioned above, we exclude some of the most subjective parts to establish the integrated evaluation model of EM-TOPSIS-PROMETHEE (abbreviated as ETP model) to manage our project. The specific steps are as follows:

In a decision problem, we set $O = [o_1, o_2, ..., o_m]$ to be the set of schemes need to be evaluated, $I = [I_1, I_2, ...I_n]$to be the set of evaluation indicators and $X = (x_{ij})_{m\times n}$ to be the decision matrix $x_{ij}$is the attribute value of scheme i relative to the indicator j).

First,we normalize the data, The processing method can be listed as follows: If the index is the benefit index:

$$x'_{ij} = \frac{x_{ij}}{max_i\, x_{ij}}$$

If the index is the cost index:

$$x'_{ij} = \frac{min_i\, x_{ij}}{x_{ij}}$$

Then,we can get the matrix$X' = (x'_{ij})_{m\times n}$. Using entropy method to determine the weight.

- Calculating the weight of each attribute value

$$p_{ij} = x_{ij} / \sum_{i=1}^{m} x_{ij}$$

- Calculating the entropy of each index

$$e_j = -(\ln m)^{-1} \sum_{i=1}^{m} p_{ij} \ln p_{ij}$$

  If necessary, perform translation on p_{ij}.

- Calculating the difference coefficient of each index.

$$g_j = 1 - e_j$$

- Calculating the final weight of each indicator and getting the set of weight.

$$v_j = g_j / \sum_{j=1}^{n} g_j$$

$$V = [v_1, v_2, ..., v_n]$$

Conducting a comprehensive evaluation

- Making the decision matrix weighted normalized.

$$Z = (z_{ij})_{m \times n}, z_{ij} = v_j \times x'_{ij}$$

- Determining the positive ideal and the negative ideal

$$Z^+ = (z_1^+, z_2^+, ..., z_n^+) \quad Z^- = (z_1^-, z_2^-, ..., z_n^-)$$

  Where:

  - $z_i^+ = max(x'_{ij})$, $z_i^- = min(x'_{ij})$

- Calculating the Euclidean distance of each evaluation scheme

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (z_{ij} - z_j^+)^2} \quad d_i^- = \sqrt{\sum_{j=1}^{n} (z_{ij} - z_j^-)^2}$$

- Determining the priority function for each index based on the dimensionless decision matrix.

$$P_j(d_{ab}) = F_j[d_j(a, b)], d_j(a, b) = x'_{aj} - x'_{bj}$$

  Selecting the priority functions.

$$P(d) = \begin{cases} 1 & \text{if} \quad d > p \\ d/p & \text{if} \quad d \leq p \end{cases} \tag{1}$$

- Determining the priority index relationship for all evaluation objects

$$\pi(d_{ab}) = \sum_{j=1}^{n} P_j(d_{ab}) v_j$$

- The formulas for calculating the positive flow and negative flow of each evaluation target are as follows:

$$\phi^+(d_j) = \frac{1}{m-1}\sum_{k=1}^{m}\pi(d_{jk})$$

$$\phi^-(d_j) = \frac{1}{m-1}\sum_{k=1}^{m}\pi(d_{kj})$$

  Where:

  - $k = 1, 2, ..., m, k \neq i$

- Normalizing the positive/negative Euclidean distance and the positive/negative flow value to get: D_i^+, D_i^-, Φ_i^+ and Φ_i^-

- Combining theD_i^+, D_i^-, Φ_i^+andΦ_i^-, The greater the value is, the better the evaluation object is. The specific formula is as follows:

$$S_i^+ = \sigma\Phi_i^+ + (1-\sigma)D_i^- \quad S_i^- = \sigma\Phi_i^- + (1-\sigma)D_i^+$$

  Let $\sigma = 0.5$.

- Calculating the overall superiority value:

$$C_i^+ = S_i^+ - S_i^-$$

  Getting the best evaluation object by sorting.Running the program and getting the result:

Table 2: Evaluation Results

Index	AZ	**CA**	NM	TX
S_i^+	-0.213	0.947	-5.491	-5.038
S_i^-	0.521	-0.394	1.000	-5.881
C_i^+	-0.734	**1.341**	-6.491	0.843
d_1	2.314	2.174	2.326	2.203
d_2	0.740	0.878	0.758	0.981
D_1	0.995	0.935	1.000	0.947
D_2	0.754	0.895	0.772	1.000
ϕ_1	-0.023	0.020	-0.232	-0.218
ϕ_2	0.003	-0.098	0.057	-0.724
Φ_1	-1.181	1.000	-11.755	-11.075
Φ_2	0.047	-1.723	1.000	-12.709

So, according to the evaluation criteria, the best state for renewable resources development is **California**.

5.3 Rationality and Superiority

It can be seen from the process of establishment that the ETP model is a very special case of the integrated evaluation model of AGA-EAHP-EM-TOPSIS-PROMETHEE. The ETP model overcomes the shortcomings of the subjectivity of Analytic Hierarchy Process (AHP) and gets rid of the disadvantage of requiring a large amount of data of TOPSIS. The ETP model prefers the PROMETHEEE in terms of steps. But it is easier. Therefore, we think it is reasonable and superior to evaluate the general situation of renewable energy consumption by using the ETP model.

6 Part1 D:Prediction Model

From the existing analysis, four main factors (industrial factors, geographical factors, population factors and climate factors) make significant difference between total energy consumption and renewable energy consumption in four states. But in addition to these four factors, there are still many unknown factors affecting these variables. And it can be seen from the diagram that although the energy data has a monotonous trend, it presents irregular fluctuations. So, in this case, we try to use the GM(1,1) model to predict.

Use a step to process the data so that it can be tested by the level than test.

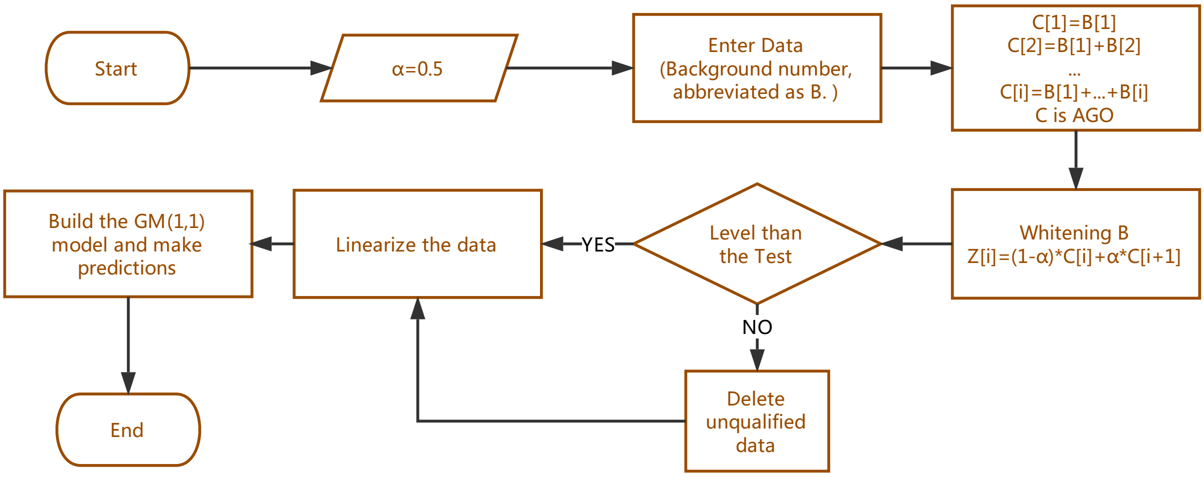

Figure 5: Data Processing Flow Chart

Where:

- The GM (1,1) prediction model requires that the annual data be continuous. Because the level ratio test data from the data of the year may be interrupted, so we use the arithmetic sequence of data interpolation, get the linearization of the data.
- To test the background number after whitening by level than the test. The specific condition is as follows:

$$\sigma(k) = \frac{x^{(0)}(k)}{x^{(0)}(k-1)} / ln(e^{-\frac{2}{n+1}}, e^{\frac{2}{n+1}})$$

6.1 The Basic GM(1,1) Model

- We number the four states and the 605 kinds of energy. According to the request of the subject, we need to consider the situation of total energy and renewable energy. So we choose the four indicators of total energy consumption, renewable energy consumption, total energy production and renewable energy production. Then we set the generation coefficient/alpha to 0.5, which is set as the equal weights neighbor generated number (the usual settings for the model).

- Selecting an indicator and importing the data. Regarding the initial data as the background number $x^{(0)}$.

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(n))$$

- The process of adding the background number $x^{(0)}$. one by one to get the sequence $x^{(1)}$ called AGO. The specific formula is as follows.

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i)$$

- Whitening the background number can get the sequence Z. The specific formula is as follows.

$$z^{(0)}(k) = \alpha x^{(0)(k+1)} + (1-\alpha)x^{(0)(k-1)}$$

- Since the new data obtained in the preprocessing stage of the data are in good nature, there is no need to do the level than the test.

- $u = (a,b)^T, Y = (x^{(0)}(2), x^{(0)}(3), ..., x^{(0)}(n))^T$,

$$B = \begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ ... & ... \\ -z^{(1)}(n) & 1 \end{pmatrix} \tag{2}$$

By using the Least squares method,Find the smallest value of

$$J(\hat{u}) = (Y - B\hat{u})^T(Y - B\hat{u})$$

,and at the same time $\hat{u} = (a,b)^T = (B^TB)^{-1}B^TY$.

- Making predictions and testing the results. Build the model:

$$x^{(1)}(k+1) = (x^{(0)} - \frac{b}{a})e^{-ak} + \frac{b}{a},\ k = 1,2,...,n-1$$

Where:

  – $\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k)$

Finally, the predicted value is obtained.

6.2 Model Test

- Testing the residual

$$\varepsilon(k) = |\frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)}|$$

If $\varepsilon(k) < 0.2$, the data can be considered to meet the general requirements. If $\varepsilon(k) < 0.1$, the data can be considered to meet the higher requirements.

- Level deviation test

$$\rho(k) = 1 - (\frac{1-0.5a}{1+0.5a})\lambda(k)$$

If $\rho(k) < 0.2$,the data can be considered to meet the general requirements.If $\rho(k) < 0.1$,the data can be considered to meet the higher requirements.

6.3 Improved GM Model

6.3.1 Exponential Smoothing Method[5]

The prediction accuracy is high if the prediction range is large and the complementarity factors is enough. We need to predict the energy situation by the data from 1960 to 2009. So the prediction error increases with the exponential model. In order to reduce the error, we use the exponential weighting method to reduce the randomness of the sequence, make full use of the useful information and make the prediction more accurate.

- For the orignal sequence $x^{(0)}(k)$,

$$y^{(0)}(k) = \alpha x^{(0)}(k) + (1-\alpha)y^{(0)}(k-1), k = 1, 2, ..., N, 0 < \alpha < 1$$

- Setting a GM model for the new sequence $y^{(0)}(k)$ and predicting to get the$\hat{y}^{(0)}(k)$
- Restore the number of columns:$\hat{x}^{(0)}(k)$

$$\hat{x}^{(0)}(k) = [\hat{y}^{(0)}(k) - \hat{y}^{(0)}(k-1)]/\beta,\ k = 1, 2, ...N, N+1, ...N+m$$

Because of the large fluctuation and weak monotonous trend, it is difficult for the GM model to predict the accurate result by using exponential smoothing method. So we choose the GM(1,1) envelope curve model.

6.3.2 The GM(1,1) Envelope Curve Model

The specific process[5] is as follows:

- Eliminating the abnormal values of the original data and establishing the main model. The curve at this time is called the curve 1
- The upper edge of the curve 1 connected to the curve 2, which becomes the upper envelope curve.
- The lower edge point of the curve 1 is connected to the curve 3, which becomes the lower envelope curve.
- Modeling the upper and lower envelope curves in Exponential Smoothing Method.
- The interval defined by the upper and lower envelope curves is the grey interval of the curve.And it helps determine the upper and lower limits of the forecast range.

We can get an interval of the predicted value from the above method. Strictly speaking, this is not a simple prediction, but a group of prediction models. In a group of models, one of the most suitable prediction models can be found by qualitative analysis. The predicted value of the model is the final prediction value.

To sum up, we can get the change range of total energy consumption, total energy production, renewable energy production and renewable energy consumption in the four states, and the prediction results are as follows:

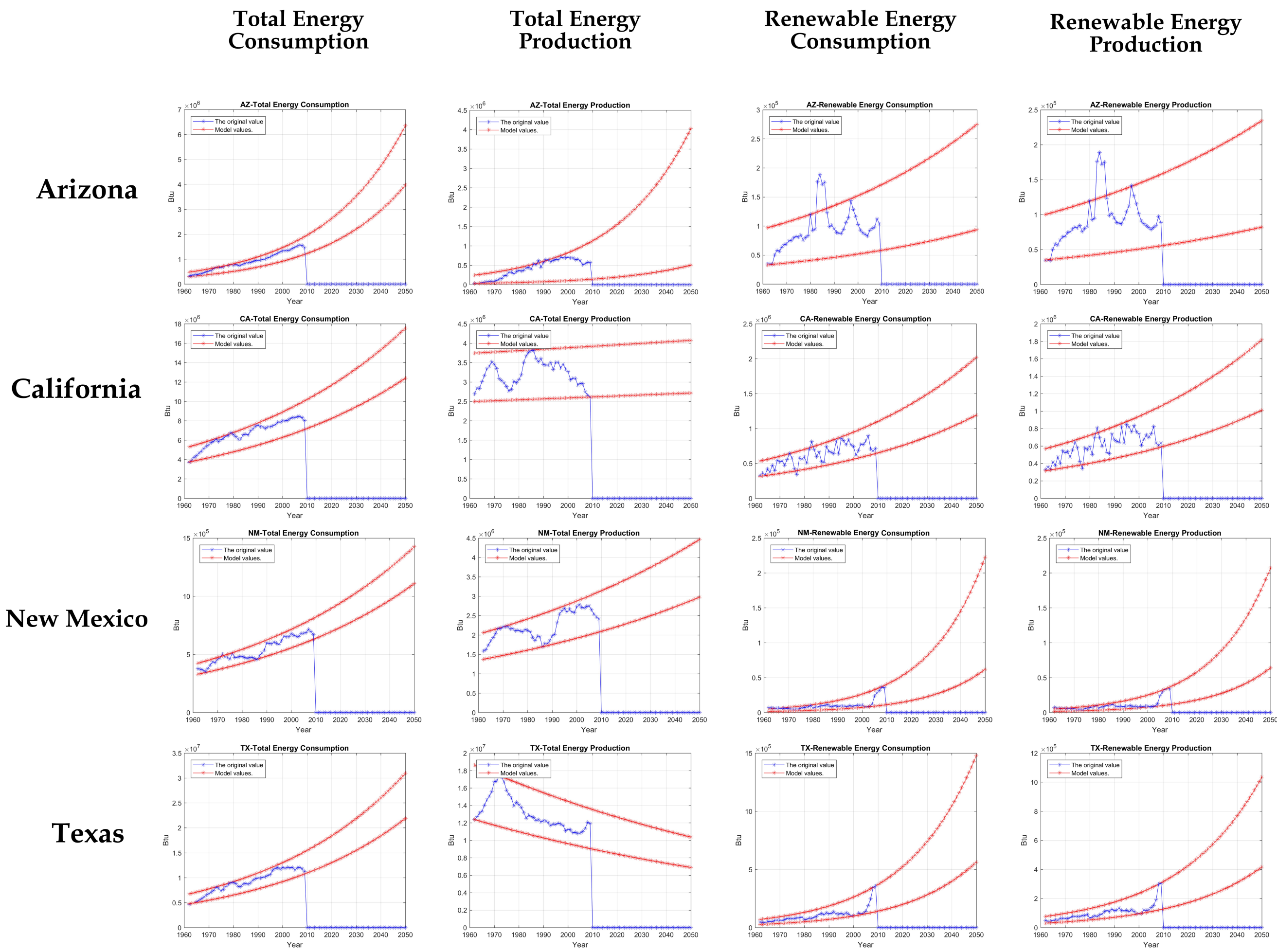

Figure 6: Data Prediction

With 5 years as a unit time, from 1960 to 2009, a better sequence $x^{(0)}(k)$ can be obtained. A new GM(1,1) model can be established and applied directly to get the corresponding values in 2025 and 2050. The data in 2025 and 2050 pass the residual test.

Table 3: Forecast Data

CA	2025	2050	**AZ**	2025	2050
TC	9761430.51	12618206.92	TC	2281293.883	4615303.741
RC	1021441.561	1407906.808	RC	116904.9929	143532.9666
TP	3487053.907	3674356.423	TP	837636.2699	1175807.948
RP	932238.3668	1207710.384	RP	97109.97024	105668.5885
NM	2025	2050	**TX**	2025	2050
TC	851590.8675	1189126.205	TC	15807790.59	23733590.31
RC	45584.37662	160318.7689	RC	199754.4955	333504.9802
TP	3203556.816	4081461.923	TP	9327042.826	7275942.773
RP	47826.21042	178629.6082	RP	196272.5424	325689.657

Where:

- TC: Total Energy Consumption.
- RC: Renewable Resources Energy Consumption.
- TP: Total Energy Production.
- RP: Renewable Resources Energy Production.

6.4 Optimization of Model

With 5 years as a unit time, from 1960 to 2009, a better sequence $x^{(0)}(k)$ can be obtained. A new GM(1,1) model can be established and applied directly to get the corresponding values in 2025 and 2050. The data in 2025 and 2050 pass the residual test.

- Optimization of model background value

The construction of the background value $Z^{(1)}(k)$ is one of the simulation error $\hat{\varepsilon}^{(0)}(k) = \hat{x}^{(1)}(k) - x^{(1)}(k)$ and the accuracy of the GM(1,1) model.

The relevant document[6] proposes an optimized background value

$$Z^{(1)}(k) = \frac{x^{(1)}(k) - x^{(1)}(k-1)}{\ln x^{(1)}(k) - \ln x^{(1)}(k-1)}, k = 2, 3, ...n$$

That is, the background value of the model is predicted by the optimized grey GM(1,1) model.

- Optimization of the corresponding function of time

The time response function of the traditional GM(1,1) prediction model is based on the initial condition of $\hat{x}^{(1)}(1) = x^{(1)}(1) = x^{(0)}(1)$ In this way, the fitting curve $\hat{x}^{(1)}(1)$ is bound to pass through the point $(1, x^{(1)}(1))$. But it is known that the fitting curve does not have to pass the first data point. At the same time, taking $\hat{x}^{(1)}(1) = x^{(1)}(1) = x^{(0)}(1)$ as the initial condition does not accord with the "new information priority principle" in grey system theory. So it is very unreasonable.

The relevant document[6] proposes an optimized time response function as follows:

$$\hat{x}^{(1)}(k+1) = \frac{\sum_{i=1}^{n}(x^{(1)}(i) - \frac{b}{a})e^{-ai}}{\sum_{i=1}^{n} e^{-2ai}} + \frac{b}{a}, k = 1, 2, ...n$$

According to the above two optimization methods, we establish a new GM(1,1) model. Based on the model, we can predict the relevant data.

Table 4: The Relevant Data

	2025	2050
AZ	97109.97024	105668.5885
CA	932238.3668	1207710.384
NM	47826.21042	178629.6082
TX	196272.5424	325689.657

7 Part2: Four State Energy Targets and Actions

Based on a series of range data predicted by the GM (1,1) envelope curve model, we use the ETR model to select the best energy profile and use it as the goal of each state's development.

7.1 Assumptions

- **The rate of electricity produced from renewable energy and renewable energy production remains still.**The rate of electricity total production and energy total consumption remains still.
- **The value of I2 remains as much as it is in 2009.** That is growth rate of electricity total production from renewable energy remains still.
- **I4-I6 are under impact of politics.**Hence in this condition I4-I6 can be regarded as functions of only time.

Based on the above assumptions, $I_4 \sim I_6$ are policy-related indicators which can be considered as functions of time. So they can be considered as an invariants in this ETP evaluation model.

Above all, here comes a conclusion that the result of the ETR evaluation model is just depend on I3. That is the bigger I_3 shows, the better the corresponding energy profile is. Because of the value of I_3 equal to the rate of Renewable Energy Production and Total Energy Consumption we got that the bigger renewable energy production is, the better its corresponding energy profile is. Then we can choose the biggest renewable energy production as the required goal.

Table 5: Goal

	2025	2050
AZ	184033.9849	234365.4162
CA	1305802.627	1816468.488
NM	71834.50437	207194.2317
TX	493628.7362	1034408.458

7.2 Multiple Regression of Renewable Energy Production

In order to clarify the impact of geographical, industrial, demographic and climatic factors on the production of renewable energy, the multiple regression model is set up as follows.

$$EP_{AZ} = 0.056I - 0.645T + 0.786P + 0.004W_1 - 0.156W_2 + 0.936W_3 + 0.076W_4 - 0.020W_5$$

$$EP_{CA} = 0.054I + 0.315T - 0.556P + 0.010W_1 + 0.685W_2 + 0.638W_3 + 0.217W_4 + 0.052W_5$$

$$EP_{NM} = -0.141I - 0.088T + 0.242P - 0.016W_1 - 0.028W_2 + 0.145W_3 - 0.034W_4 + 0.918W_5$$

$$EP_{TX} = 0.005I + 0.261T + 0.141P + 0.073W_1 - 0.808W_2 + 0.181W_3 + 0.373W_4 + 1.121W_5$$

Where:

- EP:Renewable Energy Production.

The whole model can pass the F test, and the several adjusted R2 of the model are 0.9894, 0.9925, 0.9711 and 0.9712. Measured by this standard, the several equations are pretty to explain the characteristics of the data. The residual can be tested by the normality of Shapiro-Wilk under the condition of 0.05. It can be seen from the residual graph that the residuals fit the homogeneity of variance, indicating that the regression equation can accurately describe the renewable energy consumption in the four states from 1960 to 2009. It can be seen from the coefficient of variance expansion that there is a collinearity between the independent variables. But because of its actual meaning in the model, it is not appropriate to delete these independent variables.

We believe that the implementation of the policy has a great impact on industry, transportation and population while the impact on the consumption of climatic resources is relatively small. As for the production of renewable energy, industrial factors have less impact. In other ways, the situation in several states is very different. In Arizona, the increase in population has an important positive effect on increasing the production of renewable energy, the increase of traffic energy consumption can reduce the production of renewable energy. In California, the increase of population can reduce the production of renewable energy, the increase of traffic energy consumption can increase the production of renewable energy. In addition, California has lower per capita energy consumption due to its more efficient use of energy due to the right climate. In New Mexico, the impact of geography is small. In Texas, the population has small impact, and the increase of traffic energy consumption can increase the production of renewable energy.

7.3 The Policy

- The four states unite for building common transportation system, popularizing renewable and cleaned energy for transportation, communicating each other about new technology and carrying out corresponding fertility policy.
- In California,the government should pay more attention to the development of industry, improve the level of urban traffic and control the population.
- In Arizona ,the government should emphasize the development of the industry, popularize the use of clean traffic energy and promote population growth.
- In New Mexico, the governmentneeds great efforts to manage traditional industries and transport and promote population growth.
- In Texas the government,should pay attention to the development of industry, improve the level of urban traffic and promote population growth.

8 Sensitivity Analysis

During the construction of the gray prediction model GM(1,1), the number of neighbor generation can be constructed by the following formula:

$$z^{(0)}(k) = \alpha x^{(0)}(k+1) + (1-\alpha)x^{(0)}(k-1)$$

Normally, the value of α is 0.5. Then we change the value of α to study its effect on the result of the function. The following table lists the changes in the total energy consumption of California in 2025 and 2050 when the value of α is changed.

Table 6: The Change α

α	2025	2050	2025	2050	α	2025	2050	2025	2050
0.41	10275579	13282826	0	0	0.51	10275579	13282826	0	0
0.42	10275579	13282826	0	0	0.52	10275579	13282826	0	0
0.43	10275579	13282826	0	0	0.53	10275579	13282826	0	0
0.44	10275579	13282826	0	0	0.54	10275579	13282826	0	0
0.45	10275579	13282826	0	0	0.55	10275579	13282826	0	0
0.46	10275579	13282826	0	0	0.56	10275579	13282826	0	0
0.47	10275579	13282826	0	0	0.57	10275579	13282826	0	0
0.48	10275579	13282826	0	0	0.58	10275579	13282826	0	0
0.49	10275579	13282826	0	0	0.59	10275579	13282826	0	0
0.5	10275579	13282826	0	0	0.6	10275579	13282826	0	0

The first row of the table is the year, the first column is the α value. The second and the third column respectively is the predicted data of the model in 2025 and 2050. The fourth and fifth columns are the relative errors between the predicted data whenÎśtakes different values and 0.5 in 2025 and 2050.

The table shows that there is no significant change in the data we care about when changing the value of α. The changes in the other three states is similar to that in California. We list only one state's data to illustrate the results.Other results are in the appendix.Therefore, it can be concluded that the model's data will not be affected when the value of Îś takes a slight change in 0.5.

9 Strengths and Weaknesses

- Strengths
  - The effects of 4 factors on total energy consumption and renewable resources are investigated by multiple regression. The model reflects the actual situation comprehensively and objectively, and the $R^2$of the model is very good. The residual can also be proved to be very stable by the normality test.
  - The evaluation method of this paper combines three methods: EM, TOPSIS, and PROMETHEE. Although each method has its own defects, the comprehensive use effect is very good.
  - In this paper, the basic GM model is not only used in the prediction, but also the model is further improved. Because of more data and longer prediction time, the results of GM model may have great error. The use of exponential smoothing and enveloping models can greatly improve this situation.
- Weaknesses
  - In the regression model, in order to make the model practical, some colinear variables are not deleted. These variables affect the accuracy of the model to a certain extent.

- In Part 2, due to the lack of accurate data, there are only a few indexes after the hypothetical evaluation system, which makes a certain defect compared to the full evaluation model.

10 Our Memo

To: Mr. Governors

From: Team#81166

Date: 13 February, 2018

Subject: Profile , Predictions and Recommended goals

Over the past 50 years, the four states have a great difference in the production and consumption of total energy, as well as the production and consumption of renewable energy.

According to the data,it can be found that, in Arizona, although energy consumption is less, has long been in an energy deficit. In New Mexico's energy situation was very steady with less production and consumption, could meet self-sufficiency and energy surpluses. In Texas the energy situation was very impressive with abundant consumption and production. The production and consumption level of California the energy level were leading. However, from the perspective of the ratio of production to consumption, the state was experiencing an increasingly serious energy deficit situation.

Combined with the data of the past 50 years in each state, we have adopted an improved GM(1,1) model to predict the trend of the next 50 years. The total energy consumptionof the four states showed a significant upward trend, while the growth rate of energy production is relatively slow. It is a wonder that the total energy production in Texas will decline. In the aspect of renewable energy production and consumption, the rate of growth in New Mexico and Texas is evident, suggesting that the two have the great potential in the development of renewable energy. The other two states are growing slowly but at a higher starting point. There were systems for the development and utilization of renewable energy in a large scale.According to the data in 2050,the four indicators in California and Texas are more than twice those in New Mexico and Arizona.

Based on the above prediction, we make the following suggestions.Interstate cooperation is useful. For example, in renewable resources, because of the late start of Texas, California can carry out technical support to Texas and accelerate the development of Texas. In terms of total energy production and consumption, California is in a state of energy deficit for a long time. Texas can support resources in California to alleviate the energy deficit in California.

To sum up, our goals are as follows:

The goal of renewable energy production to California is 1300.802.62 Billion Btu in 2025 and 1816468.488 Billion Btu in 2050;to Arizona is 184033.9849 Billion Btu in 2025 and 234365.4162 Billion Btu in 2050; to New Mexico is 71834.50437 Billion Btu in 2025 and 207194.2317 Billion Btu in 2050; to Texas is 493628.7362 Billion Btu in 2025 and 1034408.458 Billion Btu in 2050.

Sincerely,Team#81166.

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Appendices

Table 7: The Change Of α CATC

α	2025	2050	2025	2050
0.4	10275579.08	13282826	0	0
0.41	10275579.08	13282826	0	0
0.42	10275579.08	13282826	0	0
0.43	10275579.08	13282826	0	0
0.44	10275579.08	13282826	0	0
0.45	10275579.08	13282826	0	0
0.46	10275579.08	13282826	0	0
0.47	10275579.08	13282826	0	0
0.48	10275579.08	13282826	0	0
0.49	10275579.08	13282826	0	0
0.5	10275579.08	13282826	0	0
0.51	10275579.08	13282826	0	0
0.52	10275579.08	13282826	0	0
0.53	10275579.08	13282826	0	0
0.54	10275579.08	13282826	0	0
0.55	10275579.08	13282826	0	0
0.56	10275579.08	13282826	0	0
0.57	10275579.08	13282826	0	0
0.58	10275579.08	13282826	0	0
0.59	10275579.08	13282826	0	0
0.6	10275579.08	13282826	0	0

Table 8: The Change Of α CARC

α	2025	2050	2025	2050
0.4	1089318.275	1501464.865	0	0
0.41	1089318.275	1501464.865	0	0
0.42	1089318.275	1501464.865	0	0
0.43	1089318.275	1501464.865	0	0
0.44	1089318.275	1501464.865	0	0
0.45	1089318.275	1501464.865	0	0
0.46	1089318.275	1501464.865	0	0
0.47	1089318.275	1501464.865	0	0
0.48	1089318.275	1501464.865	0	0
0.49	1089318.275	1501464.865	0	0
0.5	1089318.275	1501464.865	0	0
0.51	1089318.275	1501464.865	0	0
0.52	1089318.275	1501464.865	0	0
0.53	1089318.275	1501464.865	0	0
0.54	1089318.275	1501464.865	0	0
0.55	1089318.275	1501464.865	0	0
0.56	1089318.275	1501464.865	0	0
0.57	1089318.275	1501464.865	0	0
0.58	1089318.275	1501464.865	0	0
0.59	1089318.275	1501464.865	0	0
0.6	1089318.275	1501464.865	0	0

Table 9: The Change Of α CATP

α	2025	2050	2025	2050
0.4	3523808.063	3713084.781	0	0
0.41	3523808.063	3713084.781	0	0
0.42	3523808.063	3713084.781	0	0
0.43	3523808.063	3713084.781	0	0
0.44	3523808.063	3713084.781	0	0
0.45	3523808.063	3713084.781	0	0
0.46	3523808.063	3713084.781	0	0
0.47	3523808.063	3713084.781	0	0
0.48	3523808.063	3713084.781	0	0
0.49	3523808.063	3713084.781	0	0
0.5	3523808.063	3713084.781	0	0
0.51	3523808.063	3713084.781	0	0
0.52	3523808.063	3713084.781	0	0
0.53	3523808.063	3713084.781	0	0
0.54	3523808.063	3713084.781	0	0
0.55	3523808.063	3713084.781	0	0
0.56	3523808.063	3713084.781	0	0
0.57	3523808.063	3713084.781	0	0
0.58	3523808.063	3713084.781	0	0
0.59	3523808.063	3713084.781	0	0
0.6	3523808.063	3713084.781	0	0

Table 10: The Change Of α CARP

α	2025	2050	2025	2050
0.4	981996.1587	1272171.367	0	0
0.41	981996.1587	1272171.367	0	0
0.42	981996.1587	1272171.367	0	0
0.43	981996.1587	1272171.367	0	0
0.44	981996.1587	1272171.367	0	0
0.45	981996.1587	1272171.367	0	0
0.46	981996.1587	1272171.367	0	0
0.47	981996.1587	1272171.367	0	0
0.48	981996.1587	1272171.367	0	0
0.49	981996.1587	1272171.367	0	0
0.5	981996.1587	1272171.367	0	0
0.51	981996.1587	1272171.367	0	0
0.52	981996.1587	1272171.367	0	0
0.53	981996.1587	1272171.367	0	0
0.54	981996.1587	1272171.367	0	0
0.55	981996.1587	1272171.367	0	0
0.56	981996.1587	1272171.367	0	0
0.57	981996.1587	1272171.367	0	0
0.58	981996.1587	1272171.367	0	0
0.59	981996.1587	1272171.367	0	0
0.6	981996.1587	1272171.367	0	0

Table 11: The Change Of α AZTC

α	2025	2050	2025	2050
0.4	2624007.728	5308650.837	0	0
0.41	2624007.728	5308650.837	0	0
0.42	2624007.728	5308650.837	0	0
0.43	2624007.728	5308650.837	0	0
0.44	2624007.728	5308650.837	0	0
0.45	2624007.728	5308650.837	0	0
0.46	2624007.728	5308650.837	0	0
0.47	2624007.728	5308650.837	0	0
0.48	2624007.728	5308650.837	0	0
0.49	2624007.728	5308650.837	0	0
0.5	2624007.728	5308650.837	0	0
0.51	2624007.728	5308650.837	0	0
0.52	2624007.728	5308650.837	0	0
0.53	2624007.728	5308650.837	0	0
0.54	2624007.728	5308650.837	0	0
0.55	2624007.728	5308650.837	0	0
0.56	2624007.728	5308650.837	0	0
0.57	2624007.728	5308650.837	0	0
0.58	2624007.728	5308650.837	0	0
0.59	2624007.728	5308650.837	0	0
0.6	2624007.728	5308650.837	0	0

Table 12: The Change Of α AZRC

α	2025	2050	2025	2050
0.4	121826.1775	149575.0714	0	0
0.41	121826.1775	149575.0714	0	0
0.42	121826.1775	149575.0714	0	0
0.43	121826.1775	149575.0714	0	0
0.44	121826.1775	149575.0714	0	0
0.45	121826.1775	149575.0714	0	0
0.46	121826.1775	149575.0714	0	0
0.47	121826.1775	149575.0714	0	0
0.48	121826.1775	149575.0714	0	0
0.49	121826.1775	149575.0714	0	0
0.5	121826.1775	149575.0714	0	0
0.51	121826.1775	149575.0714	0	0
0.52	121826.1775	149575.0714	0	0
0.53	121826.1775	149575.0714	0	0
0.54	121826.1775	149575.0714	0	0
0.55	121826.1775	149575.0714	0	0
0.56	121826.1775	149575.0714	0	0
0.57	121826.1775	149575.0714	0	0
0.58	121826.1775	149575.0714	0	0
0.59	121826.1775	149575.0714	0	0
0.6	121826.1775	149575.0714	0	0

Table 13: The Change Of α AZTP

α	2025	2050	2025	2050
0.4	896743.9415	1258778.651	0	0
0.41	896743.9415	1258778.651	0	0
0.42	896743.9415	1258778.651	0	0
0.43	896743.9415	1258778.651	0	0
0.44	896743.9415	1258778.651	0	0
0.45	896743.9415	1258778.651	0	0
0.46	896743.9415	1258778.651	0	0
0.47	896743.9415	1258778.651	0	0
0.48	896743.9415	1258778.651	0	0
0.49	896743.9415	1258778.651	0	0
0.5	896743.9415	1258778.651	0	0
0.51	896743.9415	1258778.651	0	0
0.52	896743.9415	1258778.651	0	0
0.53	896743.9415	1258778.651	0	0
0.54	896743.9415	1258778.651	0	0
0.55	896743.9415	1258778.651	0	0
0.56	896743.9415	1258778.651	0	0
0.57	896743.9415	1258778.651	0	0
0.58	896743.9415	1258778.651	0	0
0.59	896743.9415	1258778.651	0	0
0.6	896743.9415	1258778.651	0	0

Table 14: The Change Of α AZRP

α	2025	2050	2025	2050
0.4	98768.7463	107473.5579	0	0
0.41	98768.7463	107473.5579	0	0
0.42	98768.7463	107473.5579	0	0
0.43	98768.7463	107473.5579	0	0
0.44	98768.7463	107473.5579	0	0
0.45	98768.7463	107473.5579	0	0
0.46	98768.7463	107473.5579	0	0
0.47	98768.7463	107473.5579	0	0
0.48	98768.7463	107473.5579	0	0
0.49	98768.7463	107473.5579	0	0
0.5	98768.7463	107473.5579	0	0
0.51	98768.7463	107473.5579	0	0
0.52	98768.7463	107473.5579	0	0
0.53	98768.7463	107473.5579	0	0
0.54	98768.7463	107473.5579	0	0
0.55	98768.7463	107473.5579	0	0
0.56	98768.7463	107473.5579	0	0
0.57	98768.7463	107473.5579	0	0
0.58	98768.7463	107473.5579	0	0
0.59	98768.7463	107473.5579	0	0
0.6	98768.7463	107473.5579	0	0

Table 15: The Change Of α NMTC

α	2025	2050	2025	2050
0.4	910414.5505	1271265.159	0	0
0.41	910414.5505	1271265.159	0	0
0.42	910414.5505	1271265.159	0	0
0.43	910414.5505	1271265.159	0	0
0.44	910414.5505	1271265.159	0	0
0.45	910414.5505	1271265.159	0	0
0.46	910414.5505	1271265.159	0	0
0.47	910414.5505	1271265.159	0	0
0.48	910414.5505	1271265.159	0	0
0.49	910414.5505	1271265.159	0	0
0.5	910414.5505	1271265.159	0	0
0.51	910414.5505	1271265.159	0	0
0.52	910414.5505	1271265.159	0	0
0.53	910414.5505	1271265.159	0	0
0.54	910414.5505	1271265.159	0	0
0.55	910414.5505	1271265.159	0	0
0.56	910414.5505	1271265.159	0	0
0.57	910414.5505	1271265.159	0	0
0.58	910414.5505	1271265.159	0	0
0.59	910414.5505	1271265.159	0	0
0.6	910414.5505	1271265.159	0	0

Table 16: The Change Of α NMRC

α	2025	2050	2025	2050
0.4	52461.93041	184506.9017	0	0
0.41	52461.93041	184506.9017	0	0
0.42	52461.93041	184506.9017	0	0
0.43	52461.93041	184506.9017	0	0
0.44	52461.93041	184506.9017	0	0
0.45	52461.93041	184506.9017	0	0
0.46	52461.93041	184506.9017	0	0
0.47	52461.93041	184506.9017	0	0
0.48	52461.93041	184506.9017	0	0
0.49	52461.93041	184506.9017	0	0
0.5	52461.93041	184506.9017	0	0
0.51	52461.93041	184506.9017	0	0
0.52	52461.93041	184506.9017	0	0
0.53	52461.93041	184506.9017	0	0
0.54	52461.93041	184506.9017	0	0
0.55	52461.93041	184506.9017	0	0
0.56	52461.93041	184506.9017	0	0
0.57	52461.93041	184506.9017	0	0
0.58	52461.93041	184506.9017	0	0
0.59	52461.93041	184506.9017	0	0
0.6	52461.93041	184506.9017	0	0

Table 17: The Change Of α NMTP

α	2025	2050	2025	2050
0.4	3361691.375	4282931.795	0	0
0.41	3361691.375	4282931.795	0	0
0.42	3361691.375	4282931.795	0	0
0.43	3361691.375	4282931.795	0	0
0.44	3361691.375	4282931.795	0	0
0.45	3361691.375	4282931.795	0	0
0.46	3361691.375	4282931.795	0	0
0.47	3361691.375	4282931.795	0	0
0.48	3361691.375	4282931.795	0	0
0.49	3361691.375	4282931.795	0	0
0.5	3361691.375	4282931.795	0	0
0.51	3361691.375	4282931.795	0	0
0.52	3361691.375	4282931.795	0	0
0.53	3361691.375	4282931.795	0	0
0.54	3361691.375	4282931.795	0	0
0.55	3361691.375	4282931.795	0	0
0.56	3361691.375	4282931.795	0	0
0.57	3361691.375	4282931.795	0	0
0.58	3361691.375	4282931.795	0	0
0.59	3361691.375	4282931.795	0	0
0.6	3361691.375	4282931.795	0	0

Table 18: The Change Of α NMRP

α	2025	2050	2025	2050
0.4	53387.98213	199402.6757	0	0
0.41	53387.98213	199402.6757	0	0
0.42	53387.98213	199402.6757	0	0
0.43	53387.98213	199402.6757	0	0
0.44	53387.98213	199402.6757	0	0
0.45	53387.98213	199402.6757	0	0
0.46	53387.98213	199402.6757	0	0
0.47	53387.98213	199402.6757	0	0
0.48	53387.98213	199402.6757	0	0
0.49	53387.98213	199402.6757	0	0
0.5	53387.98213	199402.6757	0	0
0.51	53387.98213	199402.6757	0	0
0.52	53387.98213	199402.6757	0	0
0.53	53387.98213	199402.6757	0	0
0.54	53387.98213	199402.6757	0	0
0.55	53387.98213	199402.6757	0	0
0.56	53387.98213	199402.6757	0	0
0.57	53387.98213	199402.6757	0	0
0.58	53387.98213	199402.6757	0	0
0.59	53387.98213	199402.6757	0	0
0.6	53387.98213	199402.6757	0	0

Table 19: The Change Of α TXTC

α	2025	2050	2025	2050
0.4	17169696.44	25778336.24	0	0
0.41	17169696.44	25778336.24	0	0
0.42	17169696.44	25778336.24	0	0
0.43	17169696.44	25778336.24	0	0
0.44	17169696.44	25778336.24	0	0
0.45	17169696.44	25778336.24	0	0
0.46	17169696.44	25778336.24	0	0
0.47	17169696.44	25778336.24	0	0
0.48	17169696.44	25778336.24	0	0
0.49	17169696.44	25778336.24	0	0
0.5	17169696.44	25778336.24	0	0
0.51	17169696.44	25778336.24	0	0
0.52	17169696.44	25778336.24	0	0
0.53	17169696.44	25778336.24	0	0
0.54	17169696.44	25778336.24	0	0
0.55	17169696.44	25778336.24	0	0
0.56	17169696.44	25778336.24	0	0
0.57	17169696.44	25778336.24	0	0
0.58	17169696.44	25778336.24	0	0
0.59	17169696.44	25778336.24	0	0
0.6	17169696.44	25778336.24	0	0

Table 20: The Change Of α TXRC

α	2025	2050	2025	2050
0.4	221971.7465	370598.3325	0	0
0.41	221971.7465	370598.3325	0	0
0.42	221971.7465	370598.3325	0	0
0.43	221971.7465	370598.3325	0	0
0.44	221971.7465	370598.3325	0	0
0.45	221971.7465	370598.3325	0	0
0.46	221971.7465	370598.3325	0	0
0.47	221971.7465	370598.3325	0	0
0.48	221971.7465	370598.3325	0	0
0.49	221971.7465	370598.3325	0	0
0.5	221971.7465	370598.3325	0	0
0.51	221971.7465	370598.3325	0	0
0.52	221971.7465	370598.3325	0	0
0.53	221971.7465	370598.3325	0	0
0.54	221971.7465	370598.3325	0	0
0.55	221971.7465	370598.3325	0	0
0.56	221971.7465	370598.3325	0	0
0.57	221971.7465	370598.3325	0	0
0.58	221971.7465	370598.3325	0	0
0.59	221971.7465	370598.3325	0	0
0.6	221971.7465	370598.3325	0	0

Table 21: The Change Of α TXTP

α	2025	2050	2025	2050
0.4	8876103.595	6924169.108	0	0
0.41	8876103.595	6924169.108	0	0
0.42	8876103.595	6924169.108	0	0
0.43	8876103.595	6924169.108	0	0
0.44	8876103.595	6924169.108	0	0
0.45	8876103.595	6924169.108	0	0
0.46	8876103.595	6924169.108	0	0
0.47	8876103.595	6924169.108	0	0
0.48	8876103.595	6924169.108	0	0
0.49	8876103.595	6924169.108	0	0
0.5	8876103.595	6924169.108	0	0
0.51	8876103.595	6924169.108	0	0
0.52	8876103.595	6924169.108	0	0
0.53	8876103.595	6924169.108	0	0
0.54	8876103.595	6924169.108	0	0
0.55	8876103.595	6924169.108	0	0
0.56	8876103.595	6924169.108	0	0
0.57	8876103.595	6924169.108	0	0
0.58	8876103.595	6924169.108	0	0
0.59	8876103.595	6924169.108	0	0
0.6	8876103.595	6924169.108	0	0

Table 22: The Change Of α TXRP

α	2025	2050	2025	2050
0.4	217766.8165	361356.7078	0	0
0.41	217766.8165	361356.7078	0	0
0.42	217766.8165	361356.7078	0	0
0.43	217766.8165	361356.7078	0	0
0.44	217766.8165	361356.7078	0	0
0.45	217766.8165	361356.7078	0	0
0.46	217766.8165	361356.7078	0	0
0.47	217766.8165	361356.7078	0	0
0.48	217766.8165	361356.7078	0	0
0.49	217766.8165	361356.7078	0	0
0.5	217766.8165	361356.7078	0	0
0.51	217766.8165	361356.7078	0	0
0.52	217766.8165	361356.7078	0	0
0.53	217766.8165	361356.7078	0	0
0.54	217766.8165	361356.7078	0	0
0.55	217766.8165	361356.7078	0	0
0.56	217766.8165	361356.7078	0	0
0.57	217766.8165	361356.7078	0	0
0.58	217766.8165	361356.7078	0	0
0.59	217766.8165	361356.7078	0	0
0.6	217766.8165	361356.7078	0	0