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2018
MCM/ICM
Summary Sheet

Since the 21st century, although the Information Industry, Biological Sciences and Technology are developing rapidly. They are all based on the energy, and the impact of energy on the world economy still occupies the first place. It is therefore necessary to understand how energy generation and usage will affect future social development.

In the United States, four states – California, Arizona, New Mexico, and Texas are the prime subjects of our study. They wish to form a realistic new energy compact focused on increased usage of cleaner, renewable energy sources. In this paper, we aim to perform data analysis and create models to characterize their energy development, and use our findings to come up with suggestions for policy makers of four states, by means of data visualization. At the same time, we also predict future energy trends within the appropriate range and set goals for their interstate energy compact.

Our solution consists of five parts.

First of all, we perform a series of data-preprocessing methods such as de-noising and deduplication on the data given, and select the index which we deem important by principal component analysis. After that, we can sort out a clean data set.

Second, we reasonably improve the conventional regression analysis model, on the basis of the LOESS local fitting regression. We propose a comprehensive measurement of factors, the multivariate integration into an independent variable. From a macro perspective, we consider the 50 years' trend of energy evolution from 1960 to 2009. In the form of chart clearly shows the similarities and differences between the four states. We find that it is closely related to the geography, industry, population and climate of the four states. Among all of them the most closely relationship is the industrial development.

Next, we set up a comprehensive evaluation system, selecting several groups of variables related to the cleaner energy and renewable energy. Through appropriately improved TOPSIS method, we enhance the standardization of the attribute values and obtain comprehensive evaluation index of four states. What's more, we find that California has the best performance in the usage of cleaner, renewable energy in four states. We also found that New Mexico has the lowest comprehensive evaluation index, which may be related to the huge production of non-renewable energy sources such as oil, natural gas and coal.

Then, based on the time series forecasting model properly innovated, we combine our own comprehensive measurement of factors to forecast energy development situation in 2025 and 2050. According to the results, we suggest that the four states need to take measures to strengthen the interstate energy mutual cooperation as soon as possible. In this way, they can increase the utilization of clean and renewable energy, otherwise the trend of future energy development is not optimistic. To achieve the goals of interstate energy compact, we think that the efforts should be made to realize the diversification of energy, promote energy conservation project in order to improve the energy efficiency. And four states should work together to make full use of market mechanisms to encourage the development of new energy, and increase the energy reservation.

Finally, we tested and analyzed our models by computer simulation. Although we have a small deviation between the actual value and predictive value, the overall trend was consistent. That means in order to maximize the utilization efficiency of renewable energy, taking measures to strengthen the energy cooperation between the four states is urgently needed.

We expect that the renewable energy industry will bring considerable benefits to the United States, such as reducing dependence on imported oil and natural gas, the improvement of environmental quality and reducing carbon emissions, etc. so as to achieve truly "energy independence" goal.

The Analysis and Prediction Of Energy Usage in Four States

Memo to the Governors

To: Group of Governors
From: Team 83687
Date: February 12,2018
Subject: Energy review and outlook

Dear governors，
We'd like to briefly go over and summarize the energy profiles of the states up to 2009, and then set forth our predictions about energy usage absent any policy changes. And at the last part of this memo, we come up with our recommended goals for the energy compact to adopt.

After we use Principal Component Analysis and data visualization to analyze all kinds of the 605 energy variables in 50 years, we come up with a clear and understandable energy profile for each state. You can have a brief knowledge about the energy consumption, production, distribution of the major energy sources used in each sector (including commercial, industrial, residential, transportation sectors), and the major energy sources usage in the power sector.

In combination with our proposed comprehensive measurement factors, we have established a new Time Series Forecasting Model. Under the premise of no policy change in each state, we predict that renewable energy sources such as wind and solar energy in all states could become a major source of electricity by 2025. We predict negative values of consumption shown in the table above. and you can see the strengthen of people's energy-saving awareness in the future from it. We predict that by 2050 all four states will have to give up their coal, and even natural gas and nuclear power will not be used anymore. All energy comes from renewable sources. For California, renewable solar energy is undergoing dramatic growth; for Texas, the use of wind far outweighs other renewable energies; in Arizona, hydro power generation is likely to be dominated by wind power; for New Mexico Wind energy continues to hold the dominant position in renewable energy. Overall, by 2050, wind energy from renewable sources will beat other sources of energy to become the foremost energy source in four states.

Finally, we have also given the proposed goal in the above, the goal is divided into three parts, respectively, from the energy conversion, energy saving and storage point of view. From the perspective of energy conversion, we suggest the governors of the four states to shift their energy consumption from oil industry to new clean energy and make full use of their advantages altogether for the better life of the states; From the perspective of saving energy, We recommend that four states establish an energy ceiling every year in the energy compact as a goal for energy consumption; In terms of energy storage, We recommend that all four states, based on their production capacity and energy consumption capacity, jointly accomplish an energy storage deployment goal. We predict that all four states will jointly achieve the 10GW energy storage deployment goal by 2050.

Above are our review and outlook of energy in four states. Please let us know if you have any questions.

Best wishes,
Team 83687

Solution

Restatement and Clarification of the Problem

As energy has become one of the vital necessities in the survival and development of human beings, more and more governments has switched their attention onto the issue about the energy. There are four states—California, Arizona, New Mexico and Texas—that wish to make a contractual agreement on the energy policy. They seek to provide the instruments and framework for cooperative state efforts to enhance and contribute to the well–being of the region's people.

- To process the data given, we perform a series of data-preprocessing methods and select the index which we deem important by principal component analysis. After that, we can sort out and get a clean data set. By data visualization and principal component analysis, a clear and understandable energy profile comes out.
- In order to see how the four statesâĂŹ energy profile has evolved from 1960 to 2009, we improve LOESS model to fit the local regression. We propose a comprehensive measurement of factors, the multivariate integration into an independent variable. From a macro perspective, we consider the 50 yearsâĂŹ trend of energy evolution, from which we discuss the the similarities and differences of the four states.
- For the purpose of setting up a comprehensive evaluation system, we select some kinds of variables related to renewable energy to measure the TOPSIS models. And give each state a composite score to evaluate how they perform in their energy profile.
- To predict the energy profile of each state in 2025 and 2050, we promote the time series third exponential smoothing method. Based on the results and conclusion mentioned above, we discuss further about the future trend of renewable energy usage.

General Assumptions and Justification

- In our first model, it was designed to describe the energy evolution of four states over 50 years. We chose to analyze the problem from a macro perspective, for the following reasons. Firstly, the data variables provided are relatively high and variable, and cannot be easily applied to traditional linear regression. Secondly, the structure of equation in macroscopic model is more suitable for numerical analysis, such as finite difference method. Thirdly, the macro paradigm has been improved in local fitting and regression analysis, so we think it has the basic ability to describe the overall energy profile. This is the main assumption that shapes the basic structure of our first model.
- In our second model, we consider only a few variables that are the most relevant to renewable energy, thus simplifying the model. In this case, the TOPSIS method is improved because the weight of the attribute value is more reasonable. This is the main assumption of our second model.
- In our third model, we make a reasonable prediction of the future energy development trend with the combined factors proposed before, which is the main assumption of our third model.

Notations

Synbol	Description
$\Delta_i(x)$	Consumption of the Principal Energy Resources
$W_i(x)$	Maximum for x_i close to x
$\hat{g}(x)$	Linear Combination of the Δ_i^x
r_{ij}	Normalized Vector Obtained By a Normalized Characteristic Matrix
w_j	Weight of the jth Indicator
v_{ij}	Weight Normalized Value
$A^\star$	Ideal Solution

Data Pre-processing

1. **Handle noisy data.** A noisy data test has been conducted on the data given and the results show that there are no isolated points, so then we can go on to the subsequent work.

2. **Remove rows with zero values.** Under the background, we discuss an initial analysis of the data given. The zero values represent there is no energy consumption or production, so the storage of energy resources will not be changed. That means the rows with zero values has no substantial meaning and we decide to neglect them.

3. **Get rid of duplicate and dirty data.** By applying duplicated function and factor function in R, we find the MSNs with the same description but different units. Then we simplify and only keep one of each them.

Model Design and Justification

Energy Profile

To provide energy suppliers, consumers, and policy makers with a comprehensive statewide energy profile, an overview of energy use, energy resources and energy supply is presented by data visualization. Detailed information is included on the consumption and production of the principal energy resources specifically used in the state. And we use Principal Component Analysis to find out what these principal energy resources are, simplifying all the 605 variables and merging some kinds of energy resources. (e.g. the Petroleum includes Crude oil, Distillate fuel oil, Miscellaneous petroleum etc). Disaggregated energy consumption by users is described and additional detail on use in the residential, commercial, industrial, and transportation sectors is provided. The energy profile also presents information on electricity, its uses and generation.

By summing up all the data we need of 50 years, here comes the energy profile of each state.

Arizona State Energy Profile

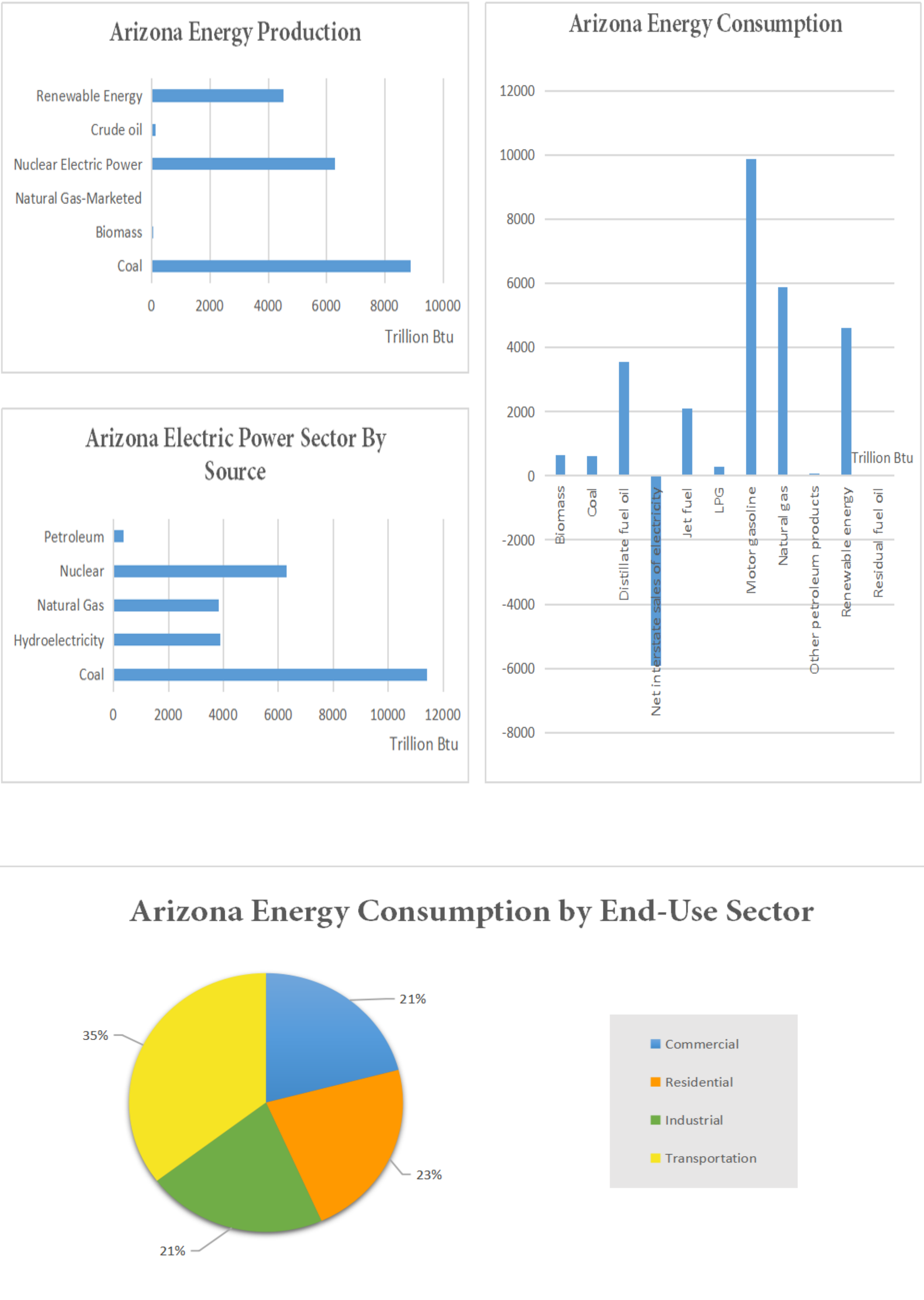


Figure 1: Arizona State Energy Profile

California State Energy Profile

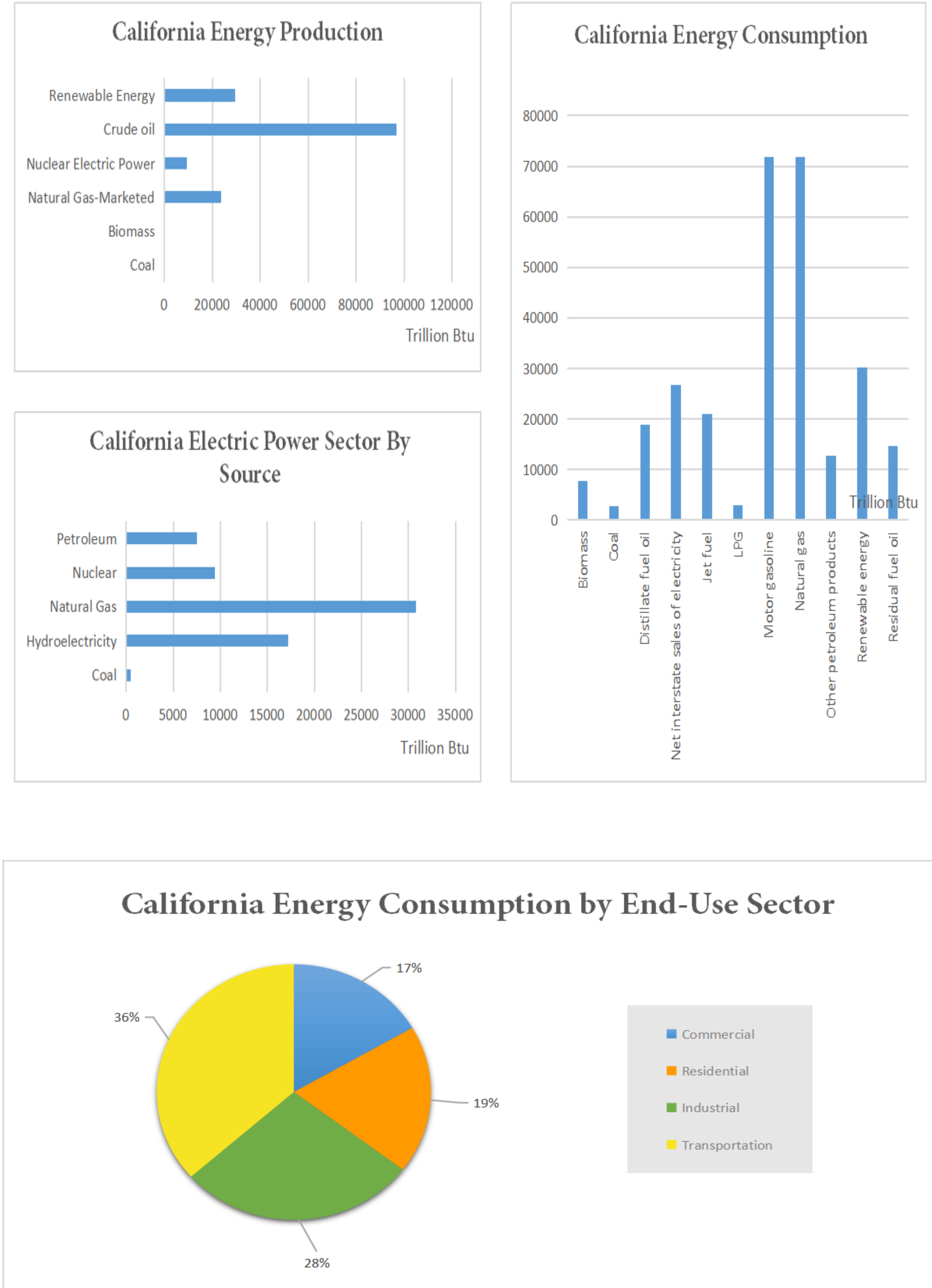


Figure 2: California State Energy Profile

New Mexico State Energy Profile

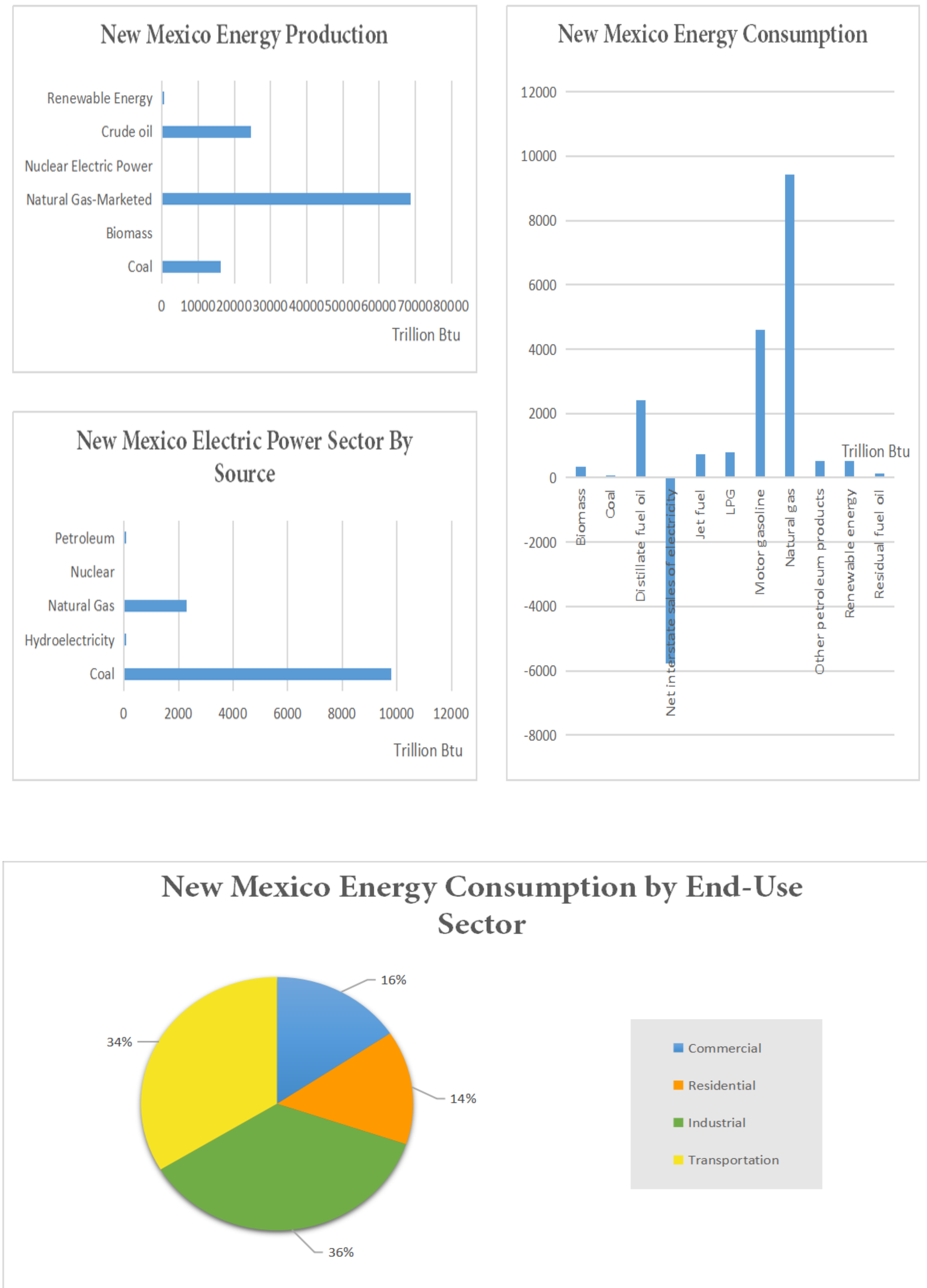


Figure 3: New Mexico State Energy Profile

Texas State Energy Profile

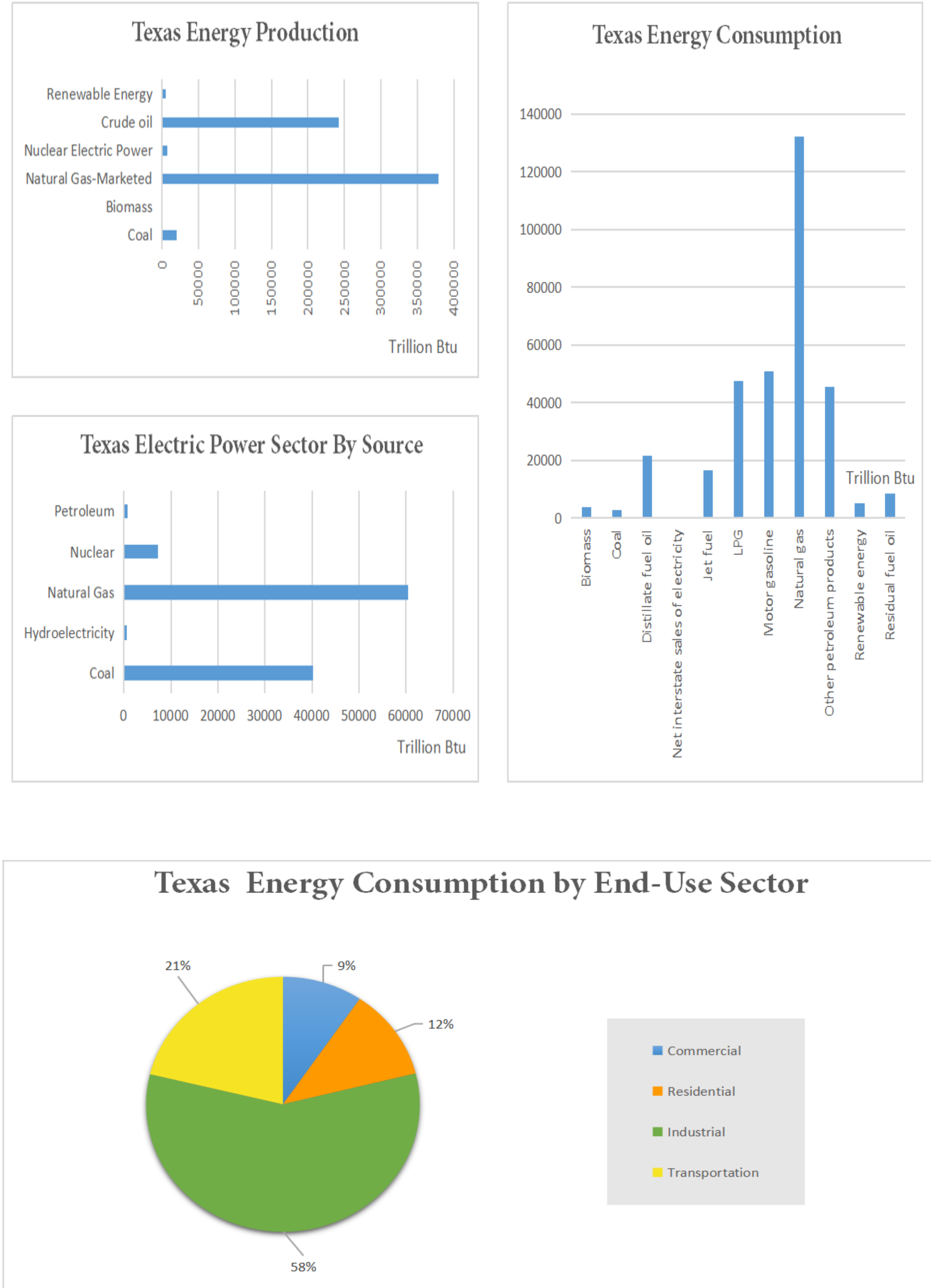


Figure 4: Texas State Energy Profile

Locally Weighted Regression Model

Our model takes Locally Weighted Regression, or LOESS, to make local fitting for each independent variables by using the weighted least squares method.

We first let y be measurement of the dependent variable, and let $\Delta_i(x)$ (i=1 $\cdots\cdots$ 11, n=11) be measurements of the eleven independent variables, representing the consumption of the eleven principal energy resources which are selected by the Principal Component Analysis respectively. Here are the table below showing the relationship between the variables and their MSN.

CLTXB	**NGTXB**	**MGTXB**	**DFTXB**	**JFTXB**	**LGTXB**
$\Delta_1(x)$	$\Delta_2(x)$	$\Delta_3(x)$	$\Delta_4(x)$	$\Delta_5(x)$	$\Delta_6(x)$
RFTXB	**POTXB**	**BMTCB**	**RETCB**	**ELISB**	**TETXB**
$\Delta_7(x)$	$\Delta_8(x)$	$\Delta_9(x)$	$\Delta_{10}(x)$	$\Delta_{11}(x)$	$\Delta_q(x)$

To carry out locally weighted regression we must have a distance function p in the space of the independent variables. For the multiple-regression case it is sensible to take p to be Euclidean distance in applications where the independent variables are measurements of position in physical space.

Locally weighted regression also requires a weight function and a specification of neighborhood size. The weight function used in the Tri-cube function:

$$T(u) = \begin{cases} (1-|u|^3)^3 & 0 \leq \text{u<1} \\ 0 & \text{otherwise} \end{cases}$$

We now let $d(x)$ be the distance of the qth-nearest x_i to x. Then the weight for the observation (y, x_i) is

$$W_i(x) = T(\frac{\Delta_i(x)}{\Delta_{(q)}(x)})$$

In this function, $\Delta_q(x)$ represents the total end-use energy consumption, with the MSN TETXB. Thus $W_i(x)$ as a function of i is a maximum for x_i close to x, decreases as the x_i increase in distance from x, and becomes 0 for the qth-nearest x_i to x. Instead of thinking in terms of q, the number of points in the neighborhood, we think in terms of $f = \frac{q}{n}$, the fraction of points in the neighborhood. As f increases, $\hat{g}(x)$ becomes smoother.

The loess estimate, $\hat{g}(x)$, is a linear combination of the $\Delta_i(x)$,

$$\hat{g}(x) = \sum_{i=1}^{n} W_i(x)\Delta_i(x)$$

Since each $\hat{\Delta_i(x)} = L\Delta(x)$, where L (locally weighted regression) is an n $\times$ n matrix and $\hat{\varepsilon}$=(I-L)$\Delta(x)$, where I is the n $\times$ n identity matrix. The loess fitting is based on the regression analysis of the local fitting. Due to its huge complexity in computation, we have adopted the geom_smooth function toolkit in R to achieve loess fitting.

Therefore, we adopt a weighted average of multiple energy factors of each year to obtain an integrated energy factor, and fit the fitting curve graph from 1960 to 2009 so that in a way that is easily understood by the governors and helps them to understand the similarities and difference between the four states.

The resultls are shown in Figure 5, 6 and 8.

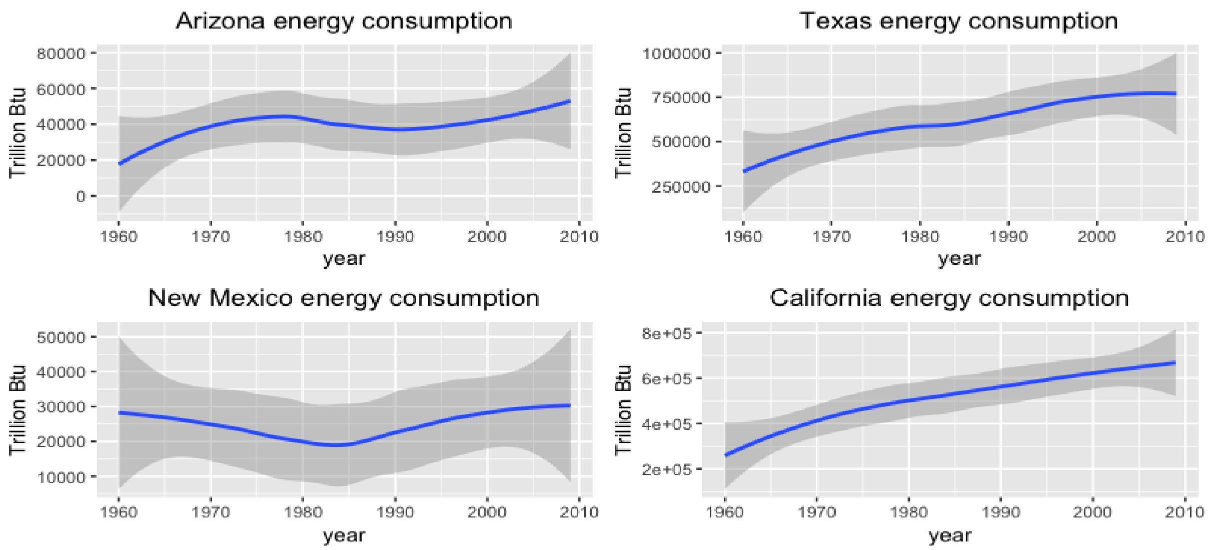


Figure 5: Four States' Evolution of Energy Consumption from 1960-2009

In overall, from the aspect of energy consumption, all four states are on an upward trend, with Texas consuming far more than the other three states.

Since Texas has the second-largest population and the second-largest economy, the state leads the nation in total energy consumption, accounting for more than one-eighth of the U.S. total. Texas also leads the nation in total petroleum consumption, as well as distillate fuel oil, residual fuel oil, and liquefied petroleum gases. The state has many energy-intensive industries, and the industrial sector accounts for the largest share of state energy use.

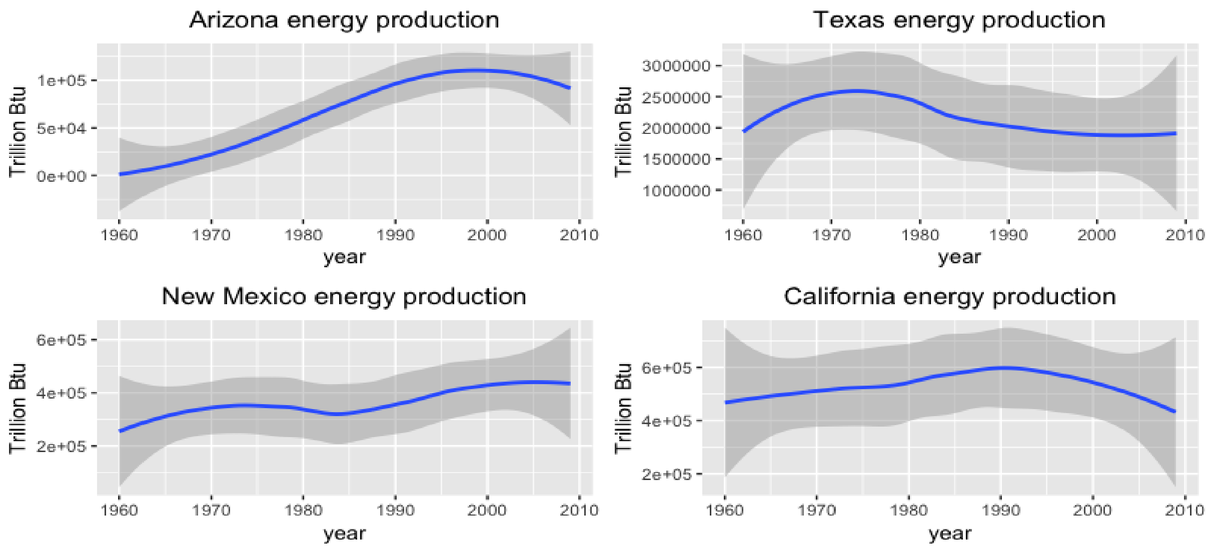


Figure 6: Four States' Evolution of Energy Production from 1960-2009

As for the energy production, there was a clear upward trend in Arizona, a slight increase in New Mexico, and the rest of two states remain steadily unchanged. However, when it comes around 2010, they all show a slight downward trend. What's more, compared among all the four states, Texas produces far more energy than the rest of the others.

It is clear from the figure that Texas produces significantly more energy than the other three, largely because of Texas's strong capacity to produce oil and natural gas, which depends both on it's predominant geographic location and its leading ability to process crude oil, horizontally drill and hydraulically fracture. Geographically, Texas extends about 800 miles west and north to south over the widest eastern part of the country, with large area of crude oil and natural gas fields on the vast land, as well as the uranium deposits in southern Texas. Talking about the refining and processing of crude oil, many of the Texas refineries are complex facilities that use additional refining processes beyond simple distillation to yield larger quantities of lighter, higher-value products. And the scientific and technological progress in horizontal drilling and hydraulic fracturing also make natural gas production in Texas on the rise.

Other factors also contribute to the energy production. For example, with a significant number of sunny days across vast distances, Texas is among the leading states in solar energy potential as well. It has rapidly developed its wind energy, and become first in the nation in wind generated electricity.

The significant upward trend of energy production in Arizona can be easily explained by its geographic location. Arizona is best known for its iconic landscape, from the Grand Canyon to the southern Saguaro Desert. The state has few fossil fuel resources but abundant solar and geothermal potential. Elevation of Arizona from the northern peak of more than 12,000 feet to the desert in the lower reaches to the southwestern offshore level. Some of the highest in the state are atop the Colorado Plateau in northern Arizona. Across more than 100 miles, marks the Mogollon Rim steep slope on the southern rim of the Colorado Plateau, which is the largest wind potential in Arizona. While larger areas, including large amounts of snowfall, part of Arizona is semi-arid, abundant sunlight giving some of the country's largest solar potential.

Figure 7: Elevation Map of Arizona

Talking about the slight downward trend, on the one hand, the subprime mortgage crisis in 2008 influenced the sales volume of light vehicles to hit the bottom, and the oil demand in the whole industry maintained a downward trend. On the other hand, due to California's leader role in many energy-intensive industries, it makes extensive efforts to increase energy efficiency, along with the implementation of alternative technologies, also restraining the growth in energy demand. That's why we can see the production decline near the year 2010.

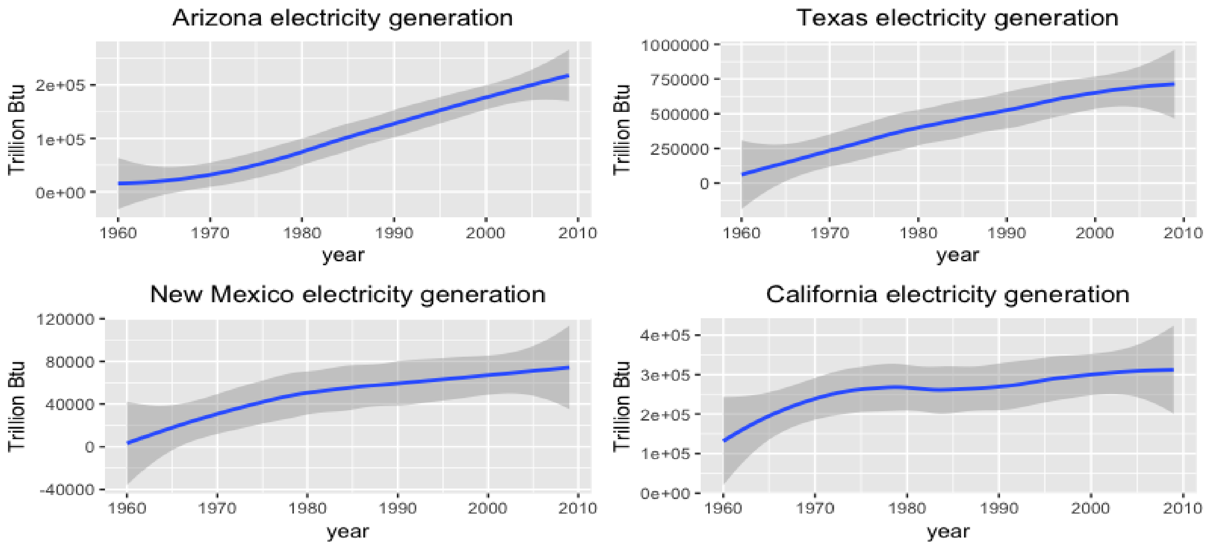


Figure 8: Four States' Evolution of Electricity Generation from 1960-2009

As the only state that has an independent power grid in all four states, Texas generates more electricity than any other state. Texas has abundant natural gas resources to bring it many natural gas power plants. And there is a large part of the electricity generated from them. In addition, Texas as the largest lignite coal producers and coal-fired power plants in the United States, make a huge contribution to the production of power. Together with the fact that nuclear power plants provide about one-tenth of the state's net electricity generation, climate-influenced wind power generation and solar power from the sunny days make the amount of Texas' power generation much higher than the other three states.

TOPSIS Model

We use the mathematical model of the TOPSIS method to establish m evaluation targets $D_1, D_2 \cdots D_m$, representing Arizona, California, New Mexico and Texas. Each target has n evaluation indices $X_1, X_2 \cdots X_n$. Here, we define $m = 4, n = 4$.

Description	Evaluation Indice
X_1	Renewable energy production
X_2	Renewable energy total consumption
X_3	Total end-use energy average price
X_4	Resident population including Armed Forces

Table 1: the Definition of Evaluation Indices

According to given data that we extracted, we establish the following feature matrix:

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & & \vdots & & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & & \vdots & & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} = \begin{bmatrix} D_1(x_1) \\ \vdots \\ D_i(x_j) \\ \vdots \\ D_m(x_n) \end{bmatrix} = \begin{bmatrix} X_1(x_1) & \cdots & X_j(x_i) & \cdots & X_n(x_m) \end{bmatrix}$$

Calculate the Normalized Matrix

The characteristic matrix is normalized to obtain a normalized vector r_{ij}, and establish a normalized matrix about the normalized vector r_{ij}.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} (i = 1, 2 \cdots, m, j = 1, 2 \cdots, n)$$

Construct the weight normalization matrix

By calculating the weight normalized value v_{ij}, a weight normalization matrix about the weight normalized value v_{ij} is established.

$$v_{ij} = w_j r_{ij}, (i = 1, 2, \cdots, m, j = 1, 2, \cdots, n)$$

Among them, w_j is the weight of the jth indicator. In ASP-based dynamic alliance manufacturing resource assessment model, we use Delphi method as the weight determination method here.

Determine the ideal solution and anti-ideal solution

Determine Ideal Solution $A^\star$ and Anti-Ideal Solution A^- from Weighted Normalized Value v_{ij}:

$$A^\star = (max_i vij | j \in J_1), (min_i v_{ij} | j \in J_2), |i = 1, 2, \cdots, m = v_1^\star, v_2^\star, \cdots, v_j^\star, \cdots, v_n^\star$$

$$A^- = (min_i vij | j \in J_1), (max_i v_{ij} | j \in J_2), |i = 1, 2, \cdots, m = v_1^-, v_2^-, \cdots, v_j^-, \cdots, v_n^-$$

J_1 is a set of profitability indicators, which represents the optimal value of the i-th indicator. J_2 is a set of lossy indicators, which represents the worst value in the i-th indicator. The larger the profitability index, the more favorable the evaluation result; the smaller the loss index, the more favorable the evaluation result. On the contrary, the evaluation result is unfavorable.

Calculate the distance scale

That is, calculate the distance from each target to the ideal solution and anti-ideal solution. The distance scale can be calculated by n-dimensional Euclidean distance. The distance between the target and the ideal solution $A^\star$ is $S^\star$ and the distance to the anti-ideogram A^- is

S^{-}:

$$S^{\star} = \sqrt{\sum_{j=1}^{n} (V_{ij} - v_j^{\star})^2}$$

$$S^{-} = \sqrt{\sum_{j=1}^{n} (V_{ij} - v_j^{-})^2}$$

$v_j^{\star}$ and v_j^{-} are the distance from the jth target to the optimal target and the worst target respectively, v_{ij} is the weight normalization value of the jth evaluation index of the ith target. $S^{\star}$ is the degree of closeness between each evaluation goal and the optimal goal. The smaller the $S^{\star}$ value, the closer the evaluation goal is to the ideal goal, and the better the plan is.

Calculate the closeness of the ideal solution $C^{\star}$

$$C_i^{\star} = \frac{S_i^{-}}{S_i^{\star} + S_i^{-}}, i = 1, 2, \cdots, m (0 \leq C_i^{\star} \leq 1)$$

When $C_i^{\star} = 0$, $A_i = A^{-}$, indicating that the goal is the worst goal. When $C_i^{\star} = 1$, $A_i = A^{\star}$, indicating that the goal is the best goal. In the actual multi-objective decision-making, the optimal goal and the worst goal are unlikely to exist.

Sort according to the closeness $C^{\star}$ size of the ideal solution

According to the value of $C^{\star}$ in ascending order to sort the various evaluation goals. The larger the ranking results of closeness to $C^{\star}$ value, the better the target is. The maximum evaluation of the $C^{\star}$ value is the best evaluation target.

Here, we get the data matrix:

$$a = \begin{bmatrix} 88571.38442 & 103493.2854 & 19.66482377 & 6587.653 \\ 635062.3653 & 712704.4602 & 18.4052811 & 36887.615 \\ 33785.17435 & 35635.38371 & 17.17897394 & 2007.315 \\ 303697.0626 & 356634.8206 & 15.37924605 & 24770.651 \end{bmatrix}$$

Through the above model processing, the four states obtained a composite score:

State	California	Texas	Arizona	New Mexico
Composite Score	0.9581	0.4937	0.1019	0.0347

Then we can easily conclude that, among all the four states, California has an outstanding performance in the usage of cleaner, renewable energy in 2009. It has the highest composite score in the four indices, residential population, average price of end-use energy and renewable energy production and consumption.

That may thanks to the state' leading role in conventional hydroelectric power and wind energy, and its powerful capacity in electricity generation from solar, geothermal, and biomass resources. Several of the world's largest solar thermal and solar PV plants are in the state's south-eastern deserts, and substantial geothermal resources are also found in California's coastal mountain ranges

At the mean time, the California Solar Initiative encourages Californians to install solar power systems on the rooftops of their homes and businesses, and establish an emissions cap-and-trade program as part of the state's Global Warming Solutions Act of 2006. California's Low Carbon Fuel Standard, issued in January 2007, called for a reduction of at least 10% in the carbon intensity of California's transportation fuels by 2020. The policies promulgated one after another are also promoting the usage of renewable energy among the state.

Time Series Prediction Model

We create the time series forecasting model. Based on the historical evolution of energy use in these states, we find that the change of the time series from 1960 to 2009 shows the trend of quadratic curve. Therefore, we choose the triple exponential smoothing method, and the formula is:

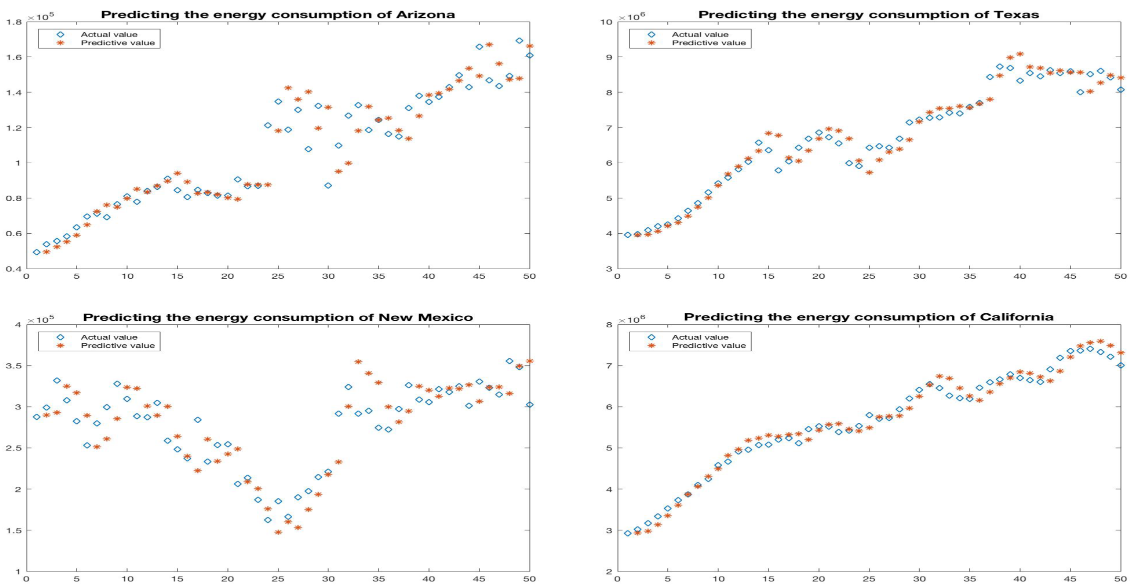
$$\begin{cases} S_t^{(1)} = ay_t + (1-a)S_{t-1}^{(1)} \\ S_t^{(2)} = aS_t^{(1)} + (1-a)S_{t-1}^{(2)}) \\ S_t^{(3)} = aS_t^{(2)} + (1-a)S_{t-1}^{(3)} \end{cases}$$

In the formula, $S_t^{(3)}$ is the three exponential smoothing value.The prediction model of three exponential smoothing is:

$$\hat{y}_{t+m} = a_t + b_t m + C_t m^2, m = 1, 2, \cdots$$

In this formula,

$$\begin{cases} a_t = 3S_t^{(1)} - 3S_t^{(2)} + S_t^{(3)} \\ b_t = \dfrac{a}{2(1-a)^2}[(6-5a)S_t^{(1)} - 2(5-4a)S_t^{(2)} + (4-3a)S_t^{(3)}] \\ c_t = \dfrac{a^2}{2(1-a)^2}[S_t^{(1)} - 2S_t^{(2)} + S_t^{(3)}] \end{cases}$$



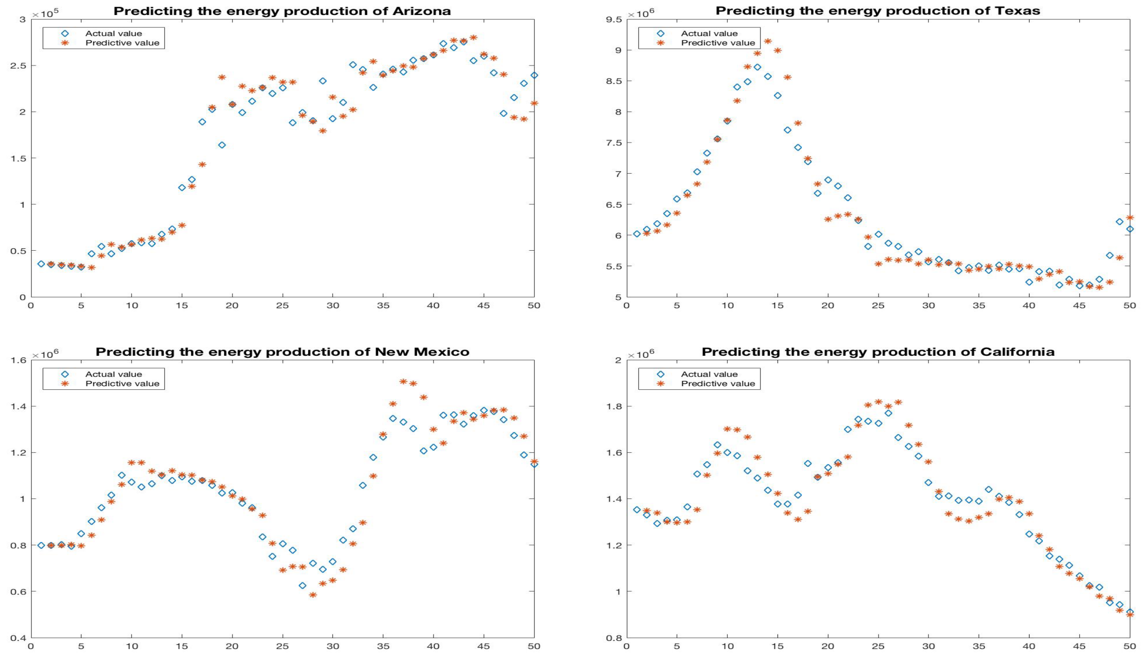


Figure 9: Predicting the Consumption and Production of Four States

State	Arizona	California	New Mexico	Texas
Production in 2025	2.2206×10^5	4.2417×10^5	-8.6631×10^5	1.3340×10^7
Consumption in 2025	2.2365×10^5	3.7423×10^6	1.1420×10^5	4.1978×10^6
Production in 2050	2.8642×10^5	-2.0278×10^5	-8.1546×10^6	3.7909×10^7
Consumption in 2050	3.6403×10^5	-1.0414×10^7	-7.3323×10^5	-1.0835×10^7

Table 2: Predicted Values of Consumption and Production

Some of the predictive value in the table have become negative. That is because the United States is a country whose energy production depends largely on the oil industry, so the petroleum is heavily weighted in its energy consumption. When there is a negative value for consumption or production, it shows that the exploitation or use of oil has been substantially reduced or even completely replaced by renewable energy.

Goals and Actions Toward the Goals

According to the prediction above, oil, coal and other large amounts of traditional energy used at present are gradually depleting. By 2050, oil resources will be depleted and the energy crisis will swell the world. Areas heavily dependent on traditional energy sources will suffer very badly and may lead to a substantial contraction in industry.

In theory, natural resources such as sun and wind seem to be inexhaustible. So it seem necessary for the states to shift their energy consumption from oil industry to new clean energy, and spare no efforts to promote the development of the renewable energy. As the share of renewable energy in energy consumption gradually increases, it is vital to study how to utilize these energies efficiently. Meanwhile, Based on the criteria we have set up before, we can measure a state's performance on the usage of clean energy by these four indices, the amount of renewable energy production, consumption, residential population and energy prices.

After investigation, we found that every state has at least one kind of renewable energy with potential for development. California's suitable climate brings a solar power advantage. Substantial geothermal resources are also found in California's coastal mountain ranges and the largest complex of geothermal power plants in the nation. Texas, compared to other states, which located in the hub: the perennial wind power generation has a stable source, far ahead of the other three states. In addition, that brought the country's largest solar energy potential in Texas land area and a high level of direct solar radiation to the state of Arizona. Renewable energy power generation is the utilized by hydraulic power, powerful winds from the eastern part of New Mexico plateau brings rich wind. And the climate is characterized by rich sunshine, making use of solar energy with the increase of photovoltaic power generation facilities. So based on the facts mentioned above, we will suggest the governors of the four states to shift their energy consumption from oil industry to new clean energy and make full use of their advantages for the better life of the states.

Here are the three actions to meet their energy compact goals.

- **Guide the public and community organizations to participate in and create a good social atmosphere.** To effectively use renewable energy, it must be a combination of state responsibility and social support. Take a multi-channel, flexible way to mobilize public participation, encourage non-governmental organizations and social organizations to organize publicity and training. We will step up popular science education in the whole society and increase public enthusiasm for using renewable energy. Advertise through the media, as widely advertised, to inform citizens how to use renewable energy efficiently in their daily lives. Through the activities of the experimental community, let us experience the environmental changes brought about by the use of renewable energy. Through reading activities, using animation to do demonstration, so that small citizens to develop self-awareness. Strengthen public's concept of using renewable energy conscientiously, especially in rural areas, we must further strengthen the construction of renewable energy service system. Grassroots organizations do a good job of propaganda and guidance, strive to improve farmers 'awareness of renewable energy usage, changing farmers' traditional life energy consumption patterns, and encouraging the use of biogas and biomass energy.

- **Emphasize on development and innovation of technology research and reduce the cost of renewable energy.** Whether renewable energy can be used efficiently lies on the technical breakthrough. Not only businesses can run on renewable electricity, every home in every building can have a grid of underground cables. Any home that uses renewable energy to generate electricity, if there is still some electricity unused, they can input the rest into the grid to gain extra revenue. The government should proceed with the study as soon as possible to further upgrade the smart grid and start building transmission lines between the four states, so that clean-energy power can be shipped to other states. Promoting the application of renewable energy can be achieved significantly by reducing costs and the gap between its power generation and ordinary electricity. The government should encourage technological innovation in enterprises. The government should implement the plan of "high-tech strategy" and continuously increase investment in research and development of energy-using technologies so as to achieve sustained and rapid growth for renewable energy innovation.

- **Use all kinds of economic means and incentive policies to improve the utilization of renewable energy.** The governments can give new equipment investment compensation. Renewable energy power generation equipment can obtain government investment compensation, and the compensation range is determined by the year of equipment production. In order to make the enterprise innovative, they should improve the utilization of equipment and reduce the cost, the compensation range is reduced every year. The government gives subsidies to the use of renewable energy in a variety of ways. For example, subsidies are given to the use of biological materials and power generation - heating joint equipment and subsidies for the use of renewable energy for heating. In order to improve the utilization of renewable energy, different types of subsidies can be added. Tax preferential policies are introduced. If we collect the ecological tax on mineral energy and natural gas, we will exempt from the ecological tax on the use of renewable energy such as wind energy, solar energy, geothermal power, water power, garbage and bio energy. Give support to the financing policy. For enterprises with good effects on the use of renewable energy, the government gives state guaranteed loans or low interest rates.

Model Testing and Error/Sensitivity Analysis

In order to apply our model to the given data, we compare the predictive values with the actual values, and get the following charts.

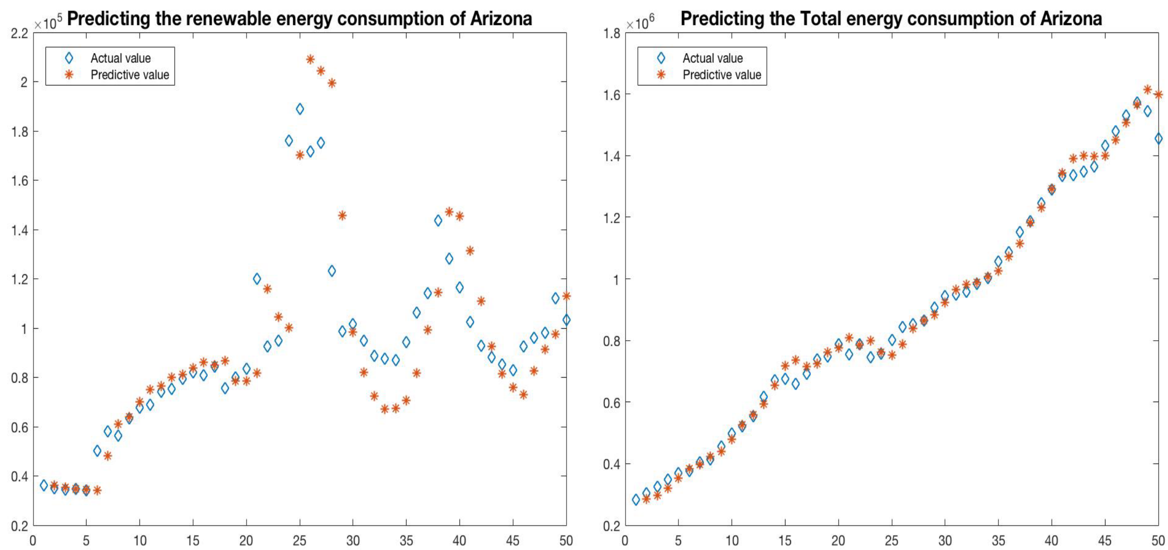


Figure 10: Predicted Consumption Value

A certain amount of confidence in environmental models is necessary for policy making decisions, and the currently policy makers do not have a sufficient level of confidence to make the best decisions. Because of this necessity, it is especially important to achieve as much confidence in our predictions as possible, and we will perform sensitivity analysis.

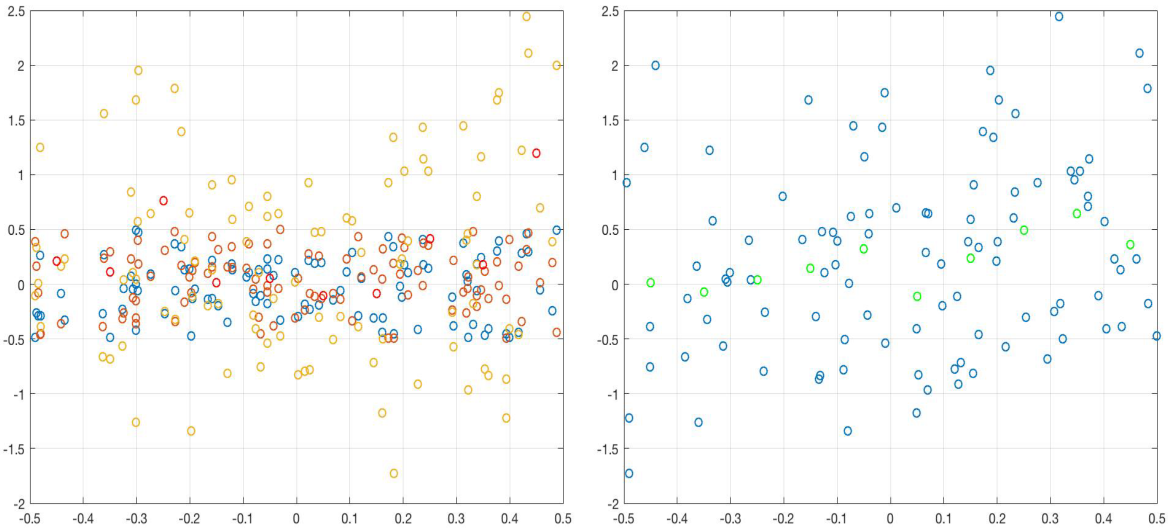


Figure 11: Sensitivity Analysis

Strengths and Potential Areas for improvement of the Model

In this paper, we set up three models, namely LOESS local fitting regression model, TOPSIS model, three exponential smoothing time series forecasting model. All three models are conventional models, but we make reasonable improvements to the traditional models by analyzing the data and visualizing the data. mainly include:

1. Weighed according to the proportion of multivariate in the total amount, constructed a comprehensive measurement factors by the idea of similar weighted average.
2. We use principal component analysis to select the efficiency and cost attributes, and construct a set of weight vectors based on a large number of data rules to make the attribute values more standardized.
3. Based on the traditional time series forecasting model and combined with comprehensive measurement factors, we reasonably predict future energy development trends, using the third exponential smoothing method.

However, there are some areas for improvement in our model, mainly including:

1. Our model analyzes the energy profile mainly from a macro perspective, but there is no in-depth discussion of the specific energy analysis.
2. Our prediction model does not fit the complete curve, only directly through the prediction equation to find the energy synthesis value.
3. just simulate the total energy consumption for all, lacking in generality for particular energy sources.

References

[1] Hinman G, Devlin T, Eby T, et al. Washington State energy-use profile, 1960-1981[J]. 1981.

[2] Famili A, Shen W M, Weber R, et al. Data preprocessing and intelligent data analysis[J]. Intelligent Data Analysis, 1997, 1(1):3-23.

[3] American Wind Energy Association, Texas Wind Energy, accessed December 4, 2017.

[4] U.S. EIA, Electric Power Monthly (February 2017), Table 1.14.B.

[5] Moore B. Principal component analysis in linear systems: Controllability, observability, and model reduction[J]. Automatic Control IEEE Transactions on, 1981, 26(1):17-32.

[6] Cleveland W, Devlin S. Locally Weighted Regression: An Approach to Regression Analysis by Local Fitting[J]. Publications of the American Statistical Association, 1988, 83(403):596-610.

[7] William S. Cleveland, Susan J. Devlin. Taylor Francis Online :: Locally Weighted Regression: An Approach to Regression Analysis by Local Fitting - Journal of the American Statistical Association - Volume 83, Issue 403[J]. Journal of the American Statistical Association.

[8] Cleveland W S. LOWESS: A Program for Smoothing Scatterplots by Robust Locally Weighted Regression[J]. American Statistician, 1981, 35(1):54-54.

[9] Naes T, Isaksson T, Kowalski B. Locally weighted regression and scatter correction for near-infrared reflectance data[J]. Analytical Chemistry, 1990, 62(7).

[10] Box G E P, Jenkins G M. Time Series Analysis: Forecasting and Control[J]. Journal of Time, 2010, 31(4):238-242.

[11] Kilian L. New Introduction to Multiple Time Series Analysis, - by Helmut LÃijtkepohl[J]. Economic Record, 2007, 83(260):109âĂŞ110.

[12] Chris Chatfield, Andreas S. Weigend. Time series prediction: Forecasting the future and understanding the past : Neil A. Gershenfeld and Andreas S. Weigend, 1994, âĂŸThe future of time seriesâĂŹ, in: A.S. Weigend and N.A. Gershenfeld, eds. (Addison-Wesley, Reading, MA), 1-70[J]. International Journal of Forecasting, 1994, 10(1):161-163.

[13] Martinetz T M, Berkovich S G, Schulten K J. Neural-Gas" network for vector quantization and its application to time-series prediction[C]// IEEE Transactions on Neural Networks. 1993:558-569.

[14] Kasabov N K, Song Q. DENFIS: dynamic evolving neural-fuzzy inference system and its application for time-series prediction[J]. IEEE Transactions on Fuzzy Systems, 2002, 10(2):144-154.

[15] Famili A, Shen W M, Weber R, et al. Data preprocessing and intelligent data analysis[J]. Intelligent Data Analysis, 1997, 1(1):3-23.

Appendices

Appendix A First appendix

Input matlab source:

```
%Predicting the energy profile of Arizona for 2025 and 2050
%Assuming without any policy changes by each governor's office.
clc,clear
yt=load('consumption_AZ.txt');
n=length(yt); alpha=0.3; st0=mean(yt(1:3));
st1(1)=alpha*yt(1)+(1-alpha)*st0;
st2(1)=alpha*st1(1)+(1-alpha)*st0;
st3(1)=alpha*st2(1)+(1-alpha)*st0;
for i=2:n
    st1(i)=alpha*yt(i)+(1-alpha)*st1(i-1);
    st2(i)=alpha*st1(i)+(1-alpha)*st2(i-1);
    st3(i)=alpha*st2(i)+(1-alpha)*st3(i-1);
end
xlswrite('consumption_AZ2.xls',[st1',st2',st3'])
at=3*st1-3*st2+st3;
bt=0.5*alpha/(1-alpha)^2*((6-5*alpha)*st1-2*(5-4*alpha)*st2+(4-3*alpha)*st3);
ct=0.5*alpha^2/(1-alpha)^2*(st1-2*st2+st3);
yhat=at+bt+ct;
xlswrite('consumption_AZ3.xls',yhat','Sheet1','D2')
plot(1:n,yt,'D',2:n,yhat(1:end-1),'*')

legend('Actual value','Predictive value','Location','northwest')
xishu=[ct(end),bt(end),at(end)];
yhat2025=polyval(xishu,16)
yhat2050=polyval(xishu,41)
```

Appendix B Second appendix

Input R source:

```
#åŕijåĔĕæŢřæ■ő
dyn.load('/Library/Java/JavaVirtualMachines/jdk-9.0.1.jdk/Contents/Home/lib/server/libjvm.dylib')
library("rJava")
library("xlsxjars")
library("xlsx")
seseds<-read.xlsx(file = "ProblemCData.xlsx",sheetIndex = 1,header=TRUE)
View(seseds)


consumption<-read.xlsx(file = "total end-use consumption.xlsx",sheetIndex = 1,header=TRUE)
View(consumption)

seseds2<-merge(seseds,consumption,all.y = TRUE)
View(seseds2)
write.xlsx(seseds2,file = "seseds2.xlsx")

consumption_AZ<-seseds2[seseds2$StateCode=="AZ",]
View(consumption_AZ)
write.xlsx(consumption_AZ,file = "consumption_AZ.xlsx")
consumption_AZ_sum<-aggregate(consumption_AZ[4],consumption_AZ[1],sum)
consumption_AZ_sum$Data<-consumption_AZ_sum$Data/1000
View(consumption_AZ_sum)
```

```
write.xlsx(consumption_AZ_sum,file = "consumption_AZ_sum.xlsx")

consumption_TX<-seseds2[seseds2$StateCode=="TX",]
View(consumption_TX)
consumption_TX_sum<-aggregate(consumption_TX[4],consumption_TX[1],sum)
consumption_TX_sum$Data<-consumption_TX_sum$Data/1000
View(consumption_TX_sum)
write.xlsx(consumption_TX_sum,file = "consumption_TX_sum.xlsx")

consumption_NM<-seseds2[seseds2$StateCode=="NM",]
View(consumption_NM)
consumption_NM_sum<-aggregate(consumption_NM[4],consumption_NM[1],sum)
consumption_NM_sum$Data<-consumption_NM_sum$Data/1000
View(consumption_NM_sum)
write.xlsx(consumption_NM_sum,file = "consumption_NM_sum.xlsx")

consumption_CA<-seseds2[seseds2$StateCode=="CA",]
View(consumption_CA)
consumption_CA_sum<-aggregate(consumption_CA[4],consumption_CA[1],sum)
consumption_CA_sum$Data<-consumption_CA_sum$Data/1000
View(consumption_CA_sum)
write.xlsx(consumption_CA_sum,file = "consumption_CA_sum.xlsx")

production<-read.xlsx(file = "production.xlsx",sheetIndex = 1,header=TRUE)
View(production)

seseds3<-merge(seseds,production,all.y = TRUE)
View(seseds3)
write.xlsx(seseds3,file = "seseds3.xlsx")

production_AZ<-seseds3[seseds3$StateCode=="AZ",]
View(production_AZ)
production_AZ_sum<-aggregate(production_AZ[4],production_AZ[1],sum)
production_AZ_sum$Data<-production_AZ_sum$Data/1000
View(production_AZ_sum)
write.xlsx(production_AZ_sum,file = "production_AZ_sum.xlsx")

production_TX<-seseds3[seseds3$StateCode=="TX",]
View(production_TX)
production_TX_sum<-aggregate(production_TX[4],production_TX[1],sum)
production_TX_sum$Data<-production_TX_sum$Data/1000
View(production_TX_sum)
write.xlsx(production_TX_sum,file = "production_TX_sum.xlsx")

production_NM<-seseds3[seseds3$StateCode=="NM",]
View(production_NM)
production_NM_sum<-aggregate(production_NM[4],production_NM[1],sum)
production_NM_sum$Data<-production_NM_sum$Data/1000
View(production_NM_sum)
write.xlsx(production_NM_sum,file = "production_NM_sum.xlsx")

production_CA<-seseds3[seseds3$StateCode=="CA",]
View(production_CA)
production_CA_sum<-aggregate(production_CA[4],production_CA[1],sum)
production_CA_sum$Data<-production_CA_sum$Data/1000
View(production_CA_sum)
write.xlsx(production_CA_sum,file = "production_CA_sum.xlsx")


electricity<-read.xlsx(file = "Net Electricity Generation by source.xlsx",sheetIndex = 1,header=TI
View(electricity)

seseds4<-merge(seseds,electricity,all.y = TRUE)
```

```
View(seseds4)
write.xlsx(seseds4,file = "seseds4.xlsx")

electricity_AZ<-seseds4[seseds4$StateCode=="AZ",]
View(electricity_AZ)
electricity_AZ_sum<-aggregate(electricity_AZ[4],electricity_AZ[1],sum)
electricity_AZ_sum$Data<-electricity_AZ_sum$Data/1000
View(electricity_AZ_sum)
write.xlsx(electricity_AZ_sum,file = "electricity_AZ_sum.xlsx")

electricity_TX<-seseds4[seseds4$StateCode=="TX",]
View(electricity_TX)
electricity_TX_sum<-aggregate(electricity_TX[4],electricity_TX[1],sum)
electricity_TX_sum$Data<-electricity_TX_sum$Data/1000
View(electricity_TX_sum)
write.xlsx(electricity_TX_sum,file = "electricity_TX_sum.xlsx")

electricity_NM<-seseds4[seseds4$StateCode=="NM",]
View(electricity_NM)
electricity_NM_sum<-aggregate(electricity_NM[4],electricity_NM[1],sum)
electricity_NM_sum$Data<-electricity_NM_sum$Data/1000
View(electricity_NM_sum)
write.xlsx(electricity_NM_sum,file = "electricity_NM_sum.xlsx")

electricity_CA<-seseds4[seseds4$StateCode=="CA",]
View(electricity_CA)
electricity_CA_sum<-aggregate(electricity_CA[4],electricity_CA[1],sum)
electricity_CA_sum$Data<-electricity_CA_sum$Data/1000
View(electricity_CA_sum)
write.xlsx(electricity_CA_sum,file = "electricity_CA_sum.xlsx")



library(ggplot2)
p1_consumption_AZ<-ggplot(data=consumption_AZ, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="Arizona energy consumption", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = consumption_AZ)

p2_consumption_TX<-ggplot(data=consumption_TX, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="Texas energy consumption", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = consumption_TX)

p3_consumption_NM<-ggplot(data=consumption_NM, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="New Mexico energy consumption", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = consumption_NM)

p4_consumption_CA<-ggplot(data=consumption_CA, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="California energy consumption", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = consumption_CA)

library(gridExtra)
grid.arrange(p1_consumption_AZ,p2_consumption_TX,p3_consumption_NM,p4_consumption_CA, nrow=2)


p1_production_AZ<-ggplot(data=production_AZ, aes(x=Year, y=Data/1000)) +
```

```
  geom_smooth() +
  labs(title="Arizona energy production", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))
loess(Data~Year,data = production_AZ)

p2_production_TX<-ggplot(data=production_TX, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="Texas energy production", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))
loess(Data~Year,data = production_TX)

p3_production_NM<-ggplot(data=production_NM, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="New Mexico energy production", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))
loess(Data~Year,data = production_NM)

p4_production_CA<-ggplot(data=production_CA, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="California energy production", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))
loess(Data~Year,data = production_CA)

grid.arrange(p1_production_AZ,p2_production_TX,p3_production_NM,p4_production_CA, nrow=2)


p1_electricity_AZ<-ggplot(data=electricity_AZ, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="Arizona electricity generation", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäăÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = electricity_AZ)

p2_electricity_TX<-ggplot(data=electricity_TX, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="Texas electricity generation", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäăÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = electricity_TX)

p3_electricity_NM<-ggplot(data=electricity_NM, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="New Mexico electricity generation", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäăÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = electricity_NM)

p4_electricity_CA<-ggplot(data=electricity_CA, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="California electricity generation", x="year", y="Trillion Btu")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäăÿŁè£ŹäÿĂèąŇ
loess(Data~Year,data = electricity_CA)

grid.arrange(p1_electricity_AZ,p2_electricity_TX,p3_electricity_NM,p4_electricity_CA, nrow=2)




Total_consumption<-read.xlsx(file = "Total end-use energy consumption.xlsx",sheetIndex = 1,header=
View(Total_consumption)
seseds_consumption<-merge(seseds,Total_consumption,all.y = TRUE)
View(seseds_consumption)
View(seseds2)
y<-merge(seseds2,seseds_consumption,all = TRUE)
View(y)
```

```
z<-y[y$MSN=="TETXB",]
View(z)
d<-rep(z$Data,each=11)
View(d)

z<-seseds2[order(seseds2$StateCode,seseds2$Year),]
View(z)
z$total<-d
View(z)
z$Data<-(z$Data/z$total)*z$Data
View(z)


consumption_AZ2<-z[z$StateCode=="AZ",]
View(consumption_AZ2)
#write.xlsx(consumption_AZ2,file = "consumption_AZ2.xlsx")
consumption_AZ2_sum<-aggregate(consumption_AZ2[4],consumption_AZ2[3],sum)
View(consumption_AZ2_sum)
write.xlsx(consumption_AZ2_sum,file = "consumption_AZ2_sum.xlsx")
ggplot(data=consumption_AZ2_sum, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="", x="year", y="")+
  theme(plot.title = element_text(hjust = 0.5))  #äźŞåřśåŁăäÿŁè£ŹäÿĂèąŇ
loess(consumption_AZ2_sum$Data~consumption_AZ2_sum$Year)
predict(loess(consumption_AZ2_sum$Data~consumption_AZ2_sum$Year))

consumption_CA2<-z[z$StateCode=="CA",]
View(consumption_CA2)
consumption_CA2_sum<-aggregate(consumption_CA2[4],consumption_CA2[3],sum)
View(consumption_CA2_sum)
write.xlsx(consumption_CA2_sum,file = "consumption_CA2_sum.xlsx")

consumption_NM2<-z[z$StateCode=="NM",]
View(consumption_NM2)
consumption_NM2_sum<-aggregate(consumption_NM2[4],consumption_NM2[3],sum)
View(consumption_NM2_sum)
write.xlsx(consumption_NM2_sum,file = "consumption_NM2_sum.xlsx")


consumption_TX2<-z[z$StateCode=="TX",]
View(consumption_TX2)
consumption_TX2_sum<-aggregate(consumption_TX2[4],consumption_TX2[3],sum)
View(consumption_TX2_sum)
write.xlsx(consumption_TX2_sum,file = "consumption_TX2_sum.xlsx")




Total_production<-read.xlsx(file = "Total energy production.xlsx",sheetIndex = 1,header=TRUE)
View(Total_production)
seseds_production<-merge(seseds,Total_production,all.y = TRUE)
View(seseds_production)
View(seseds3)
y<-merge(seseds3,seseds_production,all = TRUE)
View(y)
z<-y[y$MSN=="TEPRB",]
View(z)
d<-rep(z$Data,each=6)
View(d)

z<-seseds3[order(seseds3$StateCode,seseds3$Year),]
View(z)
z$total<-d
```

```
View(z)
z$Data<-(z$Data/z$total)*z$Data
View(z)

production_AZ2<-z[z$StateCode=="AZ",]
View(production_AZ2)
production_AZ2_sum<-aggregate(production_AZ2[4],production_AZ2[3],sum)
View(production_AZ2_sum)
write.xlsx(production_AZ2_sum,file = "production_AZ2_sum.xlsx")
ggplot(data=production_AZ2_sum, aes(x=Year, y=Data)) +
  geom_smooth() +
  labs(title="", x="year", y="")+
  theme(plot.title = element_text(hjust = 0.5))  #äź§åřśåŁäÿŁè£ŹäÿĂèąŇ
loess(production_AZ2_sum$Data~production_AZ2_sum$Year)
predict(loess(production_AZ2_sum$Data~production_AZ2_sum$Year))

production_CA2<-z[z$StateCode=="CA",]
View(production_CA2)
production_CA2_sum<-aggregate(production_CA2[4],production_CA2[3],sum)
View(production_CA2_sum)
write.xlsx(production_CA2_sum,file = "production_CA2_sum.xlsx")

production_NM2<-z[z$StateCode=="NM",]
View(production_NM2)
production_NM2_sum<-aggregate(production_NM2[4],production_NM2[3],sum)
View(production_NM2_sum)
write.xlsx(production_NM2_sum,file = "production_NM2_sum.xlsx")


production_TX2<-z[z$StateCode=="TX",]
View(production_TX2)
production_TX2_sum<-aggregate(production_TX2[4],production_TX2[3],sum)
View(production_TX2_sum)
write.xlsx(production_TX2_sum,file = "production_TX2_sum.xlsx")




states_2009<-read.xlsx(file = "2009.xlsx",sheetIndex = 1,header=TRUE)
View(states_2009)
criteria<-read.xlsx(file = "criteria.xlsx",sheetIndex = 1,header=TRUE)
View(criteria)
x<-merge(states_2009,criteria,all.y = TRUE)
View(x)

criteria_AZ<-x[x$StateCode=="AZ",]
View(criteria_AZ)
write.xlsx(criteria_AZ,file = "criteria_AZ.xlsx")

criteria_CA<-x[x$StateCode=="CA",]
View(criteria_CA)
write.xlsx(criteria_CA,file = "criteria_CA.xlsx")

criteria_NM<-x[x$StateCode=="NM",]
View(criteria_NM)
write.xlsx(criteria_NM,file = "criteria_NM.xlsx")

criteria_TX<-x[x$StateCode=="TX",]
View(criteria_TX)
write.xlsx(criteria_TX,file = "criteria_TX.xlsx")
```

Appendix C Third appendix

Input matlab source:

```
%Determining which of the four states appeared to have the ąřbestąś profile for use of cleaner, re
clc, clear
a=[88571.38442  103493.2854 19.66482377 6587.653
635062.3653 712704.4602 18.4052811  36887.615
33785.17435 35635.38371 17.17897394 2007.315
303697.0626 356634.8206 15.37924605 24770.651];
[m,n]=size(a);

for j=1:n
    b(:,j)=a(:,j)/norm(a(:,j));
end
w=[0.3 0.3 0.2 0.2];
c=b.*repmat(w,m,1);
Cstar=max(c);
Cstar(3)=min(c(:,3))
C0=min(c);
C0(3)=max(c(:,3))
for i=1:m
    Sstar(i)=norm(c(i,:)-Cstar);
    S0(i)=norm(c(i,:)-C0);
end
f=S0./(Sstar+S0);
[sf,ind]=sort(f,'descend')
```