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2018
MCM/ICM
Summary Sheet

Energy Profile—Description, Evaluation and Prediction

Summary

Energy production and usage are highly considered by the U.S. Recently, there are four states planning to form an energy compact, which focuses on the usage of renewable energy sources. In this paper, we model to analyze and describe the energy profile. Then evaluate the "best" state and predict energy condition of every state. In addition, we need to determine several renewable energy usage goals and identify some practical actions for the compact.

Firstly, we establish a **Multi-Dimensional Description (MDD)** model, which includes two sub-models, **MDD--Based on Statistics** and **MDD--Based on Lasso-PCA**. In the section based on statistics, we define and calculate a set of descriptive indicators. In another section, based on Lasso-PCA method, we explore the dominant energy factors of GDP. Through horizontal and vertical comparison to the indicators and analysis to the dominant factors, we obtain the energy profile of each state, as well as their similarities and differences. Afterwards, we discuss the influential factors from the perspectives of population, industry, commerce and geography.

Secondly, we construct a **Scoring Model with Adjustable Weights**. To start with, the usage of renewable energy in each state is intuitively observed through the pie chart. Next, we weight and add the production, consumption and growth indicators of renewable energy. By calculating the scoring model we find that California is the "best".

Meanwhile, in order to predict the energy profile, every energy indicator is regarded as time series. However, since there are outliers in the data, we pre-process the time series using the **Laida Criterion-Linear Extrapolation** method. Then, the Autoregressive Integrated Moving Average (ARIMA) method is applied to forecast the energy profile in 2025 and 2050

Based on the conclusions above, we determine three renewable energy usage goals, that is reducing the nonrenewable energy production share in total energy production, promoting the contribution of renewable energy consumption to GDP and reducing the relative rate of energy production surplus. Finally, we recommend three actions that the compact may take to realize the goals.

Keywords: Energy profile; Renewable energy; Evaluation; Prediction

Contents

1 Introduction

In this section, we introduce the background of the problem, list the tasks at hand, and construct our problem-solving process which is presented by a flowchart.

1.1 Background

1.1.1 Problem Restatement

Energy production and consumption are major portion of any economic system and have been attached great importance all over the world. In different states of the U.S., they are affected by geography, climate, population and industry environment. Additionally, the federal government decentralize energy policy to state level. Therefore, energy situations of distinct states are obviously different. In order to foster cooperation in energy field, many states usually tend to form interstate compacts. In the compacts, all the state should consent to the same specific policy issue, and cooperate with each other, thus solving a variety of energy issues with assistance from other states.

Recently, there are four states -- California, Arizona, New Mexico and Texas -- planning to form a realistic new compact, which focuses on increasing usage of renewable energy. The given data file has provided database of energy production and consumption, along with some demographic and economic information of the four states. This paper performs data analysis, builds a model to describe energy profiles, assesses and predicts energy developments of the four states, and at last raises several renewable energy usage goals and some practical recommendations for them.

1.1.2 The Tasks at Hand

- Build a descriptive model, which is on the basis of the provided data of the four states, to analyze and describe their historical energy profile from 1960 to 2009.
- Consider the development of clear and renewable energy in the four states, and figure out their similarities and differences. Study and clarify the modeling results with regard to the aspects of geography, industry, population and climate.
- Formulate a set of evaluation criteria, then use the criteria to evaluate the renewable energy generalization of the four states.
- Predict the energy profile, especially about the renewable energy usage of each state under the circumstance that there are not any policy changes.
- Determine the renewable energy usage targets for 2025 and 2050 based on the profile, the criteria and the prediction, and state them as goals for this new four-state energy compact.
- Raise at least three actions the four states may take to achieve the goals.
- Prepare a one-page memo for the Governors including the state energy profiles, the predictions and the recommended goals for the energy compact.

1.2 Modeling Flowchart

On the basis of problem statement above and the tasks at hand, a problem-solving process is formed. Then the modeling flowchart is delivered as follows.

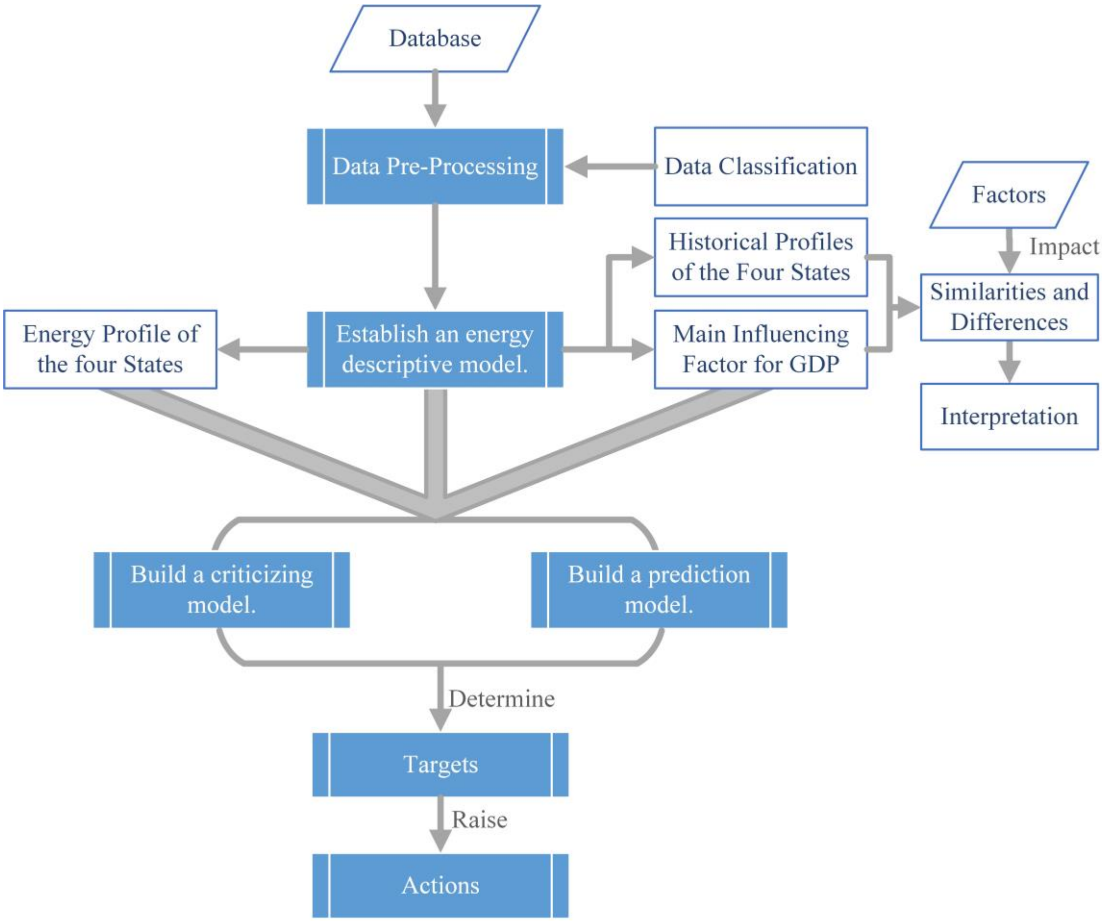


Figure 1: Modeling Flowchart

2 Assumptions and Notations

2.1 Assumptions and Declarations

In order to simplify the course of modeling and draw some reasonable conclusions from the model, several assumptions and declarations are made as follows:

Declaration 1: The nuclear energy is not advocated by us due to the following reasons.

- The nuclear waste is much hard to be disposed, and the nuclear contamination will jeopardize the environment and human race.
- The nuclear plant and reactor have safety hazards. In fact, there have been several serious nuclear explosions in recent decades, like in Chernobyl, Ukraine, 1986 and in Fukushima, Japan, 2011.
- There is a large amount of controversy about the use of nuclear energy all the time.

- The nuclear plant has poor thermal efficiency, hence it discharges more waste heat than other power plants.

Assumption 1: The development and utilization of renewable energy in each the four states won't reach the limitation before 2050.

Assumption 2: Non-governmental organizations like Environmental Defense Fund and The Nature Conservancy don't get involved in development on renewable energy before 2050. In order to remove their influence to our prediction.

2.2 Notations and Descriptions

Here we list the symbols and the descriptions which will be used later, as shown in Table 1.

Table 1: Notations

Symbol	Description
r_1	The relative rate of energy production surplus.
r_2	Total renewable energy consumed per dollar of real GDP.
r_3	The proportion of total renewable energy consumption in total energy consumption.
r_4	The proportion that different kinds of renewable energy consumption account in total renewable energy consumption.
r_5	Growth rate of renewable energy share in total energy consumption.
r_6	Rate of renewable energy production in total energy production.

3 Multi-Dimensional Description Model

3.1 Definition and Classification of Energy

According to the U.S. Energy Information Administration[12], energy sources are classified as follows:

- **Nonrenewable energy**. They do not form or replenish in a short period of time, including nuclear energy as well as fossil fuels like crude oil and coal.
- **Renewable energy**. Unlike nonrenewable energy, renewable energy sources are able to regenerate naturally in a short period, including geothermal, hydropower, wind, solar and biomass energy.

3.2 Data Pre-Processing

Before analyzing in detail, the Excel data needs to be processed, to make the energy information more clear and logical.

(1) Put the variables belonging to the same state together, and that will be four parts.

(2) Detect which variables are counted and how many years they have been counted.

There are 605 variables in the sheet "msncodes". However, not all of the 605 variables are counted in the sheet "seseds". Therefore, we need to detect which variables are counted and how many years they have been counted.

Table 2: Starting Statistical Years for Different Variables

Year	Variable Amount	Continuous Counting Years	New Variable Amount	New Variable
1960	318	50	318	(Appendix Table 1)
1970	576	40	258	(Appendix Table 2)
1977	578	33	2	GDPRX, TETGR
1980	583	30	5	SFCCB, SFEIB, SFINB, SFRCB, SFTCB

(3) Place the variables of the same kinds of energy source together, according to the definition and classification of energy in Section 3.1.

After the variables have been divided in view of they are related to different states, we rank them in the light of different energy sources they related to.

While analyzing the consumption of renewable and nonrenewable energy, we find that the number of renewable energy total consumption (RETCB) is equal to the sum of several variables. That is to say:

$$\text{RETCB} = \text{BMTCB} + \text{GETCB} + \text{SOTCB} + \text{HYTCB} + \text{WYTCB}\,.$$

What's more, the fossil energy total consumption (FFTCB) is also equal to the sum of other variations:

$$\text{FFTCB} = \text{CLTCB} + \text{PMTCB} + \text{NGTCB}\,.$$

So according to the definition in Section 3.1 and energy numerical relationship above, classification and description of the variables are showed in Table 3:

Table 3: Variable Classification Based on Source Types

Energy Type	Symbol	Description
Renewable (RETCB)	BMTCB	Biomass total consumption.
	GETCB	Geothermal energy total consumption.
	SOTCB	Photovoltaic and solar thermal energy total consumption.
	HYTCB	Hydroelectricity total production.
	WYTCB	Electricity produced from wind energy.
Nonrenewable (FFTCB+ NUETB)	CLTCB	Coal total consumption.
	PMTCB	All petroleum products total consumption excluding fuel.
	NGTCB	Natural gas total consumption including supplemental.
	NUETB	Electricity produced from nuclear power.

In addition, about BMTCB in Table 3, we find that it is equal to the sum of WWTCB (wood and waste total consumption) and EMTCB (Fuel ethanol, excluding denaturant, total consumption), that is

$$\mathrm{BMTCB} = \mathrm{WWTCB} + \mathrm{EMTCB}.$$

(4) Gather the energy variables on the basis of which social sectors they are consumed by.

In the Excel data we discover that the energy variables are also connected with the four different social sectors, that is residential, transportation, commercial, and industry.

(5) Standardize the excel data to remove negative impacts brought by the different dimensions and scales.

3.3 Multi-Dimensional Description Model

In this section, we construct the multi-dimensional description (MDD) model to describe the four states' energy profiles, energy evolution profiles, especially the renewable energy situation. MDD model could be divided into two sub-models. That is MDD Model—Based on Statistics and MDD Model—Based on Lasso-PCA Method.

- **MDD Model--Based on Statistics.** Using the given energy variables and defining energy statistical indicators to describe the energy profiles, energy evolution profiles, especially the renewable energy situation for every state.
- **MDD Model--Based on Lasso-PCA.** Combining the Lasso and PCA method to detect the dominant energy factors that have significant impacts on GDP for every state.

3.3.1 MDD Model--Based on Statistics

We operate the MDD Model—Based on Statistics in two dimensions, that is horizontal comparison and vertical comparison.

- **Horizontal Comparison** means comparing and analyzing the energy indicators between different states **during the same period**.
- **Vertical Comparison** means comparing and analyzing the energy indicators in every state **at different historical periods**.

On the one hand, in order to figure out the energy profile of each states, we carry out horizontal comparison. For every state, some significant indexes are statistical counted as follows.

(1) TETCB & TETPB: Total energy consumption & Total energy consumption per capita.

(2) TNACB: Total energy consumed by the transportation sector excluding the sector's share of electrical system energy losses.

(3) TNCCB: Total energy consumed by the commercial sector excluding the sector's share of electrical system energy losses.

(4) TNICB: Total energy consumed by the industrial sector excluding the sector's share of electrical system energy losses.

(5) TNRCB: Total energy consumed by the residential sector excluding the sector's share of electrical system energy losses.

(6) r_1: The relative rate of energy production surplus. It is defined and calculated by the follow formulation.

$$\begin{aligned} r_1 &\triangleq \frac{Total\ energy\ production - Total\ energy\ consumption}{Total\ energy\ demand} \\ &= \frac{TERPB - TETCB}{TETCB} \end{aligned} \tag{1}$$

(In fact, TETCB represents the energy demand amount.)

(7) Total consumption of all kinds of energy defined in Section 3.2.

On the other hand, to research the historical evolution of the four states' energy profiles, we carry out the vertical comparison. We define and calculate the following energy indictors.

(1) TETGR: Total energy consumed per dollar of real gross domestic product(GDP).

(2) r_2: Total renewable energy consumed per dollar of real GDP. It is defined and calculated by the follow formulation.

$$\begin{aligned} r_2 &\triangleq \frac{Renewable\ energy\ total\ consumption}{Total\ real\ GDP} \\ &= \frac{RETCB}{GDPRX} \end{aligned} \tag{2}$$

(3) r_3: The proportion of total renewable energy consumption in total energy consumption. It is defined and calculated by the follow formulation.

$$\begin{aligned} r_3 &\triangleq \frac{Renewable\ energy\ total\ consumption}{Total\ energy\ consumption} \\ &= \frac{RETCB}{TETCB} \end{aligned} \tag{3}$$

(4) r_4: The proportion that different kinds of renewable energy consumption account in total renewable energy consumption. It is defined and calculated by the follow formulation.

$$r_4(i) \triangleq \frac{i}{RETCB}, \quad i = \{BMTCB, GETCB, SOTCB, HYTCB, WYTCB\} \tag{4}$$

3.3.2 MDD Model--Based on Lasso-PCA Method

GDP is a core indicator while estimating economic and financial status of a region. This indicator also associates closely with a region's energy status, which includes energy structure and types, generation and consumption. In this section, the state's energy profile, as well as their similarities and differences are examined from the relationship between GDP and energy factors.

We combine Lasso and PCA methods.

Firstly, we use Lasso to select the variables and estimate the parameters. [1]

Assuming the following independent variables X (explanatory variables), and dependent variable Y (response variable):

$$X = \left(X_1, X_2, ..., X_p\right) \in R^{n \times p}, \ Y \in R^{n \times 1}.$$

The linear model between Y and $X_1, X_2, ..., X_p$ is as follows:

$$Y = \beta_1 X_1 + \beta_2 X_2 + ... + \beta_p X_p + \varepsilon \tag{5}$$

Where $Y = \left[y_1, y_2, ..., y_n\right]^T$, $X_j = \left[x_{1j}, x_{2j}, ..., x_{nj}\right]^T$, $j = 1, 2, ..., p$. $\beta_1, \beta_2, ..., \beta_p$ are regression coefficients.

For linear model in Equation (1), Lasso regression could be represented as:

$$\hat{\beta}^{lasso}(\lambda) = \underset{\beta}{\arg\min}\left\{SSE + \lambda \sum_{j=1}^{p} \left|\beta_j\right|\right\} \tag{6}$$

where SSE is residual sum of squares:

$$SSE = \sum_{i=1}^{n}\left(y_i - \sum_{j=1}^{p} x_{ij}\beta_j\right)^2 \tag{7}$$

where λ is a constraint parameter.

In our paper, GDP of every state is the response variable Y, and the other 582 variables are explanatory variables X. With the assistance of Lasso, we could find the independent variables which have significant influence to GDP and calculate the variable coefficients.

Secondly, we extract the principle components through PCA, and conduct principle component analysis on the obtained independent variables. And finally we identify the major factors that affect the GDP of every state[2].

3.4 Modeling Results and Analysis

3.4.1 Energy Profiles by Horizontal Comparison

By calculating the horizontal comparison indictors defined in section 3.3, we draw the conclusions of every state's energy profiles. The results are showed below.

- **Total energy consumption & Energy consumption per capita**

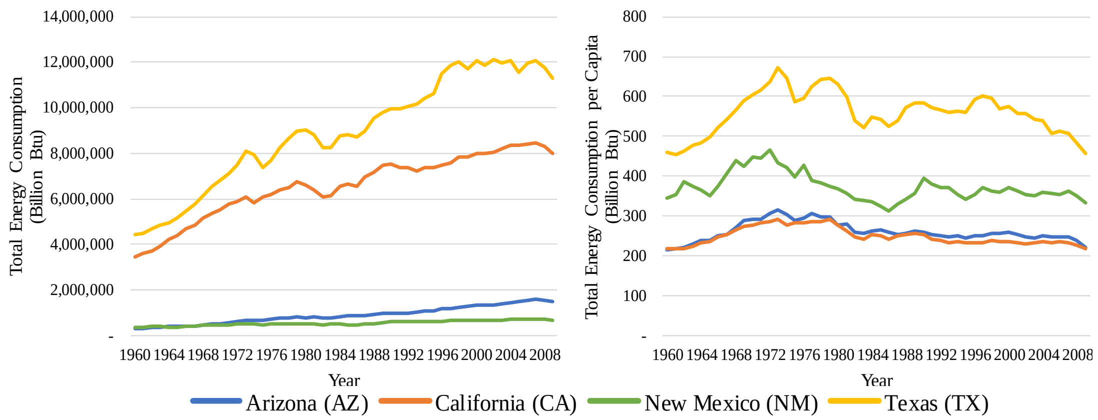


Figure 2: TETCB & TETPB of the Four States

Quick-Fact 1: Texas consumes the largest amount of energy, California second. New Mexico and Arizona consume the least.

Quick-Fact 2: Total energy consumption of every state is on the rise. Compared with Arizona and New Mexico energy consumption of California and Texas grow rapidly with larger increases.

Quick-Fact 3: As for energy consumption per capita, Texan is the highest, New Mexican second. Californian and Arizonan are the lowest and similar.

- **Energy consumption in different sectors**

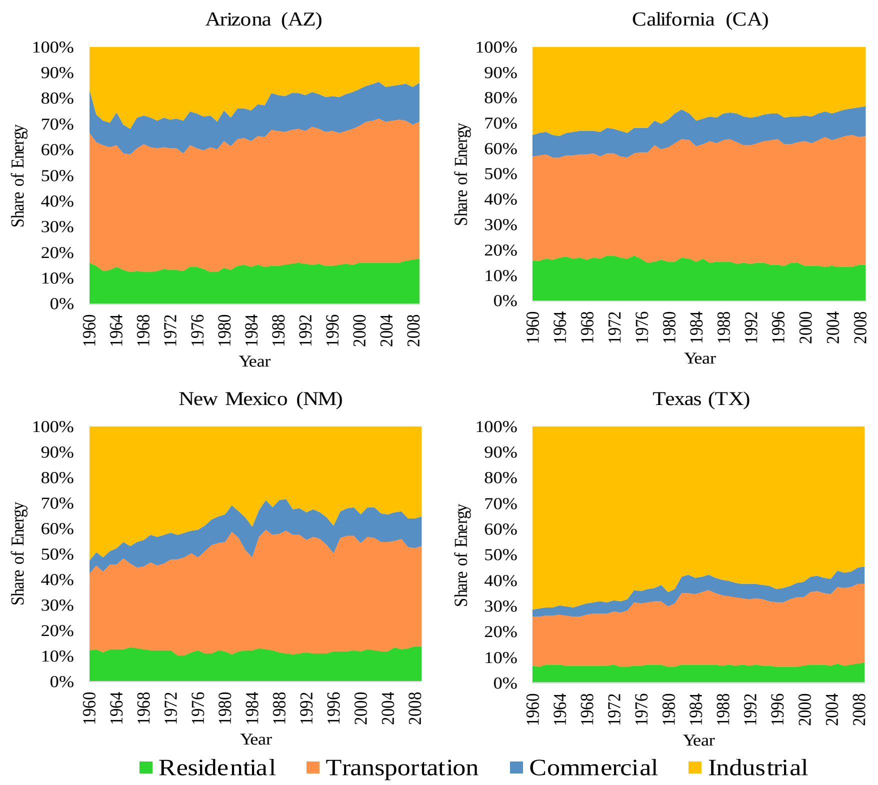


Figure 3: Energy Consumption in Different Sectors of Four States

Quick-Fact 4:

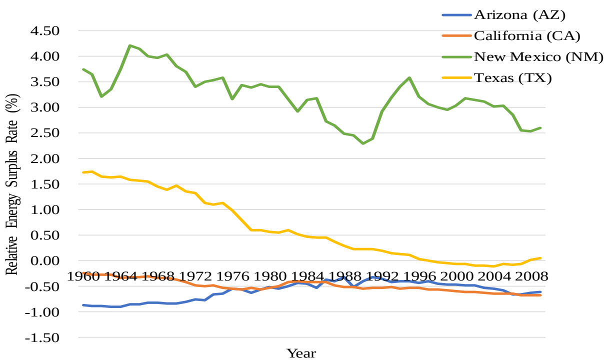
For Arizona, its transportation energy consumption share is the largest in total energy consumption. Industry is the second and shows a downward trend. Commercial and residential are the least and maintain stable levels.

For California, it has the similar condition with Arizona in terms of energy consumption in different sectors.

For New Mexico, its transportation energy consumption share is the largest in total energy consumption. Industry is slightly lower than transportation. Commercial and residential are the least and maintain stable levels.

For Texas, its industry energy consumption share is the largest in total energy consumption. Transportation is the second and shows upward trend. Commercial and residential are the least and maintain stable levels.

- **Relative rate of energy surplus**



Quick-Fact 5: New Mexico and Texas maintain the state of relative energy production surplus, though excess rate of Texas has obvious downward trend. Another two states have slight insufficient energy production.

Figure 4: Relative Energy Surplus Rate in 4 states

- **Consumption of various kinds of energy sources**

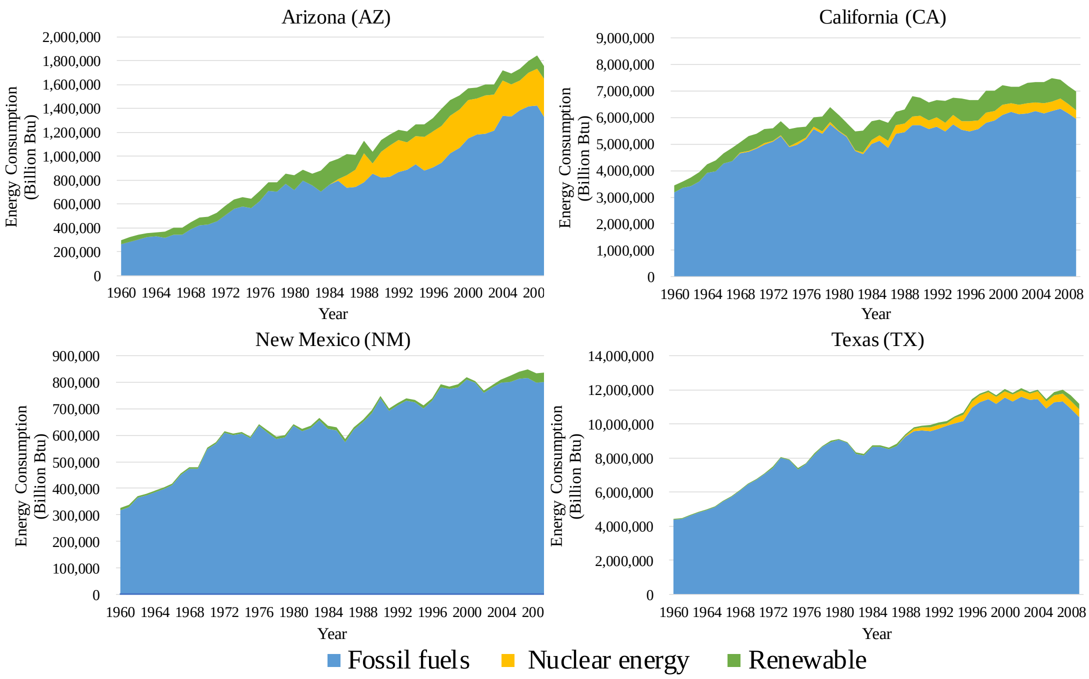


Figure 5: Consumption of Different Energy in the Four States

Quick-Fact 6:

For the four states, fossil energy occupies the absolute dominance in total energy consumption, and its usage amount takes on ascendant trend.

In terms of nuclear energy, there are three states using this kind of energy. Among them, California develops and uses it for the longest time. Nuclear energy utilization proportion in Arizona is the highest.

3.4.2 Energy Profile & Renewable Energy Situation by Vertical Comparison

By calculating the vertical comparison indictors defined in section 3.3, we draw the conclusions of every state's energy profiles, especially the detailed conditions of renewable energy.

- **Total energy consumed per dollar of real GDP & Total renewable energy consumed per dollar of real GDP**

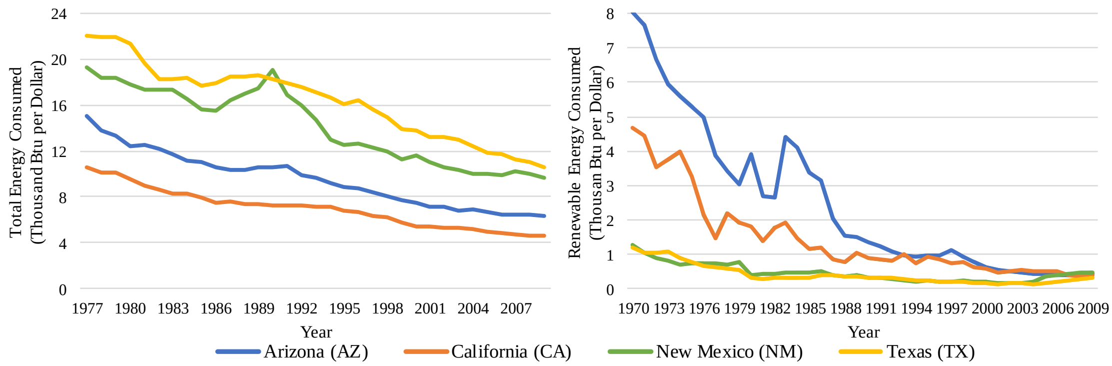


Figure 6: TETGR & r_2 of the four states

Quick-Fact 7: Both the total energy and renewable energy consumed per unit GDP decline, which reflects that all the four states improve their energy efficiency.

- **Proportion of renewable energy consumption in total energy consumption**

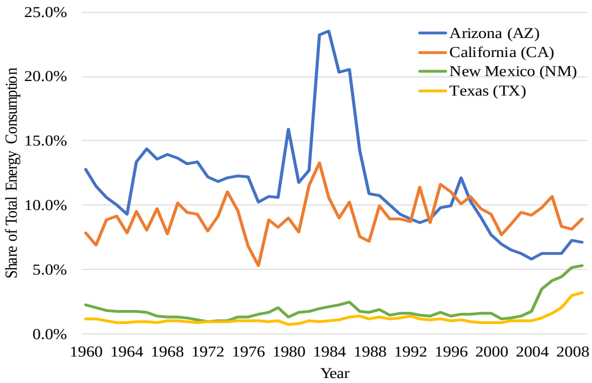


Figure 7:Renewable Energy Share of Total Consumption for the 4 states

Quick-Fact 8:

Renewable energy share of total energy consumption in New Mexico and Texas all maintain a low level before 2004, but rise after 2004. As for Arizona and California, the share fluctuates largely, but maintain a high average level.

- **Proportion of different renewable energy consumption in total renewable energy consumption**

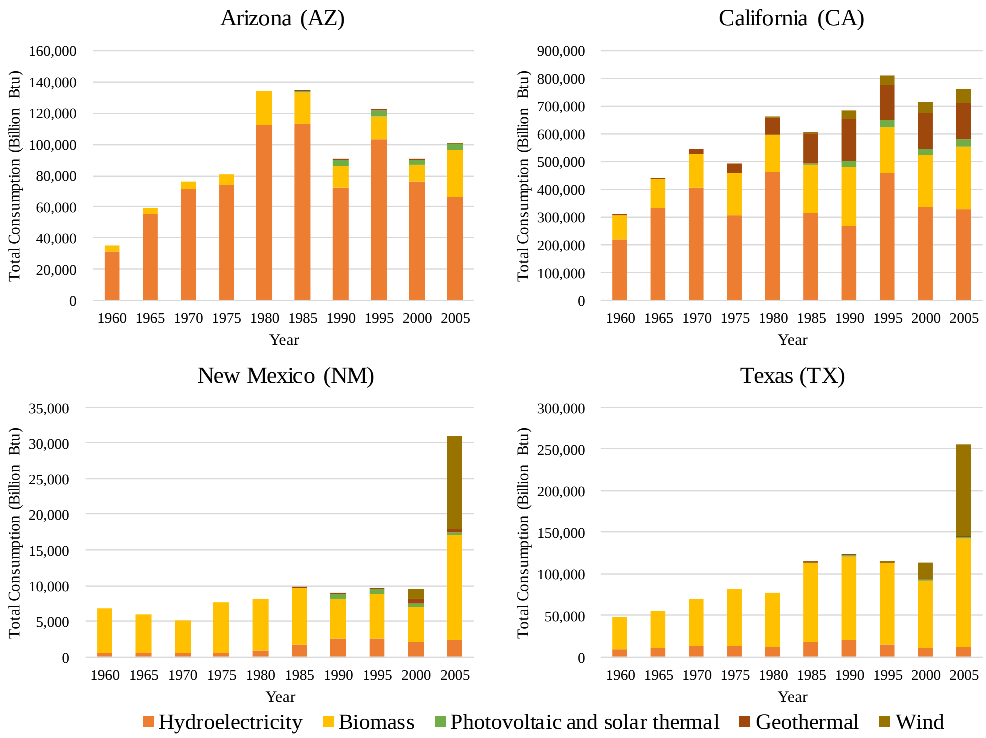


Figure 8: Share of Different Kinds of Renewable Energy

Quick-Fact 9:

For Arizona, its leading renewable energy is hydroelectricity.

For California, its main renewable energies are hydroelectricity and biomass.

For New Mexico, the dominant renewable energy is biomass, but it begins to increase the utilization of wind energy from about 2000.

For Texas, it has the similar renewable energy using trend as New Mexico.

3.4.3 GDP-Energy Relationship Analysis by Lasso-PCA Method

By applying Lasso-PCA method we figure out the principle energy factors that mainly influence the GDP of every state. The results are as follows. (Due to space limitations, another three states' solution processes of Lasso and complete data results of PCA are all in the Appendix.)

- **Lasso-PCA analysis for Arizona**

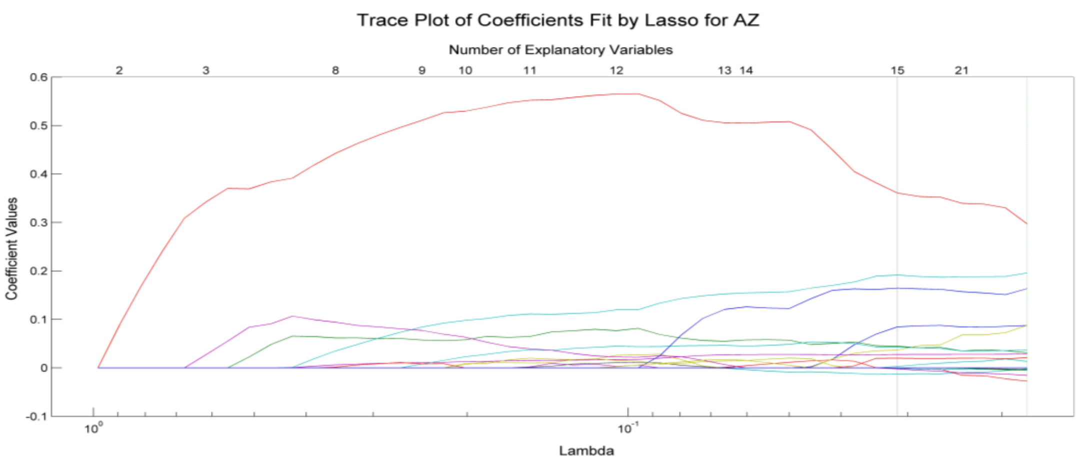


Figure 9: Variables Selection and Coefficients Estimation via Lasso

The colorful curves stand for the selected variables and their corresponding coefficient values.

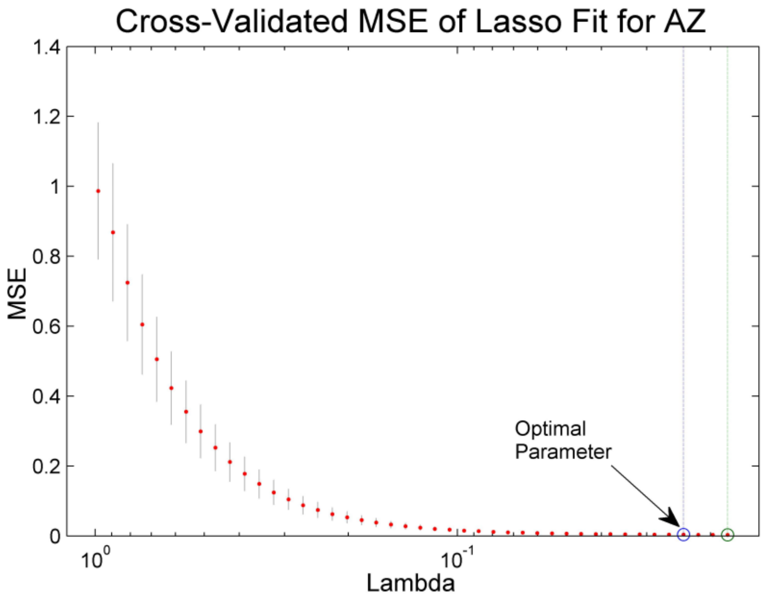


Figure 10: Optimal Parameter (λ) Selection of Lasso

Select the optimal parameter (λ) based on the Cross-validation criterion.

Then the principle component analyzing results are as follows.

Table 4: PCA for Selected Variables of Arizona

PC	Principle Energy Factor
PC1	Commercial and residential electric energy consumption.
PC2	Industrial and commercial fossil energy consumption.

- **Lasso-PCA analysis for California**

Table 5: PCA for Selected Variables of California

PC	Principle Energy Factor
PC1	Commercial, residential and transporting electric energy consumption.
PC2	Residual fuel oil total consumption.

- **Lasso-PCA analysis for New Mexico**

Table 6: PCA for Selected Variables of New Mexico

PC	Principle Energy Factor
PC1	Total residential energy consumption.
PC2	Naphtha-type jet fuel consumed by the transportation sector

- **Lasso-PCA analysis for Texas**

Table 7: PCA for Selected Variables of Texas

PC	Principle Energy Factor
PC1	Distillate fuel oil consumed by the transportation sector.
PC2	Geothermal and solar energy consumed in the residential sector

3.4.4 Factors Causing Similarities & Differences

By description of energy profile, we can easily figure out the similarities and differences. Now we try to explain them from the following factors.

- **From Total Population**

With increase of population, total energy consumption also increases.

Population in California is the most of the four states. That is the reason why transporting electric energy influence the GDP most. And in Figure 2, because of large population, though total energy consumption is the largest in four states, the energy consumption per capita is not the highest.

- **From Industry and Commerce**

Arizona develops the manufacturing industry mostly, which means industry energy consumption mainly influences its GDP.

Economy in California is the most developed, especially high-tech industry and tertiary industry. Considering that development of industry and commerce rely on transportation so much. That's why commercial and transportation is PC1 in Table 5.

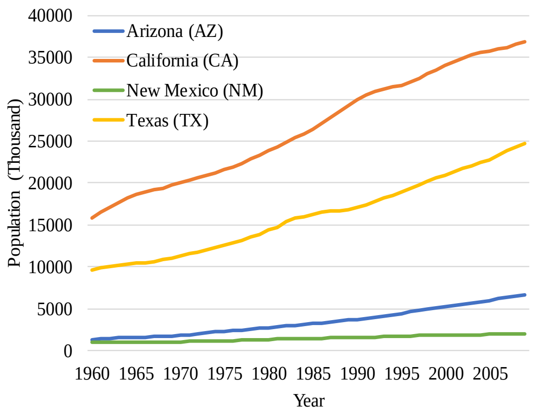


Figure 11: Population of the four states

New Mexico have the most abundant nonrenewable energy source, it's the main source of income. That's why in Figure 6, the fossil fuel takes most of the area. So New Mexico has the most energy surplus in Figure 4.

Texas is famous for its fossil fuel and petrochemical industry, which is alike New Mexico. So in Texas and Mexico, variables of fossil fuel and its related products influence GDP very much.

- **From Geography and Climate**

For Arizona, it has great terrain drop and Colorado River, so hydroelectricity in Arizona takes the most share of renewable energy, as showed in Figure 9. And its climate changes dramatic during a year. So in order to sustain normal life and business needs, combing with PC1 in Table 4, the commercial and residential electric energy consumption influence its GDP most.

For California, it also has great terrain drop and rivers, so hydroelectricity is also usable and efficient.

For New Mexico, it has typical desert climate. So it is warm and dry for the whole year. Agricultural is one of its important energy source. So biomass takes more share of renewable energy than others.

For Texas, it has developed agriculture. That provide possibility to develop its biomass energy too.

4 Scoring Model with Adjustable Weights

In this section, we define a scoring model to determine which of the four states have the "best" profile for use of cleaner, renewable energy in 2009.

4.1 Scoring Model

To begin with, we look through the general situation of renewable energy for each state in 2009, with Figure 9.

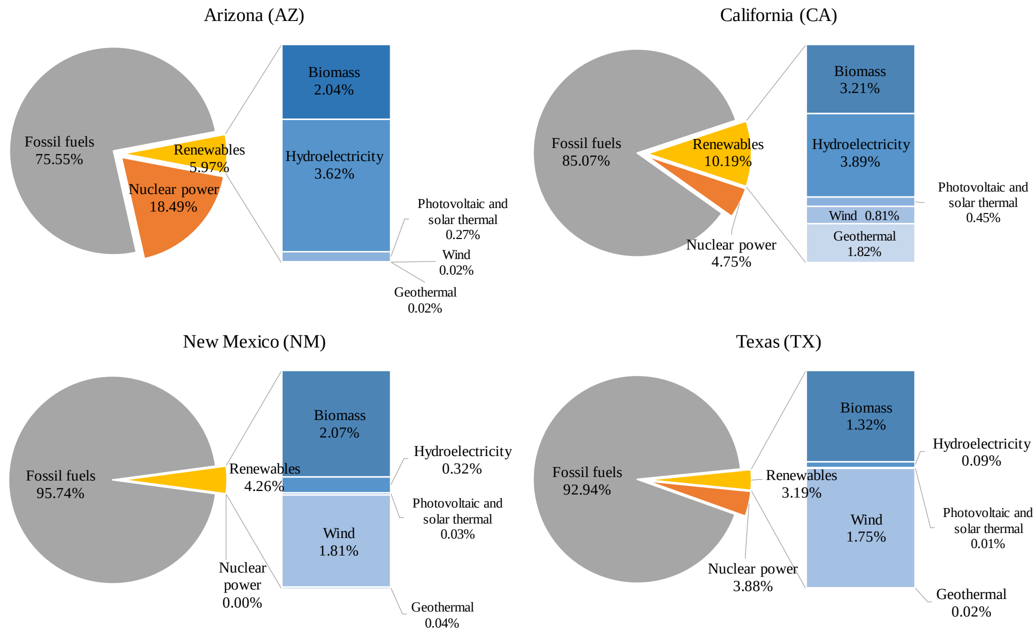


Figure 12: General Situation of Energy in 2009

From the Figure 13 we can find California has the largest renewable consumption share in total energy consumption share.

However, Figure 14 only contains the static energy consuming information of 2009. In order to access the renewable energy situation of every state more comprehensively, we define the following two indicators.

- r_5 : Growth rate of renewable energy share in total energy consumption.

$$r_5 = \frac{r_3 \ of \ 2009 - r_3 \ of \ 2008}{r_3 \ of \ 2008} = \frac{r_3(2009) - r_3(2008)}{r_3(2008)} \tag{8}$$

This indicator reflects the dynamic information of renewable energy consumption.

- r_6 : Rate of renewable energy production in total energy production.

$$r_6 = \frac{Renewable \ energy \ production}{Total \ energy \ production} = \frac{REPRB}{TEPRB} \tag{9}$$

This indictor reflects the production situation of renewable energy. Actually this indictor could better show how much the attention one state paying to renewable energy.

Then we define a scoring index, and it is calculated by the following equation.

$$Score = w_1 r_3 + w_2 r_5 + (100 - w_1 - w_2) r_6$$
$$s.t. \begin{cases} 0 < w_1 < 100 \\ 0 < w_2 < 100 \\ 0 < w_1 + w_2 < 100 \end{cases} \tag{10}$$

- Consider the three important indicators above at the same time. That can introduce the renewable energy situation in all aspects.
- Weight of each indicator is changeable. In fact, any rank is essentially **conditional rank** (rank changes with changing weights), because the ranking rules, which are measured by weights, will be influenced by the managers' subjective opinions. Certainly, we will make our own criteria by assigning specific weights.

4.2 Modeling Result

Then on the basis of the scoring model, we plot the 3D-figure of scores and weights.

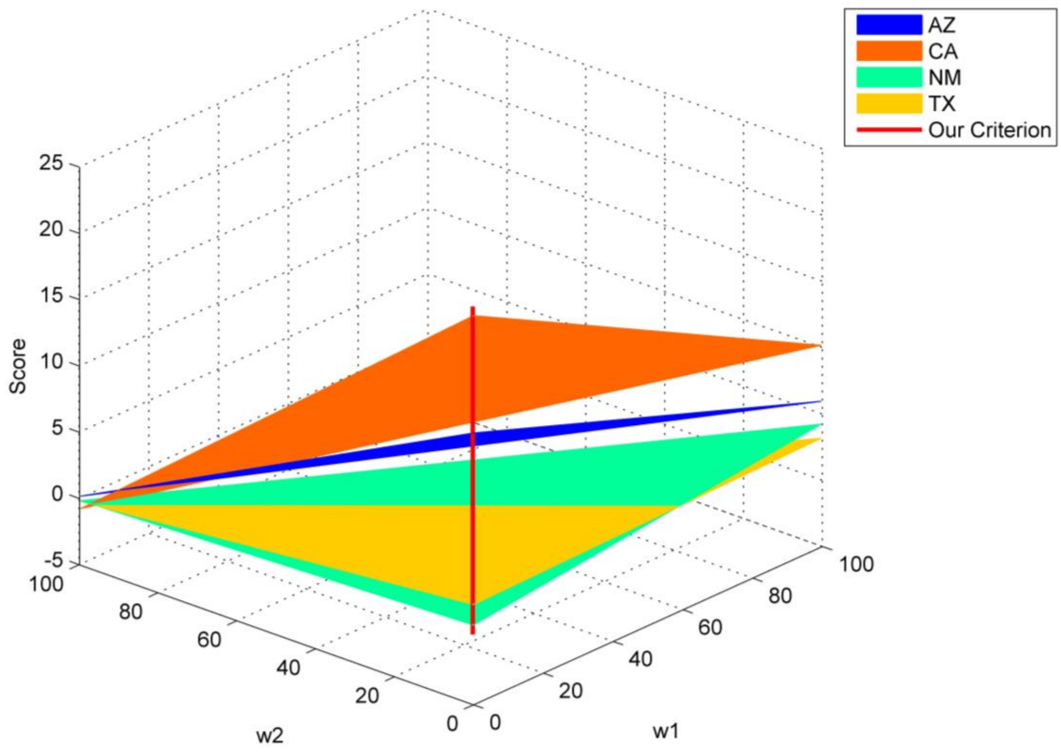


Figure 15: Scores Changing with Weights

From Figure 16, we can find that the score planes cross with each other, under some weights. Therefore, different weights will bring different ranks, and that is conditional rank.

On the foundation of our weights allocation that w_1 is 20 and w_2 is 20, the rank and scores are as follows:

Table 8: Score and Rank of Every State

Rank	State	Score
1	California	16.50
2	Arizona	10.53
3	Texas	2.12
4	New Mexico	1.42

5 Predicting Model and Result

In this section, the calculated indictors above are regarded as time series. We use Autoregressive Integrated Moving Average (ARIMA) to predict them. What should be noticed is that high quality and stability of data are all-important in any prediction model. Therefore, we pre-process the time series by 3σ criterion-linear extrapolation method[3][7]. That is:

- Eliminate outliers by 3σ criterion (Laida criterion)
- Data filling by linear extrapolation in which the value of $x\left(kT+\Delta t\right)$ is calculated and filled by

$$x\left(kT+\Delta t\right)=x(kT)+\frac{x(kT)-x\left[(k-1)T\right]}{T}\Delta t \tag{11}$$

Where $x(kT)$ is time series value of k -th moment. In our model, $T=\Delta t=1$ year. So the Equation (11) can also be rewritten as follows:

$$\begin{aligned} x\left[(k+1)T\right] &= x(kT)+x(kT)-x\left[(k-1)T\right] \\ &= 2x(kT)-x\left[(k-1)T\right] \end{aligned} \tag{12}$$

Then we apply ARIMA to predict the time series[6][8].

The notation $ARIMA\left(p,d,q\right)$ refers to the model with p autoregressive terms, d degree of differencing and q moving-average terms. The $ARIMA\left(p,d,q\right)$ model is written as follows:

$$x_t=\phi_0+\sum_{i=1}^{p}\phi_i x_{t-i}+\varepsilon_t+\sum_{i=1}^{q}\theta_i\varepsilon_{t-i} \tag{13}$$

Where $\left\{x_1,x_2,...,x_p\right\}$ denotes a time series, $\phi_1,\phi_2,...\phi_p$ and $\theta_1,\theta_2,...,\theta_q$ are the parameters of the model, the random variable ε_t denotes white noise, p , q are both non-negative constant integers.

Table 9: Prediction of Indictors 1

	Arizona (AZ)		California (CA)	
Year	**2025**	**2050**	**2,025**	**2,050**
Total Energy Consumption	1,830,846.88	2,194,416.70	8,462,532.59	8,661,179.77
Fossil fuels	1,567,994.88	1,896,850.06	6,006,069.45	5,997,189.15
Renewable	108,481.74	108,004.20	784,466.76	774,778.41
Residential	0.1882	0.2041	0.12	0.10
Transportation	0.5525	0.554	0.53	0.55
Commercial	0.1474	0.1498	0.11	0.11
Industrial	0.1118	0.0914	0.23	0.23
r_3	0.0593	0.0492	0.09	0.09
r_6	0.1948	0.1867	0.29	0.26

Table 10: Prediction of Indictors 2

	New Mexico (NM)		Texas (TX)	
Year	**2025**	**2050**	**2,025**	**2,050**
Total Energy Consumption	692,848.08	706,913.57	12,304,135.66	12,788,496.14
Fossil fuels	802,972.68	802,873.22	11,040,729.07	11,153,848.69
Renewable	42,704.67	58,650.4	528,503.32	616,068.98
Residential	0.12	0.12	0.07	0.07
Transportation	0.43	0.43	0.28	0.28
Commercial	0.11	0.11	0.06	0.06
Industrial	0.33	0.33	0.58	0.59
r_3	0.06	0.08	0.04	0.05
r_6	0.02	0.03	0.06	0.08

(The energy units are all Billion Btu)

6 Targets and Actions

In this section, we raise three renewable energy usage targets for the energy contact. Then, we give rise to three actions the contact may take. Especially, based on geography condition analysis for each state, we put forward a set of customized development and utilization scheme for their renewable energy.

6.1 Targets for Energy Compact

- **Target 1**

The nonrenewable energy production share in total energy production ($1-r_6$) should be controlled and limited under a level-α.

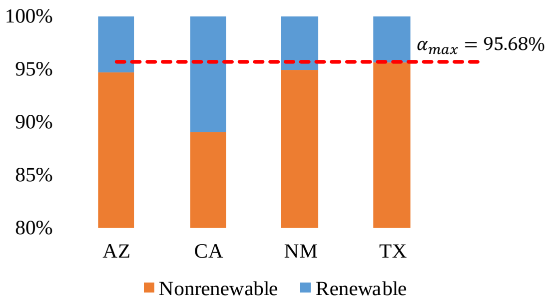


Figure 17: Energy Production Shares in 2025

α should be stipulated according to regulations below by the supervision department of the energy compact.

$$\alpha \le \alpha_{max} \tag{14}$$

α_{max} stands for the maximum $(1-r_6)$. Take Figure 17 as an example which describes prediction of $(1-r_6)$ in 2025. α_{max} should be equal to $(1-r_6)$ of TX.

- **Target 2**

By linear regression, we can obtain the linear regression equation between GDPRX and every energy variable. We define renew-GDP indictor and calculate it.

$$renew\text{-}GDP = \frac{\partial(\text{GDPRX})}{\partial(\text{RETCB})} \tag{15}$$

Essentially, renew-GDP stands for the contribution of renewable energy consumption to GDP and it should be promoted.

- **Target 3**

Reduce the relative rate of energy production surplus, which means r_1 should be cut down for some states.

6.2 Actions

- **Action 1**

In order to control and limit $(1-r_6)$, the energy compact may set a supervision department and relevant treaties. This department is consist by staff from all the four states, and have the power of reporting the energy consumption profiles.

- **Action 2**

The compact may establish an electricity concentration and decentralization center. This center will collect the surplus energy together, and then sell them out. The member of the compact enjoy priority and discount when buying the energy.

- **Action 3**

For Arizona, the development and utilize of hydroelectric station should be increased. Because its's great terrain drop and the Colorado River.

For California, it also has great terrain drop and rivers, so hydroelectricity is also usable and efficient.

For New Mexico, the solar power should be developed with greater scale, because of its desert climate.

For Texas, the wind power should be developed more vigorous and used because it's coastal and has abundant land and sea breeze.

7 Model Evaluation

7.1 Strengths and Weaknesses

7.1.1 Strengths

1. Energy status of every state is quantified in many different aspects. And results of these aspects are presented by intuitive and visualized methods.

2. GDP is the core indicator while estimating economic and financial status. The relationship between GPA and energy condition of the four states in different period, is considered by us.
3. The excellent Lasso method is applied by us in this passage. What's more, we combine Lasso with PCA, thus figuring the main influencing energy factors to the GDP.
4. Construct a scoring model with adjustable weights. This model has strong popularization, because different managers could adjust the weights according to their own preferences..

7.1.2 Weaknesses

1. There are not quantitative analysis to the actions which have been recommended by us.

7.2 Future Plans

1. Quantitatively analyze the actions which have been recommended by us.
2. Investigate and research the impact of policy on energy profiles

8 Conclusion

We can state our modeling conclusions from the following five aspects:

1. we establish a Multi-Dimensional Description (MDD) model to describe the energy profile. MDD model could be divided into two sub-models--MDD model—Based on Statistics and MDD model—Based on Lasso-PCA Method.
2. Through the solution of the model, we obtain the energy profile of each state, as well as their similarities and differences. Then we discuss the influential factors to similarities and differences among four states from the perspectives of population, industry and geography.
3. We construct a Scoring Model with Adjustable Weights which weight and add the production, consumption and growth indicators of renewable energy. We find the "best" state is California.
4. We use the Autoregressive Integrated Moving Average (ARIMA) method to predict the energy profile in 2025 and 2050
5. Based on the four conclusions above, we determine three renewable energy usage goals -- reducing the nonrenewable energy production share in total energy production, promoting the contribution of renewable energy consumption to GDP and reducing the relative rate of energy production surplus. Finally, we give rise to three actions the contact may take to realize the goals.

9 Memo

To: Governors
From: Model Team #88124
Date: February 13, 2018
Subject: Energy Profiles, Predictions and Recommended Goals

Recently, after being informed that your four states are planning to form a new energy compact, our team model to analyze, describe, and then predict energy profile of each state. Know we are writing here to introduce the state profiles, the predictions and the recommended goals presented by us.

Until 2009, Arizona has the lowest rate of excess energy, which is almost similar to California. At the same time, it has almost the highest share of renewable energy in total energy consumption. Then, California has the lowest energy consumption per capita. Moreover, New Mexico has the least total energy consumption, which is close to Arizona. But New Mexico has the largest energy surplus rate. Afterwards, Texas has the highest total energy consumption, and the lowest renewable energy consumption rate in total consumption.

What's more, we also discover that, for all of the four states, though consumption of energy maintain growth in general, the consumption of renewable energy has always been small as if a drop in the bucket. That's the main similarity but also a trouble of your four states.

On the basis of the model we raising and calculating, in the coming 2025, both the rates of renewable energy production and consumption taking in total energy are unsatisfactory. Though among the four states, California has the highest rates (9% consumption and 29% production). And these numbers will only change a little in 2050.

Therefore, we would like to propose three recommendations.

- All the four states could set up a supervision department, which is responsible for supervising factories and enterprises with too much nonrenewable consumption (the standard could be stipulated by the compacts).
- Establish an electricity concentration and decentralization center. This center will collect the surplus energy together, and then sell them out. The member of the compact enjoy priority and discount when buying the energy.
- Customize special indexes according to actual situation of every state. Every member in the compact have the responsibilities and obligations to provide and receive assistance as much as they can.

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11 Appendix

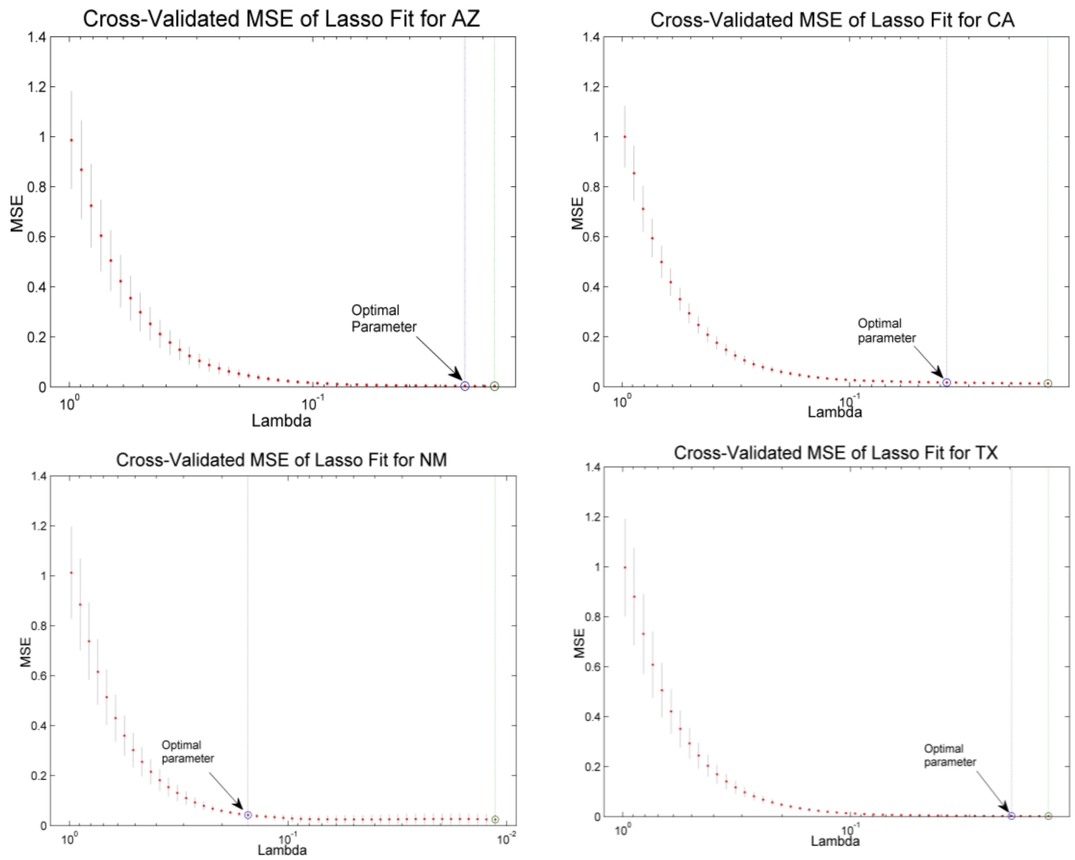
Appendix Table 1: Variables Counted from 1960

ABICB	CLOCK	ELIMB	FNICP	JKTCB	LOICB	NGACP	NNTCB	PCEIP	RFTXP	WDCCB
ABICP	CLOCP	ELIMP	FOICB	JKTCP	LORCB	NGCCB	NUEGB	PCICB	ROPRB	WDEIB
ARICB	CLPRB	ELISB	FOICP	JNACB	LOTCB	NGCCP	NUEGP	PCICP	SGICB	WDICB
ARICP	CLPRK	ELNIB	FSICB	JNACP	LOTXB	NGEIB	NUETB	PCRFB	SGICP	WDRCB
ARTCB	CLPRP	ELNIP	FSICP	JNTCB	LUACB	NGEIK	NUETP	PCTCB	SNICB	WDRCP
ARTCP	CLRCB	EMACB	GECCB	JNTCP	LUACP	NGEIP	P1ICB	PCTCP	SNICP	WSCCB
ARTXB	CLRCP	EMCCB	GEEGB	KSCCB	LUICB	NGICB	P1ICP	PLICB	SOEGB	WSEIB
ARTXP	CLTCB	EMFDB	GEEGP	KSCCP	LUICP	NGICP	P1TCB	PLICP	SOEGP	WSICB
AVACB	CLTCP	EMICB	GEICB	KSICB	LUTCB	NGLPB	P1TCP	PMTCB	SOHCB	WWCCB
AVACP	CLTXB	EMLCB	GERCB	KSICP	LUTCP	NGLPP	P1TXB	POICB	SOTCB	WWEIB
AVTCB	CLTXP	EMTCB	GETCB	KSRCB	LUTXB	NGMPB	P1TXP	POICP	SOTXB	WWICB
AVTCP	COICB	ENACP	GETXB	KSRCP	LUTXP	NGMPK	PAACB	POTCB	TEACB	WWTCB
AVTXB	COICP	ENCCP	HYCCB	KSTCB	MBICB	NGMPP	PAACP	POTCP	TECCB	WWTXB
AVTXP	COPRK	ENICP	HYCCP	KSTCP	MBICP	NGPZB	PACCB	POTXB	TEEIB	WXICB
BMTCB	DFACB	ENPRP	HYEGB	KSTXB	MGACB	NGPZP	PACCP	POTXP	TEICB	WXICP
CLACB	DFACP	ENTCP	HYEGP	KSTXP	MGACP	NGRCB	PAEIB	PPICB	TEPRB	WYEGB
CLACK	DFCCB	ESACB	HYICB	LGACB	MGCCB	NGRCP	PAEIP	PPICP	TERCB	WYEGP
CLACP	DFCCP	ESACP	HYICP	LGACP	MGCCP	NGTCB	PAICB	REPRB	TETCB	WYTCB
CLCCB	DFICB	ESCCB	HYTCB	LGCCB	MGICB	NGTCK	PAICP	RETCB	TETPB	
CLCCP	DFICP	ESCCP	HYTCP	LGCCP	MGICP	NGTCP	PAPRB	RFACB	TETXB	
CLEIB	DFRCB	ESICB	HYTXB	LGICB	MGTCB	NGTXB	PAPRP	RFACP	TNACB	
CLEIK	DFRCP	ESICP	HYTXP	LGICP	MGTCP	NGTXK	PARCB	RFCCB	TNCCB	
CLEIP	DFTCB	ESRCB	JFACB	LGRCB	MGTXB	NGTXP	PARCP	RFCCP	TNICB	
CLHCK	DFTCP	ESRCP	JFACP	LGRCP	MGTXP	NGVHB	PATCB	RFEIB	TNRCB	
CLICB	DFTXB	ESTCB	JFTCB	LGTCB	MMTCB	NGVHP	PATCP	RFEIP	TNTXB	
CLICP	DFTXP	ESTCP	JFTCP	LGTCP	MSICB	NNACB	PATXB	RFICB	TPOPP	
CLKCB	DKEIB	ESTXB	JFTXB	LGTXB	MSICP	NNCCB	PATXP	RFICP	UOICB	
CLKCK	DKEIP	ESTXP	JFTXP	LGTXP	NAICB	NNEIB	PCCCB	RFTCB	UOICP	
CLKCP	ELEXB	FFTCB	JKACB	LOACB	NAICP	NNICB	PCCCP	RFTCP	USICB	
CLOCB	ELEXP	FNICB	JKACP	LOCCB	NGACB	NNRCB	PCEIB	RFTXB	USICP	

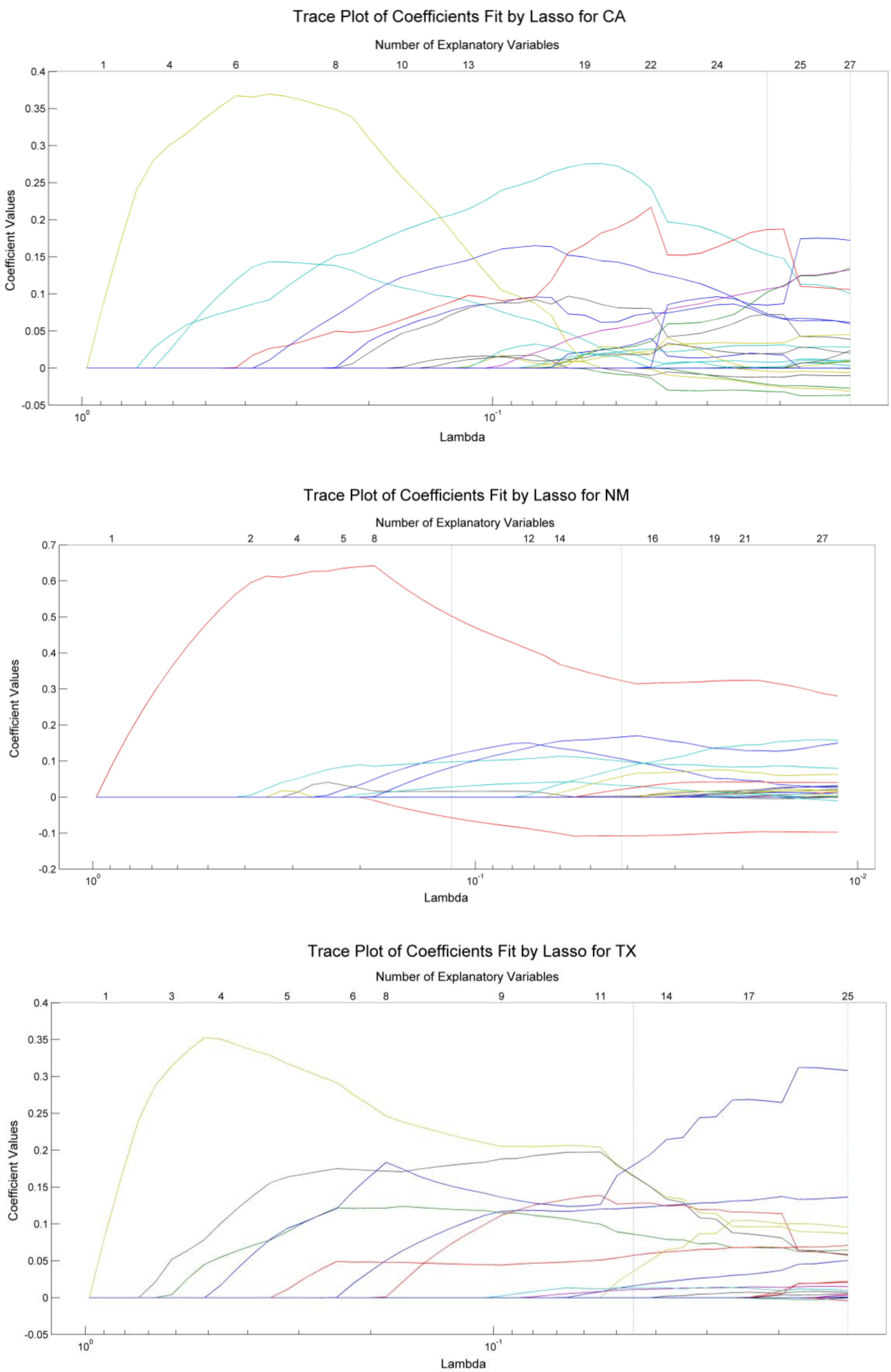
Appendix Table 2: Variables Counted from 1970

ARICD	CLRCD	DKEID	FNICV	KSTXV	MGCCD	NGTXV	PATXV	POICV	TEGDS	WWISB
ARICV	CLRCV	DKEIV	FOICD	LGACD	MGCCV	NUEGD	PCCCD	POTCD	TEICD	WWIXB
ARTCD	CLRFB	ELEXD	FOICV	LGACV	MGICD	NUEGV	PCCCV	POTCV	TEICV	WWTCD
ARTCV	CLTCD	ELEXV	FSICD	LGCCD	MGICV	NUETD	PCEID	POTXD	TEPFB	WWTCV
ARTXD	CLTCV	ELIMD	FSICV	LGCCV	MGTCD	NUETV	PCEIV	POTXV	TERCD	WWTXD
ARTXV	CLTXD	ELIMV	GDPRV	LGICD	MGTCV	P1ICD	PCICD	RFACD	TERCV	WWTXV
AVACD	CLTXV	EMACV	GETXV	LGICV	MGTXD	P1ICV	PCICV	RFACV	TERFB	WXICD
AVACV	CLXCD	EMCCV	GOCCB	LGISB	MGTXV	P1TCD	PCISB	RFCCD	TETCD	WXICV
AVTCD	CLXCV	EMICV	GORCB	LGRCD	MSICD	P1TCV	PCTCD	RFCCV	TETCV	
AVTCV	DFACD	EMTCV	HYTXV	LGRCV	MSICV	P1TXD	PCTCV	RFEID	TETPV	

AVTXD	DFACV	ESACD	JFACD	LGRFB	NGACD	P1TXV	PEACD	RFEIV	TETXD
AVTXV	DFCCD	ESACV	JFACV	LGTCD	NGACV	P5RFB	PEACV	RFICD	TETXV
CLACD	DFCCV	ESCCD	JFTCD	LGTCV	NGCCD	PAACD	PECCD	RFICV	TNSCB
CLACV	DFEID	ESCCV	JFTCV	LGTXD	NGCCV	PAACV	PECCV	RFISB	WDRCD
CLCCD	DFEIV	ESICD	JFTXD	LGTXV	NGEID	PACCD	PEEID	RFRFB	WDRCV
CLCCV	DFICD	ESICV	JFTXV	LUACD	NGEIV	PACCV	PEEIV	RFTCD	WDRSB
CLEID	DFICV	ESISB	KSCCD	LUACV	NGICD	PAEID	PEICD	RFTCV	WDRXB
CLEIV	DFISB	ESRCD	KSCCV	LUICD	NGICV	PAEIV	PEICV	RFTXD	WWCCD
CLICD	DFRCD	ESRCV	KSICD	LUICV	NGISB	PAICD	PERCD	RFTXV	WWCCV
CLICV	DFRCV	ESRFB	KSICV	LUTCD	NGRCD	PAICV	PERCV	SNICD	WWCSB
CLKCD	DFRFB	ESTCD	KSRCD	LUTCV	NGRCV	PARCD	PETCD	SNICV	WWCXB
CLKCV	DFTCD	ESTCV	KSRCV	LUTXD	NGRFB	PARCV	PETCV	TEACD	WWEID
CLOCD	DFTCV	ESTXD	KSTCD	LUTXV	NGTCD	PATCD	PETXD	TEACV	WWEIV
CLOCV	DFTXD	ESTXV	KSTCV	MGACD	NGTCV	PATCV	PETXV	TECCD	WWICD
CLOSB	DFTXV	FNICD	KSTXD	MGACV	NGTXD	PATXD	POICD	TECCV	WWICV



Appendix Figure 1: Optimal Adjustment Parameter λ with Lasso Method



Appendix Figure 2: Trace Plot of Coefficients Fit by Lasso

Appendix Table 3-1: PCA Score Table for Arizona

PC	Score	CLEIK	DFACB	ESCCB	ESCCP	ESRCB	ESRCP	FNICD
PC1	84.89	-0.25	0.28	0.27	0.27	0.28	0.28	0.26
PC2	5.71	0.10	0.02	-0.04	-0.04	0.02	0.02	0.30
PC3	3.82	-0.14	-0.02	0.20	0.20	0.14	0.14	-0.28
PC4	2.12	-0.39	-0.20	-0.17	-0.17	-0.18	-0.18	0.24
PC5	1.73	0.33	0.07	0.20	0.20	0.11	0.11	-0.13
PC6	0.92	0.76	0.05	-0.02	-0.02	-0.01	-0.01	0.19
PC7	0.38	0.17	0.26	-0.09	-0.09	-0.02	-0.02	-0.31
PC8	0.25	0.15	-0.39	0.03	0.03	0.00	0.00	0.45
PC9	0.09	0.06	-0.39	-0.09	-0.09	-0.07	-0.07	-0.58
PC10	0.07	-0.06	0.70	-0.23	-0.23	-0.08	-0.08	-0.03
PC11	0.02	0.05	0.09	-0.10	-0.10	-0.37	-0.37	0.12
PC12	0.01	-0.01	0.11	0.48	0.48	-0.46	-0.46	-0.03
PC13	0.00	0.00	0.00	-0.01	-0.01	0.02	0.02	0.00
PC14	0.00	0.00	0.00	-0.19	0.19	-0.68	0.68	0.00
PC15	0.00	0.00	0.00	0.68	-0.68	-0.19	0.19	0.00

Appendix Table 3-2: PCA Score Table for Arizona

PC	Score	MGCCB	NGRCV	NGVHB	NGVHP	POICV	SNICD	TEGDS
PC1	84.89	-0.18	0.27	0.27	0.27	0.24	0.27	-0.19
PC2	5.71	0.52	0.23	0.23	0.23	-0.08	0.08	0.67
PC3	3.82	0.72	0.05	-0.16	-0.16	-0.25	0.01	-0.33
PC4	2.12	0.33	-0.16	-0.02	-0.02	0.59	0.25	-0.21
PC5	1.73	0.03	-0.02	-0.36	-0.36	0.61	-0.02	0.33
PC6	0.92	0.20	-0.01	0.20	0.20	0.15	-0.05	-0.46
PC7	0.38	-0.01	-0.30	0.03	0.03	-0.12	0.82	0.08
PC8	0.25	-0.13	0.39	-0.32	-0.34	-0.25	0.41	-0.10
PC9	0.09	-0.06	0.59	0.18	0.18	0.21	0.10	-0.01
PC10	0.07	0.06	0.50	-0.19	-0.20	0.03	-0.06	-0.10
PC11	0.02	0.02	0.01	0.00	-0.01	-0.04	-0.03	-0.05
PC12	0.01	-0.01	0.07	0.07	0.03	-0.03	0.05	0.04
PC13	0.00	0.00	-0.01	0.71	-0.70	0.00	-0.01	0.00
PC14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PC15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table 4-1: PCA Score Table for California

PC	Score	CLACK	CLTXB	DFACB	ESACB	ESACP	ESCCB	ESCCP	ESCCV
PC1	79.54	-0.20	-0.13	0.22	0.23	0.23	0.23	0.23	0.23
PC2	5.98	-0.27	0.16	-0.02	0.13	0.13	0.00	0.00	-0.02
PC3	4.15	0.11	0.50	0.10	0.05	0.05	0.17	0.17	0.12
PC4	3.79	0.02	0.65	0.01	0.02	0.02	-0.02	-0.02	-0.05
PC5	2.11	0.02	0.09	-0.25	-0.02	-0.02	-0.10	-0.10	-0.06
PC6	1.60	0.64	0.22	-0.19	-0.13	-0.13	0.03	0.03	0.01
PC7	0.74	-0.17	0.29	0.08	-0.07	-0.07	-0.01	-0.01	0.01
PC8	0.54	0.18	-0.32	-0.23	-0.19	-0.19	0.18	0.18	0.00
PC9	0.41	0.41	-0.15	-0.08	0.31	0.31	-0.05	-0.05	-0.34

PC10	0.36	0.21	-0.07	0.85	-0.18	-0.18	-0.13	-0.13	-0.09
PC11	0.21	-0.02	0.03	-0.09	-0.23	-0.23	-0.12	-0.12	-0.13
PC12	0.17	0.12	0.03	0.00	-0.21	-0.21	0.09	0.09	0.05
PC13	0.13	0.26	0.01	0.17	0.28	0.28	-0.01	-0.01	-0.04
PC14	0.11	-0.10	-0.05	0.02	-0.20	-0.20	-0.16	-0.16	-0.08
PC15	0.05	0.07	0.04	0.03	0.06	0.06	0.00	0.00	-0.29
PC16	0.04	0.27	-0.07	0.08	-0.04	-0.04	0.18	0.18	0.61
PC17	0.03	-0.11	0.04	0.04	-0.13	-0.13	0.48	0.48	-0.33
PC18	0.02	0.06	-0.05	0.10	0.01	0.01	0.17	0.17	-0.38
PC19	0.01	-0.06	0.02	0.07	-0.03	-0.03	0.10	0.10	-0.25
PC20	0.00	0.00	0.00	0.00	-0.70	0.70	0.00	0.00	0.00
PC21	0.00	0.00	0.00	0.00	0.03	-0.03	-0.37	0.37	0.00
PC22	0.00	0.00	0.00	0.00	0.04	-0.04	-0.12	0.12	0.00
PC23	0.00	0.00	0.00	0.00	-0.02	0.02	-0.59	0.59	0.00

Appendix Table 4-2: PCA Score Table for California

PC	Score	ESRCB	ESRCP	GECCB	LGACD	LGCCV	LGRFB	MGACP	NGTCP
PC1	79.54	0.23	0.23	0.22	0.22	0.21	-0.12	0.22	0.17
PC2	5.98	-0.04	-0.04	-0.11	0.07	0.17	-0.27	-0.02	-0.15
PC3	4.15	0.15	0.15	0.01	0.08	0.02	0.61	0.19	-0.18
PC4	3.79	-0.01	-0.01	0.32	-0.17	-0.22	-0.36	0.06	0.42
PC5	2.11	-0.09	-0.09	-0.05	0.10	0.20	0.47	-0.15	0.58
PC6	1.60	0.10	0.10	-0.10	0.16	0.16	-0.27	-0.10	-0.31
PC7	0.74	-0.07	-0.07	-0.22	0.22	0.54	-0.22	-0.20	0.14
PC8	0.54	0.17	0.17	-0.03	-0.01	-0.03	-0.18	0.15	0.44
PC9	0.41	-0.01	-0.01	0.22	-0.19	0.46	0.06	0.06	0.05
PC10	0.36	0.07	0.07	-0.09	-0.07	0.13	0.02	0.01	0.15
PC11	0.21	0.18	0.18	-0.28	0.22	-0.14	0.07	0.08	0.10
PC12	0.17	-0.01	-0.01	0.34	-0.25	0.06	-0.04	0.21	-0.02
PC13	0.13	0.03	0.03	-0.12	-0.03	-0.49	-0.02	-0.34	0.14
PC14	0.11	-0.12	-0.12	0.61	0.12	-0.01	0.10	-0.04	-0.14
PC15	0.05	-0.23	-0.23	-0.22	0.24	-0.14	-0.06	0.74	0.02
PC16	0.04	-0.39	-0.39	-0.02	0.13	-0.01	0.01	-0.03	0.11
PC17	0.03	0.02	0.02	-0.07	-0.23	-0.01	0.06	-0.19	-0.04
PC18	0.02	-0.11	-0.11	0.26	0.65	-0.13	-0.01	-0.25	0.01
PC19	0.01	-0.32	-0.32	-0.17	-0.32	0.06	0.03	-0.01	-0.01
PC20	0.00	-0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
PC21	0.00	-0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.00
PC22	0.00	-0.61	0.61	0.00	0.00	0.00	0.00	0.00	0.00
PC23	0.00	0.27	-0.27	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table 4-3: PCA Score Table for California

PC	Score	NGVHP	PCEIV	PERCV	RFTCB	RFTCP	TPOPP	WSCCB
PC1	79.54	0.19	0.21	0.23	-0.18	-0.18	0.23	0.22
PC2	5.98	0.34	0.15	0.00	0.52	0.52	-0.14	0.13
PC3	4.15	-0.14	-0.09	0.08	0.19	0.19	0.15	-0.15
PC4	3.79	-0.18	0.03	-0.15	-0.01	-0.01	0.03	0.18

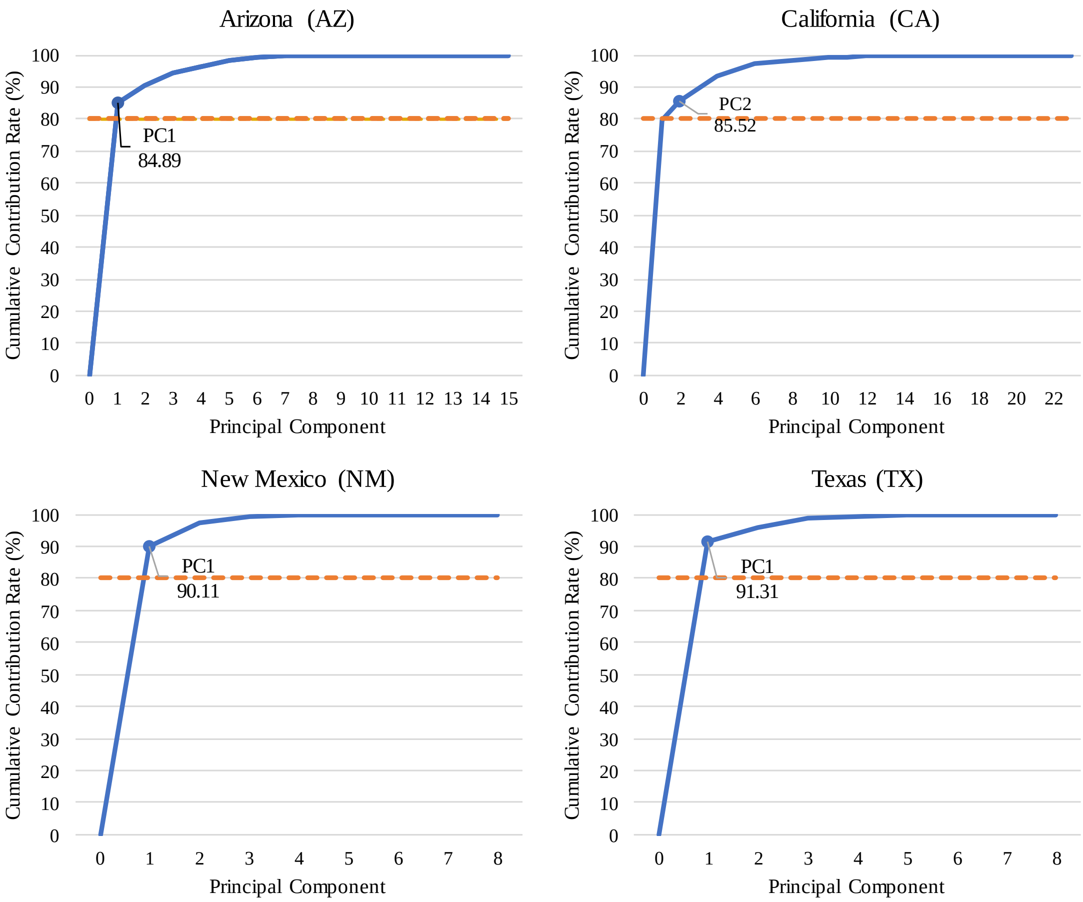
PC5	2.11	0.35	0.34	-0.06	-0.04	-0.04	-0.11	0.00
PC6	1.60	0.15	0.39	0.06	-0.09	-0.09	0.09	0.04
PC7	0.74	-0.14	-0.33	0.33	-0.12	-0.12	-0.07	-0.31
PC8	0.54	-0.24	0.03	0.12	0.30	0.30	0.16	-0.30
PC9	0.41	-0.17	-0.27	0.03	0.08	0.08	-0.10	0.26
PC10	0.36	0.01	0.15	-0.14	0.09	0.09	-0.07	0.01
PC11	0.21	0.09	-0.36	0.22	0.03	0.03	0.09	0.64
PC12	0.17	0.66	-0.42	0.00	-0.03	-0.03	-0.06	-0.19
PC13	0.13	0.22	-0.10	0.51	0.02	0.02	-0.08	-0.17
PC14	0.11	-0.15	0.22	0.54	0.09	0.09	-0.08	0.04
PC15	0.05	0.01	0.11	0.13	-0.08	-0.08	-0.25	-0.13
PC16	0.04	-0.11	-0.12	0.01	0.07	0.07	-0.13	0.30
PC17	0.03	-0.06	0.13	0.09	-0.07	-0.07	-0.44	0.19
PC18	0.02	0.07	-0.18	-0.33	0.04	0.04	0.19	-0.06
PC19	0.01	0.08	0.09	0.18	0.01	0.01	0.71	0.08
PC20	0.00	0.00	0.00	0.00	-0.01	0.01	0.00	0.00
PC21	0.00	0.00	0.00	0.00	-0.56	0.56	0.00	0.00
PC22	0.00	0.00	0.00	0.00	0.34	-0.34	0.00	0.00
PC23	0.00	0.00	0.00	0.00	0.28	-0.28	0.00	0.00

Appendix Table 5: PCA Score Table for New Mexico

PC	Score	ESRCB	JNACB	JNACP	LGACD	MGICV	MGTCV	TERCB	TPOPP
PC1	90.11	0.37	-0.34	-0.34	0.36	0.33	0.35	0.37	0.37
PC2	7.42	0.01	0.51	0.51	0.14	0.56	0.39	-0.01	-0.07
PC3	1.76	0.14	0.28	0.28	0.66	-0.54	-0.16	0.14	0.24
PC4	0.52	-0.44	-0.22	-0.22	0.56	0.00	0.30	-0.45	-0.32
PC5	0.15	-0.02	0.04	0.04	-0.30	-0.54	0.78	0.11	0.02
PC6	0.03	-0.23	0.02	0.02	-0.12	0.05	0.04	-0.51	0.82
PC7	0.01	0.77	-0.01	-0.01	-0.01	-0.07	0.06	-0.61	-0.16
PC8	0.00	0.00	-0.71	0.71	0.00	0.00	0.00	0.00	0.00

Appendix Table 6: PCA Score Table for Texas

PC	score	DFACB	DFACP	ESRCB	ESRCV	GECCB	GORCB	LGACD	TPOPP
PC1	91.31	0.35	0.35	0.37	0.37	0.35	0.33	0.35	0.37
PC2	4.69	-0.40	-0.40	-0.05	0.02	0.30	0.73	-0.23	0.08
PC3	2.63	-0.36	-0.36	0.18	0.28	-0.47	-0.02	0.63	0.10
PC4	0.69	-0.24	-0.24	0.01	0.01	0.75	-0.48	0.28	-0.10
PC5	0.49	-0.16	-0.16	0.43	0.07	-0.06	-0.34	-0.49	0.63
PC6	0.10	-0.01	-0.01	-0.22	0.88	0.00	-0.12	-0.30	-0.25
PC7	0.08	-0.02	-0.02	0.77	-0.03	-0.01	0.06	-0.15	-0.61
PC8	0.00	-0.71	0.71	0.00	0.00	0.00	0.00	0.00	0.00



Appendix Figure 3: Principle Component Score of Every State