For office use only	Team Control Number	For office use only
T1 ________________	73635	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	C	F4 ________________

2018
MCM/ICM
Summary Sheet

Data Analysis For Clean Energy

Summary

We analyze the sectors and structure of energy to build up models fitting the realistic situation in each state respectively, predict the usage of cleaner, renewable energy for each state, propose the criteria measuring the usage and propose the feasible actions to improve the usage of cleaner and renewable energy by analyzing the models.

First, we determine the most important variables based on our knowledge of the data and visualization. Then we filter out the predictors that significantly correlated to the response by BCor-SIS and Stepwise method. Build up the model and analyze to address how the energy profile evolves against time.

Second, we define two criteria to measure the usage of cleaner, renewable energy sources: **The coefficient of energy structure** and **Per capita renewable energy consumption**. Then we evaluate the usage of cleaner renewable energy of each state based on the criteria and predict it for 2025 and 2050.

Finally we propose goals for the new four-state energy compact based on the prediction, our knowledge of the similarities and differences as well as the criteria. And we also propose several feasible and reasonable actions to help them achieve the goals.

The sparkling advantages of this paper are:

- Filtering variables based on both our knowledge of data and statistical method BCor-SIS will ascertain that the predictors will be highly correlated with responses and agree with common sense and life experience
- The criteria we propose can not only measure the energy structure but also the usage of cleaner, renewable energy from individual prospective

Keywords: Cleaner energy; Energy structure;Data analysis; Bcor-SIS

Contents

1 Introduction

1.1 Background

Energy is a fundamental factor for lives and development of human society. In the past, the main energy consumed by mankind was primary energy such as petroleum, natural gas and coal, and secondary energy electricity. Nowadays, some problems have seriously affected the prospects of energy development, such as the rapidly growth of energy total consumption, the increasing demand of energy , the restrictions for energy supply, the seriously damage of ecology and the low proportion of cleaner and renewable energy sources.

In order to increase the usage of cleaner, renewable energy sources for four states, Arizona, California, New Mexico and Texas, the key point is to seek out the possible influential factors and build up models for them. Consequently, we can find out the reasonably energy strategy and make a prediction to set appropriate goals.

1.2 Our Tasks and Analysis

PART 1

- **A** In order to determine and describe the energy profile for each of four states, we should classify the variables first and determine the most important variables. Then filter out some predictors we think is correlated to the variables from all 605 variables and use statistical method to validate them. Plot all the variables we select against Year and describe the aggregate energy profile for each of four states.

- **B** In order to develop a model to characterize how the energy profile of each of the four states has evolved from 1960 to 2009, we regress the variables in the energy profile against Year so that we can describe the evolution of the energy profile. Then in order to address the usage of cleaner, renewable energy sources, we determine the important variables to describe the usage of cleaner, renewable energy as responses and filter out some relevant predictors for each states based on stepwise method and knowledge of the data, as predictors. Then we perform general linear regression on responses and predictors for each states to clarify the similarities and difference between the four states.

- **C** In order to figure out the criteria to measure the usage of cleaner, renewable energy, we look into several academic essays[3] and finally determine to adopt the coefficient of energy structure and per capita renewable energy consumption so as to measure the whole picture of energy structure as well as the renewable energy consumption from individual prospective.

- **D** In order to predict the energy profile of each state for 2025 and 2050, we use the model we built above to perform the prediction. The predict performance of the model will be analyzed later.

PART 2

- **A** In order to determine renewable energy usage targets for 2025 and 2050 and state them as goals for this new four-state energy compact, we obtain the average growth rate per annum for P and Q, then use it to calculate the value of P and Q for 2025 and 2050. We compare these values with the predicted ones we get in our model and determine the goal.

- **B** In order to propose several feasible actions, we analyze the sign of the model predictors and take it as a kind of symbol for increasing or decreasing some aspect of the energy consumed sector or altering the energy structure. Along with some academic essays[3], we identify and discuss several actions.

A list of parameters is provided in Table 1.2.1.

Table 1.2.1: Parameters used in the general model

Parameter	Description
$CRTCB$	Cleaner and renewable energy total comsumption
Y_1	Total energy consumption
Y_2	Cleaner and renewable energy total comsumption
P	The coefficient of energy structure
Q	Per capita cleaner and renewable energy consumption
R^2	Coefficient of determination
A	Initial value
B	Changed value
m	Average growth rate per annum
n	Year
$PRESS$	Prediction sum of squares
SSE	Error sum of squares

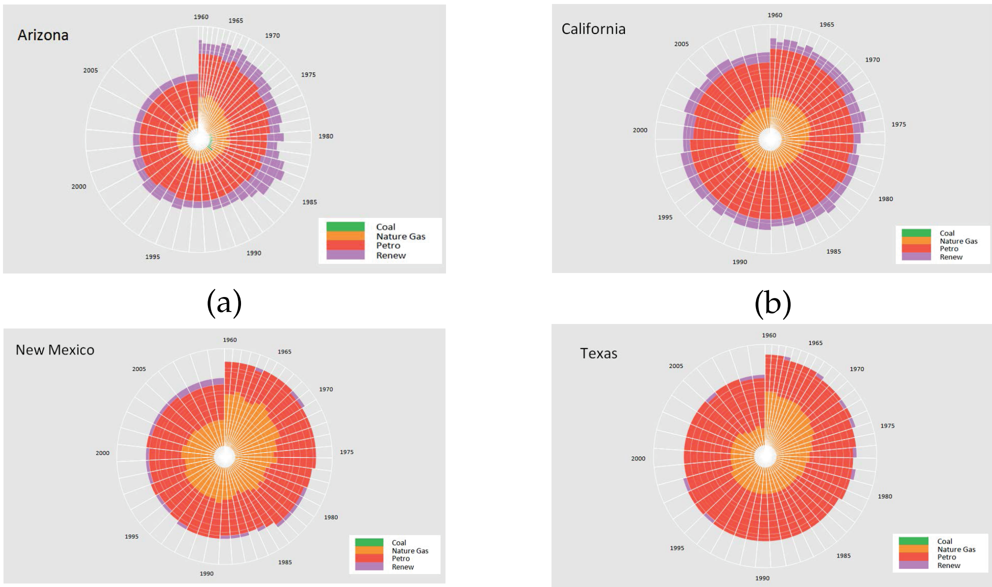
2 Building and Solving the Model

2.1 Part I

A

In order to give a thorough energy profile, we divide the variables into different sectors and different kind of energy and give the energy profile below.

Firstly, we want to study the energy structure of each state. We divide energy sources into petroleum, natural gas, coal, renewable energy and nuclear energy .



(a) (b) (c) (d)

Figure 1: Primary Energy Sources.

We can observe the primary energy allocation of each state from the image.

- Similarity:
  1. Coal consumption is very low in the proportion of total energy consumption
  2. Petroleum products consumption accounts for the highest percentage of total energy consumption
  3. Natural gas consumption decreases as the year increases

- Divergence:
  1. California has the highest energy consumption

2. The usage of renewable energy of Arizona and California is higher than the other two states
3. In New Mexico and Texas, the consumption of natural gas is similar to that of petroleum products

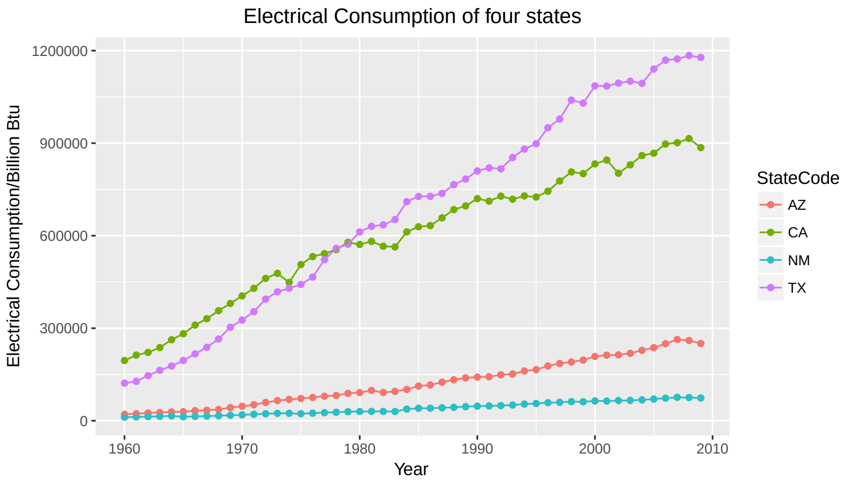
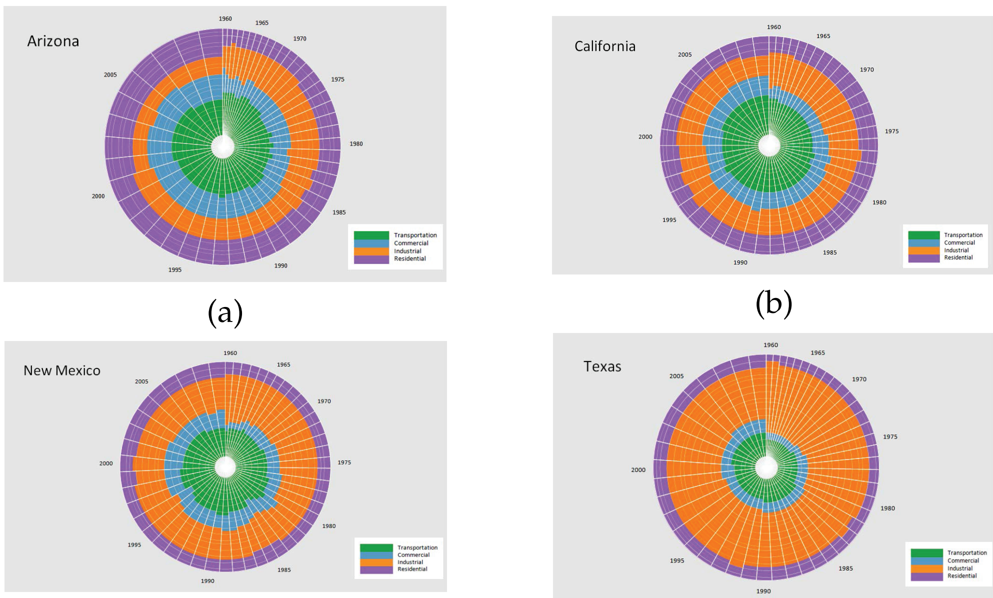


Figure 2: Electricity Total End-Use Consumption.

Secondly, we can observe that the electricity consumption of Texas and California far exceeds that of Arizona and New Mexico. Among them, New Mexico has been in a steady low-state during 1960 to 2009, while electricity consumption in Arizona increased but not significantly from 1960 to 2009 . On the contrary, electricity consumption in California and Texas have been rapidly growing.



(a) (b) (c) (d)

Figure 3: Energy Consumption by End-Use Sector.

Thirdly, we study the end-use sectors of energy consumption of each state. Divided by end-use sectors, there are residential sector, commercial sector, industrial sector and transportation.

We can observe that the energy usage and trends of each state are different. In general, the consumption of industrial sector of the four states has decreased while the other three sectors have increased. In particular:

- Arizona has a more evenly distributed energy usage among all four sectors
- California consume more energy in industrial sector and transportation
- New Mexico and Texas, the energy consumption of Industrial sector occupies most of the total consumption. And this situation in Texas is more significant

Lastly, we want to describe the total energy consumption of each state.

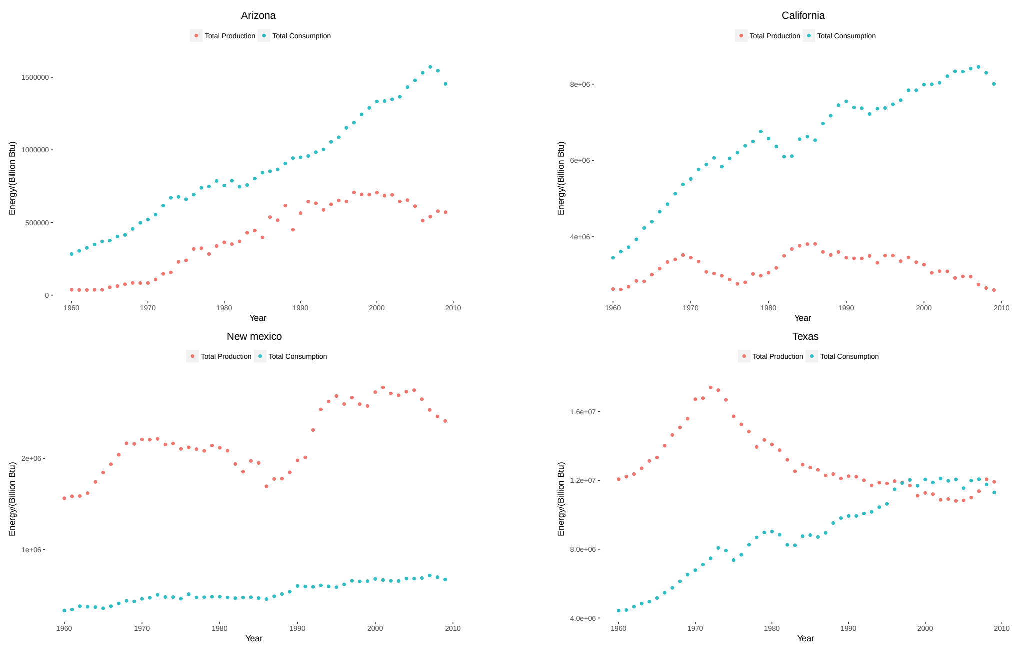


Figure 4: Total Energy Consumption & Production.

We can observe from Figure 4 that the energy production and the energy consumption of each state are different.

- Energy consumption is higher than energy production in Arizona and California, with California exceeding more
- The energy production exceeds energy consumption a lot in New Mexico
- The energy consumption in Texas shows an upward trend with time, energy production showed a downward trend. And since the 20th century the two have been balanced

In terms of the energy consumption in these four states, coal, petroleum products and natural gas are the majority, while renewable energy accounts for a small proportion. These lead to some urgently problems such as high energy consumption per unit of output, low energy efficiency and environmental pollution. In order for a better energy prospect, the development of renewable energy is particularly important. Currently, the renewable energy includes solar energy, biomass, geothermal energy, hydropower, wind energy and so on. Although the prospects for renewable energy are promising, there are still too few of them for the time being.

The summary of the energy profile for each state are displayed as follow.

California High energy consumption, high proportion of oil consumption, average usage of energy, better prospects for renewable energy, high consumption of electricity

Arizona Low energy consumption, high proportion of oil consumption, average usage of energy, great prospects for renewable energy, low consumption of electricity

New Mexico Low energy consumption, a similar proportion of oil and natural gas consumption, mainly usage of energy for industry, poor prospects for renewable energy, low consumption of electricity

Texas High energy consumption, a similar proportion of oil and natural gas consumption, mainly usage of energy for industry, poor prospects for renewable energy, high consumption of electricity

B

In order to describe the energy profile of each state, especially the usage of cleaner, renewable energy sources, we take 3 variables, TETCB, NUETB and RETCB, we interested in from all 605 variables as the responses. We add up the data of NUETB and RETCB, coded as CRTCB. We define TETCB as Y1 and CRTCB as Y2.

Definition 1. *CRTCB = NUETB + RETCB*

- $Y1 = TETCB$ Total energy consumption
- $Y2 = CRTCB$ Cleaner and renewable energy total comsumption

In order to study Y1 and Y2, we list 16 variables below as predictors that we thought might be relevant according to the energy profile of each state in Part 1 A.

Table 2.1.1: X

MSN	Description
NNACB	Natural gas consumed by the transportation sector.
NNCCB	Natural gas consumed by the commercial sector.
NNICB	Natural gas consumed by the industrial sector.
NNRCB	Natural gas consumed by the residential sector.
PAACB	All petroleum products consumed by the transportation sector.
PACCB	All petroleum products consumed by the commercial sector.
PAICB	All petroleum products consumed by the industrial sector.
PARCB	All petroleum products consumed by the residential sector.
NGACV	Natural gas expenditures in the transportation sector.
NGCCV	Natural gas expenditures in the commercial sector.
NGICV	Natural gas expenditures in the industrial sector.
NGRCV	Natural gas expenditures in the residential sector.
PAACV	All petroleum products total expenditures in the transportation sector.
PACCV	All petroleum products total expenditures in the commercial sector.
PAICV	All petroleum products total expenditures in the industrial sector.
PARCV	All petroleum products total expenditures in the residential sector.

We plot X, Y1, Y2 against time respectively, discovering that most of them have general linear relationship. Consequently, we decide to apply the general linear regression model.

In order to pick out the variables that are significantly correlated with Y1 and Y2 respectively among 16 variables, we used a statistical method named stepwise.

We find that in California all 16 variables are not significantly correlated with Y_2, so we take SIS method to solve it.

- We use BCor-SIS[4], a generic non-parametric sure independence screening procedure based on ball correlation, is able to pick out explanatory variables related to response. The linear, non-linear or linear interaction effect relationship can be captured by BCor-SIS even though data is heavy tail or existing outliers. More importantly, BCor-SIS is able to retain all of the important features in the model with probability tending to 1 under mild conditions. Ball correlation is defined as follow in reference.

Definition 2 (Ball correlation).

$$BCor^2_{\varpi}(X,Y) := BCov^2_{\varpi}(X,Y)\,/\sqrt{BCov^2_{\varpi}(X)\,BCov^2_{\varpi}(Y)}$$

if

$$BCov^2_{\varpi}(X)\,BCov^2_{\varpi}(Y) > 0,$$

otherwise

$$0.$$

The detail definition of $BCov$ can be read in the reference. The detail procedure has been programmed in the R package $Ball$, so we utilize the core function $bcorsis$ to find out several X which are correlated to CA's Y_2. Then we use the stepwise procedure to narrow down the range of X. Finally we establish a simple linear regression model indicating the relationship between Y_2 of CA and JKTCB.

The results are shown below.

Table 2.1.2: Arizona

$variable$	$Function$	R^2
Y∼X	Y1 = 2.672e + 00 PAACB + 7.598e + 02 PARCV + 8.822e + 04	0.99
Y∼X	Y2 = 1.331 PAACB - 2.590 PAICB - 56430.379 + 05	0.75
X∼Year	PAACB = 9.005e + 03 Year - 1.758e + 07	0.94
X∼Year	PARCV = - 3.581e+02 Year + 9.056e-02 Year^2 - 4412.7658	0.77
X∼Year	PAICB = 1.199e+05 $\sin(0.006114Year + 113.9)$ +9660 $\sin(0.2221Year - 185.6)$+3571 $\sin(0.3512Year + 68.1)$	0.8847

Table 2.1.3: California

$variable$	$Function$	R^2
Y∼X	Y1 = 1.900e+00 PAACB + 2.177e+06	0.96
Y∼X	Y2 = 1.587 JKTCB -4.833 NGICV + 2.267e+05	0.8
X∼Year	PAACB = 37550 Year - 72108586	0.95
X∼Year	JKTCB = 1.178e04 Year - 2.301e+07	0.9347
X∼Year	NGICV = 142.1 Year -280361.8	0.8

Table 2.1.4: New Mexico

$variable$	$Function$	R^2
Y∼X	Y1 = 3.452e+00 PAACB + 2.800e+06	0.92
Y∼X	Y2 = 7.5412 PAACV -31.2067 PARCV + 1369.9210	0.84
X∼Year	PAACB = 2191.3 Year - 4203950.9	0.87
X∼Year	PAACV = - 1.265e+04 Year + 3.201 Year^2 +1.250e+07	0.83
X∼Year	PARCV = 1400 $\sin(0.009562Year + 138.2)$ +134.6 $\sin(0.2108Year - 101.1)$+73.48 $\sin(0.3946Year - 141.7)$	0.9

Table 2.1.5: Texas

$variable$	$Function$	R^2
Y∼X	Y1 = - 688.2 NGRCV + 2.280 PAACB + 1.748 PAICB + 1.926e+06	0.97
Y∼X	Y2 = 316.169 NGRCV - 1.416 NGICV - 80714.039	0.70
X∼Year	NGRCV = 49.839 Year - 97939.195	0.87
X∼Year	PAACB = 39914 Year - 77366230	0.96
X∼Year	PAICB = 46513 Year - 90187886	0.89
X∼Year	NGICV = 3.88e04 $\sin(0.004484Year + 148.3)$+ +1124 $\sin(0.2694Year - 218.1)$	0.8426

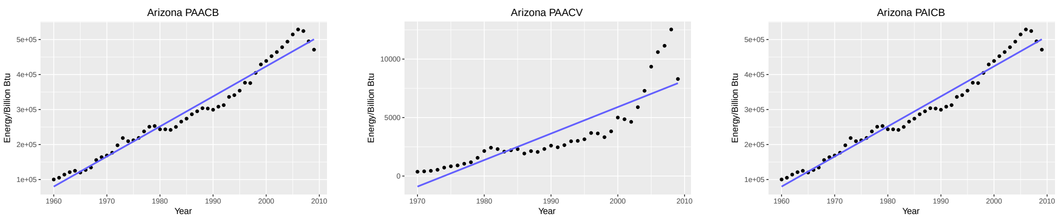


Figure 5: Arizona

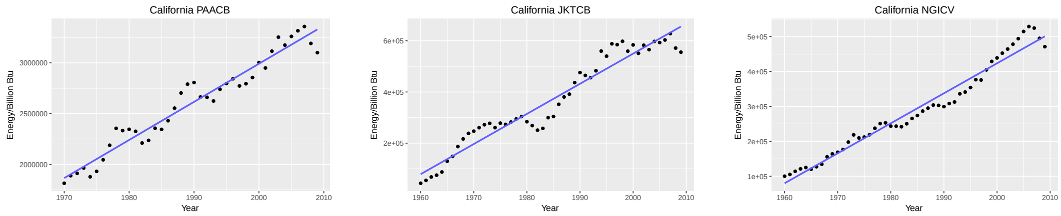


Figure 6: California

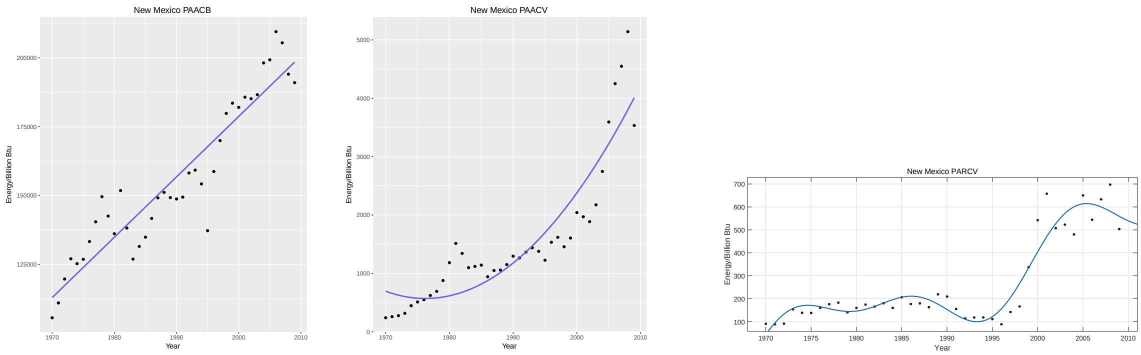


Figure 7: New Mexico

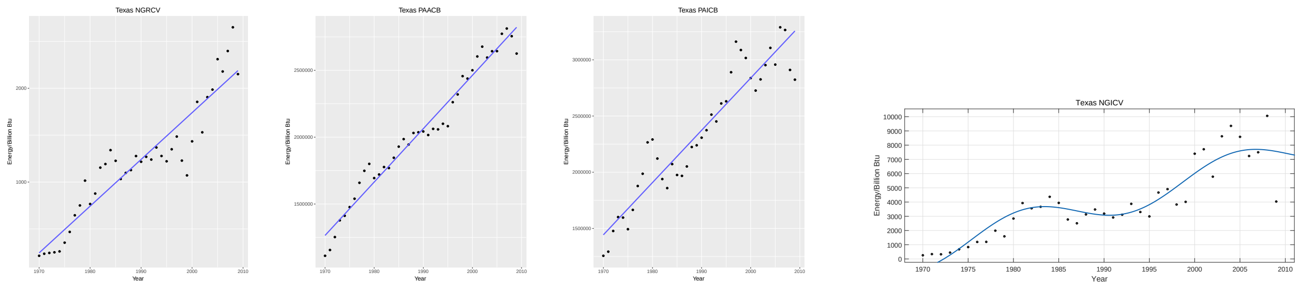


Figure 8: Texas

From Figure 5-8, we can see how the energy profile of the four states has evolved from 1960 to 2009.

In order to clarify the usage of cleaner, renewable energy sources, we use the model we developed above, choosing Y_2 to observe.

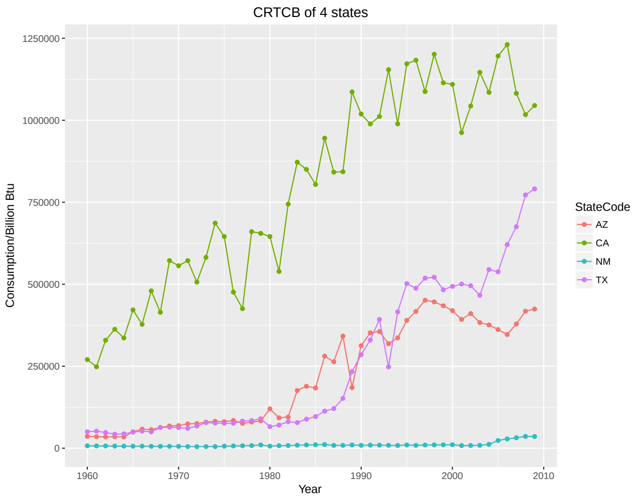


Figure 9: CRTCB of Four States

As the Figure 9 shown, **California triumphs and has much larger CRTCB than other states**. Taxes and Arizona are in the middle, while New Mexico is left behind.

Table 2.1.6: Arizona

MSN	Description
PAACB	All petroleum products consumed by the transportation sector.
PAACV	All petroleum products total expenditures in the transportation sector.
PAICB	All petroleum products consumed by the industrial sector.

Table 2.1.7: California

MSN	Description
JKTCB	Kerosene-type jet fuel total consumption.
NGICV	Natural gas expenditures in the industrial sector.

Table 2.1.8: New Mexico

MSN	Description
PAACV	All petroleum products total expenditures in the transportation sector.
PARCV	Natural gas expenditures in the industrial sector.

Table 2.1.9: Texas

MSN	Description
NGRCV	Natural gas expenditures in the residential sector.
NGICV	Natural gas expenditures in the industrial sector .

From the chart, we notice that all petroleum products consumed by the transportation sector is highly correlated with CRTCB in both Arizona and New Mexico, while in Texas, Natural gas expenditures in the residential sector (including supplemental gaseous fuels) influence the CRTCB most.

The CRTCB in both Arizona and New Mexico are highly correlated to petroleum products consumption, which explain why they have the similar amount of CRTCB.

But in California, it's unusual that the Kerosene-type jet fuel total consumption is highly correlated to the CRTCB, which is not included in the primary 16 putative variables. It leads to the difference between California and other three states.

Table 2.1.10: Influential Factors Ranking[5]

Factors	AZ	CA	NM	TX
Population	3	1	4	2
Precipitation	4	2	3	1
Industrial Consumption	3	1	4	2
CRTCB	3	1	4	2

For other possible influential factors, we notice that both the population and industrial development in California and Texas are greater than other states, and the precipitation of them is more than others too,**which explain why they have similar amount of CRTCB.**

On the contrary, the population and industrial development in New Mexico and Arizona are a lot less than other states and the precipitation of them is less than others too,**which explain why they have similar amount of CRTCB and lead to the difference between Arizona, New Mexico and other two states.**

These may indicate that the precipitation is helpful for cleaner and renewable energy like hydroelectricity, and the industrial development and large number of people will help to improve the technique for efficiently utilizing cleaner and renewable energy.

C

To measure the usage of cleaner, renewable energy of each state, we construct two criteria with several items in ProblemCData (TETCB, TPOPP, NUETB, RETCB) .We note that the nuclear energy is classified as a clean energy.

- NUETB Electricity produced from nuclear power.
- RETCB Renewable energy total consumption.
- CRTCB Clean and renewable energy total consumption.

$$P = \frac{CRTCB}{TETCB - CRTCB} \tag{2.1.1}$$

$$Q = \frac{CRTCB}{TPOPP} \tag{2.1.2}$$

- P The coefficient of energy structure.
- Q Per capita renewable energy consumption.

Energy structure coefficient measures the ratio of cleaner, renewable energy and non-renewable energy, and then reflects the pros and cons of energy structure.

Per capita renewable energy consumption measures the per capita possession and use of clean and renewable energy of each state.

Extract the 2009 data in the table to calculate the two parameters

Table 2.1.11: Clean and Renewable Energy Profile of each state

Parameter	StateCode	Data	Unit
P	AZ	0.411821567	
P	CA	0.150124942	
P	NM	0.056166556	
P	TX	0.075256654	
Q	AZ	64.39565759	Billion Btu/Thousand
Q	CA	28.32804045	Billion Btu/Thousand
Q	NM	17.75276113	Billion Btu/Thousand
Q	TX	31.92083625	Billion Btu/Thousand

We can observe that the energy coefficient of Arizona is 0.411821567, which shows that clean renewable energy is an important component of the state's energy structure. It shows that the energy structure of Arizona is the best among the four states. At the same time, the per capita renewable energy consumption in Arizona is 64.39565759, which shows that the per capita renewable energy in Arizona is the largest of the four states. **Base on the above analysis, Arizona tends to have the best overview of using clean renewable energy.**

D

We utilize the model in Part 1 B to predict the responding X, Y_1, Y_2, Population, P and Q as Table 2.1.12 - 2.1.15 shown.

We notice that the prediction of Arizona is accord with the energy profile mentioned in Part 1 C. The superiority of the energy structure allows the usage of cleaner, renewable energy to develop quickly and steadily in Arizona. **In our prediction, Arizona still rank first.**

Table 2.1.12: Arizona

item	2025	2050
P	0.452402	0.4723146
Q	75.54587	79.75629
Y1	1997790	2807026
Y2	622282.4	900486.5
Population	8237.146	11290.476
PAACB	650952.2	876085.5
PARCV	224.0283	497.3537
PAICB	72445	80723

Table 2.1.13: California

item	2025	2050
P	0.1887399	0.2097572
Q	33.66994	34.60925
Y1	9643963	11427588
Y2	1531202	1981405
Population	45476.83	57250.74
PAACB	3930179	4868929
JKTCB	844500	1139000
NGICV	7390.7	10943.2

Table 2.1.14: New Mexico

item	2025	2050
P	0.06419801	0.130102
Q	19.57257	35.67529
Y1	792942.3	954717.7
Y2	47834.44	109911
Population	2443.953	3080.872
PAACB	233505.7	288289.1
PAACV	8187.221	17995.202
PARCV	489.5409	870.4646

Table 2.1.15: Texas

item	2025	2050
P	0.06082602	0.07269759
Q	28.73616	32.58344
Y1	14754519	18204769
Y2	845999.8	1233752
Population	29440.25	37864.39
NGRCV	2985.782	4231.769
PAACB	3460351	4458210
PAICB	4000992	5163818
NGICV	12216	16588

2.2 Part II

A

Based on our criteria for the usage of cleaner, renewable energy sources, we calculate the average growth rate m of P and Q from 1960 to 2009. In this way, we can obtain P and Q by assuming the average growth rate m stay constant in 2025 and 2050 respectively. Compare the values with the predicted ones we get in Part 1 C.

$$B = A\,(1+m)^{n-1} \tag{2.2.1}$$

$$m = \sqrt[n-1]{\frac{B}{A}} - 1 \tag{2.2.2}$$

Our rule is: If the calculation number is lager, we set it as the goal for this new four-state energy compact, else we enlarge the predicted number to a reasonable value and state it as goal for this new four-state energy compact.

The results are shown in the form below.

Table 2.2.1: Average Growth Rate

	P	Q
AZ	0.021315071	0.017599788
CA	0.011696542	0.010447306
NM	0.018457856	0.017116619
TX	0.039182484	0.037680338

Table 2.2.2: Calculated & Predicted Value

	2025 Calculated Value		2050 Calculated Value	
	P	Q	P	Q
AZ	0.57711842	85.13119123	0.977818952	131.6782089
CA	0.180824429	33.45301437	0.241831986	43.37874788
NM	0.075260448	23.2915244	0.118889463	35.60136662
TX	0.139191909	57.68882105	0.363839159	145.4391596
	Predicted Value		Predicted Value	
AZ	0.452402	75.54587	0.4723146	79.75629
CA	0.1887399	33.66994	0.2097572	34.60925
NM	0.06419801	19.57257	0.130102	35.67529
TX	0.06082602	28.73616	0.07269759	32.58344
	Goal		**Goal**	
AZ	0.577118	85.131191	0.977818952	131.6782089
CA	0.19	34	0.241831986	43.37874788
NM	0.075260	23.291524	0.14	36
TX	0.139191909	57.68882105	0.363839159	145.4391596

B

In order to provide several feasible actions, we analyze the variables mentioned above, which will significantly influence the usage of cleaner and renewable energy source. Here are several actions we propose for the four states.

- **Reduce the use of LPG and gas as the fuel for gas burner.**

Because Natural Gas is environment-friendly and cleaner than petroleum products and coal. Meanwhile, Natural Gas is far cheaper than petroleum products or coal. So, increase the proportion of Natural Gas total expenditures can help improve the energy structure, so that the usage of cleaner and renewable energy sources will be hence improved.

- **Increase the utilization of nuclear power to produce electricity. Add more nuclear power plants.**

Utilizing cleaner and renewable energy sources in the industrial sector will decrease the consumption of petroleum products in industrial sector, which protect the environment from destroying. Also, nuclear power is a new superior energy which will meet the increasing demand of electricity as well as increase the usage of cleaner and renewable energy sources.

- **Develop the technology utilizing the cleaner and renewable energy sources to increase the cost performance together.**

Because the price and capacity of cleaner, renewable energy sources are not satisfactory enough now. Improving the technology will surely improve the per capita renewable energy consumption as well as the energy structure.

2.3 Part III

Demanded memo is on the last page of this paper.

3 Evaluation of the Model

We use the PRESS and SSE criteria to evaluate the **predict performance** of our model about Y1 and Y2. PRESS is a measure of how well the use of the fitted values can predict the observed responses. The PRESS criterion is obtained by deleting the i^{th} case from the data set, estimating the regression function to obtain the predicted value for the i^{th} case and calculating the error sum of square as PRESS. SSE is also such a measure; the difference is that we don't delete cases in calculating SSE. So the predict capability is considered to be great if PRESS is not much larger than SSE. The PRESS and SSE for each model are displayed below.

Table 3.0.1: Model Validation

	PRESS	SSE		PRESS	SSE
AZ			NM		
Y1	2.75E+10	2.42E+10	Y1	6.18E+10	5.69E+10
Y2	2.25E+11	1.95E+11	Y2	4.81E+08	3.89E+08
CA			TX		
Y1	9.79E+11	8.94E+11	Y1	2.25E+14	2.91E+12
Y2	5.15E+11	9.15E+10	Y2	7.24E+11	6.16E+11

As the chart shown, most of our models have outstanding predict performance while others have normal performance.

4 Strengths and weaknesses

4.1 Strengths

- **Reliability** After we select the variables preliminary, we filter and validate them by the BCor-SIS method. And cross filtering makes variables selected more reliable.

- **Reasonability** For the variables that have periodical volatility, we regress them against time by sum in sine method. The results agree with common sense and life experience which shows that our model building is very reasonable.

- **Conciseness** The number of variables used to predict the model is not too much, but the R-square of the model are all above 0.7 which simplifies the calculation and keep its reliability.

- **Extensibility** Algorithms for building models can be used in other states. It allows us to use the algorithms to describe the energy profile of other states or other aspects of energy.

4.2 Weaknesses

- **Electricity is ignored** Based on the classification of the energy, we ignore the variables about electricity in our model and may lose some information when we make prediction.

- **Over-Simplicity** Criteria involved in human judgments may be over-simplified.

5 Conclusion

According to the general linear regression model, we describe the energy profiles of four states separately, as well as the assessment of clean and renewable energy sources, and make prediction based on the model we built.

First of all, we select reliable and relevant predictors from the given data for research, and study the relationship between responses and predictors by means of general linear regression. Secondly, we develop the criteria for measuring the usage of cleaner, renewable energy and predict it based on the model. Then we propose the goals of clean and renewable energy development of four states through the algorithm we create mentioned above. Finally, we have a better understanding of the energy profile in four states.

To sum up, we observe that the proportion of clean and renewable energy in all states is still low. Therefore, optimizing the energy structure and developing clean and renewable energy are an important issue . Therefore, the four states should adopt some actions and cooperate with each other to establish a realistic contract for the clean and renewable energy.

Memo

To : The group of Governors of four states

From : Team #73635

Date : Feb 12th, 2018

Subject : Energy profiles as of 2009, predictions without policy changes and recommended goal for the energy compact to adopt.

We use the following items to describe the energy profile in 2009. In terms of energy consumption, California and Texas are higher than Arizona and New Mexico. In terms of the usage of energy, California and Arizona appear more average while New Mexico and Texas seem to mainly consume energy for industry. In regard to prospects for renew-able energy, California ranks first, Arizona ranks second, and New Mexico and Texas are left behind.

Based on the criteria of the usage of clean and renewable energy and the corresponding functions, we can predict P (**the coefficient of energy structure**) and Q (**Per capita renewable energy consumption**) based on the model we built without policy changes. Arizona has the highest P and California ranks second and New Mexico ranks third and Texas has the lowest P. In terms of Q, Arizona has the highest Q while other three states have similar Q in the future.

We use m (**Average growth rate per annum**) of P and Q to set goals. Firstly, we find out each m of P and Q of each state. Secondly we set the calculated value as goal of each state. In order to achieve this goal, each state needs to adopt several measures as following.

- Reduce the use of LPG and gas as the fuel for gas burner.
- Increase the utilization of nuclear power to produce electricity. Add more nuclear power plants.
- Develop the technology utilizing the cleaner and renewable energy sources to increase the cost performance together.

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