For office use only	Team Control Number	For office use only
T1 ________________	72819	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	C	F4 ________________

2017

MCM/ICM

Summary Sheet

(Your team's summary should be included as the first page of your electronic submission.)

Type a summary of your results on this page. Do not include the name of your school, advisor, or team members on this page.

Summary

In order to aggregate the brief outline of energy structure four states in America(California (CA), Arizona (AZ), New Mexico (NM), and Texas (TX), considering 605 variables, this paper classify all those kinds of energy and simplify the large amount of data for the governors.

Our solution is consist of three sections. First of all, we analyze the data of energy consumption and production in four states for. We select about ten factors which dominate the energy usage among those 605 variables, in order to depict the profile of energy. Meanwhile, we classify all those factors into two categories: renewable energy and that produced by traditional fossil fuels. From these two perspectives, we figure out the similarities and differences between those four states.

Secondly, in order to predict the energy usage of 2025 to 2050, we introduce the regression model to fit the curve of the relation between the usage of each kind of energy distinguished by its source and the time.

Thirdly, basing on the influential factors of those four states, like geography and climate, we set up a trail of rules to calculate the weighted mean of the average annual growth rate of the ratio of clean energy usage to grossing energy use. Corresponding the proportion clean energy taking up of the total energy usage, we rank the four states from one to four so as to evaluate which state has the best profile of energy usage.

Finally, we present our goals for the new four-state energy compact, according to our criteria and predictions. Intending to make four states optimize energy consumption structure, we provide three actions and predict the effect for the governors as reference.

Memo

From: Team # 72819
To: Four Governors of California, Arizona, New Mexico and Texas
Date: 11 February 2018
Subject: Energy Production

In order to aggregate the brief outline of energy structure four states in America(California (CA), Arizona (AZ), New Mexico (NM), and Texas (TX), considering 605 variables, this paper classify all those kinds of energy and simplify the large amount of data for you, and we try to give you a resonable comparison between each state.Basing on it, we want to povide with the solution for a better understanding.

Our solution consists of three parts.Firstly we compare the 2009 new energy ratio of total energy consumption , which shows the progress new energy has already achieved.The result is shown

State	AZ	CA	TX	NM
Ratio	0.293902	0.202973	0.098176	0.027905
renewable cleaner energy useage(Billion Btu)	388474	818273	640379	18023

Secondly we make prediction on the ratio of new energy to total energy consumption in 2050, without any policy changes, which shows the developing trends and foresight of renewable energy for each state.The result is shown by the following table:

State	AZ	CA	TX	NM
Predicted Ratio	0.319480	0.239627	0.221396	0.027844
Predicted renewable cleaner energy useage(Billion Btu)	401469	990364	1528449	17605

Thirdly, basing on the influential factors of those four states, like geography and climate, we set up a trail of rules to calculate the weighted mean of the average annual growth rate of the ratio of clean energy usage to grossing energy use. Corresponding the proportion clean energy taking up of the total energy usage, we rank the four states from one to four so as to evaluate which state has the best profile of energy usage.Our quatificated and theoretically achievable goal is shown in the table below:

$x_{i,y}$ / i	$G_{i,2025}$ (Billion Btu)	$H_{i,2025}$ (Billion Btu)	$N_{i,2025}$ (Billion Btu)	$S_{i,2025}$ (Billion Btu)	$W_{i,2025}$ (Billion Btu)
AZ	0	90583.57829	306087.5749	32745	783041.7714
CA	131686.1982	2010.674617	359194.7941	33144.54474	800148.4574
NM	0	2010.674617	0	33467.41398	787341.3059
TX	0	14228.53307	424216.4031	33009.7314	1080936.629

$x_{i,y}$ / i	$G_{i,2050}$ (Billion Btu)	$H_{i,2050}$ (Billion Btu)	$N_{i,2050}$ (Billion Btu)	$S_{i,2050}$ (Billion Btu)	$W_{i,2050}$ (Billion Btu)
AZ	0	90583.57829	306091.2176	44192.18158	1468001.063
CA	131687.2416	2010.674617	359195.4027	44192.18158	1468001.063
NM	0	2010.674617	107288.3959	44192.18158	1468001.063
TX	0	14228.53307	424268.1783	44192.18158	1468001.063

Finally, we present our goals for the new four-state energy compact, according to our criteria and predictions. Intending to make four states optimize energy consumption structure, we provide three actions and predict the effect for the governors as reference.

Thank you for taking precious time reading our solution.We sicerely hope that after take our suggestion in our solution you will achieve the final goal of developing cleaner and ecofriendly energy source for your state.

Thank you all for your help in putting this new system into place.

Best regrads,
Management

CONTENT

1. Introduction

1.1. restatement of the problem

There is no doubt that energy consumption and production take up an increasingly large part of any economy. Any effort to optimize the structure of the energy usage should be taken prioritized consideration. Meanwhile, the expenditure of traditional energy sources (petroleum, natural gas, coal) has become unaffordable, which hampering the speed of development severely. On the setting of this times, in 1970, 12 western states in the U.S. formed the Western Interstate Energy Compact, purpose of which to provide the instruments and framework for cooperative state efforts to "enhance the economy of the West and contribute to the well-being of the region's people."

California, Arizona, New Mexico and Texas wish to form a realistic and practicable new energy compact focused on increased usage of cleaner, renewable energy sources. In order to do so, they made a through investigation on energy consumption and production from 1960 to 2009.

However, the result appears to be unsurmountable, for the reason that there are 605 variables which made it an arduous journey to make objective decisions basing on the result for those governors. Moreover, each state has its own set of regulation, which may vary at different times. A justified criteria is badly needed to assess each state's energy usage profile.

In accordance to the result of the investigation, this paper selects several important parts of the data so as to represent the overall description of the energy source and makes a set of rules in order to rank which state seems to the 'best one'. We also provide governors a few suggestions in order to achieve the final goal of the compact.

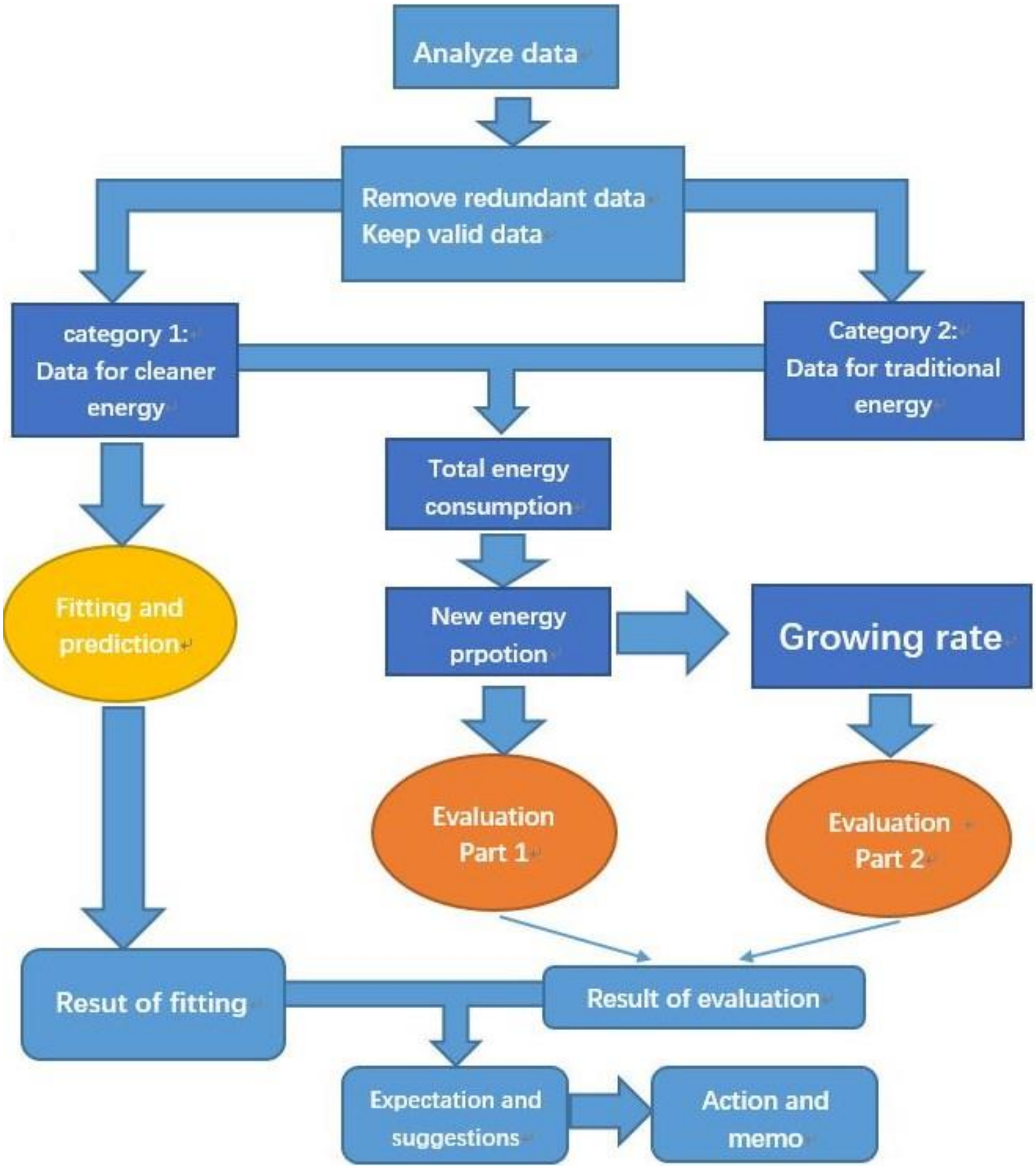
1.2. Assumptions

1. All the petroleum products are all considered to be made from petroleum, which is included in the total consumption. We don't want to take synthesis into consideration.
2. Social and natural environment do not change to greatly and if governors don not change any policy, no technical breakthrough will be made related with energy source this paper analyzes.
3. The topography factors which great influence the energy production will not change greatly. For example, the hydroelectricity facilities will not work normally
4. All the cleaner and renewable energy is used to produce electricity.
5. We ignore the effect of the change of price or capital limitation.
6. Zero or low production of cleaner energy in the beginning of the year of the investigation is attributed to the technology limitation

1.3. Flow Chat

The complete flow chart of the paper is shown in Figure 1

Figure 1



2. Data Analysis

Firstly, we dismiss part of those data, with different units, which describe the same sort of energy source. Then, we unify with the same unit, Billion Btu all the data which is related with the profile of energy consumption and production (those converting factors, population or price related ones can be identified). Among them, we dismiss those which focus on the distribution of energy consumption. For example, CLICP, coal consumed by the industrial sector, has anything but to do with the whole picture of energy profile. Apart from that, as assumption?, we deny the necessity to analyze all those derivate products, like Kerosene which is one of the products of coal. So we only pau attention to coal, natural gas, fuel oil (including residual fuel oil and distillate fuel oil) as traditional energy while energy produced from geothermal energy, hydro energy, wind power, nuclear reaction and solar energy as renewable and cleaner energy. (Though whether nuclear energy is renewable and cleaner energy source has been a controversial issue, in this paper we consider it as cleaner energy source ?).

After that, we can easily select those outline the profile of energy. Thus, we get list of variables highly related with the gross energy consumption, which is presented by list.

Table 1:Renewable,Cleaner Energy and Traditional Energy

Renewable and Cleaner Energy	Traditional Energy
GEEGB	CLTCB
HYTCB	NNTCB
NUETB	DFTCB
WYTCB	RFTCB
SOTCB	

3. Constant

Denote the list of four states $i \in \mathcal{S} = \{AZ, CA, NM, TX\}$, the list of seven kinds of energy $x \in$ E $= \{C, O, NG, G, H, N, W\}$, the list, constants and the variables are as following.

Table 2: $\mathcal{S}$ List

Constant	AZ	CA	NM	TX
State	Arizona	California	New Mexico	Texas

Table 3: E List

Constant	MSN	Clarification
C	CLTCB	Coal total consumption
O	D&RFTCB	The sum of distillate fuel oil total consumption and residual fuel oil total consumption.
NG	NNTCB	Natural gas total consumption (excluding supplemental gaseous fuels)
G	GEEGB	Electricity produced from geothermal energy by the electric power sector
H	HYTCB	Hydroelectricity total production
N	NUETB	Electricity produced from nuclear power
S	SOTCB	Photovoltaic and solar thermal energy total consumption.
W	WYTCB	Electricity produced from wind energy

Table 4: Constants and variables

Constant	Clarification
y	Particular year
$x_{i,y}$	MSN x in state i in year y
$T_{i,y}^t$	The sum of 3 kinds of traditional energy consumption in state i in year y
$T_{i,y}^n$	The sum of 5 kinds of cleaner, renewable energy power in state i in year y
$T_{i,y}$	The sum of all 8 kinds of energy power in state i in year y
$R_{i,x,y}$	The ratio of energy $x_{i,y}$ to $T_{i,y}$ in state i in year y

$Q_{i,x,y}$	The rate of $R_{i,x,y}$ growth in state i in year y
$\overline{Q_{i,x,y_1,y_2}}$	The average of $Q_{i,x,y}$ in state i from year y_1 to year y_2
$\omega_{i,x}$	The weight of energy which MSN x describes to cleaner, renewable energy in state i
I_i	The development index of state i

4. Profile of four states

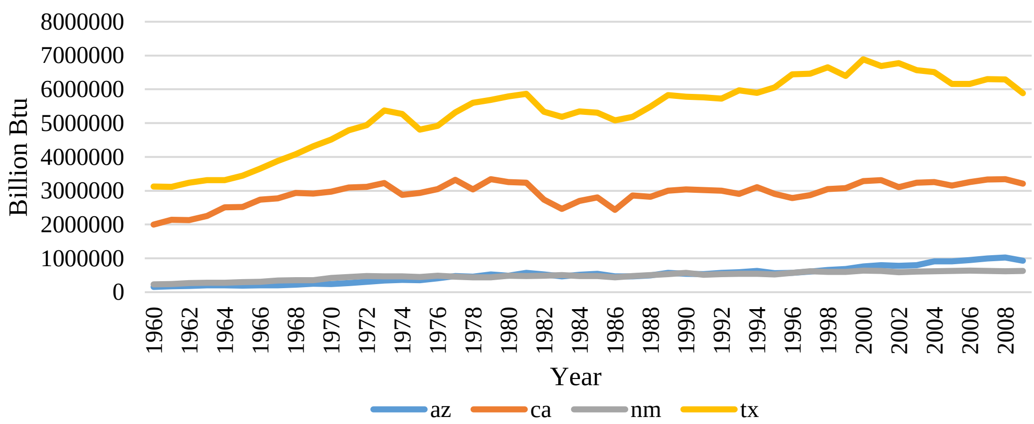
We wanted to find an overview of energy use across the four states from 1960 to 2009, taking into account changes in total energy, "old energy" and "new energy" usage, respectively.

To begin with, we use the formula

$$T_{i,y}^{t} = C_{i,y} + O_{i,y} + NG_{i,y}$$

to calculate the usage of traditional energy for the 50 years each state, and depict the curve of them, shown in Figure 2.

Figure 2: Traditional Energy

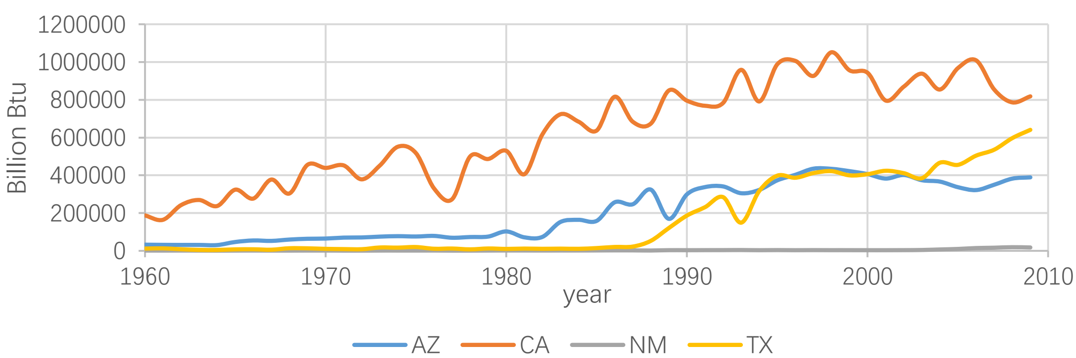


Secondly, we use the formula

$$T_{i,y}^{n} = G_{i,y} + H_{i,y} + N_{i,y} + S_{i,y} + W_{i,y}$$

to calculate the usage of cleaner and renewable energy for the 50 years each state, and depict the curve of them, shown in Figure 3.

Figure 3: cleaner and renewable energy

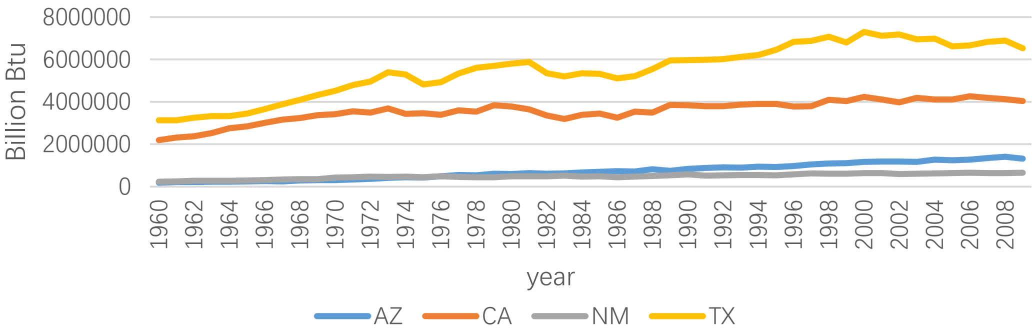


Thirdly, we use the formula

$$T_{i,y} = T_{i,y}^{t} + T_{i,y}^{n}$$

to calculate total usage of energy for the 50 years each state, and depict the curve of them, shown in Figure 4.

Figure 4: Total Energy

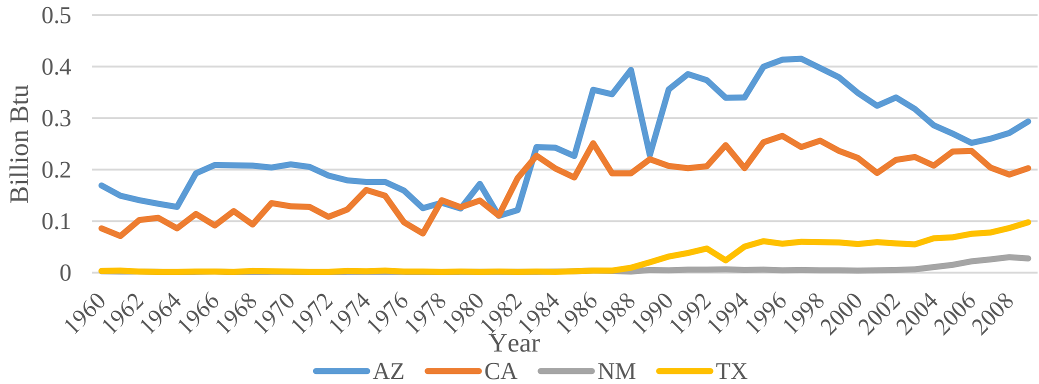


Finally, we use the formula

$$R_{i,y}^{n} = \frac{T_{i,y}^{n}}{T_{i,y}}$$

to calculate The ratio of renewable and cleaner energy consumption to traditional energy consumption for the 50 years each state, and depict the curve of them, shown in Figure 5.

Figure 5: Ratio



We make a brief explanation bellow:

The total energy and "old energy" usage has been increasing slowly, with a small amount of usage; the usage of "new energy" has been rapidly increasing and the usage has been relatively high; the share of "new energy" in total energy has been on the rise , which is the highest.

The use of total energy and "old energy" has been slowly increasing and the consumption has been relatively large. "Old energy" has been slightly reduced in recent years; the use of "new energy" has been increased at a faster rate with the highest utilization rate; "New energy "The proportion of total energy in the rising volatility, the proportion of which is relative high.

Total energy use and "old energy" usage have been increasing slowly with small usage; "new energy" has started to be used in recent years with the least consumption; "new energy" as a percentage of total energy has increased slightly in recent years, which is the lowest.

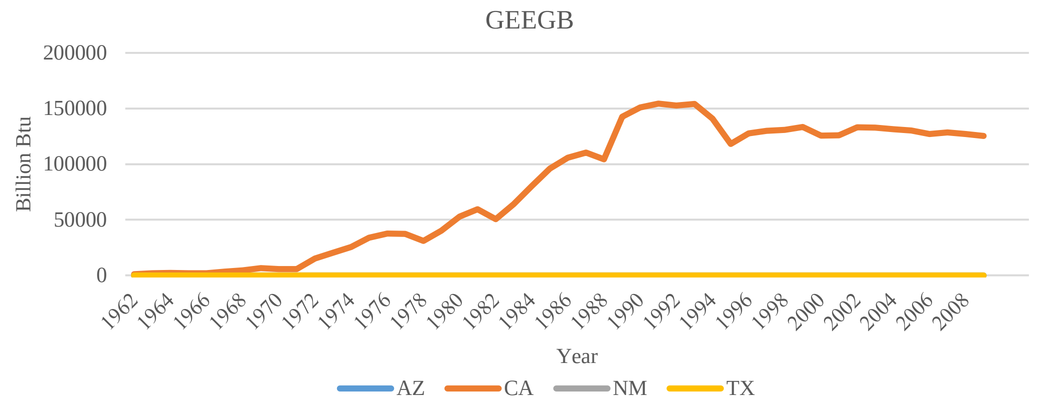
The use of total energy and "old energy" has been slowly increasing and the amount used is the largest. "Old energy" has been slightly reduced in recent years. "New energy" started to be used at the end of the 1980s and its use rate increased rapidly in fluctuation. Use a large amount; "new energy" in the proportion of total energy in the late 1980s increased slowly, which is relatively low.

5. Comparison and Prediction

In this part, after we analyze the profile of production and consumption of energy basing on the data of the investigation and make comparison between different states in terms of several influential factors. We compare the difference and similarity in energy profile and try to give a brief explanation.

5.1. Comparison

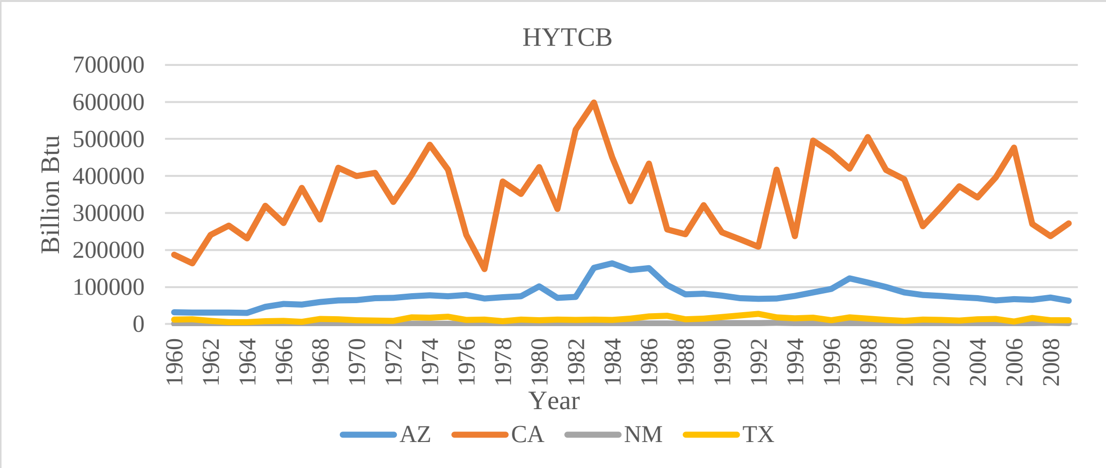
5.1.1. Geothermal Energy



Difference: Only California started using geothermal energy in 1972, increasing constantly in productions over years, while other three states do not develop such a renewable energy source.

Reasons: Only CA is located at volcanic and earthquake zone where geothermal resource id adequate.

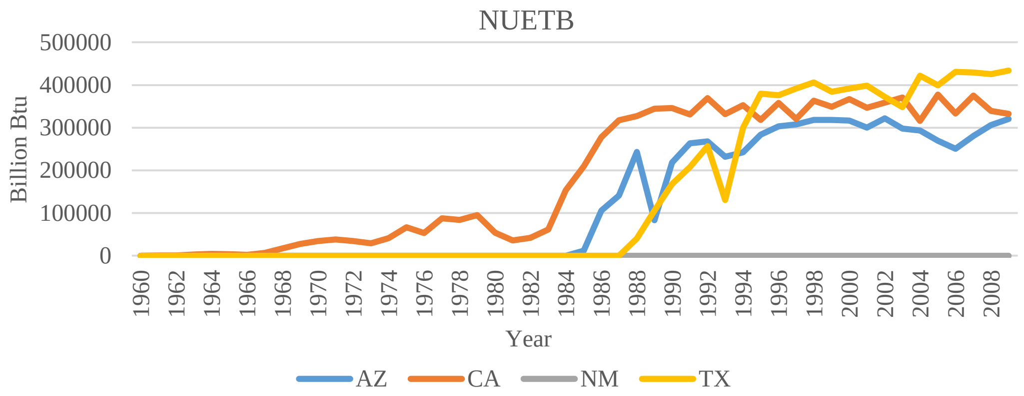
5.1.2. Hydro Energy



Difference and similarity: the usage of hydro energy fluctuates violently over time while the total production of hydroelectricity doesn't change too much. AZ and CA have a relatively larger amount of hydroelectricity production.

Reason: hydro energy is largely dependent on climate, which varies greatly over time. In the places of AZ and CA, water resource is abundant . NM and TX are near desert, lack of water.

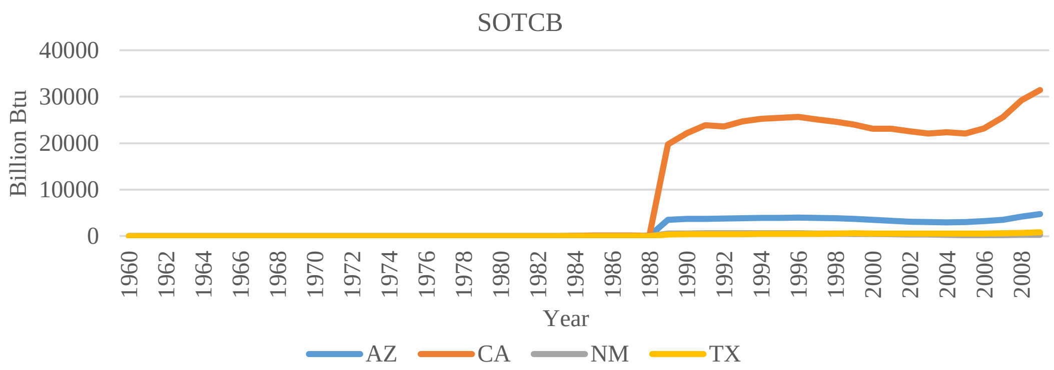
5.1.3. Nuclear Power



Similarity and difference: Over the fifty years, except NM didn't use nuclear energy, all the states started to use it from different period of time, and reached a same level in 2009.

Reason: nuclear reaction needs water as coolant.

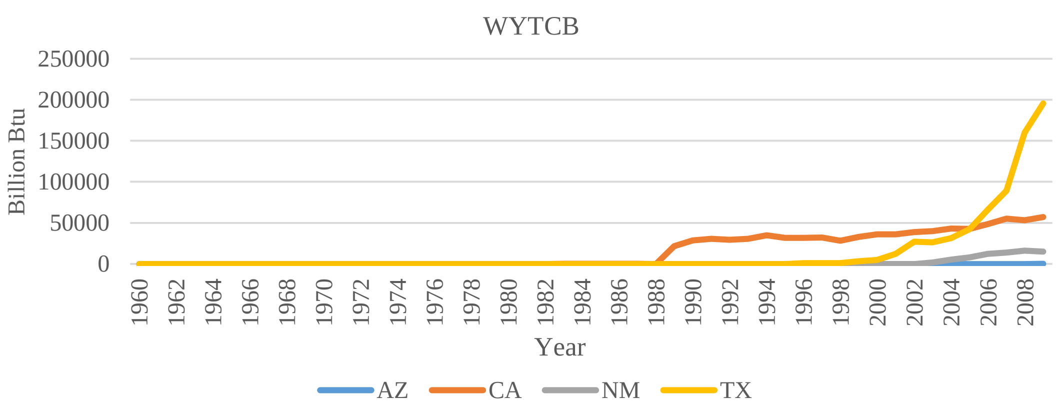
5.1.4. Solar Energy



Similarity and differences: CA and AZ have long history of using solar energy, and its production became stabilized recently.

Reason: Sun light and technology determine the usage of solar energy. The expenditure of it can be great.

5.1.5. Wind Power



Similarity and difference: CA first used wind power, the production of which turned out to be little and easily stabilized.

Reason: wind power usage is high dependent on technology and topography factor, as well as the power of wind in local places.

5.2. Prediction

To predict the profile of energy usage, we decide to use Logistic regression. The advantages of this modal is listed below:

1. some cases (especially those sources which are well developed) have already been neatly described by logistic model.
2. The variety of the data meets the requirement of logistic regression
3. This model has the ability to make prediction.
4. Logistic regression is effective and common used.

(If a certain sort of energy happened to be constant 0 in the data from the beginning, we assume this energy had not been used).

The fitting formula we used is

$$f(x) = \frac{1}{a + be^{-c(x-S_y)}} + S_d$$

Here, S_y is the stating year, S_d is the amount of energy produced in the initial year x is the number of the year. a, b, c are all fitting coefficient.

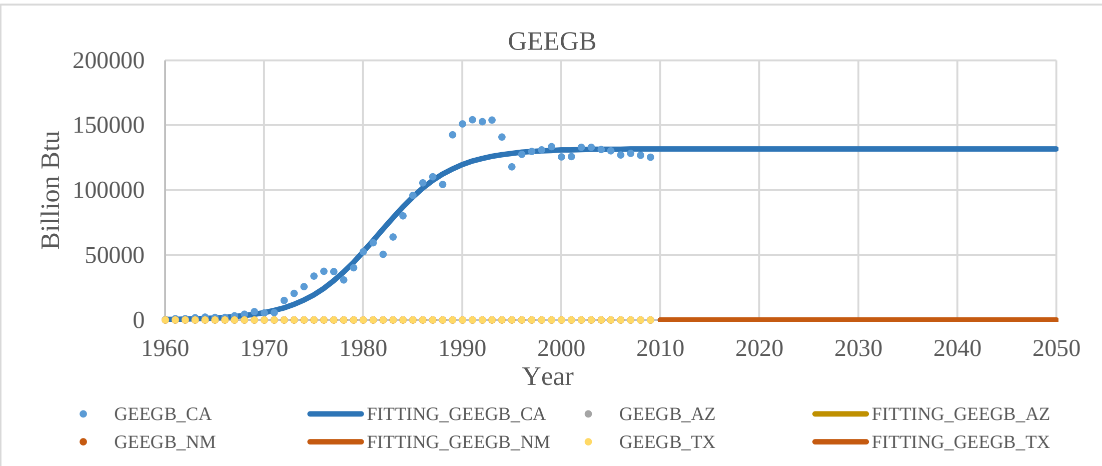
After analyze the data using our modal, we found only 10 cases neatly fitted, including:

NUETC_AZ, SOTCB_AZ, GEEGB_CA, NUETB_CA, SOTCB_CA WYTCB_CA, WYTCB_NM, NUETB_TX, SOTCB_TX, WYTCB_TX.

For those we fail to use our modal, we found the situation of them is greatly by other factors (climate, topography). For example, hydroelectricity development fluctuates so greatly that once we use Logistic regression the average of r^2becomes lower than 0.3 which means they cannot be successfully fitted.

So we used the average of date to predict them.

The data for those cases we use are shown below (billion btu)

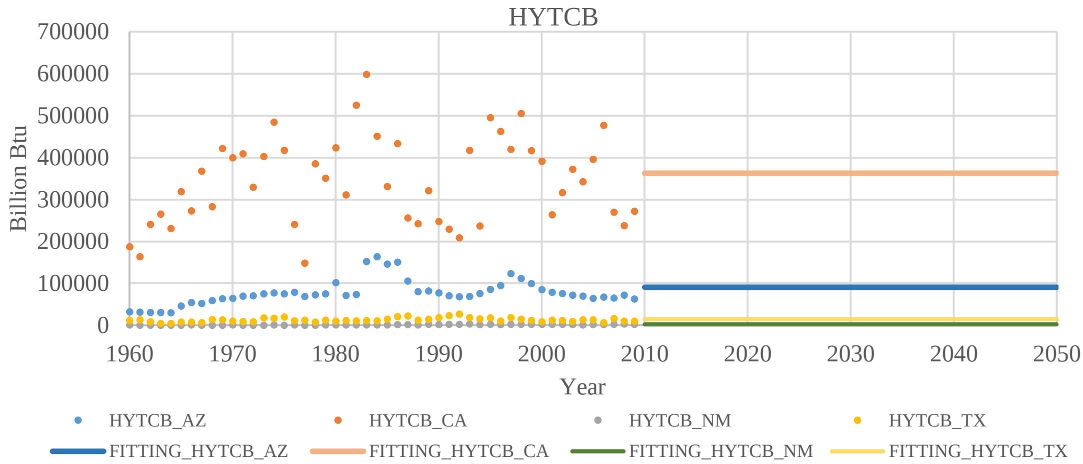


GEEGB_AZ 0

GEEGB_CA $f(x) = \frac{16000}{0.1215+40.88e^{-0.2707(x-1960)}}$ $R^2 = 0.9945$

GEEGB_NM 0

GEEGB_TX 0

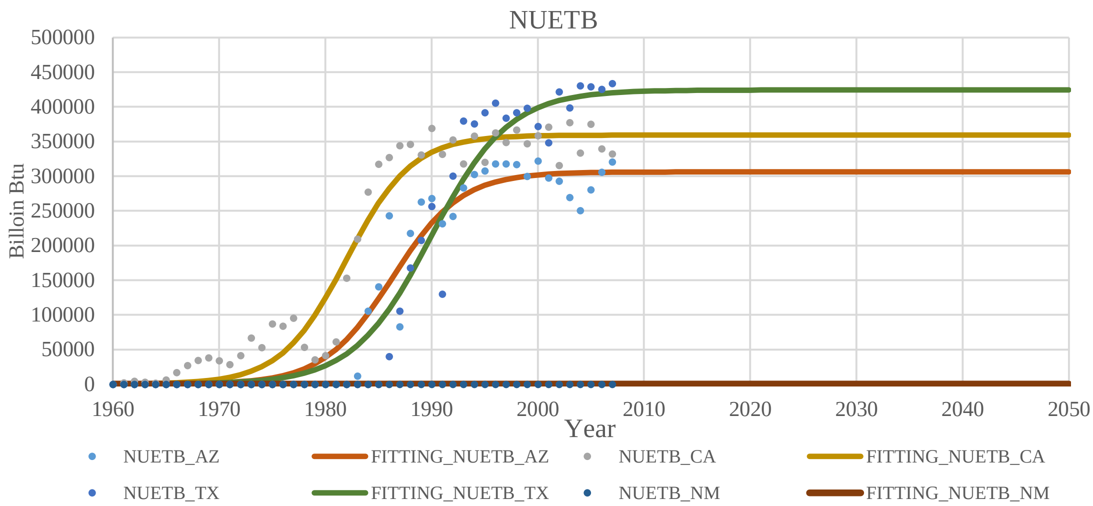


HYTCB_AZ 90583.57829

HYTCB_CA 362378.2254

HYTCB_NM 2010.674617

HYTCB_TX 14228.53307

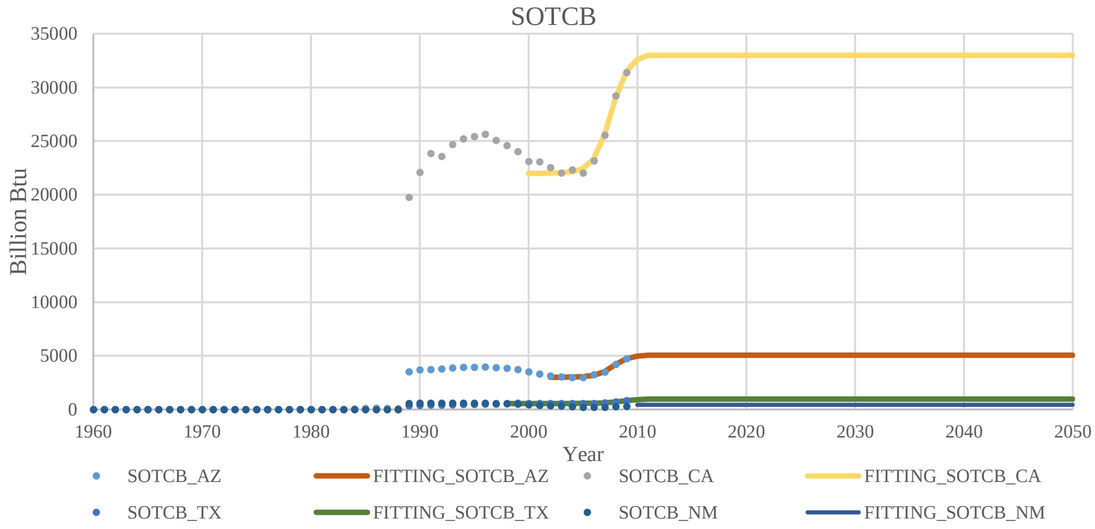


NUETB_AZ $f(x) = \frac{1000000}{3.267+20390e^{-0.3089(x-1960)}}$ $R^2 = 0.9525$

NUETB_CA $f(x) = \frac{1000000}{2.784+6601e^{-0.324(x-1960)}}$ $R^2 = 0.956$

NUETB_NM 0

NUETB_TX $f(x) = \frac{1000000}{2.357+14250e^{-0.2726(x-1960)}}$ $R^2 = 0.9615$

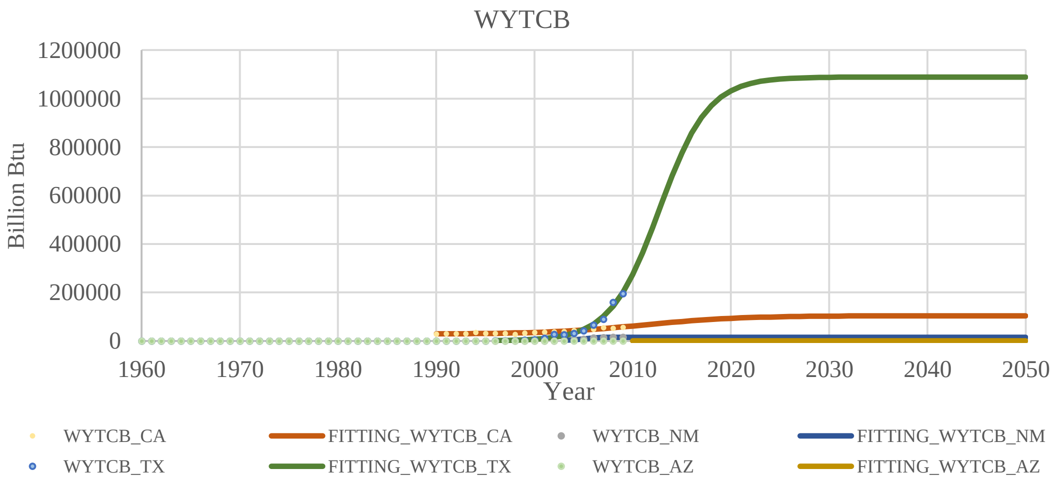


SOTCB_AZ $f(x) = \frac{400}{0.1933+500.2e^{-1.359(x-2002)}} + 3000$ $R^2 = 0.992$

SOTCB_CA $f(x) = \frac{10000}{0.8973+11040e^{-1.242(x-2000)}} + 22000$ $R^2 = 0.9693$

SOTCB_NM 442.946

SOTCB_TX $f(x) = \frac{1}{0.002355+495.2e^{-1.156(x-1998)}} + 560$ $R^2 = 0.98$



WYTCB_AZ 288.3592

WYTCB_CA $f(x) = \frac{1000}{0.01316+1.157e^{-0.2023(x-1989)}} + 28000$ $R^2 = 0.9504$

WYTCB_NM $f(x) = \frac{100000}{7.356+118.1e^{-1.294(x-2003)}} + 2000$ $R^2 = 0.9839$

WYTCB_TX $f(x) = \frac{10000}{0.009183+7.316e^{-0.3394(x-1996)}}$ $R^2 = 0.9867$

According to the formula and predictive analysis, we made two table about each of the "new energy" usage in each state in 2025 and 2050,shown in Table 5 and Table 6.

Table 5

$x_{i,y}$ / i	$G_{i,2025}$ (Billion Btu)	$H_{i,2025}$ (Billion Btu)	$N_{i,2025}$ (Billion Btu)	$S_{i,2025}$ (Billion Btu)	$W_{i,2025}$ (Billion Btu)
AZ	0	90583.57829	306087.5749	5069.322297	288.3592
CA	131686.1982	2010.674617	359194.7941	33144.54474	99658.09161
NM	0	2010.674617	0	442.946	15594.34475
TX	0	14228.53307	424216.4031	984.6284476	1080936.629

Table 6

$x_{i,y}$ / i	$G_{i,2050}$ (Billion Btu)	$H_{i,2050}$ (Billion Btu)	$N_{i,2050}$ (Billion Btu)	$S_{i,2050}$ (Billion Btu)	$W_{i,2050}$ (Billion Btu)
AZ	0	90583.57829	306091.2136	5069.322297	288.3592
CA	131687.2416	2010.674617	359195.4021	33144.54475	103958.6455
NM	0	2010.674617	0	442.946	15594.34475
TX	0	14228.53307	424268.0807	984.6284501	1088968.374

6. Evaluation

Our assessment of the use of "new energy" in four states in 2009 will be divided into two parts: an overview of the use of new energy in 2009 and an overview of the "new energy" development in 2009.

6.1. Part 1 the assessment of the situation of new type of energy source

For this part of the evaluation, we use the 2009 "new energy" in all four states as a percentage of total energy use, and the higher the percentage, the better the use. See table for details.

Table 7

T / i	$T_{i,2009}$ (Billion Btu)	$T^n_{i,2009}$ (Billion Btu)	$\frac{T^n_{i,2009}}{T_{i,2009}} \times 100\%$
AZ	1321782	388474.3	29.3902%
CA	4031434	818273.4	20.29733%
NM	645872.8	18023.09	2.790502%
TX	6522754	640379.3	9.817621%

The table shows that in 2009 the four states "new energy" share of total energy use and high to low rankings: AZ, CA, TX, NM. So AZ 2009 "new energy" use the best profile.

6.2. Part 2 Assessment of Situation of Development

For this part of the evaluation, we use the four states' 2009 development index I_i as a measure, and the higher the development index, the better the development.

Firstly, we use the formula

$$R_{i,x,y} = \frac{x_{i,y}}{T_{i,y}} \times 100\%$$

$$Q_{i,x,y} = \frac{R_{i,x,y} - R_{i,x,y-1}}{R_{i,x,y-1}} \times 100\%$$

$$\overline{Q_{i,x,y_1,y_2}} = \frac{\sum_{y=y_1}^{y_2} Q_{i,x,y}}{y_2 - y_1 + 1}$$

Calculate the annual average growth rate of each renewable and cleaner energy in the total energy proportion of each state from 2006 to 2009 $\overline{Q_{i,x,2006,2009}}$, as shown in the Table 8

Table 8

i \ $\overline{Q_{i,x,2006,2009}}$	$\overline{Q_{i,G,2006,2009}}$	$\overline{Q_{i,H,2006,2009}}$	$\overline{Q_{i,N,2006,2009}}$	$\overline{Q_{i,S,2006,2009}}$	$\overline{Q_{i,W,2006,2009}}$
AZ	0%	-1.8364%	3.214166%	10.71643%	0%
CA	-0.3457%	-4.90854%	-2.01213%	9.971233%	8.331383%
NM	0%	13.68729%	0%	7.718478%	18.95028%
TX	0%	14.07953%	2.609145%	10.53253%	48.38389%

Our comparison should be made basing on the general developing situation, rather than simply made an arbitrary judgement basing on the growing rate of the percentage, cleaner energy takes up, of the total energy assumption. Since the exploiting and application of cleaner energy is fairly restricted by geographical factors and human factors, consequently we aggregate all those seemingly reasonable factors, including longitude, topography, climate, hydrology, local policy, seismic zone, technology, development prospect and population in order to arrange weighted proportion for each state,

For instance, topography factors hold particularity in California than in other three states, for California is located in the region ringing the Pacific Ocean that is prone to earthquake and volcanic activities. Doubtlessly, the geothermal energy source relatively prudent compared with the other three states where geothermal energy is absent. As geothermal energy is highly relied on the topography factor, we decide to give California 1 point while others 0.

Hydro energy, as acknowledged to all, is considered as a sort of cleaner and renewable energy with long history. However, the it is greatly dependent on the condition of topography factor with great demand of the fall of river level. Only AZ and CA show their competence in developing hydro energy, for they meet the requirement. Even so, the hydroelectricity production can fluctuate violently over years because of the change of climate over time. For example, in California the recent drought greatly decreases the amount of hydroelectricity production.

Besides, nuclear energy is a kind of high-technical energy source with a rosy prospect for the effectiveness and extreme little material usage. From that point of view, nuclear energy is regarded as the major energy source in the future. What is shown by the result is consist with our assumption. Except NM, all the states have the similar result in terms of amount of electricity produced by nuclear together with their developing trend. As this part of energy source is quite independent of most factors that are different between each state, we argue that each state has the ability to fully develop nuclear power, so we give each state a relatively high score. As for NM, particularly lack of water which is a necessity for nuclear reaction as coolant, the development of nuclear source is restricted. However, NM still have the potential to make a breakthrough. So we give NM 1.5.

Solar energy collecting is largely dependent on the technology factor. So, we give four states equal score.

Wind power is quite similar with solar power, except for its low converting effectiveness. However, technology involved is relatively simple and easy to make progress. We give the highest point to wind part except AZ, where mountains and hills take large area of the state, which makes it hard to build facilities to collect wind energy, and thus, we give AZ 1.5, lower than others.

Through the above analysis, we give a weight scale table about the weight of the development of each renewable and cleaner energy to the all renewable and cleaner energy in the four states, as shown in the Table 9.

Table 9

i \ $\omega_{i,x}$	$\omega_{i,G}$	$\omega_{i,H}$	$\omega_{i,N}$	$\omega_{i,S}$	$\omega_{i,W}$
AZ	0	0.17	0.4	0.28	0.15
CA	0.1	0.13	0.32	0.2	0.25
NM	0	0.13	0.15	0.32	0.4
TX	0	0.12	0.38	0.18	0.32

Finally, we used the formula

$$I_i = \sum_{x=G,H,N,S,W} Q_{i,x,2006,2009} \times \omega_{i,x} \times 100$$

calculate the renewable and cleaner energy" development index I_i for each state, shown in the Table 10

Table 10

I_i \ i	AZ	CA	NM	TX
I_i	3.97408	2.760529	11.82937	20.05972

The table shows that the four states "new energy" development index in 2009. And the rank from high to low is TX, NM, AZ, CA. So the best one of the renewable and cleaner energy development is TX in 2009.

7. Suggested Action and Goal

7.1. Action

We will give 3 suggested actions as followed.

1. Monitoring the practice of developing renewable and cleaner energy source

Governors should take any measure to maintain the condition of developing renewable energy source. As we can see from the profile of the energy usage, cleaner energy usage takes up an increasingly large part of the total amount of energy usage. This is what we want to witness. So governors should pay attention to keep this fine trend moving, like providing the department related to cleaner energy usage more budget.

2. 'Helping hand'

We found great part of difference of the development of the new energy source between four states is largely influenced by technology factor and talent resource. In other words, certain type of energy can never be controlled by the objective factors (topography, climate). Let us suppose that one state inherits all the relatively advance technology and facilities, it is predictable that the state will catch up with others. To make a more convincing suggestion, we would like to provide our prediction after taking the step. For solar energy, one of the biggest problem an innovator meet is the high expenditure to build solar energy facilities. So if CA, who did really well in solar energy exploiting, gives a hand to other three states by sharing advanced technology or offer them a more cost-saving way to build more facilities. It is sure those three states will catch up with the footstep of CA more easily.

3. Finding another way

As some factors greatly affects the development of renewable and cleaner energy, we should take big breakthrough in technology into consideration. Specifically, in DX, nuclear-related career is greatly hampered because of scarcity of water which is necessary for nuclear reaction. Nevertheless, why can't we find an alternative for water as the coolant? We have also found an increase of the solar production in CA after long years of keeping unchanged, which means a breakthrough in solar energy production. As we can learn from the result, the development curve of an energy source (especially that is fully developed) will be shown happens to be an 'S'. Only when an advanced and more effective method is introduced, can the production this type of energy gets the chance of increasing once more.

To make our suggestions more convincing, we predict how may a certain energy source develops after the governors follow our words and take steps. We create a situation that from 2009 to 2015, each state can take the chance to seek 'help' from others. From 2015 to 2050, governors should motivate a technological innovation particularly on that which is fully developed. We practice our solution on nuclear energy, wind energy and solar energy. Our results are shown by Figure 6,Figure 7 and Figure 8.

Figure 6: Nuclear Energy Prediction

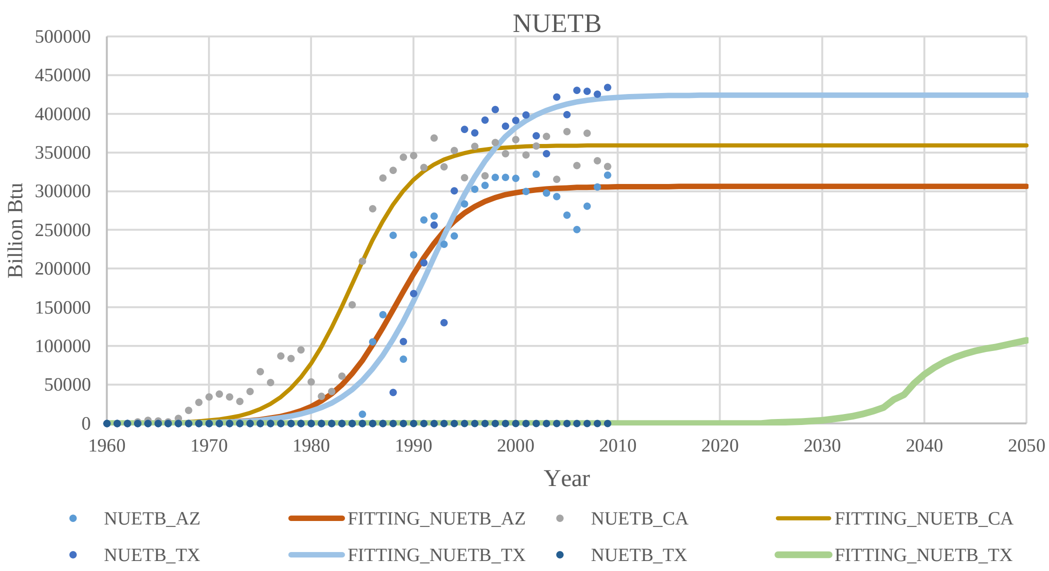


Figure 7: Solar Energy Prediction

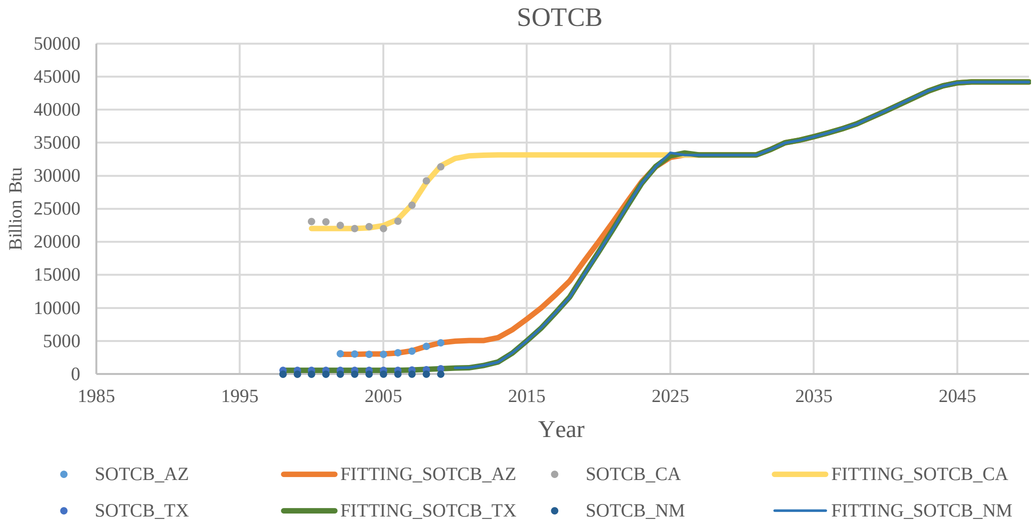
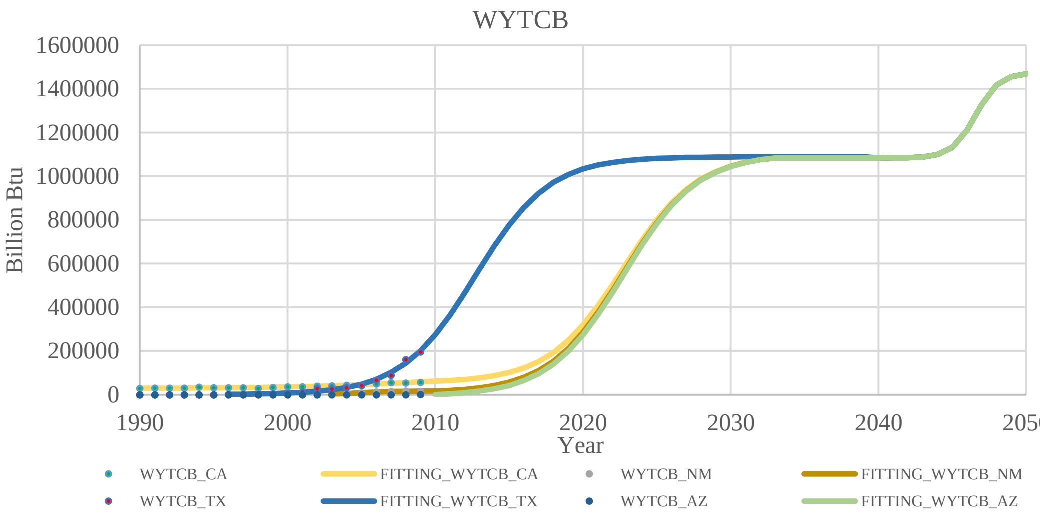


Figure 8: Wind Energy Prediction



7.2. Goal

Through the analysis in 7.1, our goal is presented as followed.

Table 11: Goal of 2025

$x_{i,y}$ / i	$G_{i,2025}$ (Billion Btu)	$H_{i,2025}$ (Billion Btu)	$N_{i,2025}$ (Billion Btu)	$S_{i,2025}$ (Billion Btu)	$W_{i,2025}$ (Billion Btu)
AZ	0	90583.57829	306087.5749	32745	783041.7714
CA	131686.1982	2010.674617	359194.7941	33144.54474	800148.4574
NM	0	2010.674617	0	33467.41398	787341.3059
TX	0	14228.53307	424216.4031	33009.7314	1080936.629

Table 12: Goal of 2050

$x_{i,y}$ / i	$G_{i,2050}$ (Billion Btu)	$H_{i,2050}$ (Billion Btu)	$N_{i,2050}$ (Billion Btu)	$S_{i,2050}$ (Billion Btu)	$W_{i,2050}$ (Billion Btu)

AZ	0	90583.57829	306091.2176	44192.18158	1468001.063
CA	131687.2416	2010.674617	359195.4027	44192.18158	1468001.063
NM	0	2010.674617	107288.3959	44192.18158	1468001.063
TX	0	14228.53307	424268.1783	44192.18158	1468001.063

8. Error Analysis

8.1. Energy in S shape

A total of 10 S-shaped: where the respective R^2 as the Figure 9.

Figure 9: R^2

MSN_State	R^2	MSN_State	R^2
NUETC_AZ	0.952	WYTCB_CA	0.950
SOTCB_AZ	0.992	WYTCB_NM	0.984
GEEGB_CA	0.995	NUETB_TX	0.962
NUETB_CA	0.956	SOTCB_TX	0.980
SOTCB_CA	0.969	WYTCB_TX	0.987

All R ^ 2> 0.95 which means the fitting line is credible and reliable.

Some data were collected too late, if we can get access tp the previous year's data fitting will be better: For example, NUETB_AZ is only from 1985.Those data collected adequately, the fitting process can be successful, like GEEGB_CA and NUETB_CA.

8.2. Hydro Energy

Due to the large hydrological conditions and the large fluctuations in water, the data fluctuate too much and the results of the fitting difference R^2 are all lower than 0.3 and therefore cannot be fitted. Taking into account the hydropower has been saturated so there will be no breakthrough in the future so take the average of 30 years. If given for the future development of hydropower technology, we can better predict it.

8.3. Others

Data due to late measurement or no development, all Data are 0, which can only be used as the data of the year 2009 before there was a new technological innovation (one at a time). Better predictions can be made if relevant plans and expected research results are developed for the development of corresponding energy sources.

References

1. https://pacinst.org/publication/impacts-of-californias-ongoing-drought-hydroelectricity-generation/
2. https://en.wikipedia.org/wiki/Arizona
3. https://en.wikipedia.org/wiki/California
4. https://en.wikipedia.org/wiki/New_Mexico
5. https://en.wikipedia.org/wiki/Texas
6. https://en.wikipedia.org/wiki/Hydroelectricity
7. https://en.wikipedia.org/wiki/Solar_energy
8. https://en.wikipedia.org/wiki/Wind_power
9. https://en.wikipedia.org/wiki/Geothermal_power
10. https://en.wikipedia.org/wiki/Nuclear_power
11. http://www.jstor.org/stable/23322913
12. https://en.wikipedia.org/wiki/Logistic_regression