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Summary Sheet

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1 Introduction

instroduction content

2 Establishing Energy profile

Our aim is to use the Energy profile to represent the total annual consumption of various energy sources and their structure. According to the official website of the data introduction, we divide energy into five categories which are Coal, Natural Gas, Petroleum, Renewable Energy and Nuclear electric power. This energy profile includes the annual consumption of five energy sources and describes their changes from 1960 to 2009. In addition, we use the annual energy consumption of the five major energy sources in different industries to reflect changes in the use of different types of energy in different industries

2.1 Data analysis and preparation

2.1.1 Energy classification

Energy sources have been classified into five main kinds. Each class has some variables which listed in the memo page.

- Coal
Includes coal(CL) and coal coke(CC). Recorded as $coal$. Then $coal = \{CL, CC\}$
- Natural Gas
Includes natural gas (NN). Recorded as ng . Then $ng = \{NN\}$
- Petroleum
Includes aviation gasoline(AB), crude oil(CO), fossile fuels (ff), jet fuel(JF) etc. Recorded as $petro$. Then $petro = \{AB, AR, AV, CO, DF, FF, FN, \dots\}$. More variables are listed in the memo page.
- Renewable Energy
Includes fuel ethanol(EN), geothermal energy(GE), solar energy(GO), wind(WY) and wood(WD) etc. Recorded as re . Then $re = \{BM, EN, EM, ES, GE, GO, \dots\}$
- Nuclear electric power
Includes nuclear electric power(NU). Recorded as nu . Then $nu = \{NU\}$

2.1.2 Four kinds of industries

- Residential sector
An energy-consuming sector that consists of living quarters for private households.
We choose to use RCB (residential energy consumption, data in British thermal units (Btu)) to measure its energy consumption.

- Commercial sector

An energy-consuming sector that consists of service-providing facilities and equipment of: businesses; federal, state, and local governments; and other private and public organizations. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities.

We choose to use *CCB* (commercial energy consumption, data in British thermal units (Btu)) to measure its energy consumption.

- Industrial sector

An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods.

We chose to use *ICB* (Industrial energy consumption, data in British thermal units (Btu)) to measure its energy consumption.

- Transportation sector

An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another.

We chose to use *TCB* (Transportation energy consumption, data in British thermal units (Btu)) to measure its energy consumption.

2.1.3 The calculation process

- Calculation of the total consumption of five kinds of energy sources Filter the given variables. What we need is the total annual consumption of each kind energy sources. For example, the total consumption of coal(*coalTCB*) is *CLTCB* + *CCTCB*.

The more general way to represent the total consumption of each kind energy sources is

$$\begin{aligned}
 coalTCB &= \sum_{i=0}^n var_i TCB \quad var_i \in coal, n = |coal| \\
 ngTCB &= \sum_{i=0}^n var_i TCB \quad var_i \in ng, n = |ng| \\
 petroTCB &= \sum_{i=0}^n var_i TCB \quad var_i \in petro, n = |petro| \\
 reTCB &= \sum_{i=0}^n var_i TCB \quad var_i \in re, n = |re| \\
 nuTCB &= \sum_{i=0}^n var_i TCB \quad var_i \in nu, n = |nu|
 \end{aligned}$$

- Calculate the consumption of five kinds of energy sources in four sectors separately From the data, we choose the energy consumption of all energy sources

in each sector and then add up according to the sector. For example, $coalRCB$ (consumption of coal in the residential sector) is: $CLRCB + CCRCB$. As well, use symbols to represent this is

$$coalACB = \sum_{i=0}^n var_i ACB \quad var_i \in coal, n = |coal|$$

$$coalCCB = \sum_{i=0}^n var_i CCB \quad var_i \in coal, n = |coal|$$

$$coalICB = \sum_{i=0}^n var_i ICB \quad var_i \in coal, n = |coal|$$

$$coalRCB = \sum_{i=0}^n var_i RCB \quad var_i \in coal, n = |coal|$$

$$ngACB = \sum_{i=0}^n var_i ACB \quad var_i \in ng, n = |ng|$$

$$ngCCB = \sum_{i=0}^n var_i CCB \quad var_i \in ng, n = |ng|$$

$$ngICB = \sum_{i=0}^n var_i ICB \quad var_i \in ng, n = |ng|$$

$$ngRCB = \sum_{i=0}^n var_i RCB \quad var_i \in ng, n = |ng|$$

And the rest three kinds of energy sources (*petro, re and nu*) have similar formula.

2.1.4 Formula for energy profile

To get the final formula, we have one step to do. Use every kinds of annual consumption to divide it own fields of total annual consumption. Such as, record the total energy annual consumption is $TETCB$, and the result of using $coalTCB$ to divide $TETCB$ is noted as $coalVT$.

$$coalVT = \frac{coalTCB}{TETCB}$$

And use $coalVA$ to record $coalACB$ to divide $TEACB$.

$$coalVA = \frac{coalACB}{TEACB}$$

More variables have been listed in the memo page.
The final representation of the formula is

$$EP = \begin{pmatrix} coalVT & coalVA & coalVC & coalVI & coalVR \\ ngVT & ngVA & ngVC & ngVI & ngVR \\ petroVT & petroVA & petroVC & petroVI & petroVR \\ reVT & reVA & reVC & reVI & reVR \\ nuVT & 0 & 0 & 0 & 0 \end{pmatrix}$$

* Note that Nuclear electric power doesn't have variables to represent the annual consumption in different sectors. But it is still an important energy sources, so we keep it.

2.2 California' energy profile

Stretching two-thirds of the way up the West Coast, California is the nation's third-largest state and also California is the most populated state in the nation, and, with the largest economy, its total energy demand is second only to Texas. California's extensive efforts to increase energy efficiency, along with the implementation of alternative technologies, has restrained growth in energy demand. California is also rich in energy resources. The state has an abundant supply of crude oil and is a top producer of conventional hydroelectric power. California also leads the nation in electricity generation from solar, geothermal, and biomass resources. Transportation dominates California's energy consumption profile. More motor vehicles are registered in California than in any other state, and commute times in California are among the longest in the country. The state also accounts for one-fifth of the nation's jet fuel consumption.

2.2.1 Petroleum

For California, oil is its primary source of energy, with oil accounting for more than 60% of total energy consumption in the past 50 years. However, it can be seen that the share of oil in total consumption after constant technological innovation showing a weak downward trend. In particular, in the industrial sector, the proportion of oil used in the past few years has dropped in volatility and has been shown to complement each other with natural gas. With the growth in the use of natural gas, oil may be gradually replaced. However, in the transportation sector, the share of oil used is close to 100% and there is no downward trend. In the commercial and residential sectors, the proportion of oil used has risen to some extent, reaching around 40% and 50% in 2009. It shows that California is very dependent on oil. Although the overall trend is declining, it can not leave the oil in the short term.

2.2.2 Natural gas

California accounts for less than 1% of total U.S. natural gas reserves and production. After the 1970s, California's natural gas production experienced a gradual and complete decline over the past 30 years. From 30% in the 1960s and now up and down at 20%. The demand for natural gas in California is not so strong, and from the data analysis, it has been relatively stable at about 20% in recent years. The use of natural gas in the dwelling sector has dropped continuously from 80% to 45% in 50 years. The same is true of the commercial sector, which started to decline continuously after rising to 70% in the 1970s and reached 25% in 2009. Contrary to the previous one, the industrial sector seems to consider natural gas as a substitute for petroleum. After a decline in the 1970s, it rose from fluctuations in the mid-1980s to a 47% share and is still on the rise.

2.2.3 Renewable energy

California is among the top states in the nation in electricity generation from renewable resources and leads the nation in generation from solar, geothermal, and biomass energy. California is also the nation's third-largest producer of electricity from conventional hydroelectric power and the fifth-largest producer from wind energy. With the development of science and technology, the ratio of renewable energy sources shows a steady and steady rise in total energy consumption. This is evident in the residential and commercial sectors and has been rising for 50 years. In the residential sector, the share rose from 8% to 17% and in commerce from 12% to 23%, but the charts in recent years show that the rate of increase is declining steadily. In industry, however, the share of renewable energy in the last 50 years was the highest since the oil crisis, and the share of renewable energy declined after the 1970s, recovering slightly from 2000 to 2009.

2.2.4 Coal

California does not have any coal reserves or production and has phased out almost all use of coal for electricity generation. As you can see from the table, California's demand for coal is extremely low, even lower than the demand for renewable energy in 2000-2009. No matter in the commercial, transportation, residential or industrial sectors, there is an extremely low proportion of those coming out to zero and there is no continuing upward trend.

2.3 Arizona' energy profile

Arizona is known for its iconic vistas from the Grand Canyon in the north to the Saguaro deserts in the south. The state has few fossil fuel resources, but it does have abundant solar and geothermal energy potential. Elevations in Arizona vary from peaks more than 12,000 feet high in the north to nearly sea level in the lower

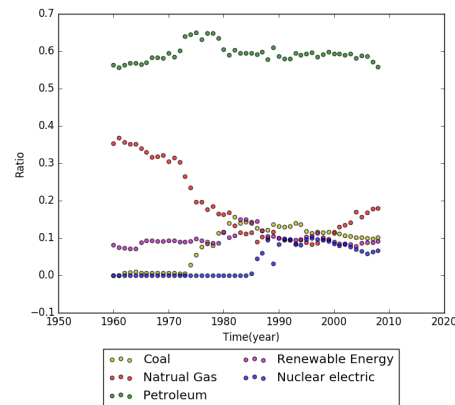
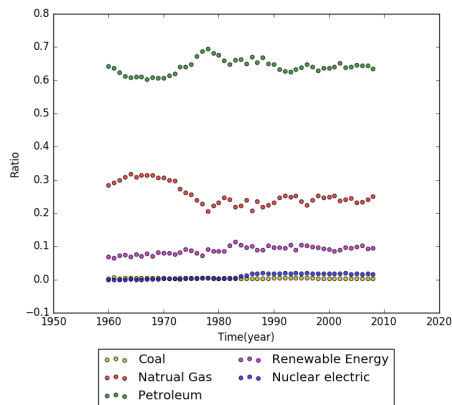


Figure 1: Energy consumption, California Figure 2: Energy consumption, Arizona

deserts to the southwest. And abundant sunshine gives the entire state some of the nation's greatest solar power potential. Because the main economic activity in Arizona is not energy-intensive, the country's per capita energy consumption is the lowest in the country. The transportation sector is the largest consumer of terminal energy in Arizona, followed by the residential market. The main energy source in Arizona is oil.

2.3.1 Petroleum

Arizona does not have any refinery. Gasoline and other petroleum products are supplied by pipelines in Southern California and Texas. The transportation sector, which is the most dependent on oil, has risen to about 2005 from the 1960s, rising almost from 82% to 95%. Since 2005, the share of renewables and natural gas has slightly declined. According to calculations, nearly ten barrels of oil will be used for the transport sector and the rest will be basically used in the industrial sector. The use of oil in the industrial sector as a whole is on the rise, rising from 27% to 65% and is still on the rise. In the residential and commercial sectors, the share of oil also increased, with the residential sector rising from 16% to 50% and stabilizing, with 30% of the commercial sector turning 52%. On the whole, Arizona is getting more and more dependent on oil.

2.3.2 Natural gas

Arizona has no significant gas reserves. The share of natural gas from the 1960s to the 1990s has been declining until it showed an upward trend in the late 1990s. In all four key sectors, the use of natural gas, in general, has been declining. In the commercial sector, the share of natural gas dropped rapidly from 64% to below 10% from 60% to 20% in the industrial sector and seems to be still on the decline. In the industrial sector, from the 1960s to the 1990s, the proportion of natural gas dropped rapidly to below 10% and then to 15%. And fluctuated around 15% in the 1990s and early twenty-first centuries. In the residential sector, the share of natural

gas has been declining, from 70% to 15%, and the post-term decline has been softer than the previous decline. In the transport sector from 22% dropped to about 5%, and in 2009 by the rising trend. Natural gas was once one of the main sources of energy in Arizona, but natural gas is no longer as important for Arizona as the cost of other energy uses goes down.

2.3.3 Renewable Energy

Arizona's renewable energy standards require that investors in the power utilities and retail power providers receive more and more electricity from renewable sources. Renewable energy has been one of Arizona's major energy sources and its share has been close to 10% between the 1960s and the 1980s, with a sharp increase of nearly 15% between 1980 and 1985, Then retreated. Since 2001, the share of renewable energy has risen slowly and has continued to rise. The share of renewable energy in the industry has been rising for 30 consecutive years, up to 20% and a slight decrease since the 1990s. However, the proportion of renewable energy in the industry has been on a rising trend since the 21st century. Renewable energy in the residential sector has been on the rise, rising from 10% to 25% in 50 years and the energy mix has changed dramatically. Commercial and transportation sectors basically do not use renewable energy.

2.3.4 Coal

Renewable energy Arizona has two coalfields - Black Mesa, the Navajo River and the Northeast Hippo Reservation, Pinedale, south-central Arizona. These areas maintain around 1% of the country's coal reserves in producing mines. The only coal mine operating in the state is located in the Black Mesa field, one of the 30 largest coal mines in the country. Arizona started to use coal from the 1970s and quickly became a significant 12% energy source in the 1980s. It began to slowly decline to 8% (2009) in the early 1990's and remained stable. Industrial coal, which grew rapidly from the mid-1970s to the late 1980s, reached 20% at one point and quickly dropped to 8% in the early 1990s and remained stable. In addition to the three departments in the industrial sector, coal is basically not used directly.

2.4 New Mexico's energy profile

In New Mexico, there are a great deal of forested peaks and valleys of the southern Rocky Mountains, high plateaus of the Great Plains, and many spectacular desert canyons and mesas. Because of the diversity of altitude, the climate of New Mexico is changeable. In the southern desert, it is common for summer temperatures to exceed 100 degrees Fahrenheit. In the northern snow peak, the winter temperature will drop to 50 degrees below zero. New Mexico is with much land but few people. Although it is the fifth-largest state by area, it is the sixth-least densely populated. More than one in four residents live in the city of Albuquerque, and two-thirds of

the state has fewer than 10 people per square mile. New Mexico is the nation's 7th largest net energy supply state, rich in fossil fuels, minerals and renewable energy resources. The oil and gas industry, contributes significantly to the state's gross domestic product (GDP), and workers in the sector earn among the highest average weekly pay in the state. New Mexico's energy consumption per dollar of GDP and energy consumption per capita are both above the national average.

2.4.1 Petroleum

New Mexico's crude oil reserves have surpassed 4% of the U.S. It has been the sixth-largest oil producer for a long time, accounting for nearly 5% of the country's annual crude output. The Permian Basin in western Texas and southeastern New Mexico are among the most productive oil producing areas in the country. The proportion of oil in total energy consumption is as high as more than half. From 1960, the proportion of petroleum energy consumption in New Mexico increased year by year, accounting for nearly 60% by the 21st century. New Mexico's transportation sector dominates oil consumption. More than 80% of all oil in the state belongs to the sector. The industrial sector is far ahead, with only a small amount of oil being used in the residential and commercial sectors. Only about 0.1% of New Mexico households use oil products for home heating.

2.4.2 Natural gas

New Mexico, accounting for about 5% of the total natural gas reserves in the United States, is one of the top ten natural gas producers in the United States, accounting for about 4% of the country's total natural gas production. Because of the high reserves of natural gas, natural gas accounted for as much as 45% of the energy it consumed in the 1970s, comparable to oil. However, with the development of oil, coal and renewable energy, the proportion of natural gas in energy consumption has been declining year by year, reaching a minimum of 20% in the mid-1980s. From 1990 to 2009, the proportion of natural gas consumption has fluctuated between 20% and 25% and gradually stabilized.

2.4.3 Renewable energy

New Mexico has a large number of renewable resources, especially wind and solar energy, as well as hydropower, biomass and geothermal energy. New Mexico has the sixth-largest geothermal resource in the country. The climate in New Mexico is characterized by ample sunshine. And it has developed rapidly in solar technology with the support of national policies. It can be seen that the proportion of energy consumption of renewable energy is gradually increasing, approaching 10% by 2009 and there is a trend of continued growth. The proportion of energy consumption in the industrial, commercial and residential sectors has increased substantially.

In particular, the energy consumption of renewable resources in commercial and residential sectors has exceeded 20% by 2009.

2.4.4 Coal

New Mexico contains nearly 3% of the country's estimated recoverable coal reserves. New Mexico has mined coal since the 1850s. Therefore, from 1965 to 1985, the proportion of coal's energy consumption gradually increased, reaching a maximum of about 18% in 1985. However, with the increase of renewable resources and oil, the proportion of coal's energy consumption has steadily declined. Through the analysis of energy consumption in the industrial, transportation, commercial and residential sectors, it can be seen that coal accounts for the smallest proportion of energy consumption in all sectors and shows a very small proportion of nearly zero.

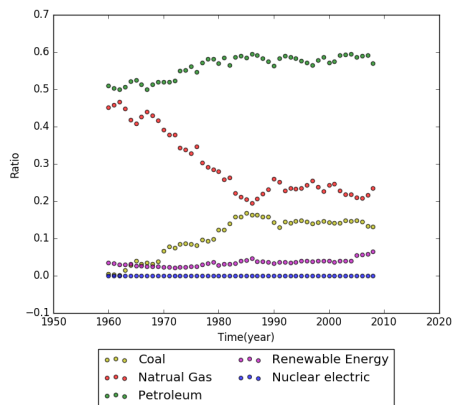


Figure 3: Energy consumption, New Mexico

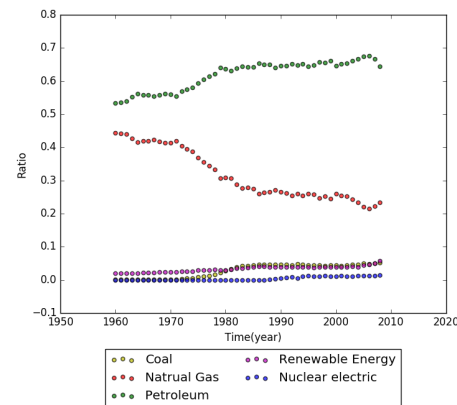


Figure 4: Energy consumption, Texas

2.5 Texas's energy profile

Texas, located in the south-central part of the United States, is the second largest in size in the United States. The Texas Almanac classifies the state into four regions: Gulf Coastal Plains, Interior Lowlands, Great Plains, and Basin and Range Province. The Texas climate varies significantly from east to west. Moist air from the Gulf of Mexico sweeps westward across the state, losing moisture as it goes. As a result, the climate ranges from humid and subtropical along the coast, where much of the state's population resides, to semi-arid on the high plains, and arid in the mountainous west. Texas is a large state with a wealth of energy resources. Crude oil and natural gas fields are present across the entire state. Texas also has abundant renewable energy resources and has rapidly developed its wind energy. Besides, Texas is among the leading states in solar energy potential. Among the states, Texas has the second-largest population and the second-largest economy. The state has many energy-intensive industries, including petroleum refining and

chemical manufacturing, and the industrial sector accounts for the largest share of state energy use.

2.5.1 Petroleum

Texas is a leader in crude oil reserves and production. More than a third of the U.S. crude oil has been proved reserves. More than a quarter of the nation's 100 largest reserves are in Texas, mostly in the Permian Basin in western Texas and south-central Florida. More than a third of the country's crude oil is produced in Texas, surpassing any other country and surpassing all federal offshore areas. From the discovery of the Spindletop field in 1901 to the subsequent discovery of various oil fields, the proportion of oil in Texas in energy consumption gradually increased to 63% in 2009. The proportion of oil consumption is related to that of natural gas. The proportion of energy consumption in natural gas is correspondingly increased in the years in which the proportion of petroleum consumption is declining, and vice versa. In the industrial, commercial, transport and residential sectors, the proportion of oil in energy consumption is on the rise.

2.5.2 Natural gas

Texas holds one-fourth of the nation's proved natural gas reserves and almost one-third of the 100 largest natural gas fields are located, n whole or in part, in the state. Texas also leads the nation in natural gas production, accounting for one-fourth of U.S. However, with the increase of oil, coal, renewable resources and nuclear resources, the energy consumption of natural gas has been on the whole declining from about 45% in 1960 to about 25% in 2009. In the industrial, commercial and residential sectors, by the mid-1970s, the share of natural gas in energy consumption was higher than that in oil, turning around in 1973, with the proportion of natural gas being exceeded by oil, and the gap between the two was growing.

2.5.3 Renewable energy

Wind accounts for nearly all of the electricity generated from renewable resources in Texas. The size of the state and the high levels of direct solar radiation in West Texas give the state some of the largest solar power potential in the nation. The agricultural and forestry sectors can provide Texas with abundant biomass and biofuel resources. Despite the large number of non-powered dams in Texas, the potential for further hydroelectric development is limited by lack of precipitation. Besides, Texas has a unique untapped geothermal resource: its large network of crude oil and natural gas wells. Renewable resources in Texas, the proportion of energy consumption increased year by year. In particular, the proportion of energy in the commercial and residential sectors has been as high as 25% to 30%.

2.5.4 Coal

Texas found large lignite coal mines in the narrow belt of Texas Gulf Coast, as well as bituminous coal deposits in north-central and southwestern Texas. Overall, the state estimates recoverable reserves of more than 9 billion tons. Texas is the seventh largest coal producer and the nation's largest lignite producer. Texas is the largest coal-consuming nation whose emissions of carbon dioxide and sulfur dioxide are mainly from electricity generation and the highest in the country. The proportion of coal's energy consumption is on the rise, reaching about 5% by 2009. However, the proportion of coal in various sectors is the lowest among all other resources.

3 Developing the Model

3.1 Assumption

According to we found that Energy consumption ralated to GDP (Gross domestic product) and population.

$$Population + GDPpercapita + Energy\ per\ unit\ of\ GDP = Energy$$

Hence we use these three variables to estimate energy consumption.

3.2 Calculate the Model

A linear regression model that contains more than one predictor variable is called a multiple linear regression model[1] Although we use linear regression, we could also have quadratic variables by using a variable x^2 as one variable of multiple variables. At first we use population and GDP as two variables to buid the model. The function can be writen as

$$EP = \alpha_0 + \alpha_1 * Population + 2 * GDP$$

In data preprocessing, We uniform the data by using *Standardscore* to scale the data into (0,1) . We choose testing data and training data randomly from the data set as testing data being 20%. In the model evaluation, we use two metrics to estimate the result. One is *MBE* (Mean absolute error regression loss), the reason we use *MBE* rather than *MSE* (Mean squared error regression loss) is that the data is small than 1. If we use *MSE*, the difference of the error is hard to distinguish. Using this metric, the small the result is the better the prediction is. Another metric is R^2 (*coefficientofdetermination*)*regressionscorefunction*. Best possible score is 1.0 and it can be negative (because the model can be arbitrarily worse). After we read the paper mentioned the third variable *EnergyperuinfofGDP*, we build the second model.

$$EP = \alpha_0 + \alpha_1 * Population + 2 * GDP + 3 * EnergyperuinfofGDP$$

3.3 The Model Results

We compared the error of the two models. By compare the R^2 score, we calculated the four states separately, find that more than a half of the result of second model is better than the first model.

4 Analysis based on the Model

4.1 California

As can be seen from the chart, with the increase of GDP and population, the demand for viable energy sources has been growing rapidly. The growth mainly comes from the commercial and residential sectors. California has deserts in the southeast, has a very abundant solar energy resources, the same as California or the nation's third largest traditional hydroelectric state and the fifth largest wind power generation, renewable energy power generation accounted for about 35% of total power generation, the same natural gas power generation. It is also increasingly becoming the main source of power generation in California. It can be seen that the two sectors with the fastest growth and the largest proportion of use are the commercial sector and the residential sector. This is closely linked with the government's active promotion of home use of solar energy and the construction of solar power plants and hydroelectric power stations in the desert. In the same way, the share of renewable energy is hard to grow or slow to grow in the industrial and transport sectors, which requires technological innovations to promote the use of renewable energy. California has the third largest oil field in the United States, and importing crude oil is not difficult, there is no tension in oil. California is heavily dependent on oil resources, and particularly in the transportation and industrial sectors, the lack of oil supplies can have a significant impact on the state of California's economy, but oil is a nonrenewable resource and all of California has taken steps to improve energy efficiency Approach to conserve the use of oil resources and reduce oil use as much as possible in the context of a unit of GDP, not only saving resources but also increasing the share of renewable resources in total resources use. California accounts for less than 1% of U.S. natural gas reserves and production. With crude oil, California's natural gas production has been declining steadily over the past two decades. Natural gas in California is mainly used for power generation and home heating, with per capita use of natural gas below the national average. According to the chart, natural gas is less likely to fluctuate swiftly due to economic and demographic changes. Therefore, the demand is relatively stable, requiring transportation and natural gas reserves. With no coal reserves or production in California. California has phased out almost all coal used to generate electricity. California's dependence on coal is very low.

4.2 Arizona

4.3 New Mexico

In New Mexico, through the analysis of the model and the search for relevant information, it can be seen that the oil and natural gas industry have a significant contribution to the country's gross domestic product (GDP). New Mexico's energy consumption per dollar of GDP and energy consumption per capita are both above the national average. The higher reserves of crude oil and natural gas in New Mexico make it high in energy consumption for crude oil and natural gas. Crude oil and natural gas have a high share of energy consumption in industry, commerce and transport. Especially at the end of the twentieth century, as a result of the rapid growth of the transport industry, the share of oil energy consumption has risen sharply. New Mexico contains nearly 3% of the country's estimated recoverable coal reserves. New Mexico has mined coal since the 1850s. However, with the development of other resources, the proportion of coal's energy consumption has been declining. In terms of renewable resources, New Mexico has a large number of renewable resources, especially wind and solar energy, as well as hydropower, biomass and geothermal energy. New Mexico has the sixth-largest geothermal resource in the country. New Mexico's climate is characterized by abundant sunshine, so the solar energy industry can be vigorously developed. It can be seen that the proportion of energy consumption of renewable energy is gradually increasing, and the proportion of energy consumption in the industrial, commercial and residential sectors has increased substantially. In particular, the energy consumption of renewable resources in the commercial and residential sectors has surged to 2009. Years are more than 20%. The proportion of energy consumption in the future of renewable resources in New Mexico will increase in proportion to the trend of energy consumption. And there are already relevant policies and industries, such as solar power, where the number of utility-scale solar PV installations in New Mexico is increasing and the number of distributed (customer-located, small-scale) solar power plants Use is also increasing. National regulatory policies also strongly support the use of distributed solar technologies.

4.4 Texas

Through the analysis of the model and related data, we can see that Texas is the second largest population and the second largest economy after California. The state leads the nation in total energy consumption, accounting for more than one-eighth of the U.S. total. On a per capita basis, Texas is sixth in the nation in energy consumption. Texas has many energy-intensive industries, including refining and chemical production, and accounts for the largest share of the industrial sector for the country's energy use. The transport sector is the second most important part of energy consumption, partly because of the large number of cars registered because of the long distances across the country. As a result, oil and gas resources account for the largest share of energy consumption in Texas. In addition, the share of renewable

energy in Texas is increasing year on year. In particular, the share of energy in the commercial and residential sectors has increased to as much as 25%. In Texas, wind power accounts for almost all of the electricity from renewable sources. There are other renewable energy sources in Texas. The size of West Texas and the high level of direct solar radiation provide the nation with the nation's largest solar potential. The agriculture and forestry sector can provide Texas with abundant biomass and biofuel resources. Texas has a unique undeveloped geothermal resource: its large crude oil and gas well network. Existing wells are connected to deeper geothermal resources and many water temperatures can reach as high as 200 degrees Celsius. On a smaller scale, geothermal resources have been used to heat and cool the homes and schools in the state. The government also gives strong support for the development of renewable resources. Especially in 1999, the Texas Public Utilities Commission first passed the state's mandate on renewable energy. It is believed that in the future, the share of renewable energy in Texas will continue to rise.

5 Criteria for the "best" profile

5.1 Construct the Criteria

We divide the evaluation of the use of clean energy into two parts. One is the total amount of clean energy and renewable energy used in each state. Secondly, the efficiency of the usage of clean energy and renewable energy. By the country's leading energy agency, the loading order policy instructs California's energy sources to respond first to demand through efficiency and demand response, before considering a new generation. According to the first part, we use the ratio of renewable energy to total consumption, the ratio of renewable energy used in various industries, and the growth of renewable energy use. In the second part, we use the per capita energy consumption and energy intensity as a measure of energy efficiency.

5.2 Criteria Mathematical Expression

- The proportion of clean energy and renewable energy consumption in the total energy consumption

$$CLREVT = ngVT + reVT + nuVT$$

- The proportion of clean energy and renewable energy consumption in four industries (Residential sector, transportation sector, Commercial sector and Industrial sector)

$$CLREVA = ngVA + reVA + nuVA$$

$$CLREVC = ngVC + reVC + nuVC$$

$$CLREVI = ngVI + reVI + nuVI$$

$$CLREVR = ngVR + reVR + nuVR$$

- Energy consumption per capita

$$ECPC = \frac{TETCB}{Population}$$

- Energy intensity Energy intensity is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP. High energy intensities indicate a high price or cost of converting energy into GDP. Low energy intensity indicates a lower price or cost of converting energy into GDP. (

$$EI = \frac{TETCB}{GDP}$$

So we can use the four states' indices are sorted by rank and ranked 4 to 1 according to their ranking, and the total score is calculated to determine which state has the best energy use.

5.3 Evaluate the profiles by criteria

We rank the four states in these four items and get the state has the best energy profile. Using this method, the score of California is 22, Arizona's score is 20, New Mexico got 19 and Texas only got 9 points. So the state has best profile of using cleaner, renewable energy is California.

6 Predict with Model

6.1 Data collecting and preprocessing

Based on our model, to predict the energy profile of 2025 and 2050 for each states requires GDP and population of each state. We found the population prediction of each states, which reference is listed in appendix. But the GDP prediction doesn't have direct data. So we use the GDP Growth Forecast to calculate the GDP in 2025 and 2050 for each state, assuming their GDP growth is equal to US. Also assuming the prediction and the calculated data is the value of GDP and population in 2025 and 2050.

6.2 Prediction progress

Using the data we collected, the prediction is as follows:

6.3 Prediction Analysis

- The prediction in 2025 California's energy agency will not change much and will not rely on coal at all. Although oil resources remain his main source

of energy, the efficiency of the use of non-renewable resources such as oil will increase as the technology for energy use increases. Will not blindly rely on oil resources, such as Tesla cars and so on, so the dependence on oil will be reduced. In addition, with the support of current policies, the use of clean and renewable energy sources will further increase, and California is expected to reach its policy goal by 2030. Arizona will have a more drastic drop in the use of coal, solar energy and other clean energy will increase the proportion of renewable energy will be larger, Arizona's geographical location is very suitable for solar energy and wind energy development and utilization, so for clean energy The use of will be greatly improved. The degree of dependence on natural gas and oil and the use of various departments did not change much, did not produce qualitative change, but has already begun to convert clean energy. The energy mix in New Mexico is subject to significant changes as the use of clean energy is very small by the year 2009 and the use of clean energy is increasing rapidly and can replace some of the natural gas to generate electricity. The demand for coal is further tightened, and the use of oil is still the largest, but because of the increased efficiency of the use of petroleum, the total amount of oil used will not increase too fast and the indirect nature will lead to an increase in the proportion of clean energy. Texas is one of the four states with the most irrational energy structure. In a short period of time, there is still no way to find the energy of alternative coal, so coal will still occupy about 20% of the total consumption. As a result, With a large population and a relatively developed industry, consumption in the oil sector continues to rise. In this case, the use of renewable energy and clean energy will continue to shrink. Although the total use of clean and renewable energy is on the rise, there is still some way to go to become the most energy-intensive source.

- The prediction in 2050 Energy use in California has entered into a good sustainable development scenario where clean and renewable energy sources have become California's major energy sources, but are still being used for oil resources but with increased energy efficiency and promotion of clean energy use on the oil only accounts for about 15%. Arizona's clean energy can account for almost 60% of total energy, the rest mainly oil, the use of oil is still further reduced, the electricity has been provided by all available energy and energy, transportation sector can replace the use of oil, then the proportion of oil will drop significantly. New Mexico will develop nuclear energy use in the next 30 years, and its share of renewable energy will further increase. Together with oil and natural gas, it will become a major part of energy use. Although the coal cannot be completely abandoned, the use of coal will decrease Trend, and tend to 0 in the future. Texas has made great strides in the use of clean and renewable energy without policy, but it is still not a sustainable energy development structure. The most important energy sources are still oil and coal the use of descending but also more than 5%, clean, renewable energy use accounted for only 35%

7 Determine the targets

According to the current government work report and the ability of each state to develop their capabilities, the goals of the four states are set first, and then the tasks are allocated according to the capabilities of each state. In the pre-development phase of the exchange of science and technology and the use of funds, It's better than before, especially for Texas. 2025 Targets: Decrease use of coal by 20%, increase energy intensity by 34%, and raise the use of clean energy by 37%. Target 2050: Completely unsuitable for coal, doubling energy intensity compared to 2009, achieving over 50% clean energy and becoming a major source of energy in a state.

8 Propose measures

- Reduce electricity and natural gas consumption by improving energy efficiency and reducing demand Targets can be reached through a variety of measures, including enhanced appliance standards, efficiency improvements in public buildings, and financial incentives for retail customers.
- The government should formulate policies to support renewable energy to prioritize and subsidize grid systems Such policies, now in place in about 50 countries, include priority dispatch for electricity from renewable sources and special feed-in tariffs, quota obligations and energy tax exemptions. Most of the electricity demand is the continuous and reliable power supply, traditionally provided by basic load power generation. Some of them are based on a wide range of predictable requirements for shorter periods (such as peak loads). Therefore, if renewable energy is connected to the grid, there will be a problem of reserve capacity.
- Vigorously develop solar power generation technology to reduce transmission losses The obvious advantage of solar and, to some extent, other renewable energy systems is that they are distributed and may be close to demand, so transmission losses can be reduced if traditional power plants are far apart. These four states can improve technology, such as the use of photovoltaic (PV) systems and the use of concentrating solar photovoltaic (CPV) for greater efficiency.
- Reduce the intermittent problems of water system power generation, improve energy efficiency The main advantage of hydraulic systems is their ability to handle seasonal (and daily) peak loads. In practice, the use of stored water is sometimes complicated by irrigation needs, which may not be in sync with the peak of electricity demand. One way to reduce intermittency is to produce hydrogen by electrolysis and send it to the gas grid.
- Development and use of nuclear energy and hydrogen energy Nuclear energy is a low-carbon energy and has a very small environmental impact. Hydrogen is widely recognized as a possible transport fuel if certain problems can be

economically overcome. It can be used in conventional combustion engines as well as in fuel cells to convert chemical energy directly into electrical energy without normal combustion. For intermittent renewable energy sources, such as solar and wind energy, matching production to grid requirements is very difficult and it is obviously not possible to exceed 20% of the total electricity supply. However, if these sources are used to make hydrogen, they can be fully utilized whenever there is a chance. In a broad sense, it does not matter if it is cut in or cut out, and hydrogen is stored and used only as needed.

References

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Appendices

Appendix A First appendix

Here are simulation programmes we used in our model as follow.

Appendix B Second appendix