Energy survey and analysis based on four US states

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Abstract. For problem A, by appropriate ways, the data provided is filtered to gain five major energy data for each state: crude oil, coal, natural gas, nucleus and renewable energy. Energy profiles for each state are obtained by plotting line charts. For problem B, A three-level indicator system is constructed to analyse and compare the energy status of each state. From 605 variables given, 23 third-level indicators are selected by principal component analysis (PCA) and manual intervention. 5 secondary indicators elected by fuzzy cluster analysis are energy economic benefits (EEB), energy structure (EST), energy sustainability (ESB), energy consumption (ECP) and Energy production (EPD). Then the indicator system is weighted by the portfolio weighting method (PWE). The weights of secondary indicators are calculated via analytic hierarchy process (AHP). And third-level indicators are calculated by entropy weight method (EWM), in order to measure the energy situation in each state. Their effect on energy profiles is analysed intelligibly, combining with the various factors.

Keywords: Energy Survey and Analysis, AHP, PWE, Resource Consumption.

1. Introduction

1.1. Background

Energy production and usage are a major portion of any economy. In the United States, many aspects of energy policy are decentralized to the state level. Additionally, the varying geographies and industries of different states affect energy usage and production. In 1970, 12 western states in the U.S. formed the Western Interstate Energy Compact (WIEC), whose mission focused on fostering cooperation between these states for the development and management of nuclear energy technologies. An interstate compact is a contractual arrangement made between two or more states in which these states agree on a specific policy issue and either adopt a set of standards or cooperate with one another on a particular regional or national matter.

1.2. Restatement of the problem

Along the U.S. border with Mexico, there are four states – California (CA), Arizona (AZ), New Mexico (NM), and Texas (TX) – that wish to form a realistic new energy compact focused on increased usage of cleaner, renewable energy sources. Our team has been asked by the four governors of these states to

perform data analysis and modeling to inform their development of a set of goals for their interstate energy compact. In order to finish the work, the following sub-problems are considered:

- Create an energy profile for each of the four states. And develop a model to characterize how the energy profile of each of the four states has evolved from 1960 – 2009. Analyze and interpret the results of the model. Determine which of the four states appeared to have the "best" profile for use of cleaner, renewable energy in 2009. Explain your criteria and choice. predict the energy profile of each state, as you have defined it, for 2025 and 2050
- Based on our comparison between the four states, our criteria for "best" profile, and our predictions, determine renewable energy usage targets for 2025 and 2050 and state them as goals for this new four-state energy compact. Identify and discuss at least three actions the four states might take to meet their energy compact goals.
- Summarize the state profiles as of 2009, the predictions with regard to energy usage absent any policy changes, and the recommended goals for the energy compact to adopt

2. General Assumptions

- ✧ The government policy will be stable
- ✧ The data set is real and available
- ✧ Neglect the explosive changes when forecasting

3. Organization of the Text

Symbols	definitions
EES	Evaluation of the energy situation
S-W	Shannon-Wiener index
fi (w)	Weighted distance sum of squares
ACF(i)	the average i-th resource consumption of four states
ACO(i)	the average i-th resource consumption of one states
w	Weight
Si	strategic space

4. The model and results in Part I

4.1. Energy profile of the four states

About Part I, aiming at Problem A, all energy of the four states is divided into oil, coal, natural gas, nuclear power and renewable energy. We analyze them both in terms of energy production and energy consumption. In order to show energy production of four states, the output and percentage of each type of energy are plotted in each state, which show in fig.1 to fig.4.

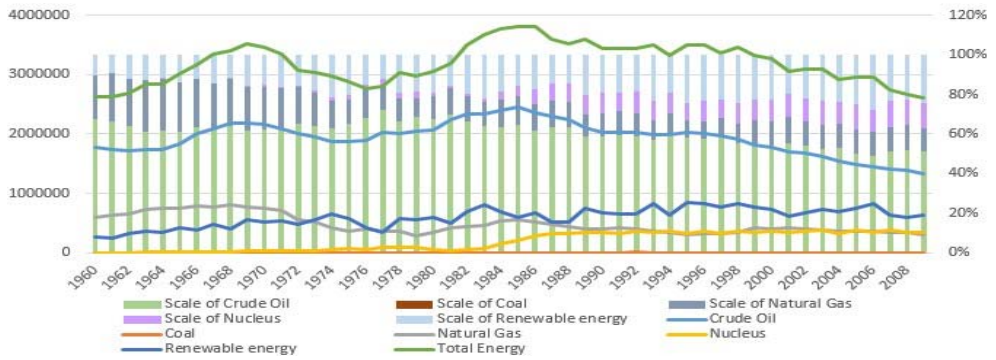

Figure 1. The energy profile of California

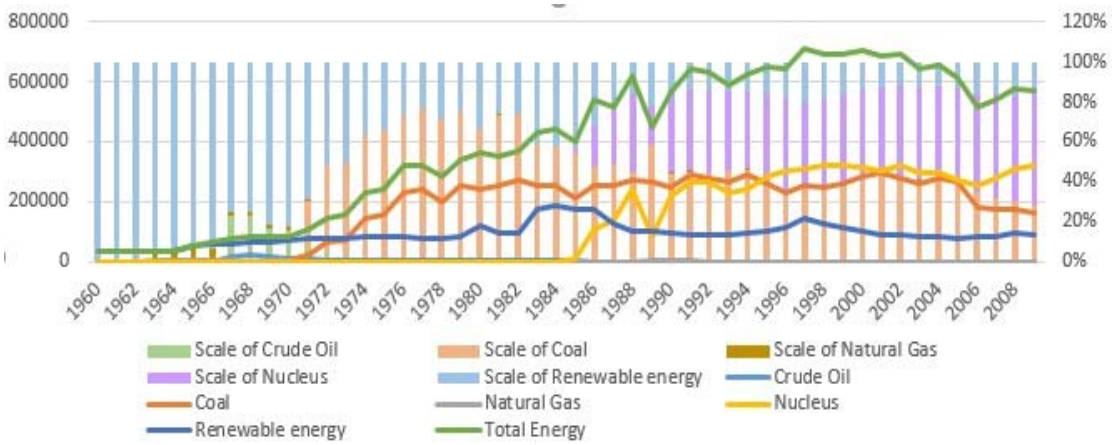

Figure 2. The energy profile of Arizona

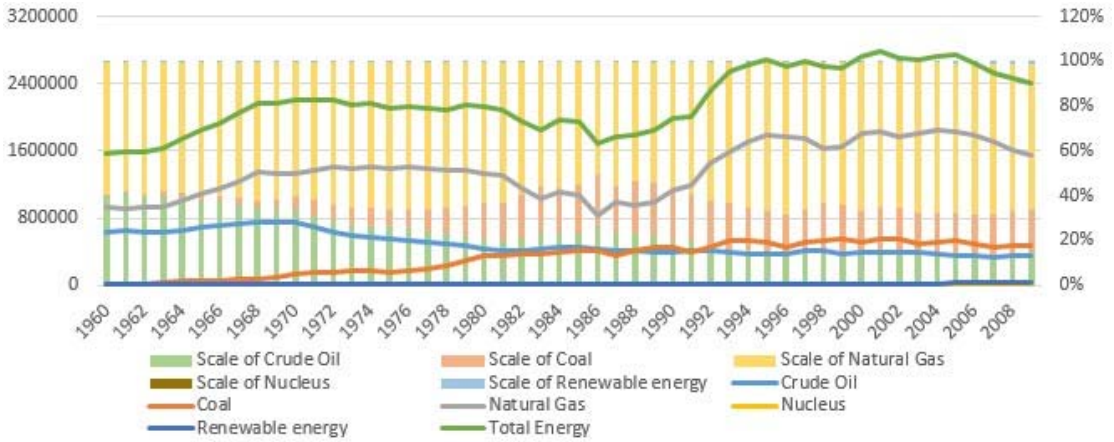

Figure 3. The energy profile of New Mexico

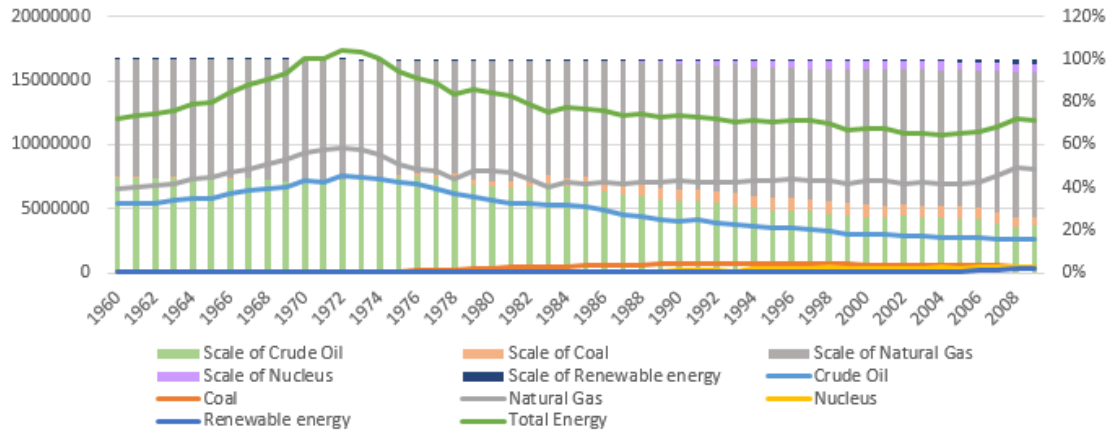

Figure 4. The energy profile of Texas

As can be seen from the figures above:

- California has the highest percentage of crude oil production in the state's total resources, more than 50%, and crude oil production is declining year by year. Production of renewable energy and nuclear energy increase and natural gas production reduce.
- In Arizona, crude oil and natural gas production consistently lower. At the early stage, production of renewable energy is the highest. With the increase in nuclear and coal resource production, nuclear energy is its main energy supply
- New Mexico's energy output is based on natural gas. Latterly, production of coal and crude oil are close to the same. The output proportion of renewable energy and nuclear power are zero basically.
- Texas has the largest energy yield, crude oil and natural gas occupy almost all, and main is natural gas. Renewable energy and nuclear energy production proportion are substantially zero.
- Regarding energy consumption, the output and consumption of oil, coal, natural gas, nuclear power and renewable energy in each state are shown in Figure 5. Among them, CAP, AZP, NMP, TXP are energy production corresponding to four states. CAC, AZC, NMC, TXC are energy consumption in four states. Since the consumption of nuclear energy is equal to the output, only one indicator of output is chosen

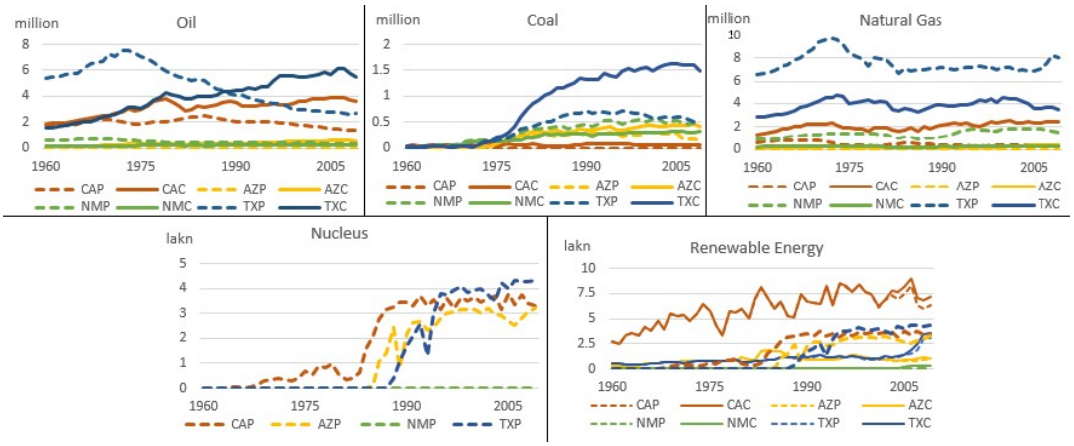

Figure 5. The energy usage of four states

a). **Oil:** It can be seen that in the later years, the output of crude oil gradually decreased. And the production far exceeded the consumption of crude oil. In them, TX is also the most of crude oil production and consumption, followed by CA. AZ's production and NM's usage are the least.

b). **Coal:** TX is produces and consumes the most coal in all four states, and consumes much more than its production after 1975. CA produces and consumes the least amount of coal. NM's and AZ's usage are in the middle.

c). **Natural Gas:** TX is rich in natural gas production, much larger tha n its use, NM is second, CA's and AZ's production are less than its use.

d). **Nuclear:** CA was the first state to use nuclear energy, and after 1985, CA, AZ, TX nuclear energy developed rapidly, NM has not used nuclear energy.

e). **Renewable Energy:** In the four states, CA produced and used the most renewable energy. After 2000, the renewable resources of TX and NM developed. The output of renewable energy in the four states was basically balanced

5. Evaluation of the energy situation

5.1. Methods an overview

Step1: Supplement the missing data from 605 indicators by fitting. The data of 605 indicators were normalized and the principal component analysis (PCA) was conducted. Export a few principal components from the original variable. Through artificial screening, they can retain the information of the original variables as much as possible, and they are not related to each other, and recombine into a new set of comprehensive indexes. Call them the Third Indicators.

Step2: Fuzzy c-means (FCM) of the new indexes was carried out, and a set of energy partition with five indexes was obtained. Call them the second indicators. To make the target variable more concise, and can represent the characteristics of the original variable and facilitate data processing.

Step3: Normalization of the third indicators. Then entropy weight method is used to evaluate the data obtained to get every weighted value of third indicators

Step4: The second indicators is analyzed with the AHP method. And the relative importance weight of each secondary index is obtained.

Step5: Using the weight value in step3 and step4, the numerical value of the primary index is calculated.

5.2. Results of problem B

After step 1, all of 605 variables on each of these four states' energy production and consumption are selected as 24 third indicators and 5 secondary indicators.

After step 2 to 4, every secondary index of four states shows in fig.7. Due to economic, geographical, population and climatic effects, as we can see, about EEB, EST and EPD, California has the highest overall ratings, and other aspects also has good goals. In the time, CA's economy and technology are outstanding. The better is Texas, in 4 indexes, it has the second better scores. Like CA, TX has good ability in technology and economy. About Arizona and New Mexico, they are inland, and there are large deserts in them, climate is dry.

After step5 we can get the numerical value of each primary indicator.

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