ENERGY CAPACITY MANAGEMENT FOR THE INDUSTRIAL SECTOR OF ZHEJIANG PROVINCE IN CHINA: A SYSTEM DYNAMICS MODEL

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1. INTRODUCTION

A well-balanced and coherent energy strategy is to safeguard the conditions for economic development. Its importance has stressed the need for effective and efficient energy management at a decentralized level. With the rapid economic development in the past decade, Zhejiang province as one of the economic hot spots in China, is facing the deterioration of energy shortage problem. Although energy supply capacity was increased several times, the trend is becoming more serious. This research focuses on the impact of energy shortage on industrial production in Zhejiang through analyzing energy supply and consumption pattern, and important factors that affect both patterns and the relationships between them and discusing the situation of energy shortage problem in near future.

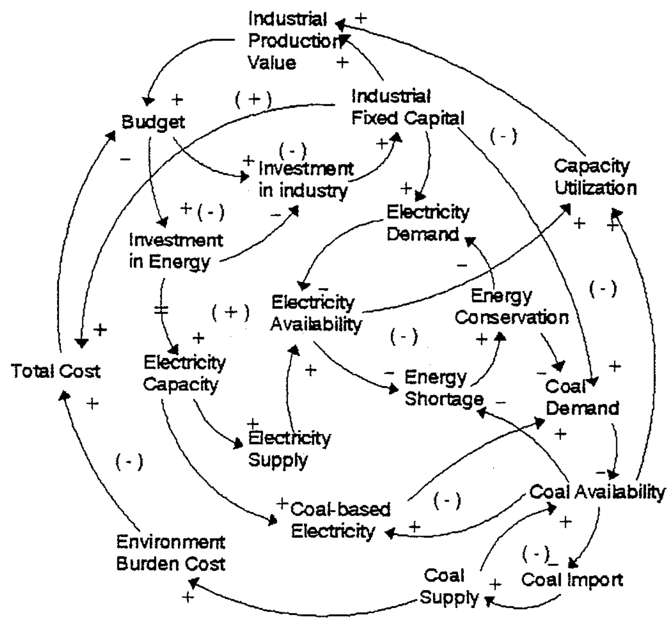
System Dynamics is used to study the complex dynamic system. A system dynamic model was built to analyze the energy shortage problem and its effects in long run. The hypothesis applied depandents to the historical evidence and related knowledge. The model built is simplified with five main sectors: Industrial production sector, Energy demand sector, Energy supply sector, Financial resource allocation sector, and Energy conservation sector. Some alternative policies are assessed through experiment with the model including finance, energy conservation, and production management policies, etc..

2. A SYSTEM DYNAMICS MODEL FOR THE ENERGY SUPPLY AND CONSUMPTION SYSTEM

Energy demand depends on the industrial production capacity which is developed according to the estimated rate and benefit rate related to the industrial capacity utilization. Energy supply depends on the energy demand and the financial resources allocation. Energy supply and demand are considered electricity and coal, other energy resources is acount for only 10% in total, besides most of oil is consumed in chemical industry sector as raw materials.

The alternative energy production mainly depends on the electricity generation including coal-based electricity and hydroelectricity. Coal production is only a complement to the supply. The characteristics of different electricity technologies affect the decision of their expansion. Coal-based electricity capacity has a low construction time and cost. The development of coal-based electricity can meet the demand in short time but it has high operation cost and environment problem. Hydroelectricity is clear and powerful in output adjustment with the change of loading, but it is resources limited and possesses the characteristics of a high construction cost, long construction period, and low operation cost. Usually, energy production capacity is expanded in the technology that minimizes the unit production cost.

Financial resources allocation is subjected to the industrial production benefit and allocation rate. Energy availability plays a role in the distribution. Other financial sources are based on the industrial production budget of provincial government and the industrial benefit, in which the national and private investment can be simplified in it. The structure of model also is desiged possible for various policies analysis from different aspects including economics, energy supply snd demand patterns, environmental impact, and the availbility of energy resources.



The General Feedback Loops of Model

The hypothsis of this system can be described in the general feedback loops illustrated. It explains how the industrial production and energy capacity are developed. Industrial production capacity is represented with its fixed capital in this model. Industrial production value, an indicator of industrial production level, is based on the fixed capital and its capital output ratio (KOR) as well as the capacity utilization. An increase of industrial fixed capital would result in an increase in the production value and its benefit which then is the source of government budget of next year. Capacity utilization is related with the energy availability and the permitted utilization which is related to the situation of energy shortage. Energy supply capacity and capacity utilization have a positive effect to the industrial production.

There also are negative functions in the system that obstruct the development of industrial production. With the expanding of the production fixed capital, the increasing energy demand leads to the energy availability decrease. If the capacity utilization decline, it would have a limiting effect on the benefit of industrial production. If more budget is used for energy capacity development, the investment of industrial production will be affected. The environmental impact from coal consumption has a negative effect on the production development.

3. Policy Experiments

Policies are tested under completely controlled conditions. The experiments focus on the analysis of budget distribution, the balance of energy demand and supply patterns including cost of energy supply capacity, the degree of energy shortage, and the rate of industry development.

Financial Policy:

During the past decades, the actual expansion rate of industrial capacity is higher than the expected rate. It makes the energy capacity development fall behind the industry development. The contradiction of energy demand and supply is going deterioration. The electricity capacity expansion in the past decades did not meet the expansion of industry capacity. It leads to industrial production in a poor capacity utilization. Stepping the parameter of energy budget fraction 10% in the model, the result shows that the policy to increase the energy budget is effective to alleviate the problem. Although the budget in industrial production is reduced, the high benefit rate would stimulate investment in industrial production from other sources. The total investment in industry can keep at a same level. It can improve electricity shortage without reduction of industrial production value and benefit. Some policy experiments such as increasing energy taxation and issuing electricity bond and stock are similar in experiments.

On other hand, government can adopt the policy of increasing interest rate in bank to slow the economic growth. It increases the production cost and decreases the production benefit rate. This policy was designed by stepping parameter of Interest_Rate from 6% to 9%. The result shows although industrial fixed capital is lower than the base run, the increased capacity utilization can keep the total industrial production value and benefit at the level of base run. Increased interest rate makes the industry expansion slowly and the energy shortage and coal availability alleviated. This case would stimulate the development of coal-based electricity capacity. The speed of electricity expansion would be close to the industrial expansion rate under this policy.

Energy Conservation Policy:

In industrial production, coal conservation can be implemented through developing economic-scale production, reducing or controlling the small-scale production or upgrading old facilities and equipment to increase the coal use efficiency. The experiment shows that the emphasis of coal conservation is counterintuitive. The industrial production value and its fixed capital are lower than base run, but the energy availability is still not improved obviously. To analyze the related feedback loops, this problem is from the coal supply system based on coal demand. Quota coal is allocated according to the regional coal demand by Central Government. The coal conservation policy can reduce the coal demand, but the relative lower coal demand would share a less quota. The efforts of coal conservation can not get a reasonable repayment exactly. The present coal supply policy will hinder the implementation of coal conservation policy.

Electricity conservation can be implemented through upgrading old electric appliance to increase the efficiency of electricity use. This policy is designed by stepping the fraction of electricity conservation investment. The result shows that the electricity availability is improved and the behavior of industrial production has a favorable shifting too. The investment in electricity conservation can be repaid from industrial benefit.

Adjustment of Industrial Production Pattern:

To make great efforts on the development of industrial production with high added value, high technology, and low energy intensity, such as microelectronics, precision electrical machinery etc. may bring about a higher industrial production value with low energy consumption rate. This is a strategy to shift the industrial production pattern to a low energy intensive pattern. The results shows that all indicators related to energy shortage are improved with the increase of capacity utilization. Besides, this policy is not only beneficial to alleviate the energy shortage problem but also helpful to alleviate the environmental impact from energy consumption.

4. CONCLUSION

The structure and behavior of energy system can be represented in system dynamics model effectively. The simulation experiments in this study are significant to generate a behavior that is qualitatively similar to the real world observations and to enable a logical and reasonable explanation of behaviours' patterns in variables incorporated in stepping. From the policy experiment and analyzing the resulting behavior, it seems that the way to re-allocate the financial budget is most effective to alleviate the energy problem. The government should guarantee the electricity investment and make the energy budget a higher proportion in total. Other non-financial policies of energy supply side are found to be comparatively effective including i) to strengthen electricity conservation and increase the efficiency of electricity use, ii) to increase the capacity of electricity generation, iii) to shift the industrial production pattern into a low energy intensive pattern.

REFERENCES

1. **Forrester, Jay W.**; 1980, "Tests for Building Confidence in System Dynamics Models", TIMS Studies in the Management Sciences 14, North-Holland Publishing Company.
2. **Forrester, Jay W.**, 1992, "Policies, Decisions and Information Sources for Modeling", European Journal of Operational Research 59, North-Holland Publishing Company.
3. **Qu, Geping**, 1992, "China's Dual-thrust Energy Strategy: economic development and environment protection", Energy Policy, Vol. 20, No.6.
4. **Naill, Roger F.**, 1992. "A System Dynamics Model for National Energy Policy Planning", SystemDynamics Review, Vol.8,No.1.
5. **Saeed, Khalid**, 1985. "An Attempt to Determine Criteria for Sensible Rates of Use of Material Resources", Technological Forecasting and Social Change, 28.311-323.
6. **Saeed, Khalid**. 1990, "Prevention of Dysfunctional Environmental and Social Conditions in Technology Transfer: Technology Transfer in Developing Countries", The Macmillan Press LTD, London.
7. **State Statistical Bureau of China**, 1989, "Statistical Yearbook of Energy in China", Press of Chinese Statistics, Beijing.
8. **Zhejiang Provincial Statistical Bureau**, 1992, "Statistical Yearbook of Zhejiang", Press of Zhejiang Statistics, Hangzhou.