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# AHP RESEARCH: THE STRATEGIC POSITION OF PETROLEUM IN CHINA'S ENERGY SOURCE DEVELOPMENT

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## ABSTRACT

In this report, based on superiority-analyzing preciple of dynamic systems and with the help of AHP, we analyze and study the development of strategic trend in Chinese energy system and the stratgegic position of each form of energy in energy development. Through the consultation of many energy experts who provide discussion and feedback information, we set a level structure on which, to base energy development strategy, and completely appraise every factor which may effect energy development. Furthermore, we objectively analyze the source, strength and superiority of each kind of energy and their transformation conditions including mechanism. Finally, we present some indexes, which can be used to evaluate the strategic position of each kind of energy in energy development. On this basis and with the energy experts' consulation, we draw some conclusions which ought to guide China's energy strategy.

## I. PREFACE

As we know, energy is the economic life-blood of a country. It can reflect a country's economic strength. So we can say, energy is of strategic concern. In china, an energy crisis occured in the end of 1980s, As a result, energy supply became critical over all. Energy supply decreased abruptly (decreasing 16.3 percent during 1988) and the price of some forms of energy went up sharply (during 1988, coal price increased by 40 percent, 130-200 percent in off-shore regions). The shortage of energy has been the "bottle neck" restraining China's economic development.

To a great extent, the speed of economic development is determined by the availability of energy resources. So, in order to keep the national economy developing coordinately in proportion and on schedule, we think it is of strategic meaning to research and make a scientific plan concerning energy development.

Up to now, energy experts have been discussing the strategic development of world energy. Some think that petroleum is still the most importmant energy and will keep its dominant status, from now till the end of this century, or even into the next century. Others think that, from now to the beginning of 21th century, will be the second splendid period of coal and coal will

become the bridge leading to the future. Others feel that the consumption and production of world energy will develop in the direction of pluralization which is development of mutiple energy sources instead of petroleum. In their opinion, coal will be the first substitute of petroleum, and nuclear energy, the second. Now, facing the unpredictable development of world energy and considering China's concrete conditions, we think it becomes a very importmant problem, how to research energy development strategy in china, how to define is the strategic position of each type of energy in energy development objectively and scientifically (We aim at petroleum in this paper), and how to define which sort of energy should receive priority in China. In this paper, using AHP as a tool, we research and analyze the development strategy of China's energy according to the priciple of superiority analysis of dynamic systems. In addition, we draw some conclusions with guiding ideology.

## II. The priciple of superiority analysis of dynamic systems.

In the mordern world, a cooperated system of science and technology-economy -society is increasing, which is related mutually, restrained reciprocally and complicated. In this great competitive system, full of indefinite factors and opportunities, how to attain superiority and how to keep and make full use of it, have become important factors to consider when making development strategy.

As we know, superiority refers to a development trend which accounts for the leading status. It not only includes competitive opponents, content and environment, but also possesses dynamic character. The fundamental goal of development strategy lies in winning the initiative as a whole. So, we have to regard the superiority problem as the key one when making strategy. Additionaly, if we want to get and keep superiority, we must carry through openings and create competition.

Strength is not equal to superiority. Some have mixed the two together. This creates a vague understanding. Probably it can obstruct carrying through openings, and hinder an understanding of competitive opponents and conditions deeply. Of course, competition should be supported by full strength, but strength does not equal superiority. Strength is one of the fundamental factor of competition, but only after correct tactics and high level counter-measures have been adopted, can strength be changed into superiority. Now we can summarize a formula for superiority analysis as follows:

$$\text{Superiority} = \text{Strength} * \text{Countermeasure}$$

In this formula, the organic connection is expressed only naturally. Of course, if we want to get and keep superiority in competition, we have to work hard in practice.

How can resources be changed into strength? In the past research about development strategy, resources were equated to superiority and strategic analysis was limited to natural resources. Seemingly, attached to conditions, without research about competitive opponents.

In the basic priciple of superiority analysis, resource is not equal to superiority. Morever, in definite words, not equal to strength merely after human being's cognition and exploition. Historical experiences remind us of that, if we equate resource to superiority simplely, as a result, the co-ordinating development of environment-economy-society will be destroyed seriously. A short-term action, in which economic effectiveness is sought after purely, can rusult in, not only serious environmental pollution, but also the exhaustion of resources and the incorriguble destruction of the environment. In this case, strength is formed partially and temporarily and is an unreal strength. Probably, it will weaken the ability to form complete superiority. From the above discussion, we create a simple formula to express the relation between strength and resource as follows:

$$\text{Strength} = \text{Resource} * \text{Exploition}$$

Resource - Strength - Superiority competitive system

Resource strength and superiority form a competitive system. We can express this system using a flow chart:

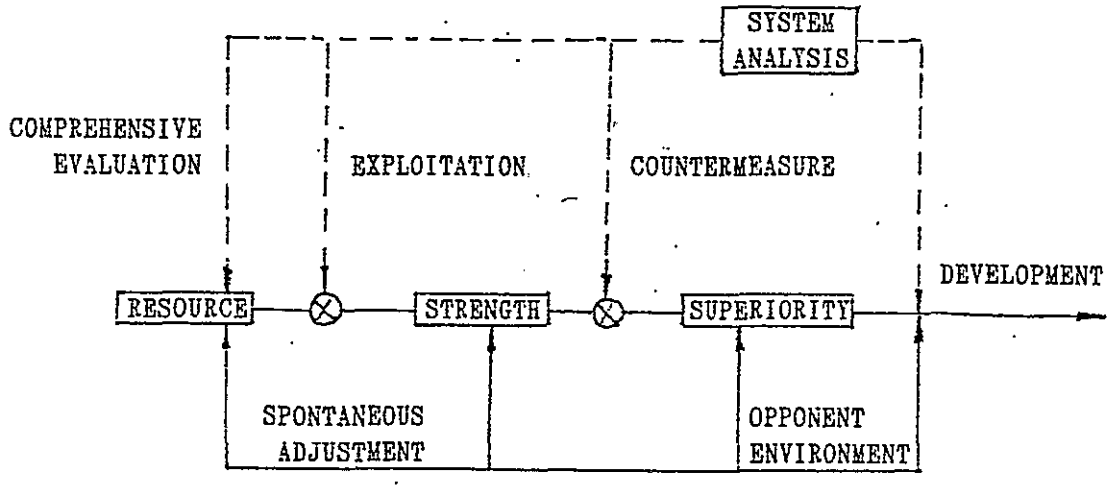


Figure 1.

Resource - Strength - Superiority Competitive System

From the figure, we find that, superiority is based firmly on strength and resource, that only with comprehensive evaluation, exploition and scientific tactics, can resource and strength be changed into superiority.

The above system possesses dynamyc features. That is to say superiority exists in tendences. So, it should be understood and mastered, application of strength or the formation and development of superiority. Additionally superiority and inferiority can be transformed into one another under some envirionmental conditions.

Social practical activities indicate, the key factors about strategic expantion, such as superiority, opportunity, break through, possess not only special hierarchy, but complicated dynamic features. That is to say: whether forming and developing superiority, catching opportunity or choosing break through, we must have an explicit dynamic concept instead of expecting to choose break through, master combat opportunity in advance. In the course of movement of competitive system, sharply perceiving and grasping tendencies and mechanism, we should make full use of favourable turns and choose a good break through. Opportunity doesn't return, once you have lost it. The fundamental task of strategic research lies in pointing out the important turns in dynamic system development and finding break through related to the initiative of whole situation. In competition, if wanting to win, we have to not only hold enough information, but also analyze superiority and inferiority correctly; not only point out what is superior and which is inferior, but master their transformable conditions and mechnisms. On the one hand, superiority includes some good factors, which can defeat an opponent, On the other hand, the superiority may develop a crisis which can produce inferiority which always les in hiding. So, in the course of strategic research, by looking far ahead and aiming high, by considering our situation, by planning as a whole, we can make full use of combat opportunity and favorable condition to form and develop our superiority. Moreover we can transform a low level onesided superiority into a high level overall one. Thus, the whole superiority of system forms at last.

## Ⅲ. The level structure model of development strategy about China's energy.

Chinese energy possesses the following features: 1. Energy resources are abundant: water resource is first place in the world, coal resource, third place, petroleum and other resources are also very rich. Plentiful energy resource is the material base which can form China's economic strength. If we make a long-term scientific energy development program, we can get and develop energy superiority.

2. The level of exploration and exploitation of energy is low. Geological deposits which have been verified are no less than 20 percent of China's oil resources. Hydraulic power's exploition only represents 3 percent of the total waterpower which can be exploited and nuclear energy is also in

a backward condition which can be described as"nuclear without energy" and "nuclear without electricity". The low degree of exploration produces insufficient reserve resource and effects the speed of exploition. As a result, resource can't be transmitted into strength. Futhermore, it can't form superiority. All of these can decrease the international competitive power in the area of energy and holds up the economic develoment of China. As a whole, this is a factor which conditions the development of China's energy development.

3. The distribution of energy resources. Most of China's verified coal deposits are concentrated in North China. The deposit proportion of South China to North China is 1:86. Half of the petroleum deposit are concentrated in North-east China. 70 percent of the water power is dispersed in South-west China and 10 percent in backward economic areas. All this has caused great difficulties in exploitation, transportation and utilization. This is another factor conditioning the development of China's energy industry.

4. Coal plays the leading role in China's energy structure. Coal deposits occupy more than 90 percent of conventional energy. Because of the source superiority of coal, it is determined that China must accept coal as the leader of its multiple energy structure, but in the long run, the coal dominated energy structure faces a severe challenge. It causes more and more immense pressure to be placed upon the environment and upon the transportation system; it causes energy utilization ratio to be low and there is serious energy waste.

5. Low energy utilization ratio and severe waste: the energy utilization ratio is 30 percent in China. Compared with foreign countries, a great desparity is obvious (Japan, America and western Europe, have respectively 27 percent, 21 percent 10 percent ). The energy consumption in producing 1$ GNP in China is 4.98 times that of France, 3.82 times that of Brazil 2.16 times that of England and even 1.65 times that of India. So we may say it is the factor restraining China's energy development. However, it supplies a favorable turn for China to excavate economized energy potentiality and improve its economic and energy structure. Grasping the chance, we can turn inferiority into superiority.

Facing the above character of China's energy development, by means of superiority analysis priciple of dynamic system, accepting each kind of energy experts' consultation, we can create a development strategy model.

Level structure is organized into a model as in the following figure:

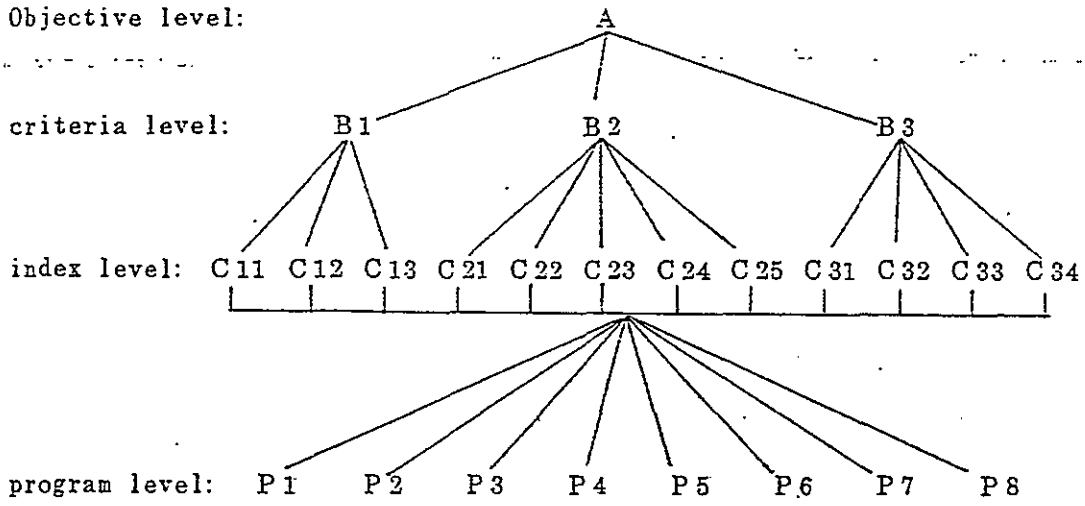


FIGURE 2: level structure of energy development strategy.
In figure: A: defining the strategic position of all kinds of energy in energy development.
P1: coal, P2: petroleum, P3: natural gas, P4: water power, P5: nuclear power P6: economic energy, P7: new energy, P8: rural energy.

In order to define the strategic position of all kinds of energy, we set three principles to evaluate. The principles of superiority analysis are as follows:

B1: resource B2: strength B3: superiority

Every principle to evaluate can also be divided into some specific assessment indecies. They are:

C11 potentiality, which refers to resource deposits in long run or geological deposits in theory or theory holding.

C12 explored deposits refering to geological deposits which have been explored and can be exploited by industry.

C13 The plenty extent of resources. refering to the assemblage. hiding depth, thickness, quality of resources, and so on.

C21 probable exploitation. which refers to the difficulty involved in exploiting the resource, including time equipment, investment, technology, bearing risk and so on.

C22 production. refering to present production or cumulative production (it can be tranformed into TCE or TOE so that we can compare them).

C23 exploration science and technology level. refering to the advance maturity, comprehensiveness of exploration-exploitation theory; to the technology, technique level and the advancement level of measure; and

to the quantity and quality of brain power, etc.

C 24 exploration--exploition expense.

C 25 the difficulty of storage and transportation refering to the difficulty extent of storage and transportation after energy exploition, including equipment, technology for storage, vechicle and throughfare for transportation, and so on.

C 31 influence on national economy, which refers to the role in improving economy and energy structre, enhancing productivity economizing energy, export of foreign exchange and development of national economy.

C 32 strategic importance. refering to the roles in improving energy development and international trade in the world (or district) range; the influence on the stability of international political structure.

C 33 competitive power; which refers to the influence which is produced by energy at the international market price on energy production and trade, in international trade.

C 34 governing pollution and environmental protection. This item refers to the role of enviromental protection if energy can previent all kinds of harmful gases and minute particles from being giving off; in the course of energy exploition or consumption.

It should be stated that we think economized energy is a kind of energy, internationally, economized energy is called "the fifth energy", and is mentioned in the same breath with coal, oil, natural gas and hydroelectricity. Kart government regarded economized energy as the cheapest and cleanest energy; While Mitalant president regarded it as the most reliable energy. Chinese energy experts agree that, by the year 2000, we should consider economize energy as a priority, and improvement economized energy as the strategy of emphasis for energy development.

New energy includes solar energy, nuclear energy, geothermal energy, wind energy, ocean energy, and so on. Nuclear energy should be a new energy, but upon considering its special status in energy development strategy, we treat it as a kind of independent energy.

Rural energy is given great weight in the structre of energy production and consumption. The Chinese argriculture ministry is regarded as the second most important " energy product ministry" after the coal ministry. So rural energy should also be thought of as a kind of energy.

According to the above model of the level structure of energy development strategy, and through the analysis research and induction to data about China's energy developmnt strategy accepting exerts consultation , we create a some judgement matrix. With the help of AHP computer software we can solve these matrix. The calculation and concerted check results are gathered together in table I.

table I: Judgement matrix's single-sequence and concerted check

| Judgement Matrix | Characteristic rector | | | | | | | | CR |
|---|---|---|---|---|---|---|---|---|---|
| A-Bi | (0.40 | 0.30 | 0.30)$^T$ | | | | | | 0.008 |
| B1-C1j | (0.25 | 0.68 | 0.069)$^T$ | | | | | | 0.008 |
| B2-C2j | (0.10 | 0.27 | 0.16 | 0.1 | 0.38 )$^T$ | | | | 0.02 |
| B3-C3j | (0.42 | 0.23 | 0.12 | 0.22)$^T$ | | | | | 0.04 |
| C11-Pj | (0.35 | 0.10 | 0.08 | 0.34 | 0.05 | 0.025 | 0.03 | 0.02 )$^T$ | 0.072 |
| C12-Pj | (0.36 | 0.15 | 0.065 | 0.35 | 0.037 | 0.02 | 0.05 | 0.016)$^T$ | 0.12 |
| C13-Pj | (0.35 | 0.12 | 0.09 | 0.07 | 0.05 | 0.22 | 0.05 | 0.047)$^T$ | 0.013 |
| C21-Pj | (0.38 | 0.10 | 0.13 | 0.048 | 0.047 | 0.2 | 0.06 | 0.04 )$^T$ | 0.005 |
| C22-Pj | (0.44 | 0.14 | 0.03 | 0.05 | 0.013 | 0.33 | 0.02 | 0.0245)$^T$ | 0 |
| C23-Pj | (0.14 | 0.27 | 0.048 | 0.06 | 0.4 | 0.04 | 0.02 | 0.02 )$^T$ | 0.099 |
| C24-Pj | (0.34 | 0.14 | 0.12 | 0.05 | 0.04 | 0.023 | 0.06 | 0.04 )$^T$ | 0.005 |
| C25-Pj | (0.018 | 0.13 | 0.074 | 0.14 | 0.15 | 0.19 | 0.15 | 0.15 )$^T$ | 0.009 |
| C31-Pj | (0.23 | 0.14 | 0.067 | 0.12 | 0.076 | 0.19 | 0.04 | 0.05 )$^T$ | 0.012 |
| C32-Pj | (0.13 | 0.4 | 0.07 | 0.04 | 0.21 | 0.03 | 0.07 | 0.047)$^T$ | 0.087 |
| C33-Pj | (0.38 | 0.23 | 0.15 | 0.10 | 0.073 | 0.028 | 0.02 | 0.02 )$^T$ | 0.057 |
| C34-Pj | (0.017 | 0.06 | 0.08 | 0.17 | 0.19 | 0.18 | 0.19 | 0.11 )$^T$ | 0.013 |

From the result of single sequencing, we can calculate the figure of general sequencing of each kind of these energies in the whole energy development. This suplies us with the scientific basis for us to define and be sure of the strategy position of them. The result of general sequencing is in table 2.

Table 2 the figure of general sequencing of each kind of energies.

| C / P W | C11 | C12 | C13 | C21 | C22 | C23 | C24 | C25 | C31 | C32 | C33 | C34 | general sequencing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | .1 | .27 | .028 | .03 | .08 | .05 | .03 | .12 | .13 | .07 | .04 | .07 | |
| P1 | .35 | .36 | .35 | .38 | .44 | .14 | .34 | .018 | .32 | .13 | .38 | .017 | .273 |
| P2 | .10 | .15 | .12 | .10 | .14 | .27 | .14 | .13 | .14 | .40 | .23 | .06 | .16 |
| P3 | .08 | .065 | .09 | .13 | .03 | .048 | .12 | .074 | .067 | .07 | .15 | .08 | .074 |
| P4 | .34 | .35 | .07 | .048 | .05 | .06 | .05 | .14 | .12 | .04 | .10 | .17 | .19 |
| P5 | .05 | .037 | .05 | .047 | .013 | .40 | .04 | .15 | .076 | .21 | .073 | .19 | .10 |
| P6 | .025 | .02 | .22 | .20 | .33 | .04 | .023 | .019 | .19 | .03 | .028 | .18 | .11 |
| P7 | .03 | .03 | .05 | .06 | .02 | .02 | .06 | .15 | .04 | .07 | .02 | .19 | .06 |
| P8 | .02 | .016 | .047 | .04 | .024 | .02 | .04 | .15 | .05 | .047 | .02 | .11 | .049 |

Using the result of single sequencing, we also can calculate the synthetic sequencing figure of the resource, strength and advantage of each kind of energy. Then we can compare the transformation of their resource, into

strength and advantage. The result is in table 3.

Table 3. the synthesis of each kind of energy

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| resource | 0.142 | 0.054 | 0.028 | 0.13 | 0.016 | 0.014 | 0.013 | 0.008 |
| strength | 0.066 | 0.048 | 0.021 | 0.027 | 0.042 | 0.058 | 0.024 | 0.023 |
| advantage | 0.067 | 0.06 | 0.025 | 0.037 | 0.04 | 0.041 | 0.024 | 0.018 |

## Ⅳ: Analysis of the result and conclusion:

The result of general sequencing (Table 2) show us:

1 : The weight of coal is maximal (0.274). Because the resource of coal is the richest. (From the weight of the resource, we can find the weight of coal is greater than the amount of petroleum, natural gas or nuclear power). It has had certain strength to some degree. We can make full use of its advantage of resource only we if program it scientifically. But, table 3 shows us that its strengths and advantages are far from being made full use of. (the weight of its strength and advantage are less than half of that of its resource). The reason is that we have only tried to settle the problem of coal production and transportation, and have overlooked its export potential. In 1986, the export quantity was 990 million tons. Though it only occupied one percent of the total quantity of that year, it occupied three percent of the world's coal trade quantity. This means that China can increase its export quantity. This also shows the gigantic shock to the world market. Now, the worsening trend of market condition for developing coal at a large scale within western country, adding they might tranfer their energy supply to help China to realize its export potential. All of these gives us the best opportunity to promote coal export. We should get hold of the opportunity and turn the potential resource advantage into real advantage.

Exporting more, getting more foreign currency. On the one hand, we can get the investment demanded by the enlargement of production scale and the strength of transportation capacity. On the other hand, we can take part in international circulation actively, in order to promote China's whole national economic construction. Coal might become the key to China's economic development in the short and middle term. So it should be developed as a priorty.

2. The analysis of the strategic position of petroleum and natural gas in energy development.

Petroleum is the blood for human survival. It also is an important strategic material. Because of its characters of being transported easily,

having high usage efficiency and its strategic impotance, it has strong competition power. Petroleum and natural gas resources have been developed quickly. Now, their strength and advantage is beyond that of coal. (We can find this from table 3). Their proportion among the energies have arisen from the 1.4 percent before liberation to 23 percent now. But, compared with the world's average level, per capita consumption is far from high, only 16 percent of he world's average level. Let's look at this in light of long-term and general scale. We find that: In China, the period of large scale oil and gas exploration is short, and the exploration level is very low. Potential deposits are very rich. (Just behind the resource of coal and water power). So Chinese oil and gas quantity is still in the developmental stage, and far from reaching its peak period. According to the forcast of some specialists, by the end of this century, after the quantity of crude oil has reached 200 million tons, the reasonal and proper quantity is from 250 to 300 million tons. Its varied curve show normal distribution. The theoretical peak quantity is 370 million tons. After the year 2000, when the quantity reaches 250 million tons, we should stabilize output for a period. This shows us the wide prospect of China's oil gas industry. So we should promote our strength in order to develop more advantages. This will cause a great effect on the adjustment and the improvment of China's energy structure and promote its international competitive capacity. We should raise oil and gas position in short and middle term energy development. This has become the strategy highlight of our energy industrial development. So we should work to develop the oil gas industry.

3. The weight of water power is just after that of coal. Water resource is the richest and cheapest one in China. Futhermore, it is renewable, creates no pollution and the excavating cost is relatively low. (it only takes one fourth of the thermo-electricity). But its excavating level is too low (the weight of strength only takes one third of resource). Compared with developed countries, (Usage efficiency: France, 95 percent; Switzerland, 98 percent). Its advantage has been developed slowly (the weight of advantage only takes 25 percent of that resource). In the meantime, this indicates that the potential of water resource in China is gigantic. We should speed up the excavation of our water resource. Especially to build some middle and small scale water-power zones, to research the possibility of large scale excavation of water-power zones and other pioneer work. To prepare for large scale excavation of water power, it is important to readjust the energy structure and distribution in China. So, we should develop water power quickly.

4. The weight of economical energy is relatively big too. (after coal, water power and petroleum). According to some energy specialist's forcast: In order to quadruple the GNP in the year 2000, a lot of energy is required half of which will come from economised energy. It will have a direct affect on whether our economic target can be realized or not. So saving is not a temporary goal. We should treat it as our main and long-term

energy policy. we should not only stress excavating, but also emphasize savingand work hard to expend saving.

5. The weight of nuclear power is in the fifth place. Nuclear power will be the only muture energy we can use to sustitute for coal and petroleum largely in several decades. We can suppose that by the beginning of the 21th century, the place of nuclear power in the world's energy expenditure will rise from third to fifth. It might rise to second place by the year 2020. Uranium resources are distributed widely in China. It is necessary to develope nuclear power. Moreover, it is relatively economical to develope nuclear power ( the ultimate cost is generaly lower than that of thermo-elect-ricity ). And its demand for transportation capacity can be overlooked. Now China has built a relatively comprehensive nuclear industry, sector, including a high-level nuclear scientific unit. These are the advantages for us to build up strength and turn it into an advantage. ( Both of the weights of strength and advantage are bigger than that of resource) Looking at the present situation and the development tendency of the world's usage of energy, considering China's condition, development and usage, we think that nuclear power is an important venue and strategy selection to settle China's energy crisis. It should be China's strategic emphasis in its middle and long term energy development.

6. The weight of new energy and rural energy is in the last place. Though new energy is a resource that we can use forever, because of technical problems, its low utilitization ratio and high cost, it is far from being used widely. Now, it is still in the stage of experiment and small -scale usage. So we should enhance scientific research early and prepare for the energy revolution in the next centery. The fundamental question of rural energy is of peasant's fuel. To settle this question, marsh gas is the key. Futhermore, there are many renewable energy resources in the countryside. (Such as wind energy and tide energy in coastal regions, wind energy, and solar energy in the plateau and grass-land ). To develope marsh gas and renewable energy further would contribute to agricultural. modernization.

Summing up, we can draw this conclusion: The strategy of energy development in China should be, not only to stress exploration, but also to emphasize saving, paying equal attention to both. Develope the coal industry as a priority, actively take part in international circulation, export more. Work hard to explore and develope petroleum and natural gas resouces. Raise their strategic position in the energy developement plan. Expanding water power and nuclear power, should be regarded as the emphasis on the middle and long-term strategy. We should treat saving as a basic policy, supply the inclined policy to it. Work hard to expand saving. Also, we should accelerate rural energy construction and do hard work to improve the energy utilization ratio. Also we should try to mitigate environmental pollution.

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# A Decision Support System for Production Investments

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In the electronics and telecommunications industry, the days where it was possible to judge a production investment based strictly on financial return have past. Such decisions must be linked to corporate strategy in order to ensure that all areas of the company move towards consistent, planned goals. This is especially important in companies whose operations are dispersed across many locations and where capital investments are large due to a high rate of automation. A production investment must be justified in the context of business strategy and should be documented in the language and form understood by management. For many who are not so familiar with business management, it is very difficult to make an investment proposal which accounts for all the necessary factors.

A joint project between Nokia Telecommunications and the University of Oulu was made with one topic investigating decision problematics in a production environment. Specifically, this study investigated repetitive decisions and the possibility of developing a special tool for such problems. In order for such a tool to be adopted by many users, it must be "ultra easy" to use and cannot demand large time investments from busy managers. This was the target for the pilot tool developed in this project. The tool is very simple in its program structure in that it is solely dedicated to production investment decisions in one company and only the essential functions are included. Using the tool is like "thinking through" the investment in the context of the strategic goals set by management. The end product of the evaluation process is an automatically generated investment proposal which can be finalized with Word for Windows. In this way the format of the proposal is in the language and form required by management.

In the model used in this study, a management team first specifies the longer term goals of the company and gives importance weights to these goals through some formalized method, for example AHP Tree or Expert Choice could be used. These goals and weights form a common criteria for any production investment decision. The constraints of repetitive use of a common upper hierarchy are reported in [1]. At the specific problem level, a decision making team would then evaluate how strongly the current problem is linked to each strategic goal and how the alternatives perform against each goal on an absolute scale. Based on this information, an overall weight for each alternative would then be generated.

In the spring of '96, a pilot version of this tool was developed and piloted in order to determine the real demand and value of such a tool. The pilot tool was pretested and evaluated by business managers. The pilot tool was distributed on an automatically installable floppy disk and includes an embedded electronic questionnaire to provide feedback. Result of this survey will be available in July 1996.

[1] Verkasalo M. (1994) 'Repetitive Use of AHP-Hierarchy'. Proceedings of the 3rd International Symposium on the Analytic Hierarchy Process, George Washington University, Washington D. C., USA.