The Industrialization Prospect Analysis of Water Resource Heat Pump Based on Scenario Planning

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Abstract: - Based on the theory of scenario planning, this paper analyzes the factors which may influence the industrialization process of water resource heat pump technology from policy, substitute energy, technology itself and application fields. With grading by experts from the importance and uncertainties factors view points in water resource heat pump, two key uncertainties factors in these factors are found out. Then based on the two factors, in combination with other determinate factors, the various scenarios of water resource heat pump technology in direction of the industrialization process are painted. Finally, as these scenarios, some suitable strategies about how to promote the industrialization of water resource heat pump technology in China are put forward in this paper.

Key - Words: - Scenario planning Water resource heat pump Response strategies

1 Introduction

At present, heat pump technology has been quickly developed all over the world as a clean and energy efficient heating and air conditioning mode, and has been widely applied to apartments, shops, hospitals, and office buildings etc. According to different heat source, heat pump technology includes water-resource, air-resource, and ground-resource heat pumps. Environmental temperature has a serious impact on air-resource heat pump. When outside temperature is lower than 0, the heat supply and energy efficiency would decrease so much [1]. Ground-resource heat pump has several disadvantages including large heat loss, low energy efficiency, and few applications [2]. Water-resource heat pump system is a high efficient air conditioning system with a combination of heating, cooling and hot water supply. Water resource includes ground water, river water, lake water, sea water, urban waste water and renewable water etc [3].

In recent years, prototype of water resource heat pump has been developed and applied successfully for heating and cooling in many developed counties. But its application also has many uncertainties in China, such as the relatively high investment at earlier stage, the technology also need to constantly improve and issues about cost-effective. Another problem is that people's awareness of water resource heat pump is also a process [4].

Scenario planning has been used in various contexts to prepare for the future. Its main application areas have been corporate and military strategy planning. Our objective is to understand the most relevant factors affecting the industrialization process of water resource heat pump in China. We apply scenario planning to analyze the application prospect of water resource heat pump.

Based on the scenario planning method, this paper provides a description of the prospect of water resource heat pump in China. With the influencing factors analysis, the suitable response strategies for the industrialization process of water resource heat pump are presented. Although the water resource heat pump has been industrialized in many developed countries, the authors are hopeful that the reader, after reviewing this, will appreciate that water resource heat pump represent a potentially attractive alternative and renewable energy source for air-conditioning system in China now.

This paper is organized as follows. Section 2 describes the principle of scenario planning. Section 3 introduces the water resource heat pump. Section 4 presents the construction of scenarios for water resource heat pump. Section 5 and 6 presents the prospect and the response strategies for water resource heat pump respectively. Section 7 concludes the paper.

2 The Principle of Scenario Planning

The scenario planning method emerged during the late 1960s when it was used in the Shell Corporation to outline future outcomes [5], [6]. The method gained prominence when it was used to predict the 1973 oil crisis. On the other hand, French academics were using the concept of the prospective to deal with the uncertain future at the same time [7]. The ideas from both sources converged into actual scenario planning methods. Some of them followed closely their intellectual groundings, [8] and [9] on Godet's prospective scenario planning method; whereas some developed the idea further, [10] and [11] on Schoemaker's scenario planning method. Recently there have been efforts to integrate scenario planning with strategic options [12].

The core concept of scenario planning is the re-perception of reality. "To operate in an uncertain world, people need to be able to reconsider - to question their assumptions about the way the world works, so that they could see the world more clearly". Scenarios are a set of plausible stories about how the future may unfold. Scenarios are not about determining which future is more probable. As Schwartz states, "the end result, however, is not an accurate picture of tomorrow, but better decisions about the future." [13].

Scenario planning is based on key assumptions of major evolutions for economies, industries or technologies, conceive various possible scenarios through detailed and rigorous reasoning or describing, and come up with strategies for different scenarios. The greatest advantage of scenario analysis is to enable managers to discover the change trends in the future and avoid the two most common decision-making errors: overestimate or less estimates the changes and impacts about the future [14]. The basic principle process of scenario planning is shown in Fig. 1

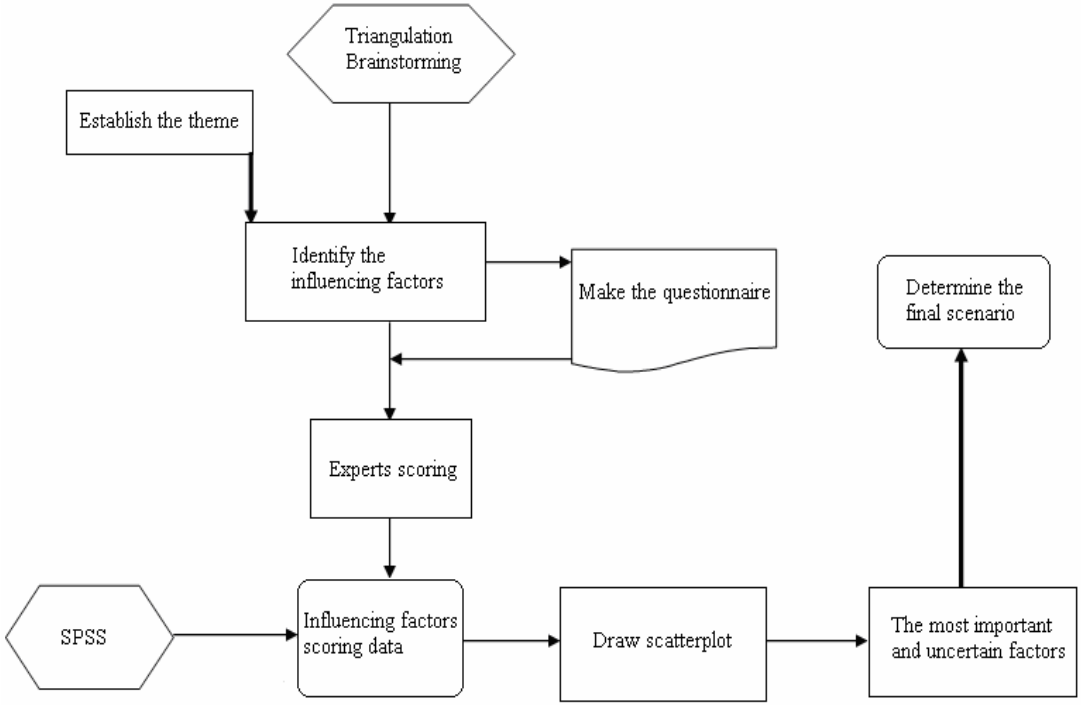

Fig.1 The process of Scenario planning

3 The water resource heat pump

Water resource heat pump technology is a kind technology which using the earth's surface in shallow water such as groundwater, rivers and lakes in the absorption of solar power, and geothermal energy to the formation of low-temperature geothermal energy resources, and adopting the principle of heat pump, through a small number of high energy input, transferring the low-temperature energy to high heat energy.

3.1 The working principle of water resource heat pump

The working principle of heat pump is driven by the electric compressor which makes working fluid (such as R22) recurring physical exercise cycle to phase-change process, at the evaporator gasification absorbs heat and condenser liquefaction send out heat respectively, with energy continuously transmission exchange, and through the valve switch realizing unit heating (or cooling) function. Fig. 2 shows a

schematic diagram of the water source heat pump. In this figure, two water streams, one being heated through condenser and the other being cooled through evaporator are shown.

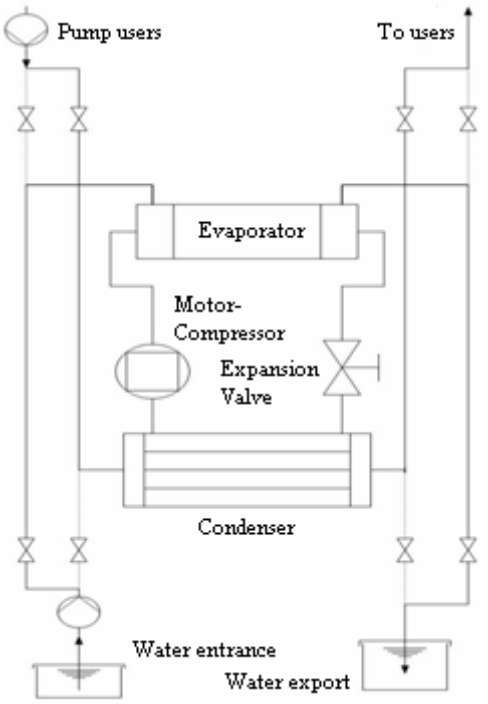

Fig. 2 The schematic diagram of water resource heat pump

The water resource heat pump heating coefficient largely depends on the operating conditions [15]. The heat pump use is economically viable when the most suitable heat source can be used and there is a low-temperature heating regime in use [16]. The water resource heat pump also has many better characteristics.

3.2 The characteristic of water resource heat pump

3.2.1 Renewable energy technology

Water resource heat pump is an air-conditioning system which utilizes solar energy resources stored in water of the earth as a cold and heat source to realize the heating energy conversion. The water is used including the groundwater, the surface part of the rivers, lakes and oceans. Surface soil and water are not only an enormous solar collector, which collected 47 percent of solar radiation energy 500 times more than the human use energy per year (the underground of water body through the soil to accept indirect solar radiation energy), but also are an immense dynamic energy balance system, and they maintain natural energy acceptance and the balance of the relative divergence. So it is possible to utilize the almost unlimited geothermal energy or solar power stored in surface soil and water. Therefore, water resource heat pump is a clean renewable energy technology.

3.2.2 High efficient energy

In winter, Unit available water temperature of water source heat pump is 12-22 □, the water temperature is higher than ambient air temperatures, so the evaporation temperature of heat pump is heightened, and also the energy efficiency. In summer, water temperature is 18-35 □, the water temperature is lower than ambient air temperature, so the condensing temperature of cooling is low, the cooling effect is better than air-cooled and cooling tower, and the crew efficiency is heightened. According to the U.S. Environmental Protection Agency EPA estimated that the well-designed installation of a water resource heat pump can save 30 ~ 40% running costs of heating refrigeration and air-conditioning.

3.2.3 Stable and reliable operation

The air-conditioning system of water resource heat pump can guarantee the needs of users open air conditioning systems in the whole year, especially in the transition seasons-spring and autumn, the air-conditioning also can run; it is the equivalent of four control air-conditioning systems. Generally, the water supply and return water temperature of water resource heat pump are relatively stable throughout a year; its volatility is far less than the scope of the air changes. Water body as a source of cold in summer and as a source of heat in winter for air-conditioning, water temperature constant, there make the heat pump run more reliable and stable, and guarantee the system more efficient and economic.

3.2.4 Significant environmental benefits

Water resource heat pumps only use electricity power. The electricity power is a clean energy. So the pollution is little generated by water source heat pumps after its energy consumption. The electricity consumption of well-designed water resource heat pump, compared with air source heat pump, which is equivalent to more than 30% reduction, compared with electric heating, which is equivalent to more than 70% reduction. Water resource heat pump can be built in residential areas, because it operating without any pollution, such as combustion, smoke and waste.

4 The Construction of Scenarios for Water Resource Heat Pump

4.1 Identify the influencing factors

4.1.1 Policy factors

There are two main policy factors affecting the technology of water resource heat pump: one is the characteristics of national policy-oriented in the development of energy saving and environmental

protection; the other is the policy about water use for nation and local [17]. People's Republic of China Renewable Energy Law was adopted at the Fourteenth Meeting of Tenth National People's Congress Standing Committee at 28 in May, 2005. Chinese enactment of the law is designed to promote renewable energy development and utilization, increase energy supply, improve energy structure, ensure energy security and environmental protection, and realize the sustainable development of economic and society. Although the law provides a number of legal provisions in principle, many content are not specific and detailed enough. Even if it get the approval of the department of water, some places will ask two charges for water abstraction and emissions, the standard of the charges is not national unity, which may result in high charges, making the charges of energy-efficient with water resource heat pump are less than compensation increased, and the economy of water resource heat pump becomes bad.

4.1.2 Market factors

Despite the nation vigorously advocates the development and use of clean energy and renewable energy in policy. However, at the mention of the option of energy consumption, market factors still play a very large leading role, such as various energy prices and the degree of access determine the choice of energy consumption for enterprises and ordinary people. Although water resource heat pump technology will have a larger space for development in the future, the pace of development will be affected by other alternative energy sources.

4.1.3 Environmental factors

On the one hand, people's environmental awareness is improving; on the other hand, the impact of various energy technologies on the environment is varying. These two factors will restrict people's option for water resource heat pump technology.

4.1.4 Technical factors

There are more technical factors about water resource heat pump itself, including the efficiency of heat pump increased through the heat pump cycling, components, and the quality of works improved, using materials technology to simplify the structure of heat, reducing heat pump costs, using monitoring technology to improve the reliability of heat pump and the simplicity of operation and maintenance, which will influence water resource heat pump replacing the other way of heat and achieve large-scale application.

4.1.5 Factors about conditions of low temperature heat source

One of the different points between heat pump and other simple heating is that it needs low-temperature, and the higher the temperature of low-temperature of heat source, the more advantageous for improving the performance and application advantages. Sometimes it is the key factor for the application of heat pump whether there are suitable low-temperature heat source or not. Therefore, using advanced technology of related fields and expanding the low-temperature heat source of heat pump, can also be an important factor for promoting the use and development of heat pump.

4.1.6 The uncertainties of application field

As long as where energy is needed, there are opportunities for heat pump application. However, to a specific hot occasion, the appropriateness of heating using heat pump, also depends on the availability of suitable low-temperature heat source, sufficient energy-powered and the high or low of heating temperature. Striving to expand application areas will be conducive to large-scale application of water resource heat pump.

4.2 Identify the most important and uncertain factors

In accordance with the six influencing factors of affecting water resource heat pump technology, by using the way of visiting and seminars, we had collected a total of 30 factors including consumers of water resource heat pump systems, maintenance crew, R & D, designers, constructors and government managers, then designed questionnaire about these factors and invited experts on water resource heat pump grading “importance” or “uncertainty” of these factors.

After 11 experts on the scoring of the questionnaire, we obtained the scoring data of the importance and uncertainties affected by various factors, then used SPSS software to analyze these data, finally calculated the average score for each factor in “importance” and “uncertainty”, the results are shown in Table 1, Table 2, Table 3 and Table 4, and draw the two-dimensional plot, it is shown in Fig. 3.

Table 1 Frequencies

Statistics

		significance	uncertainty
N	Valid	30	30
	Missing	0	0
Mean		7.5281	4.3506

Table 2 Descriptive

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
significance	30	6.10	9.09	7.5281	.80527
uncertainty	30	2.47	6.62	4.3506	.85994
Valid N (listwise)	30				

Table 3 Frequency table of importance

Importance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6.10	1	3.3	3.3	3.3
	6.23	1	3.3	3.3	6.7
	6.36	3	10.0	10.0	16.7
	6.49	1	3.3	3.3	20.0
	6.88	1	3.3	3.3	23.3
	7.14	3	10.0	10.0	33.3
	7.27	2	6.7	6.7	40.0
	7.40	1	3.3	3.3	43.3
	7.53	3	10.0	10.0	53.3
	7.79	3	10.0	10.0	63.3
	7.92	3	10.0	10.0	73.3
	8.05	1	3.3	3.3	76.7
	8.18	1	3.3	3.3	80.0
	8.31	2	6.7	6.7	86.7
	8.44	1	3.3	3.3	90.0
	8.70	1	3.3	3.3	93.3
	8.83	1	3.3	3.3	96.7
	9.09	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Table 4 Frequency table of uncertain

Uncertainty

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.47	1	3.3	3.3	3.3
	2.86	1	3.3	3.3	6.7
	3.51	1	3.3	3.3	10.0
	3.64	2	6.7	6.7	16.7
	3.77	2	6.7	6.7	23.3
	3.90	3	10.0	10.0	33.3
	4.03	4	13.3	13.3	46.7
	4.16	2	6.7	6.7	53.3
	4.42	3	10.0	10.0	63.3
	4.55	1	3.3	3.3	66.7
	4.81	2	6.7	6.7	73.3
	4.94	2	6.7	6.7	80.0
	5.06	2	6.7	6.7	86.7
	5.32	1	3.3	3.3	90.0
	5.45	1	3.3	3.3	93.3
	5.97	1	3.3	3.3	96.7
	6.62	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

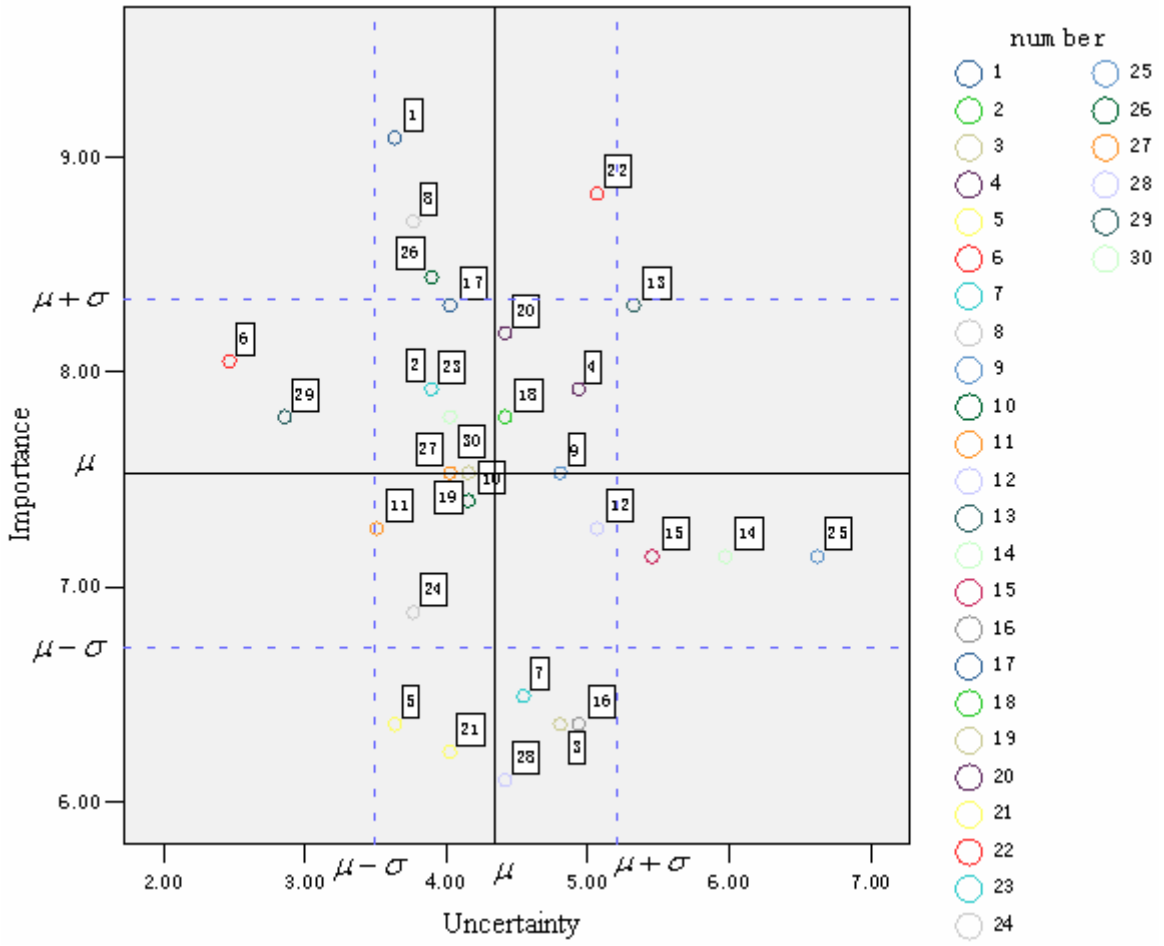

Fig. 3 Two-dimensional plot

It should be noted that in the questionnaire, for the convenience of the experts scoring on the importance and uncertainties, we divided the two attributes into 7 classes, so the scores were came out at the interval [1, 7]. Due to the average of the final distribution is more concentrated, so the paper quantified the average value into 10 points for reunification, that is, Y = X / 7 * 10.

In the above two-dimensional plot, for the two groups of data we marked the average value with a solid line, marked the standard deviation with a blue dotted line. There were the most important and most uncertain factors in the upper right corner, the more obvious factors were 13 and 22, which were the basic factors that construct the scenarios; there were 10 important factors with lower uncertainty in the upper left corner nearly, we called them "trend", which were also important factors considered when building scenarios [18]. The meanings of some dots in the two-dimensional plot were explained as follow in Table 5 and Table 6.

Table 5 The important uncertain factor

The important uncertain factors
U4: How the life of water resource heat pump is affected by water quality?
U9: In the aspect of system design, how much spaces of water resource heat pump technology for improvement?
U13: Can water resource heat pump raise in the breadth and depth of application?
U18: How long is the incremental static investment recovery period of heat pump system?
U20: How extent of impact for urban development and ecological environment brought by the use of heat pump?
U22: what is the acceptance of A for water resource heat pump system? Whether they are willing use water resource heat pump in engineering products of the future?

Table 6 Tendency

The Tendency
U1: Are the regions where water resource heat pump can be developed in our country many enough?
U2: Under the current laws, is the approval by the local water service difficult?
U6: Whether the nation will support the research and extension of the technology on policy or not?
U8: Can the current recharge technology guarantee that water quality is not destroyed?
U17: How much is the operating costs of heat pump system lower than that of the conventional central air-conditioning system?
U23: How many successful cases of do the design institute use water resource heat pump in the design? Would they like to use water resource heat pump according to their design philosophy?
U26: What is the trend about the number of patent for water resource heat pump applied every year?
U29: Can the heating effect of water resource heat pump achieve that of the traditional boiler?
U30: What kinds of building are water resource heat pump suitable for, or can be applied to all building?

5 The Prospect for Water Resource Heat Pump

Based on the factors identified by above data, combined with the two-dimensional trend of the two most important and most uncertain factor, this paper describes the industry scene of water resource heat pump. As there are many factors affecting the future scenarios, and sometimes it is difficult to grasp the trend, so the scenarios depicted in this article are relatively broad and general [19]. Our aim is only to convey the thrust of each scenario, rather than their rich details. The basic scenario building is shown in Fig. 4.

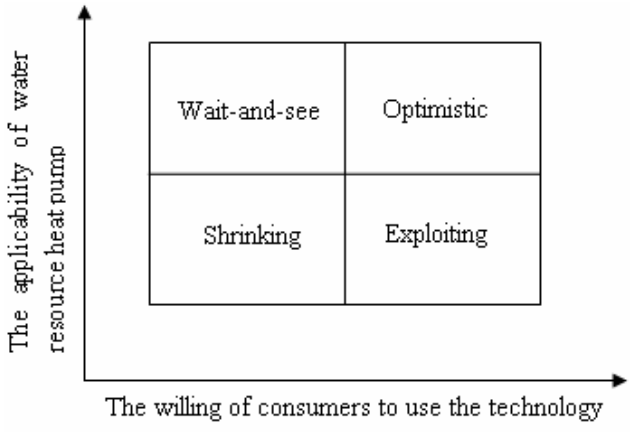

Fig. 4 Basic scenario building

The prospect of Optimistic: The applicability of water resource heat pump is very high, making consumers willing to use it. It means that the industrialization prospects of water resource heat pump are unambiguous.

The prospect of Wait-and-see: The applicability of water resource heat pump is very high, the pre-construction costs, environmental awareness and extent of understanding restricts the initiative of utilization.

The prospect of Shrinking: The applicability of water resource heat pump is relatively low; the enthusiasm of consumers is not high. It means that the industrialization prospects of water resource heat pump are gloomy.

The prospect of Exploiting: The applicability of water resource heat pump is relatively low; the enthusiasm of consumers is relatively high.

6 Response Strategies for Water Resource Heat Pump

In the content of previous section, through expert scoring, as well as statistical data, the paper identifies the two most important and uncertain factors, combined with other more important factors, depicts four possible scenarios for water resource heat pump in the future. Based on the above demonstration content and combined with the current situation, in order to promote the further extension of water resource heat pump, we consider that we need to put forward corresponding strategies for water resource heat pump from the levels of nation and enterprises.

6.1 Implement and develop energy polices

Because of larger input for new and renewable energy sources one time, significant benefits for society and environment, and economic benefit are not high direct. So they are not equipped with the ability to compete against conventional energy sources. In this case, the government support is indispensable. See from abroad experience, the countries where renewable energy develops rapid, have developed strong incentive policies. To develop technical and economic policies such as concrete and effective tax incentives, financial subsidies and low-interest loans, as well as attract domestic and foreign investors in the projects of development and construction for new energy and renewable energy, are very favorable for the development history of the industry.

In terms of taxation policy, it can be adopted indirect taxation including energy production, energy consumption and traffic to achieve energy conservation, new and renewable energy sources encouragement. In addition, the experience of European and American in promotion of renewable energy is worth learning from. Such as the organizations to promote energy technologies (OPET) set up by countries from EU, aim to assist the dissemination of information for new energy technologies and promote the application of new energy technologies. With aiding enterprises, institutions and individuals on solving difficulties and obstacles in the operation system, providing technologies, detailed information and advanced products, OPET successfully promote the extension of new energy technologies.

6.2 Improve people's consciousness about renewable energy resources

In order to improve the whole society on the understanding of renewable energy resources, and enhance the awareness of development and utilization of renewable energy, government agencies and institutions should take the lead in the use of renewable energy, and construct demonstration project of public buildings used with renewable energy, encourage large enterprises to use renewable energy, and actively involved in renewable energy technology development, equipment manufacturing and renewable energy production; grant green energy logo, energy-saving logo and corporate environmental protection rank to units and individuals on a voluntary subscription the high prices of renewable energy. Building the renewable energy training basis to promote domestic and international information exchange, as well as develop abroad cooperation and training for technical persons.

6.3 Reform the renewable energy technologies system

From the point of renewable energy technologies, it is necessary to actively promote its industrial development; we also need to set up renewable energy technology innovation system to form a more

perfect system of renewable energy industries, attract foreign enterprises investment in China, and drive its industrial development.

Main content includes: 1. the technology in new energy industry is generally weak, given there is no ability to compete on an equal footing with multinational companies, we can carry out fair competitive market environment, through the introduction of competitive investment from a number of large transnational corporations, change the competitive structure and competitive environment to make international competitiveness domestic, enhance the level of competition for new energy industries. Through imposing competitive pressure on multinational corporations, we can effectively improve the speed and the level of technology diffusion of multinational corporations, and prevent the monopoly of transnational corporations. 2. change the way focused solely on the technology in the past, we should introduce the compound technical architecture including manufacturing technology, organization and management of technology and marketing technology, or even propose technical content requirements in bidding on major projects, use of major works to promote technology diffusion of transnational corporations, force multinational companies provide technology and related training that our country needed when at the time of construction. 3. Raise the technical requirements to multinational companies when facing humanity common problems. Such as environmental, energy, health and other problems facing mankind, we should make use of environmental standards, energy efficiency standards and other means to force multinational companies to improve the technological content of investment projects, and transfer the technology to us [20].

6.4 Optimize the system and reduce cost

In the process of a technical promotion, the driving force brought by the market demand is much larger than the impact of technology promoted by universities and research institutes. The features of environmental protection and energy-saving of water resource heat pump need more time to be reflected, and these environmental benefits and social benefits are public, it is difficult to arouse interest of investors and owners. If run low-cost, long service life of water resource heat pump can be clearly distinguished from other air-conditioning system, and then these significant economic benefits in the process of industrialization for water resource heat pump will play a big roll in promoting.

Generally speaking, compared with traditional heating methods including gas stoves and coal stoves, the initial investment for the unit of water resource heat pump is relatively large; but the running cost saved from water resource heat pump in two season of heating can deduct the extra input at the beginning of investment. Therefore, in the development and application of water resource heat pump, optimizing its system and reducing the cost must be considered, in the event of primary energy being shortage, through the heat pump production and technical improvement to reduce investment costs, the advantage of heat pump technology will be more and more prominent.

7 Conclusions

In this paper, the scenario planning is used to analyze the prospect of water resource heat pump for China. The six factors which may influence the prospect of water resource heat pump are constructed. Four possible scenarios for water resource heat pump are depicted. By using the way of seminars and experts scoring, we obtain the data of each influence factors, and then use the SPSS software to analyze these data. Based on the data and scenarios analyzing, this paper presents the response strategies to the prospect of water resource heat pump.

Future study could involve building decision scenarios by verifying and re-iterating our analysis. Also, studying the applicability of the analysis to other Western European markets would be interesting. However, we intend to use the results as a starting point for further techno-economic analysis of water resource heat pump with methods providing more detail and precision than scenario planning.

Acknowledgment

This paper was supported by the National Natural Science Foundation of China under Grant 70639002.

References:

[1] Naitai Tan, Waste water-resource heat pump air conditioning technology. *Construction science and technology*. Vol. 16, 2005, pp. 62-63.

[2] Rui Fan, Yiqiang Jiang, Yang Yao, Zuiliang Ma, Theoretical study on the performance of an integrated ground-source heat pump system in a whole year. *Energy*, Vol. 33, No. 11, 2008, pp. 1671-1679.

[3] Fan R, Heat transfer analysis of geothermal heat exchanger under coupled thermal conduction and groundwater advection. PhD thesis of Harbin Institute of Technology, Harbin, China, 2006.

[4] Y. Fu, b. Li, x. Zhang. Water resource heat pump economics analysis, *Journal of Tongji University*, vol. 34, No. 10, 2006, pp. 32-36.

[5] Wack, P., "Scenarios: uncharted waters ahead",

Harvard Business Review, Vol. 63, No. 5, Sep-Oct 1985, pp. 73-89.

[6] Wack, P., "Scenarios: shooting the rapids", Harvard Business Review, Vol. 63, No. 6, Nov-Dec 1985, pp. 139- 150.

[7] Godet, M., "From forecasting to 'La prospective': a new way of looking at futures", Journal of Forecasting, Vol. 1, No. 3, July-Sep 1982, pp. 293-301.

[8] Godet, M., F. Roubelat, "Creating the future: the use and misuse of scenarios", Long Range Planning, Vol. 29, No. 2, April 1996, pp. 164-171.

[9] Godet, M., "The art of scenarios and strategic planning: tools and pitfalls", Technological Forecasting and Social Change, Vol. 65, No. 1, Sep 2000, pp. 3-22.

[10] Schoemaker, P. J. H., "When and how to use scenario planning: a heuristic approach with illustration", Journal of Forecasting, Vol. 10, No. 6, Nov 1991, pp. 549-564.

[11] Schoemaker, P. J. H., "Multiple scenario development: its conceptual and behavioral foundation", Strategic Management Journal, Vol. 14, No. 3, Mar 1993, pp. 193- 213.

[12] Schoemaker, P. J. H., "Disciplined imagination: from scenarios to strategic options", International Studies of Management and Organization, Vol. 27, No. 2, 1997, pp. 43- 70.

[13] P. Schwartz. The Art of the Long View, New York: Doubleday-Currency, 1991, pp. 9-40.

[14] Kathy Moyer. Scenario Planning at British Airways-a Case Study. Long Range Planning, Vol. 29, No.2, 1996, pp. 172-181.

[15] Saljnikov A., Goricanec D., Stipic R., Krope J., Kozic Đ., Design of an experimental test set-up for the thermal response test to be used in Serbia. WSEAS transactions on heat and mass transfer, vol. 1, iss. 4, 2006, pp. 481-487.

[16] Matavze., Krope J., Goricanec D. Cost-effectiveness of heat pump heating and of other heating systems. WSEAS transactions on applied mathematics, vol. 1, iss. 1, 2007, pp. 61-65.

[17] X. Zheng, J. He. The application of the water resource heat pump in low temperature heat source, Gas and Energetic, Vol. 26, No. 4, 2006, pp. 98-102.

[18] James A. Ogilvy. Creating Better Futures: Scenario Planning as a Tool for a Better Tomorrow. Book Reviews /Futures Vol. 35, 2003, pp. 889–899.

[19] Thomas J. Chermack, John S. Walton. Scenario Planning as a Development and Change Intervention. Int. J. Agile Systems and *Management*, Vol. 1, No. 1, 2006, pp. 46-58.

[20] Adna Jamil, Bjon Hassler, Mostofi-E-Jamil. A sustainable solution to the energy problem in rural areas in Bangladesh and other developing countries. Proceedings of the 6th WSEAS Int. Conf. on environment, ecosystems and development, 2008, pp: 48-53.