Frontiers in Economics and Management Volume 4 Issue 3, 2023
ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

Explore the Innovative Development Path of Clean Heating under the Goal of Carbon Neutrality

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Abstract

Research objectives: Through innovative development paths, the use of clean energy, the application of clean energy to heating, so that the carbon dioxide emissions of heating "offset", no longer become one of the culprits of air pollution, to achieve carbon neutrality, carbon standards, and clean heating. Main content: With the gradual drop of temperature, this winter's heating season is gradually approaching, heating is a social service to solve the basic living needs of northern residents in winter. At present, natural gas is mainly used for heating, but due to the lack of environmental quality evaluation standards in China, there is no punitive measure for the pollution caused by heat supply, making the air pollution more serious. With the development concept of "ecological priority and green development" gradually taking root in the hearts of the people, vigorously developing renewable energy and accelerating energy transformation and development has become a global consensus, and the continued use of natural gas heating is not in line with the concept of green and sustainable development. Therefore, this project innovatively proposes that clean energy can also be applied to heating, clean energy refers to energy that does not emit pollutants and can be directly used for production and life, according to the current green development situation, the use of clean energy for heating will become me The country urgently needs to adjust its energy structure, respond to climate change, and complete the inevitable choice of building a clean and low-carbon society and achieving sustainable energy development. Since the reform and opening up, with the rapid development of China's economy, the people in the central region and the southern region demand heating more and more voice, if to implement large-scale heating, continue to use non-clean energy heating is more unfeasible, southern cities use clean energy heating will be the future to protect the environment while meeting people's living needs of an important measure.

Keywords

Clean Heating; Energy Saving and Promotion.

1. Research Background

1.1. Research Background

1.1.1. Policy Background: Central Assistance, Local Response

In recent years, with the change of climate, the call to break the dividing line of "Qinling-Huaihe" central heating and develop urban heating in the south is getting louder and louder. In this regard, deputies to the National People's Congress have repeatedly put forward motions and suggestions such as "redrawing the demarcation line of heating along the Yangtze River" and "accelerating the development of China's heating market in 100 cities in southern China": Zhou Hongyu suggested accelerating the construction of a clean and low-carbon heating management system and mechanism in the south, establishing a clean heating operation mechanism of "government guidance and market operation" and improving relevant technical standards; Li Yin, Cao Baohua and other NPC deputies suggested that for the purpose of

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

improving people's livelihood and promoting clean heating, support the development of clean energy heating enterprises and projects, and vigorously develop multi-energy complementary heating models of clean resources such as biomass and solar energy.

In this context, local governments actively respond to the call of the state to promote the reform of clean heating methods. All pilot cities have formulated clean heating subsidy policies for coal-to-gas and coal-to-electricity, and some cities have also formulated renewable energy subsidy policies such as biomass and solar energy, which play a decisive role in promoting the task of clean heating transformation in pilot cities. The Anhui-Guisu region, represented by Nanjing, Changzhou, Hangzhou, Ma'anshan, etc., is gradually developing a clean and low-carbon heating system with multi-energy complementarity and combined cooling and heating by using renewable energy (such as geothermal, river water sources, etc.) and clean energy (such as natural gas, electricity, etc.).

As far as the development of clean and low-carbon heating systems is concerned, China is gradually showing the trend of "central assistance, local response"; As far as the implementation of the policy is concerned, the central and local policies and regulations have promoted the development of energy-saving heating to a certain extent, and the scale of low-carbon heating supply in various parts of the south has increased greatly. On the whole, the construction of clean and low-carbon heating system and mechanism in southern China has gradually entered a good situation.

1.1.2. Background of the Times: Clean Heating, The General Trend

Under the goal of "carbon neutrality", Southern Heating is facing new problems of people's livelihood and energy shortage. Compared with the north, heating in the south has a shorter heating time and a lower concentration of residential areas, and there are problems such as low efficiency of heating equipment, high heating costs, and low residents' willingness to pay and satisfaction. At the same time, in view of the difference in geographical characteristics between the north and the south, the southern heating should not copy the northern central heating method, the southern cities have abundant rivers, lakes surface water and other clean and renewable energy, suitable for the development of low-energy, clean and low-carbon heating mode through multi-energy complementarity and combined heating and cooling and heating.

In the Anhui-Guisu region, which is rich in water resources, taking Changshu City, Jiangsu Province as an example, Jiangsu Shou Innovation Energy Technology Co., Ltd. invested about 420 million yuan to tailor a green energy station project for Binjiang New City. This is the first green energy station project in Changshu City that uses surface water sources for energy. The project adopts the river water source heat pump system for energy supply, and combines key technologies such as high-efficiency heat pump technology, energy management and natural energy utilization to establish a complete regional green energy utilization system. Throughout the country, China adds about 2.63 billion square meters of buildings every year, of which 100 million square meters can be used for clean heating, and if all are implemented, the annual energy-saving standard is 660,000 tons, equivalent to 360,000 mu of afforestation. Practice has proved that new low-carbon heating models such as geothermal heating and southern heating can greatly reduce the heating cost of residents, and have far-reaching practical significance for people's livelihood and low-carbon economy.

Therefore, making full use of the resource endowment of the southern region to develop clean and low-carbon heating will become the general trend in the sustainable development of modern society, and to a certain extent, it has promoted the development of China's overall energy economy.

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

2. Exploration of the Willingness to Promote Clean Heating and its Development Suggestions

2.1. Based on Descriptive Statistical Analysis, the Promotion Intention of Clean Heating is Explored

2.1.1. Policy Support Attitude: Biased Towards Diversification

53.66% of the respondents believed that "dividend enterprises research and production, tax incentives, and technical support" would help the promotion and use of clean heating systems; 67.48% of the respondents believed that "increasing publicity and popularizing knowledge about clean heating" would help promote the use of the system; 69.92% believed that "formulating explicit regulations and making mandatory regulations on energy-saving heating behavior" was conducive to promoting the use; 67.48% believed that "economic support and increased investment in environmental protection undertakings" would help to promote the use of it; 0.81% believed that other measures contributed to the promotion of clean heating systems. Based on the above analysis, it can be seen that the policy support that the public believes is conducive to the promotion and use of clean heating systems is biased towards diversification.

2.1.2. Strengthen Promotion: Diversification of Methods and Suggestions

69.11% believed that the promotion of clean heating should be strengthened on new media platforms; 61.79% believe that promotion should be strengthened in the news/ newspapers/ magazines; 71.54% believed that the promotion should be strengthened in infrastructure advertising; 60.98% believed that promotion should be strengthened on television; 1.63% believe that the promotion of clean heating should be strengthened in other aspects. On the whole, it can be seen that residents should strengthen the publicity and promotion of clean heating and suggest diversification.

2.1.3. Participation in Relevant Activities: Overall Participation is High

Among the 3,888 respondents, 7.32% said that they would definitely participate in the publicity and training activities related to clean heating carried out by the community. 55.28% said that they could consider participating, and 34.15% said that they would decide whether to participate or not by looking at whether others would go; 3.25% explicitly stated that they would not attend the relevant activities. Comprehensive analysis shows that most residents are willing to participate in community awareness and training activities on clean heating. In general, there is a high level of participation in clean heating-related activities.

2.1.4. Future Prospects: Expectations for Water Supply Security, Energy Conservation and Environmental Protection and Heating Effects

As shown in Figure 55, when exploring the future expectations of respondents for clean heating, we found that 15.86% of respondents believed that the applicable cost was more important; 14.90% believed that hardware facilities were more important; 15.16% believed that the efficiency of daily maintenance and repair was more important; 17.84% believed that the guarantee of water supply was more important; 18.06% believed that energy conservation and environmental protection were more important; 18.17% believed that the heating effect was more important. Comprehensive analysis shows that residents' future prospects for clean heating are manifested in various aspects, among which respondents pay more attention to three aspects: water supply security, energy conservation and environmental protection, and heating effect.

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2.2. The Correlation Analysis of the Indicators Influencing Factors of Promotion Willingness based on Apriori Association Rule

2.2.1. Data Analysis: Research Design

First, identify a reference series that reflects the behavior characteristics of the system (sampled by the answer "After understanding and accepting the new clean heating method, what factors make you more willing to recommend it to others") and the comparative series that affect the behavior of the system (policy support, costs, logistics, subsidy rebates, social response, energy conservation and environmental protection, heating effect, interest driven);

Correlation rule analysis requires mining out association rules from the transactional database that meet the defined minimum level of support and minimum confidence. Only correlation rules that are greater than these two minimum thresholds at the same time can be called valid correlation rules. However, the threshold determination of minimum support and minimum confidence does not have a unified calculation method in both theoretical and practical applications, and is often set subjectively based on experience. Moreover, the data involved in the analysis of association rules is qualitative data, and if quantitative data exists, it needs to be discretized.

In summary, association rule analysis is a three-step process:

Step 1: Find all the frequent itemsets in the transactional database;

Step 2: Generate association rules from frequent itemsets, that is, association rules that meet the minimum support and minimum confidence;

Step 3: Filter "strong association rules", that is, filter association rules with a lift greater than 1.

The correlation degree analysis was carried out for 8 evaluation items (policy support, cost and expense, logistics support, subsidy rebate, social repercussion, energy conservation and environmental protection, heating effect, interest driven), and 3888 data, and the correlation relationship (correlation degree) of 8 evaluation items was studied, and an analysis reference was provided based on the correlation In this paper, the minimum rule support and rule confidence of the correlation analysis of each specific indicator are set to 10% and 70%, respectively. The correlation degree value is then calculated for subsequent evaluation judgment.

2.2.2. Analysis of Results: Logistics Support & Costs

First, information enrichment studies are conducted using factor analysis. To explore the data validity quality of the sample data, we performed the KMO test with the help of SPSS and obtained the results:

Using the KMO and Bartlett tests, it can be seen from the table that the KMO value is 0.696, which tends to 0.7, and the validity of the study data is good.

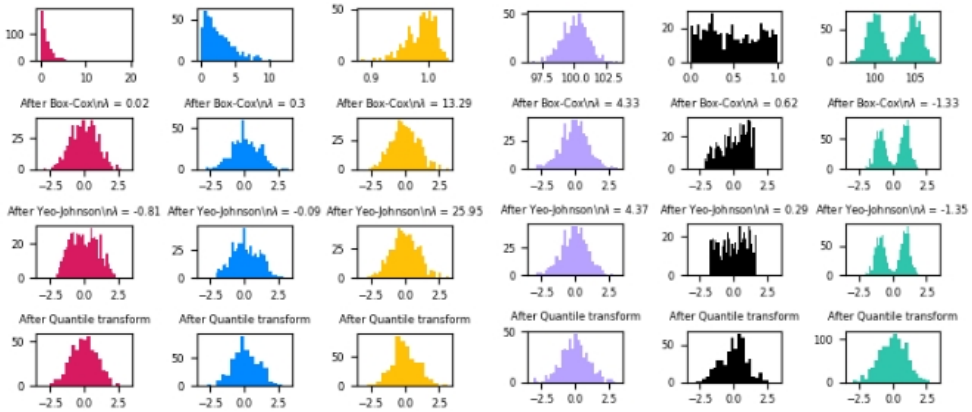

Figure 1. Normal distribution map of influencing factors within a subsystem

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

In order to meet the requirements of association rule analysis, the equidistance method is used to discretize the normal distribution mapping of the quantitative variables in the sample data. Using correlation analysis to study the correlation relationship between the above 8 basic indicators, using the Pearson correlation coefficient to express the strength of the correlation, and analyzing its correlation, the results are as follows:

Table 1. Table of Pearson correlation coefficients between factors

	heating effect	cost expenses	logistics guarantee	subsidy Rebates	society reply	energy conservation environmental protection	heating effect	interest drive
Policy support	1	0.843	0.868	0.800	0.864	0.876	0.844	0.851
Cost fees	0.843	1	0.842	0.918	0.877	0.808	0.858	0.876
Logistics	0.868	0.842	1	0.871	0.893	0.887	0.896	0.888
Subsidy rebates	0.800	0.918	0.871	1	0.883	0.825	0.888	0.884
Social repercussions	0.864	0.877	0.839	0.883	1	0.871	0.879	0.877
Energy saving and environmental protection	0.876	0.808	0.887	0.825	0.871	1	0.915	0.887
Heating effect	0.844	0.858	0.896	0.888	0.879	0.915	1	0.916
Interest-driven	0.851	0.876	0.880	0.884	0.877	0.887	0.916	1

From the above table, it can be seen that the correlation between eight influencing factors, namely policy support, cost and expense, logistics support, subsidy rebate, social repercussion, energy conservation and environmental protection, heating effect, and interest drive, is studied by using the relevant analysis, and the Pearson correlation coefficient is used to express the strength of the correlation. Specific analysis shows that there is a significant positive correlation between the above eight variables, and the correlation coefficient values are 0.843, 0.868, 0.800 and 0.864, respectively 0.876, 0.844, both greater than 0.

Table 2. Table of Pearson correlation coefficients between willingness to promote and various factors

factor	heating effect	cost expenses	logistics guarantee	subsidy Rebates	Social repercussions	energy conservation environmental protection	Heating effect	Interest-driven
Correlation	-0.588	-0.688	-0.467	-0.649	-0.748	-0.590	-0.643	-0.638

Table 3. Rules for linking basic needs between promotion intentions and factors

serial number	rules	The number of instances	Rule confidence	Rule support	Lift
R_1	$A\grave{U}D => B$	269	81.041	20.85	1.234
R_2	$B\grave{U}D => B$	211	87.204	17.037	1.328
R_3	$A\grave{U}C => E$	212	86.792	17.037	1.686
R_4	$D => E$	218	84.404	17.037	1.717
R_5	$D\grave{U}B => C$	189	85.714	15	1.665
R_6	$A\grave{U}C\grave{U}D => B$	182	87.363	14.722	1.331
R_7	$C\grave{U}D => F$	189	84.127	14.722	1.711
R8	$A\grave{U}B\grave{U}C => F$	186	85.484	14.722	2.235
R9	$B\grave{U}F => C$	159	91.824	13.519	2.401

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

Given the differences between residents' perception of different influencing factors, we will further analyze the correlation between promotion willingness and each factor.

It can be seen that the correlation coefficient values are less than 0, and there is a significant negative correlation between the willingness to promote clean heating and the eight influencing factors. In the analysis of residents' willingness to choose clean heating, a total of 8 effective rules were excavated, and the specific results estimated by the model are shown in the following table. In this project, in order to ensure the generalization of the rules, the rule with the highest degree of support is selected as the conclusion.

2.2.2.1. The User's "Focus of Attention" - Cost

From the expression, $DÙB => C$ $BÙF => C$it can be seen that among the eight major factors influencing residents' willingness to promote clean heating, no matter how users promote clean heating, they will eventually pay attention to option C, that is, heating cost fees, forming a relatively stable association rule. And the support and confidence levels are both 13.5% and above 85%. It can be seen that cost is the focus of the entire clean heating promotion that will be focused on by users anyway.

2.2.2.2. The User's "Demand Focus" - Logistics Support

From the expression, $CÙD => F$ $AÙBÙC => F$it can be seen that under the same conditions, respondents need clean heating with complete logistics support services. The support and confidence levels of the logistical support requirements will be selected by 14.722% and 84.127% respectively. Different from the traditional impression that residents are more inclined to the heating effect, users pay attention to the cost and expense as well as the reliability of logistics services.

2.3. Research on the Promotion Form Preference of Clean Heating System based on C4.5 Decision Tree Model

2.3.1. Concept and Method Selection

The purpose of the decision tree algorithm is to obtain the data classification and prediction rules under different values of input variables and output variables by learning from data. This paper chooses the decision tree-based classification algorithm because of its unique advantages: simple structure and easy to understand; The speed is fast, the amount of computation is relatively small, and it is easy to convert into classification rules; High model efficiency; Ability to process non-numeric data; Classification rules are more accurate. At the same time, on the basis of using information entropy and information gain value, the C4.5 algorithm uses the information gain rate as the criterion for selecting branch attributes, overcomes the shortcomings of bias to select attributes with multiple values when using information gain to select test attributes, and increases the function of discretization of continuous attributes and the function of incomplete data processing, and adopts a post-pruning method to avoid the highly uncontrolled growth of trees. Avoid overfitting data.

2.3.2. Establishment of C4.5 Decision Tree Classification Algorithm Model

1. Calculate the entropy of the entire data set

2. Select the best data set division method and select the feature with the highest information gain rate

(1) Calculate the entropy Ent(Dv) of the data set that excludes the features that have been used and the features that are being calculated (v is the sample set with the value of the current calculated entropy feature v), and calculate the Ent(Dv) of each feature value After adding and proportionalizing, the information entropy of the data set is : after the feature values are divided $Ent(D) = -\sum_{k=1}^{|y|} p_k \log_2 p_k$ (p k: proportion of category k samples);

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

(2) calculate the entropy increase of each feature value (a $Gain(D,a)=Ent(D)-\sum_{v=1}^{V}\frac{|D^v|}{|D|}Ent(D^v)$ is a feature in the sample set, D v: the set of all samples with a value of v for a feature);

(3) Calculate the mean value of all feature information gain, and select the characteristics whose information gain is higher than the mean;

(4) calculate the intrinsic value IV of the selected feature: (a); $IV(a)=-\sum_{v=1}^{V}\frac{|D^v|}{|D|}\log_2\frac{|D^v|}{|D|}$

(5) Use the information gain and inherent value of each feature to calculate its gain rate separately, and the gain rate is calculated: , and the highest feature is selected as the division feature; $Gain\_ratio(D,a)=\frac{Gain(D,a)}{IV(a)}$

3. According to the selected characteristics, divide the dataset according to its value and build branches

4. Remove the used features, repeating steps (2)(3)(4) in each data branch until one of the following conditions is met:

(1) The category of all data in each branch is the same;

(2) All features have been used.

2.3.3. Analysis of Results

In the process of researching the factors influencing residents' willingness to promote clean heating systems, it is concluded that logistics support, cost, energy conservation and environmental protection and heating effect are four variables that have a greater impact on residents' willingness to promote clean heating systems, so we take the four variables of logistics support, cost, energy conservation and environmental protection and heating effect as input variables for clean heating In the process of research on the influencing factors of promotion intention, the decision tree algorithm is used to analyze the views of different types of people on the promotion of clean heating system, so as to realize the accurate positioning of clean heating promotion mode.

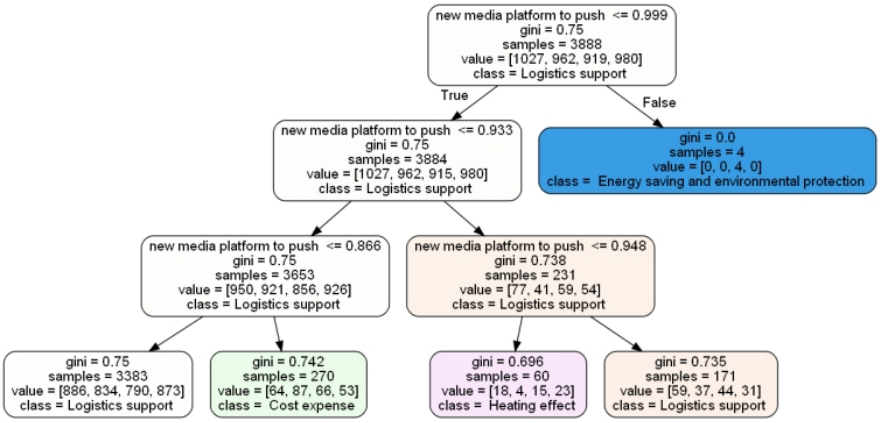

Figure 2. Come up with the results (1)

Firstly, the results of the four promotion willingness influencing variables of logistics support, cost, energy conservation and environmental protection and heating effect were standardized by the z-score method, and after data processing, the promotion index greater than 1 was set above the average, and the less than 1 was set below the average. The individual responses to the clean heating promotion form selection question in the questionnaire were converted into numerical data for easy analysis, and then the five options in the clean heating promotion form

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

answer were used as output variables respectively as new media platform push, news/newspaper publicity, infrastructure advertising, TV/radio publicity and other forms Python builds decision tree models for classification. After analyzing the form of clean heating promotion, we come up with the results shown in Figure 2.

Among the residents who prefer the promotion form of clean heating information and new media, most residents have a promotion index higher than the average level of residents in terms of logistics support, cost and heating effect, and a promotion index in energy conservation and environmental protection is lower than the average level of residents.

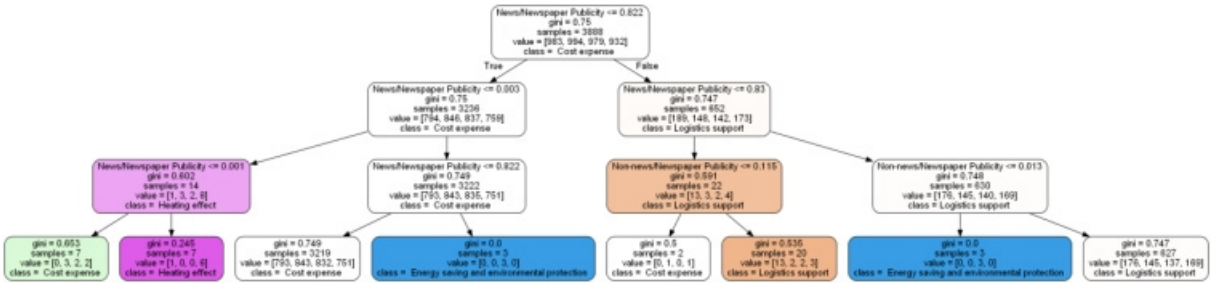

Figure 3. The results (2)

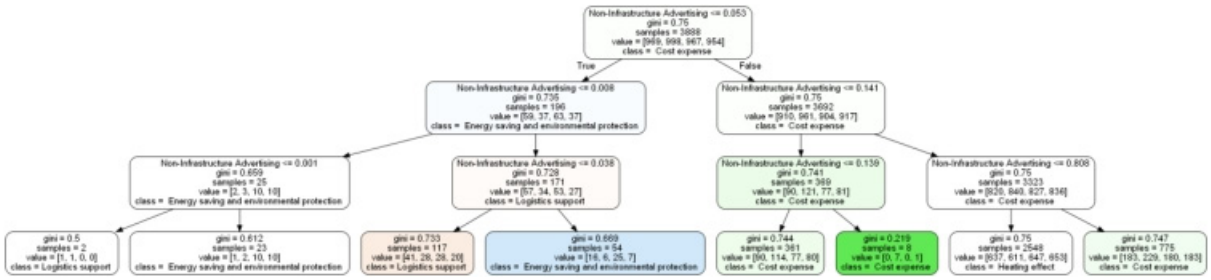

Figure 4. The results (3)

Among the residents who prefer the advertising and promotion form of clean heating information infrastructure, most of the residents have a promotion index higher than the average level of residents in terms of logistics support, cost and cost, energy conservation and environmental protection, and heating effect.

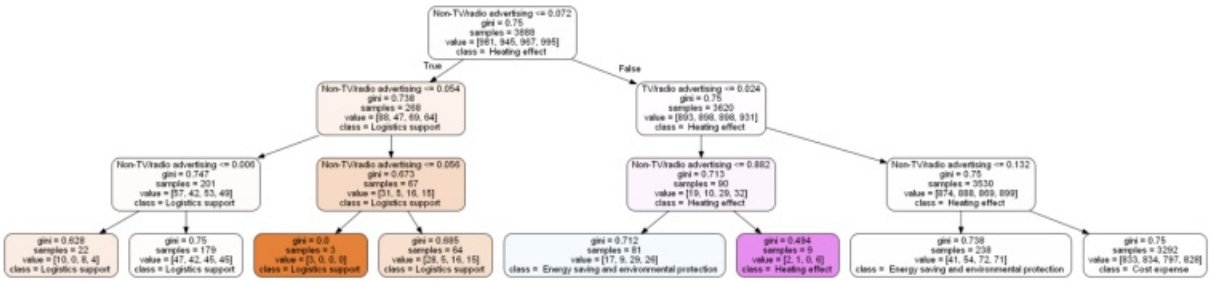

Figure 5. The results (4)

Among the residents who prefer the TV/radio publicity and promotion of clean heating information, most residents have a promotion index higher than the average level of residents in terms of logistics support, cost and cost, energy conservation and environmental protection, and a promotion index in terms of heating effect is lower than the average level of residents.

Among the residents who prefer other forms of promotion of clean heating information, most residents have a promotion index higher than the average of residents in terms of heating effect,

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cost and energy conservation and environmental protection, and a promotion index in terms of logistics support is lower than the average level of residents.

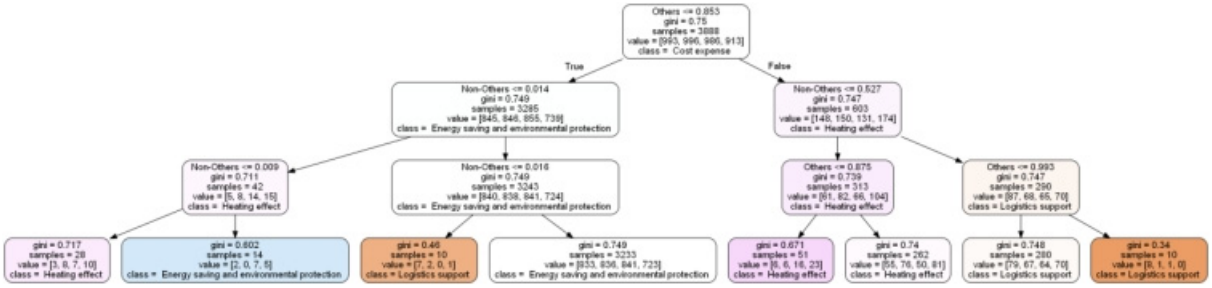

Figure 6. Analysis of clean heating promotion form

3. Development Proposals

According to this survey, the current residents of the interviewed provinces and cities have a certain cognitive basis for clean heating systems, but the overall awareness needs to be improved, at the same time, the willingness to accept the new clean heating model is relatively high, and overall, the development prospects of clean heating applications are good. Based on the above investigation and research on the application and development of clean heating in 12 provinces and cities, feasible suggestions are put forward to promote the popularization of new clean heating models in 12 provinces and cities and even the whole country from the four levels of government, enterprises, communities and individual residents.

3.1. Government

The survey shows that residents are more concerned about the policy subsidies for clean heating, so the relevant government departments can promote the vigorous development of the local clean heating industry to a certain extent through the introduction of special transactions and subsidy policies. At the same time, local governments should coordinate power grid companies and power plant enterprises to promote the implementation of clean energy heating price reduction policies; Due to the small number of clean heating enterprises, the government can introduce corresponding investment promotion policies to drive the vigorous development of regional energy-saving industries and alleviate the downward pressure on the economy through investment; In view of the "collective effect" of the new model of household use of clean heating, in order to improve people's livelihood and increase the level of heating in winter, it is recommended that the government uniformly carry out thermal insulation transformation and central heating of buildings using clean heating; Considering the limitations of the public's awareness of clean heating-related policies, it is recommended that relevant departments give priority to introducing certain clean energy heating subsidy policies to schools, nursing homes, welfare homes and other public welfare places, increase promotion and publicity, and promote these areas to effectively enjoy the convenience brought by clean heating, in order to improve the public's awareness of clean heating.

In the in-depth exploration of residents' willingness to pay and the environment, we found that residents with greater agreement on the impact of coal utilization on air quality are relatively more willing to pay. According to the cardinal utility theory, if residents believe that burning coal has a greater impact on air quality, the higher the utility of using clean energy heating to residents, and the greater their willingness to pay for clean heating Therefore, the premise of the implementation of clean heating policy should not ignore the education and awareness of residents' environmental protection knowledge.

ISSN: 2692-7608 DOI: 10.6981/FEM.202303_4(3).0018

3.2. Enterprises

Relevant enterprises should guide the selection of target customers for clean heating projects, coordinate clean energy enterprises to meet heating load demand through dispatching means, provide clean energy absorption capacity and utilization efficiency, and make full use of the difference in clean heating energy at night in winter, play the role of peak shaving and valley filling, and relieve the pressure on the heating system. Not only that, enterprises can carry out targeted marketing and publicity to target customers according to user profiles, increase the popularization of the elderly group, and suggest appropriate red line extension of residential clean heating and public welfare non-resident clean heating (schools, hospitals, etc.) to stimulate and improve users' demand for clean heating. At the same time, according to the number of users of households, a small number of people package equipment services are introduced to meet the needs of users with small numbers of households, and focus on user concerns, strive to improve the level of clean heating related technologies, reduce user costs, and do a good job in equipment maintenance services.

3.3. Community

The survey shows that there is a significant correlation between education and clean heating awareness and willingness to participate, and some respondents are not highly motivated by clean heating-related activities and publicity, and most of them are in a wait-and-see attitude. This paper uses the z-score method to standardize the three types of user variables obtained by user profile, and converts the individual answers to the question of choosing the clean heating promotion form in the questionnaire into numerical data for easy analysis, and the new media platform push, news/newspaper publicity, infrastructure advertising, and TV/ The results show that residents mainly obtain clean heating information through community publicity, so it is important to strengthen the knowledge and publicity of clean heating at the community level. Provide relevant training to residents with low cognitive ability to improve their awareness of energy conservation and environmental protection, so that they can truly understand the practical significance of clean heating, and at the same time train how to use clean heating systems, increase the publicity of clean heating, and promote the popularization and promotion of this model in the community.

3.4. Individual Residents

When the construction and operating costs of clean heating fall within an acceptable range, residents should take the initiative to assume social responsibility, carry out heating renovation work, eliminate backward and polluting coal-fired heating methods, and contribute to improving the surrounding living environment and winning the blue sky defense war. Enhance our own awareness of environmental protection, actively respond to the call of national policies, obey the leadership of the Party, and contribute to the construction of a beautiful China.

Acknowledgments

This work is supported by Anhui 2021 provincial college student innovation and entrepreneurship training program, Project number: S202110378487.

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