Fuzzy Load Forecasting of Electric Power System

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***Abstract*—In order to efficiently improve the prediction accuracy, two load forecasting model based on fuzzy theory are presented, which are fuzzy clustering model and improved fuzzy regression analysis model .The method of fuzzy clustering is used to divide the area by the similar feature of load increasing. The new division is promising to improve the result of evident degree of clustering index to power load, the weighted demarcating method is inducted. Another improved fuzzy regression analysis model combines the advantages of both fuzzyforecasting and regression analysis. According to the significance of the methods under different circumstances, it evaluates flexible and adjustable weight value by analytic hierarchy process. Finally,the improved fuzzy analytical hierarchy process are presented.**

***Index Terms*—load forecasting, fuzzy clustering, regression analysis, fuzzy judgment matrixes**

I. INTRODUCTION

The load forecast for electric power system is an important part of generation planning in electrical power system [1], which is an important theoretical base of economic operation .The essence of the load forecast is to use the known data to find the trend, then predict the future electric load status and change trend.

Load forecasting have been proposed many ways, the typical example are: Fuzzy regression analysis model [2]; time series analysis method; fuzzy clustering model; gray forecasting method and so on. As the change trend of the load forecast is decided not only its history, but also the current environmental impact. While the historical data collected and statistics are often not the comprehensive and accurate, so the above method is often unsatisfactory in the actual prediction.

In the rapid development and power supply shortage situation, a reasonable power system operation is particularly important. It provides some fundamental basis for power dispatching department to adjust the generated energy and startup and shutdown of units. Fuzzy mathematics is a new branch, which has been widely applied in the field of mineral exploration, weather forecasting and insect pests forecasting [3].

Load forecasting characteristics are frequent change, its change is a continuous process, generally speaking, it will not be a big jump, but the load forecasting on the season, temperature, and weather are sensitive, different season, different area climate, and changes in temperature will cause apparent effects on load. Load forecasting characteristics determine the total power load consisted of the following four parts basic normal load, weather sensitive load, special events, load and random load.

The load forecast for electric power system includes the largest active load; the reactive power load, and the load capacity. The size of the largest active load determines the basic data of the install capacity, the regional distribution characteristic of the active load of is the main basis of transmission planning and distribution planning. The size of the reactive power determines the foundation of reactive load power system planning; it is also an important factor which affects the safe operation of power system. In order to select the appropriate unit type, reasonable power source structure and the fuel plans, we must forecast load power. It is essential for the forecast load curve of power planning and power system, which determine the requirements of power structure, carving lower capacity, and the main basics of energy balance, which can provide some dates supplement to study of peak power system problems, pumped storage power station capacity and coordination of operation and transmission equipment. The load forecast for electric power system is divided into short-term, mid term and long term on different purpose. Short-term load forecasting model arrange for daily dispatch program and weekly schedule, including the identification of the unit starts and stops, thermal-hydro coordination, the power transfer of tie line, and economic load distribution, the mid term load forecasting is to determine the unit operating mode and equipment maintenance. Long-term load forecasting mainly base on economic development planning and the load demand for electricity power, the power network planning department do electric network transformation and expansion work. Mid term and long term forecasting, people should specially study of national economic development, the impact of national policy.

The key of the load forecasting is to collect large amounts of historical dates, to establish a scientific and

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effective forecasting model, using efficient algorithm, based on extensive research experiences, and the researcher should constantly sum up experience, in order to conform to the variation of power load. The historical load data is a side of the fundamental basis, share information adequacy and the reliability of the data, to predict the result is very important. Many survey data were collected, including electric power enterprise internal information and external information, related to the national economy department, and published and unpublished data from numerous data, pick out the useful part, namely data concentration to a minimum. The second, select the standard data should be directly related to the reliability, the third one, the latest. If the information is collected and selected properly, and it will directly affect the quality of load forecasting.

As a result of the prediction quality does not exceed the quality of information, collected and load statistics relating to the review and processing, to ensure that lay the foundation for quality prediction. We should pay attention not only to data intact, digital accurate, reflect the normal level, and data no abnormalities of the" separation", but also pay attention to information by calculating, the reliable data to verify adjustment.

The data preprocessing of data analysis, namely on the history data of the abnormal value of the smoothing and missing data to supplement, the abnormal data is mainly horizontal, vertical processing method. Data on the level of processing is in the analysis of data, before and after the two time of the load data as a reference set of data to be processed, the maximum range, when the data to be processed more than this range is considered bad data, using the method of mean value stable its change data processing in vertical load data is preprocessed into the small cycle, that different dates of the same moment load should have similarity, the same moment load value should be maintained in a certain range, for beyond the range of the bad data correction.

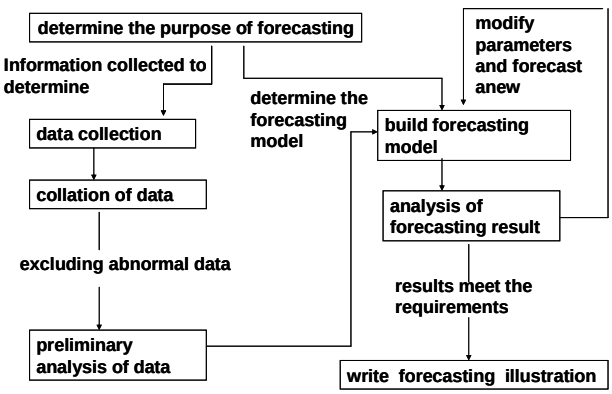

Figure 1. The process of load forecasting.

Load forecasting model is a statistical data path is wraparound, predicting model is varied, for specific information to select the appropriate model; load forecasting is an important step in the process. When the model resulting from the inappropriate choice of prediction error is too large, you need to change the model, or using some mathematical models for operation, to compare, select. After selecting the appropriate predicting technique, establish the mathematical model for load forecasting work. To influence the predicting new factor to carry on the analysis, the prediction model was modified to determine the predictive value of right.

Power load forecasting is divided into predictions of classical and modern forecasting.

Classical prediction method mainly has the exponential smoothing method, trend extrapolation method, time series analysis, and regression analysis. Base on the emerging discipline of modern theory predicting method has been successfully applied. Mainly grey mathematical theory, the methods of expert system, neural network theory, and fuzzy predicting theory. Fuzzy load predicting in recent years is the hot research direction; the following mainly introduce fuzzy load forecasting.

Fuzzy control apply the theory of fuzzy mathematics, some are unable to construct the mathematical model of the controlled process of effective control. Fuzzy system regardless of how the internal calculate, from input output point of view it is a nonlinear function. Fuzzy system for an arbitrary nonlinear continuous function, find out a kind of membership function, a kind of inference rules, a fuzzy solution method, making the design of the fuzzy system can approximate any nonlinear function.

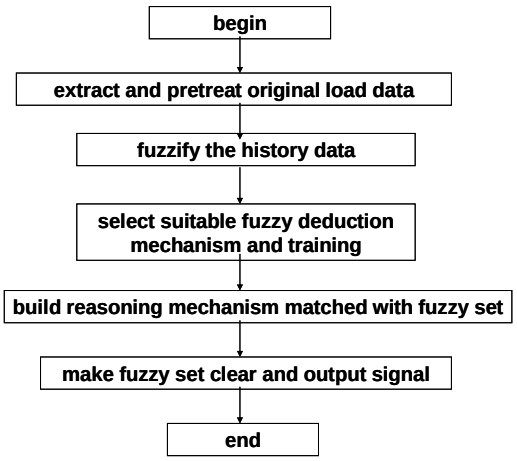

Figure 2. Fuzzy forecasting process

Fuzzy inference system is the concept advanced computing framework basing on fuzzy theory, fuzzy IF-THEN rules and fuzzy reasoning, basing on the concept of advanced computing framework. In automatic control system, decision analysis, expert systems, time series prediction, pattern recognition, and many other fields . The basic structure of fuzzy inference system generally consists of three parts: a rule base, including a series of fuzzy rules; a database (or dictionary), which defines the membership function used in fuzzy rules number, a reasoning mechanism, according to the given facts, rules, perform the reasoning process, in order to achieve a reasonable output or conclusions.

Reasoning is based on certain principles, known from one or a few which come out of a new judge to determine the dimensional process. In general speaking, the reasoning of the judge contains two parts, part of the

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judge is known for the starting point for the reasoning, called the premise (or antecedent) Another part is the result of the judge, the push by the premise a new judge, called the conclusion (or after the piece).

People understand the world in the process contains a lot of the reasoning process, reasoning on many forms, Such as direct and indirect reasoning. Indirect reasoning based on knowledge of the direction, can be divided into deductive reasoning, inductive reasoning and analogical reasoning. Deductive reasoning is the premise and the conclusion contains the relationship between reasoning, speech sounds of the most common form of reasoning is syllogistic reasoning, there is affirmative (or take-type) and the negative (or resist Take style) categories.

Assuming P, Q are the two-valued logic in two simple propositions, propositional connectives can be used "→", it will two proposition banded together, a compound proposition that P → Q with the symbols indicated. "→" is called implied in table "if ... then ..." means, as IF-THEN fuzzy rules.

In the two-valued logic, IF-THEN rules are simple, if the precondition is true, then the conclusion is true. However, if the prerequisite is a known fuzzy state or a certain degree of ambiguity, this conclusion reflect the state of ambiguity in the way: If the precondition is a certain degrees true, then the conclusion is true to some extent.

In the two-valued logic: P → Q (P and Q can only be true or false in one):

In fuzzy logic: P → Q (P introduces a degree of a certain degree Q).

Corresponds to the concept of the mathematical logic, and fuzzy logic have fuzzy proposition. Fuzzy propositions contain fuzzy logic. There are elements of fuzzy neither propositions, determine the result is often a non-true nor false, is ambiguous between true and false state. If P, Q is the fuzzy proposition, then P → Q is called the likelihood inference sentence, reasoning with this some degree of ambiguity.

Assuming $p_1, p_2, \cdots, p_n$ and Q is narrow fuzzy predicating, get the [0,1] as the true value of the real number of fuzzy predicating and inference rules set up the following form: $p_1, p_2, \cdots, p_n \to Q, CF, \tau$,Which the rules of CF as confidence that the rule is true credibility 0 <CF ≤ 1, τ is called the rules "can be applied threshold", $0 \le \tau \le 1$.

Because in many practical problems, inferences rule in the premise of the importance of the various sub-premises or the amount of information contained in each other may be not the same. In order to express practical problems, reasoning is following rules:

$$w_1 \times p_1, w_2 \times p_2, \cdots, w_n \times p_n \to Q, CF, \tau .$$

Among $p_1, p_2, \cdots, p_n$ and Q are the fuzzy logic predicate, get real value in [0,1], $w_j : w_j \ge 0 (j = 1, 2, \cdots, n)$, plus $\sum_{j=1}^{n} w_j = 1$,CF for the rule of confidence that the rule is true credibility 0 <CF ≤ 1, τ is the rule," applicable threshold", $0 \le \tau \le 1$.

In summary, fuzzy reasoning is also known as fuzzy logic, fuzzy proposition is known and the introduction of new fuzzy proposition treats as the conclusion of the process.So showing fuzzy theory is approximate reasoning.

II. Application of Fuzzy Clustering in Sub Area Load Forecasting

Current sub area load forecasting[6] divides the area by the administrative region directly and the same administrative region used the same parameters, but the division of administrative divisions is based on the needs of the administration and if the jurisdiction of the range is relatively large, even in the same region the features of load increasing may has great difference. In this case, using the same parameters studies sub area load forecasting has a great error in an administrative region.

In response to these problems, it can consider taking subdivision clustering method for n administrative region, which can subdivide the first $i (i = 1, 2, \cdots, n)$ administrative region into m_i pieces[7], so there is small $\sum_{i=1}^{n} m_i$ area totally. It regards environmental factors (output, population, etc.) affecting the load growth as index to $\sum_{i=1}^{n} m_i$ small region fuzzy clustering and clusters into r classes in order to achieve fuzzy clustering of the geographical space. Economic conditions and the law of the load growth are relatively close to each class in the small area. After clustering using same parameters are more reasonable in the same class region [8].

Fuzzy clustering [9] usually implicitly assumed the equal importance of sample various index, while the various factors of load level on the contribution of clustering end result clearly should be different. This paper introduces a weighted calibration method in order to highlight an important Index impacting on the final clustering results [10].

The purpose of standardization of original data is to exclude the influence that every index are different dimension in the original data, to make the original data distribute in the same interval and to make it classified with the same order. The common way is to make the original data except dimensional effect compressed in closed [0,1] interval. Let it have n classification object, m factor index, consisting of the following matrix [11]:

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nn} \end{pmatrix}$$

Calculate the average of the first $k (k = 1, 2, \cdots, m)$ factors: $\overline{x_k} = \frac{1}{n}(x_{1k} + x_{2k} + \cdots + x_{nk})$ (1)

Calculate standard deviation: $S_k = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_{ik} - \overline{x_k})^2}$ (2)

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Calculate standardized value: $x_{ik} = \frac{x_{ik} - \overline{x_k}}{S_k}$ (3)

Calculate standard value: through the above changes, if Matrix elements value can not be guaranteed in the closed interval [0,1], we can consider using extreme standardization formula to further control the range of matrix elements, calculating the standard value. Concrete forms of extreme standardization formula are as follows [12]:

$$x_{ik} = \frac{x_{ik} - x_{k\min}}{x_{k\max} - x_{k\min}} \quad (4)$$

$$x_{ik} = \frac{x_{k\max} - x_{ik}}{x_{k\max} - x_{k\min}} \quad (5)$$

Where: $x_{k\max}$ is maximum eigenvalue of the first k Index, $x_{k\min}$ is minimal eigenvalue of the first k Index, x_{ik} is the standardization value of x_{ik}, $0 \le x_{ik} \le 1$. When the index is positively correlated with the sample, the extreme standardization can use equation (4). When the index is negatively correlated with the sample, the extreme standardization can use equation (5). By (4) or (5) index characteristics matrix can be reduced to relatively optimal membership degree matrix.

To structure fuzzy relationship matrix, basing on various standardized data of each classified object calculated its similarity degree is need, which was called calibration. Cosine method, similar coefficient method, Euclidean distance method and the method of absolute value subtrahend are commonly used calibration methods. Calibration methods of absolute value subtrahend are as follow:

$$r_{ij} = \begin{cases} 1, i = j \\ 1 - c\sum_{k=1}^{m} \left| x_{ik} - x_{jk} \right|, i \ne j \end{cases} \quad (6)$$

Where (6): parameters c should be appropriately selected to ensure $0 \le r_{ij} \le 1$.

When selecting the calibration method, carefully analyze the inherent characteristics of the researched questions and select one or a few more appropriate calibration method. Similar relation of each element is reflected as it and at the same time building the fuzzy similarity matrix r on the matrix x is as follows:

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{pmatrix}$$

In general, the fuzzy similar matrix R is just to meet reflexivity and symmetry, but transitivity does not meet, and you can use square method to calculate the transitive closure $t(R)$ .By the transitivity on theorem of fuzzy relations, composite operation process can be applied to the fuzzy similar matrix R [13]:

$$R \to R^2 \to R^4 \to R^8 \to \cdots\cdots$$

and a Positive Integer n exists all the time to let $R^{2^n} = R^{2^{n-1}}$ and get the transitive closure $t(R) = R^{2^{n-1}}$, which is the fuzzy equivalent matrix to be solved.

In accordance with classification standards and classification requirements, use dynamic cluster analysis method in fuzzy mathematics theory, select the appropriate, intercept corresponding cut matrix and get a concrete classification result. By structuring fuzzy statistics you can test whether the number of categories is appropriate and concrete method is as follows:

$$F = \frac{\sum_{j=1}^{r} n_j \left\| \overline{x^{(j)}} - \overline{x} \right\|^2 / (r-1)}{\sum_{j=1}^{r}\sum_{i=1}^{n} n_j \left\| x^{(j)} - x \right\|^2 / (n-r)} \quad (7)$$

Where(7):F is fuzzy statistics, n_j is the number of classification object in the class j, r is classification number and the meaning of remaining symbols is as above. A λ corresponds to a classification number r, according to equation (7) you can calculate the statistical F value and the statistic submitted to F distribution whose degrees of freedom are $(r-1, n-r)$. Value F is Large, indicating that the distance between classes is large and the difference between classes is relatively large, at the same time samples are more compact and classification results are better in the same class. Value F obtained provides evidence for determining the appropriate classification by comparing the value F with [14]:

$$F_\alpha(r-1, n-r)(\alpha = 0.05)$$

It is illustrated by the weighted absolute value subtraction method. Considering in the equation (6) introducing of M-dimensional weight column vectors, for factors K whose influence is relatively large its corresponding weights α_k is relatively large, and demarcating formula impacting on the size of the Index is as follows:

$$r_{ij} = \begin{cases} 1, i = j \\ 1 - c\sum_{k=1}^{m} \alpha_k \left| x_{ik} - x_{jk} \right|, i \ne j \end{cases} \quad (8)$$

To determine M-dimensional weight column vectors, one method is synthetically to consider the relationship between all factors and the dependent variable .then either basing the practical problems needs the subjective determination or by the method of determining membership functions.

III. LOAD FORECASTING BASED ON IMPROVED FUZZY REGRESSION ANALYSIS

Long-term load forecasting in power system is also frequently used in regression analysis, and then forecasting methods are simple, which requires more historical data. As their own shortcomings, it is difficult to use in the absence of historical data. The method of fuzzy forecasting method without too much historical data characteristics, which combine the two methods, with a flexible and weighted demarcating prove that long-term load forecasting method is effective.

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The emergence of the method of fuzzy forecasting method is a new development the power system load forecast, but also a new supplement. Fuzzy forecasting introduces a "membership" concept, so that planning decisions in several mutual restraints of the target; you can choose an appropriate proportion relation to provide reference for decision makers [15].

Taking into account historical data in a certain interference values, so a smoothing preprocessing of the data is necessary.Using the following filtering technology:

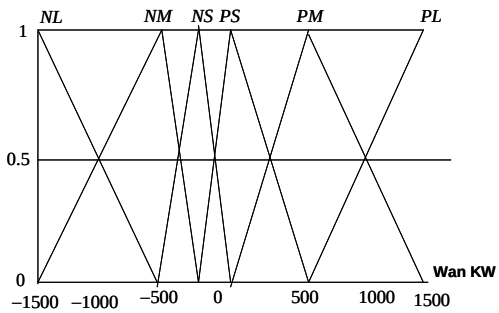
$$\text{If} \begin{cases} |y(t)-y(t-1)| > \xi_1 \\ |y(t)-y(t+1)| > \xi_2 \end{cases} \quad (9)$$

Then $y(t)=\frac{1}{2}[y(t-1)+y(t+1)]$ (10), where (10), $y(t)$ is extraction load from historical dates.

After the data pre-process, and the data pre-fuzzy. The so-called fuzzy process is to give a membership degree, making belong to a particular theory of domain, such as membership functions:

$$u_{ti}(x_t)=\begin{cases} \dfrac{x_t-a_{t(i-1)}}{a_{ti}-a_{t(i-1)}}, a_{t(i-1)} \le x_t \le a_{ti} \\ 1-\dfrac{x_t-a_{ti}}{a_{t(i+1)}-a_{ti}}, a_{ti} \le x_t \le a_{t(i+1)} \\ 0, a_{t(i+1)} \le x_t \le a_{t(i-1)} \end{cases} \quad (11)$$

Where $u_{ti}(x_t)$ is the history of the load at time x is a collection of the membership. a_{ti} base on different load characteristics set membership in the center. The historical data of membership of the membership show in figure 2. The paper will historical data divide into PL / PM / PS / Z / NS / NM / NL [16].



Fiurge 3. the membership degree of every historical data

By fuzzy logic theory, meaning from a series of dates is not very accurate, which derive almost accurate results in the process. Precondition: If X is A, then Y is B; if X is A', Y is B', then $B'=A'(A \to B)$. For example: If the voltage change rate is A, then the amount of excitation current is B, the specific amount of voltage change is A' ,then the specific the amount of excitation current is B' . In this paper, the traditional "If-Then" adopt mode inference rules. Specifically addressed as "if the load at the time t is Z / M / L, the rate at the time t compared with historical rate data is PL / PS / Z / NS / NL, and history time t compares with the next historical moment change trend is PL / PM / PS / Z / NS / NM / NL, so the next time load forecasting values is y_{t+1}. " The true value of each rule conditions is $u_r=\prod_{t=1}^{T} u_{ti}(x_t)$: The final fuzzy inference is $Y=\sum_{r=1}^{R} u_r y_{t+1}$, the total forecasting time is T, and R is the total number of rules.

Application of the methods described in this article is written procedures, an area in the past five years(2005-2009) predict the fitting load results and error control ,as shown in figure 4 and figure 5. From the results can see, the regression analysis and fuzzy theory is used in load forecasting, the load will be weighted between the two predicted values and an acceptable range, the predicting error compared with the same prediction method significantly reduce the average forecasting error rate which is 2.822 %. It is a more suitable long-term load forecasting method.

IV LOAD FORECAST BASED ON THE IMPROVED FUZZY ANALYTIC HIERARCHY PROCESS

For the rapid development of regions, long-term load forecasting results which were obtained by different forecasting methods would be a far cry from each other; even some of the predictions were valid and credible. Therefore, there were not only a variety of forecasting methods in planning decision support system ,but also its simulation decision module should be added .Applying the improved fuzzy complementary AHP method to the prediction simulation decision system and building the multi-level and multi-factor decision analysis structure of power load forecasting, it could make use of expert knowledge to construct judgment matrix that had fuzzy reciprocal of individual or population decision and calculate the eigenvector concisely and accurately. This further processed feature vectors acted prediction decision weight and obtained a satisfactory prediction decision.

Analytical Hierarchy Process (AHP) [17] made a multi-level, multi-related factors question expressed as an ordered hierarchical structure, and the method which ordered the advantages and disadvantages of alternative scheme was used to make program decisions and weight calculation. As the traditional AHP used1～9 reciprocity judgment scale and it was easy to present the problem which did not meet the consistency requirements, this paper introduced fuzzy thought and methods in hierarchy analysis and constructed judgment matrix that has fuzzy reciprocal. Judgment matrix was a matrix formed by mutual pair wise comparison, which was that all the elements on the same level was relative to some factor on the zone above comparison .Using different judgment scale, it would obtain a different matrix result , fuzzy complementary scale used 0. 1～0. 9 methods, this paper further expanded its extreme values to 0 and 1, the basic principle which took value was to have comparison

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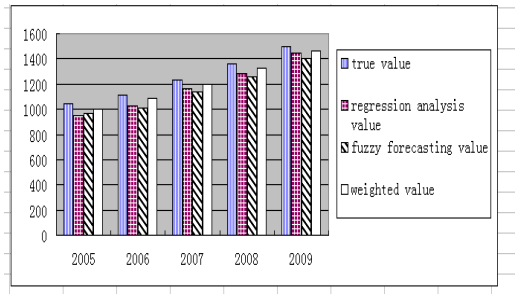

Figure 4. Analysis of forecast results.

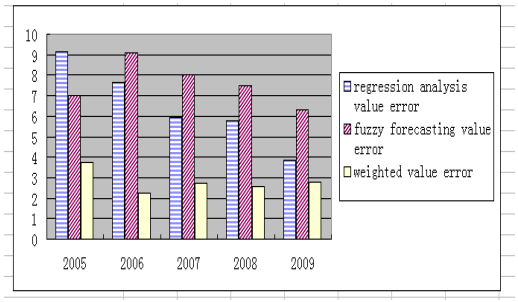

Figure 5. Comparsion of calculation error

judgment quantified with fuzzy numbers, and quantified judgment scale had a intercomparison equivalence ,namely the compared result a_{ij} between i and j and the compared result a_{ji} between j and i had the equivalent calibration relationship, or the degree that i was better than j was the same as the degree that j was worse than i, when a_{ij} ranged from 0 to 1, a_{ji} ranged from 1 to 0. It had improved the excessive differences between a_{ij} and a_{ji} when the original AHP used1-9 scale, that is to say, when a_{ij} ranged from 1 to 9, while a_{ji} ranged1 from 1/9to. In addition, Fuzzy complementary judgment matrix could be transformed into a fuzzy consistency judgment matrix by conversion formula, so consistency test was not necessary to be done, thus improving the consistency problem of the original AHP method.

For fuzzy complementary judgment matrix $A=(a_{ij})_{n\times n}$ you summed up them by row: $r_i=\sum_{j=1}^{n}a_{ij}, i=1,\cdots,n$ and transforming: $r_{ij}=\frac{r_i-r_j}{2(n-1)}+0.5$ .Then the fuzzy consistency matrix could be obtained $R=(r_{ij})_{n\times n}$. With the matrix R using the row sum normalization it obtained eigenvectors $W=[w_1,w_2,\cdots,w_n]^T$ meet:

$$w_i=\frac{\sum_{i=1}^{n}a_{ij}+\frac{n}{2}-1}{n(n-1)}, i=1,2,\cdots,n$$

Many experts participate in decision generally, so it must be extended to population decision. Suppose the number of s experts gave fuzzy complementary judgment matrix:

$$A_k=(a_{ij}^{(k)})_{n\times n}, (k=1,2,\cdots,s).$$

For matrix $A_k(k=1,2,\cdots,s)$ you summed up them by row to obtain:

$$r_i^{(k)}, i=1,2,\cdots,n; k=1,2,\cdots,s$$

with s transformation you could obtain $r_{ij}^{(k)}, k=1,2,\cdots,s$, namely obtaining fuzzy consistency matrix:

$$R_k=(r_{ij}^{(k)})_{n\times n}, (k=1,2,\cdots,s).$$

Compose operation of fuzzy consistency matrix had a clear practical significance, that was to say, it could integrate in population decision fuzzy consistency matrix given by many experts themselves to fuzzy consistency matrix, thus forming an effective Population decision. Constituting a synthesized fuzzy consistency matrix:

$$R'=(r_{ij}')_{n\times n}, r_{ij}'=\sum_{k=1}^{s}\lambda_k r_{ij}^{(k)}, \lambda_k>0\sum_{k=1}^{s}\lambda_k=1,$$

synthesized fuzzy consistency matrix R' used the row sum normalization to obtain weight vector:

$$w=[w_1,w_2,\cdots,w_n]^T, w_i=\frac{\sum_{k=1}^{s}\sum_{i=1}^{n}\lambda_k r_{ij}^{(k)}+\frac{n}{2}-1}{n(n-1)}, i=1,2,\cdots,n$$

Accordance with the above method, it could calculate the each rule eigenvector which was schematic layer to rule layer, namely n m-dimensional column vector:

$$W_k=[w_1,w_2,\cdots,w_n]^T, k=1,2,\cdots,n$$

structured relative eigenvector matrix W .Let relative eigenvector matrix $c=[c_1,c_2,\cdots,c_n]^T$, which was rule layer to target layer be, then the decision total vectors were: $\mu=Wc$.

Load forecasting model not only need accurate and forecast accuracy, at the same time, and the predicting method applicability, prediction result, economic development of the fitness and a number of evaluation criterion. So it is not only the prediction and optimization problems, but multiple criteria, multiple levels of analysis, judgment and decision problems. In order to describe and solve the load forecasting problems of scientific decision-making and the corresponding AHP method applied, the load forecasting decision of establishing analytic hierarchy structure, at the same time determine the structure of the corresponding criterion and program content. In a decision analytic hierarchy structure, three layers which are the target of layer, criteria layer and scheme layer. Among them, object G is to obtain a satisfactory power load forecasting results of decision. For the load forecasting relative factors, in criterion layer and scheme layer select the corresponding criteria and program content.

Scheme layer consist with power load forecasting decisional support system which have existed forecasting method and forecast results. Assuming the total prediction methods are M, each prediction method and its forecast results are counted as an alternative scheme decision $S_i, i=1,2,\cdots,m$. If the actual values of historical time is $x_t(t=1,2,\cdots,T_1)$, for the future time is $T_1+1\le t\le T$, using M kinds of predicting method, the forecasting result: $y_{it}(i=1,\cdots,m,t=T_1+1,\cdots,T)$, so :

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$$S_i = \{i, y_{it}, t = T_1 + 1, \cdots, T\}, (i = 1, 2, \cdots, m).$$

The criteria layer C of $C_i, i = 1, 2, \cdots, n$ can treat as decision-making subsystem; every standard consist of the total target and various factors. In order to accurate analyze and reflect the forecast and decisional problems in related factors, prediction and decision criteria are: historical data corresponding to the fitting accuracy and the future economic development corresponding, forecasting method is adaptive, forecasting result real.

The scheme layers are calculated relative to the target: respectively set up the all relative to each criterion of judgment matrix $A_k = (a_{ij})_{m \times m}, (k = 1, 2, \cdots, n)$. On n matrix A_k , then respectively calculates their characteristic column vector $W_k = [w_1, w_2, \cdots, w_n]^T, k = 1, 2, \cdots, n$.[18]

The criterion layers are calculated relatively to the target layer: Empathy, can calculate the criteria layers C of n relating to the overall goal of the judgment matrix and its characteristic vector $c = [c_1, c_2, \cdots, c_n]^T$ .According to the general vector size on ranking, abandon the poor part rank at the bottom, and on the retention of m' better program normalized weighting $\mu_i' = \mu_i / \sum_{i=1}^{m'} \mu_i, i = 1, \cdots, m'$, calculating m' optimized scheme combined forecast, obtaining forecasting and decision results are:

$$Y = [y_{T_1+1}, \cdots, y_T]^T, y_t = \sum_{i=1}^{m'} \mu_i y_{it}, t = T_1 + 1, \cdots, T .$$

Applying the methods described in this article, the results of an area is shown in figure 6.

In the theory of decision analysis [19], the feature vector are ranked from big to small, then the program are ranked from good to bad, decision will select the most satisfied a recommend as results. From the practical significance, the feature vector is the important reflection of the degree program. In the application to load

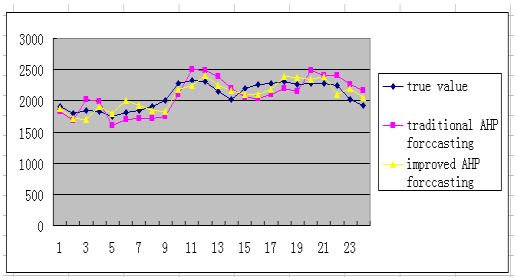

Figure 6. Comparison of forecasting

forecasting in decision-making, as a predictor of decision recommendation results can also choose the most satisfactory forecasting results, but in order to more effective plan ,various forecasting methods and related factors, so that the decisional result is more scientific, reasonable and accurate, it should be further applied the feature vector, for the forecasting results combine . However, if all the programs regardless of quality are included in the mix, it may be due to poor solution caused by the impact of errors in decision-making. Because the fuzzy complementary AHP algorithm in obtaining matrix consistency at the same time, the feature vector is also tend to be the same question, this will increase the worst scheme effect, so in the ranking of the alternatives, at the end of the programmer is thought to be inferior and were discarded. At the same time, the better programs is the normalized weights, combination calculation, the decision method to obtain the predictive value of satisfactory solution for decision support system, which is more practical, scientific, effective.[20]

V CONCLUSION

This paper took advantage of fuzzy clustering ideas to realize new subarea, thus improving prediction effect of subarea load forecasting. Aiming at the long-term load forecast for electric power system, we proposed fuzzy regression analysis algorithm. The improved fuzzy AHP was used in prediction simulating decision-making system to build multi-level and multi-factor decision-making analysis structure. In the network planning the analysis on load also required further research, particularly the kinds of factors analysis which affected load needed to be strengthened. The best way was to do the quantitative analysis of these factors on the load of influence degree. In short, accurate load forecasting was the foundation of designing excellent power system, excellent power system settings was the premise of building strong grid, strong grid was the strong support for rapid regional economic development, so making well the power system load forecasting was the very meaningful work and improving the load forecast for electric power had enormous economic and social benefits.

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