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A NATIONAL GEOTHERMAL ENERGY UTILIZATION DATABASE IN CHINA

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ABSTRACT: Geothermal fields widely distribute in China and geothermal energy utilizing methods vary greatly and, accordingly, the geothermal energy utilization data are numerous and complicated. Data and information are playing more and more important parts in various activities with the development of science and technology and enlargement of utilization scale. Because of the data proliferation, diversification, complication and importance of timeliness, data recalling, accumulating, inquiring and calculating are significant problems encountered and, solutions of which lie in the creation of databases. The National Geothermal Energy Utilization Database given in this paper is the first example of its kind in China and, its logic design and physical design have been finished. Presented in this paper is the creation of the database, its background, purpose, structure and functions.

INTRODUCTION

China has quite a long history of utilizing geothermal energy. Hot spring water was already used for irrigation as early as in the Eastern Zhou Dynasty (c. 770-256 B. C). (Yang, 1985) Beginning from the time of the first emperor of Qin (221-206 B.C.), descriptions of hot spring bath made by men of letters of each dynasty can be found in historical records. (Huang et. al., 1985) In Xiaotangshan in northwestern Beijing, geothermal fluid found its application in medical treatment in the Ming Dynasty (1368-1644 A.D.). (Lund, 1982) But it was not until 1970, did Professor Li Siguang, a well-known geologist, initiated the relatively large-scale exploitation and utilization of geothermal energy in China. During the period of the 6th five-year-plan of the state (1981-1986), the research and development of geothermal energy was brought into line with the state plan, and accordingly, the Ministry of Geology and Minerals worked out corresponding plans for prospecting and development of geothermal energy. China entered a period of nationwide unified planning in geothermal energy development, and utilization scale has been getting larger ever since. (Cai, 1987) Now the geothermal energy exploitation and utilization has been listed in the 7th five-year-plan (1986-1990) of the state and it will develop rapidly.

The Map of Hot Spring Distribution in China shows that there are hot spring manifestations over more than 3/4 of the territory and there are about 2500 geothermal points across the country. (Huang et. al., 1981) Geothermal prospecting and exploitation have been conducted in more than 20 provinces or municipalities or autonomous regions, a series of geothermal energy utilization bases, research institutes and management organizations have been established and, up till now, geothermal power generation has reached a capacity of 14.5 MW and, (DiPippo, 1986) non-electric utilization, 1945 MW. (Gudmundsson, 1985)

Since China is a large country and geothermal fields distribute widely, there are a variety of forms of utilization. Besides power generation, geothermal energy is used in industries of textile, food, dyeing, drying and heat supplying; in civil use, there are heating, air conditioning and hot water supplying; in agriculture there are seedling raising, seeds breeding, edible fungi nursing, aquaculturing, breeding and overwintering, incubating and brooding; moreover, there are uses in convalesce, physiotherapy and tourism, etc..

Thus it can be seen that the geothermal energy utilization data are numerous and complex. Of the data about a single well, there can possibly be more than 300 terms and, there are many thound geothermal wells across the country. But by means of the database, these data can be well organized and processed, and the data recalling, statistics and inquiries well facilitated and, the time required for these processes greatly reduced.

To keep abreast with the time and contribute to the geothermal energy exploitation, development, statistics and management, a database must be worked out for the automatic analysis of geothermal energy utilization data. This will help the leading organizations to decision-making, program formulating, national and international information exchanging. Therefore, the National Geothermal Energy Utilization Database has been listed in the 7th five-year-plan scientific research projects and has been undertaken by the Tianjin Geothermal Research and Training Center, Tianjin University. Much has been done about the project by the Center. Described in this paper is the set-up of a base for geothermal energy utilization data (including electric and non-electric). The structure and functions and other characteristics of the database are also introduced in this paper.

LOGIC DESIGN OF THE DATABASE

The logic design of tne database is to organize the data in a form conforming to the structure model adopted by the database management system. There are many database models among which more prevalent ones are hierarchical, network and relational ones. (Wang and Zhang, 1986) The relational model came into being relatively late, and in a database of such a model, all the data present themselves in a two-dimensional form, all the data in a row form a elementary group, or a record, and all the data in a column form a field. In the first row are names of each column, which are usually refered to as attributes or field names [illegible] frameworki the "Investigation Form of The National Geothermal Energy Utilization" was designed. Contained in this form are as follows:

1. location and affiliation:
   including province (municipality, autonomous region), country, township, village, affiliation, telephone, cable, nature of affiliation, liaison man, person in charge, other specifications;

2. profile of the geothermal well:
   including drilled or natural, No., depth, water temperature, flow rate, pressure, static level, dynamic level, barometer, thermometer, flow meter, measurement of dynamic and static water level, well head automation degree, type of pump, type of fluid, depth of casing, casing diameter;

3. utilization:
   1.) power generation:
   including type of system, type of medium, medium pressure, medium temperature, medium flow rate, installed capacity, setting time, number of wells in service, discharged water temperature, comprehensive utilization of discharged water, disposition of discharged water, operation hours per year, number of technicians, number of workers, working fluid in binary cycle system, main problems encountered, other specifications;

   2.) geothermally heated greenhouses:
   including number of greenhouses, total area, type of structure, cover material, heat supplying method, supplied water temperature, discharged water temperature, where water is discharged, water flow rate, direction of greenhouses, products and outputs, type of ventilation, thermal insulation method, structure material, automation level, economic benefit, heat supplying days per year;

   3.) geothermal overwintering fish farming:
   including number of ponds, total area, cover material, type of ventilation, shelter height, type of pond bottom, products and outputs, economic benefit, supplied water temperature, flow rate, where water is discharged, pond water temperature, automation level, heat supplying days per year;

   4.) edible fungi culture:
   including species, area, outputs, economic benefit, supplied water temperature, flow rate, discharged water temperature, heat supplying days per year;

   5.) geothermal incubation and brooding:
   including number of incubating boxes, capacity (total number of eggs), supplied water temperature, number of eggs incubated per year, egg output per year, 60-day-old chicks output per year, 90-day-old chicks output per year, incubating hall area, brooding hut area, economic benefit, water flow rate, discharged water temperature, where water is discharged, other specifications;

   6.) geothermal heating:
   including heating method, heating area, supplied water temperature, discharged water temperature, water flow rate, indoor temperature, where is heat supplied, heat supplying days per year, where water is discharged, peak modulating boiling type, maximum temperature of peak modulation;

   7.) geothermal drying:
   including product, output, supplied water temperature, water flow rate, discharged water temperature, equivalent coal or power saved per year, heat supplied days per year, other specifications;

   8.) various industrial and other utilization (fill in as many as there are):
   including project, supplied water temperature, water flow rate, discharged water temperature, where water is discharged, heat supplying days per year, equivalent coal or power saved per year;

   9.) geothermal shower:
   including supplied water temperature, water flow rate, class of bathroom, capacity (person x time/day), where water is discharged, annual income;

   10.) physiotherapy and convalesce:
   including supplied water temperature, water flow rate, number of beds, discharged water temperature, diseases on which there are most distinct curative effects, mode of physiotherapy, number of doctors, where water is discharged, annual income;

4. pipe network:
   including type of pipe network, thermal insulation material, pipe material, heat exchangers, total length of network, length of Dg50, Dg70, Dg80, DglOO, Dgl25, Dgl50, above Dg200;

5. corrosion:
   including material corroded, corrosion location, corrosion degree, anti-corrosion method, time when using started;

6. scaling:
   including scaling location and material, scale type, scale degree, scale colour, property of scale, easy or not to clean, anti-scaling method;

7. investment and economic benefit:
   including total investment, separating investment, output value, profit, equivalent coal or power saved per year;

8. chemical analysis of geothermal water and environmental pollution:
   1.) chemical analysis of geothermal water:
   including sampling date, sampling depth, sampling temperature, date of analysis, person in charge of technology, person in charge of analysis, collator, tabulator, concentrations of commonly encountered positive ions and negative ions, soluble silicon dioxide, total degree of mineralization, solid material, total hardness, permanent hardness, temporary hardness, negative hardness, total alkalinity, total acidity, free carbon dioxide, eroding dioxide, DO, COD, pH value, various harmful components, different gases, radioactive elements;

   2.) environmental pollution:
   including pollution form, degree of pollution, anti-pollution method, disposition of discharged water;

9. technical personnel:
   1.) statistics of personnel:
   including number of technicians, number of managers, number of workers, other specifications;

   2.) personnel in charge of technology:
   including names, sexes, dates of birth, educational levels, specialties, positions.

In this form, the computers' and form fillera' convenience were taken into account. We have done our best to include in the form all the data concerning geothermal energy utilization. One form deals with only one geothermal well. Natural hot springs (including hot water, boiling water and geysers) are also treated as wells, depths of which are taken to be "0". The content of the form is based on dicussions of well qualified and experienced experts on geothermal energy and many times of modifications. Up to this point, the design of the logical structure of the database is completed.

DESIGN OF THE DATABASE MODEL

The database model design is just its physical structure design. It is to select an optimum application environment and ensure the realization of the functions of the database. (Sa and Wang, 1985) According to the conditions of our computer room, we designed the structure of the database, which is illustrated in Fig.l. Detailed discriptions are presented as follows:

1. System Environment

For choice of system environment, the following aspects were considered in order to achieve operation reliability and security.

Choice of Computer The domestic "Great Wall" 0520CH, while completely compatible with the American IBM-BC, has an advanced Chinese character system. As of hardware configuration, it has a high-precision colour graphic panel and a colour display screen, which is capable of high-resolution display of graphs. So the "Great Wall" 0520CH was selected.

Choice of Operation System The GWBIOS is the operation system specially designed for the "Great Wall". Chinese character input, processing, display and printing are made possible to the convenience of Chinses character operation. (Great Wall 0520CH DOS Manual)

Choice of the Management System of the Database Based on dBASEII, dBASEIII was developed by the Ashton-Tate Corporation in America through many improvements. (Ling and Li, 1987). It offers a set of structural application development language with copious sentences, which form a independently perfect system. It facilitates flexible man-machine dialogue and advanced structural program design. (Yin et. al., 1986) So dBASEIII was selected.

Choice of Inputting and Outputting Mode In view of the characteristis of our country and the needs of the vast numbers of geothermal technicians, recalling of the database should be Chinese-characterized, therefore, Chinese charaters are used for inquiry and data output.

2. Profile of the Database

There are many approaches to the organization and design of a database system, but whatsoever mode is adopted, the data source in the database must be shared by all the different users, namely, it must be able to meet various needs. Therefore the mode of the database should be as such that various sub modes can be abstracted out of it. At the same time, the independence of the data, especially that of the logic data, should be ensured for the convenience of extension. Advanced tactics are employed, which lead to prompt response to various inquiries, and it is able to check and recover the integrity of the data and prevent damage to it caused by the external factors, the value of existence of the data source is thus preserved. Secondly, it is convenient and flexible to users, its screen display is clear and printing pleasing to the eyes. All these reflected our general thinking.

3. Specific Problems Encountered

1.) The geothermal energy utilization data fall in nine categories and these data contain a large amount of information and has a complex hierarchy. In the light of these characteristics, a subbase was set up for each category and all these subbases form a general base. Although the number of bases increased, the hierarchy is clearer and inquiry is made easier. Those involved in geothermal energy utilization are often interested in only one category, and accordingly, the corresponding base can be opened for them and the inquiry scope is thus reduced and promptness increased.

2.) All the numerical numbers in the database need to be defined with units. In order to avoid inputting various units along with these numbers for inquiry, we simplified all the units and put them together with the field names, data input rate was thus greatly increased. In inquiries, users, prompted by menus, make their choices of conditions by means of the mode of man-machine communication. Tables of phrases in common use have been compiled, input of large numbers of Chinese characters, therefore, are avoided. Input rate is increased and, input method, simplified.

3.) There are a great number of symbols of chemical elements and valences where the water quality analysis is concerned. In order to express these symbols strictly and conventionally, band 88 is exploited and the expanded character libraries of 16x16 dot matrix for screen display and of 24x24 dot matrix for printer output were employed, and these special symbols were thus created. Therefore, the expression forms of the database were, more perfect.

FUNCTIONS OF THE DATABASE

For a geothermal energy utilization database, operation instructions and functions of browse, inquiry, statistics and print are indispensible. [8, 13, 14]

We have done a lot in order to achieve these functions along with a clear physical and logical structure and operation convenience. We designed a network model for some certain subbases, for example, users may call at every record, so there are many approaches to recall a record (Fig. 1). Now all the main functions are expanded as follows:

1. Operation Instructions

Besides operation prompting under the main menu and each sub menu, we supplemented operation instructions in both Chinese and English to the whole base, and it can be called whenever wanted in inquiry and statistics. One can easily understand the operation of this software through calling the operation instructions.

2. Browse

This is to provide users with an outline of the hierarchy of this base and all the terms that may be inauired and used for statistics.

By means of browse, one can understand the general structure and functions of the database. This is accomplished through a catalogue.

3. Recalling

As has been mentioned above, the basic functions of a database is to respond users' inquiries and to complete users' various data operations. Recalling data about a certain geothermal well is encountered the most frequently and adaptability and promptness are of significance. In order to increase the promptness, we gave up the direct-search method and avoided searching the whole base for a certain single value. The technique of the indexed search, i. e., the addressing search, was employed, and the required data can be found on the storage medium by means of the key words. With this indexed file, the database management system can quickly find the corresponding record in terms of the key word given by the user. The quick sort indexing is an important intermediate step, which contributes to the quickness of inquiries about such a colossal and sophisticated database. Although it occupies some internal memory temporarily, it releases those space as soon as the inquiries are finished. Besides, different users may be interested in different parts of the database, demand also varies from user to user greatly. They may put forward all the conditions, both single and complex, that are both predictable and unpredictable, for inquiry about the database. In order that the data source be shared by different users, we did the following things:

1.) Complex conditioned inquiries confined in one subbase is a common type. We divided these inquiries into two kinds. One kind are those predictable ones that are often encountered. We designed the database in a way so that these inquiries may be finished promptly. Another kind are those unpredictable ones. Under such circumstances, the users is first given a chance to make free choices of conditions and then, according to these conditions, thro.ugh quick ordering in terms of restrictions of key words, the inquiry is finished step by step. This solved the problem of insufficient capacity of internal storage when there is too complex a condition.

2.) Inquiries concerning more than one subbase may be encountered. The whole data with regard to one well fall in more than ten subbases. We also divided these inquiries into two kinds and, through searching and recalling, the data satisfying all the prescribed conditions are found. To each well a certain number is assigned and, this is the medium between subbases. At the same time, more than one subbases may be opened in different regions simultaneously in terms of prescribed conditions and inter-regionally correlated and, therefore, the pointer in each opened subbase can move synchronically with that of the active subbase. When the selected term is a keyword and the pointer in the active subbase moves to the corresponding record, the other correlated subbases will search their corresponding indexed files for the corresponding records, in this way, all the information about the same well can be found.

3.) Statistical calculations are necessary for some data, e.g., accumulation of area and number of greenhouses, output value and profit, etc.. Sometimes number of wells that satisfy certain prescribed conditions is required. Prompted by menus, users are allowed to make their ohoioes of oonHitions. At. the same time, the amount of energy conserved may be equivalently transformed into amount of standard coal or electric power in order to cater to the need of the National Bureau of Statistics.

4.) It is necessary to design an output report according to the content of the database to show the required information more concentratively, so that reference to it and comparison with it can be made more easily. For convenience of preservation, we will print all the data about each well in one or two pieces of paper and, bind them together for long-termed preservation.

DATA COLLECTION

In order to set up a perfect database, we must work on the computer to design the structure of the database on one hand and collect data to fill in the base on the other hand. It is not easy to collect all the required data over such an expanse of land. As the investigation form aforementioned shows that it contains more than 300 terms with regard to one well. These terms are related to many subjects. Apart from these difficulties, geothermal experts are scarece on many utilization points, and geothermal systems are not well managed and, many data are unknown. Therefore, it is almost impossible to get all the required data. Despite that, the present work on geothermal energy utilization information, so meticulous and so comprehensive, is unprecedented in the People's Republic. This work will help to improve the geothermal utilization management and revise the estimation of data previously made by the information agents. Now we have three approaches to data-collecting.

1. Collect from existing literature. This is simple and easy to do, but the collected data are odd and fragmentary.

2. By means of on-line recall at the Information Agency, Ministry of Machinery and the Chinese Geological Books and Reference Materials Center, we can get investigation reports, through which data may be obtained. We can not get all the information through this channel, either.

3. Distribute investigation forms through the post office and ask the concerned geothermal experts to fill in. We will also send out information agents to various places across the country to collect the data and, at the same, urge those who have received our forms to finish the work. This will be the main channel through which we collect the data. We have printed thousands of the forms. Now our work is well under way.

EPILOGUE

This project has not yet been ultimately completed and it will take another one or two years to accomplish the work. In the work concerning database, structure designing, programing, data collecting and sorting and inputting are all arduous jobs. Many technical problems are yet to be solved. Data-collecting deals with the geothermal utilization points all over the country and its success lies in the support from those engaged in geothermal research and utilization. The National Geothermal Energy Utilization Database is a long-termed work, the data stored in the base should keep up to date, so renewal and replenishment are necessary. To speed the geothermal development of our country, we hope to establish a lone-termed information network with all the geothermal fields and organizations concerned through the database work.

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Fig.l. Illustration of the Structure of the National Geothermal Energy Utilization Database