

Discussion on Solar Energy Application in the Middle or Small Town of Western China

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Abstract: As an important energy centre, the western China faces the challenge of environment protection and sustainable development. This paper provides an analysis on the situation and problems of fossil energy and reproducible energy development and utilization in the middle or small town of western China. A technical and economic discussion on heat source modes for heating including reproducible energy, natural gas and coal is also involved here. The study shows the heat source of combination with solar energy and natural gas for heating is benefit not only to save energy and reduce environment pollution, but also to have the same total cost as the heat source with coal, so it will has a brighter future.

Keywords: western China, solar energy, natural gas, heating mode, technical and economic analysis

0. INTRODUCTION

The sustainable development is a focus subject how to utilize fossil energy or reproducible energy, and open up new energy. Coal energy accounts for more than 70 percent in Chinese energy consumption structure in long period, which becomes a main reason for environmental contamination in the northern cities China. Economic losses of environmental contamination add up to \$ 960 every year. The ultimate path to energy shortage and environmental problems rests with improving coal use ratio and changing the present situation of coal energy as a single heat source for heating.

The western China consists of twelve provinces including Xinjiang, Gansu, Qinghai, Ningxia and Shanxi in the northwest; Chongqing, Sichuan, Yunnan, Guizhou and Tibet in the southwest; Innermognolia in the middle; and Guangxi in the east. The western China, an important energy centre, has abundant fossil energy and regenerative energy comprising coal, fossil oil, natural gas, solar energy and wind energy. The rich energy also provides the major safeguard not only to the whole country economic development by transmitting electricity from the western to the eastern of China, but also to the western in itself. When the western China contributes to relieve country energy shortage and power pressure, it also faces the challenge of reasonable utilization and exploitation energy and protection virgin environment. Therefore reasonable utilization and exploitation energy and protection environment is a real and deep sense subject.

1. ENERGY ADVANTAGE AND UTILIZED STATUS IN THE WESTERN CHINA

The prolific fossil energy and regenerative energy is an advantage for the western China. Its coal reserves are 38.6 percent, where most of coal has good quality,

and hydro-energy reserves are 82.3 percent in the whole country. The petroleum and natural gas reserves are the more than the others in the western. The petroleum reserves are the most, and natural gas reserves are more than 80 percent in the whole country. The Solar energy and wind energy is rich. The solar total radiation reaches from $5.8 \times 10^9 \text{KJ}/(\text{m}^2 \cdot \text{a})$ to $8.4 \times 10^9 \text{KJ}/(\text{m}^2 \cdot \text{a})$ on a level square meter in most of the western China every year. The yearly total insolation duration is 3000 hours. The average sunshine hours are 8.2 hour. The duration intensity is $184 \sim 266 \text{W}/\text{m}^2$.

The rich energy gives the strong basis of the western sustainable development. But the western China has the character of out-of-the-way geographic position, imperfect industrialization and urbanization, and more land and less population. Population density is only 41 people every square kilometer, which is no more one tenth than the eastern. Naturally the middle and small towns have authorized in the western. The heat resource is mainly the domestic coal fired boiler. Domestic boilers of low combustion efficiency having sparkles from fume induce severe energy waste and environmental contamination. Thus transition of utilization energy mode is imperative for sustainable development. At the same time, the western can take advantage of abundant energy to realize the more heating resources. Under the situation heating by clear energy and reproducible energy has a brighter future.

The paper, taking Dongsheng district in a middle and small town named Erdos located Innermongolia for an example, provides a technical and economic discussion on heat source modes for heating including reproducible energy, natural gas and coal, and get a reasonable mode.

The Erdos' total coal reserve is as many as one sixth of the whole country ones, where worldwide maximal coal field having best coal quality can be found except for the large quantity coal to refine hard coke and the rich natural gas. Lying on the Erdos

highland, Erdos' solar energy resource only lines second after Qing-hai Tibet Plateau. Its yearly total actual sunshine hours are 3008.9 hours, and the yearly load factor is 67.8 from the southern to the northern. The yearly total average solar radiant energy reaches $5.929 \times 10^6 \text{ kJ}/(\text{m}^2 \cdot \text{a})$ providing by a local weather station. Maximum is $5.748 \times 10^6 \text{ kJ}/\text{m}^2$, while minimum is $6.037 \times 10^6 \text{ kJ}/\text{m}^2$. The average duration of day is 8.2 hour. The duration force is $550 \text{ W}/\text{m}^2$, which is far larger than the local heating index.

2 SEVERAL HEATING MODES AND THEIR TECHNICAL AND ECONOMICAL ANALYSIS

2.1 Several Heating Modes

Heat supply load mainly fell into heating load and living heat in Erdos.

Coal fired heating: this mode is widely applied at the present time, that is, district heating (civil or communal central heating) occupies about two third of heating areas, and the rest is provides by domestic boilers or stoves. The heating mode brings severe energy waste and environmental contamination, especially by the low combustion efficiency of domestic boilers or stoves with sparkles from dense fume. The denser people live, the more severe environment is.

Natural gas fired heating: despite of having rich natural gas its utilization will still be further studied. The heating area is $2.3 \times 10^7 \text{ m}^2$ by domestic boilers or stoves, which accounts for about one third compared with total heating areas. Now area heating index is supposed as $60 \text{ W}/\text{m}^2$, and the combustion efficiency of domestic boilers as fifteen percent. As a result, the coal for heating can be consumed with 8.6×10^5 tons every year. Similarly, the coal for cooking can be consumed with 9.31×10^4 tons under the conditions of having 180 thousands people and merely forty percent burning liquid gas cooking. If taken natural gas fired boiler for heating instead of the former, the discharge of SO_2 , CO_x and NO_x can be decreased by 2.39×10^7 tons, the dust discharge by 3.89×10^5 tons, and ash discharge also by 8.06×10^5 tons. It means that the three discharges separately decrease by $1.04 \text{ t}/\text{m}^2$, $0.17 \text{ t}/\text{m}^2$ and $0.04 \text{ t}/\text{m}^2$.

Heating by solar energy and natural gas: the heat by solar water heater meets partially heating load and domestic hot water load, and the rest heat load by domestic gas fired boiler. Taken heating mode by solar energy and natural gas can extremely save natural gas and reduce operating cost. The most important is ultimately change atmospheric pollution.

2.2 Economical Analysis of Several Heating Modes

2.2.1 Analyzed Method

The paper takes use of annual cost approach to analyze several heating modes. Life cycle costing can be divided into construction first cost, operational cost (including fuel cost, power rate and management cost), systemic disused cost, and systemic the present worth of salvage. As different equipments having own lifetimes in a system of heating, a systemic life cycle is defined as the least common multiple of various equipments. Then annual values of various plants can be converted by fund recovery coefficient. Based on annual values of various plants, the annual value of

heating system can be gain. The formula as following:

$$Z = \sum_{j=1}^n x_j K_j + C \quad (1)$$

$$x_j = \frac{i(1+i)^m}{(1+i)^m - 1} \quad (2)$$

where, Z is annual cost, ¥/a; n is heating plants species; K_j is invested amount of heating plants, ¥; C is annual running cost of heating system, ¥/a; x_j is fund recovery coefficient, i is net interest after monetary inflation etc, m is a life cycle of heating system.

2.2.2 First Cost and Running Cost of Several Heating Systems and Their Annual Costs Comparisons

The factors related to heating systems are different according to local conditions. The factors consist of heat resource invest, indoor system invest, managerial cost, running cost, equipment life, fuel price and relevant policy, building cost and so on. Coal or natural gas cost is respectively $120 \text{ ¥}/\text{t}$, $1.2 \text{ ¥}/\text{m}^3$ in Erdos, and heating period is 180 days. Based on Assumptions that winter heating index is $60 \text{ W}/\text{m}^2$, and area of structure is 100 m^2 , thus heating load is 6000 W . Coal low caloric heat is $16728 \text{ kJ}/\text{Kg}$, low heating value of natural gas is $36 \text{ MJ}/\text{m}^3$. Managerial cost and maintenance cost is neglect for coal fired heating. Every mode' first cost and running cost comparison is shown in table 1, fuel cost R can be calculated by the following formula.

$$R = \frac{\bar{q} T}{Q_{\text{dw}}^y \eta_1} P_g \quad (3)$$

where, $\bar{q}$ is winter heating index, W/m^2 ; T is systematic operating time, s; Q_{dw}^y is low heating value of natural gas or low caloric of coal, J/m^3 or $\text{¥}/\text{Kg}$; η_1 is heater resource efficiency, P_g is natural gas or coal price, $\text{¥}/\text{m}^3$ or $\text{¥}/\text{Kg}$. Owing to self regulation fuel cost save thirty percent. Domestic solar water heater providing 400 W is about 7 percent of heat load by natural gas and solar energy.

Operating life of heating plants is almost same for all heating methods, assuming operating life of indoor heating pipe network, coal burning boiler and solar energy collector is respectively 20, 8 and 10 years. Basing repeated renewal supposition theory, 40 years is the uniform operating life of coal burning heating system, which is the lease common multiple of operating life of all parts in system. In the useful life period, coal burning boiler will be renovated 5 times, and indoor heating system will be renovated 2 times. 20 years is the uniform operating life of heating for solar energy and natural gas, correspondingly the gas-burning boiler will be renovated 2 times. In the useful life period, the efficiency of boiler changes little and operating cost can be considered same. The result which is calculated by annual approach is showed in table 2.

Table. 1 Schemes comparison of building and operating cost for several heating systems (¥/m²)

	Scheme 1	Scheme 2	Scheme 3
Handling fee	0.0	19.0	19.0
Building cost of heat source	10.0	40.0	55.0
Building cost of indoor pipe system	32.0	32.0	32.0
Total building cost	42.0	72.0	87.0
Fuel cost every year	31.3	24.2	22.5
Efficiency of heat source	15%	90%	90%
Power rate for heating every year	0.0	2.2	2.0
Total operating cost every year	31.3	26.4	24.5

Notes: Scheme 1 refers to take fuel-coal boiler for heating; scheme 2 refers to take fuel-coal boiler for heating; scheme 3 refers to take fuel-coal boiler for heating.

Table 2. Comprehensive economic comparison of several schemes (¥/m²)

		scheme 1	scheme 2	scheme 3
Handling fee		0.0	19.0	19.0
Reduced handling fee		0.0	1.9	1.9
Building cost of heater source		10.0	40.0	55.0
Reduced building cost of heater source		1.9	6.5	8.9
Building cost of indoor pipe system		32.0	32.0	32.0
Reduced Building cost of indoor pipe system		3.8	3.8	3.8
Reduced first cost		5.7	12.2	14.6
Yearly operating cost		31.3	26.4	24.5
Annual value (interest)	10%	37.0	38.6	39.1
	8%	36.5	37.8	38.1
	4%	35.3	35.6	35.4

2.2.3 Analysis

We can draw a conclusion from table 2 that building cost of household coal burning heating system is least, and operating cost of household heating by solar energy and natural gas is least. Table 2 shows that when annual net interest is between 10% and 8%, annual cost of household coal burning heating system is least, and that of domestic heating by solar energy and natural gas is most, and that of household gas burning heating system is medial. When yearly net interest is seemed as saving interest 4%, disparity of annual approach among three methods is about 0.3 yuan/m². Difference of annual approach between heating by solar energy and natural gas and by coal is small (only 0.1 yuan/m²), which is less than the annual approach of household gas burning heating system.

3 CONCLUSION

3.1 The annual value of domestic natural gas fired heating, solar energy combined with natural gas and coal has reducing trend in turn in small and middle towns of western China, and importantly difference of the annual value is very small, justly 0.3 ¥/m².

3.2 The first cost of coal fired heat is smallest, but its operating cost is obviously higher than the others. The low combustion efficiency of fuel-coal boilers not only results in severe environment pollution, but also economically has no advantage any more.

3.3 Using solar energy and natural gas as heater source has good hands in saving energy and environment protection compared with coal. Its

economic factor is as the same as coal fired heating boiler. Thus, natural gas fired heating, especially heating by solar energy combined with natural gas comparing with coal fired heating has a brighter future in small and middle towns of western China.

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