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Analysis of Heating Energy Consumption of School Buildings in Shigatse, Tibet

SUOLANGQUZONG, Chengpeng Liu, Li Wan, Liqing Zhou, Wei Wang, Qiqi Wen

Tibet Autonomous Region Energy Research Demonstration Center, Tibet Autonomous Region Solar Energy Society; Lasa 850000, China

Abstract: This paper is launched against the background of excessive heating energy consumption in China, continuous calls for sustainable development, and unsatisfactory heating energy use in primary and secondary schools in Shigatse, Xizang. Through field research on the existing school buildings in Shigatse, Xizang, a large number of first-hand materials were obtained, and then through targeted summary and classification of the data, the key problems leading to high energy consumption, low clean energy utilization rate and poor thermal comfort of school buildings in Shigatse, Xizang were found. On this basis, further analysis will be conducted to address the issue, seeking ways and methods to utilize clean energy technologies such as solar heating to solve the heating problem in school teaching buildings.

Keywords: Shigatse School; Building energy consumption; Winter heating; Investigation and research.

1. Introduction

At present, in Shigatse, Xizang, urban schools have achieved centralized heating. Township schools generally use coal-fired boilers or stoves as the main heating source for heating. The equipment is backward, the thermal efficiency is extremely low, and environmental pollution is serious. In addition, coal-fired stoves commonly used in rural schools can only ensure the warmth of the room where the stove is located, and the stove must be taken care of regularly. Otherwise, it will automatically extinguish and the indoor temperature cannot be guaranteed, while other rooms cannot meet the requirements. Heating efficiency is low, and application is inconvenient. If the combustion is not thorough, it can easily cause poisoning of toxic gases such as CO among indoor personnel[1].

The winter heating of urban school buildings in the Shigatse region mostly adopts centralized heating, which has high fuel burning efficiency. However, in rural areas, due to the relatively remote and scattered nature of schools, some schools have fewer teachers and students, and the use of centralized heating is unreasonable. The heating equipment in the classroom is outdated in winter, and even plastic sheets are used to block the windows on the north side to resist the cold wind. The main heating methods for rural schools include stove heating and coal-fired boilers. Schools that use stoves for heating account for about half of the total number of studies, as shown in Figure 1.

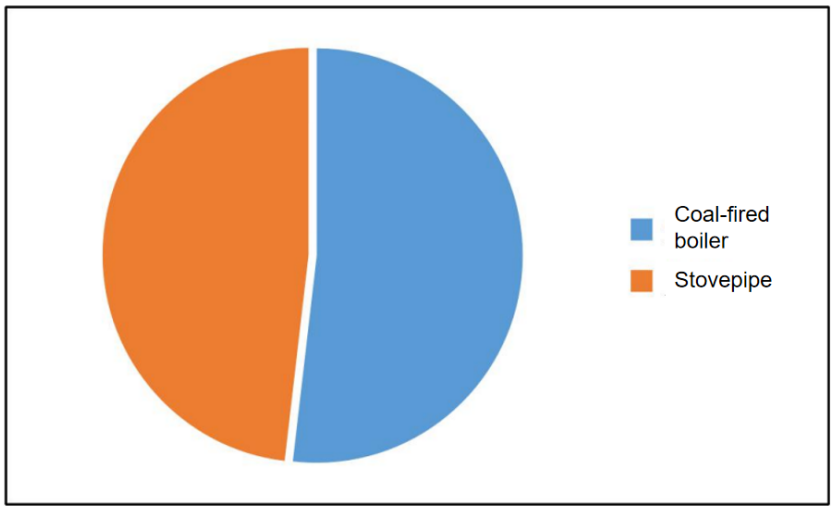

Figure 1. Winter heating method for classrooms in Shigatse school

The direct combustion heat efficiency of furnace heating is low, and the distribution of heat emitted is uneven. The temperature near the furnace is relatively high, while the temperature far away from the furnace is relatively low. Moreover, the coal smoke generated by heating with a stove can lead to indoor smoke and poor indoor air quality, affecting students' health. In the winter classroom of Liuxiang Central Primary School in Lazi County, Shigatse City, stove heating is used. According to students' feedback, the indoor air quality is poor in winter, with a foul smell that can sometimes cause discomfort. In places with good economic conditions, coal-fired boilers are also used for heating. This type of earthen boiler does not have professional personnel to guide its design, which poses great risks. Moreover, the thermal efficiency of earthen boilers is very low, and the energy consumption for heating is high, as shown in Figure 2.

Figure 2. Common heating methods for schools in the Shigatse region

This article conducts research on the energy consumption methods, heating forms, and types of schools through on-site visits. It is found that the main heating methods for rural schools in the Shigatse region are centralized heating with coal-fired boilers and separate heating with stoves. The proportion of use of these two types is similar. Generally, schools with flat houses use separate heating with stoves for each classroom, Multi story classrooms generally use coal-fired boilers for collective heating of the entire school.

2. Heating Energy Consumption Analysis

From Table 1, it can be concluded that (a) in the surveyed schools, all schools use traditional energy, and the main energy source for winter heating in rural schools is still coal, accounting for 88.9% of the surveyed schools. Some schools use crop straw firewood as auxiliary fuel. Shigatse village and town schools generally use boiler centralized heating and classroom coal stoves for separate heating. (b) The winter heating energy consumption of Shigatse village and town schools is the most important aspect of the total energy consumption of schools. Therefore, reducing the energy consumption of school heating while improving classroom comfort is of crucial significance for energy conservation, emission reduction, and the promotion and use of clean energy.

Table 1. Statistics of Energy Consumption in Research Schools in the Shigatse Region

Energy usage type			**Heating energy consumption**	
Types		**Proportion of surveyed schools**	**Heating methods**	**Proportion of surveyed schools**
Tradition Energy	Coals	82.5%	Coal-fired boiler	51.86%
	Fuelwoods	12.2%	separate stove	48.14%
Clean Energy	Solar heating	5.3%	/	/

3. Analysis of the Enclosure Structure of The Teaching Building

The outer protective structure of the building separates the external environment from the indoor space. The external enclosure structure in winter can prevent cold air from entering the interior, while also preventing heat from being transferred to the outside, improving the comfort of the building interior. The peripheral protective structure mainly includes the exterior wall, doors and windows, and roof. The energy consumption caused by the heat transfer of the peripheral protective structure accounts for about 50% of the energy consumption of heating and air conditioning[2]. Therefore, strengthening the thermal performance of the outer enclosure structure can not only reduce the energy consumption generated by winter heating, but also ensure that the indoor temperature is maintained in a comfortable state. Through research, it was found that the peripheral protective structures of school buildings in Shigatse villages and towns generally have low standards and do not meet the requirements of energy conservation.

3.1. Current Situation of Exterior Walls

The exterior wall is the most important component of the building envelope structure. According to statistics, the heat loss through the exterior wall accounts for 40% of the total energy consumption of the outer enclosure structure. It can be seen that strengthening the insulation performance of external walls plays a very important role[3].

According to research statistics, it was found that all surveyed school buildings were constructed with solid brick walls for external walls, as shown in Figure 3. 77.8% of school building walls have no insulation layer; Out of the 27 schools surveyed, 6 of the teaching buildings used 240mm solid brick walls with internal and external plastering, accounting for 22.2% of the total; There are 14 school teaching buildings that use a 370mm solid brick wall with internal and external plastering, accounting for 51.9% of the total, without insulation layer. The school buildings with insulation layers accounted for 25.9% of the total number of research, all of which were newly built teaching buildings after 2000. According to Table 2, the average heat transfer coefficients of 240mm and 370mm solid clay brick walls are 2.03 and 1.53, respectively, which are far greater than the limits in the "Energy Efficiency Design Standards for Public Buildings". Due to the poor insulation performance of the external walls, cold air infiltration is severe in winter, resulting in low indoor temperature and high humidity, and the phenomenon of condensation and mold on the internal walls, as shown in Figure 4.

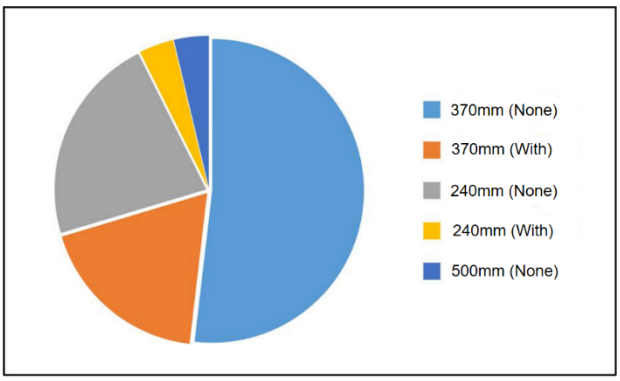

Figure 3. Statistics of survey questionnaire results on the form of classroom exterior walls

Table 2. Limitations on Heat Transfer Coefficient of Outer Envelope Structure

External walls (including non transparent curtain walls)	Body shape coefficient≤0.3	K=0.5
	0.3＜Body shape coefficient≤0.4	K=0.4

Figure 4. Current Situation of Internal Walls

3.2. Current situation of exterior doors and windows

During the survey, it was found that there are three commonly used forms of external windows in Shigatse village and town schools: single glass wooden windows, single glass steel windows, and PVC plastic steel windows, as shown in Figure 5. The most commonly used form of external window in the surveyed schools is PVC plastic steel windows, accounting for 45.8% of the total number of surveyed schools, as shown in Figure 6. Most of the doors are made of iron sheet, and there are also some plywood and glass doors, as shown in Figure 7. In recent years, the windows of some rural schools that have been renovated and newly built have been changed to plastic steel windows, which greatly improves the airtightness of doors and windows, reduces the infiltration of winter cold air, and improves the indoor thermal environment.

Figure 5. Common External Window Forms in Schools

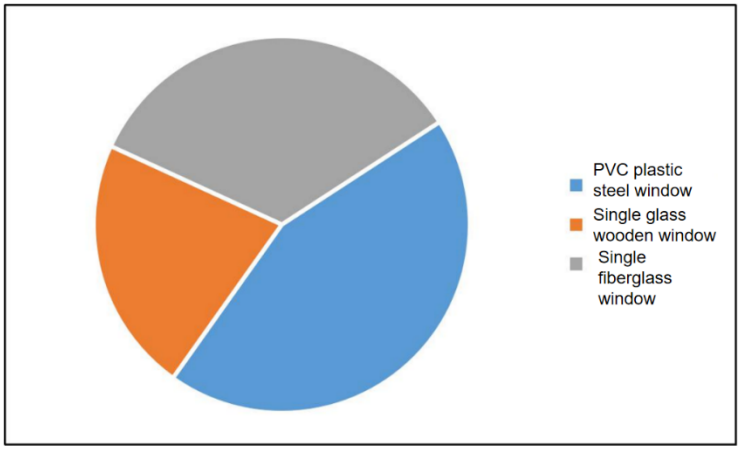

Figure 6. Statistics of Research Results on the Forms of Classroom External Windows

Figure 7. Common Forms of Doors in Schools

4. Reasons for the Current Situation of The Enclosure Structure

(a) The construction level is low. The construction technology level of rural schools in the Shigatse region is relatively low, the quality of construction personnel is relatively poor, the construction equipment is relatively backward, and the supervision procedures for engineering quality are not sound. Due to the lack of a dedicated construction team during the construction process of village and town schools, most of them are built by idle farmers during their leisure time. Without a dedicated supervision and engineering quality management department, it is difficult to ensure the quality of the project. If the mortar is not full during wall masonry, and the proportion of school buildings in villages and towns in the Shigatse region using clean water walls is relatively large, the consumption of heating energy is very high due to the infiltration of cold air in winter. In addition, the processing technology of components and accessories is relatively low, and the doors and windows produced cannot meet the airtightness requirements specified in the specifications[4].

(b) The damage to the enclosure structure is severe. The construction of village and town school buildings in the Shigatse region is mainly based on low standard construction. The thermal resistance value of the enclosure structure walls is generally relatively low, the cement joints on the walls fall off, the cold air penetration is large, the insulation performance of the ground and roof is poor, and the selected doors and windows have poor insulation and airtightness. In addition, some doors and windows are severely damaged, such as cracking of glass sealing strips, aging and deformation of doors and windows, all of which make the insulation performance of the enclosure structure worse[5]. Although low standard construction saves construction costs in the early stages of construction, it increases the winter heating costs and overall energy consumption throughout the year. In the long run, this low standard construction is very unreasonable.

5. Survey of Indoor Comfort in Teaching Buildings

In order to combine data to understand the impact of technical measures on the comfort of teaching buildings, in order to effectively understand the indoor comfort status of winter classrooms and the satisfaction of school teachers and students with the winter heating conditions of classrooms. According to the survey results, as shown in Figure 8. 96.5% of teachers and students believe that the classroom is cold, while almost everyone believes that it is coldest in the morning. 21.1% of teachers and students feel that there is often cold air around the window, and 66.7% of teachers and students feel that there may be cold air around the window at times. Therefore, measures should be strengthened to reduce cold air infiltration. Only 10.5% of teachers and students are relatively satisfied with the winter classroom heating, and the vast majority of teachers and students are not satisfied with the classroom heating. 84.2% of teachers and students believe that heating should be renovated.

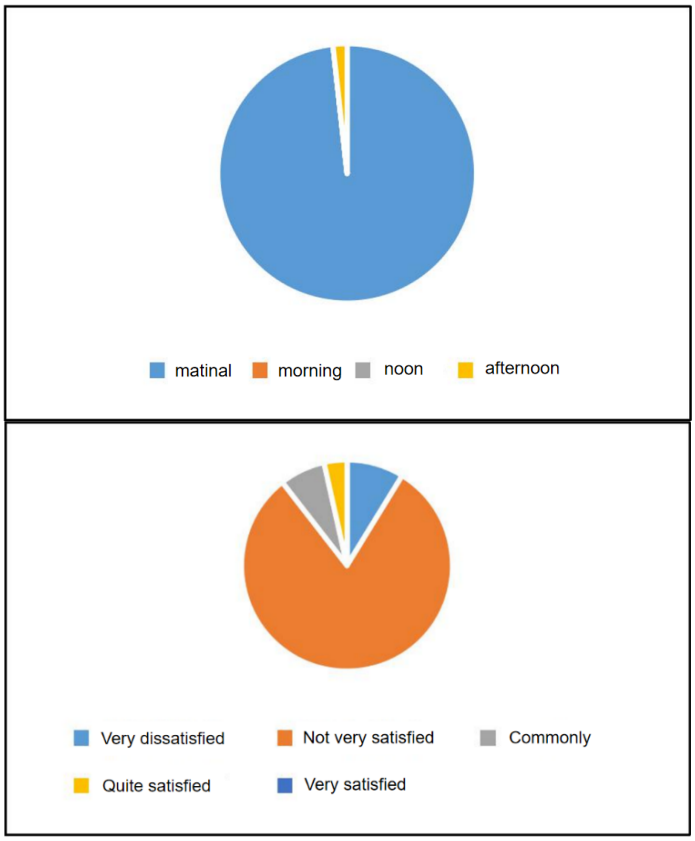

Figure 8. Statistics of Survey Questionnaire Results on Classroom Temperature

Overall, 73.7% of teachers and students are not satisfied with the indoor comfort of the classroom, while 77.2% of teachers and students believe that indoor temperature, humidity, and air quality are all important. Therefore, these three aspects should be improved to meet the requirements of teachers and students for indoor comfort.

6. Conclusion

Through field visits and questionnaire surveys, this article found that the heating conditions, proportion of clean energy use, and current energy consumption of school buildings in the Shigatse region are not optimistic, and there are many problems:

(a) The outer protective structure of the teaching building is mostly built with 240mm or 370mm solid brick walls, and there is no external insulation structure; The exterior walls and doors and windows cannot meet the requirements for airtightness. In winter, cold air infiltration is severe, and the heat loss caused by the surrounding protective structure is huge. The temperature of the classroom is extremely low, and the indoor walls are frozen and moldy. Students often have red hands due to freezing, which affects their physical and mental health and learning efficiency.

(b) Due to limited conditions, the collective heating method in rural areas of Shigatse is not reasonable. Schools generally use two heating methods, namely stove heating or coal-fired boiler heating. These two heating methods not only have low thermal efficiency and high energy consumption, but especially in classrooms heated by stoves. In winter, the doors and windows are tightly closed, and the smoke generated by stoves leads to low indoor air quality and poor comfort, which may seriously affect students' health.

(c) The energy used by the school is mainly conventional coal, and firewood from crop straw is used as auxiliary fuel. The energy usage is relatively single, and the proportion of clean energy usage is extremely low.

7. Supported Project Name

"Investigation and Research on the Promotion and Application of New Energy in Schools in Tibet Region"

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