Problems of Building Energy Consumption in Rural Schools in Linzhi, Tibet

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Abstract: The energy-saving research of school buildings in villages and towns in the severe cold areas of Linzhi Township has not yet been widely carried out. The energy consumption of schools in villages and towns in the severe cold areas of Linzhi is generally high, and the heating energy consumption in winter accounts for a large proportion of the energy consumption of school buildings. With the promulgation and implementation of energy-saving design standards for public buildings in schools in large and medium-sized cities, energy-saving activities have been carried out. In the severe cold area of Linzhi, there are a large number of buildings in villages and towns, with primary schools in each village, secondary schools and central primary schools in each township. The total energy consumption of village and town school buildings accounts for the majority of the total energy consumption of village and town public buildings. From this, it can be seen that studying the characteristics of village and town school buildings in the severe cold area of Linzhi and researching energy-saving design strategies suitable for their own characteristics based on the characteristics of village and town school buildings in the severe cold area are of great significance for the promotion and application of clean energy in schools in the Linzhi area.

Keywords: Linzhi School; Rural areas; Investigation and research; Building energy consumption.

1. Introduction

The buildings of rural schools in the Linzhi area are set up based on administrative divisions. Generally, primary schools are set up in villages and secondary schools are set up in townships. Their service radius is based on administrative divisions. Urban primary and secondary schools are established in residential areas or residential communities, with a service radius of 500m for primary schools and 1000m for secondary schools. The service radius of school buildings in Linzhi Village and Town is difficult to divide by specific distance, because the administrative divisions of villages and towns are not divided by distance, and there are unreasonable problems in setting up schools based on administrative divisions. For example, it is obviously unreasonable to set up schools according to the same standard due to different geographical locations, sizes, and populations of villages. Building orientation: The site of village and town school buildings is relatively large, and the building orientation is limited by the site conditions compared to urban primary and secondary schools. The orientation of village and town school buildings can ensure a north-south direction, and the building orientation is mainly north-south; The site of urban primary and secondary schools is relatively small, and the orientation of school buildings is relatively limited by the site conditions. The layout of buildings in the north-south direction is also limited. Some urban primary and secondary schools also adopt an inner corridor style, with classrooms arranged on both sides. In order to meet the minimum sunshine requirements, they often adopt an east-west layout, as shown in Figure 1. Building floors: Rural schools mainly have single and second floors, as shown in Figure 2. Urban primary and secondary schools mainly have four and five floors. Architectural image: Rural schools mainly have sloping roofs, with simple facades, similar styles, and less decoration; Urban primary and secondary school buildings mainly have flat roofs, with diverse facade forms and styles, and rich decorations. The difference in the layout of classrooms: In severely cold areas, the layout of classrooms in village and town schools is mainly based on external corridors, and the depth of classrooms is relatively small; In severe cold areas, urban primary and secondary schools mainly have corridors in their buildings, and the depth of classrooms is relatively large. Winter heating method: Rural schools mainly use earthen boilers and stoves for heating; The heating of urban primary and secondary school buildings is mainly centralized heating.

Figure 1. Linzhi City School

Figure 2. Linzhi Village School
2. Architectural Characteristics of Linzhi Village School

The school buildings in villages and towns in the severe cold area of Linzhi are set up based on the administrative divisions of the villages and towns. Generally, primary schools are set up in villages and secondary schools are set up in towns. Their service radius is based on the administrative divisions. Village and town schools are mainly single-story and two-story, mostly facing due south and due north.

The building function of village and town schools in the severe cold area of Linzhi is relatively simple, with a basic teaching unit classroom as the main layout form. There are relatively few other auxiliary teaching spaces, and the classroom layout mainly consists of external corridors. The depth of the classroom is relatively small, mainly including offices, computer rooms, duty rooms, guard rooms, and small libraries. The architectural space is relatively simple, the shape is generally relatively simple, and the facade decoration is relatively simple. It is suitable for the style of local village and town architecture and has strong regional characteristics.

At the same time, the structural form of village and town schools in the severe cold area of Linzhi is mainly mixed structure, with local materials as the main materials. For example, in the northeast region, the walls are mostly red bricks, with wall thicknesses of 490mm and 370mm, and the roofs are mainly sloping roofs. The roof trusses are mainly wooden and steel. The windows are mainly made of wood and steel, and most of the doors are made of iron, as shown in Figure 3. In the process of renovating rural schools in recent years, some of the windows in these schools have been replaced with plastic steel windows, which have greatly improved the airtightness of doors and windows, reduced the infiltration of winter cold air, and improved the indoor thermal environment. Replacing plastic steel windows is an effective measure for energy-saving renovation of rural school buildings in severe cold areas, and has been widely recognized.


3.1. Decentralized architectural layout

In the vast villages and towns of the Linzhi area, school buildings are distributed in units of the local farmers' residential areas. Generally, primary schools are set up in villages and secondary schools are set up in townships. Due to the scattered distribution of villages and towns and the varying sizes of villages and towns, the distribution of school buildings in villages and towns in the Linzhi severe cold area is relatively scattered. The scale of schools is relatively small and there are many, making it difficult to form large-scale schools, resulting in the phenomenon of duplicate construction. This decentralized layout is an unfavorable layout form for energy conservation[1].

3.2. Defects in the building body

3.2.1. Shortcomings in the functionality of building plans

The layout of urban primary and secondary school buildings often adopts a combination of inner corridors, which have two commonly used layout forms. One is to arrange two groups of classrooms along both sides of the corridor, and arrange toilets, staircases, or homeroom teacher's office at the end to serve this group of classrooms. Another way is to arrange classrooms along one side of the corridor, and the other side is to arrange teaching auxiliary rooms or transportation spaces. The spatial unit of the inner corridor combination is characterized by a concentrated classroom, compact area, short internal transportation lines, larger depth of the house, fewer external walls, smaller heat dissipation area in winter and heating area in summer, simple structure, and more concentrated equipment and pipelines.

The layout of village and town school buildings often adopts the form of corridor combination and row combination.
The combination of external corridors is to arrange rooms such as classrooms, offices, and staircases along one side of the corridor, which provides better lighting and ventilation conditions for the classroom. In severely cold areas, the north facing exterior corridors of village and town school buildings are divided into heating exterior corridors and non-heating exterior corridors. When the north facing exterior corridor is used for heating, it avoids the disadvantage of direct invasion of cold air in winter and excessive temperature difference between indoor and outdoor. However, the construction cost of heating exterior corridors is higher than that of non-heating exterior corridors. When facing north as a non-heating exterior corridor, the disadvantage is that cold air invades the interior through door gaps and opening during winter, and the temperature difference between the interior and exterior is too large. In the research, it was also found that some single-story buildings all use classroom row combinations, as shown in Figure 4. The entrance is directly outside, and there is no door hopper in winter, which greatly increases heating energy consumption in winter and increases the difficulty of using clean energy[2].

![Figure 4. Linzhi Village School Row Classroom](image)

### 3.2.2. Poor insulation performance of the enclosure structure

(a) The impact of low construction level on the insulation performance of the enclosure structure. The construction technology level of rural schools in severe cold areas is relatively low, the quality of construction personnel is relatively poor, 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[3]. If the mortar is not full during wall masonry, and the proportion of clean water walls used in school buildings in villages and towns in the severe cold area of Linzhi is relatively large, the penetration of cold air in winter has a significant impact on heating energy consumption.

(b) The impact of different processing methods for components on insulation performance. The processing technology for the components and parts of village and town school buildings in the severe cold area of Linzhi is relatively low, and there is no specialized processing factory, only simple on-site production, and no quality supervision and management personnel. If the doors and windows produced cannot meet the airtightness requirements specified in the specifications.

(c) The influence of the condition of the enclosure structure on the insulation performance. The construction of school buildings in villages and towns in the severe cold area of Linzhi is mainly based on low standard construction. The thermal resistance value of the enclosure wall is generally relatively low, and the cement hook joint of the wall falls off and 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 performance and airtightness. Due to the poor insulation performance of the enclosure structure, the heat loss caused by the enclosure structure is very large. Although low standard construction saves construction costs in the early stages of construction, which is only a short-term savings, it increases the winter heating costs during use and energy consumption. In the long run, this low standard construction is very unreasonable. After all, the service life of village and town school buildings should be over 30 years, as shown in Figure 5[4].

![Figure 5. Current Situation of Maintenance Structure of Schools in Linzhi Village and Town](image)

### 3.3. Backward heating methods

#### 3.3.1. Low efficiency of heating equipment

The heating equipment for rural school buildings in the Linzhi area mainly comes with their own independent boilers for heating, as shown in Figure 6. Due to the small building area and the relatively small boilers used, the thermal efficiency of these small boilers is very low and cannot meet the requirements of energy-saving standards. The heating system design is not very reasonable, resulting in low energy utilization efficiency. This is also one of the reasons for high energy consumption.

Rural schools in remote and backward areas use earthen boilers and stoves for heating: earthen boilers are not designed by professional designers, often with significant technical defects and certain risks. At the same time, earthen boilers have low thermal efficiency and high energy consumption. Furnace heating is also widely used in rural school buildings in severe cold areas, mainly using stoves to burn wood or coal for direct heating. Direct combustion for heating has lower thermal efficiency and uneven heat distribution, making it very hot near the stove and very cold away from it. The furnace is not tightly sealed, resulting in smoke leakage and poor indoor hygiene, which affects the health of students. Most lighting fixtures are relatively
inexpensive incandescent lamps, which consume a lot of electricity and are non energy-saving with low light efficiency.

3.3.2. Relatively single energy use

The heating energy consumption of rural schools in the severe cold area of Linzhi accounts for the majority of the total energy consumption. Based on research, the energy used for winter school heating is still mainly conventional coal, with firewood as auxiliary fuel. In the severely cold areas of Linzhi, some schools in villages and towns are attempting to use renewable energy for building heating, such as solar heating applications. Therefore, improving the utilization of renewable resources in rural school buildings in severely cold areas is an important component of reducing energy consumption in rural school buildings. This will be the future development direction of building energy conservation in villages and towns in severe cold areas of Xizang. The application of renewable energy in rural schools is just beginning, and it is still in the stage of experimentation and exploration. There is still a long way to go to achieve widespread application.


With the sustained and rapid development of China's economy, the increase in environmental protection efforts, and the more urgent demands of farmers to improve their living standards, the role of the energy industry in rural schools has become more prominent. Strengthen the construction of energy standards in rural schools and promote the healthy and rapid development of the new energy industry in rural schools. Under the promotion of energy construction in rural schools, the development of the energy industry in rural schools has shown new characteristics and trends.

The energy industry in rural schools, represented by solar photovoltaic/photothermal utilization, wind energy, ground source heat pumps, biomass energy, etc., has a strong development momentum and is showing a breakthrough trend. Passive solar houses have mature technology, low investment increase, energy conservation, and are beneficial for environmental protection. They are a good solution for winter heating for farmers and rural primary and secondary schools, and have a wide application market in rural schools in China's heating areas. Independent solar photovoltaic/photothermal technology is an effective way to solve the energy shortage in rural schools in the western region, with huge market potential. Ground source heat pump system is an advanced new type of environmentally friendly air conditioning equipment, which can save electricity and reduce costs. It has great market potential in rural buildings.

5. Conclusion

This paper analyzes the factors of high energy consumption of village and town school buildings in the severe cold area of Linzhi, Xizang, and takes these factors as the basic data for the study of energy-saving design strategies of village and town school buildings in the severe cold area and the promotion and use of clean energy. Due to the vast area of Linzhi's severe cold area and the wide distribution of school buildings in villages and towns, it is impossible to conduct comprehensive and detailed research. The statistics department cannot find statistical data related to school buildings in villages and towns in the severe cold area of Linzhi, so this survey can only be conducted in a certain region based on the different characteristics of school buildings in different regions. Select some representative village and town school buildings for typical research, and identify the common reasons for high energy consumption in these typical examples. After organizing and analyzing the research materials, the following conclusions were drawn:

(a) The distribution of school buildings in villages and towns in the severe cold area of Linzhi is unreasonable, and the school scale is small and relatively scattered. This leads to the phenomenon of waste of supporting facilities. Diversified utilization of funds cannot be used in a centralized manner. In the planning and layout stage, the impact of planning and layout on energy consumption is rarely considered, resulting in some forms that are not conducive to energy-saving planning and layout.

(b) In terms of functional layout and spatial combination, the school buildings in villages and towns in the severe cold area of Linzhi did not consider the energy consumption of various layout schemes, resulting in high energy consumption.
in some planar functional schemes.

(c) In the selection of building functional materials, the impact of material performance on energy consumption is rarely considered. Due to the issue of selecting functional materials, the energy consumption of the enclosure structure is high.

(d) The utilization level of clean and renewable energy is still relatively low, and some available resources have not been well utilized yet.

6. Supported Project Name

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

References


