Analysis of Economic Thickness and the Suitable Insulation Thickness of External Wall Insulation Layer

Tianqing Shen* and Xingwei Shen

Department of Urban Construction and Transportation, Hefei University, Shushan District, Hefei 236001, Anhui, China
Email: 527991576@qq.com

Abstract. From the view of appropriate technology, this paper compares and analyzes the calculated thickness, feasible thickness, economic thickness, and appropriate thickness of the external wall insulation material with the highest contribution rate from the economic point of view, and obtains the relationship, curve, and model between the economic thickness and the appropriate thickness of the thermal insulation material. The purpose is to provide a reference basis and model for the optimal design of building energy-saving external walls. It inspires the architectural designers to consider the energy conservation of buildings from the economy's perspectives and environment to get the optimal and environment-friendly energy-saving design method. The purpose is to provide a robust theoretical basis for guiding energy-saving housing investment and reducing the blindness of investment.

1. Introduction

In the energy-saving and thermal insulation system of residential exterior envelope structure, the external wall is the essential part of the energy-saving contribution, and the thickness of insulation layer is an important parameter to determine the level of building insulation. Generally, with the increase of the thickness of thermal insulation layer, the insulation performance of the enclosing construction is improved, so the building load is reduced, and the operation cost of air conditioning and heating system is also reduced correspondingly. However, the construction cost of the enclosing construction is increased likewise. Therefore, there must be a certain thickness of insulation layer (i.e. economic thickness) to make the sum of energy consumption, total cost, construction cost, and operation cost the most economical. The thickness of the insulation layer with the minimum total cost is the optimal thickness.

The theory of economic thickness of thermal insulation layer is to determine the total cost of construction from the perspective of economics. However, in today's energy shortage and environmental deterioration, the selection of insulation thickness is not only related to energy conservation, but also environmental protection. The thickening of the insulation layer will reduce the heat load. Still, this reduction does not necessarily offset the negative environmental impact caused by the production, use and scrapping process of the insulation material itself in the whole life cycle, so the ultimate goal of energy conservation and environmental protection will no longer exist. Therefore, "Suitable Insulation Layer Thickness" proposed in this paper advocates the best comprehensive benefits of economy and environment. In today's call for sustainable development, it is more reasonable and significant to comprehensively consider the thickness of insulation layer from both economic and environmental aspects.
2. Calculation Thickness and Feasible Thickness of External Wall Insulation Layer

The calculation thickness of thermal insulation layer is for a given building, to achieve the target energy-saving rate under the condition of shape coefficient, window to wall ratio, building layers, wall structure and material characteristics. The thickness of the thermal insulation layer required by the external enclosure wall can be calculated by energy-saving calculation software, which is called calculation thickness, also known as theoretical thickness. It can be divided into the static limit thickness and the dynamic limit thickness. The feasible thickness is based on the calculation of consistency, according to the structure and characteristics of exterior wall thermal insulation materials, following the construction technology and feasibility requirements of the maximum thickness standard [1, 2].

This paper analyzes the energy-saving and thermal insulation system of a residential building. It discusses the relationship between the energy-saving rate and the reduction rate of energy-saving under different calculation thickness of thermal insulation layer. Table 1 is calculated by software as follows:

| Variation of insulation layer thickness (mm) | External Wall Heat Transmission Coefficient W/( m².K) | Residential energy efficiency rates | The change rate of energy-saving reduction |
|--------------------------------------------|-----------------------------------------------|---------------------------------|-----------------------------------------|
| 0                                          | 1.66                                         | 48.95%                          | 2.82%                                   |
| 5                                          | 1.52                                         | 50.33%                          | 1.69%                                   |
| 10                                         | 1.41                                         | 51.18%                          | 1.50%                                   |
| 15                                         | 1.33                                         | 51.95%                          | 0.98%                                   |
| 20                                         | 1.21                                         | 52.46%                          | 0.82%                                   |
| 25                                         | 1.12                                         | 52.89%                          | 0.79%                                   |
| 30                                         | 1.04                                         | 53.31%                          | 0.79%                                   |
| 35                                         | 0.97                                         | 55.46%                          | 0.79%                                   |
| 40                                         | 0.90                                         | 55.94%                          | 0.87%                                   |
| 45                                         | 0.85                                         | 56.14%                          | 0.36%                                   |
| 50                                         | 0.80                                         | 56.42%                          | 0.50%                                   |
| 55                                         | 0.76                                         | 56.71%                          | 0.51%                                   |
| 60                                         | 0.72                                         | 56.87%                          | 0.28%                                   |
| 65                                         | 0.69                                         | 57.06%                          | 0.33%                                   |
| 70                                         | 0.65                                         | 57.25%                          | 0.33%                                   |
| 75                                         | 0.62                                         | 57.35%                          | 0.17%                                   |
| 80                                         | 0.60                                         | 57.53%                          | 0.31%                                   |
| 85                                         | 0.57                                         | 57.72%                          | 0.33%                                   |
| 90                                         | 0.55                                         | 57.83%                          | 0.19%                                   |
| 95                                         | 0.53                                         | 57.87%                          | 0.07%                                   |
| 100                                        | 0.51                                         | 58.02%                          | 0.26%                                   |

By analyzing the data in the table, we can get the relationship between the insulation thickness and the residential energy-saving quality, shown as figure 1, and the relationship between the insulation layer thickness and the residential energy-saving reduction rate, shown as figure 2.
Analysis of the curve change trend in figure 1 shows that when the insulation thickness of the external wall of the material is in the range of 0-40mm, the residential energy-savings rate keeps a specific field of growth trend, and the growth rate increases gradually. In the scope of 35-40mm, there is a leap. From 40mm, with the rise in insulation layer thickness, the growth trend of residential energy-saving rate gradually tends to be gentle, and after 90mm, the change of residential energy-saving pace is little; Analysis of the curve change trend in figure 2 shows that the decrease rate data of the energy-saving rate of residential buildings is more apparent. When the thickness is 35mm, there is a more significant change of energy-saving status. After 40mm, the change range of energy-saving rate decrease is slow and stable. This shows that, under a certain energy-saving rate standard, for the same building envelope except for the external wall insulation, other uses the same energy-saving insulation system, there must be a most economical insulation thickness value, under which the resident can obtain the most significant energy-saving effect.

2.1. Theoretical Analysis of the Economic Thickness of Insulation Materials
As for the economic thickness of thermal insulation materials, "Building Energy Saving Engineering Manual" and "Code for Thermal Design of Buildings" have given the calculation equation for determining the economic thickness of thermal insulation layer. Analysis of these equations, mostly from the perspective of architectural physics, some of the coefficients are difficult to determine. Therefore it is challenging to use in practical projects, and the economic thickness obtained by using equation calculation examples is often more than 100mm, which is not applicable in practical projects.

The energy consumption of buildings includes the energy consumption in the process of production and transportation of building materials, the energy consumption in the process of construction, the energy consumption of facilities to meet the functional requirements of people's work, study, entertainment and rest (i.e. operation energy consumption, such as room heating, refrigeration, ventilation, lighting, etc.) and the energy consumption of final building demolition. Therefore, strictly speaking, we should consider energy consumption in the whole life cycle of buildings. However, across the entire life cycle of buildings, there is a wide range of factors affecting building energy
consumption, and many factors are beyond the control and decision of building designers or planners, such as the production process of building materials, transportation mode, etc. Therefore, it is unrealistic to excessively pursue the whole life cycle of the economic thickness of thermal insulation materials. The calculation results only have theoretical significance and are divorced from reality. For architects, what they should strive for is how to achieve the lowest total cost in the process of building construction, operation and use, and the minimum impact of building energy-saving materials on the environment and ecology in the whole life process [3-5].

Due to the static method is used in the calculation, the cost of thermal insulation materials will not be considered in this paper, only the investment cost of materials is selected to calculate.

According to the equation of building heat consumption, it can be deduced equation (1) that the total heating cost of the external wall is equal to the sum of the one-time price of the insulation layer and heat consumption cost of unit building area in heating period of design life.

\[ C = C_1 \cdot T \cdot \left( \frac{24 \cdot Z \cdot (t_i - t_e) \cdot F_i}{A_0 \cdot (4981.68)} \right) \left( \frac{F_p}{(0.15 + R_0 + \delta \lambda)(F_p + B)} \right) + \frac{F_{B1} + F_{B2}}{(0.15 + R + \delta \lambda)(F_p + B)} \] (1)

For the exterior wall of a building in a specific area, except the thickness \( \delta \) of thermal insulation material is variable, the other parameters are fixed values. Therefore, according to the analysis of the above equation, with the gradual increase of \( \delta \), \( q_w \) gradually decreases, but the relationship between the two is not linear. At first, with the rise of the thickness of thermal insulation material, the energy consumption of the external wall can be rapidly reduced. With the increase in the thickness of thermal insulation material, \( q_w \) will quickly decrease less and less. The cost of thermal insulation materials and the thickness of a linear relationship, that is, the greater the thickness of insulation materials, the higher the cost. Therefore, from the perspective of appropriate technology, the thickness of insulation materials must have a numerical range, which can help to achieve both the least cost and the maximum energy saving.

In the equation, household appliances and human body heat dissipation), residential buildings, take as 3.8 (W/ m²).

\( t_i \)——The average indoor calculated temperature of all rooms, general residential buildings, take as 16°C;

\( t_e \)——Average outdoor temperature during heating period (°C);

\( c_i \)——coefficient of correction of heat transfer coefficient of the enclosing construction;

\( F_i \)——area of enclosure (m²);

\( A_0 \)——built-up area (m²);

\( q_c \)——index of coal consumption for heating (kg/m²), which is standard;

\( Z \)——Days of heating period (d);

2.2. Empirical Analysis on Economic Thickness of Thermal Insulation Materials
Take a project as an example. Table 2 shows the project overview, and figure 3 shows the plan,

| Table 2. Project overview. |
|-----------------------------|
| **Project Name** | **Project Address** | **WuHu City in AnHui Province** |
| 8# residential building in a community in WuHu City | A real estate development Co., Ltd in WuHu | 3053.85 m² |
| **Construction Unit** | **Built-up Area(A0)** | **Height of Building** |
| | | 15.50m |
| **Architectural Shape** | **Shape coefficient** | **Volume of Building** |
| Strip architecture | 0.27 | 9879.09m³ |
| **Number of floors** | **Building surface area** | **Volume of Building** |
| 5 | 2672.72 m² | |
Figure 3. Plan of #8 residential building in a residential area.

(1) If the thermal insulation materials used for the exterior wall and thermal bridge beam and column are polyphenylene particle thermal insulation slurry, the corrected thermal conductivity $\lambda$ is 0.07, in which $t_i=18$ °C, $t_e=5$ °C, $\varepsilon_i$ is ignored in hot summer and cold winter areas, and $T$ heating period is 72 days.

$$F_p = 1297.72 \text{ m}^2, \quad FB_1 = 336.12 \text{ m}^2, \quad FB_2 = 347.20 \text{ m}^2, \quad Ro = 0.261, \quad R = 0.178.$$  

By substituting the data into the previous equation, the calculation is simplified as equation (2):

$$qw=\frac{(18.5\cdot1981)}{3054}\cdot\left\{\frac{1298}{(0.15+0.261+\delta0.07)}\right\}+\frac{683}{(0.15+0.178+\delta0.07)\cdot1981}$$ (2)

Suppose the thickness of thermal insulation slurry of Polystyrene Powder Particles, $\delta$ is 20 ~ 100, and then substitute it into table 3.

Table 3. Energy consumption per unit building area changing with thickness of material.

| $\delta$(mm) | 10  | 20  | 30  | 40  | 50  | 60  | 70  | 80  | 90  | 100 | 110 | 120 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| $q_w$       | 16.15 | 12.67 | 10.42 | 8.86 | 7.70 | 6.81 | 6.10 | 5.53 | 5.06 | 4.66 | 4.32 | 4.02 |
| $q_c$       | 5.60 | 4.39 | 3.61 | 3.07 | 2.67 | 2.36 | 2.12 | 1.92 | 1.76 | 1.62 | 1.5  | 1.39 |

Figure 4. Relationship between insulation thickness and energy consumption.

According to Comparison & Analysis, figure 4 shows the results. It can be seen from the analysis results in the figure that when the thickness of thermal insulation material changes in the process of building heating, the decrease of energy consumption index is not linear. When the thickness of thermal insulation material is in the initial 20-70 mm range, with the consistency of thermal insulation material, the heat consumption per unit building area decreases significantly. When the thickness exceeds 70 mm, the decrease range of heat consumption becomes gentle. When the thickness exceeds 120 mm, the decrease of heat consumption is not apparent. However, with the increase of the thickness of the insulation material, the investment cost of the insulation layer always increases linearly with the expansion of the thickness. Therefore, no matter from the perspective of appropriate technology or
value theory, we all hope to get such a result, that is, the most economical investment can get a perfect function. It can be seen that thickening the insulation materials cannot get obvious savings, because the additional investment will be relatively large. What we need to adopt is the most economical thickness. Under this thickness, the most economical cost of acquisition can obtain the maximum energy saving.

For the economic analysis of using thermal insulation materials, coal price $C_1=0.5$ yuan/kg, assuming that the service life of thermal insulation material $T$ is 25 years, the price of Polystyrene Particles is 1000 yuan/m³, the surface area of exterior wall and thermal bridge column and beam $S$, is 1981 m², and the build-up area $A_0$ is 3054 m². It can be obtained by substitution (3):

$$C = C_1 \cdot T \cdot \frac{24 \cdot Z(t_i-t_e) \cdot F_i}{A_0 \cdot 4981.68} \cdot \left[ \frac{1298}{0.411 + 0.07} \right] + \frac{683}{0.328 + 0.071981 \cdot 1000 \cdot \delta} + \frac{3054 \cdot 1981}{0.07328}$$

Select the thickness of insulation layer $\delta$ in the range of 10 ~ 100. Then, obtain table 4 and figure 5.

**Table 4.** Comparison of cost after using thermal insulation materials.

| $\delta$(mm) | 10  | 20  | 30  | 40  | 50  | 60  | 70  | 80  | 90  | 100 |
|--------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| $C_1$(yuan)  | 91.68 | 71.88 | 59.1 | 50.26 | 43.72 | 38.64 | 34.7 | 31.44 | 28.82 | 26.52 |
| $C_2$(yuan)  | 6.49  | 12.98 | 19.47 | 25.96 | 32.45 | 38.94 | 45.43 | 51.92 | 58.41 | 64.90 |
| $C$(yuan)    | 98.17 | 84.86 | 78.57 | 76.22 | 76.17 | 76.58 | 80.13 | 83.36 | 87.23 | 91.42 |

$C_1$ is the cost of energy consumption per unit building area of the external wall in 25 years; $C_2$ is the one-time investment cost of insulation materials; $C$ is the sum of $c_1$ and $c_2$.

![Figure 5. Relationship between thickness and cost of polystyrene particle external wall insulation layer.](image)

According to the analysis results of the above two examples, under the condition that the service life of the insulation layer is fixed (25 years), we can see that with the increase of the insulation layer thickness, the total cost in the whole life cycle of the insulation layer changes into a parabola with the lowest point, and the lowest point is 50 mm. At the same time, when the total cost is near the lowest end, that is, when the insulation layer thickness is in the range of 40-60 mm, the curve changes gently, and the cost change rate is the lowest. Because all of the above is the theoretical calculation of the economic thickness of thermal insulation materials, the calculation method is the steady-state calculation method. The analysis assumes that the enclosure structure is in the stable indoor and outdoor temperature field for a long time, so the calculation is relatively simple and often has a gap with the actual value. In the analysis, we found that different parameter values will have a significant
impact on the results. For example, if the high-cost insulation material has a short service life, the economic thickness has no comparative significance and cannot get the appropriate products. The insulation material must have a particular service life to obtain reasonable financial consistency [6-8].

2.3. Conclusion on the Economic Thickness of External Enclosure Structure

The economic benefit of the thermal insulation layer is dynamically related to the one-time investment. If the external wall of the residential building adopts the thermal insulation technology, the cost of the initial technology investment will increase. However, because it reduces the energy consumption of the residence during the service life of the insulation layer, the use cost of the tenancy will be less than that of the residential building without the external wall thermal insulation and energy-saving technology, as shown in figure 6. The insulation technology cost curve (A) will intersect with the non-insulation technology cost curve (A’) in year n. In other words, in the n-year, the economic benefits of external wall insulation technology began to show, which is a long-term financial benefit. The smaller the n value is, the higher the efficiency of energy-saving technology is, and the shorter the time to achieve economic benefits; the larger the n value, the opposite is true. At the same time, it shows that it is necessary to apply external wall insulation technology in residential buildings. So how do we determine the amount of investment? Only using a certain thickness of external wall insulation technology, the sum of initial investment and operation energy consumption cost is the lowest, which is the appropriate input point.

![Figure 6. Relationship between cost and economic benefit of external wall insulation layer thickness.](image)

It is assumed that the added value of production cost of heat preservation and energy-saving technology is Cm, and the cost value of energy saving in residential operation is Cn. The amount of Cm depends on the cost of energy-saving technology itself. The higher the price, the greater the insulation thickness. Cn depends on the energy-saving level of insulation energy-saving technology. The more advanced the technology is, the higher the operation cost can be saved. With the increase of the thickness of the external wall insulation layer, the energy-saving efficiency increases, and the total cost decreases at the same time; however, if the thickness of the insulation layer rises to a certain extent, the total price will increase rapidly. Therefore, the relationship between the external wall insulation thickness and the cost is shown in figure 7. We can see that with the increase of the insulation layer thickness, the total cost in the whole life cycle of the insulation layer changes into a parabola with the lowest point. Therefore, we can draw the concept of economic thickness as follows:
Figure 7. Optimal thickness and economic thickness of insulation layer.

(1) Point M in figure 7 is the most economical thickness point of external wall thermal insulation. It is for a given building, under the condition of given energy-saving and thermal insulation system of exterior envelope structure (except for self-insulation of external wall), the sum of energy consumption cost, construction cost and operation cost of the building, are the lowest when the external wall insulation is at this thickness. We call the thickness of the insulation layer with the minimum sum of the total cost as the most economical thickness.

(2) The economic thickness of external wall thermal insulation has a reasonable range. To make the thickness of exterior wall thermal insulation have practical economic benefits, it is not the thicker, the better, but the closer to the most economical thickness m point (A-B interval) in figure 7, the better, and the closer the thickness to this range, the more economical.

(3) If the technical level of external wall thermal insulation and energy-saving is far higher or lower than m point, the total cost will rise. If the thickness is much higher than the M point, it will lead to the waste of the investment cost. If the consistency is lower than the m point, the insulation layer thickness should be increased, because the production cost is a one-time investment, and the use cost rises year by year. Therefore, when the thickness is lower than m point, the thicker the insulation layer, the more pronounced the economic benefits.

(4) Although the economic benefits of heat preservation and energy-saving technology lower than m point are not the best, due to the low production cost, the technology may meet the economic bearing capacity of economically underdeveloped areas. If the insulation layer thickness is too high, it may lead to the increased initial investment, exceeding the local economic bearing capacity [9, 10].

3. Theoretical Analysis on the Suitable Thickness of Thermal Insulation Material in Hot Summer and Cold Winter Area
The economic thickness of thermal insulation layer is determined from the perspective of economics. In today's energy shortage and environmental deterioration, the selection of insulation layer thickness is not only related to energy conservation, but also the comprehensive problems of environmental pollution, human health and other elements. To select a suitable insulation material and its amount, we should comprehensively consider the impact of materials and products on the ecological environment, that is, the cost caused by the damage to the ecological environment in the process of production, transportation, use and recovery. Therefore, in this paper, the concept of the economic thickness of insulation layer is extended to "appropriate thickness" of the insulation layer, and the concept scope is extended to the impact of materials on the entire ecological environment so that it has a universal sense of "economy". However, the calculation of the cost of material impact on the ecological environment involves the theory of material physical and chemical energy value. So far, there is no consistent result in the international calculation of physical and chemical energy, so it is challenging to get a more comprehensive, real and unified physical and chemical energy value. Therefore, the appropriate thickness of the insulation layer proposed in this paper is also a relative concept. Only the influence factors are described and analyzed, and qualitative inference is made without quantitative
calculation and derivation. The purpose is to enlighten the energy-saving design should comprehensively consider the resource consumption of thermal insulation materials and the level of ecological environment damage, to obtain the appropriate thickness and achieve the best economic and environmental benefits [11-13].

The so-called appropriate thickness of thermal insulation material is from economic and ecological perspectives. For a given building, the energy-saving and thermal insulation system of the peripheral protective structure, the same external wall thermal insulation material, within the scope of its economic thickness, according to the impact of the material itself on the environment, ecology and health in the process of production, processing, transportation and final degradation, the dynamic relationship between the energy saved and the point can be taken as the high range or the low range, which is called the appropriate thickness of the insulation layer. It integrates ecological factors and takes sustainable development as the strategic goal. It is a theoretical point of view to balance economic growth and environmental protection. Suitable thickness is a relative concept. When weighing two or more kinds of insulation materials, the appropriate thickness can be considered for evaluation. In this paper, it extended the definition of suitable thickness and proposed the method of judging proper thickness by using the principle of equivalent factor. Two examples of materials are taken as the judgment index for analysis.

Therefore, the latent value of thermal insulation materials on the ecological environment can be expressed as follows (4):

\[ EP(j) = Q \cdot EF(j), \]  \( j \rightarrow \text{environment} \)
\[ j2 \rightarrow \text{ecology} \]
\[ j3 \rightarrow \text{health} \]

\( j1 \) environmental factor refers to less pollution and environment damage to the outside world. It includes avoiding damaging the natural environment; extracting materials as little as possible; avoiding the use of materials that can produce harmful chemicals; not dumping waste materials at will, but recycling them.

\( j2 \) ecological factor refers to the reduction of energy and resource consumption. It includes adjusting measures to local conditions, using local materials, using materials manufactured on-site; avoiding using imported materials as far as possible and using sustainable development resources; using low energy consumption materials and avoiding using high energy-consuming materials; using second-hand or recycled materials if possible.

\( j3 \) health factor refers to avoiding pollution and harm to health. This includes the use of non-mold materials or low volatile materials; the avoidance of fibers in insulation materials into the atmosphere; the assurance of adequate natural ventilation; the reduction of dust and allergic substances, creating a positive relationship between the indoor and surrounding environment.

Compared with the above three factors, the appropriate thickness of the material with high impact potential should be in the low range value of its economic thickness, that is, the A-M interval in figure 7. For the material with small impact potential, the appropriate thickness value should be within the high interval value of its economic thickness, that is, the M-B interval of figure 7 [14, 15].

Take polystyrene board and aerated concrete as examples to study and analyze.

The raw material of the polyphenylene board is petrochemical products. The petrochemical itself will consume a lot of energy in the production process. Its processing and production will lead to the release of a lot of sulfur dioxide and nitrogen oxides, and these gases will form acid rain, the photochemical oxides such as hydrocarbons will destroy the ozone layer, which will undoubtedly cause different ecological environment Degree of damage. The micro profit and waste gas of macromolecular organic matter produced by the production and processing of the polystyrene board will cause environmental pollution. Besides, if the material encounters fire, it will deliver gas to stimulate the human respiratory tract, which is harmful to human health.
The raw materials of aerated concrete come from brick-making raw materials, fly ash and other industrial wastes, coal gangue or dewatered thick sludge and other wastes. A large number of these materials are taken from urban waste gas concrete. According to local conditions, using local materials, and utilized recycled resources to turn waste into treasure. This reduces the consumption of natural resources, the energy consumption of production, environmental compliance, and maintains the ecological environment. And it will not cause health hazards to the human body; its raw materials are inorganic substances, processing and production will not produce toxic substances.

Therefore, comparing the two materials from three aspects, the production and processing process of polystyrene board has a significant impact on the ecology, environment and health. Besides, its appropriate thickness value should be considered in the low range value of its economic thickness. The production and processing process of aerated concrete will not have a significant impact on the ecology, environment and health, so its appropriate thickness value can consider its high economic thickness value inside [16, 17].

4. Conclusion and Suggestion

In this paper, the function relation of the economic thickness of thermal insulation material is obtained by equation derivation and example calculation, calculating the economic thickness of thermal insulation layer quantitatively. From the ecological point of view, the viewpoint of the appropriate thickness of thermal insulation material is put forward. On this basis, it can reach a more in-depth analysis of the relationship between economic thickness and proper thickness; It is concluded that the suitable thickness value of materials with enormous impact potential value on the ecological environment should be in the low range value of economic thickness, and the appropriate thickness value of materials with small impact potential value should be within the high inter-regional amount of economic thickness. China has a wide range of regions, significant differences in environmental and climatic conditions, and economic development is different. Residential buildings should be diversified and personalized. The research object of this paper is the residential buildings in hot summer and cold winter areas. For other climate regions, consider using which energy-saving and thermal insulation system from the comprehensive economic benefits, and select the most suitable technical approach. Therefore, the development of energy-saving housing should be in line with local conditions, do not to rush into a rush, do not to develop energy-saving housing for reaching energy-saving housing.

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