Climatic Adaptability Design Strategy of Residential Zones based on Climate Consultant and Ecotect Analysis-- Taking Weidong New Town Community as an Example

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Abstract. With the development of society and the improvement of economic level, cities have carried out large-scale construction, among which residential buildings are the fastest growing. The research on low energy consumption of residential areas and residential buildings has become the key to achieve low carbon development in China. Taking Weidong new town community in Weinan as the research area, this paper objectively and comprehensively analyzed the climate environment of the project area from the aspects of temperature, humidity, ventilation and solar radiation through Climate Consultant and Ecotect, and discussed the climate adaptability design strategy of the project area. The thermal comfort assessment of the main activity space in residential area has certain reference value for building energy saving and creating comfortable living environment.

1. Introduction
With the development of society and cities, the real estate industry has entered a golden period of economic growth. Urban housing wastes a lot of energy and resources in the whole life cycle, which seriously affects the construction of urban ecological civilization and sustainable development. According to the China Building Energy Consumption Report (2017) issued by China Building Energy Conservation Association, the total consumption of building energy in China in 2015 was 857 million tons of standard coal, accounting for 20% of the total national energy consumption. The total area of buildings has reached 61.3 billion square meters, of which the total area of residential buildings is 50 billion square meters, accounting for 85.6% of the total area of buildings, 95% of which are energy-intensive buildings [1] [2]. Residential architecture is closely related to people's lives. It not only bears people's yearning for healthy and comfortable living space, but also is the key to realize low-carbon development and transform urban-rural development from extensive to green low-carbon model.
Therefore, the research on low energy consumption of residential buildings has broad prospects and great social significance [3].

Cities should make adaptive feedback as a natural organism at different stages [4]. From the perspective of architecture and planning, it requires that all parts of the city can also give feedback to their specific environment. Climate is not only an important environmental factor, but also an important aspect to be considered in urban planning and architectural design. Different regions have different climatic characteristics. Building a good adaptation relationship between architecture and climate will be the key to achieve low-carbon sustainable development.

This paper takes the residential group as the basic research unit, using Climate Consultant and Ecotect software to analyze the climate characteristics and the climate suitability of buildings in Weinan City, Shaanxi Province, and takes Weidong New Town Community Project as an example to analyze its climate adaptability design strategy, which provides guidance for the project construction and low-energy residential building design in Weinan District.

2. Project Background
With the construction project of Weidong New Town is a key project in Shaanxi Province in 2018 and a key project in Weinan during the 13th Five-Year Plan period. The project is located between the Loess Plateau area and the Weihe plain area in the south of Linwei District, Weinan City. It covers an area of about 20 kilometres in East and west, about 2 kilometres in North and south, and has a total area of about 40 square kilometres (Figure. 1). The total investment is about 10 billion Yuan.

Among them, the core part is Weidong New Town Community Project, with an overall planning area of 4675 mu. The planned population is about 58,000, with an overall volume rate of 1.0, a building density of 3.7% and a greening rate of 55.7%. The plan is divided into five areas, namely, quality of life area, cultural leisure and recreation area, Commercial comprehensive service area, hospital area and resettlement area (Figure. 2).

Figure 1. The location of Weidong new town project

Figure 2. The planning of Weidong new town community project
3. Environmental Analysis Tool

3.1. Climate Consultant
Climate Consultant is a professional Climate data analysis software developed by the department of architecture and urban design of UCLA. There are now more than 2,100 regional meteorological data, provided by the world meteorological organization (WMO). The software can directly use Weather data in the format of EPW (Energy Plus Weather), including Weather data such as dry bulb temperature, wet bulb temperature, relative humidity, atmospheric pressure, solar radiation, wind direction and wind speed. It is characterized by that one of the four thermal comfort models can be selected for use, and different models follow different calculation and evaluation criteria. (ASHRAE Standard 55-2010) points out that thermal comfort is a conscious state expressing satisfaction with thermal environment [6]. It also includes 15 climate adaptation design strategies.

3.2. Ecotect
Ecotect is a comprehensive environmental analysis software developed by Autodesk, which can qualitatively and quantitatively evaluate the climate suitability of buildings. It includes a series of detailed environmental analysis functions, such as day lighting radiation, wind environment, spatial visibility and resource consumption analysis, etc. At the same time, it has powerful visualization analysis technology, which can directly reflect the various environmental performance of the building [7].

4. Climate Consultant Analysis
Weinan is located in the middle of shaanxi province, the northeast of the guanzhong plain, is located in 58°~ 110°35'108° E and 34°13'~ 35°52'N. Weinan city is a warm temperate semi-humid semi-arid monsoon climate, four seasons, adequate light, suitable rainfall. In addition to the Qinling Mountain area, the annual sunshine hours 2009 hours to 2528.1 hours, annual average temperature 11.5℃ to 13.6℃, accumulated temperature above 0℃ is in the range of 4250.3℃ to 5022.9℃, accumulated temperature above 10℃ is in the range of 3780.8 ℃ to 4509.4 ℃, the high value area of heat is the guanzhong area. Annual precipitation: 508 mm ~608 mm [8].

The terrain of Weidong new town community project area is complex. The general terrain of the base is high in the south and low in the north, and most of the northern base is flat. The southern elevation difference fluctuates greatly, and the maximum elevation difference is about 48 meters (the highest elevation is 391.31 meters, and the lowest elevation is 343.27 meters). Residential area located in the north of the base, relatively flat terrain, is an important place for residents to live. According to the topography of the site and the focus of this study, part of residential areas are selected as the research scope of climate adaptability analysis (figure 3).

Climate Consultant software was used to read the meteorological data (CSWD) of Weinan. The meteorological monitoring station number is 570360. The monitoring station is located in north latitude 34 ° 18 ', longitude 108 ° 55 ', from the project area, and recorded in Weinan yearbook of climate data values and trends, can be used for the analysis. ASHRAE basic comfort manual 2005 is selected as the comfort model, which belongs to the dynamic model and gives the comfort range in winter and summer, and the temperature will decrease slightly with the increase of humidity.
The Weidong new town was analyzed by using Climate Consultant software, and the Psychrometric Chart was generated. A total of 13 local Climate adaptation design strategies were formed, as shown in figure 4. The blue area in the figure indicates that the study area is in a relatively comfortable climate environment (about 1059 hours) only 12.1% of the time throughout the year. According to the effective time, the applicable climate adaptive design strategies are: (1) heating and add humidification when necessary (40.1%); (2) internal heat gain (21.1%); (3) sun shading of windows (10.0%); (4) fan-forced ventilation cooling (9.9%); (5) cooling and add Dehumidification when necessary (8.1%); (6) passive solar heating through high thermal storage materials (5.8%); (7) indirect evaporative cooling (5.7%); (8) natural ventilation and cooling (5.7%); (9) reduce humidity (5.4%); (10) night cooling effect of building materials (4.6%); (11) direct evaporative cooling (4.2%); (12) passive solar heating with low thermal storage materials (4.1%); (13) high thermal mass (3.2%). Combined with the local climate in Weinan, some practical design guidelines were proposed, such as designing suitable window cantilever and installing adjustable awning, using light-colored building materials and roof materials with high emission ability.
Table 1. The climate adaptability design strategy and monthly proportions of Weidong new town community

| Design Strategies | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec | Annual |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|--------|
| Comfort           | 0.0 | 0.0 | 1.2 | 12.8| 34.5| 33.1| 6.3 | 15.3| 28.6 | 12.9| 0.0  | 0.0  | 12.1   |
| Heating, add      | 93.5| 87.4| 68.7| 26.8| 34.5| 0.0 | 0.0 | 0.0 | 34.4 | 77.2| 95.3| 40.1 |        |
| humidification    |     |     |     |     |     |     |     |     |      |     |     |     |        |
| if needed         |     |     |     |     |     |     |     |     |      |     |     |     |        |
| Internal heat     | 0.0 | 2.7 | 18.8| 51.7| 49.5| 13.8| 0.5 | 2.3 | 52.4 | 47.8| 13.2| 0.0  | 21.1   |
| gain              |     |     |     |     |     |     |     |     |      |     |     |     |        |
| Sun shading of     | 0.0 | 0.0 | 0.0 | 5.0 | 18.3| 22.2| 28.0| 29.7| 12.1 | 3.8 | 0.0  | 0.0  | 10.0   |
| windows Fan-forced |     |     |     |     |     |     |     |     |      |     |     |     |        |
| ventilation       |     |     |     |     |     |     |     |     |      |     |     |     |        |
| cooling           | 0.0 | 0.0 | 0.0 | 3.2 | 10.3| 32.8| 27.6| 34.8| 9.0  | 0.8 | 0.0  | 0.0  | 9.9    |

Figure 5. The monthly temperature and radiation of Weidong new town community
(Source: Drawn by author through Climate Consultant 5.5)

The main climate adaptation design strategies and the effective time of each month of Weidong new town community project are shown in table 1. Under the premise of taking no measures, the thermal comfort period is mainly distributed in May, June and September. Heating and increasing humidity are the most significant ways to improve thermal comfort, especially in December, January and February, the effective time ratio reached 95.3%, 93.5% and 87.4% respectively. This is largely related to the low temperature and radiation intensity of the month (Figure 5). The adjustment of indoor temperature through internal thermal insulation materials in April to May and September to October has an obvious effect on improving the comfort level. Window shading and fan ventilation play an important role in reducing indoor temperature in summer.

5. Ecotect Analysis
According to the annual average solar total radiation distribution in Shaanxi [9], the total radiation dose between 3830 – 5163 MJ / m², Weinan region is the median of the area, about 4600 MJ / m². In addition, relevant studies show that the elderly and children are the groups with the highest participation in outdoor activities, and the activity radius of such groups is small, and the residential area becomes their main activity place [10]. At the same time, the elderly and children are people who are sensitive to the climate, especially the solar radiation. Too high or too low solar radiation will endanger health [11].
Chinese meteorological data (chn_xian_cswdepw.wea) were imported into Ecotect, and 3D modeling and local photothermal analysis were carried out on the study area, and sunshine and shadow were simulated according to the year-round sun trajectory (Figure 6). According to the main shaded areas and project planning scheme, the main scope of activities of residents can be basically determined. The annual total solar radiation and sunshine intensity are analyzed by using the built-in calculation tool of Ecotect. The analytical grid of 10 m to 10 M size is adopted (Figure 7). According to the analysis result, nutrient-laden east new city community projects in solar total radiation is 1200 KWh / m², 4320 MJ / m², and Shaanxi province meteorological observatory data are basically identical.

**Figure 6.** The sunshine and shadow analysis of Weidong new town community

(Source: Drawn by author through Ecotect 2010)

**Figure 7.** The total solar radiation analysis of Weidong new town community

(Source: Drawn by author through Ecotect 2010)
In general, the Weidong new town community project provides residents with good thermal comfort in the main activity areas such as landscape nodes, squares and entrances. We need shade in summer and sunshine in winter. This requires us to adopt a design strategy of climate suitability to allow people to have a comfortable activity area at different times. Through the local details, we found between each residential buildings, solar radiation is low, about 336 KWH / ㎡, 1210 MJ / ㎡, is the summer place for people to enjoy the cool summer. In the main square, solar radiation in the high value area, about 1200 KWh / ㎡, 4320 MJ / ㎡, is the place that people fully enjoy the sunshine in winter, combining ecological park in the south, gives people a good living environment (Figure 8).

![Figure 8](image)

**Figure 8.** The detail analysis of total solar radiation of Weidong new town community
(Source: Drawn by author through Ecotect 2010)

6. Conclusion
Weidong new town community project is a high-quality place to create ecological livable environment at the urban level. The primary purpose of the design is to reshape the relationship between the life of Weinan citizens and nature, and closely integrate human and nature through a series of climate adaptive design strategies. Based on the Climate Consultant and the Ecotect software environment analysis, mainly from the aspects such as temperature, humidity, ventilation and solar radiation in an objective and comprehensive analysis of the project area Climate environment, it is concluded that the appropriate Climate adaptability design strategy, and through the enthalpy wet figure of nutrient-laden east new city environment (Psychrometric Chart) analysis, obtained the suitable time and the proportion of each strategy. In addition, through years of Ecotect solar total radiation simulation of the main activities of residential space has carried on the thermal comfort evaluation, think that the project at the planning level to provide residents a good living environment, to enhance the scientific nature of the project area planning and design has a certain meaning, for Weinan area of residential area ecological construction provides guidance and help.

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