Study on The Staff Regularity and Building Energy Efficiency of High-star Hotel in Urumqi

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Abstract. Urumqi is located in the arid area of Northwest China. Through field investigation, the author finds that the energy consumption of high-star hotels in Urumqi is large in off-season tourism, but the occupancy rate is low, which causes a lot of energy waste. According to the data analysis of law of indoor activity in each area of high star hotel in Urumqi, this paper puts forward that through building buffer space, according to the different function of building, different treatment should be carried out for different use frequency of building space. According to different use temperature requirements, the use space can be arranged from the inside to the outside in order to form a gradient space, and dividing the various areas of the hotel into heating space, transition space and temperature damping space can achieve the purpose of energy saving effectively.

1. Introduction

1.1. Climatic characteristics
Urumqi is located in the central part of Xinjiang. It is the farthest city in the world and the largest city in the arid region of northwest China. It belongs to the mid-temperate continental arid climate. The hottest is July and August is the hottest, with an average temperature of 25.7°C[1], and it is the peak season of tourism in Urumqi, during which the climate is comfortable and pleasant, and the building can maintain the appropriate temperature environment by means of passive temperature regulation measures, so the building energy consumption is correspondingly low during this period; while the average temperature in October-March, which is the off-season of tourism in Urumqi, is only -15.2°C[1] during this period of time. Because of the harsh and cold climate in Urumqi, it is necessary to heat indoors for a long time to ensure a certain degree of comfort, so huge energy consumption has been generated, but because of the off-season tourism, the utilization rate of hotel buildings is low, so the energy waste is serious.

1.2. Development Trend of Large High-Star Hotels in Urumqi
In recent years, the tourism industry in Urumqi has achieved rapid development. The total tourism revenue and the total number of tourists have achieved rapid growth. In 2018, Urumqi completed a total of 46.24 million tourists, with a year-on-year increase of 40.01%, and total tourism revenue reached 69.4 billion yuan, with a year-on-year increase of 54.26%[2]. Both the number of receptions and tourism revenue hit a new high in recent years. In February 2019, the Urumqi Municipal
Government officially designated the tourism industry as a strategic pillar industry of Urumqi. With the rapid development of tourism, Urumqi hotel industry has also developed strongly. According to the data of Ctrip.com, there are currently 16 five-star hotels and 43 four-star hotels in Urumqi. However, most large-scale high-star hotels have complex and comprehensive functions such as entertainment, conference, catering, accommodation, etc., and their comfort level is higher than that of ordinary public buildings. With the continuous improvement of hotel star ratings, energy consumption is also increasing. According to incomplete statistics, the energy consumption of some hotel buildings has accounted for 10% to 15% of annual operating income, and energy consumption has become one of the important factors for the profitability of operators.

2. Law of indoor activity about high-star hotels in Urumqi

2.1. Overview
Research shows that among many factors affecting building energy consumption, personnel behaviour plays a decisive role in energy consumption, but the individual's perception of cold and warm has more influence on residential buildings and less impact on public buildings. The existing domestic and foreign researches mainly focus on how to establish a more accurate model of human activity behaviour for accurate simulation research. It does have a good guiding effect on the energy-saving design of buildings, but it is too detailed and has low operability.

Zhou Xin et al. at Tianjin University proposed that the energy consumption of office buildings is closely related to the time of personnel in the room, and has little relationship with the outdoor light intensity[3]. However, since the guest rooms of the hotel building are more like residential buildings, they are often affected by personal behaviour. Therefore, more room-adjustable ways should be adapted, such as window ventilation, indoor temperature and lighting adjustment, etc. According to a study by Zhou Weiyi et al at Tianjin University, the occupancy rate of rooms is the most influential on hotel energy consumption[4]. Therefore, this article will simplify the hotel staff's room time according to space and behaviour, and carry out data analysis on the lighting and air conditioning (refrigeration, heating) demand in the building for the personnel in the room, so as to better guide the passive energy-saving architecture design.

2.2. Hotel customer classification and characteristics
The customers of the hotel building can be divided into two categories: nonlocal customers and local customers. Affected by the climate, there are obvious differences in the number of nonlocal tourists in Urumqi during the low and peak seasons of Tourism. During the peak season, the hotel rooms are full, while in the off-season, the hotel occupancy rate has dropped sharply, only half of the peak season. The number of local customers has higher stability than that of nonlocal customers, and the difference between low and peak seasons is small.

The first problem that nonlocal customers need to solve is accommodation. They are often not in the room during the day and return to the hotel at night. The demand for breakfast is higher in catering, while the demand for lunch and dinner is lower. Nonlocal customers who attend meetings tend to stay at the hotel, so there is no obvious floating of flow of people.

The main service items of local customers are catering, meeting and leisure, and accommodation is rarely used. The main consumers of lunch and dinner in the catering section of the hotel are local customers. Meetings attended mainly by local customers often bring a large number of instantaneous crowds. Local customers often hold wedding ceremonies in banquet halls, and often pack several rooms to entertain relatives and friends. Affected by climate, Hotel bathing centre passenger flow will increase in winter.
Table 1. Classification and characteristics of large high-star customers in Urumqi

| Personnel            | Demand       | Importance | Functional space             | Using characteristic                                      |
|----------------------|--------------|------------|------------------------------|-----------------------------------------------------------|
| **Nonlocal customers** | Accommodation| A          | Guest room area              | Difference between the off-season season is obvious       |
|                      | Diet         | B          | Dining area                  | Breakfast                                                  |
|                      | Office, meeting| C         | Meeting & banquet area       | Hotel accommodation                                        |
|                      | Leisure      | C          | Wellness area                | Hotel accommodation                                        |
| **Local customer**   | Diet         | A          | Dining area                  | Lunch, dinner, wedding                                     |
|                      | Wedding, annual meeting, conference | B | Meeting & banquet area     | Instantaneous heavy traffic                               |
|                      | Leisure      | B          | Wellness area                | Large flow of people in non-working time                   |
|                      | Accommodation| C          | Guest room area              | Low frequency of use                                       |

Note: In the order of importance of different needs for customers, A is the most important, B is the medium, C is not important.

2.3. Rules of Use in Different Areas

The space of the hotel complex can be mainly divided into guest room area, conference area, catering area, wellness area, lobby area, administrative office area and underground garage area. The staff in the administrative office area are basically office workers, so the rule of staff in the room has not changed very much all the year round. The lobby area is often located at the main entrance of the hotel, including lobby bar, front desk, waiting area, etc. It needs to meet the needs of customer registration, leisure, business talks and so on. It has a higher requirement for indoor environment comfort, so the lobby area often needs a long time to adjust the indoor environment by mechanical means, and the amount of energy consumption has little to do with the law of its personnel in the room, while the underground garage area does not require high temperature comfort, so this area has little impact on hotel energy consumption, so this paper focuses on the using law of guest room area, conference area, catering area, and wellness area. Each area can be further subdivided according to different space usage rules and space comfort requirements.

2.3.1. Guest room area

The guest room area includes standard rooms, executive lounges, suites and presidential suites, as well as auxiliary spaces such as corridors, elevators, cloth rooms, room service centers, and equipment rooms. There are obvious differences in the occupancy rate of Urumqi hotel rooms during the low and peak seasons, and the occupancy rate in the peak season is about double that of the off-season. In winter, there are often a large number of rooms that are vacant.

The set temperature of the interior of the room is basically the same in winter and summer, and it is about 24 °C. It is the area with the highest temperature setting requirements. In addition, the humidity requirements of various rooms are kept between 40-60%. In addition to the interior of the room, the rest of the customer's use areas such as the executive lounge, corridor, and elevator floor temperature requirements are relatively low, mainly reflected in the winter temperature can be appropriately reduced to about 20 °C, the use of cloth, equipment room and other staff use area There is almost no temperature setting requirement, and the winter temperature is higher than 5 °C.

Table 2. Usage rules of the guest room area

|          | Set temperature (℃) | Time law | Area ratio |
|----------|----------------------|----------|------------|
|          | Summer | Winter | Peak season | Low Season | 72% | 150 square meters / set |
| Guest rooms, suites | 24-26 | 22-24 | Figure 5-1 | Figure 5-2 | 72% | 150 square meters / set |
| Presidential suite | 24-27 | 22-25 | - | - | 150 square meters / set |
| Room service center | 24    | 20    | All day    | A set     |

|
The personnel indoor rate of standard room and the suite have a significant gap in the off-peak season (Figure 1, Figure 2). Because of the lower occupancy rate, the personnel indoor rate of the off-season is reduced to about half of the peak season, but the law of change in the personnel indoor rate with time is basically the same. The rooms in the peak season are basically full, and the occupancy rate of the staff at night is basically 100%. During the day, the customers are basically traveling outside. Only a small number of customers stay in the rooms or have staff to enter the room for cleaning, so the personnel indoor rate is low, 14:00-15:00 is the lunch break, and the personnel indoor rate has slightly increased. At 2:00-7:00 in the morning, the customers have basically rested, and the usage rate of lighting equipment is basically zero. Every day from 7:00-9:00 is the wake-up time, during which time the use of lighting equipment will increase rapidly, but the sun will rise at around 8:00, and the growth rate of light usage will decrease. During the day, it is mainly the dark part of the room or the working table using the light, so the lighting equipment utilization rate is low. After 19:00, as the outdoor illuminance decreases, the light usage rate rises as the personnel indoor rate increases. During the off-season, the occupancy rate of guest rooms has dropped significantly, which is about 50%. Due to the reduction in daylight hours and the reduction in outdoor illumination, the period of use of the lights is slightly extended. Moreover, due to the increase in the proportion of customers traveling during the off-season business, the 9:00-10:00 am and office demand at night increased, and the usage rate of lighting equipment during these two periods remained at a relatively high level. The elevators and corridors in the building need 24 hours to meet the illumination and temperature requirements, and the staff in the linen and equipment room have low personnel indoor rate and low temperature and humidity requirements.

2.3.2. Conference area
The conference area mainly includes all kinds of small conference rooms and large multi-functional halls. Large multi-functional halls that can hold large conferences or banquets often include the main hall, the front hall, the lounge, the tea room, the independent kitchen, the bathroom and the storage section. Among them, the area of the main hall accounts for the largest proportion, and the setting temperature requirement is the most stringent. It needs to meet the comfort of participants for a long time. Generally, it is 23-25°C in summer and 21-23°C in winter. The setting temperature of service rooms such as lobby, lounge and tea room is lower than that of the main hall, which is 26-28°C in summer and 20-22°C in winter. Independent kitchen is mainly for banquet use, storage room is mainly

| Executive Lounge | 24-26 | 18-20 | 10:00-22:00 | Four/eight bay |
|------------------|-------|-------|------------|---------------|
| Corridor, elevator room | 25-27 | 20-22 | All day | 25% |
| Cloth room, equipment room | - | ≥5 | All day | One on each floor |

Note: Source data is quoted from "Hotel Building Design Code" JGJ62-2014
used to store all kinds of furniture and supplies, there is no clear requirement for temperature in summer, winter can only meet the temperature above freeze-proof temperature.

Table 3. Usage rules of the conference area

| Set temperature (℃) | Time law          |
|---------------------|-------------------|
|                     | Summer | Winter | Peak season | Low Season |
| Main hall           | 23-25   | 21-23  |             | 55%        |
| Front hall, lounge, pantry | 26-28   | 20-22  | 09:00-22:00 | 15%        |
| Bathroom            | -       | 16     | 09:00-22:00 |            |
| Separate kitchen    | -       | 10-16  | 10:00-24:00 | 15%        |
| Auxiliary area, storage area | -   | 8-10   | All day     | 15%        |

Note: Source data is quoted from "Hotel Building Design Code" JGJ62-2014

2.3.3. Catering area

The catering area can be divided into full-time restaurants and non-full-time restaurants, where full-time restaurants provide breakfast, lunch and evening meals for a long time. The non-full-time restaurants mainly provide lunch and dinner (Figure4, Figure5). The personnel indoor rate of restaurant increases rapidly in dining time and decreases rapidly in non-dining time. The use rate of lighting equipment keeps almost the same change rule as that of people in dining time. However, the use rate of lighting equipment is slightly lower than that of other dining time periods because of the abundant illumination outside during lunch time. Because the temperature adjustment needs a certain time, the non-meal time is short, and the restaurant temperature comfort requirements are high, so the restaurant air conditioning equipment will maintain a high utilization rate during the use of the restaurant.

Table 4. Usage rules of the catering area

| Set temperature(℃) | Time law          | Area ratio |
|---------------------|-------------------|------------|
|                     | Summer | Winter |                 |
| Dining area         | 24-28   | 16-22  | 42%          |
| Public area         | 26-28   | 16-20  | 10%          |
| Kitchen area        | -       | 10-16  | All day restaurant 07:00-24:00 20% |
2.3.4. Wellness area

The wellness area mainly includes two parts of fitness and entertainment. Among them, the fitness part often includes gymnasium, indoor swimming pool, bathing center, etc. The entertainment part includes KTV, chess room, bar and so on. The temperature setting temperature in the recreation area is generally 24-26 ℃ in summer and 18-20 ℃ in winter, but the set temperature in the indoor pool in winter is much higher than in other areas, and the summer temperature is also higher.

Different functional spaces have different laws of indoor activities. Among them, the rate of gymnasium customers is higher and the time of use is longer. Therefore, it is specially studied (Figure6, Figure7). The use of gymnasium in working days and non-working days is also different. Generally, the personnel indoor rate in working days and non-working days will rise at 20:00, and at 22:00 reached the highest level in a day, but during the day, the occupancy rate of non-working days was almost twice as high as that of working days. The use rate of lighting equipment is basically the same as that of people in the gym, but because there are customer activities in the gym during business hours, the use rate of air-conditioning equipment in the gym will be maintained at a high level during the use of the gym.

| Table 5. Usage rules of the wellness area |
|------------------------------------------|
| Set temperature (℃) | Time law |
| Summer | Winter |
| Swimming pool | 26-29 | 26-28 | 10:00-21:00 |
| Gym | 24-26 | 18-20 |
| KTV, chess room, bar | 24-26 | 18-20 | 18:00-02:00 |
| Storeroom | - | 10 | All day |

Note: Source data is quoted from "Hotel Building Design Code" JGJ62-2014
3. Spatial Organization Method of Energy-saving in Large High-star Hotel

3.1. Overview
Modern architectural studies have shown that people's feelings of thermal comfort in the building space are not a constant indicator but a comfortable area, and this area will be offset in different seasons, different costumes, and different types of occupants. This shows that if only mechanical measures are taken to change the comfort of living, it will not fully meet the requirements of the occupants, but will waste a lot of energy, and through the construction of buffer space for the building, according to the different functions of the building, different architecture space with different use frequency can be treated differently. According to different use temperature requirements, the use space can be arranged from the inside to the outside in order to form a gradient space, which can achieve the purpose of effective energy conservation. Therefore, this study will divide the various areas of the hotel into heating space, transition space and temperature damping space according to the gradient of the set temperature, and arrange these three spaces reasonably to achieve the maximum energy saving effect. (Figure 8)

3.2. Energy saving method

3.2.1. Guest room area
Due to the high temperature setting requirements and the user's comfort experience, the room area should be used as a heating space. Due to the special nature of the presidential suite, the usage rate is low and the privacy requirements are high, often at the highest level. And it can basically occupy half or even one floor as the presidential suite area, which can be used as the temperature damping space of the whole building. The executive lounge is often combined with the executive suite, mostly for daytime use, with high temperature setting requirements, and generally requires a good view and space.
experience, so it should be used as a heating space, and should be used as far as possible in the south or southeast direction. Corridors and stairwells are the most frequently used areas of the room area throughout the day, but the requirements for illumination, temperature and humidity are low, so they can be used as transition areas. Storage space such as linen and other equipment rooms, in addition to meeting the antifreeze requirements in winter, basically no set temperature requirements, can be placed in the worst facing north, or the middle and end of the building, as a temperature damping space.

In addition, In Urumqi, the occupancy rate of hotel rooms in off-season tourism is low, the occupancy rate in peak season is high, and the heating season is off-season tourism. This study proposes the concept of using the partition in the low and busy seasons of the guest room area. The standard floor rooms in the guest room area are divided into the summer room area on the north side and the winter room area on the South side. The summer room area is open only in the peak season of tourism, while the winter room area is open all year round to accommodate the phenomenon of half occupancy rate in winter. The depth of summer rooms on the north side should be reduced as far as possible on the basis of meeting the use area, while the depth of winter rooms on the south side can be increased moderately. In addition, it is suggested that the number of winter rooms should account for 55-60% of the total number of rooms and 40-45% of summer rooms. On the one hand, the number of winter rooms should be slightly more to meet the reasonable elastic demand of rooms, on the other hand, the best orientation space should be arranged as many as possible for the guest room. In the off-season, the summer room area is closed. At this time, only the basic temperature needs to be maintained at the anti-freeze temperature of 5 °C or more in the summer room, and there is no need to guarantee the set temperature of 22-24 °C. According to the energy-saving design principle of public buildings, under the heating condition, the energy consumption can be reduced by 5%-10% for every 1°C reduction of indoor calculation temperature, and the closing of summer rooms can save the hotel a lot of heating energy consumption.

![Diagram](image)

**Figure 9. Schematic diagram of guest room area plane mode**

### 3.2.2. Conference area

The conference area mainly includes various small meeting rooms and large multi-purpose halls. Multi-purpose halls for large conferences or banquets often include the main hall, vestibule, lounge, pantry, separate kitchen, bathroom and storage. The main hall has the largest area and the most stringent temperature requirements. It needs to meet the long-term comfort of the participants. It is usually 23-25°C in summer and 21-23°C in winter, which can be used as heating space. Service rooms such as the lobby, lounge and pantry have lower temperatures than the main hall. The summer is 26-28°C and the winter is 20-22°C, which can be used as a transition space. The independent kitchen is mainly used for banquets. The storage room is mainly used for storing various furniture items. In
summer, there is no clear requirement for temperature. In winter, it only needs to meet the antifreeze temperature. It can be used as temperature damping space.

Figure 10. Schematic diagram of the conference area plane mode

3.2.3. Catering area
The catering area can be mainly divided into dining area, public area, kitchen area, auxiliary area and transportation area. The dining area has the strictest requirements on temperature and humidity. The indoor humidity requirement is controlled at 30%-65%, the summer temperature requirement is 24-28°C, and the winter temperature requirement is 16-22°C, which is used as heating space. The temperature requirements of public areas, corridors and other spaces are slightly reduced. The summer temperature requirement is 26-28°C, and the winter temperature requirement is 16-20°C, which can be used as a transition space. The kitchen, decontamination, and auxiliary areas based on storage functions have lower temperature requirements and can be used as temperature damping space.

Figure 11 Schematic diagram of the catering area plane mode

3.2.4. Wellness area
The wellness area includes the main functional space and ancillary service spaces. The main function space is generally composed of two parts: fitness and entertainment. Among them, the use time of the fitness part is concentrated in the daytime. Generally, it is required to have open and bright indoor environment. The requirements for setting temperature are also high. It should be arranged in the south direction as heating space. The use time of the entertainment part is mostly concentrated at night, mainly relying on mechanical heating. Passive temperature adjustment measures have little effect on the indoor environment, so it is used as a transition space. The ancillary service space is composed of a traffic area and an auxiliary area. The traffic area such as a walkway and a public area as a short-term
staying time of the customer has a lower temperature requirement and can be used as a transition space, and the auxiliary area with non-customer use such as a kitchen or a storage area can be used as a temperature damping space.

![Figure 12 Schematic diagram of the wellness area plane mode](image)

4. Conclusion
According to the different types of buildings, modernism sums up the unified design mode of its functional space and promotes the development of architectural design, but it also leads to the similarity of similar buildings in different regions. In fact, even in the same type of building, there are often different rules of use in different regions, and these differences also affect the energy consumption of buildings.

This paper summarizes the law of indoor activity in different regions such as guest room area, conference area, catering area, wellness area of Urumqi high-star hotel by analysing the different requirements of personnel in-room hours, temperature, illumination, and humidity of different regions. The hotel areas are divided into three categories: heating space, transition space and temperature damping space. The stepwise space organization design method is used to utilize the temperature damping zone space and the transition zone space to ensure the temperature stability of the heating zone and reduce the hotel energy consumption.

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