Individualization of Microclimate Air Conditioning Systems in Residential Premises

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Abstract. Individualization of a person's life is associated with the quality of the microclimate of the surrounding person in the room. Microclimate norms are associated with the satisfaction of about 75 % of people, however, 25 % is a variable that depends on the activity and characteristics of a person's metabolism at any given time, as for the seemingly stable 75 %. The formation of engineering systems, taking into account the individual characteristics of a person, will make it possible to more economically spend energy resources and spend heat energy pointwise, taking into account the need for each person. When a person has an individual place at home, where a microclimate is created that is necessary for a specific person at any given moment in time. Changes in the climate surrounding the building must also be taken into account when forming the microclimate in the individual spaces of the building, taking into account the need for each individual person.

1. Introduction
Indoors, a person can spend a fairly large part of his life, in some periods a person is at home more time, in other periods less. A person is formed in a socio-cultural environment, where his activities are determined by the level of education and personal characteristics and are individual and collective in nature. A person needs a living space protected from the external climate, the size of which is determined by socio-cultural aspects that determine a person's life position in society. The microclimate of a given living space is associated with a person's metabolism, which is variable at any given time period during the day and at all stages of a person's life. The creation of a microclimate in a residential space requires the consumption of thermal and electrical energy, which is determined by the level of development of society, human wealth and the capabilities of the state.

2. Problem statement
Individual or private or personal space in a residential building, which is occupied by one person - this is the space in an apartment or house where a person is alone, engaging in individual activities. In such a space, if it is allocated in the form of a separate room, it is possible to provide the microclimate parameters that are necessary for a particular person at any given time, depending on the metabolism and physiology of a person, taking into account the psychological, emotional and physical state.

Sometimes a person needs to concentrate so that no one distracts him from solving any problems, for example, a person can live and work at home in a remote format. Many creative tasks are individual in nature and their solution requires a person to be alone with himself. What space in a residential building...
can be allocated for one person? Since all residents of the Russian Federation have the opportunity to receive education, including higher education, such a personal or private space can be designated by the minimum living area equal to 18-20 m² ± ΔF m², since human life and activities are associated with many things and objects that a person needs, for example, a personal library, a music library, a video library (Figure 1).

\[ F = F_0 ± ΔF, \text{ square meters} \]
\[ V = V_0 ± ΔV, \text{ cubic meters} \]

**Figure 1.** The influence of socio-cultural factors on the area or volume of individual or private space in a residential building.

The time-varying metabolic or physiological state of a person determines what parameters of the microclimate a person needs at each moment of stay in a private space, which allows influencing engineering systems to create the microclimate parameters necessary for a person. This approach allows you to save heat energy if a person is hot or increase the air temperature in the room if the person is cold. If a person engages in physical education at home, then the air temperature may be required lower, and if the activity is associated with quiet activities, then the air temperature may be required higher.

It is known that spot watering of plants and considering individual needs for the growth and development of each plant in modern agricultural production gives successful yield results while reducing costs, for example, for water supply, etc.

Some people feel hot, others cold in the premises of modern apartments - this suggests that the systems that create a microclimate cannot always cope with the tasks assigned to them to create the necessary microclimate parameters for each person. In the first case, the vents open and heat is lost, which goes into the environment, and in the second case, they can turn on the electric heating by overloading the power grid (Figure 2).

Physiological, as well as interrelated psychological and emotional states of a person can be measured by using a “smart bracelet”, worn on a person's hand, and which takes readings of the physiological parameters of the functioning of the human body, which are influenced by other states. The “smart bracelet” transmits data to the automation system that regulates the operation of the air conditioning systems of the private space, and the air conditioning system rebuilds its work for a specific physical, psycho-emotional state of a person. A diagram of the interaction of a smart bracelet, a person, a microclimate in a private space and engineering systems that form a microclimate is shown in (Figure 3). The organization of the air conditioning systems should be implemented in such a way that the private space of each person in a residential building is provided with the necessary microclimate parameters.
individually. It is possible to implement such air conditioning systems, mainly for the heating system, using, for example, apartment heating systems.

![Diagram of the influence of human condition on microclimate parameters](image)

**Figure 2.** Scheme of the influence of the human condition on the parameters of the microclimate in a private space in a residential building.

![Diagram of smart bracelet interaction](image)

**Figure 3.** Scheme of the interaction of a smart bracelet, a person, a microclimate in a private space and engineering systems that form a microclimate.

A residential building consisting of private or private spaces cannot do without common or collective spaces located in apartments and between apartments. Is it possible to achieve energy savings by customizing microclimate systems in a residential building with private spaces? The answer depends on the metabolic characteristics of residents living in a residential building. Obviously, if people live in a
residential building who are always hot, then the savings in heat energy when regulating the heat flow, for example, from the heating system in the cold season, but if people live in the building who are always cold, then it is necessary to increase the heat consumption to increase indoor air temperature during the cold season.

If people are cold, they freeze, their thermoregulatory system is strained and they can get sick, work worse and their activity will be less effective, possibly with the cost of treatment, if people are hot, they sweat, which can lead to colds and also to decrease efficiency in various activities. If the air temperature of the surrounding person in the room is at the level he needs, then the possibilities for realizing life potential and active life position increase. A person gives up heat for life and its distribution between evaporation, convection and radiant heat transfer is relatively stable and familiar for the climate of the Russian Federation separately for each season of the year, climate warming leads to the need to get used to or adapt to higher temperatures, which practically did not exist. 50-100 years ago, which is associated with the need to adjust the work of the human thermoregulation system during adaptation, in which addiction is formed to new climatic conditions. This destabilization is associated with the redistribution of heat fluxes between evaporation, convection and radiant heat exchange between a person and the environment.

When implementing the heating system for a private space in an apartment building, it must be borne in mind that in the harsh winter periods in the Russian Federation, no one can live without heating, so there can be no personal space with the heating system turned off. The building must have a minimum indoor air temperature in heated rooms, below which the indoor air temperature must not be.

The microclimate in the premises of residential buildings in the Russian Federation today is formed based on the requirements of regulatory document state standard 30494-96 “Residential and public buildings. Indoor microclimate parameters “, according to which the allowable air temperature in the living room should be 18-24 °C, and for cold areas 20-24 °C, while for rooms with the elderly or disabled the permissible temperature is set at 20-24 °C, and for cold areas territories 22-24 °C. The permissible resulting temperature is set at 17-23 °C, for cold areas 19-23 °C, for rooms where the elderly or disabled people are 19-23 °C, and for cold areas 21-23 °C.

However, the required temperature regime in the room, according to the above state standard, may not coincide with the required temperature regime, considering the individual characteristics of a person. It is known that thermal comfort usually has a range from 15 °C to 25 °C, and when designing engineering systems, the temperature range of 18-20 (22) °C is often used, in addition, the temperature of a healthy person ranges from 35.5 °C to 37.2 °C, per temperature the human body is influenced by gender and age. During the day, the temperature of the human body changes by about 1 degree: minimum in the morning, maximum in the evening. In practice, there are cases when people preferred to live at an internal air temperature of + 30 °C.

If there is a variety of desired values for the internal air temperatures in an individual living space, the required range can be set in the range of 15-25 °C (30 °C), which is associated with the prevention of cooling of the premises of the building, a decrease in the incidence of diseases of residents and heat flows between rooms with different temperatures through ceilings and internal walls. Heat loss between rooms with different air temperatures through internal enclosing structures becomes significant if the air temperature difference between them is more than 3 °C, and in the case of individualization of personal space, this temperature difference can be 10-15 °C, which requires the use of thermal insulation of internal walls and ceilings.

Individualization of engineering systems that form the microclimate in terms of supply mechanical ventilation systems is devoted to the work [1,2]. The work [3] is devoted to improving energy efficiency while ensuring the parameters of the microclimate of residential buildings. The formation of favorable living spaces in buildings is dedicated to the works [4,5]. When individualizing the temperature regime, it is necessary to consider the massiveness of the enclosing structures, which requires modeling the thermal regime [6,7]. Monitoring the parameters of the microclimate and air quality [8], as well as monitoring the dynamics of the outdoor climate will allow to achieve a more accurate consumption of thermal energy for the needs of buildings [9,10]. The quality of the internal microclimate is associated
with the air-conditioning mode of the premises, which is considered in [11]. The following works are devoted to the study of individual space from the point of view of the socio-cultural factor [12, 13, 14]. The following work is devoted to understanding private space in society [15, 16].

3. Result of calculation

Consider the cold season and a living room in a residential apartment building as a private space with an individual heating system. Room of 20 m², with an outer wall of 7.4 m² and a window of 3 m². All other enclosing structures in this room are internal and without heat losses and gains. The room has a heater connected according to a two-pipe and room-by-room layout of the heating system pipes. Consider several options that consider the peculiarities of a person's stay in the room. In the first version, consider one person who is constantly in the room for 24 hours, while he is a source of warmth: from 11 pm to 6 am he rests, being at rest, from 7 to 9 am there is light work, from 10 to 18 o'clock he performs work of medium severity, from 19 to 22 o'clock, light work is performed, in the periods from 7 am to 22 o'clock in the room there are additional heat inputs of a domestic nature. In the second version, a person does the same, but leaves for work between 10 and 18 hours, turning off all household sources of heat. In Figure 4, shows how the heat flow in the room under consideration changes during the day.

Figure 4. Change in heat input into the room during the day without additional heating of the internal air.

In Figure 5 shows how the air temperature in the room changes during the day during a person's stay in the room, the temperature is in an acceptable state (option 1), while a little heating may be needed during the rest period. When a person leaves for work between 10 and 18 hours, there is no heat surplus, and the temperature drops to 15 °C (Figure 5, option 2). In this case, the savings in thermal energy will be 7% at an internal temperature of 18 °C and 11% at an internal air temperature of 20 °C.
Figure 5. Changing the air temperature inside the room without additional heating.

If a person needs a warmer microclimate, an additional heater can adjust the air temperature to the desired value, for example, to a temperature of 28 °C during wakefulness and to a temperature of about 25 °C during sleep (Figure 6, option 3) or up to 25 °C during all hours days (Figure 6, option 4). But all the same, if a person leaves the premises to work or to a store or somewhere else, then the temperature can be lowered to 15 °C (Figure 6, option 5) and the thermal energy savings will be 20 % at a temperature of 25 °C and 25 % at a temperature of 28 °C.

Figure 6. Change of air temperature inside the premises with additional heating.

The organization of the heating system in an individual private space can be as follows. Two heaters are installed in the room: 1. the main or basic heater, which forms the minimum required internal air temperature in the room, for example, equal to 15 °C, this heater can be adjusted when setting up the heating system during the construction of the building and its operation will only be controlled
temperature of the coolant depending on the outside air temperature, 2. An additional heating device, the task of which is to quickly increase the air temperature in the room to the temperature required by a person, for example, from 15 °C to 20-25 °C (30 °C), the operation of this heater can be formed with the regulation of thermal flow when interacting with a smart bracelet. The heat flow from the additional heater is also regulated by changing the temperature of the heating medium in accordance with the current climate parameters and local regulation. When accounting for the consumption of heat energy, heat consumption by the basic and additional heating devices can be carried out according to separate heat energy meters and with different tariff plans. The smaller the room, the faster you can achieve the desired indoor air temperature. The Russian Federation is one of the coldest developed countries in the world and here it is impossible to form residential areas of infinite volume and area, as this is due to economic factors, as well as the formation and maintenance of engineering infrastructure to provide buildings with thermal energy.

It is necessary to create a new type of heating device with shutdown - inclusion of additional sections, which would increase its consumer qualities. However, the task of an additional heater to quickly bring the air temperature in the room to the value required for a particular person requires additional consideration, so the concept of quickly heating the air is within 1-5-10 minutes, which can be done, for example, using a convector with a built-in fan, the operation of which will lead to an increase in the intensity of air circulation in the room passing through the finned surfaces of the additional heater and a rapid increase in the temperature of the internal air, it is possible that the fan noise can be overcome by using different speeds of rotation of the impeller: during the period of warming up the air in the room to the desired temperature maximum speed, and then, to maintain the required temperature, the speed of rotation of the impeller can be changed with a decrease to 0.

By heating the air in rooms to different temperature values in the building, the dynamics of heat fluxes between rooms inside the building is formed, which can be reduced by using thermal insulation of floors and internal walls. The dynamics of the thermal regime in a building with the dynamics of temperature regimes in the premises form the dynamics of the air regime in the flow of air between the premises of the building. When the air in the room heats up or cools down, the temperature regime inside the external and internal enclosing structures changes, which will bring the thermal regime into dynamics, taking into account the inertia of the enclosing structures, which will affect the lag in response to disturbing influences, which will occur in all rooms of the building. In addition, the dynamics of the thermal regime of the heating system will be increased in the building, which is associated with the differentiation of heat flows in the premises, considering the individual preferences of residents.

4. Conclusions
The individualization of the microclimate is associated with the individualization of all systems that form it: heating, ventilation, air conditioning. The minimum comfort limit in the Russian Federation is designated as 18 °C, but at this temperature many people feel cool, so the value of 20 °C is more often used, but there are cases when a private client asks for + 30 °C. It turns out that it is possible not to waste extra resources on maintaining the microclimate, since the individual microclimate in the room will allow to provide the necessary conditions for human life.

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