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Zoning of the south Russian territory on the energy efficiency of translucent structures

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Abstract: Zoning of the territory of Russia allows us to take into account climate parameters when designing energy-efficient buildings: the temperature of the external and internal air, the duration of the heating period and the cooling period, the intensity of solar radiation, the orientation of the facade, average cloud cover, the direction and strength of the wind, and also the parameters of the building envelope: thermal insulation properties, translucency, shading.

Keywords: energy-efficient houses, map of isolines of solar radiation, climate parameters, parameters of the building envelope, zoning of the territory

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Introduction

When designing an energy-efficient building, the climatic conditions of the construction area play an important role. The specificity of the climate of Southern Russia (Fig. 1) is the large number of sunshine hours per year (in some areas it is 1,000 hours more than in Germany (Feist, 2008)) - this factor allows the use of passive solar heating as a way to reduce energy consumption for heating a building during the cold period of the year.

The quantitative assessment of the so-called ecological trace of a city structure, or the life of a city, according to the doctrine of city planning and resettlement (strategic planning of cities), is ensured by the implementation of the principles: establishing a link between the removal of resources from the natural environment, throwing away waste into the environment, the state of public health, the lifespan and development of the structure (Ilyichev et al., 2014). Such a relationship, among other things, exists between the amount of fossil fuel burned, carbon dioxide emissions released into the atmosphere and the standard of living and public health.

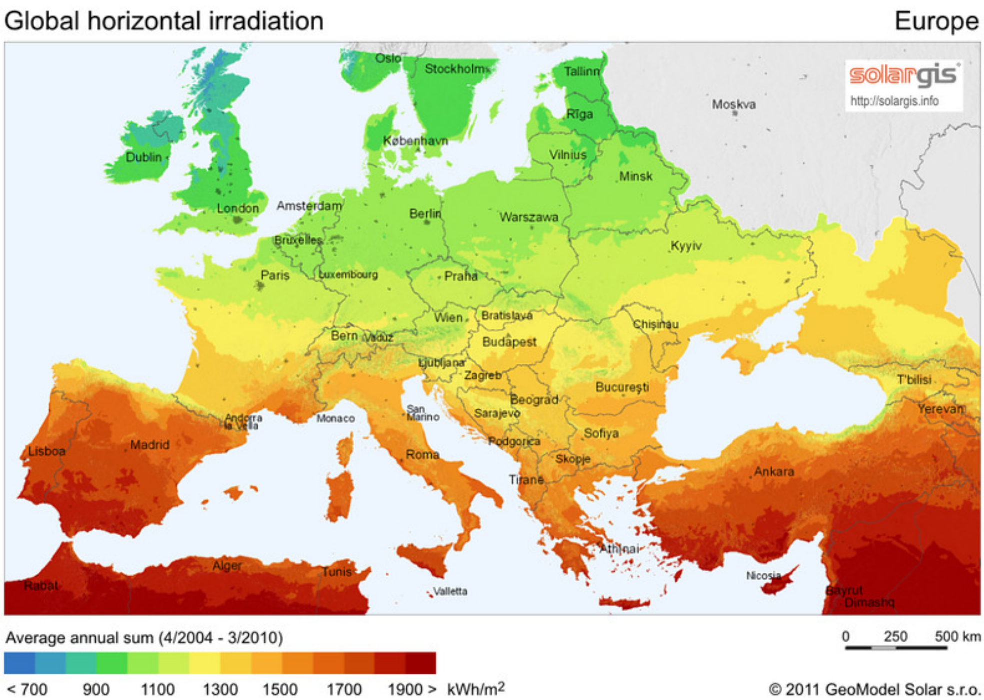

Fig. 1. Global horizontal irradiation. Europe (*Internet sources: SolarGIS-Solar-map-Europe-en.png*)

During one month of the heating period, direct solar heating through windows with an area of 10 m^2, located on the southern facade, reduces CO_2 emissions by an average of 350 kg. Solar space, located on the southern facade, leads to a reduction in CO_2 emissions by an average of 740 kg per month in the climate conditions of Crimea (Dvoretsky et al., 2018).

In accordance with the methodology proposed by the author and presented in Building Regulation (СП 1325800.2017) a map of the territory of the Russian Federation (Fig. 2) based on the total solar radiation on a horizontal surface with actual cloud conditions is needed to determine the shape and duration parameters of solar protection devices.

Five main zones were identified according to the conditions of total annual solar radiation on a horizontal surface under actual cloud conditions:

– the first zone - 900 kWh/m^2 or less;
– the second zone - over 900 to 1000 kWh/m^2;
– the third zone - over 1000 to 1100 kWh/m^2;
– the fourth zone - over 1100 to 1200 kWh/m^2;
– the fifth zone - over 1200 kWh/m^2.

Fig. 2. Zoning of the territory of the Russian Federation by the amount of solar radiation (*Building Regulation (СП 1325800.2017 "Sun Protectin Devices of Buildings. Design Rules" of the Russian Federation*)

It is necessary to provide shading of fenestration during the overheating period (cooling period of buildings) depending on the total amount of solar radiation.

1. Climate parameters

The histogram (Fig. 3) shows that three cities: Vladivostok, Simferopol, Krasnodar are located at the same latitude - 45°N.

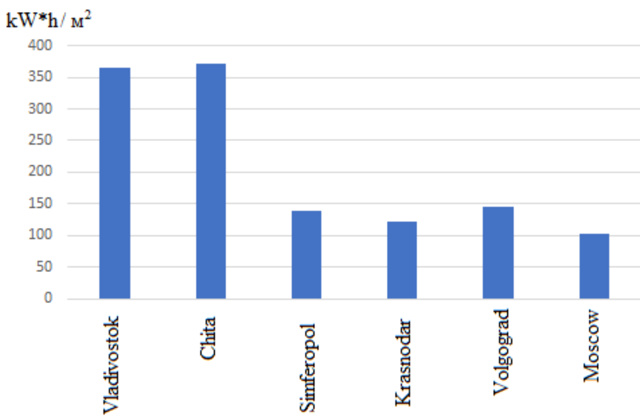

Fig. 3. Thermal solar gain for the heating period (*own research*)

However, a significant difference in the total solar radiation in these cities is associated with different actual cloud cover during the heating season.

Energy-efficient solar houses are created as a result of integrated design, which uses local energy sources and materials, and the air conditioning of the interior

is achieved more by architectural means than through engineering (Bainbridge & Haggard, 2011; Council National Renewable Laboratory, 1992).
The main climate parameter determining solar architecture is the total solar radiation on a vertical surface with actual cloud cover (СП 131.13330.2012).

To compile a map of isolines (Fig. 4) of solar radiation, it was necessary to collect data on the total solar radiation under actual cloud cover, which falls on a vertical surface of the southern orientation during the heating period in the cities of the Southern Federal District, as well as cities of neighboring countries (Sergeychuk, 2011) to provide a more accurate construction of contours.

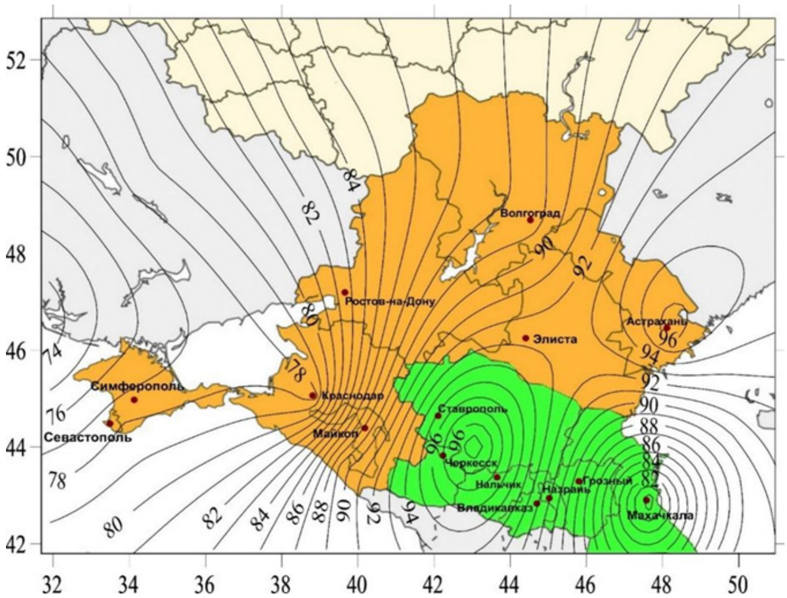

Fig. 4. Total solar radiation on the south facade with actual cloud cover during the heating period [W m^2] (*own research*)

2. Parameters of translucent structure

The study considered the specific heat loss and heat input through the windows of southern orientated structures. Double-glazed windows with a hard selective coating (K-glass) 4M1 + K4 with double binding were chosen. An isoline with a value of 0 indicates that the specific heat loss of the translucent structure of the southern orientation is equal to solar gains during the heating period (Fig. 5).

The proposed information model of the energy-efficient simulation consists of climate parameters and building envelope parameters. The climate parameters are as follows: the temperature of the outdoor and indoor air, the duration of the heating period and the cooling period, the intensity of solar radiation, the orientation of the facade, the average cloudiness, the direction and force of the wind. The parameters of the building envelope are the following: thermal insulation properties, translucent, shading.

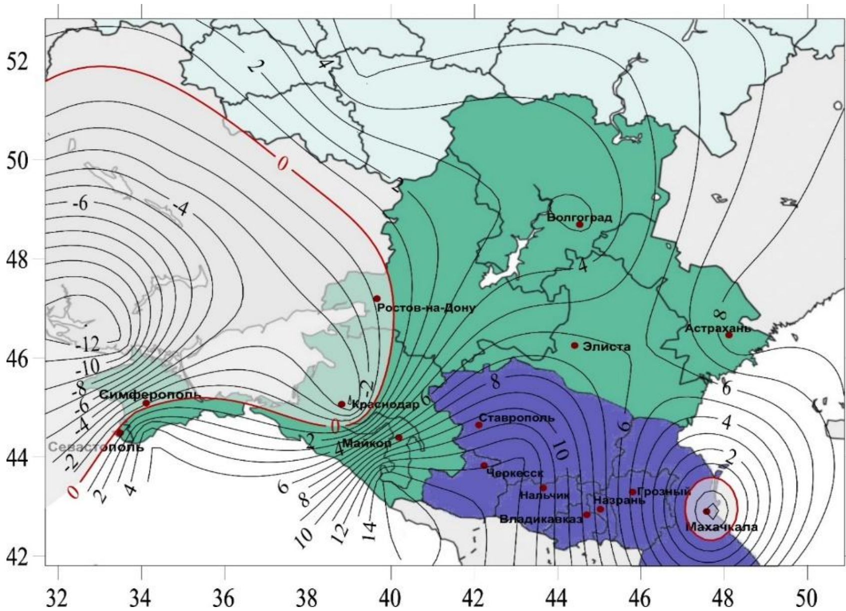

Fig. 5. The resulting energy of the windows with double glazing, with hard selective coating (K-glass) 4M1 + K4, with a double binding of the southern orientation (*own research*)

Based on this model, a contour map (Fig. 5) of specific thermal energy excess during the heating period for windows of southern orientation with the minimum allowable heat transfer resistance of a translucent structure of southern Russia has been compiled.

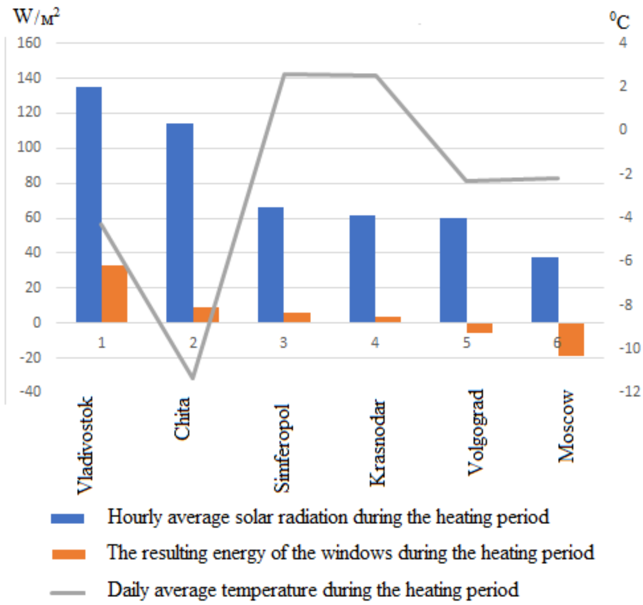

Fig. 6. Climate parameters and resulting energy of windows during the heating period (*own research*)

Despite the lowest average monthly temperature in the heating period in Chita (–11.3°C), the resulting heat energy in this city is less than in Vladivostok and higher than in Simferopol (Fig. 6). Although the average monthly temperature in the heating period in Simferopol was 2.6°C.

Conclusions

1. When designing an energy-efficient building, the climatic conditions of the construction area play an important role. Specific to the south of Russia is the large number of hours of sunshine per year (in some areas up to 1000 hours more than in Germany) this factor allows the use of passive solar heating as a way to reduce energy costs for heating a building in the cold season.
2. Despite the low average monthly temperature (–11.3°C), in Chita (52°N) one of the largest thermal solar gains in the south of Russia is for one of the longest heating periods, due to low values of actual cloud cover (5 points), and, therefore, high total solar radiation on the vertical facade of the southern orientation (114 W/m^2).

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Strefowanie terytorium południowej Rosji pod względem efektywności energetycznej struktur półprzezroczystych

Streszczenie: Strefowanie terytorium Rosji pozwala na dokładne uwzględnienie przy projektowaniu energooszczędnych budynków takich parametrów, jak: temperatury powietrza zewnętrznego i wewnętrznego, czasu trwania okresu ogrzewania i chłodzenia budynków, intensywności promieniowania słonecznego, orientacji fasad, średniego zachmurzenia, kierunku i siły wiatru, a także parametrów związanych z obudową budynku, mianowicie: jej własności termoizolacyjne czy półprzezroczystość, a także zacienienie elewacji.

Słowa kluczowe: domy energooszczędne, mapa izolinii promieniowania słonecznego, parametry klimatyczne, parametry obwiedni budynku, podział na strefy terenu