Regional features of heat supply systems development in the North

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The article discusses the features of heat in the north and the proposed method of determining the specific characteristics of the heating of buildings taking into account these features.

Keywords: **rigidity of climate, heat consumption, specific consumption of heat.**

The heat supply in the North is the most power-intensive and the most prodigal sector of economy. Republic Sakha (Yakutia) is one of the largest regions of Russia. The total area of territory makes 3083.5 thousand in sq. km. Republic consists of 446 municipal unions (33 municipal areas (ulus), 2 city districts, 49 city settlements and 361 rural settlements).

In 2007 in Yakutia 19500 thousand Gcal of thermal energy to the heating, ventilation and hot water supply of heat consumers was made, from them 13519.8 thousand Gcal was made by district heating supply system (69.3% from the general development of thermal energy), including on thermal power stations over 26% of thermal energy was made, and the distributed heating provides 30.7% of heat consumers from autonomous boilers and heating furnaces, that is equal 5987.2 thousand Gcal in a year. From this data it's visible that the distributed heating systems make the considerable part of the Republic's heat supply. The fuel consumer in autonomous sources of the heat supply makes more than third of all fuel spent for the heat supply that is caused by low technical characteristics of small boilers, especially on solid fuel.

The problem of heat supply systems fueling of northern areas in the conditions of Yakutia becomes an important state problem.

Principal type of the main fuel delivery transport, both to consumers of northern areas (ulus), and to consumers of hard-to-reach areas of Yakutia is the sailing charter. Duration of navigation on the rivers is 110-120 days in a year, on the seas of Arctic Ocean navigation to the mouths of Anabar River, Indigirka River, Kolyma River, Olenek River, and Yana River lasts 70-90 days in a year, and in some years lasts only 30-40 days. Because of multilink transport scheme (river-sea-river-highway) and the short navigating period the necessity of terminal bases creation for warehousing during the inter-navigating period appears.

In these conditions it is necessary to pay the same attention to development of distributed heating systems as well as to development of the district heating supply systems. Objects of the heat supply systems provided with these heat sources as consumers are characterized by following indicators: autonomy, insulating property, and low-power.

Autonomy is a full self-sufficiency and independence, and independence of other heat consumers. This indicator is very high and connects with primary development of steading in countryside and recently development of individual building in cities and the regional centers.

Insulating property is an indicator of transport hardness of northern territories owing to territorial dispersion in huge territory of Republic, because of a long distance and the impassability, which is the one of rigidity criteria of residing conditions.

Low power is a small volume of heat consumption, defined from paucity of the population and from consumed heat volume which speaks primary development of individual building in cities and steading in countryside. Building of rural-type settlements basically is presented by one- and two-storey houses with wood walls from the square logs and the whole timbers, consisting of more 100 thousand houses.

Creation of normal residing conditions in the North, different a severe climate depends on a heat supply quality. One of creation conditions of any life support systems in the north, considering rigid climate conditions, is exact definition of thermal energy consumption by

residential, municipal and industrial buildings and structures.

Operating experience of residential buildings and other objects in Yakutia in which it should be supported normal hygienic conditions for residing and professional experience of the person shows that a number of factors not considered by effective standards on an establishment of heat consumed impacts on heat engineering characteristics of building envelope. There are factors influencing on heat consumption:

- The complex influence on a size and character of thermal losses of temperature combination of outer air and wind exposure [1];
- The decline of thermal losses transmission through opaque building envelope, related to the solar radiation;
- The changes of heat conductivity coefficient of building envelope material in operating terms (due to the decline of humidity and senescence);
- The enhancement of heat expenses on heating of infiltration air are related to the climatic condition – cold temperatures of outer air [2];
- The foundation of building with the device of cold underground for conservation of permanently frozen soils in their natural state as steady base during erection and exploitation.

At actual dryness of Republic's climate, as well as in all Northern region of Russia relative humidity of internal air sticks to 20-30% for all heating period in the heated buildings without humidity adjusting facilities.

In these terms the account of regions climatic factors with the especially cold climate (cold temperatures of outer air and low absolute humidity, air mobility) influencing on materials physical properties (heat conductivity, humidity, permeability to air) becomes a necessity because of heat-protective properties changing and rendering considerable influence on the general thermal losses of buildings and structures. The complex of researches, sent to determination of influence on operating descriptions of the heated building is conducted for this purpose.

On the researches basis we are developed a new methodology of heat consumption calculation of buildings and structures, erected and operation in the especially cold climate conditions. It is necessary for the complete and exact account of requirement in thermal energy and fuel and energy resources and choice of heat supply systems development ways in north regions, taking into account their difficultness of access and inflexibility of climate.

New methodology of norms setting charges of heat and fuel is developed taking into account all factors influencing on this expense.

The offered methodology will consider:

1. Influence of building type on heat losses.
2. Number of storeys.
3. Influence of building form.
4. Presences of the ventilated underground and warm garret
5. Changes of materials heat conductivity of building envelope.

Suggestion is also brought on the account of wind pressure in localities with high actual speeds of wind in a cold period of year.

The offered methodology of the specific heating description determination will allow to define heat losses of residential building most exactly by comparison to before operating [3] and will assist providing of reliable fuel supply in the far north conditions with seasonal fuel delivery.

For exactness of specific heating description determination of building it is additionally accepted:

- Dividing of Republic territory by climatic areas in accordance with [4];
- Suggested to enter concepts: volume specific heating description, superficial specific heating description and area specific heating description).

In first case an index the transmission coefficient of heat building transfer or specific thermal description serves as at determination of heat losses – by volume q_0^0 (kJ/m^{2}h°C) are thermal losses of building in at the difference of temperatures between internal and outer air,

equal to a 1 degree, being on 1 m^3 of building volume.

In second case the brought transmission coefficient over of heat building transfer, which can be also defined as specific thermal the characteristic – by superficial $q_0^{П}$ (kJ/m^2h°C) are thermal losses of building at the difference of temperatures between internal and outer air, equal to a 1 degree, being on a 1 m^2 of surface building.

In third case the brought transmission coefficient over of heat building transfer, which can be also defined as specific thermal the characteristic – by area $q_0^{эс}$ (kJ/m^2h°C) are thermal losses of building in at the difference of temperatures between internal and outer air, equal to a 1 degree, being on 1 m^2 of building general area.

- New principle of specific heating description determination depending on a type, construction of building and number of storeys.
- Dependence of transmission coefficient on the year of building.
- Change of heating engineering description of materials of building envelope.

In a general view a formula for determination of heat losses looks like the following

$$Q_O = q_0 \cdot V \cdot \Delta t; \quad (1)$$

q_0 - is specific heating description of building, characterizing building heat losses at $\Delta t = 1°C$ on 1 m^3 of volume in a W/m^3·°C;

Mainly at determination of general heat losses of building in existent methodologies for dwellings building under specific heating description total thermal description of building is implied taking into account infiltration losses through building envelope [5].

In accordance with [4], next methodology of determination of q_0 (specific heating description) is offered by a formula:

$$q_O = q_{TP} + q_{инф} - q_{быт}; \quad (2)$$

q_{TP} - is a average specific expense of heat on transmission losses through building envelope [kcal/(m^3 h °C) /W/m^3 °C], which is determined on a formula

$$q_{TP} = K_{пр} \cdot K_K \cdot \beta_1 \cdot \beta_2 \cdot \beta_3; \quad (3)$$

On the basis of heat losses analysis the separate elements of building envelope are offer a next formula for determination of specific expense of heat on transmission losses.

$K_{пр}$ - is the specific brought coefficient over of heat transfer of building envelope determined for building from 01.06.96, for building from 01.07.96 to 01.01.2000 and building after 01.01.2000 accordingly.

K_K - is a coefficient of building compactness, determined on a formula:

$$K_K = \frac{S_H}{V_H}; \quad (4)$$

S_H - is a surface of heated premises walls of external measurement;

V_H - is the heated volume of a building on external measurement; in the absence of the data on a building the factor of compactness K_K should be defined under following formulas (for residential buildings):

1. for one-storeyed buildings:

$$K_к = 0{,}541 + 1{,}602\frac{1}{\sqrt[4]{V_H}} + 9{,}250\frac{1}{\sqrt[4]{V_H^3}}; \quad (5)$$

2. for two-storeyed buildings:

$$K_к = 0{,}303 + 1{,}308\frac{1}{\sqrt[4]{V_H}} + 20{,}183\frac{1}{\sqrt[4]{V_H^3}}; \quad (6)$$

H - is a building height;

β_1 - is the sum of correction factors considering a wind speed (k1), term of buildings operation, type of building envelope;

β_2 - is a factor considering a building configuration (presence in a building aired underground, technical floor, warm attic, and cellar);

β_3 - is the factor considering change of heat engineering characteristics of the building envelope materials.

β_1 is defined by the formula:

$$\beta_1 = (1 + \sum \kappa); (7)$$

κ_1 - is the factor considering additional losses of thermal energy from wind influence;

κ_2 - is the factor depending on operation term;

$q_{инф}$ - is the resulted specific heat expense on heating upward seepage air;

$q_{инф}$ shows heat quantity necessary for heating of arriving external air demanded for creation and maintenance of air cleanliness in a building. Recently with increase in thermal protection of buildings a heat share spent for heating of external air has increased from 20% to 42%. The parity of the expense of heat upward seepage air to the general expense of heat increases by heating in the beginning and the end of the heating period (Fig. 1). Calculations show that this parity for buildings of equal volume at settlement temperature of external air that more than more low this temperature (Fig. 2).

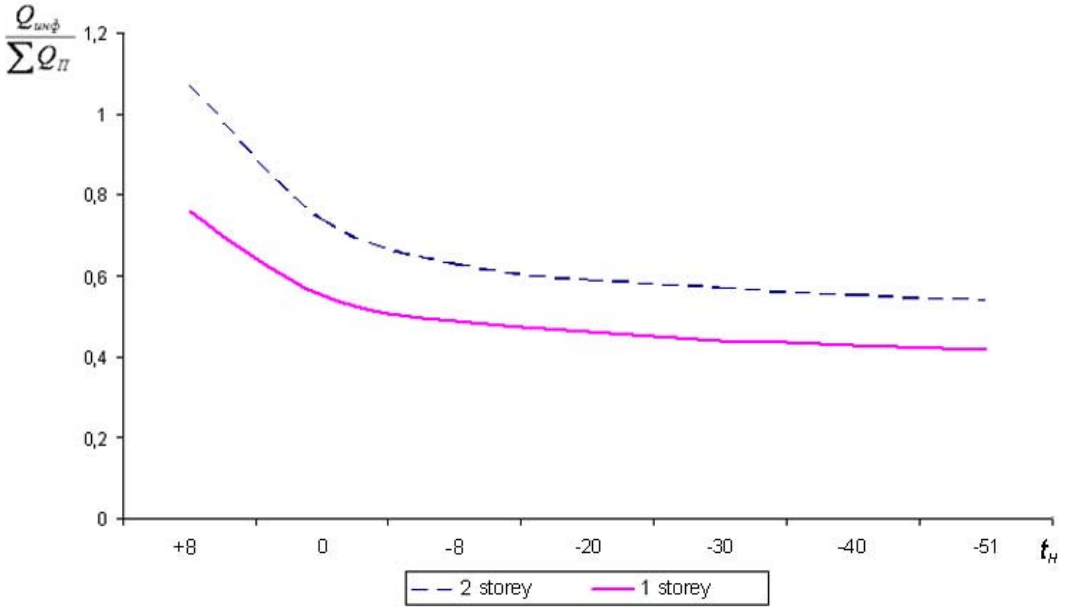

Fig. 1. The ratio of heat for heating the air infiltration to the total consumption of heat. At $t_н$ = -51 ^0C .

$q_{быт}$ - are specific household thermal emissions of a residential building it is accepted on the basis of the Russian norms [6].

The new methodology considers heat consumption features of buildings depending on following factors:

- Considers ageing of buildings (year of building construction);
- Considers deterioration heat engineering characteristics of heat-insulated materials (a material of walls and coverings);
- Number of building storeys;
- Floor height;
- The form of a difficult configuration building;
- Considers new requirements of air exchange of buildings as inhabited and public appointment;
- Considers influence of wind loading;
- Considers household thermal emissions;
- Eliminates a divergence of settlement indicators at heat consumption definition of residential buildings on volume and a floor space;
- 1 stage (since July, 1st 1996 is developed taking into account change of specifications on a heat-shielding of buildings towards increase in demanded resistance to a heat transfer of protecting designs from conditions of power savings.) and 2 stage (since January, 1st 2000);

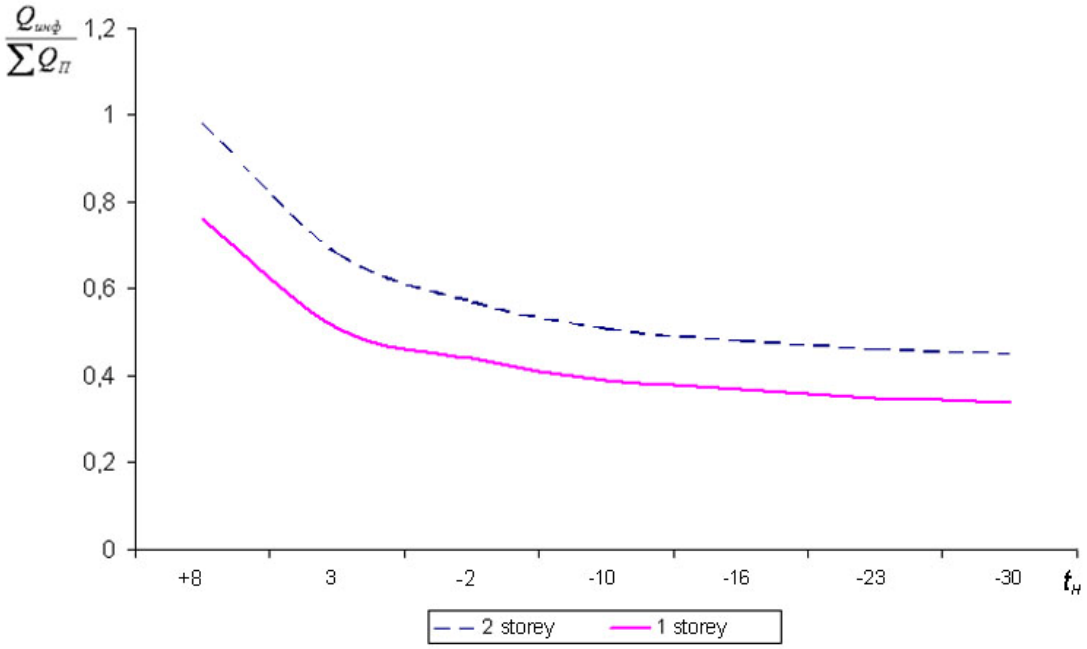

Fig. 2. The ratio of heat for heating the air infiltration to the total consumption of heat. At $t_н$ = -30 ^0C .

From conditions of heat expenses on heating of air arriving in premises for the account infiltration or submitted systems of forced ventilation, for maintenance of necessary cleanliness of air in heated premises the complex estimation of influence of meteorological parameters and physical characteristics of materials changing under its influence on heat-shielding properties of protecting designs at their operation can be defined concept introduction the general rigidity of climate S_0 in points by analogy of technical rigidity of a climate for cars and mechanisms.

For an establishment of a climate rigidity indicator it is necessary to spend a complex of the researches directed on definition of its influence on operational characteristics of heated buildings depending on regions climatologic features with a frigid climate.

The account of a rigidity indicator, at definition of resistance to a heat transfer of external protecting designs and also the account of the increased value of a heat share for heating of external air arriving in a building will allow to estimate correctly economically effective level of a heat-shielding of small volume buildings at their reconstruction and at designing of heat supply systems of small settlements and to lower the expense of financial, material, fuel and energy resources.

REFERENCES

[1] Scientific and technical report "Heat in the areas of Eastern Siberia and the Far North." Norilsk: Krasnoyarsk Promstroy NII project, 1969. 169s.

[2] Kylatchanov A.P., Popov V.L. Methods rationing thermal characteristics of the building. - Yakutsk: Polygraphist YSC SB RAS, 2000. 31 pp.

[3] Normalization of flow of heat and fuel for heating and hot water to buildings in the Yakut ASSR. - Yakutsk: State Committee YASSR, 1987. 110 pp.

[4] TSN23-343-2002 Republic of Sakha (Yakutia). Thermal protection and energy consumption of residential and public buildings / Ministry of Construction of Sakha (Yakutia), 2002. 67 pp.

[5] Energy efficient buildings - in the Moscow mass construction / Livchak VI / / Avoca, 1999, № 1, p. 13-20.

[6] SNIP 41-01-2003. Heating, ventilation and air conditioning / State Building in Russia. - M.; FSUE LAC, 2003. 54s.

BIOGRAPHIES

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