THE EXPERIENCE OF DEVELOPING THE BUILDING ENERGY REQUIREMENTS FOR THE COUNTRIES WITH DIFFERENT CLIMATIC CONDITIONS

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SUMMARY

In this paper, we consider the problem of the energy requirements of energy performance standards for the regions with big different of climatic conditions. The key measure of building energy-efficiency performance in Russia is a climate-adjusted value for specific energy consumption for heating the building during one heating season. The specific energy consumption parameter is proposed as the quantity of heat required in the heating season per square meter of the total floor area or per cubic meter of the volume of a building, per degree-day, measured in Wh/(m^2.^{o}C.day) or Wh/(m^3.^{o}C.day). This parameter has been tested on the territory of Russia with its most diverse climate conditions including 486 locations. Using this parameter the State Committee for Construction of Russia (Gosstroy RF) adopted in 1995 an amendment to the federal Code "Thermal Engineering" that provides for a considerably higher level of thermal performance. Based on this parameter a new draft of the Russian Building Energy Performance Code has been developed now. Nine regions of Russia have adopted and enforced their standards using this model; the fifteen Russian regions are developing their standards using that approach too.

INTRODUCTION

The Federal Law on Energy Conservation and the RF Government's relevant Regulation place among their top priorities the development of building standards, and the introduction of the indicators for the energy consumption for heating, ventilation and hot water supply. These

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shall be included in relevant regulation and can not be implemented without formulating the new building code requirements.

Existing federal codes have been of a prescriptive nature. Prescriptive codes limit the implementation of innovative technologies, materials and technical designs into building practice. To remove the limitations inherent in prescriptive codes, the State Committee for Construction of Russia (Gosstroy RF) issued the Code 10-01 “A system of stipulating documents in construction”, which states that new regulations should give the user ‘functional’ or ‘performance’ provisions, setting the goals but not the ways of achieving them. Existing Code *“Thermal Engineering”* [1] do not have standards which limit the overall consumption of heat energy for heating the building. In connection with the strengthening of the requirements for energy conservation, there has emerged a need to develop principles of standardization of the heat-energy indices of the building.

SETTING STANDARDS BASED ON SPECIFIC ENERGY CONSUMPTION PER DEGREE DAY

The concept is based on the following three principles:

(a) setting code provision to achieve three key goals - a certain level of heat consumption for a building; thermal comfort, in both the central part of a room and at the margins; no condensation on inner wall and ceiling surfaces;

(b) giving the designer a free hand achieving the required thermal performance, based on measurable parameters instead of a meticulous observance of certain rules;

(c) providing an opportunity to control and certify actual energy parameters of the building, to check that a building as constructed and operated sets the design goals.

The approach is to be based on requiring a standard value for specific energy consumption for heating or cooling any building. To figure out this standard value, thermal performance properties of the envelope assembly or building shell should be determined. The specific heating energy consumption (for building heating) is defined as the quantity of heat consumed in the heating period per sq.m of the total heated floor area or per cub.m of the volume of a building, per degree-day, Wh/(m^2.^{o}C.day) or Wh/(m^3.^{o}C.day).

The idea of this parameter goes back to 1994 [2], when a new index has proposed as the basis of the model regional standards for energy efficiency in buildings in Russia. These models, entitled “Energy Efficiency in Buildings. Regional Standards for Thermal Performance of the Buildings”, were developed by authors in the Research Institute for

Building Physics (known by its Russian initials NIISF), in the Center for Energy Efficiency (CENEf) (both in Russia) and in the Natural Resources Defense Council (NRDC), a non-profit American environmental organization [3].

The effectiveness of the proposed index can be shown in an example (Table 1). The 9-story residential building, designed in compliance with the Code "*Thermal Engineering*" before the amendments (see level "0" on Fig.3) and connected to a system of centralized heat supply in the different cities. The stability of this index is evident.

Table 1 Specific Energy Consumption of Buildings, q, During the Heating Season (An Example for Typical 9-story Multifamily Building)

City	Specific heat energy consumption	
	kWh/m^2	$Wh/(m^2.^oC.day)$
Verkhoyansk	467	38
Yakutsk	393	37
Omsk	256	39
Samara	195	39
Astrakhan	139	41
Krasnodar	100	40

This parameter has been tested on the territory of Russia with its most diverse climatic conditions in the range of thermal performance required by the federal Code *"Thermal Engineering"* before the amendments again. Specific heating-energy calculations were made for ten apartment buildings most typical of Russia (5-, 9- and 17- stories) located in 486 Russian locations. The calculations accounted for building dimensions; rated thermal resistance of walls, floors, ceilings and windows; rated air exchange per hour; the average indoor air temperature; duration of the heating period; and the average wind velocity and solar radiation over this period, all depending on the construction area. The received data were analyzed statistically: they were grouped in the lowest-highest values order with interval of 10 $Wh/(m^2.^oC.day)$. The histogram (Fig.1) presents the distribution of the number of cases of normalized specific energy consumption. Similar histograms, each confined to a subset of buildings of the same height, were then used to identify the annual heating energy consumption below which can be found 95% of the population in each subset.

In table 2, an analysis of this index is presented based on the example of three climate zones of the USA [4]. The data reflect the real results of energy demand in 1975-76 in 125,000 single-family row houses and 45,000 multi family buildings. Just as in the conditions of Russia, the independence of this parameter of climatic conditions of the UAS is also evident.

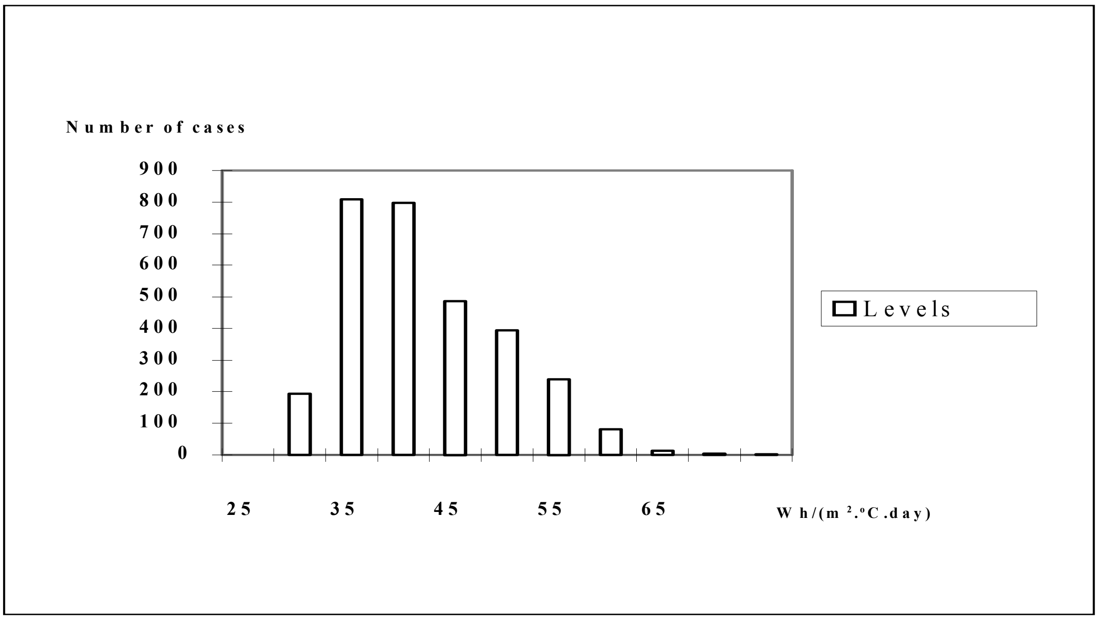

Fig.1. Number of occurrences distribution histogram to building specific energy consumption

Table 2 Specific energy consumption for heating of three climatic zones of the USA

Type of the buildings	Specific energy consumption for the zones (W.h/(m^2.^{o}C.day)		
	I - 3889 ^{o}C.day	II - 3472 ^{o}C.day	III - 1667 ^{o}C.day
Multi family buildings	47.1	50	49
Single-family row houses	52.7	49	53.8

FEDERAL STANDARD FOCUSES ON ENERGY EFFICIENT BUILDINGS

Using this parameter the Gosstroy RF adopted in 1995 amendment to the federal Code [1] which provide for a considerably higher thermal performance level in new and renovated buildings. The new standard has allowed to reduce energy consumption for buildings heating by 20 to 40% compared to the current level.

Numeric values of the new standards were obtained with the following methodology. For 486 locations in the Russian Federation, the design values and standards still in force under the above Code and the Code "Building Climatology" were used to calculate the number of Degree Days and specific energy consumption for heating different types of buildings. For those calculations 8 types of multi storied and the same number of one/ two-storied buildings were taken, which had different designs of enveloping structures. The new values of specific energy consumption were then used for calculation required areal thermal resistance of exterior walls, roofing constructions (attics included), and floors depending on the number of Degree Days in the place of construction. Thus two reduction levels for specific energy consumption were approved and the corresponding thermal performance standards for residential buildings were set on their basis:

- 20% for newly constructed and 40% for renovated buildings at the **first** stage (From the year 1995 to 1999);

- 40% for all kinds of buildings at the **second** stage (On the year 2000).

Fig. 2 shows the relationship between the number of Degree Days in any of 486 locations and the required areal thermal resistance of exterior walls of residential buildings at the first stage of standards introduction. It also shows the best-fit linear regression for that relationship.

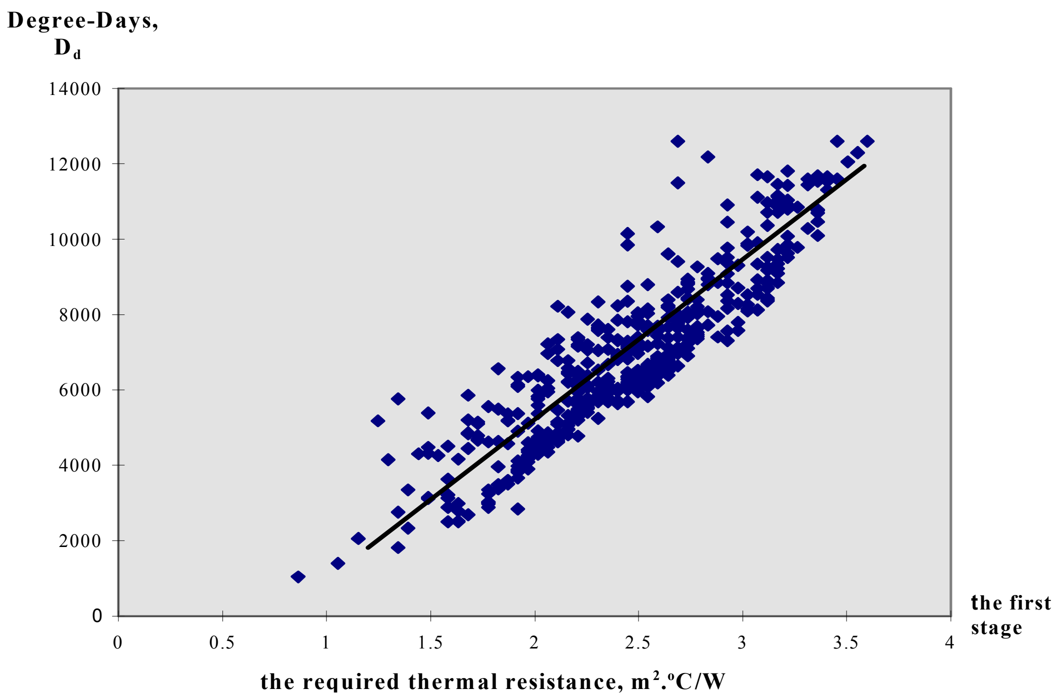

Fig. 2 The relationship between the required thermal resistance and the number of degree days

Fig. 3 compares thermal performance levels before the amendments and that have been introduced at the two stages. It is seen in Fig. 3 that the thermal performance level “0” is presented as standard requirements set for single-layer envelopes. The first-stage thermal performance level “1” approximates standard requirements already available for walls made with the use of efficient thermal insulation, and the second-stage level "2" will correlate with the current requirements in such foreign countries as Sweden and Canada.

Impact of Regional Codes on Federal Regulation Process

Since the Russian federal building code can not reflect all specific features of separate regions, it ought to contain only basic requirements. As for specific regional features, they should find their reflection in regional codes of energy efficiency standards. The Code 10-01 permits the approval of regional standards by regional administrations without Gosstroy's RF formal authorization as long as they do not contradict the federal Russian building code.

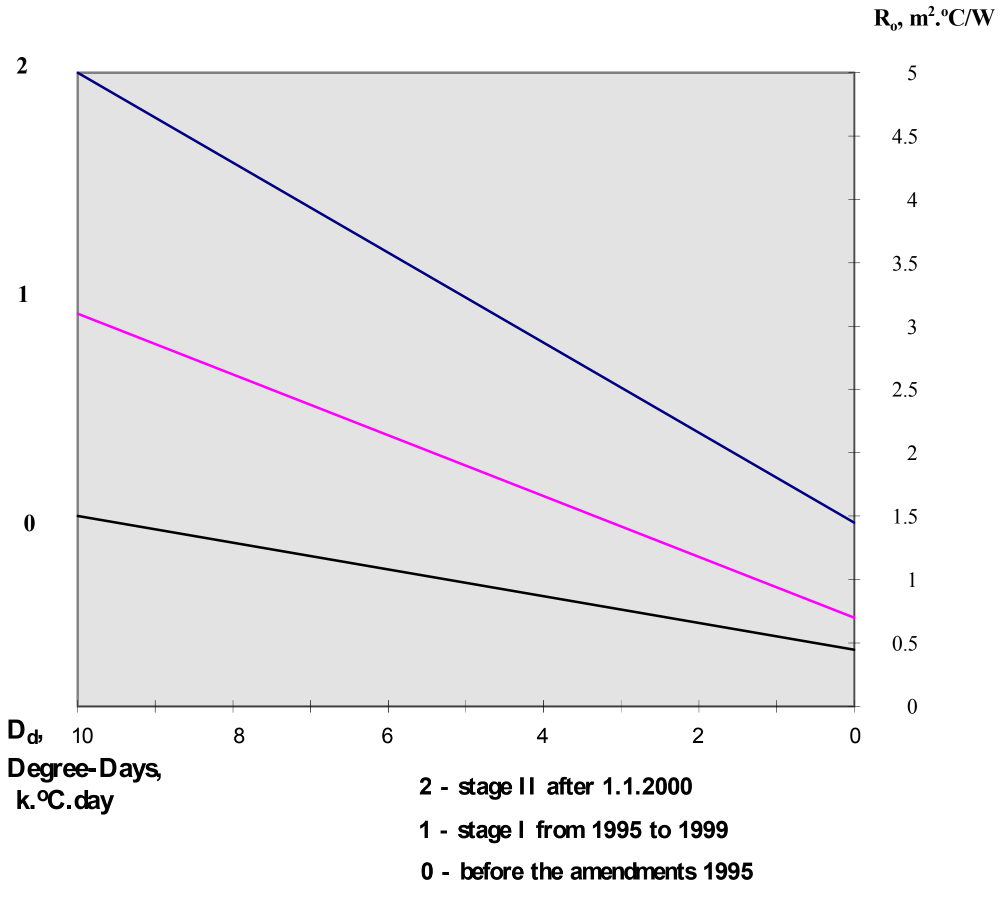

Fig. 3 The required thermal performance in buildings (for exterior walls)

Good example of realization of the offered requirements are the Moscow City Codes on energy conservation in buildings, authorized in 1999, where the requirement on specific energy consumption was established on the basis of the balance of power resources of Moscow in view of the forecast on future five years in view of possible (probable) ecological and economic consequences and technical opportunities of a Moscow building industry [5]. The cumulative energy savings through 2000 attributable to the Moscow Code equal approximately = 0.7 TWh, or about 120,000 tonnes of avoided CO_2 emissions. The nine Russian regions have developed and enforce their standards using that approach too [6]; the fifteen Russian regions are developing now their standards using that approach too.

After the evaluation test of new Code in the city of Moscow the Gosstroy RF also took a decision on the appropriateness of transfer to the above-mentioned principle of regulation at the federal level. At the present time, a new version of the federal rules and regulations of Russian Building Energy Performance Code is drafted. This building Code contains requirements to thermal insulation of buildings and limitations of specific heating energy consumption during a heating season. This document is based on the following philosophy.

Thermal insulation of buildings shall be designed in compliance with required R-values of its individual elements which are in force at the second stage of implementation of the former federal Code. In this context the compliance of the design level of specific heating energy consumption for residential and public buildings during a heating season with the rate established for a particular type of buildings shall be verified using a standardized calculation method of the Energy Passport. If the calculated specific energy consumption for heating the building is lower than the regulated value, heat transfer resistance of certain thermal insulation elements can be reduced, as compared with the required resistance (but not lower than the values which ensure sanitary-hygienic conditions and condensation non-formation), down to the values when the calculated specific energy consumption achieves the required level.

These values serve as mandated maximum heating energy consumption for proposed model code for Russian regions and for a new federal code, as listed in Table 3.

Table 3. Required Specific Energy Consumption for Heating a Building (q_h^{req}) W.h/($m^2 \cdot {}^oC \cdot$day) [W.h/($m^3 \cdot {}^oC \cdot$day)] during a heating season

Types of buildings	Number of stories			
	1-3	4-5	6-9	≥10
Residentials	32	26	22	19
Institutions of general education and offices	[10 (9)]	[9 (7,5)]	[8 (6,5)]	[--(5,5)]
Policlinics and medical establishments, boarding schools	[10]	[9]	[9]	--
Pre-school institutions	[12]	--	--	--

Note: Values q_h^{req}, W.h/($m^3 \cdot {}^oC \cdot$day) in parentheses are related to offices.

The Energy Passport of a building is another specific feature of new Moscow Code, which passport is intended to be used for controlling quality of building design, construction and operation. The Energy Passport is supposed to be used in the development of building design and in verification of compliance of the design with the requirements of the territorial regulations. In addition, it provides specific information on energy efficiency of the building to potential buyers and residents.

CONCLUSION

Russia has variation of degree days from 1000 to 11000 ^{o}C.day. The same variation for the EC's countries has 500 to 6500 ^{o}C.day about. Therefore the building energy requirements which had been tested for Russia can be use in the EC's strategy to develope a Community Model of Building Energy Code.

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