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THE BUILDING SECTOR OF RUSSIA IN AN ENERGY-EFFICIENT FUTURE. A STRATEGY FOR SUSTAINABLE DEVELOPMENT

The Russian Academy of Architecture and Construction, in conjunction with the former Gosstroi of the RF, has successively carried out and will carry out policy for conservation of energy and resources in Russia. The annual meeting of the Academy held in 2003 in Kazan under the theme "Resource and Energy Efficiency as a Motivation for Creativity in the Process of Architecture and Construction" defined in its resolutions energy and resource efficiency as one of the high-priority directions of work of the Academy. In this article we set forth the strategy of RAASN for resolution of the problem of energy efficiency in construction.

History of the question

Almost 30 percent of the fuel energy resources of our country are expended on the generation of heat energy, which is one-and-a-half times greater than for the generation of electricity. Residential buildings are the fundamental consumer of heat energy – almost 45 percent of all the heat energy generated in the country is used for heating these buildings: large thermal electricity plants generate about 34 percent, centralized boilers about 37 percent, and decentralized boiler plants about 29 percent. The overall stock of residential buildings in Russia is about 2818 million square meters, with a population of 143.6 million people, for an average area per capita of about 19.6 square meters.

In the world, as a result of the energy crisis of 1976 and over the 20 years since then, significant experience has been gathered on the efficient use of energy in residential buildings, which likewise in 1976 demanded about 25 to 35 percent of overall generated energy. Over the given period, various countries have had not only to maintain, but actually to reduce the growth of energy demand in the building sector. For example, Sweden over the decade 1978-1988 reduced its annual energy consumption in residential buildings by 28 TWh from 50 TWh in 1978, Denmark already by 1985 demanded 28 percent less heat energy for heating residential buildings than in 1972, which taking account of the growth in residential floor area over this period, leads to an actual energy savings of 47 percent for heating per square meter of floor area.

It is more correct to carry out a comparison of normalized parameters for energy consumption of the existing residential building stock, in the form of values calculated relative to the number of degree-days in the heating season: Russia - 85 Wh/($m^2 \cdot {}^oC$·day), Germany - 75 Wh/($m^2 \cdot {}^oC$·day), USA - 44 Wh/($m^2 \cdot {}^oC$·day), Sweden - 34 Wh/($m^2 \cdot {}^oC$·day). It is evident that Russia falls short of the listed countries in terms of this parameter.

Increasing the energy efficiency of the building sector is possible only by means of integration of work on energy efficiency in buildings, together with work on energy efficiency in heat supply systems for buildings. This approach corresponds with state policy, insofar as the state, in the end, is interested in reducing the expenditure of primary fuel-energy resources – the strategic base of its long-term existence.

The potential for energy and resource conservation in Russia is huge. World experience shows that there is a real possibility for curtailing energy consumption by 50 percent with a doubling of efficiency (the so-called factor 4). But for achieving such a result, multiyear joint efforts are needed from scholars, architects, building designers, specialists in heat supply, energy specialists, specialists in the construction industry, directors of building complexes and utility services, each increasing the energy efficiency of the building sector, step by step successively, through their own respective roles. Thus, for example, buildings developed by the Academy with a widened frame lead to an 18-20 percent reduction of energy consumption for maintenance of indoor comfort conditions.

In 1995, in a report to the Club of Rome, a new idea was set forth by a group of foreign specialists for the solution of environmental problems with simultaneous increasing of the efficiency of consumption of natural resources, by means of improvement of technology – to live twice as well, and at the same time to expend half as many resources, proposed as the so-called "factor 4", which is achieved by a doubling of wealth with a twofold savings of resources. Factor 4 proposes a new approach to the process, placing at the forefront the increasing of the productivity of *resources*.

In their report the authors showed practical, profitable ways, already realized, to use resources *at least four times more efficiently than we do it now*.

The proposed "factor 4" is a revolutionary idea, which must stand as a symbol of modern social and scientific-technical progress. The increase of efficiency of resource use and the curing of the illness of wastefulness open great economic possibilities. The curtailment of demand for resources by 50 percent is closely linked and, in reality, provides for a solution to the complicated problem of sustainable development for humanity, or for that group of countries that act in this way.

Buildings in which the "factor 4" principles have been realized do exist [1], for example, in the Rocky Mountains: the building that serves as the staff office of the Rocky Mountain Institute (USA); in Darmstadt (Germany), the "passive building"; De Montfort University in Leicester (UK); the staff-office complex of ING Bank in Amsterdam (Holland), the energy-efficient high-rise building "Kommerzbank" in Frankfurt-on-the-Main (Germany), the demonstration energy-efficient building in Manchester [New Hampshire] (USA), the «EKONO - House» building in Otaniemi (Finland), the VIKKI district in Helsinki (Finland) [2]. More detailed description of these buildings is beyond the scope of this paper. The important principle is that these buildings have been made a reality.

In solving the problem of energy conservation, there has been a clash with conservatism and traditional thinking in design and in the construction industry, as well as with economic costs of transition to new energy-efficient technology. With the goal of surmounting barriers of economic costs in foreign countries, state programs have been undertaken (market transformation programs) that initially subsidize new technologies and the purchase of new products, in order to soften the inevitable risk to the private producer.

A fundamental step in this direction is the creation in advanced countries of new progressive building codes and regulations, which, if followed, provide for efficient use of energy and other resources.

Founding decisions

World experience, as has been noted above, has shown that all advanced countries that have achieved real progress in the area of energy conservation have had programs encompassing scientific-technical, legislative, legal, and financial [aspects], as well as support from parliaments, congresses, and other legislative and legal bodies. Moreover, all of the countries in question have had financially-supported subprograms on experimental testing of the newest energy-saving technologies. Subprograms for stimulating the construction industry toward the output of the newest technologies have also been approved, financed by private investors. One example is subprograms that provide for the sale of the newest technologies. Without such an organizational-financial system, scientific-technical achievements on saving energy would have remained only piecemeal.

Russia's energy policy is defined by the document, developed in 1995, "Basic directions of energy policy in the Russian Federation in the period up to 2010," which was confirmed by decree of the President of the RF starting on May 7, 1995, No. 472, and in which one of the main tasks set forth is the execution "of the realization of the potential of energy conservation by means of the creation and implementation of highly-efficient fuel- and energy-consuming equipment, thermal insulation materials, and construction. It is noted that natural fuel and energy resources and the created industrial, scientific-technical, and skill potential of the energy sector of the economy is the national property of Russia. Its effective use is the necessary basis for the emergence of the country from crisis and transition to a trajectory of sustainable development, which provides for growth of the well-being of the people. Russia's energy policy is realized at the federal and regional levels by means of "concentration of basic work on the use of the potential of energy conservation in regions." In the federal Law of the RF "On energy conservation" No. 28-Ph3 from April 3, 1996, in article 6 of the initiation of standardization, there is set forth a requirement on the inclusion in building codes and regulation of indices for energy consumption for heating, ventilation, hot water supply, and lighting of buildings.

The European Parliament and the Council of the European Union have developed a Directive on the energy characteristics of buildings, which is mandatory for use in all countries in the EU [3]. The goal of the Directive is the improvement of the energy parameters of residential buildings, which in the EU consume nearly 40 percent of generated energy, taking account of local climate and indoor conditions, and also taking account of the efficient use of financial resources.

Established in the directive are:

- A general framework of a calculation method for integrated energy parameters of buildings, which must be differentiated at the regional level;
- Minimal requirements for the energy parameters of buildings for new construction and for existing buildings with a useful floor area of more than 1000 m^2 that are undergoing capital repair and rebuilding;
- Energy passportization [documentation and certification] of buildings for the possibility of comparing and assessing the energy parameters of buildings;
- A requirement for regular inspection of heat generators with a capacity of more than 20 kW and of air-conditioning systems with a capacity of more than 12 kW, with the goal of reducing energy demand. As a result, recommendations were developed for the change-out of boilers and the modernization of heating systems, or for different alternative solutions

The state governments of the EU must provide for such conditions that before the beginning of construction of new buildings with a useful floor area of more than 1000 m^2, the following sources of energy should be considered depending on local conditions:

- Systems of centralized heat supply for a district or quarter, where present;
- Autonomous installations of combined heat and electric energy;
- Installations of decentralized energy supply, based on renewable energy sources;
- Heat pumps, under certain conditions.

In the directive it is established that the basic solution of the problem of energy source, and the very burning of fuel in a boiler, intended for the transfer to water of heat released in the combustion process, is not the optimal solution. It is emphasized that the greatest effect in energy conservation is achieved in the case when residents themselves can control energy consumption and assess the results of their activity, and therefore residents must have the possibility of regulating their consumption of heat and hot water. It is necessary to design engineering systems in such a way that this possibility is provided for.

RAASN in conjunction with the former Gosstroi of the RF consequently has been carrying out and will carry out policy on energy and resource conservation in Russia. The annual meeting of the Academy, held in 2003 in Kazan [4, 5] under the theme "Resource and Energy Conservation as a Motivation for Creativity in the Architectural-Construction Process" defined energy and resource conservation in its resolutions as one of the high-priority directions of work of the Academy -- "by means of research, development of experimental designs, promotional material, demonstration projects, and implementation of advanced achievements to work toward the increase of the resource and energy efficiency of the architectural-construction and residential communal sector of Russia, and of civil construction, including energy-efficient development of infrastructure of cities and their systems, which will make possible actual reduction of demand for heat and electric energy."

At this annual meeting, basic tasks and high-priority directions for the activity of RAASN in the area of resource and energy efficiency for upcoming years were developed, including the following:

1. To develop a general strategy and regionally differentiated policy for a solution to the problem of sustainable development of cities and settlements and their systems, in the context of a model of balanced buildings "nature - society - individual person" with recommendations on optimal resource and energy consumption, significant for the reduction of irrational consumption of all kinds of resources;

2. To make a transition to a new level of design of civilian construction systems -- building, energy supply and climate control and delivery, based on the use of methods of systems analysis and optimization of the "climate - city - building" system;

3. To develop and substantiate a system of new code and recommendatory documents: codes for consumption of heat energy for heating and hot water supply, codes

for cold water supply, energy passports of buildings and heat and water supply systems. On this basis, to develop general and special technical regulations;

4. To provide for scientific activity accompanying the implementation of the most promising energy-efficient technologies, construction materials, building features, and architectural forms of buildings, and features and engineering [utility-service] equipment for mass construction and reconstruction. Within the framework of this direction, programs must be developed and realized for the formulation of requirements for market transformation for construction materials and goods, with the goal of support of energy efficiency;

5. To develop low-cost technologies for heat supply and climate control and delivery of improved technological efficiency in the following directions:

- modernization and reconstruction of the existing system of centralized heat supply on the basis of changing its structure with strengthening of the role of individual heat points, the use of the achievements of controls engineering, integration, and integration with nontraditional energy,
- expansion of the role of the use of individual, including mobile, sources of heat and energy supply, as well as local peak sources of heat,
- use of pipes made of materials that provide for long-term functional reliability for mainline transmission of heat supply and savings of heat energy;

6. To develop energy- and resource-minimizing technical solutions for buildings and structures with a reduction by 50 to 75 percent in demand for primary energy in comparison with the baseline of the year 2001. The essence of this strategy lies in finding ways to create Comfortable Energy- and Resource-Minimizing homes (KERM house) with a reduction of 67 to 75 percent in consumption of primary energy in comparison with the base year (2001) and with existing codes.

Concrete activities

The creation of a complex of new codes, standards, and methods of energy and thermal-engineering calculations of buildings with efficient use of energy is the key question of energy conservation.

NIISF of RAASN in conjunction with an array of organizations, with Gosstroi of the RF and regional executive agencies, beginning in 1994, has worked step by step to develop, approve, and implement new approaches in code development for energy efficient buildings. First of all, a new ideology was developed in 1992-1993 for codes for buildings from an energy point of view, and then in 1994, the first regional codes were developed and confirmed for the city of Moscow. In 1995 fundamental amendments were introduced into the federal code on thermal engineering in buildings, providing for a 40 percent reduction in energy expenditure for heating starting in 2001. In 1996 NIISF developed in conjunction with an array of organizations and Gosstroi of the RF confirmed a standard (GOST 30494-96) on parameters for indoor microclimate for residential and public buildings, providing for a comfortable microclimate for people in buildings. In the period from 1998 through 2003, NIISF in conjunction with regional specialists developed and implemented regional building energy-conservation codes in 50 regions of the. Among these, in 1998-99 a new edition of the energy-conserving code for the city of Moscow was developed and confirmed (MGSN 2.01-99). The new federal SNiP 31-02-01 “Single-family residential buildings”, developed in 2001 with the participation of NIISF, contained as an alternative a requirement for specific energy consumption for low-rise buildings. In this very same period, NIISF developed a complex made up of three standards, confirmed by Gosstroi of the RF, on energy auditing of existing buildings (GOST 31166-03, GOST 31167-03 and GOST 31168-03). And, finally, on the basis of experience obtained in the regions of the RF, NIISF developed in conjunction with an array of organizations and Gosstroi of the RF confirmed in 2003 the new SNiP 23-02-04 "Thermal performance of buildings" and its accompanying code of practice SP 23-101-04 "Design of thermal performance of buildings", as well as the new SNiP 31-01-03 "Multifamily residential buildings" with a section entitled "Energy efficiency". As a result, a new generation of the system of code documents has been created for design and operation of buildings with reduced demand for energy.

The new SNiP 23-02-04 “Thermal performance of buildings” is the core of this system. According to the underlying principles, it is a completely new document in its structure and area of applicability, as well as the criteria established by it for thermal performance, methods for oversight, the character and level of energy auditing, and its correspondence with European standards. Moreover, this new document conserves continuity with the replaced SNiP II-3-79* “Building thermal engineering” in the 1998 edition and provides for the very same level of energy conservation, but presents wider possibilities in the choice of technical approaches and options for meeting code-stipulated parameters. The new code, in contrast with prior codes, relates not only to designed and renovated buildings, but also to existing buildings in operation.

The new SNiP 23-02-03 presents code-stipulated indices for energy efficiency of buildings, corresponding with world levels, and methods for their enforcement. In it:

- a system for rating the energy efficiency of new and operating buildings is established;
- numerical values are established for code-stipulated indices for energy efficiency of buildings;
- rules for the design of thermal performance of buildings are given, for use with both prescriptive codes and overall energy-efficiency performance targets;
- the possibility is opened for building buildings with higher energy-efficiency performance parameters than required by code;
- the possibility is created for revealing existing buildings that must be promptly renovated from the point of view of energy efficiency;
- methods are given for oversight of compliance with code-stipulated indices of thermal performance and energy efficiency for design and construction as well as for further on, during the operation of buildings (Energy Passport).

In this SNiP, two mandatory interrelated criteria are established for thermal performance of the building and for verification of compliance with these criteria, based on:

a) code-stipulated values for thermal resistance for separate building envelope elements, calculated on the basis of code-stipulated values for [whole-building] specific consumption of heat energy for heating, retained from the previous SNiP;

b) code-stipulated specific consumption of heat energy for heating the building, which makes it possible to vary the thermal-performance properties of building envelope elements, (excluding manufactured housing), taking account systems to support microclimate [controls] and heat supply for the attainment of the code-stipulated value for this parameter.

The choice of the means by which design is to be carried out depends on the competence of the design organization or the client. Methods and paths for attainment of these code requirements are chosen during design.

In the table shown in figure 1, a building rating system is set forth according to the degree of deviation of design or measured normalized values for specific consumption of heat energy for heating the building, from the code-stipulated value. This system applies both to buildings newly entering into operation and newly reconstructed, whose designs have been developed in compliance with the requirements of the code described above, and to operating buildings, built according to codes in force before 1995.

Buildings whose designs have been developed in accordance with the new code would be rated A, B or C. In the process of real operation, the energy efficiency of these buildings may differ from the data of the design for the better (***A*** and ***B** ratings*) within the limits shown in the table. The use by local government agencies or investors of incentive measures is recommended to promote the emergence of *A*- and *B-rated buildings*.

Ratings D and E apply to operating buildings that entered into operation under codes in force at the time of construction. Rating ***D*** corresponds to codes before 1995. These ratings give information to local government agencies or property owners on the necessity of immediate or less immediate measures for the improvement of energy efficiency. Thus, for example, for E-rated buildings, immediate renovation from the point of view of energy efficiency is necessary.

It should be noted that in the new code, a possibility is foreseen for reduction of the code-stipulated level of specific consumption of heat energy for heating the building by including higher energy efficiency ratings in the design mandates for the building. For example, in the Khanty-Mansy autonomous region, executive agencies decided beginning in 2002 to design only B-rated residential housing with a mandate of a 10- to 50-percent reduction of the required specific energy consumption. In the new Moscow code MGSN

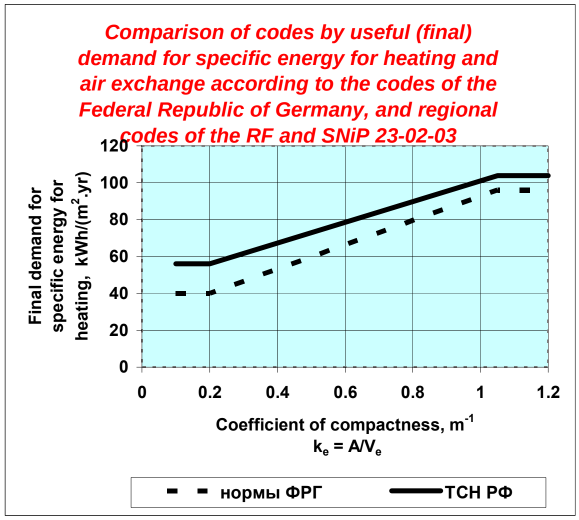
4.19-05 "Multifunction high-rise buildings and complexes" with the goal of energy conservation, design of B- or A-rated buildings foreseen, and a mandate for a 10- to 60-percent reduction of the code-stipulated value for specific energy consumption. If an A rating and a 60 percent reduction in energy consumption are mandated in the technical work plan, then such a building after entry into operation must consume two-and-a-half times less heat energy for heating. In this way, the possibility is foreseen in new codes (SNiP 23-02-03 and MGSN 4.19-05) for realizing the strategic goal of RAASN in the area of energy efficiency.

Table

Energy Efficiency Ratings for Civilian Buildings			
Letter and graphic representation	**Rating**	**Amount of deviation of design (or normalized measured) values from the code-stipulated value, %**	**Recommended measures for administrative agencies of subjects of the RF**
For new and renovated buildings			
A	**Very high**	**Less than -50**	**Economic incentives**
B	**High**	**From -10 to -50**	**As above**
C	**Normal**	**From +5 to -9**	**-**
For existing buildings			
D	**Low**	**From +6 to +75**	**Renovation desirable**
E	**Very low**	**More than 76**	**Insulating the building in the near future is necessary**

Figure 1

It is interesting to compare the code-stipulated parameters of Germany and Russia according to final specific consumption of energy for heating. The value of this parameter in the codes of Germany lie within the boundaries from 40 up to 96 kWh/(m^2·yr) under a baseline heat supply system. The values of final specific energy consumption for heating, established in the regional codes of the RF and in the new SNiP, and recalculated for the climatic conditions of Germany, lie within the boundaries from 55 up to 105 kWh/(m^2·yr) (figure 2). It is evident that German codes contain stricter requirements than Russian codes -- 20-27% for multifamily residential buildings and 9-10 % for single-family homes.



Germany Regional codes, RF

Figure 2

The achievements of Russia on creation of energy codes, harmonization with European standards, and energy conservation in the buildings sector were presented at a conference of central and eastern European countries on sustainable buildings, carried out in 2004 in Warsaw, Poland. The report [7] was highly rated, awarded a prize, recommended, and accepted at the next conference on sustainable buildings, carried out in 2005 in Tokyo, Japan.

The level achieved

Real results have already been achieved in the direction of energy efficiency.

Under the scientific direction of RAASN, NIISF with the participation of different organizations and the support of Gosstroi of the RF has carried out the implementation in construction practice of a new system of federal codes and standards, and also regional codes on building energy conservation in 50 regions of the RF. The codes provide for a 40 percent reduction in demand for energy for heating by newly introduced and renovated buildings, since 2001. The building sector has been completely transformed and has made the transition to observance of these codes. Over the period from 2001 to 2004, 146.2 million square meters of residential housing were introduced, including: in

2001 – 31.1, in 2002 – 37.8, in 2003 – 36.3, and in 2004 – 41 million square meters. All buildings built over this period were designed in compliance with new federal and regional energy-conserving codes. Over the period from 2002 to 2004, the calculated overall energy-conserving effect in terms of fuel constituted almost 140 PJ (5 million tonnes in coal equivalent), which has also led to an overall reduction in emissions of greenhouse gases at a volume of 9.5 million tonnes of carbon dioxide. With the growth in the residential building stock, growth in energy expenditures for heating these buildings is inevitable. The opportune development of the new generation of energy-conserving codes and their implementation has put the brakes on this growth. Annual consumption in terms of fuel expended for the generation of heat energy in the heat-supply system up to the end of 2004 grew only by 108 PJ in comparison with 181 PJ, if these codes had not been introduced.

There has been fundamental market transformation in the production, sale, and use of energy-efficient building materials and products, and the use of new energy-efficient technologies. A new architectural form of buildings with a widened body, homes with monolithic structure with the use of light and porous concretes, energy-efficient windows with vinyl and wood-aluminum frames and energy-conserving glass, façade systems [exterior insulation], including "moist" and "ventilated," new construction systems, for example, "Plastbau", the universal use of efficient thermal insulation, the use of modified structural/insulating concretes, the use of regulated [air] intake systems, energy-efficient heating and ventilation equipment, rooftop boilers, apartment-level heating, are far from a complete list of examples of new approaches that have proliferated under the influence of the complex of new energy-conserving codes.

The energy demand of buildings during operation is the most important question for utility services. The definition of real heat-energy parameters for operating residential buildings, the verification of the correspondence of these parameters with code requirements, and determination of energy efficiency ratings is called for by the new SNiP 23-02. With this goal, NIISF with the participation of Moskomarkhitektura (V. I. Livchak) has developed a method for energy auditing of existing buildings (GOST 31168).

The essence of the method is that consumption of heat energy for heating, average indoor and outdoor air temperature, and average intensity of solar radiation on a horizontal surface are measured in the heating season for defined intervals of time. For these very intervals of time, values for overall heat losses through the building envelope, average measured consumption of heat energy, and overall heat gains (internal gains and solar gains through fenestration) are calculated.

According to the calculated overall heat losses, for corresponding differences in temperature between indoor and outdoor air, a linear function is defined for the best fit to these data and according to this linear function, taking account of the interior dimensions of the occupied premises and the exterior envelope, an overall coefficient of heat transfer for the exterior envelope of the building and the specific consumption of heat energy for heating the building during the heating season are derived, and an energy efficiency rating for the building is established as well.

We show the determination of the energy and thermal-engineering characteristics of buildings in an example of a two-section 11-story residential building intended for municipal settlement [to replace] razed 5-story buildings in the city of Moscow, carried out in 2002-2003. The building was built with Swiss technology of the ”Plastbau” system, which is new for Russia. The building was paid for by the city, and it is experimental as a result of the use of new technology. Research was carried out in the winter of 2004. The following results were obtained.

The consumption of heat energy for heating the building over the design heating season $\boldsymbol{Q_h^y}$, MJ, was 2,916,904 MJ. The specific consumption of heat energy for heating the building over the heating season $\boldsymbol{q_h}$, kJ/(m$^2\cdot{}^o$C·day), was 70.33 kJ/(m$^2\cdot{}^o$C·day).

In accordance with SNiP 23-02, the code-stipulated specific consumption of heat energy for heating a 10- or 11-story building equals 72 kJ/(m$^2\cdot{}^o$C·day). The calculated specific consumption of heat energy for heating the building over the heating season is slightly lower than the code requirement, but according to the building rating system in Figure 1 (SNiP 23-02) the building is assigned a “normal” rating. It should be noted that the building was built according to the requirements of MGSN 2.01, where for buildings 10 stories and higher, a code requirement of 68 kJ/(m$^2\cdot{}^o$C·day) is established. In accordance with the rating system of MGSN 2.01 on categories of energy efficiency, this building is assigned to a "standard" rating.

Prospective activity

The strategic goal of RAASN is energy and resource conservation, which provides for a global twofold reduction in energy consumption for maintenance of the indoor microclimate in civilian buildings, and the improvement of the quality of life of the population.

The task of making it a reality is the *tactical task* for the creation of energy- and resource-minimizing technical approaches and energy-efficient technologies for buildings with a demand for primary energy reduced by fifty percent or more from the baseline of 2001. For this, development will be carried out and implementation will be executed of the most promising foreign and domestic energy-efficient technologies, construction and architectural forms of buildings, building elements, and equipment for large-scale construction and renovation. The defined strategy for residential construction for the long-term future after 2015 will employ promising technologies for managing energy demand by architectural-construction systems and new approaches to civil construction. The result will be improvements in the quality of life and energy security of the country.

The *first* tactical task is the development of methodological tools for the legal/regulatory base of energy conservation. The law "On Technical Regulation" places at the forefront safety of operation of civilian buildings. Safety of operation of buildings entails insuring that there is no prohibited risk that could endanger the life or health of citizens, the property of physical or legal entities, state or municipal property, or the environment. Energy and thermal safety of civilian buildings is part of overall safety of buildings.

It has been proposed that technical rules on thermal, energy, and environmental safety should be developed for buildings with "high" and "very high" energy efficiency ratings and the heating and heat-supply systems of these buildings. These technical rules must contain fundamental stipulations in the following areas: comfort within the occupied premises of the buildings, thermal performance of buildings and energy conservation, soundproofing, natural and artificial lighting, and environment and architecture.

The energy-related principle of balancing the mutual relationship of the building with the environment will be put at the foundation of drafts of technical rules. The rules will provide parameters for indoor microclimate that will protect the health of people living within.

Indoor microclimate parameters in buildings take three forms: thermal, light, and acoustic comfort. Optimal and allowed parameters enter into the meaning of thermal comfort. Where allowed parameters are violated, prohibited risk emerges, connected with the delivery of harm to the health of people living within the buildings. Thermal safety of the building is provided for by means of thermal protection of the building from the extreme external influences of the environment. This thermal protection must protect people living within even in extreme conditions -- for example, during temporary cessation in the delivery of energy over a certain period of time, during fire and other extreme situations.

The *second* tactical task lies with making concrete basic stipulations of technical rules on thermal, energy, and environmental safety for civilian buildings and parameters for their indoor microclimate. This task will be resolved by means of development of unified codes for energy conservation in civilian buildings, taking account of heating, cooling, domestic hot water, artificial light, and heat supply. The new codes will provide for reduction of expenditures for heating in civilian buildings in terms of primary energy of not less than 33 to 50 percent.

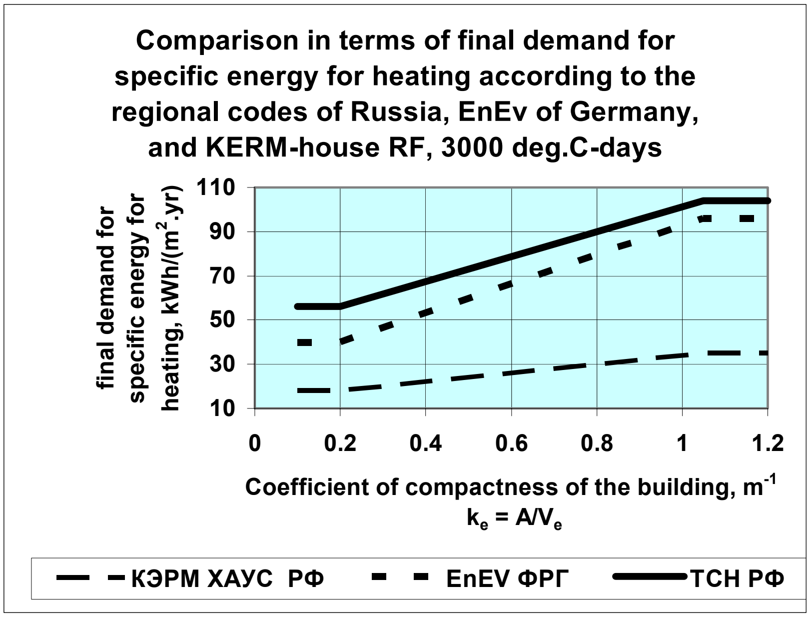
Within the framework of this task, market-transformation programs for energy-efficient construction materials, products, and components will also be developed, with the goal of creation of a national base [of domestic product availability] and reduction of dependence on foreign producers.

The result of this work will be new, more progressive national codes for design of civilian buildings and a widely accessible national base of new energy-efficient construction materials and technologies, construction and architectural solutions for new and renovated buildings.

The *third* tactical task relates to the refinement of solutions for the longer term. This task entails the development of scientific fundamentals, technical solutions, and documentation of experimental residential resource-minimizing complexes of buildings that provide for comfort (*KERM house -- sample*) with reduction by 50 percent or more in demand for primary energy resources.

NIISF of RAASN have developed basic stipulations for a new strategy for construction of Russia for the period after 2015. The essence of this strategy lies in the creation of civilian building complexes from *KERM-house sample* buildings.

It is evident that the creation of *KERM house sample* buildings with specific end-use energy consumption of 22-42 $kJ/m^2 \cdot {}^oC \cdot day$) will require the development of a system of overall energy indices, new approaches for building materials, floor plans and building geometry, and methods for their assessment for the building on the whole and for the types of energy being consumed. Design of such buildings must be carried out with the use of highly efficient, environmentally clean and durable materials and technologies. In addition, possibilities for use of both new and traditional construction materials must be researched, including especially light concrete, porous concrete, and wood. Moreover, one must use various technologies of heat transfer through the building envelope, in the distribution of ventilation air, in the incidence of solar radiation in the building, and also systems of low-temperature heat energy of the ground, water, drain waters, and air [heat pumps]. Automated systems for regulation of microclimate are needed. In these cases the aggregated expenditures of energy for production of construction materials will be taken into account, and the most energy efficient materials will be chosen.



KERM house RF EnEv Germany Regional Codes RF

Figure 3. Comparative analysis in terms of final specific consumption of heat energy for heating buildings KERM-house sample, of code requirements of EnEV of Germany and of regional codes of Russia as a function of the coefficient of compactness of a building

In many villages spread throughout the territory of Russia, decentralized sources of heat supply provide significantly greater efficiency of the use of systems of maintaining heat-related microclimate than do centralized heat supply sources.

Residential districts, constructed from such buildings, may be organized according to the principle of free planning, depending little on networks of main lines of heat supply systems. These districts may have a completely different architectural profile.

The result of this work will be new technical approaches for external envelopes, HVAC equipment, and building floor plans and geometry for multistory residential buildings and systems for their heat supply, as well as new approaches for subsequent testing of their use in practice in residential construction in regions of the RF.

In conclusion, we should note that:

Over the past ten years in Russia, thanks to new codes on energy conservation and thermal performance of buildings, a revolution in the building sector has taken place in the direction of improvement of energy efficiency of civilian (residential and public) buildings and use of new energy-efficient building materials and technologies.

The building sector, like no other industrial sector in Russia, is on a remarkable rise. In 2003, almost 36 million square meters of housing was begun to be built, in 2004 almost 41 million sq. m., and in 2005 the volume of residential construction is planned to rise to 45 million sq. m. for the year.

On the whole, the energy consumption for heating of buildings newly constructed over the last ten years has been reduced by 35 to 45 percent depending on the type of building. According to data of Gosstroi of the RF from 2003, already 6 percent (170 million sq. m) of the entire stock of residential buildings in Russia (2,818 million sq. m) comply with the requirements of new codes.

Designs of buildings with widened bodies (up to 22-25 m compared with previous 12 m) have found widespread use. There has been a transition from universal proliferation of single-layer and three-layer panel construction to monolithic-frame construction with external insulation and non-ventilated and ventilated facades, with use of light porous concretes and at high levels, light concretes with porous fills.

Windows with sealed glass units with single air spaces and double air spaces and with frames made from glued wood, wood-aluminum, or vinyl materials have begun to be used.

Housing prefabrication plants that are continuing to produce industrially-prepared buildings from panels, have made the transition to a great variety of produced goods. Buildings made from these elements do not differ in terms of outward appearance from monolithic-frame buildings. In terms of return on investment, external wall panels are three times greater in comparison with previous thermal performance systems, and are 10-15 percent cheaper, for example, in the wall panel fabrication plants in Yakutsk and Tomsk.

A strategic goal of RAASN has been defined -- energy conservation in the building sector -- and tactical tasks have been defined for resolution of this goal. RAASN's work in the area of energy conservation is leading to creation of a new legal-regulatory base (technical rules, building codes and standards) and to new technical approaches for buildings with reduction by 50 percent or more in demand for primary energy relative to the baseline of the year 2001. Development and implementation of the most promising foreign and domestic technologies, construction forms of buildings, building elements, and HVAC equipment for mass construction and renovation will be carried out.

RAASN's strategy for residential construction for the longer term after 2015 is directed at the use of promising technologies for management of energy demand by architectural-construction systems and new approaches to civilian construction. The strategy will improve quality of life, building safety, and energy security of the country on the whole.

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