Forty-Percent Savings and Beyond --

Recent Advances in Code Implementation

and Development of Super-Efficient Buildings

in Russia and Other CIS Countries

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Abstract

The Russian Federation, the Republic of Kazakhstan, and Ukraine continue to make important advances in implementation of energy codes, market transformation, and design innovation in the building sector. This paper begins by summarizing new developments, including passage and implementation of new codes and an ambitious incentive program in Moscow.

Now Russia and CIS countries are looking beyond the current generation of codes. Sustainability has become a high-priority goal, as strongly articulated in policy documents of official agencies, most notably the Russian Academy of Architectural and Construction Sciences. Pursuit of this goal is taking several forms, including integrated planning of buildings and utility systems; development of new codes; research and investment in new technology; and the launch of a new initiative to develop experimental residential comfortable energy- and resource-minimizing buildings (known by the Russian acronym as "KERM houses"), which would consume one-third to one-half the energy of buildings built in compliance with 2001 codes.

Recent advances in building energy codes in Russia, Kazakhstan, and Ukraine

Since 1994, new building energy codes have been spreading across the Russian Federation and the Republic of Kazakhstan. These new codes are predominantly based on a model code developed jointly by the Center for Energy Efficiency (CENEf), the Research Institute for Building Physics (known by its Russian initials as NIISF), the Institute for Market Transformation (IMT), and the Natural Resources Defense Council, under the support of the U.S. Environmental Protection Agency (EPA). This trend has culminated in the entry into force of the following codes.

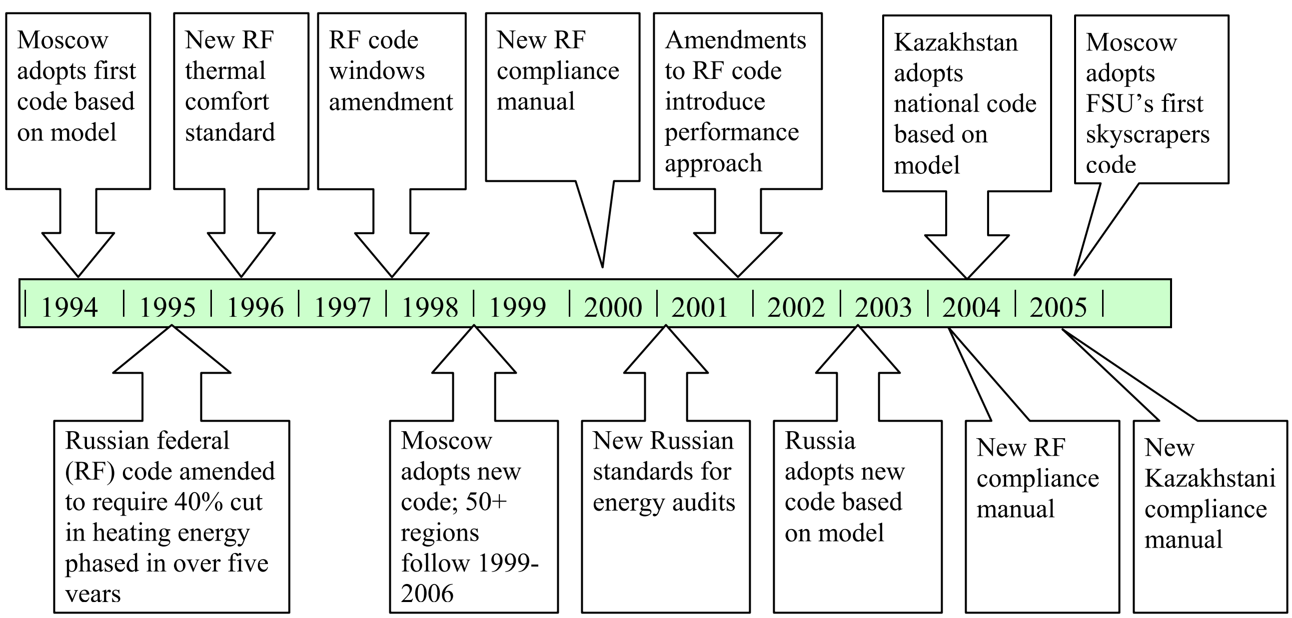
- New performance-based regional codes in 53 oblasts, krays, and autonomous republics of the Russian Federation (adopted 1994-2005);

- A new performance-based federal code applicable across the whole Russian Federation (adopted 2003); and

- A new performance-based federal code in the Republic of Kazakhstan (adopted 2004).

These codes are accompanied by various technical standards and compliance guides for building designers. Figure 1 summarizes the chronology of new codes and accompanying documents in Russia and Kazakhstan.

Figure 1: Timeline of Building Energy Codes and Standards



The new federal and regional building energy codes in Russia and the new federal code in Kazakhstan require approximately 40-percent reductions in energy consumption for heating by newly constructed and renovated buildings, compared to existing buildings built under previous codes.

Progress toward a new code in Ukraine

As of spring 2006, Ukraine is rapidly progressing toward a new federal code for energy efficiency in buildings as well. This process is under the direction of the Ukrainian Ministry of Construction, Architecture and Communal Residential Services and Ukraine's Institute for Building Physics. CENEf, NIISF, and IMT, under the support of the U.S. EPA, have offered consultation and training to assist this process.

Ukrainian authorities have integrated many of the resulting suggestions into the draft code. Because of these recommendations, the new Ukrainian code is expected to include a performance-based compliance option, a calculation methodology similar to that of the Russian and Kazakhstani codes, energy-performance rating systems, and the documentation system known as the Energy Passport. Expected energy savings relative to existing building stock will be about 40 percent, as in Russia and Kazakhstan.

The Ukrainian Ministry is currently taking account of expert recommendations, with plans to upload a final review draft to the website of the Ministry for public discussion. This step is planned for April 2006. After this, the draft should be presented for discussion and adoption in a special technical session of the Ministry. The Ministry plans to finish this process in July 2006.

A new code on skyscrapers in Moscow

NIISF has drafted two chapters and three sections of supplemental information regarding thermal performance and related energy and indoor-environment issues to the new Moscow code on skyscrapers, MGSN 4.19-05, entitled "Multifunctional high-rise buildings and building complexes." This document is the first of its kind in the former Soviet Union. Its recommendations are already being widely applied, including in the design of a four-building complex of skyscrapers (20 stories, 28 stories, 38 stories, and 43 stories tall) in Astana, the capital of Kazakhstan; in the case of these buildings, use of the Moscow code material and approaches has resulted in a design plan that calls for energy performance that beats code requirements by at least 10 percent.

Estimated energy savings to date from new codes

The onset of new codes and accompanying market transformation are especially timely given recent rapid growth in construction volumes in the former Soviet Union. In Russia in 2003 housing starts totaled almost 36 million square meters, in 2004 more than 41 million square meters, and in 2005 the volume of residential construction was planned to rise to 46 million square meters.[1] The pace of construction growth has showed no signs of slowing. All the new construction referenced above is subject to the new codes. Ukraine's residential construction volume in 2005 was at about 15 percent of Russia's. In Kazakhstan in the five months from January through May 2005, 8,794 buildings with a total area of 1,951,400 square meters were built. The vast majority of that construction (1,609,500 square meters) was residential.[2]

With the growth of residential building stock, there has been an inevitable growth in energy consumption for heating. The concurrent development of the new generation of energy-conservation codes has slowed this growth. Annual consumption of fuel for the generation of heat in Russia through 2004 grew only by 116 petajoules (PJ), compared with a baseline growth of 181 PJ had buildings been constructed in accordance with prior codes. Over the period from 2002 to 2005, the overall energy savings totaled more than 215 PJ. This has led to a 15-million-ton reduction in carbon dioxide emissions. In the period from 2002 to 2010, the cumulative reductions are anticipated to rise to more than 1,100 PJ and 75 million tonnes of carbon dioxide in Russia alone.[3] This curtailment of emissions of greenhouse gases into the atmosphere is particularly important given Russia's adoption of the Kyoto Protocol in February 2005.

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[1] "Growth of Residential Construction Volumes (from the presentation of Yakovlev at the meeting of the Government of the Russian Federation)", 12 Oct 2005

[2] AstanaBuild 2006 web site, January 27, 2006 – http://www.astanabuild.kz/en/2006/about_ex/

[3] These figures conservatively count only residential construction volumes and do not include commercial construction, which is also subject to the new codes. Carbon dioxide calculations use the following coefficients: natural gas 50 tonnes CO_2/terajoule (TJ), heavy oil [mazut] 77.3 tonnes CO_2/TJ, and coal 99.1 tonnes CO_2/TJ. Russian thermal stations and boiler plants' weighted fuel mix is about 50% natural gas, 30% heavy oil and 20% coal. Most Russian buildings rely on district heating. Based on limited field tests, we assume a 50% average energy efficiency of these centralized systems of heat supply. The 2010 savings are conservatively estimated based on the current heating fuel mix and the growing residential construction volumes in the above cited Russian government projections.

Trends in approaches to performance-based compliance

Whereas previous codes were purely prescriptive, the new codes in Russia and Kazakhstan introduce a performance-based compliance option, in which designers meet a specified whole-building target for specific energy consumption by whatever means they wish, subject to minimum comfort requirements. The onset of the performance approach in codes has meant that designers have free hands to design buildings with greater creativity and expanded flexibility to seek cost-optimal solutions, while still attaining energy performance equivalent to prescriptive requirements. While it has not been feasible for us to collect and analyze large numbers of building designs to quantify trends in compliance approaches, still we can confidently offer our sense of preferred methods, based on a number of actual building designs.

Building geometry. Unlike American performance-based codes, the Russian and Kazakhstani codes present a fixed budget for energy consumption for heating per unit of occupied floor area, not a custom budget based on the building location and overall footprint and dimensions. This means that building designers in Russia and Kazakhstan can reduce energy consumption not only by choosing high-performance materials and building elements, but also by designing wider buildings with relatively low surface-area-to-volume ratios. Thus, for example, buildings developed by the Russian Academy of

Architecture and Construction Sciences with a widened frame lead to an 18-20 percent reduction of energy consumption while still maintaining indoor comfort conditions.

Windows. In many regions, multifamily residential buildings are still made almost entirely from concrete wall panels prefabricated at factories dating back to the Soviet era. Retooling of these plants to generate more efficient panels has been happening in some areas, with some success, but in many others, technical and financial barriers limit the wall-panel plants to continued production of less thermally-efficient products. The window market, on the other hand, has been far more nimble from the point of view of technical development of more efficient products, manufacture of these products, and financing, including widespread aggressive market participation by European firms. We examined compliance documentation for four buildings in Krasnodar and Novorossisk, and found that in all four cases, designers compensated for wall panels with less thermal resistance than prescriptively stipulated, by using windows that were far more efficient than prescriptively required. We believe that similar conditions prevail in many other regions.

We can infer from the Krasnodar/Novorossiisk cases that the performance approach is probably dramatically reducing the cost of compliance relative to the prescriptive approach alone because it would be impossible to find more efficient wall panels in the area, and impractical to ship them in. The success of new windows under the new code requirements suggests that in the next round of codes, regulators should strongly consider more stringent prescriptive thermal-resistance levels for windows, with accompanying adjustments to required whole-building performance targets.

Other areas. Use of external insulation, added insulation in attics and under ground floors, and other strategies have also been widely applied to achieve compliance. Overall, based on direct observations of building designs, construction practices and sales of efficient building materials, there is no doubt that the Russian construction sector has undergone a market transformation to greater efficiency over the same period that the new building codes have entered into force. The codes have been an important factor in this transformation.[4]

Energy auditing and field testing of energy performance

Our project team has field-checked the energy performance of one operating code-compliant building against the design calculations made by the code-stipulated algorithm. This building is a two-section 11-story residential building. It was built in 2002-2003 to replace razed 5-story buildings in the city of Moscow. The building was built with Swiss "Plastbau" system technology, which is new to Russia. The building is considered experimental because of its new technology.

Field testing was carried out in winter of 2004, using a method for energy auditing of existing buildings (GOST 31168) developed by the Research Institute for

[4] See Matrosov, Yu. A., et al. Recent Advances in Energy Codes in Russia and Kazakhstan: Innovation, Energy Savings, Market Transformation. *Proceedings of the ACEEE Summer Study in Buildings*. 2004.

Building Physics, in conjunction with the Moscow Architecture Committee. Researchers measured consumption of heat energy for heating, average indoor and outdoor air temperature, and average intensity of solar radiation on a horizontal surface over the heating seasons at defined 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) were calculated for these intervals of time.

The consumption of energy to heat the building over the design heating season, Q_h^y, was 2,917 GJ. The specific consumption of heat energy for heating the building over the heating season q_h, kJ/(m^2·^{o}C·day), was 70.33 kJ/(m^2·^{o}C·day). In accordance with the Russian federal code, the maximum permitted specific consumption of energy for heating a 10- or 11-story building is 72 kJ/(m^2·^{o}C·day). This exercise confirms that the building, in actual operation as well as in design calculations, complies with code requirements. It also confirms that the compliance calculation algorithm was precise relative to actual performance in this case.

Ratings and financial incentives

New codes in both Russia and Kazakhstan call for a five-tier building energy rating system, based on energy consumption relative to code requirements. Buildings that beat code-stipulated energy-performance requirements by 50 percent or more get a rating of "A", and by 10 to 50 percent a "B". Buildings in minimal compliance get a "C" rating, while "D" and "E" ratings apply to existing buildings erected before the onset of new codes. Financial rewards are recommended, but not required, for buildings in categories A and B. No jurisdiction has yet actually granted such rewards. Notably, however, the categories are apparently finding use among building owners, who specify desired categories for planned buildings in technical instructions to designers and builders.[5]

Financial incentives for efficient buildings has taken a different, but still highly substantial form in Moscow. In May 2005, the Moscow city government adopted a new policy directive calling for major financial incentives for the creation of energy-efficient buildings in the city. Applicable only to city-financed buildings, the rule calls for proportional bonuses for architectural and engineering agencies that deliver building designs that consume significantly less energy than required by code, with short simple payback times for the incremental cost of energy-efficiency measures. Table 1 below shows multipliers applicable to standard design fees. In the case of the most efficient buildings (those that consume 30 percent less energy than required by code, with simple payback times of less than three years), responsible building-design agencies get a 50-percent bonus beyond their usual fees.[6]

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[5] See, for example, Technical Conditions for the Design of a Multifunctional Residential Complex on ulitsa Zheltoksan 2A in the city of Astana [Kazakhstan], 2005.
[6] Appendix to the directive of the Department of Civil Construction Policy, Development, and Renovation of the City of Moscow, No. 46, May 12, 2005.

Table 1

Bonuses for design of energy-efficient buildings in Moscow (multipliers applicable to standard fees)

Category	Simple payback time		
	Up to 3 years	3 to 5 years	5 to 7 years
Increased (15-29 % less energy consumption than required by code)	1.35	1.3	1.25
High, Very High (30-50 % less energy consumption than required by code)	1.5	1.45	1.4

Looking ahead: strategic policy emphasizing sustainability

Russia's energy policy is defined by the 1995 document "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." 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."

The Russian Academy of Architecture and Construction Science (known by its Russian initials as RAASN) is the country's leading technical agency working on energy efficiency in buildings. RAASN, in conjunction with the former State Construction

Committee of the Russian Federation (Gosstroi), has been carrying out and will carry out policy on energy and resource conservation in Russia. The Academy has formally resolved that energy and resource conservation is one of its high-priority directions -- "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."[7]

Basic tasks and high-priority objectives for the activity of RAASN in the area of resource and energy efficiency for coming years have developed, including the following:

1. National and regional policy strategies for sustainable development;

2. A new integrated systems approach to city planning, construction, and heat supply;

3. 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, with accompanying technical regulations and guidelines;

4. Research, development, and market transformation programs for construction materials and goods;

5. Research, innovation, and upgrades in heat supply.

6. Super-efficient model homes (KERM buildings).

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[7] V. A. Ilyichev. Energy and Resource Conservation. Boilerplate and Creativity. Works of the Annual Meeting of RAASN, 2003.

Prospective activity

The strategic goal of RAASN is energy and resource conservation, with accompanying maintenance of the indoor environment in civilian buildings and the improvement of the quality of life of the population. RAASN's agency-specific objective for achieving this strategic goal is the creation of energy- and resource-minimizing technical approaches and energy-efficient technologies for buildings with a demand for primary energy reduced by 50% or more compared with the baseline of 2001. Fulfillment of this objective, in turn, involves several areas of planned work.

The first area involves making energy conservation more consistent with legal and regulatory requirements. The law "On Technical Regulation" places at the forefront safety of operation of civilian buildings, which includes energy and thermal safety. Detailed technical rules on thermal, energy, and environmental safety of civilian buildings should be developed for new highly-efficient buildings (those that fall in categories A and B of the new rating systems). These technical rules must contain basic conditions: comfort within the occupied premises of the buildings, thermal performance of buildings and energy conservation, soundproofing, natural and artificial lighting, and environment and architecture. They will include parameters for indoor environment, to provide for the health of people living within.

In conjunction with the first area, RAASN sees the need for development of unified codes for energy conservation in civilian buildings, taking account of heating, cooling, domestic hot water, and artificial light. The new codes will provide for reduction of expenditures for heating in civilian buildings in terms of primary energy of not less than 33 percent to 50 percent.

RAASN's plan calls for developing programs for the formation of requirements for market transformation for energy-efficient construction materials, with the goal of creating a national manufacturing base for such materials and reducing dependence on foreign producers.

The result of this work will be new, more progressive national codes for design of civilian buildings and wide national availability of new energy-efficient construction materials and technologies as well as construction and architectural solutions for new and renovated buildings.

KERM buildings

Looking toward the longer term, NIISF of RAASN has 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 buildings* -- known by their Russian initials, these buildings provide for comfort while minimizing the use of energy and resources.

KERM buildings, as currently envisioned, will consume about one-third to one-half the energy of buildings built in minimal compliance with current codes (22-42 $kJ/m^2 \cdot {}^oC \cdot day$). This level of performance 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, and moreover -- various technologies of use of heat in the process of heat transfer throughout 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 must be used. Automated systems for regulation of microclimate are needed. For KERM buildings, the aggregated life-cycle expenditures of energy for production of construction materials will be taken into account, not just performance after installation, facilitating a more thoroughly rational choice of the most truly energy-efficient and resource-conserving materials to choose for construction.

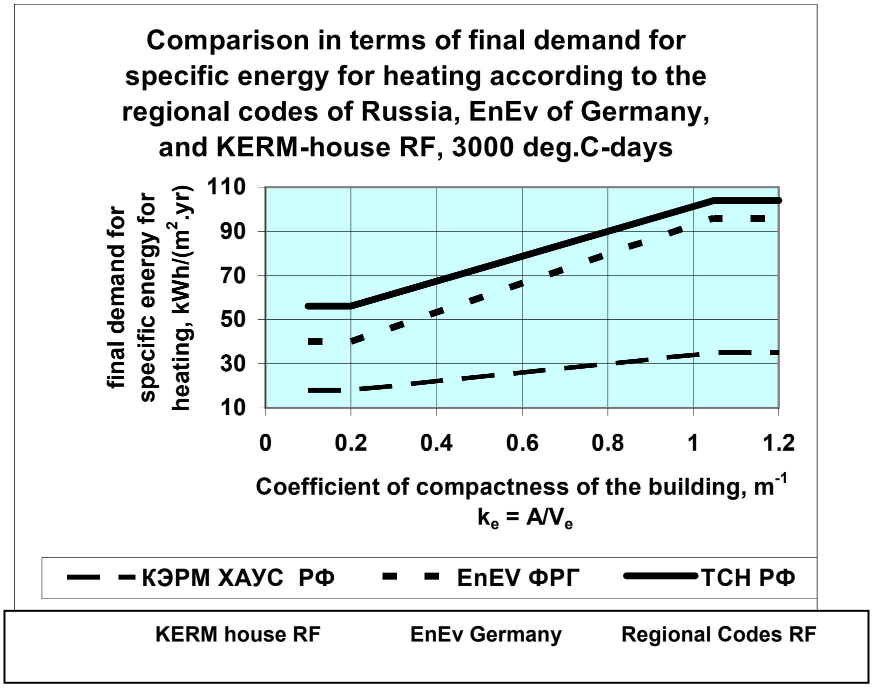

Fig. 2. Comparative analysis in terms of final specific consumption of heat energy for heating buildings KERM-house sample, of code requirements of EnEV of Germany and of regional codes of Russia as a function of the coefficient of compactness of a building

In many villages spread throughout Russia, decentralized sources of heat supply are much more efficient than centralized heat supply. Residential districts constructed from KERM buildings may be organized independently from centralized heat supply systems. These districts may therefore have a completely different architectural and engineering profile from traditional housing developments. The result may 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.

Since 2005, the Academy has been working with relevant agencies to secure land and financing to build the first KERM buildings, focusing on possibilities in Moscow.

Conclusion

Between 2004 and 2006, the Russian Federation has continued its twelve-year trend of steep progress on building energy codes. Recent progress has included continued development and implementation of new performance-based codes, with accompanying advances in rating systems, incentive programs, field verification of calculation methodology, application of new design approaches for compliance, and market transformation. Ukraine and Kazakhstan have proceeded rapidly as well with their own new codes, integrating successful elements of the model that underlies Russian regional and federal codes.

Looking ahead to the medium term and longer term, the Russian Academy of Architecture and Construction Sciences has set an ambitious new agenda for sustainability, emphasizing comfort, the indoor environment, minimization of consumption of material resources, in addition to energy efficiency. This agenda, to be realized in the form of KERM buildings, will expand traditional concepts of the building sector, to encompass life-cycle costs and energy consumption, as well as upstream heat-supply efficiency.

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