Energy Efficiency and Housing-Sector Transitions in Russia

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"All our salaries and pensions are burning up in the stoves of municipal heating stations"
--First Deputy Premier of the Russian Federation Boris Nemtsov,
as quoted by the Los Angeles Times, March 1997

Abstract. Investments to improve the energy efficiency of existing residential buildings in Russia are an important adjunct to fundamental housing-sector transitions that have been underway since the demise of the centrally planned economy in 1991. This paper analyzes the linkages between energy efficiency investments in multifamily buildings and the institutional, policy, and social aspects of those housing-sector transitions. Energy efficiency improvements can have a large impact on the speed and extent of these transitions; conversely, many features of these transitions enable or constrain energy efficiency investments. There are large technical opportunities to improve the energy efficiency of multifamily residential buildings with attractive financial returns. These returns are not difficult to achieve technically; the key challenges are financial, social and institutional in nature. Several types of energy-related policy development and capacity building may be necessary to create the proper incentives, overcome transaction barriers, and provide the maximum returns from those investments. Two recent World Bank projects illustrate possible investment and institutional approaches. A "system view" of district-heating systems is necessary, in which technical and policy changes on both the supply and demand sides are considered simultaneously.

Introduction

Transitions in the housing sector represent one of the greatest challenges facing Russia.[1] A major paradigm shift in the provision of basic housing and utility services is underway with the move to a market economy. Governments and enterprises are trying to reduce their direct involvement in housing and reduce the substantial financial burden of housing and utility services. Apartments are becoming privatized. Provision of housing maintenance services are in transition. These transitions are made much more difficult by the high costs of housing and utility services relative to household incomes and municipal budget revenues. Infrastructure dominated by multifamily buildings and large district-heating systems is costly to operate and maintain because of poorly insulated buildings, poorly controlled district-heating distribution systems, inadequate or inappropriate utility management and regulation, and lack of competitive housing maintenance. Municipal governments must subsidize housing and utility costs and provide housing allowances to low-income households. Enterprises must also subsidize housing on their balances, reducing commercial competitiveness. Governments face political difficulties in recovering the full costs of housing and utility services from households because many households cannot afford the full

[1] For basic aspects of housing-sector transitions, see Buckley and Gurenko 1995, Buichkovsky and Mints 1995, Struyk 1996.

costs. Apartment privatization by itself has not given households the incentives or means to reduce energy costs themselves.

Higher residential energy costs have caused severe budget pressures on municipal governments, which continue to subsidize housing and utility costs even after apartment privatization. Heating and hot-water costs alone averaged $30 to $50 per month for a typical apartment in 1995, about 25 to 40 percent of the average monthly wage. Typical subsidies averaged 70 to 80 percent of actual costs at the end of 1996 (Freinkman and Starodubrovskaya 1996). Municipal governments throughout Russia were typically spending 30 to 45 percent of their *total* municipal budgets on these subsidies (World Bank 1996a). In response, municipal governments have been reducing utility services. Social surveys have shown growing dissatisfaction with housing and energy services, including inadequate heating and hot water supply (see Annex 1).

A federal government decree mandates gradual phase-out of subsidies by 2003, which will have a severe impact on households. Without subsidies, housing and utility costs could reach 30 to 40 percent of average household income. In contrast, Western households typically spend 15 to 20 percent of total household income on housing and utilities. A burden on municipal governments will also remain because of housing allowances for low-income households, which will dramatically increase as housing costs become a larger share of household income.

Energy efficiency investments can have a large impact on the speed and extent of these housing-sector transitions. There is an urgent need for new investments in housing and district-heating to address serious existing infrastructure inefficiencies and a historical lack of maintenance and rehabilitation. These infrastructure deficiencies mean that housing and utility costs need to be reduced and housing and utility services need to be improved.[2] Without housing and utility cost reductions, many of the housing-sector transitions listed above will prove even more difficult. Yet cost reduction is hindered by the many market distortions and institutional barriers that exist even after privatization and energy price reform. In addition, municipal governments lack the financial resources to make investments and long-term commercial financing is still scarce compared with investment needs.

Everything in the housing sector is changing except for the buildings themselves. Although policy changes are underway, energy efficiency improvements to multifamily residential buildings have so far been extremely slow to materialize. This paper discusses technical-economic opportunities for energy efficiency, linkages between energy efficiency and these housing-sector transitions, and policies and capacity building that could foster energy efficiency investments. Examples of two recent World Bank projects for greater efficiency in the housing sector are also given. This paper is based upon Martinot (1997), which contains more details on the material presented here.

Technical-Economic Opportunities for Energy Efficiency

Multifamily residential buildings in countries of the former Soviet Union are generally in poor condition and suffer from high energy losses and inefficiencies compared to buildings in Western countries with similar climates. For example, residential space-heating intensity in Lithuania in 1990 was 2½ times higher than in Sweden and 1½ times higher than in the United States.[3] The delivery and control

[2] Housing and utility services include such parameters as indoor temperatures and comfort; hot water availability and temperature; and the safety, cleanliness, appearance, functionality, and management of buildings. Housing and utility costs include payments for space heat, hot water, cold water, gas, electricity, maintenance services, capital repairs, and building renovations.

[3] Residential space-heating intensity is a measure of how much heat is required for given levels of indoor comfort,

of heat in district-heating networks and buildings can also be very inefficient. Heat and hot water savings are most important because heat and hot water represent two-thirds to three-quarters of total residential energy consumption. A combination of demonstration-project experience and technical analyses demonstrates convincingly that energy efficiency improvements to multifamily residential buildings are an economically and technically viable way to reduce the costs of operating these buildings and to improve energy services (see Annex 2 for details and notes of these demonstration projects and analytical studies).

Technical measures for reducing heat losses from buildings include: additional insulation on roofs, exterior walls, and basement ceilings; window replacement, renovation, or weather-stripping; improved caulking and sealing of building panel joints; new building entrance doors; and improvements to building ventilation systems. In particular, studies have highlighted high thermal losses associated with building ventilation, leaky windows, and the low thermal insulation properties of exterior walls. Measures for improving the heating systems within existing buildings include new or replacement heat exchangers in building substations; building-level meters, valves, and automatic control systems for regulating the heat entering the building; apartment-level heat and hot-water meters; thermostatic radiator valves for controlling the heat to individual apartments; heat balancing valves for balancing the heat flows within the building; and hot water and heat pipe insulation. Measures for reducing electricity and gas consumption include replacing or renovating electric or gas appliances, such as stoves, refrigerators, lights, and hot water heaters.

Although it is possible to analyze the energy efficiency potential of individual measures, most building renovations will include combinations of measures, and the net effect is based upon the interaction of the individual effects. Extensive research in Sweden has shown clearly that the actual savings from measures depends on how they are combined. Therefore, integrated analysis of packages of measures is preferable. Most technical measures must be applied to the building as a whole rather than to individual apartments, so this analysis must be done on a building level.

Integrated combinations of these measures can be designed to offer short payback periods. Some potential measures, such as exterior wall insulation, have significantly longer payback periods by themselves and thus extend the payback periods of combinations that include them. A medium-level package of technical measures in most buildings can be designed with payback periods of 5 years or less and will reduce energy consumption by 15 to 30 percent. There is some variation depending on building type, number of apartments per building, and climatic zone. Replacing, renovating, or weather-stripping existing windows alone can provide substantial savings. Payback periods of 5 to 10 years are common for medium-level packages of measures. Energy consumption reductions of up to 50 percent are possible with extensive retrofit packages that include exterior wall insulation, although payback periods are significantly longer, extending to more than 20 years in some cases. A basic-level package of measures can cost from \$300 to \$900 per apartment and save from 10 to 20 percent of heat and hot-water consumption. A medium-level package can cost from \$600 to \$1,300 per apartment and save 15 to 30 percent. An extensive renovation can cost from \$1,500 to \$3,000 or more per apartment and save 40 to 50 percent or more.

Technical measures can be grouped into three categories: (a) passive-technology measures such as insulation, ventilation improvements, improved heat balancing and other heating-system improvements, and low-flow shower heads, which all reduce the energy required to produce given levels

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adjusted for different climatic conditions. The figure for Lithuania in 1990 was about 200 KJ/m²/degree-day, compared to 130 in the United States and 80 in Sweden (Kazakevicius et al 1996; Schipper and Meyers 1993). Many Western countries had intensities of 200 KJ/m²/degree-day in the 1970s but have increased the efficiency of residential buildings substantially since then.

of comfort and service without any occupant intervention; (b) behavior-related measures such as valves and controllers, which allow occupants to regulate and control energy consumption to desired levels of comfort and service; and (c) meters, which alter the way heat payments are calculated and create incentives for energy efficiency investments and energy consumption reductions.

Although passive-technology measures are straightforward, heat controls and meters pose special problems because their energy-saving effect depends on household behavior and the existence of administrative and regulatory structures that support consumption-based metering and billing. Building-level meters are essential for any retrofit strategy because of the clear incentives created. But the question of metering and controls at the apartment-level is more complex. Installation of meters on heating pipes is prohibitively expensive because the physical arrangements of heat pipes within buildings require that each radiator in an apartment have its own heat meter. Nevertheless, inexpensive evaporative-type heat allocators (costing perhaps $5 to $10 each) may be attached to each radiator. Heat allocators are in common use in Denmark, Germany, and France, and have recently been mandated in Sweden. Some analysts have cautioned against apartment-level meters, citing measurement inaccuracy, unfair billing if corrections are not applied for the location of an apartment within a building, and tampering. There are also extra administrative costs and difficulties of reading and billing based upon apartment-level meters. Obviously, without the incentives created by apartment-level metering, radiator thermostat valves are unlikely to save much heat unless apartments are overheated and residents use the thermostat valves to regulate comfort. Experience in the Nordic countries leaves little doubt that without apartment-level meters, households will consume more heat.

Major building improvements, like roof renovations, exterior wall insulation, and new windows, are more costly and may only make sense if the entire building is undergoing renovation. In this case, the added costs for improved energy efficiency can be much lower because the renovation work would occur anyway. A roof that must be repaired provides a good opportunity to add extra insulation, as the incremental costs of the insulation will be highly cost-effective. Similarly, the additional costs for exterior wall insulation will be much more cost-effective if undertaken when major facade renovations are being made anyway.

Linkages Between Energy Efficiency and Housing-Sector Transitions

The linkages between energy efficiency investments and housing-sector transitions mean that energy efficiency improvements are an important compliment to policy reforms in accelerating transitions in the housing sector in at least three important ways. First, technical measures to reduce energy consumption also reduce the operating costs of buildings and can delay or eliminate the need for future investments in energy-supply infrastructure. Reduced operating costs and delayed investment requirements can improve the willingness of municipal governments and eventually tenants to accept divested housing from enterprises. Reduced operating costs can also support reduced subsidies because the full costs become more affordable to households. Second, heat and hot-water metering, coupled with consumption-based billing, create incentives for households to reduce energy consumption and invest in energy efficiency measures. The need to collectively reduce energy consumption in buildings can, in turn, stimulate the formation and operation of homeowner associations, which is an important step toward greater private responsibility for housing. Third, building-level metering, coupled with consumption-based billing, shifts the full costs of district-heating distribution losses from consumers to district-heating companies. This shift places both incentives and responsibility for distribution losses with the same agent--the district-heating company--and can support transitions in utility management and supply-side cost reductions.

Conversely, transitions in the housing sector have a large influence on the incentives for investing in energy efficiency. Federal or municipal government incentives to invest in energy efficiency can depend on a number of conditions, including: (a) subsidies paid for heat and hot water (level of cost recovery); (b) energy regulation that affects the actual costs of utilities to the government; (c) the possibility of avoided investments on the supply-side; and (d) the costs of targeted housing allowances to low-income households for utility payments. Likewise, household incentives to invest in energy efficiency are affected by a number of conditions: (a) the energy tariffs they pay; (b) the extent to which their apartments are privatized; (c) whether their energy payments are fixed or based on actual consumption; (d) whether energy is metered at the building-level or at the apartment-level; (e) the size of their household income and affordability of investments; and (f) existing levels of comfort, which depend upon whether heat is undersupplied to buildings and who controls the supply.

Privatization and higher energy costs, traditional "free-market" prescriptions for improved energy efficiency, have not resulted in reduced energy losses in apartment buildings because of serious barriers that are rooted in housing-sector transitions. Even after apartment privatization, there is little incentive for private owners to invest in energy efficiency or to adjust their heat consumption. In fact, energy-efficiency improvements are practically impossible under current conditions. There are eight main problems:

(1) *Lack of owner responsibility for buildings*. The institutional and management structures associated with responsibility for buildings have not changed at all after privatization. Generally, this means that municipal governments, through municipal housing maintenance organizations, are still responsible for building operation, maintenance, and capital improvements.

(2) *Lack of homeowner associations*. Most energy efficiency measures require changes to the common areas and equipment of buildings, not to individual apartments, and thus require a collective decision-making mechanism. But residents of apartment buildings can only be collectively responsible for their building after they organize into a homeowner association. Although the first national law on homeowner associations was passed in 1993, almost no homeowner associations had formed by 1997, for several reasons: (a) effective legal frameworks have been slow in emerging; (b) residents are reluctant to assume responsibility for a building that may require substantial and costly repairs; (c) once an association forms, the financial losses resulting from households that do not pay their utility bills become the responsibility of the association (rather than the municipal government, local utility company, or an enterprise), and thus are shared by all households within the building; (d) guidelines and decision-making models of how homeowner associations should behave are lacking.

(3) *Lack of heat and hot-water metering*. Heat, hot water and gas are not metered in apartment buildings. Without meters, households do not pay for consumption according to actual use, but instead pay a fixed monthly amount based on the size of their dwelling, the number of registered inhabitants, and the type of appliances present (i.e., stove, water heater, and bath). Households face zero marginal-cost for their energy consumption and thus have no incentive to conserve or invest. Although building-level metering is a necessary first step, apartment-level metering would create a larger range of conservation incentives.

(4) *Lack of heating controls*. The most effective heat control in the Soviet era was to open a window, even in the dead of winter, because radiators lack adjustable valves. In household surveys, virtually all respondents wanted regulators on their radiators. Entire buildings can be over- or under-heated because there are no building-level controls that residents can adjust, and heat-supply levels are determined by the operators of central heat-supply plants.

(5) *Lack of capital*. The lack of financing for households, homeowner associations, and real-estate developers is a serious obstacle. Banks aren't willing to lend without adequate collateral and guarantee mechanisms, but homeowner associations have few assets. The institutional problem of how to secure a collective loan (by a homeowner association) with individual property (apartment titles) requires that new laws be enacted (as was done in 1995 in Lithuania). In order to obtain financing, households must also have good information about technical opportunities, costs and benefits, and realistic managerial and technical capabilities for specifying, contracting, and supervising building improvements.

(6) *Variation in socioeconomic status and household income among households in the same building*. In the Soviet era, building occupancy was generally assigned without regard to the socioeconomic status or income of households. Consequently, buildings now house an essentially random mixture of socioeconomic groups. The wide variation in income among households living in the same building results in wide variations in affordability of housing costs and investments, and can affect the ability of homeowner associations to reach collective investment decisions.

(7) *Housing allowances*. Targeted housing allowances limit incentives of low-income households to invest in energy efficiency because the allowances effectively put a cap on total monthly heat and hot-water payments regardless of consumption (provided total payments are above the subsidy threshold).

(8) *Other utility regulatory issues*. Deficiencies in municipal utility regulations are still many. For example, the basic institutional question of who purchases, owns, and maintains heat meters is not resolved. Administrative and regulatory structures will need to be created to bill households according to actual consumption once meters are installed. New regulations will be needed to specify how district-heating companies must permit consumers to vary their heat consumption autonomously, a situation which may necessitate technical or operational changes in the district-heating system itself.

Transitions in the housing sector also have a large influence on the type of returns possible from energy efficiency investments. Some returns are financial, such as reduced utility bills, reduced building maintenance and repair costs, avoided investment costs of new energy supply capacity, and increased housing asset values. Other types of returns include increases in indoor comfort (changes in indoor temperatures and other comfort parameters), especially in the case of underheated or poorly balanced buildings, and reduced air pollution from fuel combustion. The degree and distribution of these returns depends on several factors, including: (a) energy prices and investment costs; (b) subsidies and expenditure-sharing arrangements; (c) building characteristics; (d) existing level of energy delivery and services; (e) heat-supply markets and institutional structures; (f) district-heating system technical characteristics; (g) characteristics of power plants or heating boilers; (h) energy policies and regulations and the capabilities of regulatory authorities; and (i) the level of development of real-estate markets and the marketability of buildings.

For example, lower utility bills depend on the level and structure of utility tariffs and the structure of heat-supply markets. If building-level metering and consumption-based billing were instituted on a large scale, district-heating companies might be forced to absorb additional costs if bills based on actual consumption are lower. But this depends upon the structure and level of tariffs. Or if the district-heating company is able to sell the avoided heat consumption from residential buildings to an industrial consumer at a higher tariff, then the district-heating company also benefits. Two other regulatory mechanisms have important effects on financial returns: (a) regulations that give district-heating companies financial incentives (returns on capital investment) to invest in energy efficiency in distribution systems; and (b) regulations that ensure that the highest-cost heat production plants are closed first as demand falls. Economic returns depend on the actual fuel savings achieved through energy efficiency measures, plus any savings in operating, maintenance, and avoided-capacity costs. Institutional arrangements, district-heating system characteristics, and the structure of heat-supply markets determine how energy savings at the building-level translate into actual fuel savings at a power plant (this is a complicated issue; see below).

Policies and Capacity Building for Energy Efficiency Investments

Overcoming the barriers discussed in the previous section means providing or enhancing some combination of: (a) information about technical opportunities and their associated costs, energy savings, and financial returns; (b) managerial and technical capabilities of homeowner associations, municipal governments, building maintenance organizations, and/or third-party intermediaries (for specifying, contracting, and supervising renovations); (c) the ability of households to reach investment decisions collectively through homeowner associations; (d) the availability of long-term credit; (e) adequate collateral and/or guarantee mechanisms for loans; (f) regulations and institutions for consumption-based heat and hot-water metering and billing; and (h) increased capabilities and numbers of design and construction firms familiar with energy efficiency measures.

Municipal governments should consider investments in residential buildings. Even though municipal housing and utility subsidies are declining, if the investment payback time is short enough, governments should still see positive cash flow from the investment (reduced subsidy burdens). Nevertheless, if an investment is made in a building that is expected to become privately maintained and operated before investment costs are fully recovered, then there must be viable mechanisms for the government to recover investment costs from the future operators (such as a homeowner association or private maintenance company). Heat meters are a good target for initial investments, and municipal governments in Ukraine have begin to do this.

Municipal governments also need to develop administrative systems for consumption-based metering and billing in the residential sector, along with regulations to specify a new system of consumption-based energy tariffs. With building- or apartment-level metering, a database of building characteristics must be created in order to allocate building-level heat meter readings among all households within a building. An agency must be created, equipped, and trained to read heat meters and calculate heat payments on a monthly or annual basis. New administrative mechanisms must incorporate calculated payments into household energy bills. New municipal regulations must give appropriate authority and budgets to the new agencies. Without new regulations, district-heating companies are not likely to allow changes in consumption that will require changes to their systems. Regional energy commissions may also need to approve the transformation of residential heating tariffs from a per-square-meter to a per-gigacalorie basis.

Municipal regulations can also encourage technical and managerial changes in district-heating systems so that energy demand reductions in residential buildings are translated into maximum fuel savings at power plants. Substation controls are one obvious technical example. The ability of district-heating producers to sell "surplus" heat to industrial customers (thus reducing industrial fuel consumption) may require new regulatory provisions or approaches. New regulatory provisions may also be needed if net revenues to district-heating companies decline because of wide-spread building-level metering. New regulatory mechanisms could provide increased incentives for district-heating companies to reduce distribution losses and forestall the need for increased tariffs as revenues decline. These regulatory changes may be needed at municipal, regional, or national levels, depending on who the heat producers are.

Government policies should promote formation and operation of homeowner associations as vehicles for collective decision-making and action for energy efficiency. Barriers to the formation of homeowner association have already been mentioned in the previous section, and government policies should be designed to overcome these barriers. Functioning associations then need access to organizational, legal, financial, and technical advice. Public advisory centers are one way to provide this support. In a test activity, the Lithuanian Ministry of Construction and Urban Development helped four homeowner associations go through a process of borrowing from commercial banks and implementing energy-efficiency improvements. Direct assistance was provided to the associations at each step in the process, including: (a) inviting associations to take the loan, (b) obtaining a mandate from association members, (c) gathering technical and procedural information, (d) preparing a proposal that identified options and their respective costs and benefits, (e) choosing a course of action and inviting bids from contractors, (f) selecting a bid, (g) negotiating with contractors, (h) negotiating with commercial banks, and (i) overseeing construction and installation. The activities in this project illustrate the kinds of support homeowner associations require (World Bank 1996b).

Even with functioning homeowner associations, public education campaigns, training programs, and other educational resources are important for educating households about energy efficiency. For example, regulations to implement consumption-based metering and billing will cause households to fears that energy bills will increase. These fears must be addressed through public information. Also, experience from existing homeowner associations and retrofit projects could be publicized through radio or television interviews with participating households. Associations need to understand the opportunities, the possibilities for credit, and the requirements for project management, procurement, contracting, and supervision skills or services. Management and procurement are especially important because most energy-efficiency projects require careful design and involve many types of materials, equipment, and installation expertise.

Public-sector projects also should consider demonstrations of autonomous heating boilers because of their importance to the housing sector. Autonomous heating boilers offer a long-term option for restructuring district-heating systems, which may be favored by households once the proper incentives are in place. Yet the information gaps and uncertainties associated with autonomous heating boilers will seriously hinder private-sector initiatives. Research and demonstrations are needed to help provide information, reduce uncertainties, and give a basis for effective investment decisions related to autonomous heating boilers.

Finally, commercial banks may need assistance that enables them to understand and appraise the technical and financial merits of energy efficiency projects and to create appropriate financing mechanisms and procedures. Banks also need to understand households as prospective clients and how to evaluate their credit-worthiness. Experience from pilot projects is needed to identify the arrangements necessary for commercial credit facilities that offer long-term lending to homeowner associations. Some type of government guarantee mechanism, at least in the earlier stages of lending, will probably be required.

Two World Bank Project Examples

The Russian Federation Enterprise Housing Divestiture Project and the Lithuania Energy Efficiency/Housing Pilot Project are two recent investment projects for energy efficiency in residential buildings. In the Russian project, municipal-government investments in energy efficiency reduce the costs of operating residential buildings in conjunction with other housing-sector policy measures that are also designed to reduce operating costs; together the investments and policy measures support the divestiture of enterprise housing. In the Lithuanian project, energy efficiency investments by homeowner associations with commercial bank financing support domestic policies to sustain the privatization of housing and the development of commercial lending in the housing sector. Because transitions in the housing sector are ongoing, these two projects have a transitional and pilot/experimental nature. The experience from these two projects should be carefully monitored and disseminated because it will prove valuable to future projects.

The Russian project provides $300 million in World Bank financing for basic energy efficiency measures in an estimated 3,500 divested multifamily residential buildings in six cities (Petrozavodsk, Cheropovets, Volkhov, Vladimir, Ryazan, and Orenberg). Municipal governments borrow capital, manage the design and implementation of energy efficiency retrofits, and repay the loan from the general municipal budget. Municipal governments recover their loan costs through the resulting lower payments for heat and other utilities for residential buildings. As household cost-recovery for utility services is phased in, municipal governments will continue to recover their retrofit investment costs in this manner. Household utility bills will include amounts for loan repayment, but total bills will be lower than if the investments had not been made. Because of the need for the greatest positive impact on municipal and household budgets in the short-term, financing covers only high-return packages of energy efficiency measures with payback periods of five years or less. The main constraint on the total size of investment for each city is not the availability of cost-effective retrofit opportunities but the credit-worthiness of municipal governments (and the related constraint of the need to secure guarantees for loans from regional and national governments).

The Lithuania Energy Efficiency/Housing Pilot Project makes almost $15 million available to approximately 200 to 300 homeowner associations, through commercial banks, for energy efficiency investments. The project encourages formation of homeowner associations and develops their technical and managerial capacity to undertake such investments. The project also introduces commercial banks to the concept of long-term lending for housing and housing improvements. Finally, the project supports the development of private markets for energy consulting and housing renovation services. Investments per building are expected to range from $20,000 to $150,000 (which amounts to $100 to $3,000 per dwelling).

The project illustrates a potential model for energy efficiency improvements. A homeowner association commissions a consulting firm to conduct an engineering evaluation of potential energy efficiency improvements, to provide economic-cost and financial-return estimates, and to develop an investment proposal that meets the collective needs of the building's households. The homeowner association then borrows capital from a commercial bank based on this proposal. The loan is secured by the right of the homeowner association to levy charges on all households, a right granted by a 1995 law. The same consultant then prepares a technical specification for the work, and the homeowner association bids the work to construction contractors with assistance from the consultant. The consultant supervises the renovation work and certifies its acceptability and performance. In addition, the commercial bank may have an inspection and certification requirement. The homeowner association pays the contractors with the bank loan and bears the investment risk. Households pay lower energy bills and repay the loan in monthly installments using their monthly energy-bill savings. While all retrofit measures do not have to be strictly related to energy efficiency, the overall financial returns must be high enough to justify the loan and ensure credit-worthiness.

The following types of technical assistance and institutional development are provided by the project to support participants and other stakeholders:

- Advice to households on how to form and operate homeowner associations will be provided through local advisory centers (run by the Lithuanian Association of Homeowners' Associations). In addition, formation of homeowner associations may be facilitated by eliminating unfavorable legislation or by available government assistance programs.

- Advice will be provided to households and homeowner associations on technical, financial, legal, and social aspects of energy efficiency improvements to their buildings. This assistance includes assessment of the scope for energy efficiency improvements, preparation of investment proposals acceptable to commercial banks, procurement of materials and services, and supervision of retrofit installations.

- Public information and education programs will help homeowner associations understand the technologies, costs, benefits, and financing of energy efficiency improvements and help them understand how to seek bank credit for these improvements.

- Loan appraisal support and training will be given to help commercial banks understand the technologies, costs, and benefits of energy efficiency improvements.

- Technical, financial analysis, contracting, and marketing training will be provided to energy consultants and building-rehabilitation contractors.

- Studies will be done on housing maintenance organizations and on government assistance programs to the housing sector (including existing homeowner association programs and renovation and heating subsidy programs).

It is still unclear which financial and institutional mechanisms will prove most successful. In particular, the willingness and ability of homeowner associations to take responsibility for maintenance and renovation of their buildings and to borrow capital and assume loan risks requires further understanding. Through privatization, a dwelling may be the first real property that households have ever owned, so they will be understandably reluctant to put this property at risk. It is clear that an extensive learning process will be required to produce changes in the behavior of households and homeowner associations necessary for successful housing-sector reform. Working examples and models will be more effective learning tools than abstract information, and projects like these are important for providing a base of reliable and credible information on technical measures, financial mechanisms, and institutional models.

District-Heating Systems: A System View

In conjunction with energy efficiency investments in residential buildings, improvements in district-heating systems are also important. Improvements to district-heating systems typically fall into one of three categories: more efficient heat production in boilers, improved regulation and control of heat flows within distribution systems, and improved insulation of distribution system pipelines. In general, the debate about the relative merits and timing of improvements on the supply-side versus the demand-side of district-heating systems has not produced clear consensus. Rather, this debate has indicated that both supply-side and demand-side improvements should be addressed simultaneously in ways that make short-term economic sense while at the same time confronting the long-term issues. Short-payback-time improvements in district-heating systems in conjunction with renovations to the buildings they supply are important. In general, the district-heating and building energy efficiency problem lends itself well to concepts of least-cost, integrated-resources planning concepts when looked at from a system viewpoint.

Autonomous sources of heat are a technology that should be considered carefully in the context of both supply-side and demand-side improvements to district-heating systems. There is no question that Soviet-era district-heating systems will undergo long-term technical and institutional restructuring. That restructuring may include much greater use of autonomous heating boilers serving individual buildings and greater use of apartment-level heaters. Although experts in both Russia and Western countries recognize that well-maintained district-heating systems with cogeneration are usually more efficient than autonomous heat sources, these experts also conclude that greater economic and technical efficiency can be achieved with autonomous heat sources in the appropriate geographical and technical circumstances in Russia.

This paper advocates concurrent investments on both the supply and demand sides, and concludes that energy-related policies and capacity building should also address both the supply and demand sides of district-heating systems. As discussed above, the actual fuel savings (and thus economic and air-quality benefits) from energy efficiency investments in buildings depend on the technical and institutional characteristics of district-heating supply systems and heat-supply markets. Energy-related policies and capacity building that integrate the supply and demand sides are especially important in the context of three other heat-supply-market and institutional issues: (a) incentives to reduce district-heat distribution losses once building-level heat meters are installed; (b) heat meter ownership, installation, and maintenance; and (c) district-heating demand that is displaced (and/or supplemented) by electric and gas heating. The important question is not whether to start on the supply-side or on the demand-side, but what are the financial, institutional, social, and policy approaches that will produce the most cost-effective solutions.

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Annex 1: Social Survey Results

Household surveys in multifamily apartment buildings were conducted in three cities (Ryazan, Vladimir, and Volkhov) in 1995 as part of Russian government and World Bank project-preparation activities for the Enterprise Housing Divestiture Project (Guzanova and Diachenko 1995a and 1995b). A random sample of between 300 and 500 households was selected in each city. The surveys focused on occupants' perceptions of housing maintenance and utility services and better understanding of the most significant technical problems and opportunities for reducing utility costs. Below are some of the major findings.

Overall dissatisfaction with housing and energy services is prevalent. A majority of households were dissatisfied with overall communal services because of high rent and utility payments, inadequate heating and hot-water supply, and problems with sewerage. In two surveys, a majority of households found their apartments either "rather cold" or "very cold" in winter, while in a third survey, one-third of households reported the same thing. Other areas of dissatisfaction included humidity and ventilation (cold drafts from windows and doors).

The reliability of heat and hot water supplies was an issue. In two surveys, 13% to 15% of households reported no hot water for periods of 90 days or longer each year; in another survey, 65% of households had no hot water for 45 to 90 days each year. On average, hot water is shut off for 30 to 45 days during the summer months. In addition, emergency interruptions occur six to seven times per year, sometimes for periods lasting up to four days. Between 10% to 25% of households have to wait more than five minutes at night for hot water once taps are opened.

Some households use supplemental heating sources when their dwellings become too cold. In wintertime, 20% to 30% of households in two surveys use supplementary sources of heat (plug-in electric heaters or gas kitchen stoves) either frequently or constantly. Another 30% do so occasionally. In a third Russian survey, 30% of households use supplemental heating at least sometimes during the winter, and 40% of households use supplemental heating during the fall and spring before and after the heating season.

Most households have already taken steps to improve their comfort and reduce energy losses from their apartments. Seven-five to ninety percent of households reported resorting to makeshift weatherization and insulation, including improvements to windows, balconies, and front doors. (Locations of colder apartments as reported by households tend to correlate with the expected colder locations in buildings, such as corner apartments and first-floor apartments, indicating that better heat balancing could improve distribution of comfort within buildings.)

Households believe they would reduce energy consumption with marginal-consumption billing. Seventy-five to eighty-five percent of Russian households would prefer to pay for their space heat and hot-water consumption according to meters rather than on the fixed basis in place now. Households believed that bills would be reduced because inadequate amounts of heat are being delivered. Most households (80% to 90%) would like heat regulators on their radiators so they can control their own heat consumption. About half of the households would keep apartments cooler at night if controls and metering were available. A majority of households would welcome low-flow showerheads and faucet caps to reduce hot and cold water consumption if they had to pay for water according to metered consumption.

Willingness to pay for energy efficiency measures generally still appears low. In two surveys, no more than 15% to 20% of households were willing to pay for measures like replacement of radiators, temperature regulators on radiators, insulation of windows, insulation of doors, and caulking of cracks and cavities in the walls. Households favored using loans to improve apartment or building appearance and safety, with increased apartment comfort and reduced utility bills as only second and third priorities, respectively. One survey mentioned specific loan amounts on questionnaires, and only 6% were willing to borrow $520 with a monthly payment of $8.

Annex 2: Case Studies and Analyses of Technical-Economic Opportunities

Martinot (1997) analyzed nine case studies of actual energy efficiency retrofit projects in Russia, Ukraine, Estonia, and Lithuania that took place between 1993 and 1996. A summary of these case studies is presented in Table 1. In addition, several analytical studies for Estonia, Latvia, Lithuania, and the Russian federation have been conducted in recent years associated with World Bank project-preparation activities and with the UNDP/World Bank Energy Sector Management Assistance Program (ESMAP), EU PHARE assistance, and Danish bilateral assistance (Table 2). For detailed descriptions of the case studies and analytical studies, including differing assumptions and corrections and use of the data presented, see the full report (Martinot 1997).

The range of energy savings estimates and payback periods found in these studies and demonstrations reflects several types of variation: (a) different assumptions about future district-heat service levels, (b) future heat costs (some project analyses used heat prices found in Western European countries that were far higher than those expected in the country where the demonstration was conducted), (c) inclusion or exclusion of renovation costs not related directly to energy efficiency improvements, and (d) uncertainties about performance estimates of renovation measures. Other variations in payback period may result from the difference in costs between imported and domestically purchased materials and equipment.

While a fairly robust aggregate picture of energy-savings potentials emerges from the analytical studies and retrofit demonstration projects, individual energy-savings performance estimates must be viewed with some caution. There are many difficulties in making accurate energy saving performance estimates. The most important is the lack of a consumption baseline if no meters or metered data existed prior to retrofits. Comparison with design consumption norms is usually misleading because actual building performance can vary substantially from the norms. Comparison with similar buildings that have not been previously calibrated is unreliable because the experience shows that even seemingly identical buildings can vary substantially in energy consumption under identical conditions. For example, the initial experience with metering in the city of Ryazan in the Russian Federation (Battelle 1996b) shows that neighboring identical buildings connected to the same district-heating system can vary in heat consumption by up to 40 percent. The best performance data will come from experiments in which identical buildings are monitored and calibrated against each other prior to retrofitting one of them, and then the future performance of the retrofitted and unretrofitted buildings is compared (the approach taken in Ryazan).

In addition, simple metering of energy flow into a building is insufficient to draw meaningful conclusions; accompanying information is needed on corresponding outdoor and indoor air temperatures in order to accurately characterize the building's thermal behavior. Finally, energy savings vary depending on the amount of heat supplied to a building. If buildings are undersupplied with heat, energy savings attributable to the retrofit measures may be significantly less than estimated.

Table 1. Experience from Retrofit Demonstration Projects

Location (and primary reference)	*Building type*	*Retrofit measures*[a]	*Cost per building (US$)*[a]	*Cost per apartment (US$)*[a]	*Energy savings (percent)*[b]	*Payback period (years)*[a,b,c]
Tartu, Estonia (Fjärrvärmebyran 1994)	5-story, 60-apt.	window tightening	3,700	60	6	5
Tartu, Estonia (Fjärrvärmebyran 1994)	5-story, 60-apt.	heat control and window tightening	6,800	110	6	9
Tartu, Estonia (Fjärrvärmebyran 1994)	5-story, 60-apt.	heat control and balancing, window tightening	12,000	200	28	4
Haljala, Estonia (Virudan 1993)	3-story, 18 to 36 apts.	thermostat valves	5,600	230	15 to 27[d]	3 to 7
Petrozavodsk, Russian Federation (Finnish Energy Conservation Group 1996)	5-story 60-apt.	heat control and substation	25,000[e]	420[e]	22[e]	4[e]
Ryazan, Russian Federation (Battelle 1996c)	5-story 60-apt.	heating system retrofits	40,000	670	---[f]	---[f]
Vilnius, Lithuania (Danish Building Research Institute/COWI 1995b)	16-story 65-apt.	heating system, pipe insulation, apt.-level meters	45,000	690	19	8
Tallinn, Estonia (Rolén et al. 1994)	9-story 72-apt.	basic package	60,000	830	15 to 28[g]	5 to 11
Tallinn, Estonia (Danish Building Research Institute/COWI 1995a)	5-story 40-apt.	basic package	45,000	1,100	24	14
Ryazan, Russian Federation (Battelle 1996c)	5-story 60-apt.	insulation and sealing of walls, doors, windows	75,000	1,250	---[f]	---[f]
Ryazan, Russian Federation (Battelle 1996b)	9-story 144-apt.	extensive package	180,000	1,250	---[f]	---[f]
Tallinn, Estonia (Swedish Natl. Board 1995)	5-story 60-apt.	basic package	90,000	1,500	15 to 28	7 to 20
Tallinn, Estonia (Axovaatio 1996)	5-story 60-apt.	extensive package	170,000	2,800	30 to 50[h]	7 to 14
Kiev, Ukraine (Sogelerg 1995)	---	heat control and insulation	---	---	---[f]	---[f]

--- Not available.

a. Costs and payback periods include a building-level heat meter in all projects, which in the case of simple investment packages significantly increases the package payback period (as in Tartu, Estonia). Costs and payback periods are based on direct material, equipment, and installation costs, including taxes, but do not include project management and design costs, which varied substantially because of the demonstration nature of the projects. All costs are actual unless noted as estimates.

b. Variation in energy savings and payback period reflect differences between theoretical estimates and actual measurements (actual tend to be lower than theoretical), different scenarios of district-heat supply conditions, the range of uncertainty in measurements, and variations among multiple buildings in the same demonstration project. Some payback periods and energy savings are author's best estimates based on data presented in project reports and field research (see also Martinot 1995a) and may vary from the payback periods and energy savings given in those reports.

c. Heat prices used in payback period estimates are all $20/Gcal.

d. Haljala project estimates for energy savings were 28% based on measurement of the total heat consumption of a small town from one year to the next, including industrial consumption, uncorrected for degree-days. Author's conservative estimate is 15% energy savings.

e. Costs and savings for Petrozavodsk are pre-retrofit estimates.

f. Estimates for energy savings and payback periods for the projects in Ryazan and Kiev will be available in 1997 after analysis of building measurements taken during the 1996/97 heating season.

g. Original project estimate was 28% energy savings under a normal heat supply regime while actual measured savings were 15% under a curtailed heat supply regime.

h. Original project estimate was 40 to 50% energy savings under a normal heat supply regime while measured energy savings relative to a partially calibrated reference building were 30% under a partially curtailed heat supply regime.

Source: primary references given in table; details in Martinot 1997.

Table 2. Costs, Savings, and Payback Periods from Analytical Studies

Study	*Building size (stories)*	*Number of apart-ments*	*Retrofit package type*	*Cost per apart-ment (US$)*	*Energy savings (percent)*	*Payback period (years)*
Lithuania, World Bank	5	100	Basic	100	22	2
Lithuania, World Bank	5	32	Basic	250	17	6
Lithuania, World Bank	5	100	Medium	400	34	5
Russian Fed., Stork	5	100	Basic	410	28	4
Lithuania, BCEOM	9	72	Medium	430	26	5
Lithuania, BCEOM	5	100	Medium	520	32	6
Lithuania, BCEOM	10	36	Basic	540	31	4
Lithuania, SWECO	5	100	Basic	610	40	13
Lithuania, World Bank	5	32	Medium	750	44	7
Russian Fed., EHDP	9-14	---	---	750	30	3
Lithuania, SWECO	9	81	Basic	800	40	7
Lithuania, BCEOM	5	60	Medium	870	42	5
Russian Fed., EHDP	5-8	---	---	980	30	4
Lithuania, SWECO	5	60	Basic	1,050	41	12
Lithuania, BCEOM	4	16	Medium	1,100	29	6
Russian Fed., EHDP	2-4	---	---	1,130	30	4
Estonia, COWI	4	32	Medium	1,130	30	15
Lithuania, SWECO	5	20	Basic	1,150	45	12
Estonia, COWI	7	144	Medium	1,150	20	13
Lithuania, SWECO	9	32	Basic	1,300	58	13
Lithuania, SWECO	5	100	Medium	1,300	53	20
Lithuania, SWECO	9	81	Medium	1,400	45	10
Lithuania, World Bank	5	32	Extensive	1,400	42	13
Lithuania, BCEOM	9	72	Extensive	1,450	47	10
Lithuania, World Bank	5	100	Extensive	1,500	45	15
Estonia, COWI	5	45	Medium	1,600	25	18
Lithuania, SWECO	5	60	Medium	1,850	50	18
Lithuania, SWECO	9	32	Medium	1,950	65	18
Lithuania, SWECO	5	20	Medium	2,050	57	18
Lithuania, BCEOM	5	60	Extensive	2,050	52	9
Russian Fed., Gabrielsson	5	118	Extensive	2,400	33	15
Lithuania, BCEOM	10	36	Extensive	3,400	48	16
Lithuania, BCEOM	4	16	Extensive	4,300	53	13

--- Not available.

Note: Heat prices used in payback period estimates are all $20/Gcal.

Source: Battelle 1996a; BCEOM 1995; Danish Building Research Institute and COWIconsult 1993a; Kazakevicius et al. 1996; Stork Comprimo 1996; SWECO 1995; World Bank 1996a and 1996b; Gabrielsson 1995.

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