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Energy efficiency and renewable energy in Russia

Transaction barriers, market intermediation, and capacity building

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Technical-economic and geographical opportunities for energy efficiency and renewable energy in Russia are enormous – cost-effective investments are possible in district heating systems, buildings, and industry, and for wind, biomass, solar and geothermal energy. Market-level energy prices, privatization, and the possibility of independent power production all favor investments in these technologies and technology transfer with other countries. But many transaction barriers limit such investments and transfers, especially barriers that are related to capital, information, infrastructure, market institutions, human resource capabilities, and institutional incentives. Market intermediation and joint ventures are important in overcoming these transaction barriers. International policies, for example by bilateral and multilateral agencies, should facilitate market intermediation. Capacity building should target skills in economic analysis, management, and finance; information services; regulatory development; new market intermediation institutions; stronger legal and market institutions; and implementation mechanisms supporting independent power producers. Policies that encourage and support energy service companies are especially important.

Keywords: Sustainable energy development; Market failures; Economies in transition

Introduction

Russia is the third-largest contributor to total carbon-dioxide (CO_2) emissions in the world, after the United States and China. In 1994, Russia ratified the United Nations Framework Convention on Climate Change, thereby pledging to reduce its CO_2 emissions.[2] Technologies for energy efficiency and renewable energy are among the most important means for reducing CO_2 emissions in Russia, and greater domestic development and investment in these technologies, as well as international technology transfers, can have a large impact on global climate-change mitigation.

In addition to global environmental benefits, the economic, social and local environmental benefits from energy efficiency and renewable energy are important to Russia. Pressing economic problems in Russia still provide the most direct motivation for energy efficiency. For example, heating and hot-water costs averaged \$30 to \$50 per month for a typical apartment in 1995, while the average monthly wage was around \$120. Municipal government subsidies for residential heating and hot water absorbed one-third or more of total municipal budgets in 1996 (Martinot, 1997). In industry, energy intensities are 30–100% greater than comparable industries in the West, making Russian industry less competitive and more costly.

Governments and enterprises in Russia also see production of energy efficiency and renewable energy technologies as important for economic development – as a means to employ production capacity and skilled workers that have been idled by the economic downturn of recent years. Greater regional autonomy from lower

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[2] CO2 emissions in Russia have fallen significantly in recent years because of the large drop in industrial output and associated energy consumption since 1991. In fact, Russia may be one of the few countries in the world whose CO2 emissions in 2000 will be less than in 1990.

dependence on regionally imported fuels is another motivation. In a 1994 interview, the president of the Kalmykia regional electric power utility, which was building a 22 MW wind farm using Russian designed and manufactured wind turbines, gave five main reasons why he had decided to pursue wind energy development: (a) to increase regional independence; (b) to mitigate against increasing gas and oil prices in the future; (c) to reduce the influence and control of Gazprom over the economy and enterprises in the region; (d) to put Russian defense factories back to work; and (e) to showcase Russian technologies and demonstrate national technological pride (Martinot, 1995).

Investments in and international technology transfer of energy efficiency and renewable energy technologies, while attractive from many viewpoints, have been minimal in practice since the demise of Soviet central planning in 1991. This paper conveys a five-part argument: (a) favorable conditions like market-level energy prices and privatization exist; (b) huge technical potentials and economically profitable opportunities exist; (c) Russians are highly technically qualified to take advantage of those opportunities; (d) many transaction barriers seriously limit investments in these technologies and hinder international technology transfer with other countries; and (e) new institutions and market-oriented skills, market intermediation, and joint ventures are especially important in overcoming these transaction barriers.

This paper is based upon the author's Ph.D. dissertation research, conducted from 1990 to 1995 (Martinot, 1995). The research synthesized many unpublished Russian sources collected during field research in the former Soviet Union from 1992–1995, including more than 20 case studies of actual energy efficiency and renewable energy projects and almost 200 interviews with managers, engineers, government officials, research scientists, and bilateral and multilateral agency staff in Russia and several other FSU countries. The case studies documented significant international technology transfer and domestic investment projects: private firms like Honeywell, Danfoss, IVO international, and Kenetech Windpower were undertaking commercial and demonstration activities; Russian municipal heating companies, private industrial enterprises, and electric utilities were undertaking energy efficiency and renewable energy projects; the United States, Sweden, Finland, Denmark, Germany, the United Kingdom, and the European Union were providing international assistance; and the World Bank approved loans for energy efficiency.

Energy and economy in Russia

While Russia's per-capita energy consumption is roughly equivalent to developed countries in Western Europe and elsewhere with similar climates and industries, the structure of Russia's energy consumption is quite different from these countries. The structure of primary energy consumption in 1994 was overwhelmingly natural gas (48%), followed by oil (25%) and coal and other solid fuels (22%), with contributions from hydroelectricity (3%) and nuclear (2%). Non-hydropower renewable energy contributes practically nothing. Industry's share of total electricity consumption in Russia is comparable to that in OECD countries, but the residential share is much less (10% in Russia compared with 25% in OECD countries). In addition, heat production and consumption is much more important in Russia than in most other industrial countries; heat represents 40–45% of final energy consumption across all sectors, while two-thirds or more of total energy consumption in the residential sector is for heat and hot water (Batenin, 1990; Center for Energy Efficiency, 1995; Levine *et al*, 1992; Nekrasov *et al*, 1993).

Russia's 150 million people, in 89 separate regions, have experienced enormous economic, political, and social dislocations and changes since the breakup of the Soviet Union in 1991. Lifting of price controls, privatizations, economic reforms, political battles, currency reforms, soaring crime, and a growing polarization between the poor and the rich have been among the most visible. In the early years, inflation was high and energy prices soared. Industrial output crashed by 50% in statistically reported sectors from 1990 to 1993 and has been stagnant. Poverty and subsistence living have become the norm for a majority of the population. With the demise of state central economic planning, relationships between enterprises underwent fundamental changes. Many enterprises became financially insolvent but continued to do business anyway. Accumulation of vast inter-enterprise and government debts created a serious 'non-payments' crisis. New laws and frequent revisions to existing laws, along with conflicts between local, regional, and federal laws and a lack of enforcement mechanisms, has left great legal uncertainties and vacuums. Natural gas, oil and electricity prices throughout Russia have reached levels found in Western Europe. Energy is no longer subsidized except for residential heat and hot water and for electricity cross-subsidies from industrial to residential consumers.[3] Industrial enterprises, residential apartments, and energy supply companies have been formally privatized to a large extent (IEA, 1995).

Unsubsidized energy prices and privatization are often heralded as the keys to greater energy efficiency (see World Bank, 1993). But private ownership in Russia has not automatically translated into increased responsibility or market-oriented actions. For example, in the residential sector most apartments are privatized, but residents are not responsible for the maintenance of the buildings themselves nor for investments, like for energy efficiency,

[3] Average subsidies by municipal governments for residential heat and hot water were 70–80% of total costs, but are mandated by the federal government to decline to zero by 2003.

to improve the buildings. Motivation is lacking because heat and hot water are unmetered. Even with capital and motivation, the institutional mechanisms (homeowner associations) through which residents could make such investments are missing (Martinot, 1997).

In the industrial sector, enterprises must undergo radical changes before they can respond fully to market-level energy prices. In the Soviet economy, central planners told enterprises exactly how much to produce, who their customers and suppliers were, and at what price to buy and sell. Specialized design institutes separate from enterprises were often responsible for developing new products and processes, and incentives discouraged innovation by enterprises themselves. Each enterprise generally produced a narrowly specialized output (see Nove, 1986). Now, enterprises must make their own business decisions, such as investing in energy efficiency or producing more energy-efficient products. Enterprise managers must learn to think creatively about cost reductions, identify and select suppliers, market their products, broaden their product lines, build innovation capacity, and manage their financial balances and resources. 'Most enterprises in the present-day Russian economy are still very far from becoming privately owned corporations to which standard incentive schemes can be applied. Instead they constitute a new and previously unknown class of enterprises that we call post-state-owned enterprises' said Yavlinsky and Braguinsky (1994, pp. 92–93).

Opportunities for energy efficiency

There is no question that energy use in Russia is much less efficient than in most developed countries. A number of studies show that typical energy intensities in Russia are 20% to 100% higher than in countries with comparable climates and industries (Bashmakov and Chupyatov, 1991; Levine *et al*, 1991; Martinot *et al*, 1995; Nekrasov *et al*, 1993; Opitz, 1994; Schipper and Cooper, 1991; US Congress, 1993). Estimates of energy intensity based upon energy/GDP ratios are unreliable because of the problems of GDP measurement and equivalencies, and because, as one Russian banker said in a 1993 interview, 'it is impossible to measure the economy of Russia or the incomes of Russians, since most people and many enterprises avoid paying taxes by hiding large shares of their income' (Martinot, 1995). One study, Schipper and Cooper (1991), compared Soviet and Western energy intensities using structural indicators by end-use sector. They found that, by adopting Western equipment and energy management practices in use in 1990, energy intensities in the former Soviet Union could be reduced by at least 20% to 35% in all sectors. Potential gains from the newest, rather than average, equipment and processes are even larger.

The reasons why existing energy use is inefficient are well-known and stem from the former planned Soviet economic system: (a) enterprise managers lacked incentives to minimize production costs; (b) energy quotas and allocations resulted in energy being wasted or dumped to maintain allocations; (c) technological change was inhibited by a lack of incentives to innovate and because any changes could mean problems in obtaining new inputs and greater risks in meeting production targets; (d) single-enterprise monopolistic production of many goods meant that goods were always in demand no matter what their characteristics; (e) the drives to produce large quantities of apartments in the 1950s and 1960s left quality and energy characteristics as secondary priorities relative to total production volume; and (f) large centralized district heating systems were assumed to have advantages a priori, and potentially more-efficient alternatives were never considered. In a few sectors, like electric power generation and transmission, energy efficiency was explicitly promoted with specific incentives (Bornstein, 1985; Chistovich, 1990; Nove, 1986).

While the Soviet legacy has left Russia with inefficient and uncompetitive industries and infrastructure, it also has created large technical opportunities for energy efficiency that offer high economic returns. The above-noted international comparisons of energy intensities and the structure and level of energy consumption in Russia, together with a large body of evidence on technical-economic potential from the author's case studies and other sources suggest that huge energy-efficiency improvements are not only technically possible but also provide attractive economic and financial returns (IEA, 1995; Kogan, 1993; Martinot, 1995; Schipper and Martinot, 1993 and 1994; U.S. Congress, 1993). Many opportunities exist to save 10-30% of total energy consumption with simple payback times of 1 to 5 years. Key sectors are:

District heating systems. District heating is one of the most important forms of energy supply and consumption in Russia; 75% of Russia's population receives heat from district heating systems. But boilers and distribution systems are inefficient and poorly controlled, and supply and distribution pipes are poorly insulated. Network losses, while designed to be no more than 10–15%, can reach 30% because of poor maintenance and leakages. While large combined heat-and-power (CHP) plants are theoretically efficient at delivering heat, the combination of distribution system losses and poor heat control can negate this advantage, especially if the electricity production is a by-product rather a primary product (true in many circumstances; see Martinot, 1997). Energy efficiency measures include automated controls to optimize heat production and distribution according to fluctuations in heat demand and outdoor temperatures; combustion analyzers and controls for boilers; and better insulation of pipes. In some situations more decentralized alternatives, like autonomous heating boilers, may improve efficiency.

Buildings. Technologies for improving the heating systems within existing buildings include new or replacement heat exchangers; building-level meters, valves, and automatic control systems; apartment-level heat meters and thermostatic radiator valves; heat balancing valves; and hot-water-pipe and heat-pipe insulation (Martinot, 1997; Opitz, 1994; World Bank, 1996). Building thermal envelopes can be improved with additional roof and wall insulation, window replacement, window weather-stripping, improved sealing of building panel joints, new entrance doors, and mechanical ventilation systems. Integrated combinations of these measures can offer payback times of five years or less. Exterior wall insulation has significantly longer payback periods. Electricity consumption in buildings is a less significant target for energy efficiency because few major appliances exist and lighting loads are small, but more efficient lighting and refrigerators offer some potential.

Industry. A wide range of industrial processes can be replaced by more energy-efficient ones, although these changes will likely be made in the context of a larger modernization effort. More-efficient electric motors offer large savings potential, but replacement of motors solely for energy efficiency benefits is often not cost-effective. Cost-effective improvements to existing processes and equipment can be made, for example more efficient gas burners and combustion controls, lighting replacements, variable-speed-drive motor controls, and secondary process-heat recovery. Many 'low-cost/no-cost' measures are also cost-effective, such as boiler tuning and monitoring, better energy management, minor process changes, and plugging of steam and pressurized air leakages. Industrial cogeneration with combined-cycle gas turbines can be a cost-effective and more efficient alternative to purchased electricity and heat.

Opportunities for renewable energy

Many opportunities exist for renewable energy in Russia, particularly for wind, biomass, solar hot water, and geothermal (Batenin, 1990; Kozlov, 1990 and 1994; Martinot, 1992; Nilsson *et al*, 1992; Perminov, 1993; Russian Ministry of Agriculture, 1994; Shpilrain, 1992; Strebkov, 1993). Wind energy resources are especially plentiful in the Northwest, Far East, and North Caucasus regions. Biomass resources in the form of unused wood wastes are plentiful in the forest-industry-rich Northwest and Far East and represent an important fuel for both heat and electricity production. While good year-round solar resources exist only in the most southern regions, summertime-only solar resources for supplemental hot-water heating exist throughout the country. Four key markets for renewable energy are:

Electricity for electric power grids from wind and geothermal. Favorable regions for grid-connected wind farms are Rostov, Stavropol, Krasnodar, Volgograd, Kalmykia, Kaliningrad, Leningrad, Murmansk, Maritime, and Khabarovsk. The North Caucasus region in particular provides a congruence of favorable conditions for wind farms, including good wind resources, flat terrain dominated by agricultural uses, high population densities, and severe electric power deficits in the regional electric grid. Geothermal resources have been identified in Stavropol, Krasnodar, Sakhalin and Kamchatka.

Electricity for small settlements from hybrid wind/diesel and biomass. Approximately 20 million people in Russia live in regions where Russia's 'unified' electric power grid does not penetrate. Most are connected into smaller, autonomous power grids, but many are served by standalone generation systems using either diesel fuel or gasoline. Hybrid wind-diesel systems and biomass-fired plants can replace or supplement these existing diesel and gasoline generators cost-effectively. Favorable regions for this market are Karelia, Murmansk, Vologda, Archangelsk, Komi, Maritime and Khabarovsk.

District heating from biomass. In smaller cities and towns where coal or fuel-oil district-heating boilers are small (less than 10 MW), these boilers can be converted to burn biomass fuels (especially wood wastes from forest products industries). Favorable regions for this market are Leningrad, Karelia, Vologda, Novgorod, Maritime and Khabarovsk.

Summertime solar hot-water heating for buildings. In most district-heating systems, boiler plants must continue to run during summer months to produce domestic hot water. During the summer, the energy consumption to produce this hot water is especially inefficient. Solar hot-water heating in the summer months for apartment buildings and single-family houses connected to heat-only boilers in district-heating systems can allow shutdown of district heating systems during four to six summer months each year and result in significant economic savings.

Russian technological capabilities and market-oriented shortfalls

Russia has technological capabilities that parallel most developed countries. The technological infrastructure, scientific and technical knowledge, engineering and technical skills, factories and equipment are all well developed. Substantial evidence indicates that Russian capabilities to develop and produce most energy efficiency and renewable energy technologies are excellent. Practically all needed technologies are produced and available in Russia – meters, valves, insulation, sensors, automatic controllers, pre-insulated piping, variable speed drives, high-efficiency lighting, gas turbines, heat pumps, wind turbines, solar photovoltaic cells, solar water heaters, and biogas digesters – although the performance of some of these technologies may be less than their Western counterparts. Russian technological capabilities to install, operate, and maintain energy efficiency and renewable energy technologies are also highly developed.

But Russians still lack the associated market-oriented skills and institutions to take full advantage of these technological capabilities. Key underdeveloped capabilities are business management, finance, marketing, creative product development and innovation, quality assurance, economic analysis (like cost-benefit and lifecycle analysis), legal, contracting, and accouting skills. 'No one knows how to write a Western-style business plan here' said one businessman, although many have also emphasized that Russians are learning fast. Russians also lack 'commercial know-how,' which is an innovative, creative, and experience-based ability to turn an idea or design into a reliable, quality commercial product or service. A common theme expressed in the author's interviews was that 'great ideas and opportunities exist if only they can be evaluated and commercialized'. The above technological capabilities and associated market-related deficiencies are the direct results of the Soviet paradigm of economic development practiced for 70 years (Hanson, 1985; Cooper, 1991; Nove, 1986; Martinsons and Valdemars, 1992).

Transaction barriers

Transaction barriers[4] to energy efficiency and renewable energy in Russia are similar in many ways to those in developed and developing countries (see for example Stern and Aronson, 1984; Reddy, 1991; Levine *et al*, 1994; World Bank, 1993; Jackson, 1993). In Russia many of the sources of risk, institutional structures and conditions, experience and skills deficiencies, cultural 'mentalities', and infrastructure characteristics are unique and persistent reminders of Russia's Soviet heritage. The main influence of many of these barriers is greater uncertainty in transactions about opportunities, costs, and benefits. Other barriers limit full and correct information from reaching those who need it. Still others are related to legal and market institutions, property rights, and contracts; their main influence is to increase the costs of property rights and contract enforcement or to reduce the availability of collateral for financing. Others stem from missing skills and human resource capabilities or missing institutional structures or incentives. The most significant transaction barriers determined and characterized through the author's research (published sources, case studies, and interviews) are grouped and described in six categories below. Other sources confirm many of these barriers in the Russian context (see for example Usiyevich, 1993; US Congress, 1993 and 1994; Evans, 1995; Kvint, 1994; IEA, 1995).

Capital. The opinion of practically all Russians interviewed was that a lack of long-term capital was a key barrier. The lack of capital availability reflects risks and uncertainties. In 1993, Russia was rated 149th among 169 countries in terms of investment risks by Euromoney Journal (Feller and Mikheyev, 1994). This rating has since improved, but still lags far behind most other developed countries. 'The maximum time horizon for [domestic] bank loans is two years now', an economist with a leading Russian bank said (*Moscow Tribune*, 7/27/94), 'no one will touch real investment while there's so much uncertainty'. Uncertainty partly results from macroeconomic instabilities in inflation, currency rates, and changing and conflicting tax laws. At a microeconomic level, banks are unwilling to lend because information about the financial condition and solvency of a particular enterprise is difficult to obtain or determine because there are no established financial disclosure rules, norms, or laws. Compounding this problem is a cultural legacy of deceit from the Soviet era, when enterprise managers routinely misreported economic information and performance, a practice considered necessary for normal enterprise operation (Nove, 1986). Loan risks are also increased because large interenterprise debt makes the financial conditions of borrowers indeterminate and contingent upon the likelihood of debt repayment along chains of debtors. Availability of collateral for loans is hindered because the land itself under privatized enterprises and buildings is still state-owned and thus not available for collateral purposes. Finally, enterprise managers and government officials are unused to thinking about the costs of capital in investment decisions because in the Soviet economic system capital was essentially a free good allocated on the basis of politics and economic planning.

Information. The lack of information about energy efficiency and renewable energy costs, benefits, geographic resources and opportunities is a major barrier. While enterprise managers may know about the technologies needed, information about economic and financial costs and benefits is often lacking. There are many reasons for the lack of information, including historical centralization of information in the Soviet period among authorities in Moscow, highly personalized contacts and networks as the basis for contemporary economic activity, lack of enterprise marketing departments and activities, changing relative and absolute prices, little historical experience on which to base cost estimates, unavailable cost data, and physically unmetered heat consumption or poor energy accounting practices (which means that consumption baselines are lacking). Renewable energy never received priority in the Soviet economic system, so good resource data are lacking. Foreign entities operating in Russia face difficulties getting information because of the highly personal networks that

[4]Transaction barriers are also called 'market failures', 'market imperfections' or 'market barriers'.

channel most information flows. Even equipment price lists from enterprises are sometimes unavailable to 'strangers'.

Infrastructure. No heat meters exist in residential and service buildings, and rarely in industrial buildings. This situation has two important implications. First, building residents pay a fixed monthly amount for their heat and hot water consumption, and thus have no incentive to reduce consumption. If heat meters and valves are installed in individual apartments, and consumer bills are based upon actual consumption, then consumers can regulate their own heat and face the marginal costs of such regulation. But apartment-level metering is problematic. Heat distribution within buildings is typically designed so that radiators are connected in series, with supply pipes running vertically through the building. Thus each of the four or five radiators in a typical apartment is connected to a different distribution pipe, requiring a separate meter for each radiator. Inexpensive evaporative-type allocation heat meters on each radiator are possible, and can be used to allocate total building consumption across all apartments. A second implication of the lack of meters is that there is no historical heat consumption data with which to create a baseline to project or measure energy savings. Energy savings often have to be estimated based upon design standards or norms for the 'before' consumption. Case studies showed that 'before' estimates based upon design standards or norms can be very misleading, producing great uncertainty in the actual energy savings achieved or possible. This uncertainty undermines the credibility of projected or claimed energy savings. The director of one of Russia's first energy-service companies, in a 1994 interview, emphasized this barrier: 'enterprises cannot measure their energy consumption, and so are hesitant to do anything about it'. Another transaction barrier related to the technical characteristics of district heating systems is that the link between energy savings at a building and actual fuel savings at the district-heating plant is complex and depends on district-heating system operational and technical changes (Opitz, 1994).

Market and contract institutions. The legal and institutional underpinnings of functioning market economies are often taken for granted in advanced market economies, but are powerful derterminants of market activities (North, 1990). North goes so far as to say that 'the inability of societies to develop effective, low-cost enforcement of contracts is the most important source of both historical stagnation and contemporary underdevelopment [in developing countries]'. In Russia, many aspects of business activities are not covered by any existing laws, or if laws exist there are no viable implementation and enforcement mechanisms, including detailed regulations and government agency capacity. Contract enforcement is problematic because a viable court system for resolving contract disputes does not yet exist. Other means have evolved, such as private third-party arbitration, and emphasis on personal trust and long-term business relationships. A lack of 'contract institutions' refers not only to formal institutions for enforcement and resolving disputes, but also to more informal ones like consensus on standard practice in particular fields or industries (to which reference can be made in contracts) and accepted payment and delivery terms. In addition to the obvious problems for investments in energy efficiency and renewable energy brought about by these conditions, interenterprise debt combined with the lack of enforcement mechanisms for debt collection also makes energy appear cheaper than its price would imply, because enterprises that do not pay their energy bills have less incentive to save energy.

Experience base, skills, and 'mentality'. Enterprise managers and workers lack experience and skills related to business planning, cost-minimization, innovation, marketing, finance, negotiation and competition. This lack of experience results from decades of working within the Soviet centrally planned economic system. For example, the historical organizational separation of innovation from production (into design bureaus and production enterprises) has left enterprises themselves with less capacity to innovate to improve energy efficiency. Western-style accounting practices, now necessary in many situations, are still unfamiliar to most. For energy-efficient technologies to be demanded, managers first have to gain experience in thinking in cost-minimizing terms and in innovating to reduce costs. Managers must think competitively. They must understand finance and how to negotiate loans and performance contracts with outside vendors and suppliers. 'Managers may have a marketing course, or a cash-flow analysis course, but no *experience* or understanding of the real world' said one Russian businessman in a 1993 interview. Further, managers are not used to independent and creative thinking and to taking responsibility themselves, he said, because most workers in the Soviet era were accustomed to simply following orders and plans 'from above' without question. These 'mentality' factors were stressed by many interviewees.

Institutional arrangements and incentives. Institutional innovations and structures are lacking that would provide the proper framework and incentives for investments in energy efficiency and renewable energy. For renewable energy, utility electric-power monopolies and the absence of institutional frameworks for independent power producers have been barriers in many countries including Russia. For energy efficiency, two examples related to residential apartment buildings and district-heating systems are illustrative:

Residential apartment buildings. Privatization of residential apartment buildings, coupled with meters to measure actual heat consumption, should lead to greater incentives for residents to improve the energy efficiency of their buildings. Residents could form a homeowner association and pool their property rights so that the association would have collateral to borrow money from banks to make energy-efficiency improvements. Besides the transaction, information, risk, and capital availability barriers, this model is not yet viable in Russia. Even if some or all apartments in a building become privatized, the *responsibility* for the maintenance and repair of the building still remains with the municipal government. The key issue – responsibility for the buildings – has not altered with privatization. It is possible that homeowner associations will form and assume responsibility for building repair and maintenance, but several factors suggest that this process will be difficult: (a) homeowners may be reluctant to assume financial responsibility for a potentially dangerous building in need of substantial repairs, (b) private housing maintenance firms may not exist, and (c) residents may be reluctant to assign their property rights to the association.

District-heating networks. Incentives and responsibility for district-heating distribution losses are institutionally mismatched. Municipal administrations pay heat-supply companies for heat delivered to residential buildings as it leaves the heat plant, not as it enters the buildings. There is a standard allowance for distribution losses, but distribution losses in reality can be much higher. Thus heat-supply companies have little incentive to improve the efficiency of heat-distribution systems. If heat meters were installed in buildings and payments made for heat as it enters buildings, incentives for improvements would shift appropriately to the district-heating companies themselves.

The importance of market intermediation

One implication of the transaction barriers described above is that market intermediation is very important for energy-efficiency and renewable-energy investments and technology transfer. Market intermediation provides the knowledge, information, skills, services, financing, and analysis that is necessary to overcome transaction barriers, but that either or both parties to a potential transaction may be unwilling or unable to provide. In a perfectly frictionless economy, market intermediation is unnecessary; all parties possess perfect and costless information, transaction and contracting costs are zero, capital markets are perfect, and parties act with complete economic rationality. But in both developed and developing countries, market intermediation for energy-efficiency and renewable-energy investments is important because conditions are far from these ideals.

The need for market intermediation to overcome transaction barriers is often discussed in the context of technology development, both internationally and in purely domestic contexts. For example, Heaton *et al* (1994, p. 20) have proposed sector-specific market intermediation as an important policy goal for greater international technology transfer, development and co-operation:

> In intermediation, third parties create linkages, transmit knowledge, and expedite other transactions for the principals. The greater the barriers that separate parties who could create relationships of mutual benefit, the greater the need for intermediation. In technology development, the value of intermediation is well-recognized.

The importance of market intermediation is demonstrated convincingly by much of the author's research evidence. Strong and pervasive transaction barriers require equally strong and pervasive market intermediaries. And the character of these intermediaries is not strictly economic, but may involve substantial political, bureaucratic, and legal functions. Table 1 lists important market intermediation functions in Russia. Almost none of these functions existed in the Soviet planned economy because they were simply not needed. Now these functions represent the greatest challenge to energy efficiency and renewable energy investments and technology transfer in Russia. As one example, cost estimation is a highly evolved field in the West with many established sources of information and experience from which to draw, but in Russia cost estimation is an entirely new field in which very few have experience.

In the United States, market intermediation for energy efficiency and renewable energy by third parties has taken several specific forms. Examples include energy service companies, special regulatory incentives that give an intermediation function to an existing regulated organization (like electric power utilities in the case of demand-side management programs), laws allowing independent power producers which have spawned 'project developer' intermediaries, and appliance and equipment labeling standards. In developing countries, many of these same forms of market intermediation have been discussed in the literature. For example, Reddy (1991) stresses information campaigns and demonstrations, third-party packaging and financing of energy efficiency

Table 1 Important Market Intermediation Functions in Russia

Securing the support of government officials
Finding and matching potential investment and joint venture partners
Arranging sources of finance and engineering financing schemes
Evaluating and verifying information about partners and projects
Obtaining information about technologies and understanding markets
Identifying potential investment projects
Estimating the costs, benefits, and risks of investment projects
Packaging projects for public or private investors
Securing and structuring credit guarantees and guarantees of project performance
Developing licensing arrangements
Negotiating and writing contracts
Engendering trust among project participants
Obtaining necessary licenses and government approvals
Preparing technical specifications and bidding documents
Bidding and selecting bids for equipment and installation services
Managing, supervising, monitoring, and evaluating projects

projects, appliance and equipment labeling standards, demand-side management programs, independent energy-service companies, least-cost electric utility planning, independent power producers, and attitude changes and training among financiers and government officials. In describing the government interventions necessary for developing renewable energy production and marketing systems in developing countries for mature energy technologies, Hurst (1990) makes the case for governments to play an intermediary role. Interventions include provision of information to consumers and manufacturers, taxes and subsidies, credit services, direct support of the distribution system, and direct participation in equipment manufacture.

The above examples from the literature are all relevant to Russia. Departments or agencies of municipal and regional administrations, non-profit organizations, electric power utilities, and enterprise associations are organizational forms that can provide market intermediation functions in Russia. Information and business intermediaries have been important, like the non-governmental Center for Energy Efficiency in Moscow (Chandler *et al*, 1996). In the future, Russian commercial banks may also prove to be significant intermediaries in project evaluation and financial mechanisms. Four specific organizational forms of market intermediation deserve further comment:

Energy service companies. In Russia, energy service companies are one of the most important vehicles for market intermediation. The functions listed in Table 1 take considerable skill and training, which argues that firms specializing in these skills, like energy service companies, will be better able to perform these functions than consumers or production enterprises. Revolving loan funds for energy efficiency, now taking hold in some Eastern European countries, could be one source of capital for energy service companies.

Demand-side management. Demand-side management (DSM) is a form of market intermediation by electric utility companies that had gained acceptance in some countries, but Russian utilities will need significant support to provide this type of intermediation. The reasons that the World Bank (1993) gives as to why DSM is not prevalent in developing countries correspond quite closely to the problems of DSM in Russia: end-use markets are not highly competitive, energy supply enterprises are weak institutions that have major difficulties even in supplying energy and collecting bills, regulatory bodies do not exist, and there is a lack of government understanding and support of DSM initiatives.

Independent power producers. A recent Russian law on energy efficiency for the first time allows independent power production in Russia. This law should make possible electric power production from renewable energy sources and cogeneration by private developers. But this law merely says that non-utility producers of electricity may sell electricity to regional utilities, and that regional utilities must buy this power from the producer at a contracted price that is subject to approval by the regional energy commission. There are many implementation details and mechanisms that need to be in place before such transactions can occur.

Energy efficiency funds. Market intermediation is also evident in the 'Russian approach to energy efficiency', embodied by federal- and regional-government energy efficiency funds. These centralized funds are financed with taxes on energy sales, and allocate funds to investment projects and to developing manufacturing capability and industrial conversion for production of energy efficiency equipment. A few regional funds were operating successfully by 1995.

The importance of joint ventures

Joint ventures with foreign multinational corporations represent another means for overcoming transaction barriers, one that also takes advantage of Russian technological capabilities. Joint ventures with the Soviet Union, allowed for the first time in 1987, were seen by the Soviets as an active technology transfer mode that provided access to needed technological innovation and commercial know-how while making use of existing technological capabilities (Sherr *et al*, 1991). Others saw the potential for joint ventures specifically for energy efficiency improvements (Cooper, 1991). Since 1992, the gap in understanding across the old East–West border means that the close working relationships and long-term commitment that a joint venture brings are important (as opposed to more arms-length technology transfers that have traditionally worked between developed countries). Some research on joint ventures suggests that they work best when both sides have similar technological capabilities, can share complementary skills and resources, and where relations with host-country governments and institutions are difficult for foreign partners alone (Datta, 1988; Chowdhury, 1992), factors all relevant to Russia.

In a Russian joint venture, foreign partners can supply capital and the business, financial, marketing, and commercial know-how that Russians lack (especially commercialization of already-developed but unmarketed Russian technologies). Russian partners can help to overcome many of the transaction barriers previously mentioned: obtaining information through personalized contact networks, negotiating the maze of conflicting laws and regulations, getting government approvals, finding domestic suppliers and partners, obtaining licenses, and understanding markets. Examples of manufacturing joint ventures have been the Windenergo joint venture in Kiev between Kenetech Windpower and the Ukrainian government (which started to manufacture wind turbines in Ukrainian production enterprises in 1993 based upon a licensed US design), and the Sovlux US–Russian joint venture in Moscow to manufacture solar photovoltaic panels. Joint venture energy service companies may also be viable and a good way to channel the training, know-how, and capital from Western partners into providing the market intermediation functions outlined previously.

International policies for capacity building, development assistance, and technology transfer

The conventional development prescription for improved energy efficiency is elimination of subsidies (energy priced at long-run marginal costs), privatization, and greater institutional effectiveness (World Bank, 1993). This prescription is inadequate for Russia given the many serious transaction barriers discussed in this paper, many stemming from the lack of legal and market institutions and the need for new institutional forms or institutional transformations. Alternatively, more institutionally oriented views of development are relevant for Russia, for example the views of North (1990), that institutions underlie and shape economic development, and of other perspectives from the field of institutional economics (Hodgson *et al*, 1994).

Traditional development approaches to energy efficiency and renewable energy have emphasized provision of equipment and technical assistance. USAID's Commodity Import Program for Russia has been one such approach. While these approaches may be partially appropriate for countries with low domestic technological capabilities, they do not create sustainable markets and they result in underutilization of the extensive technological capabilities of Russian enterprises. Other approaches highlight market intermediation, as described in existing policy literature on energy efficiency, renewable energy, and technology transfer, although greater emphasis is needed on market intermediation in applying this literature to Russia. Agenda 21 also emphasizes the importance of market intermediation for technology transfer of environmentally sound technologies, and calls for information networks and clearinghouses, collaborative networks of technology research and demonstration, and efforts to support private direct foreign investment and joint ventures (Jackson, 1993; Kozloff and Shobowale, 1994; UN, 1993; World Bank, 1993).

International policies should be directed at providing loan capital under reasonable terms; providing education and training in economic analysis, management, and finance skills; establishing information services to make information more available and reliable; developing new market intermediation institutions and other institutional innovations that reduce transaction barriers; strengthening legal and market institutions (like enforcement mechanisms, contracting, accounting, and credit rating standards and practices); developing energy efficiency codes and standards and viable enforcement mechanisms for them; and promoting joint venture formation and sustainability for both equipment manufacturers and energy service companies. Policies that encourage and support energy service companies are especially important – training, creating favorable business conditions, providing information and market research, developing financing schemes and guarantee mechanisms, and testing institutional and contractual models.

These activities represent a type of 'capacity building', a term commonly used by the United Nations and other international agencies (UN, 1993). Some examples of capacity building seen in practice include business plan training (Evans, 1996) and training in energy management and energy service businesses (IEA, 1994). In these cases, capacity building means increasing the capabilities of Russian managers and engineers to analyze the economic and financial aspects of identified technical opportunities and to understand business management principles, including project management, marketing, presentation, finance, and entrepreneurship.

Capacity building should target regional and local government officials, activists, economists, scientists and researchers, industrial workers, engineers, managers, bankers, and lawyers. One notable need for capacity building is for regional energy commissions throughout Russia, which received independent legal status in 1995 and have increasing power to regulate energy activities, investments, and tariffs in individual regions. These regional energy commissions may play a role in establishing mechanisms and regulations for newly allowed independent power producers, and also in enforcing energy efficiency codes and standards (along with other regional and local agencies). Yet these commissions have had little staff or expertise to carry out their responsibilities, and have been dominated by officials from the energy companies that the commissions are supposed to regulate.

Policies to promote technology transfer must recognize Russia as a complex combination of conditions found in developed countries, developing countries, and historically in the Soviet Union. For example, the willingness of multinational firms to transfer technologies to other developed countries may depend upon factors such as relative production costs, potential for domestic market exposure, trade barriers, investment share and management control, and intellectual property protection. The willingness to transfer technologies to developing countries may also depend upon factors such as repatriation of profits, maturity of the market, and difficulties in securing government approvals and licenses. The motivations of Soviet managers to engage in technology transfer depended upon needs for missing or undersupplied equipment and for new innovations (Campbell, 1985; Hanson, 1985). Today, Russians often want foreign technology for its (perceived or real) superior quality. All of the above factors are relevant for Russia.

Conclusion

Technical-economic and geographical opportunities for energy efficiency and renewable energy are enormous in Russia, with many cost-effective investments possible. Market-level energy prices and privatization would suggest that these opportunities can be realized, especially given Russia's formidable scientific and technological capabilities. This paper has argued that many transaction barriers seriously limit investment in these technologies and technology transfer with other countries, and that new institutions and market-oriented skills, market intermediation, and joint ventures are especially important in overcoming these transaction barriers. International agency policies should address transaction barriers by facilitating market intermediation.

Capacities needed include skills in economic analysis, management, and finance; information services; new market intermediation institutions; stronger legal and market institutions; and implementation mechanisms supporting independent power producers. International agency policies that help to establish and support energy service companies are especially important.

Domestic policies and regulations should also develop market intermediation and create new energy-related institutions. The 1996 Russian federal law 'On Energy Efficiency' is an encouraging first step. The law broadly addresses energy policies and regulations, investment financing, metering and billing, energy audits, equipment production, independent power production, standards and certifications, building codes, education and training, and statistics. But effective national-level implementation of these provisions is problematic; domestic policies supporting energy efficiency and renewable energy will be more effective on the local and regional levels. For example, new regulations and institutions that support consumption-based metering and billing for residential heating and hot water are needed at the municipal level. And regional energy commissions need to establish regulations and institutions to govern competition and contracting for independent power producers.

Russia remains an enigma – with a complex combination of characteristics and conditions typical of developed countries, of developing countries, and also of the old Soviet Union: inefficient infrastructure and industry, almost-universal centralized heating networks, the largest land area and most varied geography of any country in the world, the second largest producer of electricity and the largest producer of natural gas of any country in the world, highly advanced technological capabilities and skills, poorly developed market and legal institutions and skills, management mentalities conditioned by decades of central economic planning, high specialization and fragmentation of industrial production, strong organized crime influences in many economic activities, evolving capital markets, low per-capita incomes, and high per-captia energy consumption. For Russia to act in accordance with the Framework Convention on Climate Change and to address grave economic and social problems, energy efficiency and renewable energy must make critical contributions. International assistance and policies can help, but only with careful and sufficient attention to Russia's unique capabilities and needs.

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