ENERGY EFFICIENCY AND RENEWABLE ENERGY IN RUSSIA: PERSPECTIVES AND PROBLEMS OF INTERNATIONAL TECHNOLOGY TRANSFER AND INVESTMENT

by

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ABSTRACT

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Case study and other research evidence, along with prior studies and literature, demonstrate that there are huge technical-economic opportunities for cost-effective energy-efficiency investments in the industrial, residential, and heating sectors in Russia, and that renewable energy sources, especially wind, solar, and biomass, can play a significant and cost-effective role in energy supply in some geographic regions. The evidence also shows that technological capabilities of Russians to exploit these technical-economic potentials are strong, but that market-related capabilities are still weak.

Market-level energy prices, privatization, and greater institutional efficiency, all traditional policy prescriptions for developing countries and countries in transition, are insufficient conditions for exploitation of these technical-economic opportunities. The evidence illustrates that many transaction barriers severely limit economic activities, including technology transfer, that would result in greater energy efficiency and renewable energy supplies. Lack of developed capital markets and long-term capital is a commonly cited problem for Russia. But even with greater capital availability, uncertainty and lack of information in different forms represent formidable transaction barriers. Other barriers relate to missing institutional mechanisms; missing or mismatched incentives; weak legal and market

institutions; cultural factors; and a lack of experience and training in economic management, finance, law, and marketing.

Existing literatures on energy efficiency, renewable energy, international technology transfer, multilateral development lending, and environment-motivated technology-transfer are analyzed for their relevance to post-Soviet Russia. In Russia, energy efficiency and renewable energy investments and technology transfers reflect a complex combination of elements from developed country, developing country, and Soviet Union perspectives within these literatures. This combination is evident in patterns of energy consumption, technology and sectoral potentials, indigenous technological capabilities, transaction barriers, institutional arrangements and constraints, propensities to transfer technology and modes selected, development policies and approaches, and capacity building.

Transaction barriers underscore the importance of market intermediation and joint ventures. Market intermediation provides the knowledge, information, skills, market services, financing, and analysis necessary to overcome transaction barriers. Joint ventures with foreign multinational corporations represent another means for overcoming transaction barriers, one that also takes advantage of Russian technological capabilities.

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CHAPTER 1

INTRODUCTION

Introduction and Questions

Global climate change has been a much-debated subject, but little question remains that the global climate is changing, with possibly grave consequences for human societies. Technologies for energy efficiency and renewable energy have become recognized as an important means for reducing carbon-dioxide (CO2) emissions and mitigating global climate change. In Russia this is equally true.

Russia is the third-largest contributor to total CO2 emissions in the world, after the United States and China (World Resources Institute 1994).[2] In December 1994, Russia signed the United Nations (UN) Framework Convention on Climate Change, thereby pledging to reduce CO2 emissions. For this reason and for other social and economic reasons, the problems of investment in and development and deployment of these technologies are recognized as high domestic priorities. Thus one of my research questions has been: What are the potentials and problems associated with these technologies in Russia?

With the rise of transnational environmental problems like global climate change, attention has been focused on international technology transfer as an instrument to mitigate these problems. Historically, Western technology-transfer and cooperation played a significant role in some key aspects of the Soviet Union's development ever since the 1920s. International technology transfer leading to energy-efficiency improvements and greater deployment of renewable energy could lead to substantial reductions in CO2 emissions in Russia. Obvious questions from a technological perspective are: Are foreign technologies needed? Will they provide technical benefits unavailable otherwise? Other questions I have asked from an economic transaction perspective: Are these technology transfers likely to happen? What forms are they likely to take? What are the barriers? Under what conditions are

[2] Data are available for the USSR; Russian share is estimated.

transactions more likely to happen? How do the characteristics of Russian enterprises, organizations, and institutions influence transactions? From a normative economic development perspective (the phrase "sustainable energy development" is relevant; see Chapter 10) I have asked: What forms should transfers take in order to contribute to economic development? And finally, from a policy perspective, I have asked: How should policy-makers, bilateral and multilateral agencies, and non-governmental organizations intervene to promote transfers?

Historically, technology transfer has been motivated primarily by the commercial activities of private companies seeking profitable business activities, and especially by multinational corporations. Technology transfer also has played a significant role in the efforts by multilateral agencies to promote economic development in developing countries. The Soviet Union relied on transfers of technology to meet deficiencies in its own technological development and innovation activities, and shortfalls of material supplies in the centrally-planned economy.

Literature on all three of these situations is potentially relevant to post-Soviet Russia. Russia continues to undergo many changes, and the context and conditions underlying my questions have been far from understood. With the breakup of the Soviet Union in 1991, the Communist Party and the centrally-planned administrative economic system vanished. No persons or mechanisms were left "in charge" of the economy. In the enormous vacuum that followed, political leaders, enterprise managers, and government officials in Russia and other former republics scrambled to create new political and economic structures and change existing ones to match new realities. Much of the economic "momentum" remained, in the sense that most enterprises and political and administrative bodies could keep doing exactly what they had been doing (or not doing) before, and the economy continued to run in much the same way that it had before the breakup.

Lifting of price controls, privatizations, economic reforms, political battles, currency reforms, and other changes since the beginning of 1992 have led to enormous economic, political, and social dislocations. Inflation soared (over 1000% in both 1992 and 1993); energy prices grew even more (gas prices increased by 40,000% from 1991 to 1993); industrial output crashed (by 50% in statistically-reported sectors from 1990 to 1993 by some estimates); poverty and subsistence living became the norm for a majority of the population (average monthly wages were $90 equivalent in mid-1994, while prices for many goods were rising towards Western levels); economic relationships between enterprises underwent huge changes; vast inter-enterprise and government debt was accumulated as production and sales of many goods continued even though customers were not paying; the old Russian parliament was disbanded with the help of the Russian army; a new constitution was adopted; all forms of crime soared; ethnic regions demanded autonomy; many skilled scientists and engineers emigrated; laws and tax regulations changed frequently and drastically; regional authorities passed laws contradicting national ones; most economic activity continued to be practically unregulated; and many enterprises were technically insolvent (80% of all enterprises in the machine-building industry by 1994 by one estimate, for example) and awaiting the axe of bankruptcy laws (for a basic source of economic and energy statistics, see for example: Center of Economic Analysis and Forecasting 1993b; Center for Energy Efficiency 1995a; Russian Ministry of Statistics 1993; and various economic newspapers given in the Sources of Evidence section).

Yet the physical infrastructure, geographical resources, "human capital," and many cultural tendencies remained largely unchanged. These characteristics include energy industries that produce the greatest output of oil and gas of any country in the world; electricity production second only to the United States; a vast centralized system, unequalled anywhere in the world, for supplying heat to buildings and industry; enormous scientific and technical capabilities; managers conditioned to think and act in accordance with the incentives and mandates of the old Soviet system; a high proportion of energy-intensive and polluting industries like steel, chemicals, and building materials; huge energy-consumption inefficiencies in industrial processes, buildings, motor vehicles, freight transport, and heat supply; and large hydroelectricity, wind, biomass, and geothermal resources. These infrastructures, resources, and people are located in 89 different administrative regions throughout the Russian

Federation, ranging in geography from arctic tundra to mountains to forest to steppe farmland to semi-desert.

Thesis Statements

My thesis consists of two linked components: (1) despite huge existing technical-economic opportunities for energy efficiency and renewable energy, and despite advanced Russian technological capabilities, many transaction barriers limit technology transfer and investment in technologies for energy efficiency and renewable energy; (2) transaction barriers and other aspects of technology transfer and investment are a complex combination of elements described from developed country, developing country, and Soviet Union perspectives in literatures on technology transfer, energy efficiency, renewable energy, and multilateral and bilateral energy-related lending.

Two corollaries to this thesis are: (1) market intermediation functions are more important for overcoming transaction barriers in Russia than existing literatures emphasize; (2) joint ventures are an important mode of technology transfer with Russia that can help overcome transaction barriers, utilize domestic technological capabilities, and provide economic development benefits.

Organization of Dissertation

Chapters 2 and 3 provide background information on relevant literatures and the macro-economic environment in Russia relevant to the research. Chapters 4-8 provide evidence and analysis in support of the thesis, and Chapter 9 argues the two corollaries. Supplementing the information in Chapters 2-9 are a series of case study descriptions and a series of annexes. The annexes provide additional literature excerpts and interpretations, and additional descriptive material about Russia and the Soviet Union. Evidence sources (interviews and documents) specific to each case study are listed at the end of each case study description. The "Sources of Evidence" section lists interviews, conferences, and Russian serials that contributed to the evidence. The "References" section contains both published literature and unpublished (or less-available) Russian documents obtained through personal contacts during field research. Case studies and annexes are referenced at appropriate places throughout the main chapters.

Chapter 2 provides an overview of literatures relevant to the thesis. This chapter then reviews and characterizes literatures on energy efficiency, renewable energy, World Bank energy-sector lending, technology transfer for sustainable development and environmental benefits, and international technology transfer. This review allows a subsequent analysis of the coincidence of different perspectives in these literatures to conditions in post-Soviet Russia.

Chapter 3 provides basic background information for understanding subsequent chapters. This background includes historical and current energy prices, energy efficiency and renewable- energy related policies, and technology markets.

Chapter 4 analyzes the technical-economic potential for energy efficiency. Patterns of energy consumption, technology and sectoral potentials, and causes of inefficiency are compared and analyzed with respect to existing literature.

Chapter 5 analyzes the economic and geographical potential for renewable energy, including factors like domestic technology development, resources, and motivations.

Chapter 6 shows that Russians have a technological capability that parallels most developed countries, but that they lack the associated managerial, financial, legal, and market-transaction skills and institutions to take full advantage of that capability.

Chapter 7 analyzes transaction barriers to investment and technology transfer. These transaction barriers also are compared with the barriers described in literatures on energy efficiency, renewable energy, and technology transfer.

Chapter 8 analyzes existing literatures related to technology transfer of energy efficiency and renewable energy for their relevance to Russia, including literatures dealing with commercial firms, multilateral and bilateral development agencies, and international organizations promoting technology transfer for environmental benefits. Matches and mismatches are identified in the following specific areas: propensity to transfer technology by commercial firms, modes of technology transfer selected by commercial firms, multilateral and bilateral agency policies and approaches, and capacity building for environmental-technology transfer.

Chapter 9 argues that transaction barriers underscore the importance of market intermediation and joint ventures for energy-efficiency and renewable-energy investments and technology transfer.

Chapter 10 summarizes the main arguments and conclusions in the dissertation, describes the contributions made to relevant literatures, and discusses two important themes relevant to Western policies for energy-efficiency and renewable-energy technology transfer with Russia.

Research Evidence

This research took place over a period of five years from 1990 to 1995. The field work took place from early 1992 to late 1994, during which time I spent a total of 18 months living and conducting research in Russia, Belarus, Ukraine, and Estonia. The research included over two hundred face-to-face interviews and discussions with researchers, managers, engineers, government officials, multilateral and bilateral agency officials, businesspeople, and consultants in Russia, Belarus, Ukraine, Estonia, Lithuania, Sweden, Denmark, Finland, and the United States. Research evidence also included personal visits to project sites, participation and presentations at numerous conferences and seminars, and written reports and journal and newspaper articles collected in the field.

Twenty-three case studies of technology transfer with Western entities and domestic investment involving both energy-efficiency and renewable-energy technologies illustrate and support the thesis with concrete examples and evidence. These case studies represent a comprehensive view (from the rather extensive network of contacts I was able to build) of the significant programs and projects undertaken by Western and domestic entities in Russia, Estonia, and Ukraine from 1992-1994, related to technology transfer of energy efficiency and renewable energy. These technologies and projects were essentially the first ones "out of the starting gate." The projects were conducted by private multinational corporations, bilateral government agencies, multilateral agencies, and non-governmental organizations. In most cases I collected case study information directly from project participants on both sides of the technology transfer transaction. Information came from interviews with project participants, personal site-visits, conference reports, published and unpublished documents provided to me by project participants, journal articles, and newspaper articles.

Verification that the case studies presented here for 1992-1994 are a fairly exhaustive list of the activities underway comes from several sources: (a) extensive field work and interviews over a long period of time with many different people and organizations involved in energy efficiency and renewable energy; (b) newspaper searches; (c) repeated follow-up of any announced program or project; and (d) an International Energy Agency seminar in Paris in 1994 (OECD case study), in which all significant OECD member-country energy-efficiency assistance programs to Russia were described (by then the research evidence was sufficient that I could describe all of these programs myself).

The Meaning of "Technology Transfer"

Conventional economic views of technology see it as essentially an information-based commodity that is costlessly reproduced and transmitted from one agent to another. Technology is often public, but sometimes proprietary. But even when proprietary, the assumption is that were certain secret documents made public, the technology would be known by all. In this view technology transfer is as simple as making a photocopy of design documents or obtaining a working artifact.

My view of technology is that it is knowledge brought about through a non-trivial learning process, and that technology transfer is thus fundamentally a process of learning. Transfer of inanimate objects -- machines and blueprints, etc. -- does not constitute technology transfer except where learning takes place among the recipients of these objects (as it inevitably must, at least in some minimal ways) during the process of selection and purchase or after the equipment has been physically transferred.

This view is widely shared among many in the field of technology transfer. For example, Kranzberg (1986) gives a similar view:

> I start with the proposition that technology is knowledge. Although technology deals with devices, products, and techniques, it takes only a moment's reflection to realize that these are products of the human mind and ingenuity--and they are concrete manifestations of knowledge. (p.30)

Rosenberg and Frischtak (1985) echo this view:

> Many chapters in this volume argue that, instead of being regarded as public information, technology might be more usefully conceptualized as a quantum of knowledge retained by individual teams of specialized personnel. This knowledge, resulting from their accumulated experience in design, production, and investment activities, is mostly tacit, that is, not made explicit in any collection of blueprints and manuals....each individual firm is a locus where the progressive accumulation of technical knowledge takes place... (p.vii)

Robinson (1991) sees technology transfer as a relationship rather than an act, and therefore calls it "technology communication." His definition of technology communication also emphasizes knowledge and skills:

> The development by people in one country of the capacity on the part of nationals of another country to use, adopt, replicate, modify, or further expand the knowledge and skills associated either with a different manner of consumption or product use, or a different method of manufacture or performance of either a product or service. (p.1)

Kranzberg (1986) sees three fundamental types of technology transfer: material transfer, design transfer, and capacity transfer. These types can be located upon a spectrum of passive-to-active transfer, in terms of the learning required by supplier and/or recipient. Material transfer, the most passive, is the transfer of machines and materials as in direct sales and trade. Design transfer occurs when the designs, blueprints, and other static representations of technology are transferred, and is less passive than material transfer. And finally, capacity transfer is the most active, and represents the transfer of knowledge, expertise, and experience from one person or group to another. Different modes of technology transfer also correspond to different placements along this passive-to-active spectrum. Direct foreign investments, such as joint ventures and wholly-owned subsidiaries, are commonly associated with more active forms of transfer, turnkey plants to a lesser extent, and direct equipment sales the most passive.

Scope and Usage of "Energy Efficiency" and "Renewable Energy"

I have focused the research on physical changes to demand-side infrastructure. Policy changes that affect economic activity and energy-consumption decisions indirectly are discussed in Chapters 2 and 3, but are not the primary focus. Rather, I focus primarily on physical improvements to the efficiency of energy utilization of secondary energy sources -- heat and electricity -- in the industrial and residential end-use sectors. While there are enormous gains in energy efficiency possible on the energy supply side, the technology transfer transactions for supply-side improvements are not as problematic.

The research has not emphasized energy-efficiency improvements in transport and agriculture. One reason is that energy-efficiency improvements in transport are directly related to the fuel efficiency of automobiles, trucks, buses, and trains. Energy-efficiency improvements in the transport stock will come from improved Russian product designs through greater enterprise competitiveness and innovation, activities that are discussed in later chapters, but will also be significantly affected by the relative shares of imported Western vehicles -- another form of technology transfer. Energy use in agriculture was not covered due to lack of available evidence, and was deemed less significant from a technology-transfer viewpoint. It appears that agriculture faces even greater transaction barriers for energy efficiency than those in buildings or industry.

The four forms of renewable energy considered in this dissertation are wind, solar, biomass, and geothermal. Other forms of renewable energy like tidal energy are not as practical. Hydroelectricity is already in widespread use throughout Russia, and most major sites have already been developed or face environmentally-related public resistance. Micro-hydropower is a form of renewable energy pursued in Russian scientific research, and resources do exist, but the applications are limited and the equipment needed is less likely to require technology transfer.

Generalization to and from Other Former Soviet Republics

The results of this research for Russia are partially generalizable to Belarus and Ukraine. Since the breakup of the Soviet Union in 1991, each former republic has tried to forge its own way into the future. Although Russia, Ukraine, and Belarus each became internationally recognized as independent states, they have maintained close economic and social ties for several reasons: the geographic distribution of economic productive capacity, which cut across republic boundaries; the fact that ethnic Russians make up large portions of the populations of Belarus and Ukraine; and the fact that Russians, Belarussians and Ukrainians share a similar Slavic history, culture, and language. Despite the fierce independence shown by Ukrainians, particularly those in the Western half of the country, they are very much economically dependent on Russia, and there may be greater degrees of explicit economic integration fashioned in the future.

Experience and case studies from Estonia and Ukraine are drawn upon here when relevant to Russia. Because Estonia and Ukraine inherited much of the same types of infrastructure and technologies that exist in Russia, saw their people trained and developed in the Soviet educational and economic planning systems, and have faced many of the same types of economic reform problems that Russia has (with very different outcomes so far), the experience from Estonia and Ukraine is partially relevant to Russia. Of course the outcomes and speed of economic reform, cultural factors, and the political situation are quite different in Estonia and Ukraine than in Russia. But much of the experience taken from Estonia and Ukraine is relevant because it relates to technical improvements to the building and district-heating infrastructure, or to technology transfer transactions with a formerly Soviet country that is income-poor, skills-rich, capital-poor, and whose managers often still think with a mentality reflective of a former planned-economy.

A Note About Statistics

All statistical data for Russia and the Soviet Union presented here should be viewed with skepticism, and for this reason statistical data are included here sparingly and as secondary rather than primary evidence. The manipulation of statistical data to suit political and management purposes in the Soviet era was well known (see Nove 1986, the Soviet Management Culture annex, and the Decline of Centralized Coordination annex). For a good description of the problems with Soviet statistical energy data, see Schipper and Cooper (1991), and Schipper and Martinot (1994b). Since 1991, economic and energy data reporting and statistics continue to suffer from similar problems, with the added problem that the "unreported" economy in Russia has grown enormously (estimates range from 20-40% of total GDP), while the formal reported economy has seriously declined. Among the reasons for this situation are tax evasion; barter exchanges; lack of transaction-reporting regulations and mechanisms; acceptance of "norms" as "actuals"; and statistical manipulation. Chapter 7 describes these phenomena in more detail.

CHAPTER 2

LITERATURE REVIEW

Technology transfer, development, sustainable development, energy efficiency, and renewable energy are such interdisciplinary and multi-faceted subjects that there is no single set of literatures that can be readily identified, but rather a vast array of potentially relevant literature which must be sifted and sorted. I began this research by examining several bodies of literature that I supposed were the most relevant. These literatures (and representative works) include the geography, technology, economics, and politics of energy in the former Soviet Union (Campbell 1980, Gustafson 1989, Lydolph 1990, Martinot 1991, Schipper and Cooper 1991); the Soviet-era economic system (Nove 1986, Gregory 1990); energy-efficiency technologies and economics (Philips 1991, Levine et al. 1991, Levine and Meyers 1992, Schipper and Meyers 1993, World Bank 1993a); renewable-energy technologies and economics (Jackson 1993, Johanson et al 1992, Rader 1989); demand-side management (DSM) and integrated resources planning (IRP) (Krause et al 1988, Gellings and Chamberlin 1988); power sector restructuring and privatization (World Bank 1993b); economic reform and restructuring in formerly planned economies (Aslund 1994, Yavlinsky and Braguinsky 1994); economic development and sustainable development (Korten and Klauss 1984, Gilpin 1987, Riddel 1987, Holmberg 1992, World Bank 1992a, Norgaard 1994); technology transfer with the Soviet Union before 1991 (Zaleski and Wienert 1980, Hanson 1985, Bornstein 1985, Stockholm Environment Institute 1991, Sherr et al. 1991); international technology transfer (Rosenberg and Frischtak 1985, McIntyre and Papp 1986, United Nations 1990b, Robinson 1988 and 1991, Reddy and Zhao 1990, Sagafi-nejad 1991); technology transfer for sustainable development or environmental benefits (MacDonald 1992, Nakicenovic and Victor 1993, Guertin et al 1993, Heaton et al 1991, Heaton et al 1994); the role of technology in economics (Rosenberg 1982); technology choice and assessment (Goulet 1977, Srinivasan 1982, Willoughby 1990); organizational and economic sociology (Scott

1992, Arrow 1974); economic regulation (Kahn 1988); and international political economy (Gilpin 1987). In addition, several methodological literatures and approaches have been employed in this investigation, and these are described in the Methodological Approaches annex.

In the course of the research it became very clear that many Russian enterprises want to produce energy-efficiency and renewable-energy technologies themselves, and want to enter into joint ventures with Western firms in order to do this. Also the potential for joint-venture energy-service companies, common in U.S. energy-efficiency strategies and practices, took on greater significance. Further, many factors revealed throughout the investigation pointed to joint ventures as important vehicles for technology transfer with Russia. Thus the literatures on international production and theories of multinational corporations (Gilpin 1987, Cantwell 1989, Pitelis and Sugden 1991, Brown et al 1993), corporate decisions to form joint ventures versus wholly-owned subsidiaries (Datta 1988, Kogut 1988, Chowdhury 1992, Shane 1993), international joint ventures (Parkhe 1993), and particularly joint ventures and business development between Russia (or the former Soviet Union) and Western countries (United Nations 1988, United Nations 1990b, Sherr et al 1991, Feller and Mikheyev 1994, Kvint 1994) took on more importance towards the end of the research. This last literature on Russia and joint ventures is different from traditional East-West technology-transfer writing because it represents a vastly different business climate, which began with Perestroika and the opening up of the Soviet Union to joint ventures in 1987. This climate continued to be transformed with the demise of the Soviet Union and the Communist Party in 1991, yet many common features of the Soviet-era and post-Soviet literatures still remain.

Towards the end of the research I realized that especially relevant literatures are also transaction cost economics (Williamson 1985, 1989, 1991) and institutional economics more generally (North 1990, Furubotn and Richter 1991, Hodgson et al 1994, Dietrich 1994), because of the enormous transaction costs present in the Russian economy indicated by the field evidence and the resemblance of some behaviors of economic actors in Russia to models of "bounded rationality" and "opportunism."

Transaction costs also appeared as significant elements in theories of international production and international joint ventures (Hennart 1991).

It was also clear through the course of the research that the World Bank, national governments, the European Union, and the United Nations were all actively involved in energy sector technology transfer with Russia through international development assistance efforts. So the following literatures took on greater importance: World Bank energy-sector lending (Philips 1991, World Bank 1981, 1992a, 1992b, 1993a, 1993b, 1993c); technology transfer for sustainable development by the United Nations and governments (United Nations 1993a, 1994a, 1994c, 1994d); and bilateral energy assistance associated with economic restructuring and development of market economies (U.S. Congress 1993, U.S. Congress 1994, United Nations 1992).

This dissertation makes a direct contribution to some of the above literatures in terms of their relevance and application to Russia. These target literatures are energy efficiency, renewable energy, World Bank energy-sector lending, technology transfer for sustainable development and environmental benefits, and international technology transfer, and are reviewed in this chapter. Other literatures with relevance to Russia and the research thesis, but to which this research makes no direct contribution, are reviewed in separate annexes and their relevance is discussed as appropriate in the body of the dissertation. These annexes are Economic Development Literature and the Transition to a Market Economy; International Technology Transfer Models and Frameworks; Multinational Corporation Literature, Joint Ventures and Foreign Investment; Technology Transfer to the Soviet Union Before 1991; Transaction Cost Economics and Institutional Economics Literature Applied to Russia, and United Nations Agenda 21.

Literature Deficiencies

Many of the conditions in post-Soviet Russia are unfamiliar to Westerners and Russians alike. Unfamiliarity leads to limited or incomplete understanding of the problem, which in turn leads to incompletely or inadequately formed policy solutions and uninformed decision-making. An existing example of this incomplete understanding comes from the early literature on macroeconomic policies for economic reform and marketization of post-Soviet economies. Many Russian economists have argued that these policies have suffered especially from an incomplete understanding of significant institutional factors present in post-Soviet Russia (see Economic Development and the Transition to a Market Economy annex).

Four problems with existing literatures that this research attempts to address are: (1) The situation in post-Soviet Russia after 1991 is so different in many respects from what it was before 1991 that the application and relevance of any existing literature to post-Soviet Russia is uncertain and needs further exploration and research. (2) Literature on technology transfers and technology development within a market-oriented perspective emphasizes free-market economic efficiency without a strong reference to or account of the institutions, culture, and politics which underlie and shape markets. (3) Policy literature on promoting technology transfer emphasizes economic and technology development as primary goals; literature on transfers specifically to promote environmental benefits is relatively new and tentative. (4) With Perestroika in the late 1980s and since the breakup of the Soviet Union in 1991, much new information has come to light on issues ranging from the geography and structure of energy consumption to energy supply and market institutions. Some of this information was previously unknown to Western researchers and has yet to be adequately incorporated into existing literature.

Energy-efficiency literature

The word "efficiency" can mean many things. From a technical-economic point of view, there exist two meanings of energy efficiency in terms of energy intensity per unit of economic activity. "Technically possible" is the level that could be achieved from a purely technical standpoint given the best available technologies. Here the analysis is primarily technological. "Economically efficient" is the level at which total lifecycle costs of a good or service are minimized, including production, utilization, and energy costs. Here, economic cost-benefit analysis is the analytic backbone; if the discounted benefits of an investment over the life of that investment are greater than its costs, the investment should be made, otherwise it should not (assuming that the discount rate reflects an equilibrium of capital markets). This also requires the neoclassical model of perfectly rational economic actors and perfect competition. These actors making these cost-benefit calculations through a perfect market mechanism will cause the energy efficiency of goods and services on the market to reach "economically optimal" levels.

From a price point of view, changes in relative prices can reduce some levels of economic activity, which will result in less energy consumption, and these changes could also be viewed as "energy efficiency." Obviously, higher (market-clearing) energy prices will result in decreased levels of energy consuming activities, depending on price elasticities.

From a social and organizational point of view, energy efficiency can also come from changes in levels of economic activity related to changes in behavior, values, preferences, and institutions. Some examples are lower thermostat settings through social pressure or norms, changes in working patterns or home location choices that lower transportation consumption, fewer passenger-miles driven due to carpooling or mass transit choices, and organizational or management changes that allow improved routing of trucking, reduction of material waste, and fundamental institutional changes that alter patterns of economic behavior.

It is common to speak of an "energy efficiency gap" (Levine et al 1994), which is the difference in energy intensities between actual in-use technologies and either the "economically efficient" or "technically possible" points. Much of the literature attempts to understand existing and best-possible energy-consuming technologies, understand social patterns of economic activity and their impacts on energy consumption, quantify energy efficiency gaps, explain the reasons why the gaps exist, and offer policy solutions for reducing market failures and thus the gaps. While some economists argue that the "energy efficiency gap" is minimal, and that it is really a product of the analysis (which may fail to include hidden costs or incorrectly specify parameters), estimates of this gap in the U.S. range from 30% to 75% for electricity (Fickett et al 1990).

Applying the theory of welfare economics to energy efficiency, the economically efficient level of energy efficiency is automatically reached in perfect markets, in which prices fully reflect true costs, complete and identical information exists among consumers and producers, perfect capital markets exist, actors are perfectly rational and utility maximizing, and transaction costs are zero. Thus follow the commonly-cited market failures associated with energy efficiency: (1) energy prices do not reflect true (long-run marginal) costs; (2) incomplete information exists among consumers and producers; (3) externalities exist; (4) consumers have short time horizons (their discount rate is much higher than the market rate); (5) consumers have limited or "bounded" rationality (March and Simon 1958) or engage in "satisficing" behavior (March and Simon 1958; Stern and Aronson 1984); (6) transaction costs exist; (7) capital markets are not perfect; (8) public goods exist; (9) costs and benefits (and thus incentives) are institutionally mismatched.

One problem with a neoclassical market-failure approach is that it tends to overlook institutional or organizational factors, which are difficult to include (Johnson and Bowie 1993). For example, common prescriptions for market failures are to internalize externalities through taxes, raise energy prices to reflect true costs, and improve capital markets, all attempts to "move" the real system towards the ideal, or optimal system. Useful in this context is a much greater emphasis on organizations and institutions and how different arrangements lead to the above-cited market failures (or rather, market barriers in an institutional context). Here the analysis of transactions and transaction cost economics can be more useful than traditional externality or even market-failure approaches. "Market failure is a more general category than externalities and it is better still to consider a broader category, that of transaction costs, which in general impede and in particular cases completely block the formation of markets" (Williamson 1989, p.11, citing Kenneth Arrow). An institutional, transaction-oriented approach focuses on what is possible, rather than what is optimal.

An example of the "barrier literature" includes Reddy (1991), which provided an interesting characterization of the barriers to energy efficiency from the perspectives of the different agents involved in energy-efficiency improvements (consumers, end-use equipment manufacturers, end-use equipment providers, energy-carrier producers and distributors, financial institutions, the government, and international and multilateral aid agencies).

Besides the market failure and barrier literatures, much of the literature on energy efficiency focuses on policy and regulatory mechanisms for achieving greater energy efficiency. One such policy solution that has received wide attention is integrated resources planning and demand-side management activities by energy supply companies, primarily electric utilities (Krause et al 1988, Gellings and Chamberlin 1988). Here the rationale is that market failures affecting investments in demand-side energy-efficiency investments can be overcome if the utility itself makes the investments. Common assumptions associated with demand-side management are that the utility has longer time horizons than consumers, faces the true marginal costs of production rather than the average costs that consumers face, has cheaper and more accessible capital, and understands the relevant technologies and economics involved. Appliance efficiency standards are another policy solution. Here the assumptions are that short time horizons and lack of information cause consumers to buy less efficient appliances than they otherwise would, even though higher efficiency appliances have lower total lifecycle costs.

Common policy prescriptions for developed countries are to provide technical and managerial training, capital, and support of institutional development. Literature characterizing the energy-efficiency problem in developing countries (Levine et al 1991, Levine et al 1992, Levine and Meyers 1992, Philips 1991, World Bank 1993a) has prescribed making energy efficiency a higher political priority, institution building, and policy reform related to energy prices and private sector roles.

Poor energy efficiency in Eastern Europe generally has been characterized as resulting primarily from the lack of market conditions and inadequate training and knowledge (USAID case study 1991 document, U.S. Congress 1993, United Nations 1992, Levine et al 1991). An analysis of this characterization is left to Chapters 5, 7, and 8.

<u>Renewable Energy Literature</u>

Much of the renewable energy literature focuses on technical and economic characterization of different renewable-energy technologies in different applications (see for example Ahmed 1994). Other literature focuses on renewable energy as part of national energy strategies, and the problems of greater adoption (see for example U.S. Department of Energy 1990). Many characterizations of the barriers to renewable energy "dissemination" are given in the literatures (see for example U.S. Congress 1994, Grubb 1993, Hurst 1990). Another major theme, especially in developing countries, is the creation of new markets for renewable energy, both on the supply and demand sides (see for example Hurst 1990; World Bank 1981). Research on stimulation of demand has focused on demonstration projects, policy recommendations, training and education, technical-economic studies of specific projects, and technology selection and adaptation. Research on stimulation of supply has focused on development of domestic research and development capabilities, developing production capabilities, links between R&D and the commercial sector, technology transfer within, between, and from industrialized countries, and local supply and distribution networks and marketing.

After the oil crisis of the 1970s, renewable-energy technologies were seen as extremely promising for developed and developing countries alike. During the 1970s and 1980s, many renewable energy projects were conducted in developing countries, many of them through multilateral and bilateral aid agencies. Reviewing and analyzing the experience from these projects was another major part of the literature in the 1980s and early 1990s (Foley 1993; Hurst 1990; Barnett 1990). Although there were some successes, many of these projects were considered dismal failures. Often they were simply technically unsound. Technologies were frequently transplanted from a developed country context to a developing country context without regard to local conditions. Maintenance was costly and when the foreign assistance experts went home, projects languished. Spare parts were in short supply and local people had no skills to maintain equipment. Equipment was expensive relative to conventional energy sources and was not replicated. "The technology pushed in developing countries was often inadequate or inappropriate to the local conditions, or both" (Grubb 1993, p.240). Although as Barnett cautions,

> In many cases, the investment in energy technologies in the rural Third World has been so modest and so recent that questions of success are premature. In others, the programs were designed to be experimental and set out with the main objective of increasing understanding of the issues. Such understanding has often been successfully achieved despite poor performance of the technologies and their associated infrastructure. (p.542)

Yet as Foley (1993) says, "many projects were, in fact, little more than technical research exercises masquerading as energy assistance" (p.198).

The theoretical perspectives used to understand diffusion of renewable-energy technologies in developing countries have been extremely varied and diverse, and no one perspective has emerged to cover all of the cases, technologies, or policy questions. Perspectives have varied from views of the process as "communication systems" among networks of groups, as technological characteristics fitting specific needs of users, as technology adaptation, as a phenomenon of incremental technical change, and as evolution with complexity and feedback. Barnett identifies nine key issues present throughout this literature: the role of market and state, diffusion strategies and the role of participation, the performance of the technology, understanding user needs, the political economy of involved agents, financial returns to the user, the macro policy environment, and overhead and training requirements and costs.

In developed countries, more recently, as some renewable-energy technologies have become competitive with conventional energy and serious commercialization has begun, an emerging research question has been simply: Why isn't renewable energy doing as well as the opportunities and economics suggest? (Jackson 1993) This question brings up a set of market obstacles, similar to those present for the "energy efficiency gap" (Grubb 1993; see Chapter 7).

Renewable development is also linked to national industrial policy. In the 1980s Denmark made a conscious decision to support a wind-power industry with subsidies and targets, and "Denmark is now established as the world's leading manufacturer of wind turbines, and domestic subsidies have been withdrawn on the grounds that it can now compete unaided" (Grubb 1993, p.250).

Government polices to support commercialization of renewable energy were enacted in the 1970s and early 1980s in the United States and several European countries. These policies recognized that a fledgling industry that had to compete in established markets with established industries would need special support. In addition to increased funding for R&D, the U.S. approach was to provide tax credits and deductions for equipment, regardless of its performance. In Denmark, capital grants of up to 40% were given to wind developments, but contingent on performance and environmental criteria (Elliot 1993). Both approaches helped to create stronger, commercial industries in wind turbines. In the United States, renewable energy also got a boost through the Public Utilities Regulatory Act (PURPA) of 1978, which created competitive bidding by independent power producers for utility contracts for new generation capacity. More recently in the United Kingdom, after electric-power-system privatization in 1988, private regional electric utilities were required to bid and purchase set amounts of renewable power sources each year, with the higher costs of these sources being subsidized by levies on fossil fuel consumption. But the track record of this program was questionable (Elliot 1993).

In the early 1990s, an important question was still the comparison of the costs of renewable energy relative to conventional forms of electric power and heat generation, especially since oil prices were lower in real terms than before the oil crisis of the early 1970s (Barnett 1990). Many authors have lamented that low fossil fuel prices, the "baseline" against which renewable energy has to complete, have meant that many renewable-energy technologies are still not competitive and have not fulfilled the promise that many saw in the 1970s and early 1980s. Thus the literature has turned to identifying those technologies and applications that are closest to commercialization by virtue of their economic competitiveness, and to the problems of developing markets for these technologies. In addition, economic and policy literature has analyzed the addition of environmental, political, and social externality premiums to conventional forms of energy as a way to make renewable energy more competitive in economic evaluations (Hohmeyer 1993).

A key dimension of renewable-energy technologies reflected in the literature is the degree of market maturity. Maturity is also a reflection of their economic competitiveness with conventional forms of energy. Technologies with established commercial markets in developed countries include grid-connected wind turbines, passive solar building technologies, solar hot-water and space heating, off-grid photovoltaic systems, and geothermal steam-generated electricity. Technologies still in a research, development, or pre-market phase include grid-connected photovoltaic plants, solar-thermal electricity generation, tidal wave power, ethanol production from biomass, and electricity from biomass (gasification and combined cycle).

There have already been many successful cases of mature renewable-energy technologies that have established markets in developed countries being diffused in developing countries. Hurst (1990) gives an example of Argentina in 1960s and water-pumping windmill technology. A U.S. manufacturer of windmills licensed its technology to an Argentine manufacturer (of farm implements), and this manufacturer was able to successfully develop production of these windmills at a cost only half that of production in the United States, and marketed them domestically to become the largest producer in the country. Although a market for the windmills already partially existed in Argentina, initial production was for export back to the United States.

Another example given by Hurst (1990) is solar hot-water heaters, which have mature markets in many developed countries, like Japan (2 million systems installed), Israel (600,000 systems installed), the United States, and Australia. Solar hot-water heaters have made inroads in developing countries such as China (150,000 square meters installed), Turkey (with 50 domestic manufacturing firms established), Kenya, and New Guinea.

World Bank Energy-Sector-Lending Literature

The World Bank's energy-sector policy in Central and Eastern Europe was elaborated in 1992 (World Bank 1992). The World Bank recognized the problems of institutional rigidity (lack of policy experience at the government level and lack of managerial and financial autonomy and accountability at the enterprise level), inadequate energy demand management, high energy intensities, dependence on single-source energy imports, and poor enterprise performance in terms of economic efficiency. The primary policy requirements that the World Bank prescribed were government intervention and regulation based upon specific strategies, privatization and restructuring of enterprises to provide cost-minimizing incentive structures, energy prices that reflect true economic costs (long run marginal costs for domestic sources or border prices for imports), sustainable environmental management entailing modernized legal/institutional/regulatory frameworks and enforcement mechanisms, technological modernization and retrofittings, and diversification of energy imports. While recognizing that "economic pricing and enterprise reform are essential for more efficient energy use," also mentioned were "non-price measures to improve energy efficiency" such as delineating institutional responsibilities, developing a strategy combining market-forces, regulation, and government support, and providing technical assistance because "most energy users are unfamiliar with efficient technologies."

A major World Bank policy paper (1993a), "Energy Efficiency and Conservation in the Developing World," spelled out the World Bank's new energy efficiency policies. Existing policy elements prior to this paper reflected the structuralist, neoclassical view of development: make markets competitive, remove energy price subsidies and let energy prices reflect economic costs (long run marginal), and promote energy supply-side institutional reform to make supply-side enterprises more efficient. The main criterion for energy efficiency lending in a development context, according to the bank, is the economic rate of return: "Increased energy efficiency....is only worth pursuing up to the point where...the economic rate of return is greater than or equal to the cost of capital" (p.15). The new policy gives greater attention to two aspects of the existing policy: greater attention to energy pricing and institutional and structural factors, and lending only to energy supply enterprises willing to undertake structural reform. It also adds two new elements to the existing policies: market intermediation and technology transfer.

Market intermediation is needed to reduce the "relatively high" (p.72) transaction costs associated with information, management, technology, and financing. The bank will support intermediation by "identifying, supporting, and financing both public- and private-sector initiatives that can serve the intermediation function and pursue DSM objectives." In some countries this might mean a utility-based Integrated Resource Planning approach that includes demand-side management, while in others it might mean separate, dedicated energy efficiency institutions that can provide these services. Services cover technologies, financing, and practical experience, and include information dissemination, referrals, training and consulting, establishment of energy-service companies, energy audits, drafting of codes and standards, identification of macroeconomic and sectoral barriers and policies for their reduction, technology intermediation between potential supplier and recipient firms (including energy-service companies), and feasibility, evaluation, and packaging of potential projects for World Bank, commercial and other donor funding.

Technology transfer is discussed only briefly in this paper. In particular, there is no discussion of how the Bank's bidding requirements and procedures affect technology transfer and capability-building within a recipient country. And

> There is the need to put in place policies, legislation, mechanisms, systems, institutions, and incentives that facilitate technology transfer and encourage the use of the most efficient competitive technologies.....Long term potential for major improvements in the conversion of energy into environmentally-benign economic output lies in incentive structures or processes that channel new investment into the most up-to-date and efficient competitive technologies.....[In addition to actions discussed previously,] initiatives such as joint ventures, increased private sector participation, additional information dissemination, and putting in place energy-efficiency building codes, appliance manufacturing standards, and enforcement mechanisms, can be encouraged. (p.76-77)

In terms of relevance to energy-efficiency investments, the Bank characterizes developed versus developing countries as shown in Table 1. I have added a characterization of Russia to this table to highlight differences and similarities.

Technology Transfer for Sustainable Development and Environmental Benefits Literature

Much of the literature on technology transfer for sustainable development and environmental benefits has come from the United Nations. Prominent among this literature is Agenda 21, the "blueprint for sustainable development" agreed upon by 178 countries at the United Nations Conference on Environment and Development (UNCED) in June 1992 (see United Nations Agenda 21 annex). In Agenda 21, technology transfer is seen as a significant potential instrument of sustainable development. Technology transfer is included under the section on means of implementation, as Chapter 34 titled "Transfer of environmentally sound technology, cooperation and capacity-building."

TABLE 1: WORLD BANK CHARACTERIZATION OF ENERGY EFFICIENCY

	Energy consumption	Energy prices	Market structure for energy use	Energy supply-side institutions	Information barriers
Developing countries (World Bank)	low per-capita high growth rates	Low	protected industries public monopolies bias against efficiency in finance	public monopolies command and control regulation opaque accountability	relative lack of intermediation of information, technology, and finances
OECD countries (World Bank)	high per-capita low growth rates	market based	competitive markets easy entry and exit	public and private enterprise transparent regulation checks and balances	market-based information, technology, and financial intermediation
Russia (based on research)	high per-capita low growth rates	cost based	public monopolies private, non-market enterprises buildings with no owners	public monopolies private unregulated monopolies self-accountability and quota allocation	lack of intermediation, technology information, supplier and recipient information

Five main objectives are given in Chapter 34. The document calls for promoting, facilitating, financing, and supporting: (1) access to scientific and technical information; (2) conduct of actual transfer projects; (3) maintenance and promotion of indigenous technologies, (4) capacity-building for human resource development, institutional capacities for R&D and implementation, and integrated sector assessments of technology needs; and (5) long-term technological partnerships between potential suppliers and recipients of technology.

The literature on technology transfer to developing countries for sustainable development and energy efficiency generally goes no further than to call for greater "access" to technologies by developing countries than free markets and multinational corporations would normally provide, and to provide greater international training, assistance and capital (United Nations 1993a, Levine et al 1991, McDonald 1992, Nakicenovic and Victor 1993). Some of the focus is on technology selection and adaptation, and the institutional capacities to achieve successful and appropriate selection and adaptation (Nakicenovic and Victor 1993). Other elements are new institutions for technology transfer, indigenous technological capacity building, and national policies for taxes, tariffs, foreign exchange, and property rights.

The literature on technology transfer for environmental benefits has emerged only since the mid 1980s. Prior to this emergence was of course decades of work on the role of technology transfer in economic development. But environmental factors or motivations were usually never more than secondary for such transfers, and environmental technology was treated simply on its economic merits without consideration of the environmental benefits. The difference more recently is that environmental sustainability has become primary in discussions of technology transfer, and technology transfer as an explicit instrument for environmental goals is now discussed. The United Nations, particularly in connection with the Conference on Trade and Development (UNCTAD) and the Commission for Sustainable Development, which was established in the wake of UNCED in June 1992, has produced the bulk of this literature. The World Bank created an environmental policy department and an environmental unit in each of its four area divisions in 1987, and began to include the environment more explicitly. Other work on technology transfer for sustainable development is sparse and could not be considered to be a unified body of literature at this time (see for example McDonald 1992; Guertin et al 1993; Baram 1994).

The subject of "joint implementation" has also become a prominent subject in literature about environmentally-sound technology transfer, investments, and international projects to mitigate climate change. Joint implementation was defined very broadly in the Framework Convention on Climate Change, which was opened for signature at the United Nations Conference for Environment and Development in June 1992 and entered into force in March 1994, as "efforts to address climate change...carried out cooperatively by interested Parties" (Wexler et al 1994). The working or operational definitions given to joint implementation since then by governments and private agents have varied greatly, and no consensus has emerged as to what joint implementation really means. Technology transfer of energy efficiency and renewable energy under some type of international joint-implementation regime with Russia is possible in the future under this Framework Convention. Further, any of the intermediaries being proposed in the context of joint implementation could provide important intermediation functions lacking in Russia.

International Technology Transfer Literature

International technology transfer is certainly an interdisciplinary subject, and as such has been written about by scholars and practitioners of economics, political science, history, management, industrial relations, international business and finance, marketing, law, sociology and anthropology. Not surprisingly, while technology transfer frameworks and models are numerous in the literature, there are no coherent, overarching theories of technology transfer, but rather a patchwork of research focusing on different facets of the subject. Reddy and Zhao (1990) agree that "given the inherent complexity of the subject, findings, conclusions, and contentions of what we know about international technology transfer are fragmented along various specialties" (p.1).

Some of the major themes and research topics present in the literature (Robinson 1991, Sagafi-nejad 1991, Rosenberg and Frischtak 1985, Reddy and Zhao 1990, McIntyre and Papp 1986) are: the propensities to transfer or seek transfer among supplier and recipient firms; costs and benefits of transfer; technology choice and price; corporate management and choices of the mechanisms and modes of transfer; effectiveness of transfer in meeting specified goals; diffusion of technologies as a result of transfer; impacts on home and host countries; the role of technology transfer in strategies of multinational corporations; the role of technology transfer in development and the developmental impact of private transfers; modernization and innovation strategies of recipient country governments or firms; the changing technological balance of power between countries; home and host governments as facilitators or gatekeepers; national dependencies on technology imports; the implications of free trade versus protectionism for international technology transfer patterns; intellectual property protection; the role of science and technology in development; sectoral-specific and country-specific analysis (case studies); and regulatory regimes and mechanisms for controlling transfer, including international codes of conduct.

The literature could be distinguished by the perspectives of supplier and recipient sides. On the supplier side, the literature tends to be focused more on corporate policy than on public policy, and tends to come from theories of the firm and the fields of corporate policy, organizational behavior, and strategic management. This literature is rooted in liberal, neoclassical economic thinking. On the recipient side, the literature tends to focus on host governments and national economies, on market imperfections, and on policies of government intervention and control.

From a political-economy perspective, technology transfer literature could be divided into three different categories each with a different focus or concern. There are commercial transfers between developed countries (West-West) emphasizing competitiveness, multinational corporations, business and management strategies, and issues of technological "balance of power." There are transfers between developed and developing countries (North-South) emphasizing strategies for economic growth and development and how best to use government aid. There are transfers and cooperation with the former Eastern-bloc (East-West) emphasizing strategic and security issues like the impact of imported technology on military strength, and how unique features of the centrally-planned economies lead to a need for imported technology.

Many country analyses have been conducted in the literature, looking at the characteristics of technology transfer to a specific recipient country or from a specific supplier country over some fixed time period. These studies are usually empirical, looking at economic statistics and perhaps utilizing surveys and interviews to understand the patterns of transfer, the predominant modes and mechanisms of transfer, motivating factors (propensity to transfer), and the country-specific barriers and facilitating factors (see for example Smith 1981). As one specific example, Behrman, Behrman et al (1991) looked at technology transfer to China. The important factors affecting technology transfer decisions that they found are analyzed in Chapter 8. India is another interesting case relative to Russia. India has pursued policies of low reliance of imports of technology and consequently has developed strong technological capabilities and self-reliance in many areas (Lall 1985). While these policies have slowed economic growth and development, they have generally been considered successful (Ahmad and Wilke 1986). The literature on technology transfers to the Soviet Union and Russia includes both country-level and sectoral-level research, and is reviewed later in the Technology Transfer to the Soviet Union annex.

Another closely connected body of research deals with sectoral studies, usually also from or to one specific country, but on an industry or sectoral level (see for example Safarian and Bertin 1987). While renewable energy and some energy-efficiency technologies could be considered specific "sectors," the wide application of energy-efficiency technologies in all areas of the economy makes specific sectoral analysis too limiting. Specific studies of energy-efficiency technology transfer have been given in the review of the energy efficiency and renewable energy literatures elsewhere in this chapter.

Other literature looks specifically at the human and cultural elements in technology transfer, either from a managerial perspective of how to make the process smoother and more effective (especially for "soft" technology; Morgan 1991), or from the perspective of systematic human resources development as an important vehicle for transfer (Stewart and Nihei 1987). Both perspectives share the common element of technology transfer as a learning and inter-personal information exchange and communication process, and thus as very dependent on cultural, social, and managerial factors.

Finally, the role of multinational corporations in the technology transfer process is primary. "There is little debate in the literature that the primary "agent" of technology transfer from the home country is the multinational corporation" (Reddy and Zhao 1990, p.286). McIntyre and Papp (1986) agree:

> To a large extent, the technology transfer phenomenon is best understood from the perspective of interdependence. This is because the preponderance of international technology flows tends to be commercially motivated, with the multinational corporation occupying the commanding heights. The multinational, usually a private sector entity freed from many national constraints, is often the critical transmission belt of capital, ideas, and technology across national boundaries, according to the transnationalist perspective. (p.5)

In exploring the complex and extensive literature on international technology transfer, I have let six authors be my primary guides. Three of these authors are noted for their work in reviewing this literature and synthesizing from it (Reddy and Zhao 1990, Sagafi-Nejad 1991, Robinson 1991 and 1988). The collection by McIntyre and Papp (1986) provides a comprehensive view of the subject from a political-economy perspective. Contractor (1991) is well-known for his work on technology transfer by multinational corporations and theories of the firm. And finally, the collection by Rosenberg and Frischtak (1985) provides a basic conceptual orientation and several specific country cases. Within these sources and from others emerge several different models and frameworks for conceptualizing and analyzing technology transfer (see the International Technology Transfer Models and Frameworks annex).

Some commonly cited shortcomings or characteristics of the international technology transfer literature are (McIntyre and Papp, Robinson): (1) it lacks an overall integrating theoretical framework; (2) much of the research tends to be case-study oriented for specific sectors, countries, or firms; (3) it overemphasizes North-South transfers at the expense of West-West (which have become dominant), South-North, and former East-South transfers; (4) the literature is divided into West-West, North-South, and East-West categories, with little overlap or unification of these different categories; (5) much of the analysis is based upon economic logic and reasoning, and excludes important non-economic factors that inhibit or accelerate technology transfers and flows; (6) technology transfer literature has also focused almost exclusively on commercial transfers, and thus one significant neglected aspect of this literature is bilateral and multilateral scientific, educational, and training exchange programs (Sagafi-nejad 1991).

CHAPTER 3

BACKGROUND: ENERGY PRICES, POLICIES AND TECHNOLOGY MARKETS

This chapter provides basic background information on historical and current energy prices, energy-efficiency and renewable-energy-related policies, and technology markets. The treatment in this chapter is very basic: for more details see the following annexes: Commercial Business Environment and Joint Ventures Since Perestroika; Decline of Centralized Coordination and Ministries: Enterprises on Their Own; Energy Development Policies in the Soviet Period; Energy Supply and Regulation Organizations in Russia; Energy Consumption Quotas; and Regional Variation of Electricity and Heat Prices.

This chapter shows that energy prices have rapidly been approaching levels found in many developed countries, yet will probably remain below these levels because of low energy production costs in Russia, cost-based pricing, the "non-payment crisis" of enterprise and consumer indebtedness, and social and moral issues. Unlike energy prices in many developing countries, energy prices in Russia are no longer directly subsidized except for residential heat and hot water. Federal-level government policies for energy efficiency have not made any real difference, and policies at the local and regional levels are much more likely in the future to have an impact on energy-efficiency and renewable-energy investments.

Energy Prices

Energy prices underlie economic comparisons of energy efficiency and renewable energy with conventional forms of energy, and are therefore the starting point of this dissertation. In the Soviet period, energy prices were fixed and regulated by the state at arbitrarily low values. For example, the industrial electricity price in December 1991 before price liberalization started in 1992 was 3 kopeks/kWh, which was about 0.5 cents/kWh equivalent, about ten to twenty times lower than typical electricity prices in the United States (the differential would be less based upon purchasing-power parity or measures of relative income).

In 1992, the prices of many goods were freed from state control, and many prices soared. Energy prices were still regulated by the state, but nevertheless increased in 1992 more than most other goods. Figure 1 shows energy prices for natural gas, mazut (heavy fuel oil), electricity, and heat for the period 1991-1995, expressed as dollars according to the ruble-dollar exchange rate.

By 1994, the oil, gas, electricity, and heat supply industries were self-supporting from their revenues and required no government subsidies. Being natural monopolies (except oil), their prices were regulated by the government, primarily based upon production costs and specified profit margins. As of early 1994, energy prices were still significantly below levels common in Western countries. Oil prices were about 50% of world levels, retail natural gas prices in the central regions of European Russia were about 20% of Western European levels, and electricity prices were anywhere from 10-50% of typical electricity prices found in the United States, depending on the customer category and region of Russia (see Regional Variation of Energy Prices annex). Low primary fuel costs (in turn because of low domestic production costs for these fuels) meant that energy prices remained lower than those typically found in either developed or developing countries. Further, the true costs of maintenance, capital improvement and depreciation were not being included in heat or electricity costs.

By mid-1995, some energy prices had risen to levels comparable with those in other developed countries based upon exchange-rate conversion, while other prices were still lower. Gas prices in the center of European Russia had reached almost $50 per thousand cubic meters (tcm), which was close to the netback price given transportation costs to Europe and a gas price in Europe of about $80/tcm. Mazut prices had reached border prices of $90/ton and some Russian mazut consumers were preparing to purchase mazut from foreign rather than from domestic sources. Electricity prices in the center of European Russia in April 1995 were typically about 2 cents/kWh to industrial customers and 1 cent/kWh to residential customers (based upon exchange rates). And heat prices to industrial customers in July 1995 were about $14-18/Gcal, about one-third of typical prices in Western Europe.

In 1994, the World Bank estimated that long-run marginal-costs of natural gas in the center of European Russia would rise to $40/tcm, which the World Bank considered the "economic value" of gas based upon real production and transportation costs including capital depreciation and profit mark-up (interview with the World Bank task manager of a gas distribution loan to Russia under preparation, 9/22/94). If the World Bank's analysis is correct, gas prices may not rise any higher. Since most of Russia's electricity and heat production in the center is based upon gas (see Structure of Energy Supply and Demand annex), electricity and heat prices may not rise much more either, although they may begin to include a larger component for maintenance, capital depreciation, and replacement.

Thus a key difference between low energy prices found in Russia (relative to prices in the United States and Western Europe) and low energy prices often found in developing countries is that Russian energy prices are not directly subsidized from state budgets, with the exception of residential space heating and hot water (which is subsidized from municipal budgets; see below). Rather, subsidies in Russia take two forms: (1) cross-subsidies from industrial to residential consumers; (2) subsidies from future generations of energy consumers because current energy prices only cover operating and some maintenance costs, and do not include deferred maintenance, capital depreciation and the costs of infrastructure replacement. Besides these subsidies, the reason energy prices remain lower than in other countries is that the costs of energy production in Russia are low and energy is priced on a cost-plus-profit basis.

While Russian electricity prices are more reflective of electricity prices found in developing countries, the situation in Russia also contrasts with that in many developing countries. In developing countries, energy may be priced at close to short-run marginal costs, but these costs are much higher than in Russia because they often reflect high import prices for fuel. For example, in 1990 the World Bank surveyed electricity tariffs in the 1980s to determine whether tariffs in developing countries were based on long-run marginal costs as advocated by World Bank policy (Levine et al 1992, p.55). The survey of electricity prices of over 60 developing countries found that subsidies grew during the 1980s. Average tariffs in 1983 in developing countries were only 55% of the average prices in OECD countries.

Heat prices in Russia to residential consumers have been much lower than to industrial consumers because of direct subsidies from municipal governments (in the case of municipal-owned housing) or from enterprises (in the case of enterprise-owned housing). These subsidies for heat consumption in the residential sector have not depended on whether apartments are privatized or not. In 1993 in Moscow the city government paid for 95-97% of the cost of heat supply for city residents, according to the head of the Moscow Government Department of Energy Efficiency, and based upon figures supplied by the head of the city finance department and by the city statistical office (interviews 2/9/94, 2/16/94, 2/14/94). In other words, the city paid heat-supply companies their full tariffs for heat supplied to residential buildings, and then charged consumers only 3-5% of these amounts in the form of monthly heating bills. The head of the Moscow Government Finance Department estimated that these subsidies represented 5-10% of the total city budget (interview 2/16/94).

While subsidies like these were scheduled to decrease over the period 1994-1998 until municipalities were recovering the full cost of heating from residential consumers, the speed and magnitude of these subsidy decreases will depend on average wages and the ability of consumers to pay increasing shares of their income for heat. By mid-1995 this cost-recovery was approaching 10-20% and even 30% in some cities in Russia (from evidence in the World Bank Enterprise-Housing Divestiture case study). Until such time as cost-recovery becomes substantial, city governments rather than residential consumers face the greatest incentives to reduce residential heat consumption, since they are paying the bills. City government not only is motivated to reduce heat losses in the buildings themselves, but also in the heat distribution-system since heat is paid for as it leaves the heat plant, not as it enters residential buildings.

Energy Prices as a Moral and Social Issue

During the period 1992-1995, the subject of energy prices sparked much heated argument and interest in Russia. While higher energy prices reduce demand and encourage energy efficiency and alternatives in the longer term, the shorter-term economic and social impacts of higher energy prices were deemed serious, and energy prices were treated as not only an economic question but a moral and social one. In fact, the question of energy prices has had much more to do with unpaid debts, politics, organizations, social stability, and unemployment, than with the idealized workings of a market economy.

The standard economic argument is that internal energy prices should reflect their true value on the world market, which is the opportunity cost of using the energy domestically. This argument neglects the extremely long time periods and capital necessary for industry and other users to become more efficient in response to higher prices. It also ignores the relative poverty of consumers and enterprises and the lack of payment enforcement mechanisms: if prices rise too much, consumers and enterprises will simply stop paying their energy bills (this has already happened on a large scale; see the section on the non-payment crisis below). Any argument for government redistribution of "windfall profits" from higher prices by the energy industries to those hardest hit by higher prices also fails to consider the political inability to accomplish such redistribution effectively; few trust the government to spend its revenues wisely or effectively because of politics and corruption.

One common Russian viewpoint is that since Russian industry is less efficient than Western industries, energy prices must remain lower to compensate and keep Russian industries competitive both abroad and domestically. Another viewpoint questions why a resource-rich state like Russia should "charge itself" world prices for its own resources when such prices will hurt domestic consumers and producers in the short run. Another viewpoint is opposed to creating a need for more government social subsidies (to enable the poorest segments of the population to pay higher energy prices) at a time when efforts are being made to lower subsidies. With an average monthly wage of $80-100 equivalent, the average residential consumer cannot afford to pay Western-level prices for electricity, gas, and heat, especially when residential district-heat delivery systems are so inefficient (see District-Heating Systems annex and Chapter 4).

Energy Prices and the Non-Payment Crisis

One objection to higher energy prices was coming from the energy supply utilities themselves. Understanding this point requires some further discussion. The main idea is that energy suppliers have traditionally focused on meeting output targets, and their main concern and interest is still in increasing output (as evidenced by several sources and interviews, for example U.S. Congress 1994, and Moscow City Council seminar on DSM and energy efficiency, 7/23/92). Increased output means more jobs for utility workers, more political influence, and larger organizations. Energy suppliers are concerned that if prices rise, demand will fall and their expansion plans will be jeopardized. They are also concerned that higher prices will just make debt and non-payment problems worse.

Energy prices are interconnected with the severe "non-payment" crisis as it was called in 1993 and 1994. Debts between enterprises, the government, workers, consumers and the energy industries mounted in 1993 and 1994, threatening the stability of the economic system and the ability of many enterprises to keep working. Many enterprises continued to purchase or receive goods and energy supplies without paying for them. Some observers felt that the non-payment crisis was not caused directly by economic reform, but indirectly as enterprises consciously withheld payments they could otherwise make because there were insufficient penalties and regulations to cause them to make on-time payments (interview with an investment broker, 9/22/94; Moscow News, 8/19/94, "How to Solve the Problem of Non-Payments"). Rather, payments that were delayed two months would be worth much less because of inflation then at the time they were due.

The non-payments crisis hit the energy sector the hardest, as many enterprises (especially privatized ones) considered energy bills as the lower priority among many obligations (interview with an investment broker, 9/22/94). Other enterprises felt that the government would eventually have to step in and subsidize the energy arrears. By January 1994 energy consumers owed 9 trillion rubles ($7 billion) to the fuel and energy industry and inter-enterprise debt was an equivalent amount (Business World Weekly, #8/101, "Russian Fuel and Energy Sector in Dire Straits"). This crisis threatened the ability of energy suppliers to meet even their operating costs. In 1993 and 1994 Gazprom had trouble meeting its operating costs due to this non-payment crisis. By 1994 it was owed billions of dollars equivalent by its customers, much of that from Ukraine. While Gazprom may finance much of its capital expansion and development programs in the future with Western credits backed by future gas exports (it was given the right to do this in 1992), it may have to raise domestic gas prices in response to the non-payment crisis and/or to continue to cover its operating costs. At the same time, some Western analysts familiar with Gazprom (Gustafson et al 1993) were suggesting that Gazprom was opposed to raising gas prices because it did not want to reduce domestic demand and thus jeopardize a series of ambitious gas-production expansion programs.

One example of the seriousness of the non-payments problem and its relation to energy supply occurred in 1995:

> ST. PETERSBURG GAS SUPPLY CUT DUE TO NONPAYMENT. The Lentransgaz Company, a major natural gas supplier in northWestern Russia, cut back St. Petersburg's gas supply to 13.5 million cubic meters a day, Interfax reported on 21 August. Until recently, the city had consumed as much as 15 million cubic meters of gas a day. Lentransgaz acting director Yurii Streltsov told the news agency that the leadership of Gazprom's northWestern affiliate was forced to implement the tough measures to encourage debt payments from St. Petersburg's major consumers. Lentransgaz is demanding 400 billion rubles ($91 million) of the total 1 trillion rubles ($227 million) owed by St. Petersburg. (Report by Thomas Sigel, OMRI, Inc., 1995)

The electric power sector faced similar problems from the non-payment crisis and had trouble meeting its operating costs from revenues. The following anecdote illustrates this point dramatically (Moscow Times, 7/30/94, "Nuclear Workers Stage Sit-In Over Pay"). Nuclear power plant workers in

Smolensk staged a protest in mid 1994 over non-payment of their wages for the past four months. The Russian national electric utility (RAO "EES Rossii") owed the nuclear plant $70 million equivalent for electricity purchases and over $3 million equivalent for back wages. RAO "EES Rossii" said it could not pay $1.5 billion equivalent it owed to all its suppliers, including $400 million it owed to nuclear power plants, because it was itself owed $5 billion equivalent by its customers. A plant worker said the nuclear plant was operating at 20% of its full capacity because it did not have any money to purchase necessary nuclear fuel and parts.

Payment problems will in general keep energy prices lower, as higher prices will simply increase delinquencies. The president of the national electric utility (RAO "EES Rossii") in early 1994 came out against both economic penalties for delinquencies and sanctions in the form of supply interruptions (Business World Weekly, #8/101, "Russian Fuel and Energy Sector in Dire Straits"). Economic penalties would simply go unpaid as well, he said, and would just increase the insolvency of consumers. Supply interruptions were politically unacceptable and would just increase already-grave social problems. He even felt that lower energy prices in the short-term might be desirable.

Thus because of the non-payments crisis and energy supply companies that are struggling just to pay salaries and fuel costs, energy prices are likely to continue to reflect only short-run marginal costs in the near future, with perhaps some allowance for capital improvement, replacement, and depreciation beginning in the medium and longer-term. Energy supply companies are likely to increase prices just enough to cover their costs and expansion needs.

Policy Attempts to Improve Energy Efficiency Since 1991

The Energy Development Policies in the Soviet Period annex describes how energy efficiency was the subject of much rhetoric and the goal of attempted reforms during the Soviet Period, especially during Glasnost under Gorbachev. But little changed in reality. The same could be said of federal-level policies for energy efficiency since 1991. At the regional and city levels, more policies were taking hold and achieving real change. Historically, an energy inspectorate called "Energonadzor" under the Ministry of Energy and Power (now under the Ministry of Fuel and Energy and comprising 4000 people) was responsible for ensuring that enterprises' energy consumption met established "norms." But as the head of the energy efficiency department of the Ministry of Fuel and Energy put it (interview 2/9/93):

> Our Energonadzor auditors can go to a plant and give "good advice," but the plant is not obligated to listen. If fines are levied for not following the advice, the plants just won't pay the fine, as they aren't even paying for the energy. Also, there is a problem that too much power in one person (the Energonadzor auditor) leads to corruption and bribery, not energy efficiency. So the actual influence of our ministry is rather limited in energy efficiency, unless it is willing to finance projects. And we have very little money for projects.

Authorities in Russia commonly see the energy-efficiency problem as one of capital acquisition and then central-administrative investment in energy efficiency. Given the historical Soviet background, this is hardly surprising. But there are many problems with a central-administrative approach (see Stern and Aronson 1984), for example that it ignores other competing uses for the investment funds, is open to corruption, and limits many forms of public participation in decision-making. One only needs to look to various energy efficiency programs, either drafted or operational, to see this approach:

(1) In 1992 a government decree established the Russian Energy Saving Fund (RESF) administered by the Ministry of Fuel and Energy (World Bank Energy Sector case study, United Nations ECE Energy Efficiency 2000 conference, Moscow, 9/93). The fund was to collect capital and then allocate it to various energy-efficiency investments in different branches of the economy. The fund was to include both federal and regional levels of administration. The RESF was charged with financing scientific studies, drafting norms and standards, providing equity financing for energy efficiency projects, supporting the development of manufacturing capabilities for energy-efficiency equipment and materials, and providing preferred credits for small energy efficiency projects. Various proposed mechanisms for acquiring capital for the fund since that time have been proposed, but none has been implemented and the fund remained empty at the end of 1994. One funding proposal was for

a 0.5% surcharge on energy sales in the general economy (a huge amount of money), another was for penalties on "inefficient" energy users. Of course one big problem with such a fund handling massive amounts of capital is the likelihood of corruption or investment decisions based on politics. An executive board and supervisory council were established to guide the fund, but the independence, real influence, and knowledge of efficient investment decision-making of these bodies is critical. Some Russian government officials and businessmen doubt that this fund will ever be capitalized (interview with regional representative of IVO International, Moscow, 1/11/94).

(2) This type of mechanism was established in Moscow and the Chelyabinsk region as well. By early 1994, an energy-efficiency fund in Chelyabinsk was actually operating, had collected 500 million rubles ($350,000 equivalent) through a 1% tax on energy tariffs, and was allocating capital to energy efficiency projects, primarily production and installation of meters and controls (Moscow International Energy Club meeting, 2/26/94). The Moscow government in late 1992 approved a three-year program for energy savings in Moscow with an initial annual budget of 275 million rubles to finance research, standards, production facilities for energy-efficiency equipment and purchases of heat meters, valves, and pumps (Moscow Government 1992; interview with deputy head of Moscow Government Department of Energy Efficiency, 8/12/93).

(3) The Moscow government program also took an administrative-command approach to energy efficiency (Moscow Government 1992). All industrial consumers were to be categorized according to whether they were "efficient" or "inefficient" consumers and assessed energy surcharges according to this classification. Yet the number of audits necessary and the potential for corruption makes this kind of program virtually unworkable.

(4) A draft national law on energy efficiency, first written in 1992 but still not passed by parliament provides for a similar goal (VNIIKTEP 1993b): collect capital through taxes and surcharges on energy and invest this capital under the direction of central authorities (the very central authorities who drafted the law). The non-governmental Moscow Center for Energy Efficiency (CENEF) wrote

its own version of a comprehensive national law on energy efficiency in response to the government version (Center for Energy Efficiency 1993b). This draft also calls for a 1% tax on energy (0.3% national and 0.7% regional) to finance energy efficiency programs and projects. It calls for an independent Federal Energy Efficiency Agency of the government, as well as regional agencies, to conduct a wide range of activities like developing policy, assisting with efficiency program implementations, making recommendations on specific measures and mechanisms, conducting research and development, coordinating all levels of government, collecting information, promoting business, involving experts, conducting public education, etc. The law also includes provisions like an "industrial top ten" set of highly visible projects, a government buildings efficiency program, standards and certifications, tax incentives and other economic mechanisms. An interesting and potentially constructive provision of the CENEF draft law calls for foreign investors in energy efficiency who have purchased investment insurance from multinational or government agencies to receive compensation from the energy savings funds for the costs of this insurance upon achievement of demonstrated energy savings. Another provision calls for international cooperation on standards and certification. But many observers aren't optimistic that federal-level legislation will ever be passed, and think that regional and local laws are much more likely. "There are no federal laws on energy efficiency, so we had to make one for Moscow" said the head of the Moscow Government Department of Energy Efficiency (interview 8/12/93).

Finally, an "Energy Strategy for the Russian Federation" under development since 1992 by the Ministry of Fuel and Energy and the Academy of Sciences includes energy efficiency in its plans and anticipates investments in energy efficiency by government and industry (Russian Ministry of Fuel and Energy 1994, also interview with head of department of energy efficiency, 8/12/93).

Policies for Renewable Energy

Government policies to support commercialization of renewable energy were enacted in the 1970s and early 1980s in the United States and several European countries. In the Soviet Union, renewable energy received support for basic scientific development and technology research, but was never "commercialized" and made no contribution to energy supply (see Energy Development Policies in the Soviet Period annex and Chapter 5). In Russia, government support of renewable energy since 1992 has been minimal except for some technology development activities, and is likely to remain so because of more pressing social problems that demand budgetary support. Support from the privatized national electric power utility RAO "EES Rossii" appeared more substantial (see Chapter 5).

The special policy incentives to promote renewable energy treated in the literature, such as tax breaks, purchase mandates, and subsidies are probably not that relevant to Russia, as it is very difficult to imagine renewable energy being that high of a political priority on a federal level. On a regional level, regional electric power utilities and individual enterprises will probably take the lead in the future without special incentives, based upon the perceived costs and benefits of renewable energy. Demand for wind power by regional electric power utilities without any special incentives is demonstrated in the Kalmykia, Windenergo, and Bergey Windpower case studies. In all these case studies, regional electric utilities (in the regions of Kalmykia, Crimea (Ukraine), Maritime, Khabarovsk, Komi, Krasnodar, and Leningrad) have initiated wind energy projects themselves or have been willing partners in initiatives by others, both domestic and foreign. Anecdotes have been heard of industrial factories or hospitals in regions with severe electric power shortages being interested in local wind-turbines for backup or production-process electricity needs, where the costs of electric power outages are great (Bergey and EPA/NRDC case studies).

While Western literature has emphasized economic valuation of environmental externalities of conventional forms of energy as a way to boost the economic competitiveness of renewable energy (U.S. Department of Energy 1990, Johanson et al 1992), no evidence suggested that this process would occur in Russia. Rather, the "value" of renewable energy may be enhanced by adding premiums for the degree of local autonomy and independence that renewable energy fosters (see Chapter 5). In addition, as physical supplies of conventional energy become more difficult to obtain in some regions of Russia because of delivery problems due to institutional and political factors, the premium for renewable energy becomes the opportunity value of having any energy at all.

Existing Markets for Energy Efficiency and Renewable Energy

Demand for energy-efficiency and renewable-energy technologies by Russian enterprises and energy supply companies is dependent upon a number of factors, some economic and some not, and some similar to those in Western companies and some unique. These factors may include cost reduction, access to long-term capital, jobs and employment, regional or local autonomy, reduced political power of outside influences, or increased political power of energy supply companies. In the Soviet period, enterprises had little motivation or incentives for technological innovation, including improvements in the energy efficiency of either their product designs or their production processes (see Chapter 3). More recently, enterprises have become interested in energy-efficiency improvements for a variety of reasons (see the Moskvich case study and the Minsk Industrial Enterprises case study). In addition, energy utilities and governments have become interested in renewable energy for a number reasons (see the Ukraine Government, Kalmykia, and the NUTEK Biomass-Fueled-Boiler case studies).

In general, the market demand for many energy-efficiency technologies was in the very immature stages in 1994, and what demand existed was primarily by municipal governments or the federal government. Various foreign manufacturers in Russia (Danfoss and Honeywell case studies) were actively working to create markets for their products, and acknowledged that these markets did not really exist yet.

The demand for domestic energy-efficiency technologies and technical services among domestic industrial enterprises was much greater than for foreign energy-efficiency technologies and technical services, because the price differential was up to two or three times cheaper in 1993-1994. This is illustrated by a comparison between the Honeywell and Nagatino case studies, where costs for a functionally similar system were up to four times cheaper using domestic technologies and Russian manpower for system engineering, design, and programming. The director of one of the few existing domestic energy-service companies in Russia as of late 1994 stated that industrial enterprises could not afford foreign technologies such as those of Honeywell, and that in fact Honeywell had only so far been able to sell to the federal or municipal governments, which were less cost-sensitive, or to foreign joint ventures (hotels), which could afford the higher costs (interview 2/10/94).

The existence of demand for biomass heating technologies (especially conversion of existing oil-fired boilers to wood-fired capability) by local municipal district-heating companies in Estonia and Russia is clearly supported by the NUTEK case study. The demand for boiler conversion technology by local district-heating companies and municipalities in Estonia was motivated by a fuel cost savings of about 50% (in 1993). A desire for domestic independence from Russian oil sources also existed on a national level in Estonia. In Russia in the St. Petersburg region, NUTEK also was pursuing potential projects for these biomass boiler conversions. While in 1993 and 1994 the economics of this technology were much more favorable in Estonia than in Russia because of the differences in mazut prices, by 1995 mazut prices in Russia had approached border prices and the economic attractiveness of this technology in Russia had increased closer to that in Estonia. The longer-term economic competitiveness of biomass compared to oil or gas in Russia is still highly uncertain because of changing relative energy prices. Also not clear is the extent of timber or wood waste resources for power or heat generation, given their use for lumber and paper production.

Demand for energy-efficiency technologies by municipal governments is affected by the level of their information and knowledge of these technologies, and in some regions more than others, by the extent to which local activist groups are similarly educated and can pressure government officials to take such technologies more seriously in municipally-owned district-heating systems, electric power generation and distribution, and in municipally-owned residential buildings, schools, hospitals, and industrial enterprises. The "intermediation" necessary here is first and foremost training and public education (Moscow City Council seminar 7/23/92; EPA/NRDC IRP and OECD case studies).

Many interviewees and other research evidence indicated that many Russian enterprises exist that can produce energy-efficiency and renewable-energy technologies (see Chapter 6). But the initial market experience in these enterprises is very limited, and it is unclear how they will perform or behave in a larger market that is at least partially open to foreign competition. The supply of technologies is likely to be a mixture of domestic and foreign brands, with the stigma of poor quality continuing to be attached to domestic production relative to foreign imports.

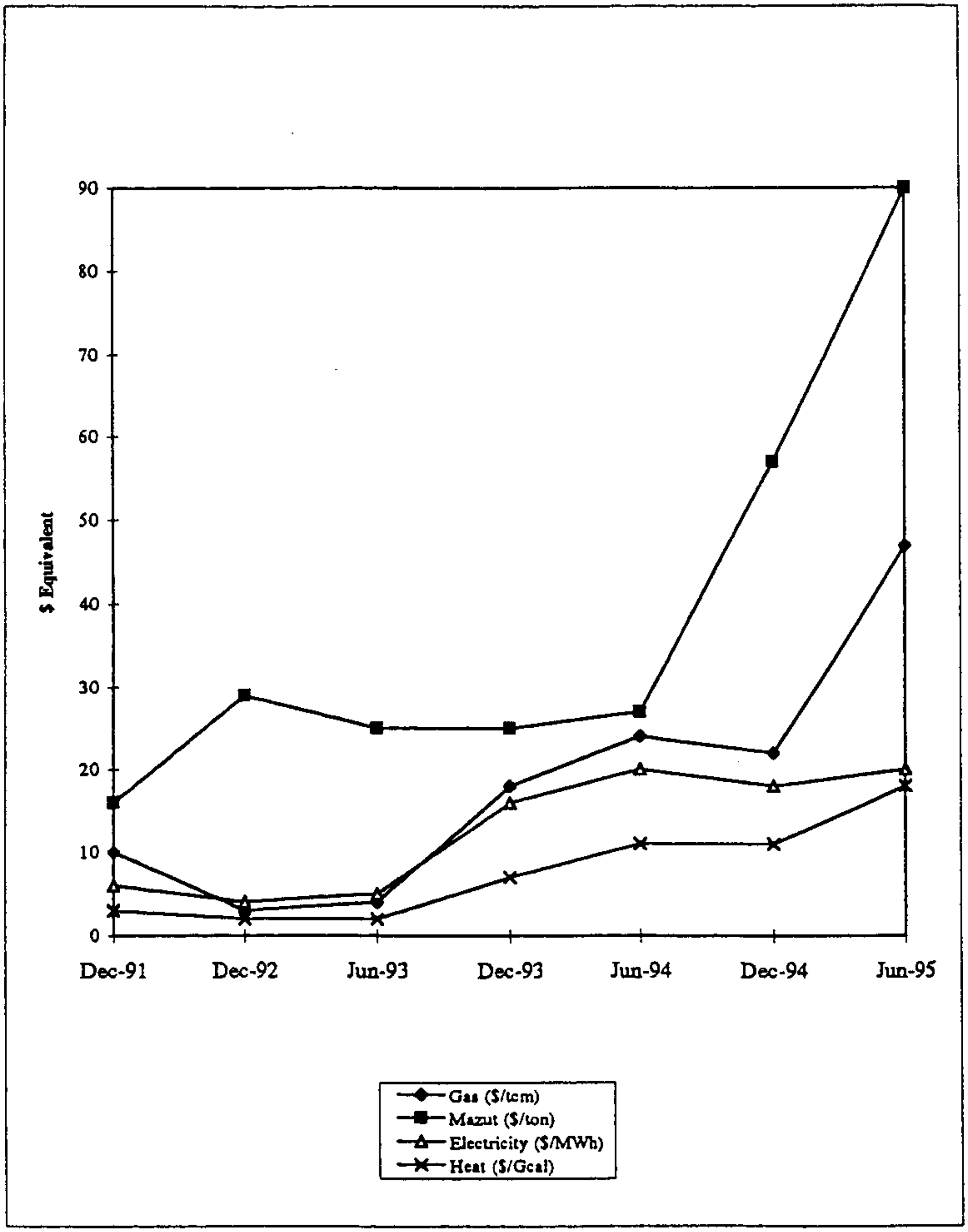
For example, in the World Bank Energy Sector case study in Estonia, World Bank advisors in Estonia recognized that Estonians were ultimately capable of producing boiler conversion equipment themselves, and that special measures should be taken to ensure that domestic production was encouraged through the project for boiler conversions. New wood-fired boiler technology was de-emphasized because the advisors recognized that it would have to come from abroad, and the project emphasized boiler conversions that could be produced domestically. "Limited international shopping" was the bidding mode selected, which gave an advantage to domestic manufacturers over full "international competitive bidding."

The NUTEK case study is another good example. NUTEK explicitly designed its program so that the technologies involved would remain simple and could be produced by domestic Estonian manufacturers. While bids for the initial projects were awarded to Swedish manufacturers (in the first project, the Estonian enterprise had a choice of Estonian and Swedish bids, and choose the Swedish one), NUTEK's intention was to promote local manufacturing and joint ventures with Swedish companies. One way it proposed to do this was to require that Swedish companies bidding in the future have an Estonian joint-venture partner.

"Western companies must first understand the Russian markets for their products, and then they must understand why they can't sell their products here" said the director of the Moscow Center for Energy Efficiency (interview 8/17/94). There is a certain degree of confidence building necessary first. Western companies, especially smaller ones, will probably first try to sell their products before committing to establishing joint ventures or wholly-owned subsidiaries. This is the approach that Danfoss took, until it had acquired enough confidence to build its own factory in Moscow even though a market for its products really did not exist yet (Danfoss case study). Rather, the company took a chance that by producing its radiator thermostat valve products in Moscow it could create a market, for example by convincing government officials that such valves should be required in all future building renovations or new buildings.

The initial supplies of investments and technology transfer in 1992-1994 were strongly influenced by a desire to get a "foot in the door," to learn about Russian markets, and to understand the requirements and pitfalls of doing business in Russia. The Honeywell, Windenergo, and Danfoss case studies demonstrated this. Many foreign companies have decided that the primary goal of their initial involvement should be a "learning experience." The President and CEO of Conoco, Constantine Nicandros, in describing the first Russian-American joint venture to develop a new oil field (called Polar Lights), wrote "we chose to participate in developing this relatively small field with two goals in mind: to use the project as a test case to learn whether or not we could successfully do business in Russia and, if we could, to use it as a platform for future investments. As a learning experience, it has been very successful" (Harvard Business Review, May-June 1994, p.40).

Figure 1: Natural Gas, Mazut, Electricity, and Heat Prices in Russia, 1991-1995



CHAPTER 4

ENERGY CONSUMPTION AND TECHNICAL-ECONOMIC EFFICIENCY POTENTIAL

In this chapter, energy intensities and the structure and level of energy consumption in Russia are compared with those characteristics in other countries. This comparison, together with a large body of evidence from the case studies, suggest that huge energy-efficiency improvements are possible and economically cost-effective in Russia from technology transfer and investment using both Western and Russian technologies. Specific technologies with high potential for energy-efficiency improvements are reviewed, along with specific estimates of potential. Evidence is provided from both published sources and from the case studies.

From this chapter it is evident that the patterns of aggregate energy demand and the technical structure of energy infrastructure in Russia are unique relative to other countries, both developed and developing. This difference greatly influences the process and character of energy-efficiency improvements and the application of existing literature to energy-efficiency problems in Russia.

Energy Consumption and Intensity

There is no question that energy use in Russia is much less efficient than in most developed countries. Energy intensities in many sectors are in fact more reflective of those found in developing countries. By considering average Western equipment and energy management practices in use at the time, Schipper and Cooper (1991) compared Soviet and Western energy intensities by end-use sector. They found that energy intensities in the former Soviet Union could be reduced by 25% for space heating supplied by district heat supplies, by 35% for space heating from on-site boilers, by 20% for water heating, by 25% for new refrigerators and other electric appliances, and by 20% for new cars and aircraft.

Other comparisons of energy consumption between the former Soviet Union and Western countries are more vague, partly because up until recently the data were simply not available to make such comparisons. The literature contains many statements like "the Soviet Union...[is] among the most wasteful users of energy and raw materials" (Goldman 1986, p. 38) and "final energy intensities [in Eastern Europe and the CIS] are between 1.5 times and twice those of the European Community" (United Nations ECE case study report ENERGY/AC.11/R.29, 1993).

Comparisons based upon energy-to-GDP ratios are highly suspect because of the problem of exchange rates and currency conversion factors, especially in formerly planned economies where official exchange rates had little to do with economic value. Comparisons based upon Russia's GDP since 1992 are highly suspect because "its impossible to measure the economy of Russia or the incomes of Russians," said one investment banker (interview 7/7/93), "since most people and many enterprises avoid paying taxes by hiding large shares of their income -- up to 90% of personal income may be hidden." Commonly cited energy-to-GDP ratios for the former Soviet Union were 2 to 4 times higher than those for developed countries. As one example of the problem with energy-to-GDP ratios, data from the World Bank and OECD (see Schipper and Martinot 1994b, p.48), show that the 1990 energy-to-GDP ratio for Estonia based upon official exchange rates was more than 300% of that for the United States, while the same ratio based upon purchasing power parity was only about 130%. Other realistic estimates are also in this range. For example, Deimezis (1990) estimated energy consumption per monetary unit of industrial output at 170% of Western European levels.

On a per-capita basis, energy use in Russia is roughly equivalent to that in many developed countries. Total primary energy consumption in Russia in 1990 was about 8 kW per-capita (Nekrasov et al 1993), which is comparable to many developed countries. Based upon a detailed analysis of energy consumption in Estonia that included international comparisons, Schipper and Martinot (1994b) found that energy use per capita in Estonia was comparable to Western European levels in 1990, despite Estonia's much lower GDP per capita. "Comparatively high energy intensities in manufacturing and residential space heating, and the [high] levels of freight are the key reasons for this result" (p. 63). Offsetting the higher energy intensities are lower levels of activity: lower per-capita living area, lower passenger travel per-capita, and lower material consumption per-capita. Energy intensities suggested by this study confirm that final energy intensities are 125% to 200% of those found in developed countries.

Other aspects of the Russian energy supply system are supposedly more efficient than their Western counterparts. The most notable example is cogeneration-produced space heating for buildings and industrial processes (see the District-Heating Systems annex). But surplus heat-production capacity in some locations, large district-heating system distribution losses (typically estimated at 30%; see annex), and extremely poor heat regulation of final consumption (which causes residents to regulate heat supply by opening windows) moderate the efficiency gains from cogeneration. Cooper et al (1992) suggest that "just over 50% of the heat supply coming out of a cogeneration facility goes towards useful consumption" (p.16); in this case a potential gross efficiency for cogeneration of over 70% would be reduced to only 44%.

Energy use in Russia peaked in 1990 and has been declining since. By 1994 primary energy consumption per capita was 20% below its 1990 level (Center for Energy Efficiency 1995a). This trend primarily reflects the decline of industrial production, but also reflects lower energy consumption in the residential and transport sectors as energy prices relative to other goods have risen dramatically (see Chapter 3) and levels of service, comfort, and activity have fallen. Energy consumption was expected to recover only slowly by the end of the 1990s to pre-1990 levels (see Schipper and Martinot 1993). This compares with an average annual growth of energy consumption in developed countries of 0.7% from 1970-1990, and 5.3% in developing countries (Levine et al 1991).

Energy-efficiency literature for developing countries has thus emphasized energy efficiency as a substitute for new capacity additions in situations of rapidly growing demand, particularly in electric power. The avoided costs of such capacity additions tend to be higher than the average or even marginal costs of the existing system, giving powerful economic arguments for energy efficiency. In Russia, however, growth in demand will be slow in reappearing, and thus for the shorter term many gains from energy-efficiency improvements must be valued at their avoided fuel and operating costs only, not avoided capacity costs. This reduces the economic advantages of efficiency relative to other countries.

The Importance of Heat Relative to Electricity

Electricity consumption per-capita in Russia in 1990 was roughly equivalent to that in OECD countries -- about 7000 kWh per year (Levine et al 1991, and Center for Energy Efficiency 1995a). But this parity hides the importance of heat relative to electricity in all sectors but industry. Electricity consumption represents only 16% of total final consumption in the residential sector and 25% in the commercial and municipal sectors (Nekrasov et al 1993). By contrast, in the United States in 1993, electricity was 38% of final consumption in the residential and commercial sectors (Energy Information Administration, 1994). Furthermore, the inefficiency of electricity generation and transmission in developing countries is stressed in energy-efficiency literature (20 to 40 percent less efficient in developing countries, according to Levine et al 1994), while this is not so much of a problem because of the high level of technological development of Russia's electric power sector (see Electric Power Systems annex and Chapter 6). It is true that transmission losses in Russia are large, but this is due not to technical inefficiency, but rather to the large geographical distances that must be covered.

Much of the energy-efficiency literature for both developed and developing countries focuses on electricity. For example, over 50% of World Bank investment from 1986-90 in energy-efficiency components of projects, and over 50% of the projects with an energy-efficiency component related to the electric power sector (World Bank, 1993a, p.22), which is "always one of a developing country's largest commercial energy consumers" (World Bank, 1993a, p.29). This emphasis reflects the geographical and climatic situations of most developing countries in more temperate zones where heating requirements are less. It also reflects the fact that electricity production and transmission in developing countries is often much less efficient: Levine et al (1991) conclude that "many power plants in developing countries consume 20 to 40 percent more fuel per kilowatt-hour of electricity, and suffer transmission and distribution losses 50 to 100 percent higher, than in OECD countries" (p.3). Finally, as countries develop, electricity use tends to grow tremendously, especially in the commercial sector with the advent of modern office buildings and air conditioning (which is very rare in Russia).

This emphasis on electricity in the literature runs from technical economic analysis, to institutional and market barriers, to policy solutions, to developmental impacts of new energy development. The emphasis has been on electricity savings through electric utility DSM programs, residential and commercial lighting and electric water heating, appliance efficiency standards, drive power in industry, and electric power generation and transmission (see Levine et al 1991). Many of these measures are calculated on "conservation supply curves" at cost-of-conserved energy values from -1 cent/kWh to 4 cents/kWh.

In contrast with developing countries, electricity production and distribution in Russia is relatively efficient. Electric power technology is one of the few areas where Russia in fact equals or exceeds the capabilities of developed countries (see Chapter 6). In contrast to both developing and developed countries, heating is of much greater importance to residential energy use in Russia than electricity (heat and hot water combined represented over 50% of total energy consumption in the residential sector; see Structure of Energy Supply and Demand annex). Another related factor is that electricity consumption daily peaks are not as pronounced in Russia as in many other countries and peaking turbines are much less common in Russia's electric power generation mix (see Electric Power Systems annex). In most developed countries, daily peaks are caused by residential consumption in the morning and evening hours, while in Russia, residential consumption is a much smaller fraction of total consumption, and daily peaks are caused by industrial processes operating at peak production hours (see Moskvich case study for an example). Many energy-efficiency measures in developed countries that are designed to reduce load at peak times of the day result in large capacity savings in addition to fuel savings. But in Russia these types of savings are much less available, and are primarily related to a variety of industrial processes in the industrial sector. In regions with severe electric power deficits, the problem that electric utilities face is how to reduce load during much of the day, and often industrial enterprises are asked to shut down or curtail their use for several hours each day (Integrated Resources Planning for the North Caucasus conference, Moscow, 11/30/93-12/3/93; see also EPA/NRDC IRP case study).

Especially relevant to Russia would be literature from the 1970s on building energy efficiency in countries where heating energy efficiency is of greater importance, such as in Scandinavia and Northern Europe. These countries underwent a major transformation in the efficiency of heat use during that period (see Schipper et al 1985).

The Causes of Inefficient Energy-Use

There are good reasons why energy use is inefficient relative to that in Western countries. Some of these reasons can be found also in developed and developing countries. For example, equipment and infrastructure were designed, developed, and produced during a period when energy (and other inputs and materials) were extremely cheap. Undervalued inputs led to much economic inefficiency in general. According to one economic analyst of Soviet industrial enterprises, if true economic values could have been attributed to the outputs and inputs of enterprises, it would have been found that many enterprises were negative-value production centers; the value of their outputs was less than the value of their inputs (Erickson lecture 10/14/94).

Many reasons are unique to formerly planned economies. It was well known that what I call "Soviet management culture" included few incentives or motivations for innovating, reducing costs, or reducing the inputs of energy and materials necessary to produce required outputs (see Nove 1986 and the Soviet Management Culture annex). Other objectives, such as meeting quantity-of-output targets (like completing construction of so many apartments in the current Five-Year-Plan or producing so many automobiles in the current month), securing needed inputs, or ensuring that the next plan was acceptable received the most attention by enterprise managers, ministry officials, party apparatchiks and central planners. Incentives often worked directly against innovations that might have resulted in increased energy efficiency. One notable exception was the power generation industry, which is quite efficient technically because incentive targets specifically addressed the efficiency of production.

Case study and other research evidence showed that many elements of Soviet management culture remain today. Over and over, the "mentality" factor of enterprise managers and engineers was stressed by interview subjects. "Culture" is an apt term because it reflects deeply ingrained beliefs and worldviews about how to behave, which are not changed or replaced easily or quickly (see Stern and Aronson 1984 for other examples related to energy use). This subject, and the related question of why energy use remains inefficient in Russia, is taken up in Chapter 7.

The reasons why district-heating systems and residential building heating are some of the most inefficient uses of energy are also clear. Comparison of investments into different possible alternatives of centralized and non-centralized heat supply was never made or considered important, according to a Russian heat supply expert (Chistovich 1990). Research on non-centralized heat supply was minimal because centralized systems were assumed to have advantages a priori. Construction of large heat-and-power (cogeneration) plants was conducted by the national Ministry of Energy, which received priority capital funds, while construction of smaller, building-level heat systems was the responsibility of the local municipality, which did not have as good access to capital funds. In addition, large (100-700 MW) boilers were favored in these centralized systems, which made the number of substations, buildings, and residents connected to one boiler plant extremely large (often 50,000 to 100,000 people), and increased the problems of controlling the system. In the words of Nekrasov et al (1993):

> Heat loss in dwellings and public buildings has been a problem for a long time, but it increased sharply with large-scale housing construction in the 1960s and 1970s. At that time, the deceptive cheapness of fuel and the attempt to economize by building low-quality housing led to colossal energy losses, which are extremely difficult to eliminate. In a number of Russia's

> regions, the acceptable heat loss standard is 1.5-2 times higher than in similar climatic conditions elsewhere in the world. And the actual losses are even greater than the standard losses due to the low quality of both construction and exploitation [operation and maintenance] of housing. (p.488)

District-Heating System Technologies for Improved Energy Efficiency and their Economic Potentials

District heating is one of the most inefficient yet important forms of energy supply and consumption in Russia (see the District Heating annex for a fuller technical and geographical description of these systems). There is the largest potential gap to be made up in heating. Meters and valves are rare. Heat production is inefficient and/or expensive. Heating equipment in buildings is old and poorly maintained (partly because it has been the responsibility of municipal governments). District heat distribution-systems are poorly controlled (if at all). Supply and distribution pipes are old and poorly insulated. And opening windows in wintertime is often still the only method to regulate heat comfort.

Energy efficiency and rehabilitation in district-heating systems represent very high domestic priorities for Russia. "Automation of the heat supply systems is of great importance for the national economy" concludes Chistovich (1990, p.41). He estimated that 8-10% of total fuel consumption for district heating can be saved through automation (for the former Soviet Union as a whole). The main goal of such automation is to optimize heat production and distribution according to real-time fluctuations in heat demand, hydraulic conditions, and outdoor temperatures. Such control should take place in the heat plants, substations, and individual buildings and apartments.

The World Bank (1992, pp.7-8) echoed these conclusions. "Among the [urban] services experiencing the most significant problems is district heating.... There are major existing problems with these systems. There is a lack of heat energy generated in several cities, and in most cities the condition of distribution networks, especially the secondary distribution networks, are in poor shape--critically poor shape in a few. Several cities have reported system failures for varying periods in cold months.

Huge wastage of energy is universal in these systems as there are inadequate controls on the usage and a lack of energy savings measures."

The World Bank then concluded that "the Bank strategy [in urban services] ought to be directed at assisting selected cities in rehabilitating and in making more energy efficient their existing district-heating systems. Expansion of existing networks ought to be resisted unless it could be shown that such expansion is the only practical option. Because of the major energy wastage that is occurring in operating these systems, and because of the critical importance of these systems to the successful operations of cities in a cold climate, investments in this urban service are likely to pay the highest economic dividends of any investment in urban services at this time" (p.8-9).

The importance of heat and the short-term prospects for improvements in heat supply and consumption efficiency is underscored by the case study evidence. Virtually all of the case studies involving energy efficiency and fuel switching emphasized district-heating systems in one way or another. Honeywell automated a district-heating plant and distribution network in Moscow for a district of 100,000 people (Honeywell case study). Danfoss renovated a polyclinic and other buildings using radiator thermostatic control valves and began to produce these valves in Moscow for the Russian market (Danfoss case study). The Danish government sponsored installation of thermostatic control valves in two entire villages in Estonia (Danish Building-Heating-System case study). IVO International was active in district-heating supply and distribution projects in several cities in Russia (IVO case study). The Swedish government agency NUTEK was replacing oil-fired district-heating boilers by biomass-fired equivalents in Estonia, and was also renovating the heating systems in residential buildings in Estonia (NUTEK case study). The earliest U.S. Agency for International Development (USAID) energy-efficiency assistance projects in Russia were district-heating system audits in two Russian cities (USAID case study). The World Bank concluded that the best way to reduce residential building operating costs was through heating system efficiency improvements and building-shell thermal improvements (World Bank Enterprise-Housing Divestiture case study). The second World Bank energy loan to Russia included capital for energy-efficiency improvements in gas-fired heating boilers for district heating systems (World Bank Energy case study).

Technologies for improving the heating systems within existing buildings include building-level meters, valves, and automatic control systems for controlling the heat entering the building, apartment-level heat meters and thermostatic radiator valves for controlling the heat to individual apartments, heat balancing valves for balancing the heat flows within the building, pipe insulation, and new substations.

Radiator thermostat valves, common features of heating systems in the Nordic countries, are virtually unknown in Russia (Danfoss, Honeywell, Danish Building-Heating-System case studies). There is great interest in such valves, and the Ministry of Construction even included heating controls in its new 1994 standards for new building construction and renovation. Yet some experts question whether these valves are necessary, given that overheating of apartments is much less of a problem in contemporary Russia than in the former Soviet period due to economically-induced cutbacks in district heat output. Schools, hospitals, and some government buildings are likely to remain "overheated," however, and represent the best targets for such valves, according to a researcher at the Center for Energy Efficiency (interview 9/15/94).

Building thermal envelopes also can be improved. Measures include additional roof and wall exterior or interior insulation; window replacement, renovation, or weather-stripping; improved caulking and sealing of building panel joints; new entrance doors; and mechanical ventilation systems. The World Bank Enterprise-Housing Divestiture and the Building-Energy-Efficiency case studies show that most of these measures could payback in five years or less, except for exterior wall insulation, which had payback periods in the range of 15 to 25 years.

Improvements to district-heating systems include combustion controls and analyzers at heat plants, automated control systems for distribution networks, variable speed drives on motors and pumps, pipe insulation, new pipelines, and new heat exchangers in substations.

Losses in district-heating networks, although theoretically only 10-15%, are typically more like 30%, according to Cooper et al (1991). This gap between theoretical and actual losses was verified repeatedly in the case study and other research evidence. Thus other important improvements in district-heating systems include leak detection and repair (often simple and cheap), replacement of distribution pipes with modern pre-insulated pipes, upgrade of substations and building-level substations, and even replacement of centralized supply with individual building-level systems where gas distribution is available. In general, individual building-level systems are more efficient than centralized heat-only-boiler production and distribution-systems because distribution losses are minimal, even if the individual boilers themselves are less efficient. When considering the efficiency of systems that include combined-heat-and-power plants, however, the question becomes much more complicated.

Many of the measures to improve efficiency in heating systems are relatively low-cost, with payback times of less than five years at domestic energy prices, and some with payback times as little as one or two years. All of the case studies related to district heating mentioned previously fall into this short-to-medium payback-time category. Potential savings from these measures range from 10-20% for the simplest building retrofits or distribution system controls, to up to 50% for more extensive improvements. For details on individual savings and costs, refer to the detailed case studies and their Russian-source references.

As one example, the World Bank Gas Distribution loan to Russia (World Bank Energy Sector case study) showed internal rates of return on energy-efficiency investments in district heating systems up to 70% and more, even with an assumption that gas prices will not rise beyond 40-50% of Western European levels (depending on geographical location).

As another example, the Building-Energy-Efficiency and Danish Building-Heating System case studies provided more detailed data of building-energy-efficiency improvements based upon the experience from several retrofit projects. In buildings, seven technologies were considered to have low-to-medium payback times (up to 8-10 years): building-level heat metering, roof or attic insulation, renovation or replacement of substation, building-level automatic heat control valves, window weather-striping, renovation or replacement of selected windows in some cases, and replacement or insulation of heat piping in the basement. Some of the basic building "packages" done in these retrofits had payback times of 5-8 years, with energy savings estimated from 15% to 30% of total heat consumption of the retrofitted buildings. One retrofit project had estimated the following payback times: new substation 5 years, roof insulation 11 years, weather stripping 2 years, and pipe insulation 13 years. Installation of radiator thermostat valves and building-level heat regulation systems in two small towns in Estonia was estimated to save approximately 15-30% of heat consumption, although pay back times had not been calculated.

Improvements to district-heating systems with long term paybacks must be considered carefully in the context of the long-term heating system trends. The World Bank (1992c) wrote:

> From the "long haul" perspective, district heating systems in the Russian context are likely to be regarded as "dinosaurs" that will need to be replaced. Given that Russia has rich petroleum resources, especially natural gas, it does not make sense to create power at central locations and then accept heat losses across a lengthy piped network. Where natural gas or other clean burning energy resources are made available, district heating systems probably will be relegated in time to (at most) the dense central areas of cities, and for serving selected major industrial enterprises. Individual (private) heating systems serving individual homes or apartment blocks will gradually become the norm. (p.8)

Two significant trends will affect district heating in the longer-term future. The first is the installation of individual heating boilers in buildings to replace district heat supplies. The second is the move to industrial cogeneration by some enterprises using combined-cycle gas turbines. "District heating is not the future for Russia" said a researcher at the Center for Energy Efficiency (interview 9/15/94). Nevertheless, most of the energy-efficiency improvements possible in district heating systems will pay back in the short term, and can offer attractive investments even if the longer-term future of these systems is in doubt.

The experience with district heating in Denmark (Danish Energy Agency 1993) and other Nordic countries shows that district heating <u>can</u> be efficient, and these countries continue to develop their district-heating systems. The difference is one of physical and technical scale: Russia's systems are simply too big to be efficient, while Nordic systems tend to have much smaller dimensions than those in Russia.

<u>Industrial Sector Technologies for Improved Energy Efficiency and their Economic Potentials</u>

New industrial processes will be important sources of improved energy efficient in industry: the share of older technology open hearth steel furnaces, wet-process cement mills, and older paper and pulp making equipment is very high. In general, new processes use somewhat more electricity than older processes, but use considerably less total (or primary) energy than older ones. New industrial process technologies in those industries with a greater chance of long-term survival in Russia will provide the greatest opportunities. These industries include many of the basic extractive and intermediate processing industries, along with automobile manufacturing, building materials, synthetic materials like polyester and plastics, and agricultural machinery.

Evidence for industrial energy efficiency savings potentials and costs comes from a large number of industrial audits already conducted (European Union, USAID, and IVO International case studies, and Schipper and Martinot 1994b), as well as other case study evidence (Moskvich Auto Factory and Minsk Industrial Enterprises case studies).

More efficient gas burners and combustion controls are important, along with technologies for secondary-process-heat recovery. Motors consume the greatest share of electric power in Russia, yet perhaps only 3-5% of these motors have variable speed drives installed (interview with director of electric power research institute, 9/9/94). Motors installed in industry represent the majority of uses, including pumps, mechanical process power, compressed air, and heating and ventilation systems. These motors tend to be very inefficient relative to Western practice (because their efficiency ratings were not designed with true lifecycle cost calculations, as is common in the West), and also tend to be oversized, since the poor supply and availability of motors (like all commodities in the Soviet economy) meant that enterprises often had to install whatever was available.

A survey of six industrial enterprises in Estonia by the Swedish National Board for Industrial and Technical Development (see Schipper and Martinot 1994b) showed that savings of 10-30% could be obtained in industry through improvements in operations and maintenance, space heating, cooling processes, and air compression. Other audits in Estonia and Russia have tended to group potential savings into three categories according to economic payback: (i) no-cost/low-cost or short-term measures with typical paybacks of less than one year, (ii) medium-cost or medium-term measures, which might pay back in 2-4 years, and (iii) high-cost or long-term measures with paybacks of longer than 5 years.

(i) No-cost/low-cost or short-term measures. Proper boiler tuning and monitoring were clearly the most popular measures, with the audits showing 1-6% potential savings, with more typical savings in the range of 2-4%. Some audits showed 2-3% savings strictly through tuning oxygen levels in combustion. Better energy management was another popular measure and savings of 10% were commonly cited through better monitoring, accounting, and control. Changes in manufacturing processes were another measure where 5-15% savings were cited, through changes in equipment-operating practices and procedures. Other low-cost measures cited were proper preventive maintenance of equipment, better loading of process ovens and furnaces to reduce total cycle costs, plugging steam and pressurized air leakages, reducing hot-water wastage and losses, and substitution of electric heating for central heat in certain types of workspaces.

(ii) Medium-cost, medium-term measures. One of the main types of medium-cost measures is secondary heat recovery from flue gases and process furnaces, with payback times on the order of two to three years cited. Improved insulation of pipes, furnaces, and ovens is another medium-cost measure. And finally, increased return of heating steam condensate could result in significant savings. In some of the audits, only 40-70% of the condensate was being returned, and an improvement of 30% was feasible.

(iii) High-cost, long-term measures. Lighting measures were considered high-cost measures, undoubtedly because of low electricity prices. Savings from lighting improvements were given in one case as 10%, although greater savings are undoubtedly possible. Other high-cost measures include converting heating systems from steam to water, steam-on-demand, rather than continuous steam, systems for some technological processes, and burner-automation systems for boilers. Because of electricity prices that are lower than typically found in Western countries (see Chapter 3), many industrial electricity efficiency measures common in the West will not be as cost-effective.

Technical Potentials in Other Sectors and Their Economics

(a) Residential-sector and service-sector electricity. Since electricity consumption is a much smaller share of building energy consumption than heat, the importance of electricity efficiency is diminished in Russia relative to the experience in other countries and the United States. As of mid-1995, electricity prices in the residential sector were still much lower than industry because of cross-subsidies and low electricity production costs (see Chapter 3). Prices of typically one cent per kWh (U.S. equivalent) do not make for cost-effective replacement of inefficient lighting, refrigerators, and other appliances with more energy efficient versions. One audit by the EU TACIS program (European Union case study) presented data leading to payback times (at current domestic electricity prices) for more efficient lightbulbs in one school that were over 100 years! Electricity efficiency in the residential sector is likely to be a much longer term process until cross-subsidies are eliminated, and even then electricity prices will likely remain low relative to those in many Western countries.

(b) Electric power systems. Industrial cogeneration with combined-cycle gas turbines could be considered a form of energy efficiency in this sector, as this technology is more efficient than conventional centralized heat-and-power plants. Preliminary estimates by the Center for Energy Efficiency (interview with researcher 9/15/94) suggested that surplus Russian gas turbines used in combined-cycle cogeneration plants could cost $4 million (40 MW plant), about one-tenth of the equivalent cost of such a plant in the West, and could provide payback times of just one to two years. Efficiency improvements in electric power plants and transmission and distribution systems involve improved component efficient, such as generators, turbines, and transformers; boiler monitoring and tuning. This sector is already quite efficient, and the conventional inefficiencies found in electric power systems in many developing countries are not present in Russian systems to any great degree.

Economic Calculation Caveats

The exact economics of most energy-efficiency measures are difficult to calculate because the potential quantities of saved energy are difficult to estimate. While electricity flows and consumption are fairly well known and possible to estimate, heat flows are often unmetered and vary depending on year-to-year climatic conditions and operating regimes of the district-heating systems, so there is no baseline historical data with which to compare or estimate savings from specific measures. This problem was evident in several of the case studies (Honeywell, Danfoss and Danish Building-Heating-System case studies). Further, there is no way to predict simply "technical" efficiency potential independent of heat system operation and decisions about levels of apartment comfort (heating consumption) in the future (see Chapter 7). This problem adds greatly to the uncertainty in many energy-efficiency investment decisions.

The costs of the measures themselves were difficult to estimate in a longer-run meaningful way in the period 1991-1994. Relative prices of most goods in Russia continued to change throughout the period 1992-1994, some drastically. In 1992 prices were fairly meaningless, but by 1994 relative prices (in real terms) were stabilizing and had begun to reflect real "value" or costs. Thus by 1994 it was possible with greater confidence to estimate the costs of efficiency improvements. Yet the lack of developed markets meant that price and cost data were still speculative, and not yet grounded in real market exchange and production. Furthermore, cost estimation is a new field in Russia, and not many people are yet working on it or trained in it (this point was evident again and again in interviews and case studies, for example in an interview with a researcher at the USA-Canada Institute in Moscow, 9/21/94).

Nevertheless, many estimates in the case studies and research evidence suggested that Russian equipment for energy efficiency could cost two to four times less than comparable equipment imported from the West, a conclusion supported by a senior researcher at the Center for Energy Efficiency (interview 1/25/94).

CHAPTER 5

RENEWABLE-ENERGY ECONOMICS, GEOGRAPHY, AND MOTIVATIONS

This chapter reviews the current state of renewable energy technology development in Russia, domestic production costs in comparison with international production costs, and the geographical resources for several forms of renewable energy. From this chapter it is clear that Russians have themselves developed many renewable-energy technologies (although have not deployed them commercially), and that economically favorable geographical opportunities exist for renewable energy development in Russia, particularly for wind, solar thermal, and geothermal.

This chapter also discusses two important motivations for renewable energy development in Russia that are not seen in renewable energy literature: (1) conversion of idle industrial capacity into productive use, and (2) increased regional autonomy (economic, political, technical) from Moscow and central authorities.

In contrast to many Western countries and developing countries, Russia receives practically no share of its energy supply from renewable energy sources.[3] Wood supplies perhaps 1% in the form of wood stoves for heating in remote areas and Siberia. This contrasts with the United States, which received about 4% of total primary energy from non-hydro renewable energy forms (U.S. Department of Energy 1990), and with developing countries, which as a group receive 35% of primary energy from biomass (Hall 1993). Yet the opportunities are enormous. Because of its varied latitude, climate, and terrain, and its enormous size, a variety of renewable energy forms, from solar to wind to geothermal to tidal are all possible in Russia, as compared to many smaller developed or developing countries where one potential form predominates because of the homogeneity of geographic conditions. Thus it is not

[3] The definition of renewable energy used in this dissertation does not include hydropower (see Chapter 1).

possible to characterize Russia as a whole with respect to renewable energy, but reference must always be made to specific regions within Russia.

Because of the importance of heating in Russia relative to most other developed and developing countries (see Chapter 4), renewable-produced heat (from biomass, wind, solar, or geothermal) is more important relative to the emphasis it has received in the renewable energy literature. Literature on biomass-fueled district-heating boilers and other heating systems from Scandinavian countries is particularly relevant, for example.

<u>Renewable-Energy Technologies and Costs</u>

Over the last several decades the Soviets conducted research and development on several forms of renewable energy, including solar thermal, solar photovoltaic, wind, geothermal, biomass, and tidal power (Batenin 1990, Martinot 1991, Campbell 1980). These efforts resulted in a few test installations and some fairly well-developed science and technologies, especially in solar photovoltaic cells. But practically no "commercial use" of renewable energy has occurred to date, with the exception of a few small geothermal installations. Of course wood is burned for heating and cooking, but this consumption is less than 1% of the total primary energy input for Russia. And small (1-kW to 10-kW) water-pumping wind turbines were produced in the earlier decades of the Soviet Union through to 1990, with an estimated 10,000 installations in place by the 1950s. With the breakup of the Soviet Union, Russia inherited most of this renewable technology, but Ukraine still possesses significant technological expertise and some research installations for wind turbines and solar-thermal power. In the early 1990s, much of the scientific research was continuing with decreasing amounts of government funding, but by 1994 most research on renewable energy continued only within the context of commercialization by private enterprises and research institutes, often working collaboratively.

Technologies developed historically in the Soviet Union within its scientific research establishment included the smaller water-pumping wind turbines mentioned, wind turbines up to 100-

kW for electricity generation, residential solar hot-water heaters, passive solar heating of buildings, photovoltaic cells for use in satellites (and more recently amorphous silicon and gallium arsenide cells), one geothermal power plant (11 MW), one tidal power station, and one solar-thermal electricity power plant (5 MW).

By 1992, the renewable-energy technologies closest to commercialization in Russia by virtue of their economic competitiveness included many of the same technologies in the West: grid-connected wind turbines, biomass-fueled heating boilers, off-grid wind-diesel hybrid systems, residential solar hot-water heaters, and geothermal electricity from underground steam. Others were still in the non-commercial development stages, like grid-connected photovoltaics.

There have been several domestic technology developments in wind energy in the early 1990s. For example, a commercial 1000-kW wind turbine has been developed by a prominent aerospace factory "Radyga" located near Moscow in cooperation with the Tushinskiy production enterprise, and prototypes have been built (Wind Power in Russia Conference, Moscow, 4/28/94; interview with head of renewable energy department of RAO "EES Rossii," 9/16/94). The first installation of these 1000-kW turbines was to be a 22-MW wind farm in Kalmykia (see Kalmykia case study). The science-production association Vetroen in Russia and the Yuzhnoye factory in Ukraine also developed a 250-kW turbine and installed several of them in the Crimea in 1993-94 with financing by the Ukrainian government. Several small wind farms of 2 to 5 MW total were being planned in 1994 in Russia, although funding was highly questionable for most projects (for more details, see the Kalmykia and Ukrainian Government case studies).

Solar technologies have been less developed. The Soviet Union was very successful with making high efficiency solar photovoltaic cells for its satellites, although the manufacturing technology for these cells is entirely manual, as compared to automated technologies in the West (interview with head of solar engineering laboratory of the Khrzhizhanovskiy Power Engineering Institute, 7/8/92). There is one experimental 5-MW electric solar-thermal plant in the Crimea. Small-scale solar collector test installations for heat and hot water have been installed in parts of Ukraine, Kazakhstan, and Central Asia. A 1-MW solar photovoltaic project in the North Caucasus region is under development.

One potential promising technology is solar hot-water heating in the summer months for apartment and single-family houses connected to district-heating systems. In most of the district-heating systems in Russia, boiler plants must continue to run in the off-season summer months merely to produce hot water for residents (of course combined heat-and-power plants run anyway, but electricity peaks occur in winter in Russia, not in summer as in developed countries with large air-conditioning loads). The energy consumption to produce this hot water is especially inefficient, as a large system is being run at minimal capacity and the distribution-system losses are substantial, whether hot water is demanded or not. Thus if comparative economic costs could be ascertained for hot-water production in the summer, solar hot-water heaters could potentially be economic even if used only from May until August.

Potential biomass technologies include both direct combustion and gasification. Most heating boilers in Russian cities cannot be converted to biomass as was being done in Estonia (see NUTEK Boiler Conversion case study) because the boilers in Russia are typically very large (50-100 MW), in order to serve the large, centralized district-heating systems. On this scale, biomass cannot be used as a direct feedstock. Rather, biomass would first need to be gasified, and then burned for either electricity or heat. In smaller cities where coal, oil or gas-fired boilers are smaller (less than 10 MW, for example), conversion of these boilers could be accomplished very similarly to those in the Estonia case, because the boilers in use in Estonia were Soviet-standard, Soviet-designed and produced boilers.

The costs of renewable energy in Russia are extremely uncertain, primarily because no commercial production has yet occurred and so little data and experience exists on technology costs, projects, and resources. The costs of anything in Russia before 1992 were fairly meaningless as a basis for economic comparison in a conventional cost-benefit sense, as the price structure of goods in the Soviet era did not reflect true economic value or costs in any Western economic sense (see Nove 1986).

Costs of equipment, goods, and services since 1992 have emerged as commercial markets have emerged. Because of the lack of markets for renewable-energy technologies, cost data simply do not exist. Wind-turbine technologies, which have been under prototype and initial commercial development, are the one exception; manufacturers have given production costs in 1993 and 1994. The lack of cost data contrasts with the situation in developed countries, where these costs have been fairly well quantified and a wealth of project experience and resource assessments already exist.

The cost of Russian-produced solar hot-water heaters (collectors) was three times less than that in Europe and two times less than in Israel, claimed the head of the renewable energy department of the national electric utility RAO "EES Rossii" (interview 1/24/94), but no additional data was found on these costs. He claimed that solar collectors cost \$50-200/kW and that solar photovoltaic panels cost \$2/kW. These costs, if true, are two to three times less than typical costs in the West (see Rader 1989, Johanson 1992 et al, and Ahmed 1994).

The research evidence and case studies suggest that total costs of wind-generated electricity in grid-connected wind farms in Russia and Ukraine using Russian or Ukrainian-produced turbines can be equivalent to or significantly less (by a factor of two or three) than the costs of such electricity in Western countries. In regions where wind is feasible, the fuel share for conventional electricity generation includes a large fraction of either oil-fired (and diesel-fired) or gas-fired generation. This works in renewable energy's favor for two reasons: (1) renewable energy competes with higher marginal-cost fuels; and (2) grid integration problems are less significant, compared to a situation where electricity comes from hydro or nuclear. In a situation where oil or gas fuel predominates, grid integration is not a significant technical problem (see Grubb 1993).

Of all renewable-energy technologies, grid-connected wind turbines seem closest to commercial development, and some cost data are available. Estimates by domestic Russian manufacturers of wind-turbine costs ranged from \$800/kW to \$900/kW equivalent (installed) for initial production of 250-kW and 1000-kW machines (Kalmykia case study). These costs are only slightly less than those in the West, although the performance of the Russian machines is likely to be significantly less until much greater operating experience is gathered. But the manufacturers also estimated that these prices could fall to $400-$500/kW with mass serial production. Thus current gas and oil-generated electricity in Russia was still far cheaper than the projected price of wind-generated electricity, which is typically 7-9 cents/kWh in the West (Rader 1989). However, the Windenergo Ukraine 100-kW turbine produced in Ukraine under license with Kenetech Windpower will cost only $300/kW installed, according to Windenergo's general director (Wind Power in Russia Conference, Moscow, 4/28/94). At this cost and with Windenergo operating assumptions (that may or may not be realistic), the projected electricity production cost from these turbines is 2.3 cents/kWh. In Ukraine, this compares with estimated average production costs of 2.8 cents/kWh equivalent for electricity from fossil fuels, although electricity prices to most consumers were still less than 1 cent/kWh. The Yuzhnoye factory in Ukraine had also developed a domestic 200-kW wind turbine for which it gave the selling price as $70,000, or about $350/kW (Business Moscow News, 11/14/93, p.7, "NPO Yuzhnoye Harnesses the Wind").

In many regions of Western countries, wind energy has become competitive with conventional forms of generation (U.S. Department of Energy 1990; Ahmed 1994; Rader 1989). Whether it is competitive with domestic prices of conventional forms of generation is still unclear, but the initial evidence available from the Windenergo case study suggests that lower turbine production costs and lower than Western-level conventional fuel costs still on balance provide a competitive match.

In many regions in the Russian Far East and Far North, electrification is supplied by diesel generators to smaller villages and settlements of native peoples and also Russian extractive industries (gas, oil, and mineral). Because of their remote locations and geographical correspondence with favorable wind resources (see Map 3), these installations are prime candidates for integrated wind/diesel systems (Bergey Windpower case study). For these applications, existing literature on remote village-level electrification in developing countries is somewhat applicable (see for example

Barnett 1990), but there are significant differences also. The differences stem from the climate conditions (cold versus tropical), the uses of the power (in the winter lighting is a much greater need in Russia because of the shorter days, for example), the social organization of remote villages and settlements (based upon one primary source of employment, often industrial), and the fact that in remote regions of developing countries, an oil-based economy does not yet exist and thus the new energy systems are providing new capabilities rather than substituting for existing ones.

<u>Renewable Energy Geographical Resources</u>

Because of Russia's huge size and geographical diversity, renewable energy resources vary considerably from region to region and for different renewable technologies. Below are rough resource potentials for wind, solar, geothermal, and biomass, given the available data collected during the research. Because renewable energy never received political emphasis or priority in the Soviet era (see Energy Development Policies in the Soviet Period annex), estimates of renewable energy potential are sketchy and incomplete, because the resources necessary for more thorough analysis were never allocated.

Wind resources. There are large areas of Russia with annual average wind speed greater than 5-7 meters/second at or near ground level, although wind speed measurement data often do not give the measurement height (Martinot 1991, Perminov 1993b, Kozlov 1990). These areas include coastal areas of the Pacific and Arctic oceans, as well as the internal Caspian, Azov, and Black Seas, high plains, and mountain regions. The North Caucasus region, large desert portions of Kazakhstan, and the Crimea in Ukraine are also good potential areas for wind development. While many of these regions are not located near populated areas or electric power grids, the Russian national electric utility (RAO) department of renewable energy has identified seventeen specific regions (out of 89 total) in Russia where development should proceed, and these are shown in Map 3 (Wind Energy in Russia Conference, Moscow, 4/28/94; interview 9/16/94). These regions include (oblasts and republics)

Archangel, Kaliningrad, Astrakhan, Volgograd, Kamchatka, Leningrad, Sakhalin, Krasnodar, Stavropol, Kalmykia, Dagestan, Karelia, Komi, Magadan, Maritime, Murmansk, and Khabarovsk. The correspondence of many, but not all, of these regions with population centers and electric power grid networks is good (see Maps 1 and 2 and Martinot 1991 for a more detailed analysis).

Solar resources. Despite the fact that the main part of Russia is located north of 40 degrees latitude, there is still a large potential for utilizing solar energy for both electricity generation and thermal heating. Practical regions for solar generated electricity in Russia include those below or near 50 degrees latitude, including Stavropol, Rostov, Krasnodar, Volgograd, Amur, Astrakhan, Kalmykia, Dagestan, Altay, and Maritime (see Map 4). Plans for solar power stations were in fact under way in some of these regions. Incoming solar energy in these regions varies from 1000 to 2500 kWh/m2 per year, based upon a useful operation of 2000-3000 hours/year (Perminov 1993). Values for some cities were given by Kukharkin (1992), for example 1340 kWh/m2 for Irkutsk (52 degrees latitude), 1290 kWh/m2 for Yakutia-Sakha (62 degrees latitude), and 850 kWh/m2 for St. Petersburg (60 degrees latitude). One estimate for the former Soviet Union said that 60 million people lived in regions where solar energy is feasible for water heating (Batenin 1990), although most of this population would have been counted in the regions of Central Asia, the Transcaucasus region, and Ukraine.

Biomass resources. Biomass wastes from agriculture, industry, and other sources in Russia are estimated at more than 300 million tons per year, which could be converted into biogas equal to 60 million tons of coal equivalent fuel (Perminov 1993b). Forest harvesting for biomass has not been discussed in the Russian literature examined. Possible reasons include: (1) politically this option has never been considered, (2) strong cultural biases exist against the use of forests for energy, and (3) the Soviet Union could not even harvest enough wood to meet demand for wood and paper -- shortages because of institutional and economic deficiencies in the forest industries were reported. Potential biomass resources from forest harvesting are plentiful in much of the Taiga and Mixed Forest vegetation zones of Russia. Nilsson et al (1992) conducted an extensive survey of the forest resources of the former Soviet Union, and particularly the European part. The "Forest Fund" of the former Soviet Union, which is dominated primarily by Russia when speaking of forests (minus the Baltics and Belarus as the main forested non-Russian former Soviet regions), includes 1.2 billion hectares (about half the total area of the former Soviet Union), with 940 million hectares classified as forest land and 810 million hectares as forested land with a total standing volume of 86 billion cubic meters (m3). The Forest Fund contains 440 million hectares of non-forested land, of which 30% is suitable for afforestation. The actual forest harvest in 1990 was 300 million m3 for the entire Soviet Union, and 175 million m3 for the European part only. The annual growth increment is estimated by experts as 1.5 billion m3/year, and the exploitable increment in the European part is estimated at 360 million m3/year. The area of commercial forest in the European portion of the former Soviet Union is over 60 million hectares, most of this in the North and Ural administrative regions of the former Soviet Union. Regions where forest and biomass potential corresponds with denser population centers and pulp and paper industry concentrations (for potential sources of biomass wastes) include St. Petersburg, Karelia, Murmansk, Vologda, Archangel, Komi, Perm, Yekaterinburg, much of the northern portion of European Russia, Khabarovsk, and Amur (see Map 5).

Geothermal resources. One estimate of the technical potential of geothermal energy in the Far East regions of Kamchatka and Sakhalin and Kuril islands is 2 million kWh per year (Perminov 1993b). In the Stavropol and Krasnodar regions in the North Caucasus, there exist thermal zones at a depth of 4-km that could be exploited by fluid circulation systems and could produce an estimated 80 million kWh per year. These regions are shown on Map 6.

Two Important Motivations for Renewable Energy in Russia

One of the primary reasons why renewable energy is attractive in Russia is that it can contribute to the conversion of military, idle or undercapacity factories to useful production of commercial technologies. Wind turbines, solar-thermal collectors, and solar photovoltaic cells are all materials-intensive technologies that require skilled labor and well-equipped production facilities. Because of the general decline in industrial production in Russia since 1990, especially the reduction of military production, many production facilities and their workers in Russia stood idle or partially idle by 1995. These facilities were hungry for alternative products to produce, and many saw renewable-energy technologies as attractive and promising. A second reason why renewable energy is attractive is that it can help foster technical, economic and political autonomy in certain regions of Russia. As more and more areas of Russia see that they must become more independent of Moscow and take matters into their own hands, they are looking for political, economic, and even technical solutions for greater autonomy.

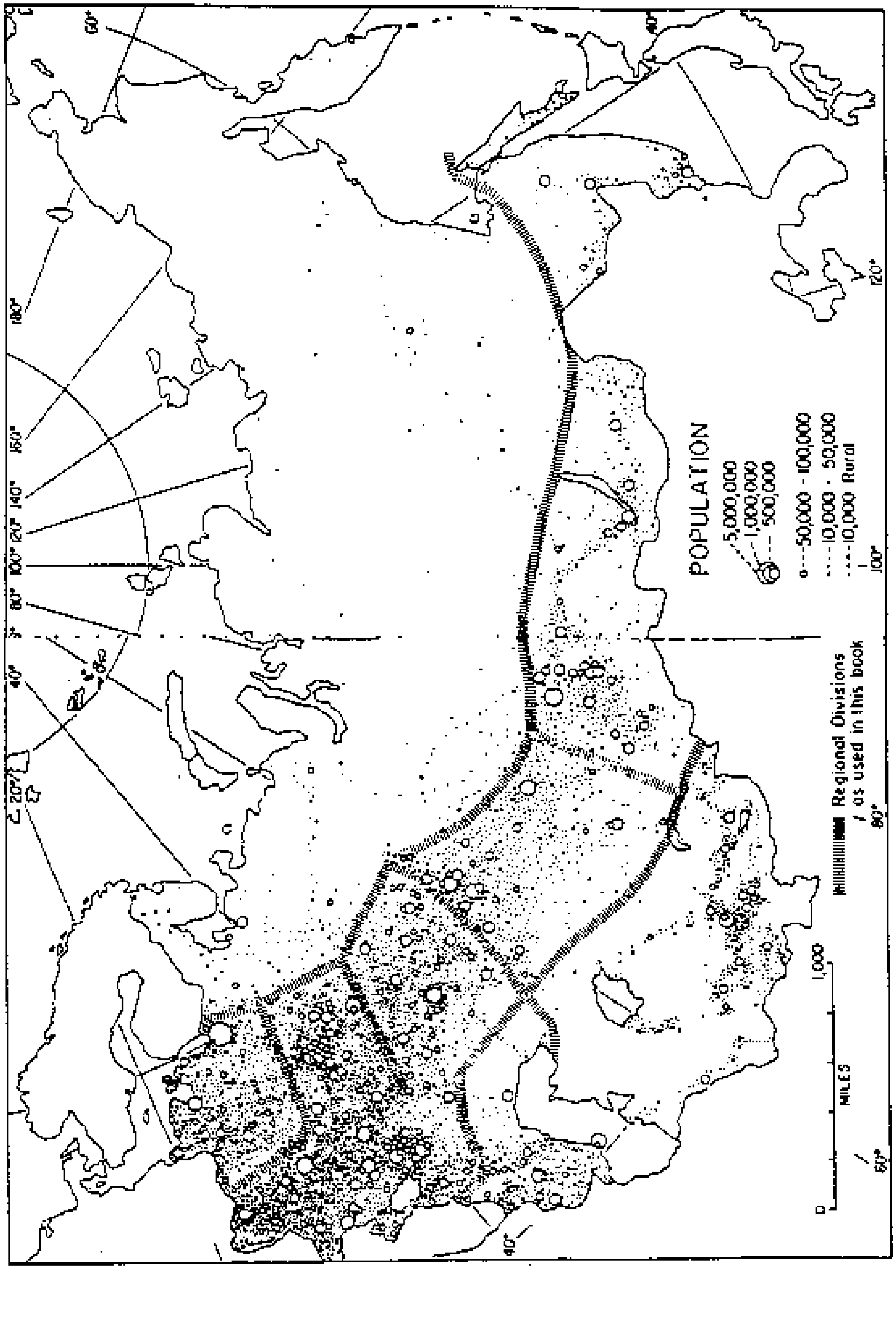
The president of the Kalmykia electric power utility, which was building a 22-MW wind farm using Russian designed and produced turbines (Kalmykia case study), gave five main reasons why he had decided to pursue wind energy development in his region (interview 4/28/94): (1) to increase regional independence; (2) to mitigate against increasing gas and oil prices in the future; (3) to reduce the influence and control of Gazprom over the economy and enterprises in the region; (4) to put defence factories in many parts of Russia back in business; and (5) to showcase Russian technologies to demonstrate a certain national pride in technology, like the space program was three decades earlier. "We want this wind power plant to show the best that we can do in Russia -- using our best aerospace technology." When finished, this windfarm would be the largest in Russia and the leading edge of Russian wind-power development. The first turbines were already being installed at the end of 1994.

Factories in the North Caucasus, an area of severe electric power shortages, have expressed interest in wind turbines to enable them to continue production during hours when they are forbidden to draw power from the grid, enabling them to increase output and retain jobs (Integrated Resources Planning Conference for the North Caucasus, 11/30/93-12/3/93, Moscow). In this case, the opportunity cost of the lost production is much higher than the cost of electricity generated by the wind turbines. Regions in the Far East, another area of electric power shortages, have begun to buy small-scale hybrid wind-diesel systems from foreign manufacturers to power hospitals and other critical electricity loads to make them more autonomous from intermittent electricity supplies (Bergey case study).

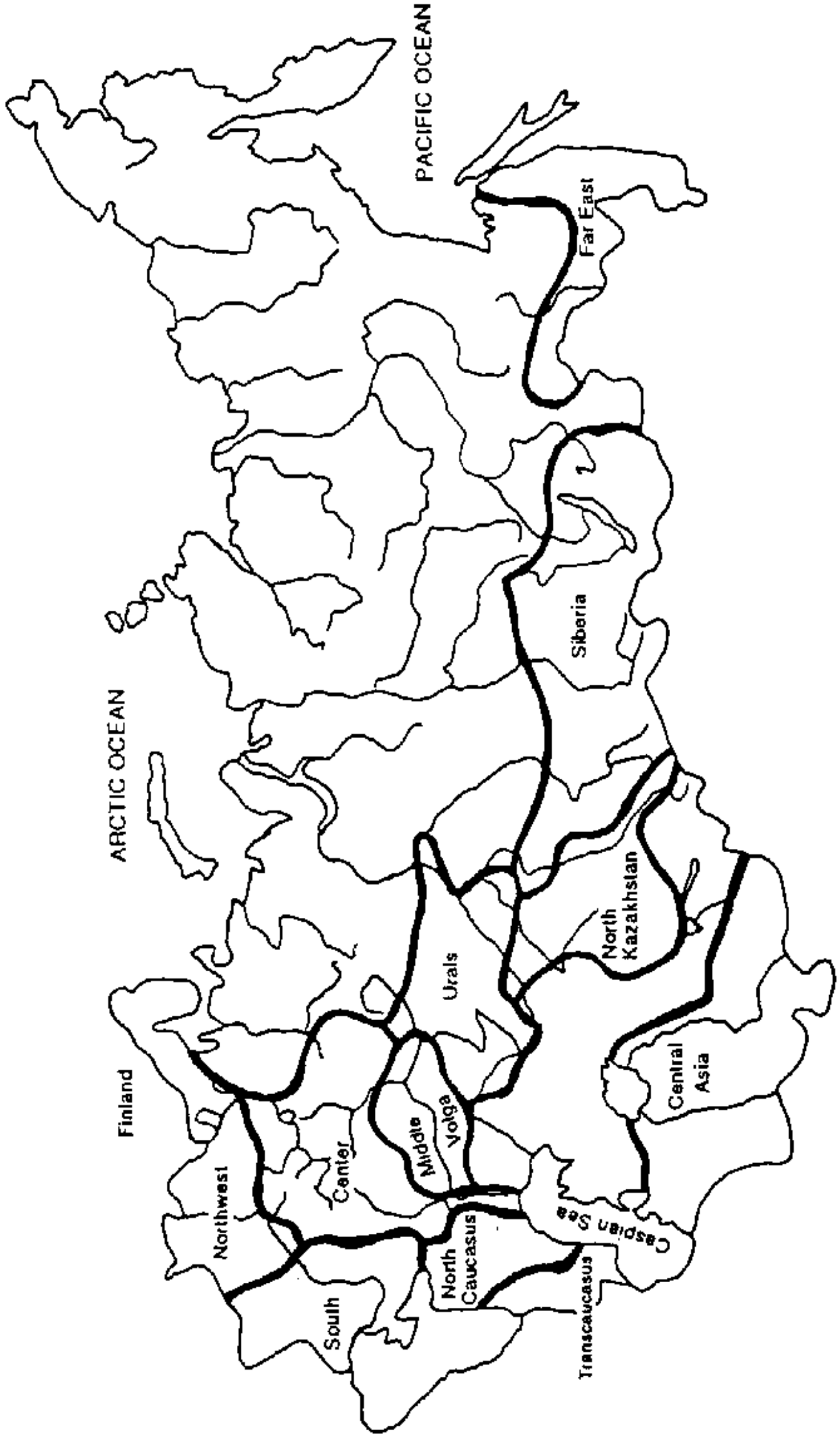
The strong support for wind energy by the Crimean electric utility, Crimenergo, and its willingness to enter into a contract for purchase of 500-MW of wind turbines from the American-Ukrainian joint venture Windenergo, has been in part due to Crimean desires for more autonomy (Windenergo case study). Crimenergo receives a large share of its electric power from elsewhere in Ukraine, and is thus vulnerable to disruption of its supply for political reasons. This is not mere speculation; in early 1994, Ukrainian officials partially cut electric power to the Crimea, citing unpaid energy debts as the reason (The Baltic Observer, 3/24/94, p.14, "Ukraine partially cuts electric power to Crimea"). Yet many regions of Ukraine also had huge energy debts to the government, and it was possible the electricity cut was part of the political battle between Crimea and Ukraine over greater autonomy, especially because the power curtailment decision came the same week as Ukrainian President Kravchuk canceled a referendum on greater Crimean autonomy scheduled to take place.

Ukrainian officials themselves see wind energy as a positive source of employment, as well as a domestic source of energy that would make Ukraine less dependent on foreign imports. There was also evidence that the cost of electricity from Windenergo wind turbines could be roughly comparable to that of electricity generated from imported oil and gas. In early 1994 the Ukrainian government approved a 0.7% tax on electricity sales to finance defence conversion, environmental projects, and wind turbines. The Windenergo general director credits approval of this tax to "education" about wind energy of government officials (Windenergo case study).

In Estonia, the NUTEK and Danish Government Boiler case studies showed that conversion of heating boilers from mazut to biomass means not only a reduction in costs, but greater national (regional) independence and more jobs. Wood chips were half the price of imported fuel oil in 1993, on a cost per energy basis, and this certainly drove the process of conversion. But all mazut consumed in Estonia is imported from Russia, and the desire for greater independence from Russia has certainly been a factor. Further, jobs for harvesting wood (and hopefully proper sustainable forest management) support the domestic economy. These case studies have great relevance for forest regions of Russia where biomass and wood wastes are plentiful.



Map 1: Population Distribution of the former Soviet Union (Hooson 1966)



Map 2: Electric Power System of the former Soviet Union -- Regional Grids (Martinot 1992)

Map 3: Favorable Wind Resources in Russia

Map 4: Favorable Solar Resources in Russia

Map 5: Favorable Biomass Resources in Russia

Map 6: Favorable Geothermal Resources in Russia

CHAPTER 6

TECHNOLOGICAL CAPABILITIES

This chapter shows that Russians have a technological capability that parallels most developed countries. Their technological infrastructure, scientific and technical knowledge, engineering and technical skills, factories and equipment are all well developed. What Russians still lack are the associated managerial, financial, legal, and market-transaction skills and institutions to take full advantage of that capability for themselves and in a global economy. They also lack "commercial know-how," which is an innovative, creative, and experience-based (not necessarily technical) ability to turn an idea or design into a reliable, quality commercial product or service. A large component of this deficiency is simply the lack of experience in producing for quality. Commercial know-how can often only be acquired through experience, and it is this experience base that the Russians lack. A common theme expressed by interviewees and seen in research evidence was "great ideas and opportunities exist if only they could be evaluated and commercialized."

These technological capabilities and associated market-related deficiencies are the direct results of the Soviet paradigm of economic development practiced for 70 years (see Nove 1986 and the Soviet Management Culture and Decline of Centralized Coordination annexes). These capabilities and deficiencies are what set Russia apart from both developed and developing countries in terms of both models of economic development and technology transfer. Russia can be considered a developed country in terms of its technological infrastructure. But the managerial, financial, legal, and market-transaction related shortcomings mean that ordinary market-based models of technology transfer between private commercial entities seeking to maximize short-term and/or long-term profits do not apply fully. Conversely, this technological capability means that models of development and technology transfer to developing countries in which this technological capability must be concurrently developed do not apply fully either. Further, some of the old conditions from the Soviet period still apply today, and so models of East-West technology-transfer still partly apply. These arguments are developed further in Chapter 8.

Soviet Technological Lag

While Soviet technological development paralleled many developed countries, it persistently lagged behind that of Western countries due to the relative isolation of the economy from the West, and because of serious deficiencies in innovation that resulted from systemic features of the economic system (see Soviet Management Culture and Decline of Centralized Coordination annexes). Morris Bornstein (1985) attempted a general categorization of Soviet technological lag as follows: (a) in high-priority, high-technology areas like military weapons and electric power generation and transmission, Soviet technology was on a par with the West; (b) in high-priority but lower-tech industries like steel, chemicals, and machine tools, Soviet technology was good at scaling up established technologies (larger open hearth steel furnaces), but poor at introducing new ones (oxygen-converted steel); (c) in lower-priority higher-tech industries like synthetic materials, computers, and automobiles, the technological lag was very pronounced; (d) in other sectors (food-processing, most consumer durables) the gap was largest.

The relative isolation of the Soviet economy from Western scientific and technological activity has meant that in many sectors of the economy the level of technology has been shaped overwhelmingly by domestic factors, according to Cooper (1991). While the Soviets invented and developed a great many new technologies, their capability to diffuse these technologies within the Soviet economy was often poor, leading to large "technology gaps" not in capability or understanding, but in adoption within productive sectors of the economy. In the energy sector, the Soviets had highly developed electric power system technologies, a viable nuclear program which nonetheless was slow to diffuse, and backward oil and gas technologies. In steel making, the continuous casting process, originally invented in the Soviet Union, produced only 20 percent of total output in 1991, compared to 90 percent or more in other countries (the Soviet Union originally sold a license for this technology to Japan). In the chemical industry, while more traditional products are produced in bulk, newer products like plastics, synthetic fibers, ceramics, and composites have been developed but are produced in much smaller quantities relative to Western countries. In cement and paper, "one finds a bias toward the volume production of relative low-grade products using traditional technologies, to the neglect of high-quality products and modern processes" (Cooper 1991, p.44). Similarly in machine tools: "the Soviet machine tool industry is capable of producing modern machine tools up to world standards, but the volume of output of such machines is limited, and the highest priority sectors are the main beneficiaries....Again we find the familiar pattern of the mass use of inferior resources" (p.44). Electronics and computing are an area where clearly the Soviet Union lagged the West, and this is expected to continue, with the vast majority of computing needs supplied by imports. Consumer products are perhaps the most backward, as the design of most washing machines now in production dates back to the 1950s, and half of all televisions produced are still black-and-white.

Energy Efficiency and Renewable Energy

The case studies and evidence showed that Russian enterprises do not need to buy Western hardware or Western technical consulting assistance in order to make themselves more energy efficient or develop renewable sources of energy (although many are actively seeking Western hardware). This may be unfortunate for Western businesses attracted to Russia by the prospect of selling their own equipment. With efficiency and renewable energy, which tend to be rather simple, straightforward technologies, the technical capability exists to produce and install all these technologies domestically. If computers are required, the hardware (PCs and controllers) will probably be imported, but software can be developed domestically. The research evidence included several examples suggesting that Russians are taking to software development in enthusiastic droves, since the main input is skilled human labor (which is in abundant supply), and since little capital investment (which is scarce) is required.

Campbell (1985), in describing the old Soviet system, agrees:

> Replacement of old equipment by energy saving versions involves some new technology inputs, especially insofar as it depends on computers, control apparatus, new materials, and similar refinements, a set of factors which generally represent difficulties for the Soviet system to manage. But for the most part the creation of more energy-economizing technology is something they can handle." (p.160)

The case studies provide several examples where domestic Russian technology exists comparable in function to foreign technologies, but at much lower cost. The head of the Moscow Government Department of Energy Efficiency, in discussing some of the early opposition to the Honeywell Tushino project (Honeywell case study), said that five plants rather than just one could be upgraded for the same money if domestic Russian technologies were used (interview 8/12/93). He was referring to the Nagatino project in Moscow, which is also the subject of a case study here. While the Honeywell Tushino project employed technically sophisticated and expensive hardware, the similar Nagatino project illustrates that equivalent domestic technology can cost much less (see Nagatino case study). Case study data shows that the Nagatino project may cost on the order of one-third of the Tushino project for equivalent energy savings. Quality and reliability may be lower, however: the main difference between U.S. and Russian equipment is reliability, said an engineer for Honeywell Moscow (interview 9/20/93).

<u>Research Evidence</u>

Domestic development and production capability is one indicator of the level of technological capability. Another indicator is evidence of existing joint ventures with foreign partners using the technology in question. Below is evidence from the research on these two indicators for energy-efficiency and renewable-energy technologies.

(a) Production of energy-efficiency equipment. According to a senior researcher of the Center for Energy Efficiency (interview 9/7/94), foreign technologies that significantly outperform domestic ones are combustion analyzers, efficient heat exchangers, and thermostatic valves. Equipment by some domestic manufacturers can compete with foreign equipment for variable speed drives, industrial process controllers, and heat pipes. Many Russian manufacturers are trying to produce heat meters and valves, but their prices are high and foreign equipment is more competitive and better quality. Energy efficient lighting can be produced domestically (notably at the 60,000-person Saransk lighting enterprise), but there are serious problems with quality relative to Western products. Temperature and pressure sensors are simple items produced by several manufacturers, but automated valves are produced in only one monopoly enterprise with a poor reputation for quality (interview with director of Thermo-IVS association, 2/4/94). Gas turbines are available surplus from former defense enterprises, often at fractions of the costs of foreign turbines, but quality relative to Western products is a problem, according to a World Bank official working on energy loans to Russia (interview 9/22/94). Factories in Moscow were capable of producing efficient sodium lamps, heat meters, heat pumps, new types of insulated district-heating pipeline, and automation and control equipment, but lacked the capital for conversion of their production equipment (interview with head of Moscow Government Department of Energy Efficiency, 8/12/93). Other research evidence was of a more general nature, like: "There are many [Russian] enterprises now which can supply this type of equipment [meters, controllers, valves, and temperature and presser sensors for district-heating system renovations]" said the head of the Mytishchi district-heating company (interview 2/22/94; see Mytishchi case study).

(b) Production of wind turbines. Wind-turbine technology development was proceeding at several enterprises. The Science-Production Association Yuzhnoye in collaboration with the Science-Production Association Vetroen were developing a 250-kW turbine. Another collaboration between Soven, Lenpromash, Radyga, and the Smolensk aircraft factory was developing a 250-kW turbine. A third collaboration was between Radyga, a prominent aerospace enterprise, and the Tushinskiy machine factory to produce a 1000-kW turbine. The first customer for this 1000-kW turbine was the Kalmykia electric utility, which plans to purchase and install 22 of these turbines (Kalmykia case study). There are two certification and test stations for these efforts, one in Ivangorod near St. Petersburg and one at the Cherkaskaya hydro station in Dagestan. The project institute of RAO "EES Rossii," along with Lengidroproyekt and Samaragidroproyekt are working on the design of several experimental wind power stations ranging in planned size from 2 MW to 50 MW in the Dagestan, Leningrad, Maritime, and Karelia regions. In the opinion of one German wind-turbine manufacturer (interview 4/28/94), Russia appears to be facing a long development process similar to what the West went through, and will probably have to make the same mistakes. This means trying vertical-axis designs before abandoning them because of problems with mechanics, reliability and fatigue; it means starting with big turbines and working down rather than the other way around; and it means trying to use aluminum blades (experience in the West showed that repeated stress caused aluminum blades to fail after a few years no matter how they were designed). Also, the experience in Germany and the United States with aerospace firms trying to build wind turbines was that these firms -- only dedicated wind-turbine companies succeeded. For example, the aerospace factory Radyga is using a gearbox on their 1000-kW wind turbine that came from their helicopters, but was designed to operate vertically. For the gearbox to be operated horizontally on a wind turbine, extra oil pumps may need to be added, which add to complexity and cost, whereas a dedicated wind-turbine company in the West would design a turbine from scratch without any oil pumps at all.

(c) Production of solar cells and water heaters (Perminov 1993a; Strebkov 1993; Kozlov 1994). Several enterprises were reportedly engaged in the development and production of solar photovoltaic cells for commercial application in Russia and for export. Some of these enterprises were former military plants. One joint venture with an American company was reported. Production capacity of photovoltaic cells for space applications was historically 500-kW/year in several enterprises, according to a solar energy researcher at the Khrzhizhanovskiy Power Engineering Institute in Moscow (interview 8/15/93). Two factories associated with the association "Integral" in Minsk were also reportedly developing a production capacity of 1 MW/year. There was apparently just one company in Russia producing active solar-thermal systems, as the remainder were located in more southern republics of the former Soviet Union (Ukraine, Central Asia, etc.). According to the head of the renewable energy department of the national electric utility RAO "EES Rossii" (interview 2/23/94), there are about five enterprises in Russia capable of producing solar collectors and another five enterprises capable of producing solar photovoltaic cells.

(d) Production of geothermal power stations. Several production enterprises in the Far East were reportedly working on small (500 kW to 20 MW) geothermal power stations (Perminov 1993a).

(e) Production of variable speed drives. Variable speed motor drives (VSDs) are a good example of a technology that does require substantial adaptation from Western versions. Unless VSDs are sold together with Western motors (not likely if a VSD is being installed to improve efficiency of an existing motor), they will have to be compatible with Russian motors. Typical motor voltages in Russia are 380 and 600 volts (V), so that Western VSDs designed for 480V have to be modified to accommodate these motors. These modifications involve substantial redesign, potentially increasing the cost of Western-supplied VSDs. For mid-range and larger motors, the standardized power (kW) ratings are also different from those in the West and could also necessitate VSD redesigns. Thus domestically-produced VSDs will have the advantage over imports of not requiring special production or modifications. This advantage could be exploited by Western manufacturers through joint ventures adapting Western designs and producing to domestic requirements. The director of the Electric Power Research Institute in Moscow estimates that there are perhaps three enterprises in Russia that have the capability to manufacture VSDs at quality and performance levels comparable to Western manufacturers (interview 9/9/94).

(f) Production of gas turbines. Gas turbine joint ventures in Russia have been formed by Pratt & Whitney, GE, ABB, and Siemens (other joint ventures related to energy have been formed by Babcock and Wilcox, McDermot, and Honeywell), according to an official of the United States Foreign Commercial Service in Moscow (interview 8/10/94; U.S. Embassy Moscow 1993a, 1993b, and 1994a). Siemens already produced its first gas turbine in 1994 through a joint venture with the Leningrad Metal Factory in a $600 million deal. Siemens also signed a deal in 1993 to buy a partial share in the Kaluga turbine plant and jointly produce turbines after an infusion of Siemens' production equipment. ABB has a joint venture called Uniturbo to produce gas turbines with a Russian military jet manufacturer ("Saturn"). A joint venture between St. Petersburg's Kirov engineering factory, one of the largest engineering complexes in Russia, and General Electric was proposed in August 1993, with GE contributing half of the $1.2 million necessary for a feasibility study, and the United States Trade and Development Administration contributing the other half (Moscow Times, 8/12/94, "G.E. and Kirov Plan Production of Turbines"). Production would be based upon GE's design, would use Russian components, and would be primarily for the Russian market. GE would supply $10 million worth of production equipment.

(g) Industrial energy efficiency audit capability. While the case studies showed that industrial enterprises can be well aware of the technical opportunities for energy efficiency in their facilities, there is often less understanding of the economics involved, especially in making a comparison of costs and benefits and calculating payback time or indicators like internal rate of return (Moskvich and Minsk Industrial Factories case studies). It appears that many energy audits can be done without much training but do require some specialized equipment, which many enterprises lack. The USAID and European Union case studies illustrate audits conducted by Western consultants with Western equipment. A senior researcher of the Center for Energy Efficiency who has focused in the area of industrial audits estimates that there are perhaps 10 firms in all of Russia with the capability to conduct energy audits in industry; four are known in Moscow, one in St. Petersburg, and one in Kostroma (interview 9/7/94). Given the enormous size of Russia and the great potential for many savings to be identified through industrial audits, it would seem that this capability would need to be a hundred or thousand times greater to satisfy the need if other transaction barriers can be overcome and if macroeconomic reforms and change create the conditions for greatly increased investments in energy efficiency.

(h) District-heating system renovations. Both the Mytishchi and Nagatino case studies illustrated projects that used primarily Russian technology, engineering, and installation to achieve significant energy savings in district-heating systems. The director of the Mytishchi district-heat company boasted of this work in 1994 (interview 2/13/94): "Within two years our experience will be used throughout Russia. Its straightforward and we can do it. We are already working with five other district-heating systems to install similar systems."

Technology Transfer and Technological Capability

The ways of acquiring domestic technological capability were characterized by Rosenberg (1982) as follows: (1) Learning by doing; (2) Learning by using; (3) Minor technological improvements; (4) Cost-reductions through improved maintenance and reliability; (5) Technological improvements that generate better science; (6) Growing interindustry relations. Acquisition has varied widely among different societies:

> One of the most compelling facts of history is that there have been enormous differences in the capacity of different societies to generate technical innovations that are suitable to their economic needs. More there has also been extreme variability in the willingness and ease with which societies have adopted and utilized technological innovations developed elsewhere. (p.8)

Ahmad and Wilke (1986) see technology transfer as a means to foster indigenous technological capabilities:

> Arms's length transfers between multinationals from rich countries and local firms have served in India, Taiwan, South Korea, and elsewhere to encourage innovation. So have joint ventures for export from developing countries that emphasize quality control. [To be successful] the rule seems to be that rich-country multinationals should either have a direct

> economic stake in local learning or else be sufficiently distant so that local firms are free to tinker. (p.103)

Conversely, "indigenous absorptive capacity" is seen by many authors as an important and necessary condition for technology transfer with developing countries. Rosenberg (1982) argues that "the most distinctive factor determining the success of technology transfer is the early emergence of an indigenous technological capacity" (p.271). Vernon (1985) takes this one step further and argues that the ability to absorb technologies from another country is becoming the single most important factor in the economic success of any particular country.

Technology transfer to the old Soviet Union and now to Russia has helped and will continue to help innovation in two key areas: quality and technology demonstration. Quality is still a big stumbling block. One of the main Western perceptions of Russian products is that their quality is dramatically inferior to equivalent products in the West. Quality assurance, statistical quality control, management for quality, and other methods common in the West are uncommon in Russian industries not in the military sector. The defense industry is a special case, because incentives were much more oriented to production for quality. Yet when given the chance, Russian workers can happily and easily produce to a Western quality standard given the proper training, motivation, and tools, as was seen in Danfoss's new manufacturing plant for thermostat control valves in Moscow (Danfoss case study).

Second, Russians want to see foreign technology demonstrations. This is natural and will help the process of technology innovation in Russia. Demonstration projects like the Honeywell Tushino district-heating system renovation (Honeywell case study) serve a legitimate function. Russian enterprises need to be able to see what is possible with Western technologies. By doing so they become more conscious of a technology gap if one exists and are more motivated to innovate to close the gap. They see the results and develop trust in a particular Western company and/or technology and are more likely to seek and enter into joint venture agreements with that company. They realize that they could do the same thing cheaper and thus see an opportunity for economic competition. In explaining why the Moscow government spent $1 million in hard currency on the Honeywell Tushino project, the head of the Moscow Government Department of Power Engineering and Energy Saving said that the government first and foremost wanted to see the capabilities of the Western technology (interview 2/9/94).

Missing Capabilities

The missing capabilities for technology transfer, technology development, and market-building for energy efficiency and renewable energy are business management, finance, marketing, product development, economic analysis (like cost-benefit and lifecycle analysis), legal, and accounting skills. A USAID energy consultant in Moscow and an official of the World Bank working in Moscow both acknowledged that these business skills were lacking, but emphasized that Russians were learning them very fast, especially through people-exchange arrangements where Westerners and Russians have the opportunity to work side-by-side in a market-oriented environment in a Western country (interviews 9/1/94 and 9/22/94). "No one knows how to write a Western-style business plan here" echoed the director of the Electric Power Research Institute in Moscow, who was engaged in establishing production of variable speed motor drives (interview 9/9/94). Because of the barriers to innovation that were present in the old Soviet system (see Soviet Management Culture and Decline of Centralized Coordination annexes), capacities for skills like innovation, creativity, and managed risk-taking are also lacking and need to be developed.

These missing capabilities were seen repeatedly in many of the case studies (especially the NUTEK Biomass-Fueled-Boiler and World Bank Enterprise-Housing Divestiture case studies). The experience from the case studies and research evidence is also supported by other recent published sources. In the May-June 1994 issue of Harvard Business Review ("The Russian Investment Dilemma"), Jean-Pierre van Rooy, the president of Otis Elevator Company, in speaking of Otis's joint venture in Russia to manufacture, install, and maintain elevators, says that "although our new Russian employees may lack expertise in sales, marketing, and accounting, their engineering skills are terrific. For example, they have already identified mistakes in some of our drawings. The transfer of Western technology into the ventures is going relatively smoothly for that reason" (p.37). In the same issue, Constantine Nicandros, President and CEO of Conoco, finds "the technical capabilities of the Russian workforce to be superior....We have also discovered that the existing infrastructure can be used effectively with much less upgrading than we originally thought....We have, of course, encountered logistical, efficiency, and managerial shortcomings...[but] I am convinced that once [our Russian colleagues] are given the tools and the opportunity to use them in a rewarding environment, their successes will rapidly rival those found in OECD countries" (p.40).

Another missing capability is that which comes from operational and commercial experience over a longer time period (and is often called "trade secrets" in the corporate world). In discussing Russian production of wind turbines, the head of the renewable energy department of the national electric utility RAO "EES Rossii" (interview 2/24/94) said that while American wind-turbine technology was not needed, American experience with operating and maintaining turbines would be critical to the success of Russia's programs. There is definitely truth to this. Extensive Western experience with operating wind-turbines and refinement of designs based upon this experience has not occurred in Russia. The most recent 15 years of wind-power development in the West has shown that this experience is critical; Western designs that have benefitted from this experience will be far more efficient than existing Russian ones. Yet as discussed elsewhere (see the Windenergo case study, the "technological pride" transaction barrier in Chapter 7, and the discussion in Chapter 9 of joint ventures), Western companies may be unwilling to provide this experience unless it is in the context of a joint venture or licensing agreement through which they can benefit.

The studies reviewed by Reddy and Zhao (1990) give several topologies of technological capability (Table 2). Common measures of this capacity are the ability to export technology, indigenous R&D, and education. A summary analysis of where Russia's strengths and weaknesses lie is summarized also in Table 2.

TABLE 2: TOPOLOGIES OF TECHNOLOGICAL CAPABILITY FROM THE LITERATURE AND CORRESPONDING RUSSIAN CAPABILITIES

Topology		Strong Russian Capabilities
I.	people	Yes
	operational experience	Yes
	effective organization	No
	problem sensing and solving mechanism	No
	necessary values and attitudes	Partly
II.	production	Yes
	investment	No
	innovation	No
III.	operational	Yes
	duplicative	Yes
	innovative	No
IV.	purchase of technology	Partly
	plant operation	Yes
	duplication and expansion	Yes
	innovation	No

CHAPTER 7

TRANSACTION BARRIERS

Chapters 4 and 5 showed that huge technical opportunities exist that are economically profitable. These opportunities are not translated into economic activity by domestic enterprises or by foreign entities through technology transfer because of serious transaction barriers. In this chapter these barriers are categorized and explained with reference to the research evidence. These barriers also are compared with the barriers described in the literatures on energy efficiency, renewable energy, and technology transfer.

Transaction barriers are more commonly called "market failures," "market imperfections" or "market barriers" in the energy-efficiency literature. Johnson and Bowie (1993) suggest that "market barriers" comes closest to an institutional explanation for why expected market functioning does not occur. Kenneth Arrow (Williamson 1989, p.11) suggests that "market failure is a more general category than externalities and its is better still to consider a broader category, that of transaction costs, which in general impede and in particular cases completely block the formation of markets." The hybrid term "transaction barrier" is more suited to cover energy efficiency, renewable energy, and technology transfer together. It also is more suited to an interdisciplinary treatment that includes economics, technology, geography, institutions, organizations, culture, and politics. When speaking of technology transfer, decisions to engage in technology transfer are decisions to conduct transactions, and the mode of technology transfer selected represents the type of transaction necessary.

Transaction barriers are grouped below into several major categories, relating to: macroeconomic conditions, lack of information, technical and geographical characteristics of heat supply infrastructure, institutions, organizational forms, culture and education, and politics. Barriers are summarized in Table 3 and covered below by category. The main influence of a

TABLE 3: TRANSACTION BARRIERS TO ENERGY-EFFICIENCY AND RENEWABLE-ENERGY TECHNOLOGY TRANSFER AND INVESTMENT IN RUSSIA

A. MACROECONOMIC AND BUSINESS ENVIRONMENT

A1. Lack of Reasonably Priced, Long-Term Capital
A2. Changing and Conflicting Tax and Tariff Laws and Enforcement
A3. High and Variable Inflation Rates
A4. Currency Conversion Regulations

B. LACK OF INFORMATION

B1. Lack of Information about Technologies, Opportunities, and Costs
B2. Lack of Information About Existence and Condition of Potential Partners
B3. Lack of Information about Site and Technology Specific Renewable Resources

C. TECHNICAL AND GEOGRAPHICAL CHARACTERISTICS OF HEAT SUPPLY

C1. No Existing Heat Meters -- Zero Marginal Cost Consumption and Uncertain Heat Savings
C2. Building Design -- Difficult to Meter Individual Residential Heat Consumption
C3. District Heat System Operating Regime Affects Heat Savings
C4. Centralized Heat Production and Distribution

D. INSTITUTIONS AND MARKETS

D1. Market Acceptance of Technologies
D2. Corruption -- Necessity to Bribe to Transact
D3. Mafia -- Necessity to Pay for Property Rights
D4. Conflicting or Missing Laws and Lack of Enforcement Mechanisms
D5. Weak or Missing Contract Institutions
D6. Interenterprise Debt
D7. State Ownership of Land
D8. Licensing Requirements
D9. Enterprise-Owned Residential Buildings
D10. Soviet-Style Accounting Practices
D11. Highly Personalized Economic Relationships and Networks
D12. Energy Supply Quotas and Allocations
D13. Equipment Testing and Certification Requirements
D14. Housing Privatization and Responsibility
D15. Institutionally Mismatched Costs and Benefits
D16. Institutional Complexity of District-Heating Systems

E. ORGANIZATIONS

E1. Monopoly, State-Owned, and "Post-State-Owned" Enterprises
E2. Separation of Innovation from Production
E3. Labor-Management Relations in Enterprises

TABLE 3 CONTINUED

F. CULTURE AND EXPERIENCE

F1. View of Capital as a "Free" Good
F2. Lack of Experience with Cost-Minimization, Innovation, Marketing, Financing, Negotiating, and Competition
F3. Cultural Conditioning for Deceit
F4. Technological Pride

G. POLITICS

G1. Involvement of Municipal or Federal Government
G2. Government Approvals and Political Influences
G3. Influence of Energy Supply Companies

large share of these barriers is greater uncertainty in transactions, either over costs, benefits, opportunities, and/or future actions. Other barriers limit full and correct information from reaching those who need it. Still others are related to legal institutions and 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. Of course transaction barriers do not occur in all situations, and there is also a difference between perceived and real transaction barriers. As the director of the EU Energy Center in Moscow put it (interview 9/6/94):

> Western mass media is the number one enemy of [foreign investment in Russia]. Western businessmen read newspapers and see only the horror stories and not what is working. 'Everyday life' needs to be seen. The perception 'its dangerous to go there' is what is creating the risk and uncertainty, not the reality.

A. MACROECONOMIC AND BUSINESS ENVIRONMENT

Many of the factors under this category could be grouped under the term "poor business environment," a term that Evans (1994) used to summarize general barriers to joint implementation for greenhouse-gas mitigation between Russia and other countries.

A1. Lack of Reasonably Priced, Long-Term Capital

The opinion of practically all Russians encountered and interviewed in the course of the research was that a lack of longer-term affordable capital was a key barrier to greater energy efficiency (see for example article by Usiyevich, 1993). Of course the lack of capital has its roots in risk and uncertainty: domestic commercial banks are unwilling to lend because of political and economic uncertainties, investment returns in the longer-term are risky because of uncertain and variable inflation, and high interest short-term loans for trading and short-term speculative activities are in demand (so why bother with longer-term loans?).

"The maximum time horizon for bank loans is two years now -- remodelling office space, currency operations, speculation" 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."

Foreign sources of capital are even less available, partly because of the perception by potential Western investors of a risky business climate and unstable political and economic conditions, but also because of the lack of strong legal institutions and contract enforcement, which makes returns from any loan or investment more risky (also refer to the Commercial Business Environment annex and other barriers below on legal institutions and contract enforcement). In 1992, Russia was rated 129th among 169 countries in terms of investment risks by Euromoney Journal, and in 1993 this rating slipped to 149th place, putting Russia soundly in the midst of many much poorer developing countries (Feller and Mikheyev 1994). In 1994 the rating improved to 90th place, but was still on a par with Iraq (Business and Investment in the CIS, 5/94, p.10).

Foreign government financing guarantees were historically provided by some countries for the Soviet Union, but many have been revoked in recent years. The president of a Dutch wind-turbine company, speaking of technology transfer to Russia (interview 4/28/94), said that his company needed risk insurance for a proposed joint venture so that if the expected returns in license fees, royalties, and export components did not materialize, his investment would be covered. The Netherlands has such a guarantee fund for foreign joint ventures, but Russia is not on the list (four years earlier the Soviet Union was on the list). China is on the list, and his company is doing a project in China.

A2. Changing and Conflicting Tax and Tariff Laws and Enforcement

Throughout 1992-1994, tax and tariff laws and enforcement kept changing radically and frequently, producing great uncertainty among businesses as to their future costs, profits, and returns from potential investments. There is supposed to be a hierarchy of laws ("zakon"), decrees ("ukaz"), and decisions ("resheniye"), but in practice many of these overlap or contradict each other. Further, local or regional tax regimes may conflict with federal ones. It is usually up to the individual customs officer, tax office, or whoever is enforcing a law to interpret conflicting laws and decide which ones to follow. A common theme during 1992-1994 in the Russian business press aimed at foreign businessmen was how the laws kept changing and how foreign business was kept away from investments in Russia as a result. A commercial secretary of the Finnish embassy in Moscow said that few Finnish companies choose to or could conduct business investments in such an environment (interview 8/10/93).

A3. High and Variable Inflation Rates

Inflation ranged from 10-40% per month in the period 1992 to early 1995 (Center for Economic Analysis and Forecasting 1993b; Center for Energy Efficiency 1995b), and great uncertainty still existed as to what would happen to inflation in the future. The variability of inflation and its high level led to great uncertainties in future costs and benefits of longer-term transactions, and consequently most business activity up to 1994 tended to be very short-term. "Its impossible to calculate real costs and profits for even a one-year project under the current inflationary conditions" said a commercial secretary of the Finnish embassy in Moscow (interview 8/10/93), "and companies won't invest with such uncertainty."

A4. Currency Conversion Regulations

Currency convertibility affects the ability of foreign investors in joint ventures or wholly-owned subsidiaries to recoup profits in hard currency, or their ability to receive paybacks from shared savings investments in energy efficiency. Without currency convertibility, barter exchange and counter-purchase agreements are necessary, as was the case in the former Soviet period (see the

Technology Transfer to the Soviet Union annex). The central characteristic of currency conversion regulations since 1992 has been their constant change.

According to Kvint (1994), "After July 1992, when the Russian banks began to hold exchange auctions, inconvertibility became less of a problem. Through banks and financial companies, Americans can buy dollars with rubles at these auctions, invest rubles in dollar-producing businesses, or opt for a barter or collateral deal instead" (p.72).

In 1994, several sources familiar with the financial markets in Russia insisted that the ruble had become fully convertible with Western currencies through the Moscow and other interbank exchange markets, and that any business with the right know-how could successfully negotiate the maze of requirements and procedures to convert rubles into foreign currency (interviews 9/3/94, 9/6/94, 9/22/94).

Yet the ruble is still far from freely convertible. Typically, conversion of rubles to foreign currency by Russian enterprises requires a contract in hand for purchase of goods or services abroad. With or without a such a contract, the "know-how" required to carry out currency transactions increases the costs of such transactions and often requires intermediaries. At least up to early 1995, Russian enterprises earning foreign currency profits from exports were allowed to keep only 50% of their profits in foreign currency, and were required to convert 50% to rubles on the currency exchange. Domestic ruble profits were not legally convertible into foreign currency.

B. LACK OF INFORMATION

B1. Lack of Information about Technologies, Opportunities, and Costs

B2. Lack of Information About Existence and Condition of Potential Partners

B3. Lack of Information about Site and Technology Specific Renewable Resources

The lack of information is a major problem for energy efficiency and renewable energy technology transfers and investments, and was evident in virtually all of the case studies. The lack of information results in many uncertainties, risks, and unavailable opportunities. There are many reasons for the lack of information:

- Historical centralization of information in the Soviet period
- Highly personalized contacts and networks as the basis for economic activity
- Lack of enterprise marketing departments and activities
- Constantly changing relative and absolute prices and costs
- Lack of financial disclosure and audit regulations and institutions
- Little historical experience on which to base cost estimates
- Cost estimates and data often not readily available or "free"
- Unmetered heat consumption means baselines are lacking

Many of these reasons are transaction barriers in their own right, beyond their contribution to the lack of information, and are discussed under institutional barriers below.

Information was centrally collected and controlled in the Soviet era, and often the greatest exercise of power was the control of information. Technical information often resided with central institutes or design bureaus, not with enterprises themselves (see Soviet Management Culture and Decline of Centralized Coordination annexes). Foreign technology-transfers and purchases in the Soviet era were made by central planning authorities, who were responsible for collecting and evaluating information about foreign technologies and firms (see Technology Transfer to the Soviet Union annex). In post-Soviet Russia, each enterprise or association of enterprises must perform these functions itself, often without benefit of prior experience, contacts, or databases. Conversely, foreign multinational, multilateral, and bilateral agents who were used to dealing only with central government authorities, after 1991 had to make contact directly with regional and municipal authorities and individual enterprises. The difficulties for foreign entities to obtain information about potential Russian partners or aid recipients were obvious in many of the case studies.

Many examples from the case study evidence show the severe lack of good cost estimations or no cost data at all. In the Moskvich Auto Factory and Minsk Industrial Enterprise case studies, energy-efficiency improvements were specified with great technical and operational detail by engineers in several types of enterprises, but they had no information on the costs of these improvements and were frequently at a loss as to how to obtain cost information. In the Energy Efficiency 2000 case study, the city of Vladimir had an ambitious program for energy-efficiency improvements in the city's district-heating systems, including technical measures and amounts of energy saved, but practically no cost data to enable calculation of investment needed and rate of return. The same was evident in the EPA/NRDC IRP case study.

Travel and communications costs also prevent greater information flow. Russian enterprises face high travel and communications costs to travel to Moscow or abroad to learn about potential technologies, their characteristics, and potential partners. So Russians depend on Westerners travelling to Russia. Western partners similarly have a difficult time learning about Russian partners. Either they must travel to individual regions of Russia (at greater time, expense, risk to personal safety and personal discomfort), or must seek referrals from central government officials or private intermediaries. Because of language barriers, face-to-face meetings with translators are often necessary. The infrastructure for internal travel within Russia, either by plane or train, is poor and fraught with service delays, flight cancellations, and risks to personal safety (from both crime and technical failures). For example, in 1994, the United States embassy in Moscow advised embassy personnel not to travel on domestic Russian airlines because of safety concerns. Western airlines serve just a few major cities within Russia.

Information about the financial condition of a particular enterprise is often difficult to obtain or determine -- it is sometimes extremely difficult or even impossible to separate the "good" from the "bad" (lecture by Erickson, 10/14/94). This is because there are no established financial disclosure rules, norms, or laws, and independent financial audit firms are relatively new (and primarily Western). In negotiating joint ventures, many Russian enterprises will either lie about or simply do not know about their financial situation -- earnings, profits, and debts (Kvint 1994). Thus for banks considering loans, energy-service companies considering energy efficiency projects, or potential joint-venture partners considering ventures, substantial risk can exist. Recourse to an outside independent auditor to examine a specific enterprise adds to transaction costs and may still not yield sufficiently complete information.

C. TECHNICAL AND GEOGRAPHICAL CHARACTERISTICS OF HEAT SUPPLY INFRASTRUCTURE

C1. No Existing Heat Meters -- Zero Marginal Cost Consumption and Uncertain Heat Savings

Almost without exception, no heat meters exist in residential and service buildings, and rarely in industrial buildings (see the District-Heating Systems annex). This has two important implications. First, building residents face zero marginal cost for their heat consumption. They pay a fixed monthly amount for heat, based upon the size of their apartment. But since residents have no means (valves) to control their actual consumption, the lack of heat meters is not seen as a problem to residents (they typically receive an oversupply of heat and open windows to control comfort).

Second, there is no historical heat consumption data with which to create a base line to project or measure energy savings. Even with installation of new meters during energy-efficiency improvements, the lack of historical metering and a "before" picture of heat consumption mean that energy savings will often have to be estimated based upon design standards or norms for the "before" consumption. Several of the case studies (Danfoss, Honeywell, European Union, Building-Energy-Efficiency 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 the estimates and projected or claimed energy savings. Several interviewees, including the director of one of Russia's first energy-service companies (interview 2/10/94), emphasized this barrier: "enterprises can't measure their energy consumption, and so are hesitant to do anything about it and just keep paying [for energy]." One of the barriers to joint implementation for greenhouse-gas mitigation between Russia and other countries cited in a study by

Evans (1994) was the need to measure and account for actual emissions reductions rather than calculated or theoretical reductions.

C2. Building Design -- Difficult to Meter Individual Residential Heat Consumption

If heat meters and valves were installed in individual apartments, and consumer bills were based upon actual consumption, then consumers could regulate their own heat and would face the marginal costs of such regulation. One obvious problem would be the creation of an entirely new system of meter reading and billing.

But the more significant problem is that of meter installation. Because of the way heat distribution within buildings is typically designed (see District-Heating Systems annex), individual apartment heat metering and billing is problematic. Radiators are often connected in series in one-pipe systems, and the supply pipes run vertically through the building. Thus each of the four or five radiators in a typical apartment is connected to a different distribution pipe, making metering of total heat consumption costly (requiring separate meters for each radiator). Small, inexpensive stick-on evaporative-type heat meters (sometimes called "allocation meters") on each radiator are possible, and are used to allocate total building consumption across all apartments. But allocation meters need to be read and replaced individually once each year. These operations, along with billing and accounting, would add new transaction costs to heat supply. In the Danish Building-Heating-System case study, use of these allocation meters in conjunction with radiator thermostat valves in a group of apartment buildings was discontinued after one year when residents voted overwhelmingly not to replace them because of the replacement and meter-reading costs. But without individual apartment heat metering (for example if only building-level metering is installed), individuals have little incentive to control their own heat consumption even if radiator thermostat valves are installed.

In the Honeywell case study, a planned third stage of the project that would have installed radiator thermostat valves and building-level meters in apartment buildings was canceled. The reason given was excessive cost; part of reason was likely that the Moscow government (which paid for part of the project) would not stand to gain financially from such an investment if residents had no incentive to use the thermostat valves (without apartment-level metering).

C3. District Heat System Operating Regime Affects Heat Savings

The operating regime and heat production levels within a district-heating system affect the potential savings from energy-efficiency measures within that system, giving greater uncertainty to future economic returns from such improvements. This was illustrated in the Building-Energy-Efficiency Renovations case study, in which one five-story apartment building was retrofitted with basic energy-efficiency measures. The retrofits were part of an experimental measurement program in which a side-by-side comparison of a retrofitted and reference building over two heating seasons was conducted to obtain accurate measurement results. An original estimate of energy savings from the measures was 30%, but the actual savings achieved was only 15%. One of the reasons cited for lower savings was that in the years of measurement, the heat supply regime was altered and much lower levels of heating were supplied (comfort was drastically lowered). In some regions of Russia, especially those with poor fuel availability or especially high fuel prices or low incomes, the heat output of district-heating systems has been lowered so that costs are lower. In an undersupply regime, the most cost-effective technical energy-efficiency measures are different than those in an oversupply regime. Thus the economic benefits of technical measures will depend upon whether a district-heating system is overheated or underheated in the future.

A further problem, underscored in the World Bank Enterprise-Housing Divestiture case study, is the combination of heat supply regime adjustment and the well-known "take-back effect" associated with energy efficiency. If the district heat-supply company does not adjust heat output in response to changes in building heat load through energy-efficiency improvements (or potentially in the future from changes in customer load due to thermostatic or building-level valves), then comfort may increase in underheated buildings or properly heated buildings may become too hot, but no fuel is necessarily saved and no financial returns occur. Adjustment of district-heating system output is based upon outdoor temperature only (see District Heat System annex), but in the future this will be a very complicated technical, legal, and organizational problem.

C4. Centralized Heat Production and Distribution

Because of the patterns and nature of Soviet urban development, in which large numbers of apartment blocks were constructed together to accommodate migration of population from the country to the cities, and because of the prevailing ideology, extremely large centralized district-heating systems made sense to the Soviets (see the District-Heating Systems annex). Often one heat plant provides space heat and hot water to hundreds of thousands of people. Yet these large central systems are not amenable to marginal energy efficiency changes on the end-use side. Any reduction in consumption in one building may only result in increased consumption in neighboring buildings, rather than fuel savings at the power plant. And even if fuel savings do occur, whose power plant they occur in is often not clear either because of the mixed responsibility (among city governments and utilities, regional energy utilities, and private enterprises) for technically-integrated district-heating systems. This problem is very closely connected with the previous one of operating regimes, the "take-back effect," and control and metering of these territorially large and technically integrated systems.

D. INSTITUTIONS AND MARKETS

D1. Market Acceptance of Technologies

Market acceptance of technologies was seen as a critical barrier by many interviewed. Until the performance and characteristics of technologies are demonstrated in real field experience in Russia, market acceptance will continue to be a barrier. While many energy-efficiency and renewable-energy technologies are mature in developed countries, they are virtually unknown (or at least non-existent) in Russia. Market acceptance was a partial justification for many of the activities documented in the case studies. Honeywell (case study), IVO International (case study), Danfoss (case study), Kenetech Windpower (Windenergo case study), and other Western companies were all trying to build markets and market acceptance of their products by engaging in demonstration projects. Honeywell spent $2 million of its own money for the Tushino demonstration project with this goal in mind. Kenetech invested $5 million from 1992 to 1994 in a technology transfer effort, also with this goal in mind. Danfoss was amassing demonstration experience by convincing government officials to install its products in government buildings.

In the case of the Honeywell project, the Moscow government contributed $1 million because it wanted to see the technology perform, and to get a better idea of its characteristics and energy saving potential in a physical demonstration, according to the head of the Moscow Government Department of Energy Saving (interview 2/9/94).

One of the primary goals of bilateral development agencies seen in the case studies was to provide assistance that would open up markets in Russia for products of firms from the assistance-granting country. Much of the assistance by USAID (USAID case study), the Danish Energy Agency (Danish Biomass-Fueled-Boiler case study), and the Swedish Board for Technical and Industrial Development (NUTEK case study) provided demonstration projects, which help create market acceptance of technologies and vendors from the United States, Denmark, and Sweden.

The value of technology demonstration as a vehicle for building markets and market acceptance should not be underestimated. In the interviews, Russian managers and officials active in the energy efficiency field were asked for the best way for foreign companies to learn about the Russian market and introduce their products into it. Their answers were the same: "conduct a small demonstration project, as a gift if necessary, and in so doing you will learn everything you need to know about working in Russia." Their answers also reflected a particular side of contemporary Russian investment culture, which could be phrased as "we [Russians] talk a lot but do little -- action means a lot, and we want to see it before we invest in it." This cultural characteristic has roots in the former Soviet economic system, where the differences were often huge between plans and actualities, and between reports of performance and actual performance.

D2. Corruption -- Necessity to Bribe to Transact

Corruption is an accepted element of business in Russia. Many Russians even see it as the only way to overcome the enormous frictions present in the economy; "without corruption, nothing might get done at all" was a common view (Mafia and Corruption annex). Many examples, both large and small, were uncovered in the research evidence and in printed sources. In speaking about obtaining foreign supplies, the manager of the Aerostar hotel in Moscow said:

> Customs is the biggest problem. There is no such thing as a written scale of taxes. You just have to trust the officials. They change the customs point when they want to, the trucks are opened every time, and things always go missing...Tulips for the opening party were stuck at the airport for day until a clerk was bribed to release them, and 120 lobsters flown in for the weekly seafood night were held to ransom. (Mayer 1993, p.35)

A commercial secretary of the Finnish embassy in Moscow said that Finnish firms routinely pay government officials for the right to do business. Typical payments are 5% of a deal to each person in authority who must approve the deal, which adds up fast. "Russians see this as a normal way of doing business" he said (interview, 8/10/93).

The general director of the Mosmatic joint venture (Mosmatic case study), in describing obstacles to the success of the joint venture, cited corruption and mafia as ever-present problems, with which every enterprise has to contend. Without the right bribes in the right places, made possible with the right connections, many contracts will be lost even if bids and proposals are high in merit, he said (interview 9/9/94).

D3. Mafia -- Necessity to Pay for Property Rights

In Western societies, property rights are enforced by the government, the courts, and the police. While property right protection is not costless (registration, legal and court fees are sometime necessary, along with private alarm systems and security personnel), it is not considered a costly activity. In Russia, mafia effectively enforce property rights more often than the government does (Mafia and Corruption annex). This form of property rights protection often comes at a steep cost. A retail store in Moscow may pay 10-30% of revenues for protection, for example, as reported by one businessman interviewed and several newspaper stories.

While the relevance of mafia to energy efficiency and renewable energy in Russia would not seem large, the pervasiveness of mafia activity in all spheres of economic life in Russia makes this an important issue nonetheless. Joint ventures may face situations in which they must pay for property right enforcement, and energy installations (conventional or renewable) or transmission facilities are always vulnerable to mafia influence.

D4. Conflicting or Missing Laws and Lack of Enforcement Mechanisms

Not only is civil law weak in general, but what laws do exist are often contradictory (lecture by Erickson, 10/14/94). Many aspects of business activities are not covered by any existing laws. Where such laws do exist, in particular laws covering the amounts, methods, and types of taxes on profits and custom duties, the laws keep changing drastically (see barrier A4). There is supposed to be a hierarchy of laws ("zakon"), decrees ("ukaz"), and decisions ("resheniye"), but in practice many of these overlap or contradict each other.

D5. Weak or Missing Contract Institutions

By "contract institutions" I mean not only formal institutions for resolving contract disputes or enforcing contracts, but also more informal ones like a consensus on standard practice in particular fields or industries, to which reference can be made in contracts (thus contracts must stand alone and must specify all relevant information and understandings directly in the contract). Accepted payment, delivery, and guarantee norms is another example of a contract institution that is still in infancy in Russia.

Existing laws that do cover contracts are not enforceable because a viable court system does not exist. Often it becomes necessity to resort to private third-party arbitration or enforcement (either neutral arbitration or the "rule of murder" referred to in the Mafia and Corruption annex).

D6. Interenterprise Debt

Another manifestation of the combination of weak law enforcement mechanisms, weak contract institutions, and rising relative energy prices has been mounting interenterprise debt, much of it for energy. Since 1992, the Russian economy has suffered from varying degrees of a "non-payment crisis" as it is popularly called (see Chapter 3). Debts between enterprises, the government, workers, consumers and the energy industries mounted in 1993 and 1994, threatening the stability of the economic system and the ability of many enterprises to keep working. Many enterprises continued to purchase or receive goods and energy supplies without paying for them. By January 1994 energy consumers owed 9 trillion rubles ($7 billion) to the fuel-and-energy industry and inter-enterprise debt was an equivalent amount.

Some observers felt that the non-payment crisis was not caused directly by economic reform, but indirectly as enterprises consciously withheld payments they could otherwise make because there were insufficient penalties and regulations to cause them to make on-time payments (Moscow News, 8/19/94, "How to Solve the Problem of Non-Payments"). This further underscores the weakness of contract enforcement mechanisms.

The non-payment crisis affects energy efficiency and renewable energy because it lowers fuel prices for conventional forms of energy under conditions of high inflation. If energy consumers pay their bills months late, the effective value of their eventual payment is reduced. And as yet no inflation-adjustment for delinquent debts had been incorporated into economic transactions. Energy supply companies are also reluctant to raise energy prices (and city governments reluctant to reduce heating subsidies) or impose penalties for late payments, for fear of still higher non-payments from consumers. This fear was voiced by the president of Russia's national electric utility RAO "EES Rossii" in a newspaper article (Business World Weekly, #8/101, 1994, "Russian Fuel and Energy Sector in Dire Straits"). The head of the energy efficiency department of the Ministry of Fuel and Energy said that penalties could not be imposed by the State Energy Inspectorate ("Energonadzor"; responsible for ensuring energy consumption in enterprises does not exceed established norms) for energy consumption above norms, because enterprises not paying for their energy would not pay penalties either (interview 2/9/94).

D7. State Ownership of Land

Land is generally still state-owned even when enterprises or buildings become privatized. This removes an important form of collateral for private banks to agree to loan money to make investments in energy efficiency (lecture by Erickson, 10/14/94). The World Bank Enterprise-Housing Divestiture case study showed that the lack of land for collateral was still a serious obstacle to obtaining private commercial capital for investments in industry and buildings.

D8. Licensing Requirements

Many types of transactions require licenses. Examples include export of oil or other goods and commodities (IVO International case study), sale of waste paper by publishing houses (Kvint 1994), and development of oil fields (Kvint 1994). The process of obtaining these licenses can be very costly (in manpower and in bribes), time-consuming to the point of being prohibitive, and with out assurance of ultimate success. Usually transactions are much easier and quicker by using Russian partners or intermediaries who already possess the license necessary for the transaction at hand, but this further increases transaction costs.

D9. Enterprise-Owned Residential Buildings

Enterprises in Russia still own a substantial share of residential buildings, a situation that is a holdover from the Soviet era when Enterprises commonly owned the social assets for their workers -- buildings, schools, hospitals, etc. In the case of enterprise-owned residential buildings where a substantial fraction of the residents do not work for the enterprise, an enterprise is under little pressure to renovate or properly maintain these buildings. Energy-efficiency improvements in these buildings, even if profitable, will receive low priority because enterprises ultimately seek to divest themselves of these assets (which are actually liabilities to them since they must subsidize the heating and maintenance costs directly). This barrier was evident in the World Bank Enterprise-Housing Divestiture case study.

D10. Soviet-Style Accounting Practices

Accounting systems and conventions in use in Russia are very different from conventional Western systems. Thus many types of transactions, joint ventures, and investments will require retraining of Russia accountants who must work with foreign accounting systems, and/or continual translation from one accounting system to another.

In the Kenetech case study, substantial resources were devoted to training Ukrainians in Western style accounting practices and in accounting for the joint venture's commercial activity within Ukraine in the Western style.

D11. Highly Personalized Economic Relationships and Networks

In the Soviet era, enterprises received orders from central planning organs and ministries for what to produce, where to get inputs, and where to send outputs (see the Decline of Centralized Coordination annex). Often an enterprise would have only one supplier and one customer. Horizontal linkages and relationships were few and weak. Economic activity since the demise of central planning has had to create these horizontal linkages, and has operated primarily on the basis of personal contacts and networks rather than impersonal, anonymous market institutions more common in the West. The lack of impersonal market-oriented arms-length transactions in the Russian economy means that economic activity and performance is very dependent on "who you know," and means that the costs and time to find and meet the necessary people and to establish relationships of trust with them are very substantial.

A vast reorganization of enterprises and industry has been taking place by the enterprises themselves, as described in the Decline of Centralized Coordination annex. Large enterprises are decentralizing. Smaller enterprises and R&D facilities are banding together into larger associations organized along particular functions, to combine the resources and skills of smaller specialized units into larger corporation-like entities with their own R&D, marketing, and financing capabilities. Part of these processes have been driven by privatization, pressures to remain competitive, the threat of massive layoffs, and the difficulties in obtaining necessary capital and materials inputs and finding markets for outputs. It has become increasing difficult for a small enterprise to operate by itself and secure inputs and find markets.

D12. Energy Supply Quotas and Allocations

Enterprises, suppliers of residential heat, and even many electric power utilities are not always able to receive the quantity of primary fuel or secondary energy that they want or need (see the Energy Consumption Quota annex). This particularly applies to natural gas, which is controlled by Gazprom, and to electricity, which is controlled by national and regional electric power utilities (see the Energy Supply Organizations annex). In general, gas and electricity supply utilities are under no obligation to serve existing or future demand. Rather, in situations where demand exceeds capacity, energy supply utilities allocate consumption among their customer base according to negotiated contracts with built-in quotas for each customer. The negotiated amounts relate to the "need" of the customer (as perceived both by the utility and by the customer). Penalties for consumption beyond quota were apparently quite steep; in 1993 the Moskvich auto factory in Moscow paid ten times the normal rate for electricity consumption over quota (interview with chief energy engineer, 7/6/93). Gas allocation quotas to municipal heat production enterprises were seen in the World Bank Enterprise-Housing Divestiture case study.

While quotas actually create an incentive for energy efficiency in one sense, they represent a barrier in another sense. Given a certain quota, an enterprise can serve unmet demand by improving efficiency in one place and using the "saved energy" elsewhere. But if the unmet demand was deemed "unnecessary" by the energy utility in the first place, the quota may be lowered and this incentive disappears. Evidence for this effect was seen in the research. In one enterprise in Minsk (Minsk Industrial Enterprises case study), the plant had substantial unmet demand for electric power (lighting and ventilation were turned down). The plant energy engineer felt that if the plant became more efficient in its use of electricity, the electric utility would simply lower its quota, rather than allow the enterprise to serve the unmet demand.

D13. Equipment Testing and Certification Requirements

For both domestic and foreign equipment producers of energy-efficiency and renewable-energy technologies, certification can be a major bottleneck to getting equipment on the Russian market. The requirements for certification are complex and vary by the type of equipment and application. Foreign equipment that has already been certified abroad may need to be re-certified for use within

Russia, or vice-versa. Certification bureaus may lack sufficient capacity and will charge fees for their services. The time delay for equipment certification may significantly increase product introduction times, but may also result in higher costs for investment projects; the bidding for equipment will be limited to equipment that has already been certified, potentially driving up costs. Equipment testing and certification was emphasized as a barrier by several interviewees, including a senior researcher of the Center for Energy Efficiency in Moscow (interview 9/15/94) and a Deputy Minister of the Estonian Ministry of Economy (interview 8/25/94). The problem was also evident in the World Bank Enterprise-Housing Divestiture case study.

D14. Housing Privatization and Responsibility

In a normal economic framework, 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 would form an owner association, pool their property rights under the association so that it had collateral, and the association would borrow money from banks to make energy-efficiency improvements. Besides the information and capital availability problems common in many other countries, this model has many serious flaws in Russia.

Privatization of apartments was underway in 1993 and 1994 in Russia, but did not lead automatically to improved institutions or incentives for energy efficiency in buildings. In fact, very little at all changed with privatization, other than tenants receiving the right to sell their apartment or deed it to their heirs. Even though 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 -- that of responsibility for the buildings -- was not altered with privatization.

Costs and charges for heat and other building services do not change after an apartment becomes privatized either. In fact the newly private owner sees no change in circumstances or costs after privatization; he still continues to pay the same monthly charges for rent (of land), maintenance, hot water, heat, gas, etc. Heat is still subsidized exactly as before.

Thus the municipal government remains in the position to invest in energy-efficiency improvements for a building. As long as the municipal government is subsidizing a large share of heating costs (currently 70-90% of heating costs are paid by the municipal government; see Chapter 3), the incentives and responsibility for improvements both reside with the municipal government. But as soon as residents begin to pay a larger share of their own heating bills (a federal law in 1994 mandated that subsidies should be eliminated gradually to zero by 1998), the municipal government will no longer directly benefit from investments in energy efficiency in buildings, and the incentives and responsibility become institutionally mismatched.

It is possible that owner associations will form and assume responsibility for building repair and maintenance, but several factors suggest they will not. The transfer of responsibility is likely to be much more complicated than most would imagine. For example, residents will worry about being responsible for a dangerous building in need of substantial repairs and be reluctant to assume this responsibility. A municipality will demand past-due rent and debts from all in the building before it will sign an agreement transferring its responsibility to the owner association, and will demand agreements regarding any outstanding external debts and loans on the building. Thus associations will be slow to form because of the required institutional innovations, agreements and transfers of responsibility. If participation in the association is mandatory, tenants will refuse to join. If not mandatory, the problem remains what to do with the "outsiders." Tenants will refuse to assign their property rights to the association; after all, their apartment is their first ever experience with private property, why should they now give it away? Thus any owner association that does form will not have collateral with which to secure loans. Any loans for common renovations thus would need to be individually secured by every tenant in the building; surely an impossible feat. All of these issues were evident in the World Bank Enterprise-Housing Divestiture case study.

D15. Institutionally Mismatched Costs and Benefits

Two examples show the problem of institutionally mismatched costs and benefits, or incentives for investment and responsibility for investment. The first example was given just above in the "Housing Privatization and Responsibility" barrier. In 1995, costs and benefits of efficiency improvements were institutionally matched: both resided with the municipality. But if responsibility for building maintenance and repair remains with municipal governments, yet tenants begin to pay for a larger share of their heat consumption costs themselves, then the incentives and responsibilities will become mismatched. Thus the announced policy of reducing municipal government subsidies for heat supply until they (supposedly) disappear altogether in 1998 (see Chapter 3), may have the perverse effect of creating greater institutional barriers to energy efficiency in buildings.

A second example is that incentives and responsibility for heat supply distribution losses are mismatched. This point was made repeatedly to me in numerous seminars and discussions with city officials. Currently, municipal administrations (on behalf of residents, including subsidies) 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 (a "norm"), usually 10-15%, but distribution losses in reality are much higher (many estimates place distribution-system losses at typically 25-30%, figures that were confirmed by the case studies; see the District-Heating Systems annex). In effect, the municipality is paying for any distribution-system losses above the norm. Thus heat-supply companies have little incentive to improve the efficiency of heat distribution-systems, which are notoriously leaky and inefficient. If heat meters were installed in buildings, payment for heat as it enters buildings would shift the incentives for distribution-system improvements from the municipal administrations to the heat-supply companies themselves. The heat-supply companies own the distribution networks, and are in a position of responsibility to improve distribution efficiency. Indeed, several of the case studies (IVO International, World Bank Enterprise-Housing Divestiture, World Bank Energy Sector, and Honeywell) showed that many opportunities are available to district-heating companies to reduce distribution-system losses if the incentives existed.

D16. Institutional Complexity of District-Heating Systems

Foreign assistance or loans for energy-efficiency improvements to district-heating systems face the barrier that management and ownership of these systems is often institutionally complex and fragmented, even though the systems themselves are technically integrated (see District-Heating Systems annex). Different organizations may be responsible for heat production, primary distribution, secondary distribution, heating equipment in buildings, and billing. Industrial enterprises may provide heat to a common system along with separate municipal heat enterprises and regional electric power utilities. Institutional complexity was one of two key barriers (in addition to financing) to district-heating system renovation cited by an official of the World Bank in Moscow responsible for municipal infrastructure lending (interview 1/20/94). Projects that attempt to provide technically integrated solutions to these systems must confront the institutional fragmentation and therefore must accommodate and include many different organizations.

E. ORGANIZATIONAL FORMS

E1. Monopoly, State-Owned, and "Post-State-Owned" Enterprises

Because of the specialized organization of production in the Soviet economic system, many existing enterprises are domestic monopolists. This means they may produce an output that is the only good of its type in the entire former Soviet Union (see Decline of Centralized Coordination annex). Except for foreign competition (weakened by high import taxes), domestic monopoly producers face few incentives to reduce the costs of production through energy efficiency. They are simply able to pass costs along to their customers. The same lack of incentives is true for state-owned enterprises, which face the same lack of incentives for innovation and cost-minimization that all former Soviet enterprises faced (see Soviet Management Culture annex). The same lack of incentives is even true for what Yavlinsky and Braguinsky (1994) call the "post-state-owned" enterprise (see the Economic Development and the Transition to a Market Economy annex). They argue that "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" (pp.92-93).

E2. Separation of Innovation from Production

The organizational separation of innovation and research and development from production in the Soviet era was well known (see Soviet Management Culture and Decline of Centralized Coordination annexes). This separation meant that enterprises traditionally lacked the ability to innovate on their own, and lacked research and development experience at an enterprise level. This lack of experience included both product and process design. Rather, innovation and research experience resides in scientific institutes and design bureaus, with whom an enterprise must contract for services. Conversely, design bureaus and research institutes have had little contact with production enterprises, and are not well-versed in the most pressing efficiency problems of production. This separation makes it more difficult for enterprises to innovate energy efficiency by themselves; they need "outside" partners to participate.

E3. Labor-Management Relations in Enterprises

One of the significant barriers to joint ventures comes from the institutional, social, and cultural dimensions of the micro-structure of Russian enterprises (lecture by Erickson, 10/14/94). In a joint venture with a Russian enterprise it may be necessary to shut down or eliminate part of the enterprise to make it profitable, and the barriers to doing this are similar to the more general problems of enterprise restructuring: the higher degree of control of the enterprise by labor rather than management and the huge resistance to change, overemployment, and extreme labor specificity, which makes change difficult due to retraining costs.

F. CULTURE AND EDUCATION

F1. View of Capital as a "Free" Good

Capital was viewed in the Soviet era as a free good, to be allocated based on technical, planning, and political criteria (see Soviet Management Culture and Decline of Centralized Coordination annexes). This view carries over to the present and makes economically efficient investment decisions more difficult. In the NUTEK case study, a boiler plant was offered capital on loan to finance conversion to biomass fuels. The management of the plant wanted to convert all three boilers within the plant to biomass, even though two of these boilers were only used for peaking. From an economic viewpoint, conversion of all three boilers was not economic (would not generate sufficient financial return to pay for the investment), and conversion of only one boiler was justified. But the plant management was not able to understand this concept; since the capital was available, why not convert all three? The consequence of this view is that enterprise managers may not make the most efficient decisions about the use of capital for energy-efficiency improvements.

F2. Lack of Experience with Cost-Minimization, Innovation, Marketing, Financing, Negotiating and Competition

Enterprise managers lack experience with cost-minimization, innovation, marketing, finance, negotiating and competition (see Chapter 6 and the Soviet Management Culture annex). This lack of experience results from decades of working within the Soviet economic system. 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. These subjects are taken up again in Chapter 8.

"Russians may have a marketing course, or a cash-flow analysis course, but no experience or understanding of the real world" said the deputy director of the EU Energy Center in Moscow (interview 7/6/93). Further, they are not used to independent thinking and to taking responsibility themselves, he said, because most workers in the Soviet era were accustomed to simply doing what they were told from above without question.

This problem carries over into all areas of business. For example, "Russians were slow to grasp the principles of negotiation" said the general manager of the Aerostar hotel in Moscow (Mayer 1993, p.35). Standard conventions and institutions of negotiation do not exist and so nothing can be taken for granted, increasing negotiation time and expense. One vintner negotiated sales of wine without mentioning that the wine sold did not include bottles or corks. If a sellers initial offer is rejected, that can sometimes amount to rejection of the entire transaction, rather than the beginning of a give-and-take negotiation.

F3. Cultural Conditioning for Deceit

One of the legacies of the Soviet era is that enterprise managers, ministry officials, and planners were routinely accustomed to lying when reporting economic information and performance, a practice that was considered culturally acceptable and often necessary for achieving normal enterprise performance (see Nove 1986 and the Soviet Management Culture annex). Yet the possibility of deceit adds greatly to uncertainties in economic transactions. The possibility of deceit also implies the importance of building trust and long-term economic relationships to transact, both costly activities in themselves, and makes short-term or one-time market transactions more risky.

F4. Technological Pride

Technological pride was emphasized by a number of Russians interviewed. It becomes a barrier when disagreement arises over whose technologies to use (for example in a joint venture or technology transfer decision), or whose consultants to use (for example in technical assistance). One typical response to USAID programs of technical assistance using U.S. consultants was "we have highly skilled and qualified people -- we do not need foreign technical consultants telling us what to do." Because Russians are technically skilled and sophisticated, the ideas, technologies, and intrusion of Western agents will not always be welcome. One of the barriers to joint implementation for greenhouse-gas mitigation between Russia and other countries cited in a study by Evans (1994) was the mismatch of the Russian desire to use Russian technologies with the Western desire to use Western technologies.

Technological pride is an important barrier to joint venture formation in Russia, because the Russians have many of their own equivalent technologies already, although maybe not at an advanced stage of commercial development. Wind turbines illustrate this problem. As shown in the wind-energy case studies, Russian and Ukrainian enterprises have developed their own wind turbine technologies and designs and would like to enter into joint ventures to produce and sell these designs. But one manager from a Western wind-turbine company said that his company would never consider using Russian technology in any joint venture. The Russian technology was simply not proven enough nor of sufficient quality or sound design, in his view. He would insist on his own company designs, which naturally he felt were the best (interview 4/28/94).

When Kenetech Windpower approached Russians about joint venture possibilities, it insisted on using its own technologies, while the Russian side was looking for partners to exploit Russian designs, according to the head of the renewable energy department of the Russian national electric utility RAO "EES Rossii" (interview 8/11/93). "But [Kenetech] said no and went to Ukraine" (see Windenergo case study). The general manager of Windenergo in Ukraine put it this way: "Now we are poor and have no money, so we have to produce a licensed machine [through a joint venture]. We just can't do it on our own with our own technology anymore, like we could have ten years ago" (conference presentation, 4/28/94). This pragmatic view was not well-received by the Russians in the conference room who heard it, in my opinion.

G. POLITICS

G1. Involvement of Municipal or Federal Government

In many cases it may be necessary to secure government participation in energy efficiency and renewable energy projects. This participation will have to be secured through political rather than economic means. In every single case study investigated except for IVO International, municipal or federal governments were a direct participant, either as transaction partner, equipment purchaser, or guarantor, even in the commercial-sector cases. For example, in the Windenergo joint venture, the Ukrainian government was the Ukrainian partner. In the Danfoss case study, Danfoss was selling radiator thermostat valves primarily to local governments. The Honeywell Tushino project was only made possible through a $1 million grant from the Moscow government and strong political support from the Mayor of Moscow. City governments were to borrow and guarantee credits from the World Bank for energy-efficiency improvements in residential buildings in the World Bank Enterprise-Housing Divestiture case study.

G2. Government Approvals and Political Influences

Government approvals were cited as a factor inhibiting Finnish commercial activity in Russia, according to a commercial secretary of the Finnish embassy in Moscow (interview 8/10/93). He said that companies had to obtain government permission for most any business deal they wanted to make . Many layers and levels of bureaucracy exist within government bodies that can effectively block projects if other political constituencies are against proposed foreign technology transfer or if officials decide that bribes or other special compensation are in order. IVO International had agreed with Kareliaenergo to make investments and provide equipment for energy efficiency in a combined-heat-and-power plant, but the deal stalled for several months because of approvals within the government (IVO International case study). Eventually, the Ministry of Economy, the Ministry of Fuel and Energy, and the Ministry of Foreign Economic Relations all had to approve a deal to export oil in repayment for the investment, and IVO International invested substantial effort to get these approvals (interview with regional director of IVO International office in Moscow, 10/1/93).

There are many powerful industrial and business lobbies within the government, and if a new foreign venture (either joint venture or wholly-owned subsidiary) is filling a niche that does not exist, then chances are it will be successful. But if its proposed products or services overlap those of power lobbies, then the foreign company will not get anywhere because of the ability of these lobbies to block approvals (no matter what the laws say), according to two investment bankers (interviews 9/1/94 and 9/3/94). Foreign businesses know that they cannot get anywhere without these approvals, and carefully verify government support all up and down the hierarchy before investing or entering into contracts (lecture by Erickson 10/14/94). The initial successes of both the Windenergo joint venture and the Honeywell Tushino project (Windenergo and Honeywell case studies) could partly be attributed to strong governmental support.

G3. Influence of Energy Supply Companies

"The energy sector is very strong" and exhibits strong monopolist tendencies, said a senior researcher at the Center for Energy Efficiency (interview 7/5/93). In 1993, four companies in Moscow considered the possibility of building their own cogeneration plants, and estimated that electricity and heat produced from their own plants would cost half as much as they had to pay to the local energy supplier, Mosenergo. But Mosenergo is powerful politically, and told these companies that their energy supply would be shut off the moment they tried to lay the foundation for a cogeneration plant. In interviews it was often said that energy producers are interested in only one thing -- more production -- and not energy efficiency. In the Honeywell Tushino project (Honeywell case study), it even appeared that the producer of heat, Mosteploenergo, was initially opposed to this project and was only interested in more heat production (interviews with the head of Moscow Government Department of Energy Efficiency, 2/9/94, and with an engineer from Honeywell, 9/20/93).

"Gazprom wants to promote gas consumption in Russia" said one USAID energy consultant in Moscow (interview 4/26/94). Gazprom's exports to Europe are taxed at a high rate so that their motivation for profits is reduced, and so that the opportunity (export) value of domestic gas savings is reduced. Rather, political control and influence through the gas allocation process (see Energy Supply Organizations and Energy Consumption Quotas annexes), and expanding domestic market share and infrastructure are chief among Gazprom's concerns. That Gazprom is one of the most powerful companies in Russia was underscored by several interviewees and printed sources.

<u>Transaction Barriers from the Literature</u>

The transaction barriers analyzed above will now be compared with those commonly found in the literatures on renewable energy, energy efficiency, and technology transfer, as reviewed in Chapter 2. Several different views are offered in each category. For energy efficiency, these views include general market failures for energy efficiency, specific barriers to energy efficiency in developing countries, and energy efficiency in Eastern Europe and the former Soviet Union.

The World Bank (Energy Sector case study; gas distribution loan document, 1993, p.13) echoes the research evidence. It wrote that "the single biggest constraint impeding the implementation of these investments is the availability of capital....Studies elsewhere have indicated that energy-efficiency investments are not made unless returns are exceptionally high (40% or higher). As a result, projects that are both economically and financially attractive in Russia are expected to languish unless a proactive initiative is undertaken to promote such investments." This barrier is one of the significant differences between barriers in Russia and other developed countries. In developed countries, developed capital markets routinely provide long-term capital for energy efficiency and other long-term investments with good economic returns.

Beyond capital availability, barriers to energy-efficiency improvements in developing countries are commonly characterized as resulting from financial constraints, institutional barriers, market imperfections and distortions, and a lack of information about technological options (Levine et al 1991, Levine 1992, Philips 1991, World Bank 1993a). The analysis of transaction barriers in this chapter add a more concrete, country-specific view for Russia to these characterizations.

Market Failure Literature Applied to Russia

Common market failures discussed in the energy-efficiency literature were presented in Chapter 2. These generic market failures, which apply to developed and developing countries alike, tend to take on special features in Russia, and be of a unique character as well. Below, each category of market failure is analyzed in the Russian context.

(1) Energy prices do not reflect true long-run marginal costs. Price distortions resulting from energy prices that are less than long-run marginal costs are certainly present in Russia, as was seen in Chapter 3. But in terms of energy prices, Russia also faces a unique situation. Energy is currently priced at approximately its short-run marginal cost, as there are no direct subsidies to the energy supply industries (only residential heat is still subsidized by municipal governments). The long-run marginal costs, however, are very uncertain, as the future costs and needs for capital investment in the energy sectors are highly uncertain and not yet adequately quantified.

(2) Incomplete information exists among producers and consumers. Incomplete information about available technologies and their effectiveness was seen in the transaction barriers described above. This market failure takes on special dimensions in Russia because much information simply does not exist (such as costs, existence of producers or suppliers, information about the financial

condition of potential partners or loan recipients, and even baseline information about current energy consumption).

(3) Externalities exist. Some environmental externalities from energy consumption may in fact be less in Russia than in some other countries because of the high fuel share of natural gas in overall energy consumption (see the Structure of Energy Supply and Demand annex). Fewer environmental externalities, both local and global, result from natural gas combustion. But most externalities are much more severe than in most developed countries. Urban air pollution is a problem; coal mine worker health and safety risks are large; coal is burned in many plants without scrubbers; the risks of oil spills from frozen and poorly maintained pipelines in severe arctic climates appear to be increasing, and the risk of nuclear accidents at nuclear power plants in the wake of Chernobyl looms very real. The appropriate values for some of these externalities relative to those in Western countries would be difficult to quantify, however.

(4) Consumers have short time horizons. Short time horizons of consumers are especially acute in Russia now because of the economic depression and decline. Because conditions are so uncertain, unpaid debts mean that many cash flow problems are occurring. Uncertain and high inflation rates mean that a ruble today is worth much more than a ruble in a year or two. Investment funds offering short-term returns of up to 1000% per year create enormous discount rates among would-be investors in energy efficiency. Enterprises struggling with economic survival also have very short time horizons (like the next payroll).

(5) Consumers have limited or "bounded" rationality. The demands of processing information and making decisions are comparable or greater in Russia than they are in Western countries, because the uncertainties are greater and the experience with making economic and investment decisions so much less. Energy efficiency never received a high priority historically, and given the competing priorities and demands of enterprise managers, local and regional officials, and banks and potential

investors in the continuing struggle just to survive in a post-Soviet economy, energy efficiency may still remain a distant priority.

(6) Transaction costs exist. Many of the transaction barriers analyzed above create high transaction costs, especially those related to the lack of information and the lack of developed legal and market institutions. This increases the costs and time requirements of information gathering and validation, contract negotiation, enforcement, and decision-making, and increases transaction risks relative to countries where these institutions are more highly developed. It appears that the level and character of transactions costs in Russia are more similar to those in developing countries than to those in developed countries.

(7) Capital markets are not perfect. Capital markets are not relatively more imperfect in Russia than in other countries, but rather they face huge uncertainties and risks in potential investments, high inflation, and competing high-return uses for capital that crowd out longer-term demands.

(8) Costs and benefits are institutionally mismatched. This problem was analyzed above as a transaction barrier for the specific case of municipal governments and residential payments for heating, and for investments in district-heating distribution-system efficiency improvements. In the case of municipal government and residential payments for heating, the municipal government functions very much like a landlord for rental tenants analogous to the landlord-tenant relationship in Western countries (even with apartment privatization). If tenants in Russia begin to pay the full costs of their heat consumption, the often-discussed institutional mismatch between tenants and landlords for energy-efficiency improvements will have a direct analog in Russia.

An Agent Framework for Energy Efficiency Barrier Evaluation

Many of the barriers described here can be mapped into a unique framework emphasizing the perspectives of different agents, as described by Reddy (1991). The perspectives that Reddy characterized are as follows: Consumers are ignorant (of opportunities), poor and/or first-cost sensitive (lacking financing), indifferent (boundedly rational), helpless (lacking intermediation/transaction skills), uncertain (about costs and benefits), or inheritors of inefficiency (by decisions of others). End-use equipment manufacturers are efficiency-blind (lack of competition, product differentiation in markets). End-use equipment providers are operating-costs blind. Energy producers are supply obsessed, centralization biased, and monopolists. Government is uninterested, skills-short, capital-short, without adequate training facilities, without access to hardware and software, a sales promoting regulator, a powerless energy-efficiency agency, a cost-blind price-fixer, a fragmented decision-maker, and a large-is-lucrative sponsor with a large-is-impressive syndrome. Multilateral and international aid agencies are inefficient-technology exporters, supply biased, anti-innovation, large-is-convenient funders, project-mode sponsors, and self-reliance underminers.

What Reddy has really done is create a set of Weberian "ideal types" (Weber 1962, Smelser 1979) of agents influencing energy efficiency and their perspectives. Weber calls these ideal types the "subjective meaning attributed to a hypothetical actor in a given type of conduct" (p. 29). Thus Reddy interprets, based upon the circumstances, interests, and resources of each category of agent, what responses will or will not occur relevant to energy efficiency. My own characterization, after Reddy, of the different agents involved in energy-efficiency improvements follows. These ideal-type characterizations are interpretations painted from a number of sources in the research, including published literature, documents obtained in the field, case studies, and individual comments and interview responses.

Residential Consumers. Consumers inherited very inefficient apartments from the former Soviet system. They are ignorant about ways to save energy. They are uncertain about future benefits (or are sure there will not be any). They are helpless to make most renovations to their apartment and building. They are choice limited to the particular refrigerators, light bulbs, and other equipment available in the stores in their city. They are poor and first-cost sensitive, and so need credit to purchase or renovate. Yet they are credit-poor because mortgages are not available. They are also fixed-cost payers for heat and hot water and unregulating consumers of heat (they have no control over their consumption).

Industrial Consumers. Like residential consumers, industrial consumers are also inheritors of inefficiency from the Soviet period, uncertain, choice limited, capital-short, and poor and first-cost sensitive. Many enterprises, especially state-owned or post-state-owned enterprises (see Decline of Centralized Coordination annex), are indifferent because of the lack of strong profit motives or competing needs for management attention. Additional traits not mentioned by Reddy are that they are also energy-quota-bound (see Energy Consumption Quota annex), in-debt, and innovation limited.

End-Use Equipment Manufacturers. End-use equipment manufacturers certainty conform to Reddy's characterization of efficiency-blind. In the Soviet era, quantity of output was primary, and the quality and characteristics of that output (energy efficiency being one of them) were secondary. The lack of competitive pressure offers little incentive to change.

Energy-Carrier Producers and Distributors. Energy producers in Russia are also very much supply obsessed, centralization biased, and supply monopolists. In addition to Reddy's characterization, energy producers are also shortage allocators in regions where energy (heat or electricity for example) is in short supply, and weakly regulated (see the Energy Supply and Regulation Organizations annex).

Local/National Financial Institutions. In contrast to Reddy's characterizations, local and national financial institutions are not so much supply biased, unfair, or anti-innovation, as they are short-term oriented, aware of future uncertainty, and capital poor.

Federal and municipal governments. The situation in Russia also differs from Reddy's characterization for federal and municipal governments. It is true that governments are skills-short, without adequate training facilities, capital-short, and with weak regulatory power. But many municipal governments are very interested in energy efficiency, because energy is such a large fraction of their total budget (when subsidies to residents for heat are included). Governments also have some access to hardware and software through many bilateral and multilateral aid programs, which have been primarily directed at government rather than private entities (for example the commodity import program of the USAID case study and the World Bank loans in the World Bank case studies). Finally, much of the large-is-impressive and large-is-lucrative mentality of the Soviet era appears to be eroding, especially in governments (exceptions could be found in energy supply industries and in construction industries).

These characterizations all confirm Reddy's, with the exception of some of those related to financial institutions and government. As can be seen from a comparison of my characterization with Reddy's, I have added several additional elements:

- Residential consumers are fixed-cost payers for heat and hot water
- Residential consumers are unregulating consumers of heat
- Industrial consumers are energy-quota-bound
- Industrial consumers are debt-bound
- Industrial consumers are innovation limited
- Energy producers and distributors are shortage allocators
- Energy producers and distributors are weakly regulated
- Financial institutions are short-term oriented
- Financial institutions are aware of future uncertainty
- Financial institutions are capital poor

As another example, one specific developing-country literature on technology transfer that appears relevant to the case of Russia is the literature for China. Behrman et al (1991) looked at technology transfer to China. They concluded that while Chinese enterprises were eager to accept foreign technology, many foreign firms were hesitant. Important barriers affecting the propensity of multinational corporations and Chinese firms to transfer technology are shown in Table 4. Barriers that correspond closely to Russia include on the supplier side: the lack of information, closed domestic markets, lack of strong government protection of intellectual property rights, and disagreements with joint-venture partners over the proportion of exports to domestic sales. This last item was not seen in any of the research evidence, but could still be a factor. On the recipient side, two significant barriers match well also: the lack of information about foreign suppliers and products, and poor information exchange and connection between enterprises and relevant government agencies and research institutes. The isolation of Russian enterprises from foreign contacts and transactions is especially notable because before 1991 all technology transactions were conducted by centralized agents like the Ministry of Foreign Trade (see Technology Transfer to the Soviet Union annex).

TABLE 4:
BARRIERS AFFECTING TECHNOLOGY TRANSFER WITH CHINA

Barriers affecting the propensity of foreign firms to transfer:

■ Lack of information about China in general
■ Closed domestic markets
■ Lack of strong government protection of intellectual property rights
■ Disagreements with Chinese joint-venture partners over exports versus domestic sales (Chinese partners wanted to export more, technology suppliers wanted to expand their market in China).

Barriers affecting the propensity of Chinese firms to seek transfers:

■ Lack of information about foreign suppliers and products
■ Poor information exchange and connection between enterprises and relevant government agencies and research institutes in China.

Barriers affecting the effectiveness of transfers:

■ Willingness or ability of suppliers to transfer know-how along with hardware
■ Capacity of recipient firms to absorb that know-how
■ Ability of recipient firms to understand the associated requirements of transferred technology
■ Cultural differences which led to higher-than-expected costs
■ Lack of supporting technological infrastructure, skills, and materials
■ Willingness of recipient firms to make necessary changes in the enterprise's organization, power structure, production layouts, employee skills and levels of employment to accommodate a new technology.

Renewable Energy Barriers

Unlike energy-efficiency technologies that are primarily off-the-shelf, mature technologies, and whose main barriers relate to financing and markets, renewable-energy technologies face barriers that are still technological, cost, and institutional acceptance related. In developed countries, the energy-efficiency problem is one of incentives and motivation for investment, while the renewable energy problem is one of research and development, implementation, commercialization, and deployment (Jackson 1993). Whereas the problems of energy efficiency have been seen as market stimulation, the problems of renewable energy have been seen as market creation or expansion.

In Russia, the problem of market creation and expansion applies to both energy efficiency and renewable energy. This is what makes the barrier of "market acceptance of technologies" so critical. While many technologies for energy efficiency are mature in the developed countries, their use in Russia is still very new and markets as such do not yet exist (examples would be thermostat control valves, variable speed drives, triple-pane windows, industrial gas-turbines for cogeneration, and automatic energy control systems). Thus many of the barriers to energy efficiency in Russia apply equally to renewable energy.

Grubb (1993) himself says that the same transaction barriers that hinder energy efficiency can hinder renewable energy development. Specific renewable energy related barriers in Russia are the lack of knowledge about resources and opportunities, high initial capital costs coupled with low long-term capital availability, lack of information, institutionally mismatched costs and benefits in some applications (like residential hot-water heating), and short-time horizons of consumers.

One key difference between Russia and the needs of developing countries in the literature involves renewable resource assessments. The literature argues that such assessments are critical to development of renewable energy in both developed and developing countries. For example, "the California Energy Commission Surveys which identified the strong winds in the broad mountain pass areas, were a critical factor leading to the development of wind in California" (Grubb 1993, p.241).

The World Bank (1981) characterized developing countries as needing additional technical assistance, education, and capability strengthening in order to be able to conduct assessments.

The research evidence showed that many Russian assessments of renewable energy resources have already taken place over the past several decades as part of the Soviet Union's scientific research and development activities, and that Russian researchers and scientists are fully capable of such assessments. The problem related to technology transfer will not be so much in conducting new resource evaluations, but rather in obtaining data or evaluations that have already been done. The new Russian penchant for selling existing data at high prices, and the difficulty or impossibility of evaluating the quality of specific data, are more germane to renewable energy resource assessments than the question of whether Russians can conduct such assessments. In the research evidence, examples were seen of existing resource evaluations done by scientific institutes, the privatized national electric utility RAO "EES Rossii," and an aerospace-defense research institute whose researchers were trying to sell the data through a commercial firm. This problem, the "privatization of data," means that potential renewable energy purchasers, like electric utilities or enterprises, will have to pay for new or existing assessments. This situation contrasts with many developments in the West, where assessments have been performed with government money by government agencies and are freely available.

Other key factors inhibiting renewable energy development have been identified as analytical conservatism in energy studies, ignorance or myths within the policy community, and paradigmatic failures of vision (Grubb 1993). Some examples of these factors in the United States are: "The analysis [of the US Technology Assessment of Solar Energy] adopted the peculiar assumption that the fledgling renewable technologies would remain fledgling" (p.242). "A major factor is the sheer difficulty of translating available information [on renewable potentials, technologies, and costs] into forms that can be readily understood by non-specialists" (p.242). And "The dominant paradigm, as displayed by official forecasts and statements, R&D funding, market supports, and national and international institutions, is that future energy supply in industrial countries will necessarily remain dominated by large centralized fossil, nuclear and hydro resources" (p.244). Russian versions to all of these factors exist; many were inherited from the old Soviet system. Central planners were obsessed with large centralized power plants, and saw renewable energy as not worth considering. Thus serious attention was never paid to funding resource assessments, technology development, and commercialization.

From a utility perspective, some of the same barriers that hinder market demand for wind turbines by utilities in the United States are present in Russia. High front-end capital costs (as opposed to lower capital costs and higher fuel costs of conventional sources) are a transaction barrier in both countries, requiring a greater availability of long-term capital. This is especially true in Russia where long-term capital availability is poor. Utility acceptance (from a reliability, scheduling, and grid integration standpoint) is another barrier in the United States, but appears to be less so in Russia and Ukraine (Windenergo, Ukrainian Government, and Kalmykia case studies). Appropriate regulatory frameworks for handling third-party generated wind power in the United States is another barrier cited (U.S. Department of Energy 1990), although this is not yet an issue in Russia because third-party producers do not exist (see Energy Supply and Regulation Organizations annex).

The U.S. Congress Office of Technology Assessment (1994) made its own assessment of the barriers to diffusion of energy and environmental technologies in Eastern Europe and the former Soviet Union, including renewable energy. Their list of barriers is shown in Table 5.

TABLE 5: BARRIERS TO DIFFUSION OF ENERGY AND ENVIRONMENTAL TECHNOLOGIES IN EASTERN EUROPE AND THE FORMER SOVIET UNION (OTA 1994)

Institutional:	Lack of comprehensive legal framework
	Multiplicity of government authorities
	Weak enforcement of regulatory standards
	Lack of market information
	Lack of market and management training
	Ambivalence about foreign investment
	Bilateral trade restrictions
Economic:	Lack of domestic capital
	High levels of political and financial risk
	Inconsistent and punitive tax regimes
	Government energy-price subsidies
	Low emissions fines
	Lack of feasibility financing for U.S. small business
Technical:	Inadequate physical infrastructure
	Lack of trained personnel
	Differences in technical standards

All of these barriers were seen in the transaction barrier analysis above, with a few exceptions. Thus this research confirms the Office of Technology Assessment findings. The exceptions for Russia are that only domestic space heat and hot water are still directly subsidized (although indirect subsidies exist as described in Chapter 3). These direct subsidies would affect domestic solar hot-water installations, although at present it would still make sense for municipal governments themselves to finance such installations where good solar resources exist. The lack of trained personnel was not seen as a problem in the case studies or other research evidence, although the lack of technically trained personnel who could also speak English, and work with computers, was seen as a problem.

Technology Transfer Barriers

The World Resources Institute studied the problem of international technology cooperation for environmental improvements (Heaton et al 1994) and found that the main impediments to the effective transfer of environmentally sound technologies were: (a) weak or distorted demand; (b) low technical capability; (c) too little information about technological alternatives; (d) misallocation of financial resources; (e) end-of-pipe approaches (to pollution); (f) missing connections between potential partners; (g) the "technology-transfer mindset" (technology transfer as hardware transfers rather than cooperative activities and learning); and (h) intellectual property rights.

In Russia, weak demand, lack of information about technological alternatives, and missing connections between potential partners have all been shown to exist. But low technical capability is not a correct characterization, nor is misallocation of financial resources. Given the uncertainties and risk, it is still too early to say whether financial resources are being allocated correctly or not. Intellectual property rights, a subject much talked about in the literature, was not explored very much in the research, but was seen as an issue in any of the research evidence.

The World Bank made little mention specifically of technology transfer barriers in its policy paper on "Energy Efficiency and Conservation in the Developing World" (1993a). All it wrote was that "the reasons technology transfer and economically-justified fuel switching do not occur more rapidly are the same reasons discussed in this paper for overall poor energy efficiency on both the supply and the demand side" (p.64). This is true, as many of the transaction barriers analyzed here apply equally to international technology transfer and domestic investments.

CHAPTER 8

INTERNATIONAL TECHNOLOGY TRANSFER PERSPECTIVES

This chapter analyzes existing literatures on technology transfer for their relevance to Russia, including literatures dealing with commercial firms, multilateral and bilateral development agencies, and international organizations promoting technology transfer for environmental benefits. Matches and mismatches are identified in the following specific areas: propensity to transfer technology by commercial firms, modes of technology transfer selected by commercial firms, multilateral and bilateral agency policies and approaches, and capacity building for environmental-technology transfer. Selection of technology-transfer mode is further analyzed in Chapter 9 in the discussion of joint ventures. This chapter further supports the thesis that energy-efficiency and renewable-energy technology transfer is a complex combination of elements from the developed country, developing country, and Soviet Union perspectives within these literatures. Other important issues from the literature are discussed briefly at the end of this chapter: technology adaptation, trade barriers, intellectual property protection, and "financial engineering."

Much of the literature on technology transfer and economic development (including the old East-West literature) makes very basic assumptions about the context and conditions in developed, developing, and Communist countries. Russia does not fit into any single one of these categories, but rather is a complex combination of all three. All three perspectives in the literatures are relevant. Technology transfer will take place within this mixed context, and policies and decisions need to account for the conditions, constraints, and dynamics of all three. Russia could be considered a "developed" country if one looks at a high degree of industrialization and urbanization, world-class scientific and technical abilities and achievements, high per-capita energy consumption, and low birth and infant mortality rates. Russia could also be considered a "developing" country if one looks at growing World Bank involvement and bilateral aid, a lack of strong legal and market institutions, low per-capita incomes, primitive capital markets, weak regulatory structures, widespread corruption, and a weak partially-convertible currency. Russia could be considered a continuation of the Soviet Union if one looks at continued administrative systems of energy supply allocations; single-source monopolist production of many goods; cultural propensities against innovation, cost-minimization, quality, and efficient capital utilization; worker collectivism and influence in production; and the highly individual and personal nature of economic relationships between enterprises. None of the above-mentioned conditions are likely to change quickly, and thus Russia will remain a complex combination of the traditional three categories.

Propensity to Transfer Technology by Commercial Firms

Propensity to transfer technology, either on the supplier or recipient side, was seen as one of the key dependent variables in the technology transfer literature (see Chapter 2 and the International Technology Transfer Models annex). From the analysis of transaction barriers in Chapter 7, the research and case study evidence, and the literature on joint ventures in Russia since 1987 (see Technology Transfer to the Soviet Union and Commercial Business Environment annexes), Table 6 shows the factors that appear to significantly affect the propensity of Russian firms to be recipients in technology transfer and foreign firms to be suppliers in technology transfer. Many of these factors for both supplier and recipient propensities to transfer can be seen in the literatures on transfer between developed and developing countries and also between developed countries. For example, transfers between developed countries may depend on relative production costs, potential for domestic market exposure, trade barriers, investment share and management control, and maturity of technology and intellectual property protection possibilities. Transfers between developed and developed countries may depend on repatriation of profits, maturity of market in the host country, and difficulties of securing government approvals and

TABLE 6:
FACTORS AFFECTING PROPENSITY TO TRANSFER TECHNOLOGY WITH RUSSIA

Factors Affecting Foreign Firms' Propensity to Transfer:

- Repatriation of profits (currency convertibility)
- Cost of production relative to Western production costs
- Ease of finding a Russian partner and ascertaining their strength, reliability and trustworthiness
- Investment share and management control retained (for joint ventures)
- Potential for domestic market exposure
- Political stability and risk
- Maturity of technology and degree of intellectual property protection possible
- Maturity of market for product in Russia
- Costs and uncertainties of transactions, including uncertain or changing legal tax and regulatory regimes and bribe costs
- Difficulty of securing government approvals and licenses
- Difficulties in conducting financial transactions

Factors Affecting Russian Firms' Propensity to Transfer:

- Availability of capital
- Desire to produce new products to replace unwanted or obsolete production
- Competitive pressure from other firms
- Desire to acquire management skills and technological know-how
- Desire for quality which does not exist domestically
- Need of products which do not exist domestically or are unavailable to enterprise

licenses. The technology transfer literature contains many country-specific and sector-specific cases and analyses, with few generalizations possible. Nevertheless, it is clear that Table 6 represents a combination of those perspectives.

In the Soviet era, the primary factors affecting propensity to transfer by Western firms were a much smaller subset of those shown in Table 6. The ability to repatriate profits and secure government approvals were primary, while the risks, uncertainties, and lack of information were much less (the credit of the Soviet Union was considered good, all deals went through central authorities, and counter-trade agreements were common; see the Technology Transfer to the Soviet Union annex). The propensity to transfer on the Soviet side was influenced by the availability of

Western credit, foreign-exchange earnings, and counter-trade possibilities, and by the need for innovation or additional quantities of goods to make up for shortfalls in the planned economy.

Some of the major differences in technology transfer now from the Soviet era are that enterprises themselves will take a much more active role in transactions (as opposed to central authorities in Moscow), cost-benefit calculations are now possible to compare the costs of domestic versus foreign technologies (before 1992 such calculations were meaningless), quality of foreign goods is likely to be a much greater factor in decisions by recipients (rather than technical need or fulfillment of Five-Year-Plan shortages), and financing through counter-purchase and barter agreements as was common the Soviet period is likely to be replaced almost exclusively by private bank or private enterprise or association fund financing (because enterprises do not have access to counter-trade or barter goods like the central authorities did in the Soviet period).

Technology-Transfer-Mode Selection by Commercial Firms

Another key dependent variable in the technology transfer literature is the mode of transfer selected. Cortes and Bocock (1984) concluded that in transfers between developed and developing countries, "the degree of local technological capability is an important element in the choice of contractual arrangements" (p.93). While turn-key plants and foreign subsidiaries have been key forms of technology transfer to developing countries historically because of low levels of domestic technological capability, technology transfer during the Soviet era and today in Russia reflects Russia's technological capabilities, and has emphasized license agreements, joint ventures, and equipment purchases without technical assistance.

The earlier history of technology transfer to the Soviet Union was one primarily of material and design transfer, with some active capacity transfer (see Technology Transfer to the Soviet Union annex). An historical Soviet preference for "passive" forms of transfer prior to the 1960s, like equipment purchases, gave way to more active forms like license agreements with technical assistance in the 1960s. These later more active-transfer efforts were more successful because of the technical assistance agreements that went along with material or design transfers. Foreign investment and joint ventures were prohibited until 1987, so these technical assistance agreements were the primary vehicle for active transfer. When joint ventures and foreign investment became legal in 1987, even more active transfers began to occur. Yet when capacity transfer did occur, the capacity so developed often wasted away due to the general barriers to innovation in the Soviet system. So the Soviet Union was forced repeatedly to "borrow" Western technological development through material and design transfer and limited amounts of capacity transfer.

Turnkey plants were regarded as an effective channel of technology transfer in the Soviet era (see Technology Transfer to the Soviet Union annex). But the reasons were quite different from those commonly attributed to developing country technology-transfers using turnkey modes, as in the analysis by Cortes and Bocock (1984) of Petrochemical technology transfer to Latin America. Traditionally, turnkey plants have been transferred to developing countries because the lack of technological capability meant that equipment transfer, design transfer, or licenses could not be effectively used. In the Soviet Union and in Russia after the Soviet Union, Russians possessed the technical abilities. But the lack of ability to innovate led to the institutional effectiveness of turnkey plants. Within the Soviet system it was much easier and faster to put in an entirely new plant with Western technical and managerial expertise than to force radical innovations on existing plants where management and workers were resistant to changes (see Nove 1986 and Bornstein 1985).

Multinational corporations, if given a choice between direct investment or arms-length licensing, will generally choose direct investment because the gains from the technological monopoly can generally be greater (see Chapter 2). This would predict that direct investment, either through wholly-owned subsidiaries or joint ventures, would be replacing arms-length licensing agreements in Russia after 1987, and especially after 1991. The research evidence tentatively supports this conclusion. Most of the big ventures in which technology transfer has taken place since 1991 appear to be wholly-owned subsidiaries or joint ventures. The case study evidence also supports this tentative conclusion for energy-efficiency and renewable-energy technologies, as seen in the Danfoss and Windenergo case studies, and as supported by the fact that no cases were found where licensing to a 100% Russian-owned enterprise with technical assistance was done or considered. The legal difficulties of intellectual property protection and the need for foreign capital in most situations where foreign technologies would now be transferred are also two strong arguments for the prevalence of direct foreign investment as a new dominant mode of technology transfer.

The most basic and simple technology-transfer mode is the sale of equipment from abroad to a Russian enterprise in exchange for foreign currency. Many of the transaction barriers analyzed in Chapter 7 inhibit such transactions, even if the economic returns are very favorable to the recipient enterprise: currency convertibility, lack of capital availability, lack of information about potential suppliers or recipients, monopoly production with no competitive pressure, lack of an innovation-and-risk culture, import tariffs, and the host of barriers that create great future uncertainties of costs and benefits. The only transactions of this type present in the case studies were Honeywell and Danfoss sales to federal and municipal governments (Honeywell and Danfoss case studies). Sales to governments avoid many of these transaction barriers: governments have hard currency, soft budget constraints with capital available, have the best contacts with foreign companies, and are not as concerned about risk and uncertainty as private enterprises are.

Another technology transfer transaction mode is that of the joint venture with technology license from the foreign partner. A foreign partner supplies a license and technical assistance for understanding and exploiting the technology, perhaps along with production equipment for producing the technology. Here a primary transaction barrier is also lack of capital on the Russian enterprise side, along with those transaction barriers associated with enterprise transformation: worker control over the enterprise; lack of experience with marketing, management, financial management; etc. This scenario was seen in the Windenergo case study, in which the domestic partner was the Ukrainian government. The government was able to supply capital to overcome the capital barrier, and an entirely new enterprise was established with newly recruited workers, to overcome the enterprise transformation barriers.

Considering both propensity to transfer and mode of transfer, does a general model of multinational technology-transfer like the Robinson model (see International Technology Transfer Models annex) apply to Russia? After an exhaustive review of technology transfer models, Yager (1991) concludes that the Robinson model is arguably the most comprehensive in an international context. In the context of Russia, Robinson's model appears versatile, general, and complete enough that it can encompass most all of the elements, barriers, factors, and issues identified in this research as potentially present in technology transfer between Western and Russian firms. The weaknesses of the model with respect to Russia appear to be in its treatment of uncertainty and information barriers, and in political power and corruption elements. The model does include a number of factors associated with "perceived risk" on both supplier and recipient sides, and "political/economic relations with host government" on the supplier side. These categories in particular could be expanded to include the risk and uncertainty factors discussed in Chapter 7 (like lack of information about potential partners), and more specific political factors (like the dependencies of political influence with sector-specific, technology-specific, and geographic-region-specific dimensions of the transfer).

<u>Multilateral and Bilateral Agency Policies and Approaches</u>

Among the conclusions reached by Rosenberg and Frischtak (1985) is that historically, expectations that "the opportunities offered by the availability of more advanced technologies would vastly simplify and accelerate the process of economic growth in developing countries,...were highly naive" (p.v). Technology transfer is much more costly and complicated than is generally believed, and depends upon many factors. Two of the most important of these are the level and direction of indigenous technological efforts and numerous aspects of the institutional setting in the recipient country. World Bank literature and Western assistance approaches to technology transfer have neglected these two aspects.

"Eastern Europe is not served by straight textbook advise" said a former head of the World Bank's East European Department (Ellman 1994, p.3). Conventional development approaches have emphasized capital equipment and technical assistance, both supplied by foreign vendors and consultants. But equipment and technical assistance is not the answer in Russia and Eastern Europe. This conventional approach to development assistance applied to Russia and Eastern Europe results in underutilization of the existing technical capabilities and the existing developed infrastructure. Rather, what is missing is capital coupled with business and finance skills, new project development and market intermediation institutions, and stronger legal and market institutions in general.

The World Bank (1993a) said that "the reasons technology transfer...[does] not occur more rapidly are the same reasons discussed in this paper for overall poor energy efficiency on both the supply and the demand side" (p.64). The explanation for why energy use is inefficient in developing countries centers on four key points: (1) energy is subsidized and thus priced below economic (long-run marginal cost or border price) levels; (2) many large industrial and commercial sectors are state-owned or monopolies, with the implication that they are inefficient; (3) monopoly public enterprises are extensions of the government and thus less efficient than their more formally regulated arms-length counterparts in developed countries; and (4) barriers are greater because of the relative lack of market intermediation (high transaction costs related to information, financing, and management), inadequate legal structures, and lack of or inability to enforce codes and standards.

With this view of the problem, the policy solutions are to eliminate energy price subsidies, set energy prices equal to long-run marginal costs, privatize industries, and promote greater institutional efficiency in energy supply organizations. But market-level energy prices, privatization, and greater institutional efficiency in Russia are insufficient conditions for rapid exploitation of the many technical-economic opportunities that exist for energy-efficiency improvements. Many transaction barriers continue to limit economic activities that would result in greater energy efficiency. The functions of market intermediation and market building, together with institutional innovations and policy development, are critically important for overcoming transaction barriers.

Others familiar with the history and specific conditions in the former Soviet Union emphasize systemic conditions, institutional problems, and factors like the "social relations of production" (Cooper et al 1992, p.61). Yavlinsky and Braguinsky (1994) argue that the liberal neoclassical approach to transformation has been inefficient and ineffective:

> 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. These coexist today in the Russian economy with a relatively small number of purely private undertakings, mostly in retailing, services, and banking, and what are still more or less state-owned enterprises, mostly in defence industries and in infrastructure......[Managers of these new post-state-owned enterprises haven't had time to adapt to market conditions], and managers who recognized new opportunities nevertheless failed to change over to normal market behavior because of a tremendously high switching cost.... To enter the market economy, [these enterprises] would have to pay for market research, create an after-service network, develop new marketable products, establish a system of quality control, shape a new network for distributors, and retrain the labor force. (pp.92-93)

Thus rather than the neoclassical development perspective, an institutional one typified by North and an innovation-oriented one typified by Schumpeter make sense in the Russian context (see the Transaction Costs and the Economic Development Literature annexes). The neoclassical liberal perspective neglects the importance of institutions, and in view of the transaction barriers shown in Chapter 7, institutions certainly cannot be neglected. On the other hand, Schumpeter's view of development as one of "creative destruction" and institutional innovation provides an alternative. Part of the reason for the technological backwardness of the Soviet Union in the face of great scientific and technical capabilities were the barriers to innovation (see Soviet Management Culture and Decline of Centralized Coordination annexes). Cooper (1991) takes a Schumpeterian perspective and notes that the traditional Soviet economic system lacked mechanisms for removal of old and obsolete institutions and organizations: "In this extraordinarily retentive system, the new does not replace the old in a 'gale of creative destruction,' but accumulates alongside it, the novel always at risk of subjection to the tenacious grip of the past" (p.47-48).

Several institutional-innovation issues are relevant to overcoming the transaction barriers from Chapter 7, and a few examples of these are given below:

(1) Enterprises must pay large transaction costs to "enter" the market, in the manner argued by Yavlinsky and Braguinsky. Given the inability to enter the market economy, enterprises continue to produce and operate much as they did in the former Soviet period, although informal networks and inter-enterprise contracts (with few legal enforcement possibilities) have replaced the state central planning apparatus as means of coordinating transactions. Yet eventually, either these enterprises will go bankrupt or be forced to pay these transaction costs and enter the market; some have already. Thus transaction costs and barriers in this sense are a major factor in the future economic development of Russia.

(2) Enterprises associations in which transaction costs and barriers can be reduced, and in which many specialized functions can be integrated, have been an important institutional innovation (although associations have also been historically present) in the Schumpeterian sense (see the Decline of Centralized Coordination annex). The fact that the association Thermo-IVS was one of the only organizations undertaking domestic energy-efficiency improvements in district heating (Nagatino case study) supports this "innovation" as important for energy efficiency. Several different enterprises were required to produce a technical system for improved energy efficiency similar in characteristics to one that Honeywell single-handedly was able to install in a similar district-heating system in Moscow. The fact that contracts with 22 different Ukrainian enterprises were necessary to produce a basic-model wind turbine (Windenergo case study) through a coordinating agent (the Windenergo joint venture) also supports enterprise associations as important innovations for

renewable-energy development as well. Associations also provide a means of providing greater accountability and incentives for performance than impersonal contractual means: "if an implementer (enterprise) does not do a good job, the association will not recommend or use that enterprise again" said the head of the Thermo-IVS association (interview 2/11/94).

(3) As was seen in the World Bank Enterprise-Housing Divestiture case study, privatization of housing by itself is having virtually no effect on the constraints, motivations, and incentives of any agents to invest in energy efficiency in buildings. All privatization does is give each resident the right to sell or rent out the privatized apartment. A much more difficult process of shifting institutional responsibility for buildings from municipalities to the tenants themselves will require that legal owner associations form within each building to be responsible for maintenance and renovation. But the difficulties of forming these associations and transferring this responsibility are great, especially in larger buildings with hundreds of tenants. Even if formed, associations will not be able to borrow for energy-efficiency investments unless tenants entrust the property rights to their apartments to the association, to be used as collateral; another process difficult to envision, given the research evidence. Responsibility may simply remain with the municipality in many cases even after privatization.

Aside from general calls for more economic and price reform, meaning creation of market conditions in general, bilateral and multilateral policies and approaches to promote technology transfer of energy efficiency tend to fall under five different categories: (1) Information programs, training, and education; (2) Short-term policy and technical consulting assistance; (3) Reorganization of assistance programs for greater responsiveness; (4) Provision of capital or equipment, sometimes accompanied by specific requirements for policy changes; (5) Reduction of trade barriers, tariffs, and restrictions. Of these five, provision of capital or equipment was seen by Russians as the most important. "We know the technology; we have all the information; we know what to do; we just need equipment!" said the head of the Moscow Government Department of Energy Efficiency (interview 8/12/93). But investment decisions involve economics and finance. For example, feasibility studies also were considered important precursors to actual investment and technology transfer, according to the Director of Energy Efficiency for IVO International, and he stressed the lack of feasibility studies (and lack of Russians' abilities to carry out such studies, especially the economic and financial aspects of them) as one item often overlooked by multilateral and bilateral development agencies (interview 10/29/93).

In terms of multilateral and bilateral lending and assistance in Russia, four mechanisms for technology transfer were seen in the case studies. The first was simply education and training, as conducted by consultants from the United Kingdom (OECD case study). The second was capital lending for energy efficiency to promote specific policy goals (the World Bank Energy-Sector Lending and the World Bank Enterprise-Housing Divestiture case studies). The third was provision of consulting assistance and equipment as grants, which typified the earlier USAID assistance (USAID case study). The fourth was capital lending coupled with technical, economic, and financial analysis assistance, by the Swedish Government (NUTEK and Building-Energy-Efficiency case studies).

The World Bank Gas Distribution loan (World Bank Energy-Sector case study) would provide capital lending for energy efficiency within a loan that would promote the following policy goals: (i) demonopolization of gas distribution; (ii) corporatization/privatization of gas distribution companies; (iii) price reform; (iv) establishment of a satisfactory legal and regulatory environment; and (v) decreased environmental impact of energy use through energy-efficiency investments. Yet these policy goals by themselves do not necessarily provide the institutional innovations necessary to overcome transaction barriers to energy efficiency. Further, the World Bank considered the primary criteria for project viability to be the economic rate of return, the ability of the borrower to repay the loan, and the ability of the borrower to finance the domestic-contribution portion of the loan. The institutional viability of these investments was not a prime concern, although an intermediation mechanism would be established (see Chapter 9; in fact, the World Bank approach automatically provides some degree of intermediation between loan recipients and technology suppliers because of the project preparation activities by World Bank staff financed by member-country grants or other sources).

The World Bank Enterprise-Housing Divestiture loan (case study) would provide capital for energy efficiency to promote specific reforms, in this case the transfer of enterprise-owned housing to municipal governments, privatization of housing maintenance services, and elimination of government subsidies for residential heating. The loan recipients are city governments, and in this case the particular approach selected appears to address transaction barriers, including institutional-related ones. Capital would be for investment in energy efficiency in city-owned residential apartment buildings (even if privatized, they are still owned by the city). Since the city government charges the tenants directly for their heat and hot-water supply, the city government is able to pass the costs of the loan, minus energy savings, onto the tenants. The city government assumes the risk due to uncertainties. Costs and benefits are institutionally matched (at least until heat subsidies are eliminated; see Chapter 7). Legal owner associations of tenants are not necessary. Mixed privatized and unprivatized apartments in the same building does not affect the process. And an organization exists (the city government) that is potentially capable of playing a role in information, economic and financial analysis, decision-making, and coordination.

USAID efforts from 1992 to 1994 in Russia also illustrate the liberal neoclassical view. The approach taken by USAID for energy efficiency in Russia and Estonia through 1994 (USAID case study) was essentially to provide foreign technical consulting services and foreign equipment. In addition, USAID funded foreign consulting studies of energy price reform and institutional reform associated with energy efficiency in 1992 and 1993. In 1994 USAID provided $90 million of equipment grants as part of its Commodity Import Program, some of this available for energy efficiency and renewable energy, for purchase of U.S. equipment and services. Essentially 100% of this $90 million stayed in U.S. hands. "We do not need 90% of technical assistance money going to

American experts" said Aleksander Jitnikov, head of a Russian commission coordinating foreign aid (Wall Street Journal, 2/24/94).

The approach taken by USAID was intended to fulfill its stated policy objective of providing technical assistance and promoting price and market reforms. This objective is consistent with the neoclassical view of development, together with the view that developing countries lack technical capabilities and require technical assistance. This approach is also consistent with its political objectives: to show that foreign aid can contribute directly to U.S. business opportunities abroad. This objective is clearly seen in the case study evidence. Yet this approach is ineffective because of its short-term focus and lack of accountability. As has been argued and suggested overwhelmingly by the evidence, long-term business involvement in which there may be losses for the first few years is key to technology transfer. The accountability of the USAID U.S. consultants was to write their reports and provide equipment and training. After that, the enterprises that received the reports, equipment, and training were solely responsible for carrying out any recommendations and actions. The case studies showed that while the recommendations were essentially sound, in some cases these enterprises did little beyond this point, and for understandable and valid reasons. In two cases the equipment reportedly sat in a closet unused. The enterprises, having received advice and equipment for free, were in no way accountable to put it to good use.

A much more effective process of development through technology transfer by multilateral or bilateral agencies for energy efficiency and renewable energy in Russia is consistent with the process illustrated in the NUTEK Biomass-Fueled-Boiler Conversion case study. There were no policy prescriptions in this case and no requirements imposed on macro policies. Rather, capital was made available to a district-heating enterprise for an investment that made economic sense to the enterprise and to the municipality in which it was located. Heat production costs would be lower. Intermediation was also supplied -- in this case by NUTEK in the form of technical-economic analysis, financial analysis, preparation of tender documents, bidding, bid evaluation, contract negotiation and award, and contract performance monitoring and enforcement. The enterprise could not perform these functions by itself, did not even understand many of them, but was included by NUTEK in the process of decision-making, and learned from it. Most significantly, the enterprise made the final decision on which bid to select based upon the technical criteria that it felt were most important in terms of reliability, operation, maintenance, etc. Thus the enterprise was not well qualified to perform the intermediation functions, but was well-qualified to make technical decisions, and NUTEK allowed it to do so. In addition, the enterprise was able to supply the technical work that it was capable of: installation of the equipment and construction of a wood-chip storage facility. Intermediation was also supplied to potential borrowers before projects got underway through a local "answer line" set up with a local Estonian expert who could answer technical, financial, and economic questions. This service was judged very important to the process by project participants. NUTEK lending in the Building-Energy-Efficiency case studies also illustrated this fourth approach of capital coupled with technical, economic, and financial analysis assistance.

Development assistance for domestic technology production (either through joint ventures or licenses) was seen in the renewable energy for developing countries literature, but was notably absent from the World Bank energy-efficiency literature or any USAID documents. The World Bank energy efficiency policy paper (1993a) does refer to the promotion of joint ventures, but does not elaborate. The United Nations Agenda 21 (Chapter 34) makes a general reference to "maintenance and promotion of indigenous technologies" and to "capacity building for human resource development, institutional capacities for R&D and implementation" (United Nations Agenda 21 annex), but does not specifically mention domestic technology production.

Technology Transfer and Capacity Building for Environmental Benefits

A literature on technology transfer for environmental benefits and sustainable development has emerged since the late 1980s and early 1990s (see Chapter 2 for a brief review). Part of this literature has been by the United Nations, especially after the United Nations Conference on Environment and Development and Agenda 21 (see Agenda 21 annex). Much of the literature focuses on what Nakicenovic and Victor (1993) call "overt technology transfer, the goal of which is to diffuse less greenhouse-intensive technologies around the world more rapidly and more extensively than would otherwise be the case" (p.523). Thus this literature is highly policy-oriented, and focuses on policy-solutions by United Nations agencies, bilateral or multilateral international development agencies, or country governments. Five types of policy solutions are typical: Public-source financing (grants or loans) for public-sector projects; encouragement of domestic technological development; development of new institutions; information exchange and "access to technologies"; and encouragement of international joint ventures and private investment

Central to all of these policies is "capacity building." The United Nations has used the term "capacity-building" to denote the enhancement of skills and capabilities among both individuals and institutions. In the literature on technology transfer for environmental benefits, much of the focus on capacity building has been on enhancing scientific and technical skills, capabilities, and institutions in developing countries. As MacDonald (1992) puts it:

> Over the longer term, useful transfer requires development of an indigenous capacity for technological adaptation, replication, and innovation by the receiving country. Thus, technology transfer covers a host of activities, commercial and other, involving the international flow of technical research, knowledge, training, studies, processes, and equipment. These activities cut a wide swathe through foreign trade, international economic assistance, and global environmental protection. (p.13)

Another example of public-source financing is the Global Environmental Facility, which provides grants to developing country governments that have ratified the Framework Convention on Climate Change for greenhouse-gas-emissions reduction projects that would not otherwise be funded if global environmental criteria were not considered. The Global Environmental Facility funds only the "incremental cost" component of any given project, which means an incremental cost that would ordinarily not be funded (from an economic viewpoint), but that would result in an incremental benefit to the global environment. The Global Environmental Facility has recognized capacity building costs to overcome transaction barriers as legitimate incremental costs. In the case of Russia, these types of incremental costs are extremely important, and can produce large environmental paybacks because of the large technical-economic opportunities that wait behind transaction barriers.

In Russia, the existing technological capability described in Chapter 6 and the transaction barriers analyzed in Chapter 7 show that capacity building, whether it comes from private joint ventures or governmental assistance programs, must be oriented towards developing market-related skills and institutions. Capacity building in Russia means strengthening the ability of governments to regulate economic activity; a stronger legal system with meaningful enforcement; financial and market institutions of all types, including contracting, accounting and credit rating standards and practices; knowledge and skills in management, finance, economic analysis, marketing, quality control; and a host of other institutional developments. Capacity building encompasses regional and local government officials, activists, economists, scientists and researchers, industrial workers, engineers, managers, bankers, and lawyers. Capacity building relates to making information more available, accessible, reliable, and cheaper, and reducing the uncertainties associated with information.

These forms of capacity building have certainly been recognized as important in developing countries as well. The United Nations (1990b) sees that indigenous technological capabilities are not only scientific and technical knowledge, but related to infrastructure and institutions:

> [Developing countries] lack the strong knowledge base, integrated physical infrastructure and diversified economy required to weather shocks and recombine existing resources in new ways to adjust to what has become a continuous process of change. They also lack the institutional mechanisms and capabilities to perceive opportunities and constraints and to translate these into effective policies for change. The financing and skills needed to innovate, to adapt and to diversify are also exceedingly rare in these countries. (p.3)

Capacity building also includes aspects unique to the legacy of the former Soviet economic and social systems. For example, the level of mobility of personnel from one location to another and from one enterprise to another has traditionally been very low, but an increase in the "capacity" for such mobility can have a great impact on the technological diffusion of innovations and ideas. Together with increased competition and the possibilities for enterprise mergers and acquisitions, the diffusion impacts of new technologies introduced through joint ventures, wholly-owned subsidiaries, or other means, will be much greater and faster. "For joint ventures to have significant impact on the technological level of the Soviet economy, it is not sufficient that each example should function satisfactorily in isolation...Under the impact of competition, take-overs, and mergers, movement of personnel, or other means the advanced experience is diffused more widely and taken up by existing Soviet organizations, the contribution to technological modernization could be much more substantial" (Cooper 1991, p.50).

In the view of British consultants training Russians in energy management (OECD case study), capacity building means three simultaneous increases in the capabilities of Russian managers and engineers: (1) the ability to identify creatively where energy efficiency (and other cost-cutting measures) is possible technically; (2) the ability to analyze the economic and financial aspects of energy-efficiency measures; and (3) business management principles, including energy management, project management, marketing, presentation, finance and accounts, report writing, training trainers, supervision, selling, and managing a consultancy. These capabilities would allow an engineer or manager to create an energy-service company in Russia to provide the market intermediation necessary for energy-efficiency improvements, and also to train others to do the same. In fact, several of the trainees of the United Kingdom's training program (which encompassed all three elements) were in fact starting their own energy-service companies in Russia.

Other Issues

In much of the literature on technology transfer to developing countries, technology adaptation is emphasized as an important issue (see Heaton et al 1994). The evidence from the case studies suggested that technology adaptation in Russia was not a significant issue, other than the expected adaptations and translations for technical dimensions, standards, and materials (Windenergo, NUTEK, Danfoss, and Danish Building-Heating-System case studies) from Western European or

U.S. standards and conventions to those standards of the old Soviet system still in use. In this respect Russia can be considered a developed country, as the technologies commonly available in Western countries appear compatible with the technical infrastructure found in Russia, except for this "standards gap."

In developing countries, the World Bank saw trade barriers as serious obstacles to technology transfer: "With regard to the trade sector, significant impediments to efficient production and end-use of energy include trade restrictions or import duties on energy-efficient technology, equipment, and appliances and restricted access to foreign exchange" (World Bank 1993a, p.40). Trade barriers may also become more significant in Russia, as calls to protect domestic industry increase with increasing employment and enterprise bankruptcies. Some imports already were being taxed heavily in 1992-1994, including a 200% import tax on new Western automobiles. Import duties are another reason why technology transfer will continue to increase through direct foreign investment in domestic production as opposed to direct equipment sales.

"Financial engineering" is a term put forth in the Russian context by the United Nations as a mechanism to enable greater energy-efficiency investments and technology transfer (United Nations ECE case study). Financial engineering implies greater attention to structuring "deals" and financial arrangements. Financial engineering has not been emphasized in either developed or developing country literatures. In the Soviet era, common "financial engineering" took the form of barter and counter-trade agreements. These types of agreements may still persist in the post-Soviet era. One example follows: The largest recent technology transfer transaction occurred between Italy and Russia (OECD case study) for a $1.9 billion project to reduce energy losses and improve energy efficiency of gas transmission lines from Siberia. Various types of equipment to improve energy efficiency of the pipelines were to be supplied both from Western Europe and from Russian-European joint ventures in Russia. Physical quantities of gas equal to reduced gas losses were to be exported to Italy by Gazprom, and proceeds of the sale were to be used to pay back a $1.6 billion loan given by Western European banks. Security of payback was enhanced by channeling the sale proceeds to an escrow account in a Western European bank, through which the loan would be repaid directly. This technology transfer transaction is an example where the costs and benefits of an energy-efficiency investment are institutionally matched; Gazprom borrows the money and is directly profiting from the improved efficiency. In this case the institutionally matched costs and benefits and the existence of a guarantee mechanism were important factors favoring this type of transaction.

CHAPTER 9

THE IMPORTANCE OF MARKET INTERMEDIATION AND JOINT VENTURES

This chapter contends that transaction barriers underscore the importance of market intermediation and joint ventures for energy-efficiency and renewable-energy investments and technology transfer. Market intermediation provides the knowledge, information, skills, market services, financing, and analysis necessary to overcome transaction barriers. Joint ventures with foreign multinational corporations represent another means for overcoming transaction barriers, one that also takes advantage of Russian technological capabilities. Evidence from the case studies illustrates several examples of market intermediation specific to Russia from already existing projects and activities. This chapter also shows that existing literature falls short in emphasizing the importance of market intermediation in Russia.

The Importance of Market Intermediation

In a perfectly frictionless economy, market intermediation is unnecessary. All agents possess perfect and costless information about all other agents, investment alternatives, costs, and benefits, and transaction and contracting costs are zero. 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. The World Resources Institute (Heaton et al 1994) has proposed sector-specific market intermediation as an important policy goal for greater international technology transfer, development and cooperation:

> 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. (p.20)

The authors continue by saying that evidence to-date with institutions that perform some intermediary functions shows that sector-specific intermediaries have advantages over broad, general-purpose intermediaries, because the technologies and applications involved are simply too diverse. Intermediaries for energy efficiency and renewable energy should to some extent be specialized, in this view. Thus for example, the intermediation functions for industrial energy efficiency may be quite different than those for residential or commercial energy efficiency.

Developed-country literature on policies for improved energy efficiency has stressed proper energy pricing, market intermediation, government regulation (efficiency standards and codes), consumer incentive schemes (like incentives for carpooling) and "market transformation" or "upstream" approaches, in which markets themselves are altered through involvement of manufacturers in voluntarily changing their product designs. In the United States, market intermediation for energy efficiency and renewable energy by third parties has taken several specific forms. Four prominent ones have been venture capital firms, special regulatory incentives giving an intermediation function to an existing regulated organization (like electric power utilities), energy-service companies, and appliance and equipment labeling standards. The PURPA legislation of 1979 allowed renewable energy to compete on an equal institutional basis with conventional forms of generation through independent power producers and their bids to electric utilities, essentially giving many independent power producers an intermediary function between renewable-energy equipment suppliers and consumers. Similarly for energy efficiency, market intermediation by electric utilities has been encouraged with demand-side-management regulatory incentives. Independent, private energy-service companies have been instrumental in providing intermediation for energy efficiency, especially for industry. And appliance and equipment consumer labeling standards to overcome information barriers have been another form of intermediation. Energy-efficiency literature also has tended to stress policy-oriented solutions for market intermediation like innovative electric utility regulations for demand-side-management (especially in the residential and commercial sectors), independent power production, and equipment labeling standards.

In developing countries, many of these same forms of market intermediation have been discussed in the literature. Reddy (1991) stresses information campaigns and demonstrations, third-party packaging and financing of energy efficiency projects for "helpless" consumers, appliance and equipment labelling 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. But even more emphasis in developing countries has been given to financing and capital availability for energy efficiency; better planning; training and technological skills development; national-level policies to promote efficiency; data and information dissemination; public education; development of indigenous technological capacity; and trade negotiations and reduced tariff barriers to encourage private-sector technology-transfers.

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.

Very little of the literature for developing countries has emphasized energy-service companies. An energy-service company evaluates opportunities, solicits and obtains financing, evaluates technical-economic opportunities, prepares technical bidding documents, bids contracts, selects bidders and awards contracts, supervises installation work, monitors performance, and receives a stream of paybacks from the customer commensurate with the energy saved. These types of transactions were just beginning to occur in Russia in 1993-1994 (see next section).

In Russia, financing and capital availability also merits first place as in developing countries. But market intermediation is relatively more important than the emphasis given it by any of the existing literature, because of the character and magnitude of transaction barriers discussed in Chapter 7. This importance is also demonstrated convincingly in much of the case study evidence (see below). Strong and pervasive institutionally-related 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. Market intermediation needs in Russia for energy efficiency and renewable energy include some or all of the functions shown in Table 7. These are all potentially important and relevant functions that must be performed either by the supplier, the recipient, or a third party. Table 7 is derived from case study evidence, barrier analysis, and the examples of market intermediation described in the next section (see also Wexler et al 1994, and Heaton et al 1994). Many of these intermediation functions are especially important to international technology transfers, because of the added difficulty that foreigners will face in performing these functions themselves or entrusting them to a recipient party.

Intermediation in World Bank Energy-Sector Lending and International Assistance

The World Bank policy paper on improving energy efficiency in developing countries (World Bank 1993a) shows that previous World Bank policies have been consistent with the liberal neoclassical view: make markets competitive, remove energy price subsidies, let energy prices reflect long run marginal costs, and promote energy supply-side institutional reform to make supply-side enterprises more efficient. Government regulation to make markets more competitive and efficient is also mentioned. In a revision to previous policies, this paper also

TABLE 7: IMPORTANT MARKET INTERMEDIATION FUNCTIONS IN RUSSIA

- Securing the support of government officials
- Finding and matching potential partners
- Arranging sources of finance and engineering financing schemes
- Discovering, evaluating, and verifying information about partners, projects, and proposals
- Understanding markets and technologies
- Identifying potential investment projects
- Analyzing the costs, benefits, and risks of investment projects
- Packaging projects for public or private investors
- Securing and structuring guarantees of project performance
- Developing licensing arrangements
- Negotiating and writing contracts
- Engendering trust among participants
- Enforcing terms of contracts or making changes as circumstances or expectations change
- Obtaining necessary licenses
- Preparing technical specifications and bidding documents
- Bidding and selecting bids
- Managing, supervising, monitoring, and evaluating projects

recognizes that market intermediation is necessary. Thus the World Bank has only more recently stressed market intermediation in the context of energy efficiency policies for developing countries. This paper calls out the need for market intermediation to reduce transaction costs associated with information, management, technology, and financing. The United Nations Agenda 21 (United Nations Agenda 21 annex) also emphasizes the importance of market intermediation for technology transfer of environmentally-sound technologies. Agenda 21 calls for information networks and clearinghouses, collaborative networks of technology research and demonstration, and efforts to support private business direct foreign investment and joint ventures. But neither of these literatures nor others goes very far in explaining or describing how market intermediation should work in different specific contexts, nor in emphasizing the institutional problems that underlie its importance.

Russian economists have argued that the liberal neoclassical approach to economic transition in Russia has been inefficient and ineffective because it has not accounted for the institutional constraints present (see the Economic Development and the Transition to a Market Economy annex). Chief among these constraints are the inability of most Russia enterprises to "enter" the market economy because of the prohibitive transaction costs and barriers associated with marketing, new product development, financing, distribution and service networks, quality control, and labor force retraining. None of these functions existed in the Soviet planned economy, as they were not needed. Energy efficiency comes into play here as a potential component of these changes, but is simply one of many vehicles for improved economic efficiency that is available to enterprises. Privatization does not alter these constraints; it merely creates a new ownership structure on paper. Higher energy prices do not alter these constraints, but are simply passed on in product prices, especially in a monopoly situation. Further, because of the existing institutional structure within enterprises by which control of production is largely in the hands of workers and shop stewards, any change must overcome worker resistance as well as management resistance. Since a more efficient enterprise is likely to mean fewer workers, worker resistance may be substantial.

The World Bank's recognition of the importance of market intermediation in its energy efficiency policy paper is more consistent with and relevant to the development needs in Russia as outlined above and elsewhere in this chapter, than its policy prescriptions. In documents for the World Bank's Gas Distribution loan to Russian under preparation in 1995 (see World Bank Energy Sector case study), the traditional policy prescriptions can be seen: demonopolization, privatization, and price reform. But more consistent with the institutional and intermediation needs in Russia were elements in the loan documents for the establishment of a satisfactory legal and regulatory environment, and for market intermediation for energy efficiency. Intermediation was deemed critical: "as a result [of institutional constraints], projects that are both economically and financially attractive in Russia are expected to languish unless a proactive initiative is undertaken to promote such investments. Therefore, it is recommended that the already established Russian Energy Savings Fund (RESF) be used as a mechanism to ensure that these projects are encouraged through a combination of studies, project preparation, information dissemination, and financing" (World Bank case study document, 1993, pp.13-14). Actually, the World Bank was hesitant to use the RESF as an intermediary because of concerns about bureaucratic, political and corrupt manipulation (see Chapter 3 for details of this fund), but decided to use it anyway, according to World Bank officials (interviews 1/13/94 and 1/22/94). Their comments suggested that the difficulty of finding any other existing intermediary or the daunting task of creating a new one influenced this decision.

The United Nations Energy Efficiency 2000 program (United Nations ECE case study) focused much of its attention on market intermediation for energy efficiency. A large part of the activities focused on intermediation through conferences, contacts, information dissemination, education, and promoting East-West business partnerships in overcoming transaction barriers. Yet these activities by themselves did not result in any concrete investment projects in the designated energy efficiency "demonstration zones" during the period 1992-1994, because intermediation functions related to currency convertibility, financing, project preparation and evaluation, and risk-reduction were missing. One attempted intermediation mechanism was a government decree (United Nations ECE case study document ECE/ENE/8) which allowed export (at border prices) of appropriate physical quantities of "saved energy" to repay Western investors. However, no institutional mechanisms were ever created within the government to implement this decree, and its practical impact has been negligible.

Examples of Market Intermediation in Russia

Because of the formidable transaction barriers that exist in Russia and their partial correspondence with those in both developed and developing countries, the need for market intermediaries in Russia is also great. In fact, all of the case studies investigated have in common the characteristic that one or two agents played a strong intermediation role and invested substantial resources in this role. Intermediation and intermediaries in Russia will include some of the characteristics of those in developed and developing countries, plus some unique ones. Several possibilities are strongly suggested by the case study and research evidence:

(a) Energy-service companies. Only a few domestic energy-service companies existed in Russia in late 1994, according to a senior researcher of the Center for Energy Efficiency in Moscow (interview 9/7/94). Because of the specialization and segmentation in the economy (see Decline of Centralized Coordination annex), energy-service companies are likely to be associations or partnerships of several different economic agents. The few examples of existing energy-service companies in 1994 are illustrative:

(a1) One energy-service company existing in early 1994 was a partnership between a technical enterprise -- "Uniservice," which included a group of engineers developing their own automated control technologies and systems similar to Honeywell -- and a bank which was dedicated to making energy-efficiency investments (called "ESKOM" bank, which stands for the initials in Russian "energy saving complex" (or group)). The company felt it was directly competing with Honeywell.

In fact it had already invested in energy efficiency in heating, hot water and ventilation systems in one sports-equipment factory which had originally talked with Honeywell. The uniservice and ESKOM combination was focusing on domestic Russian industrial enterprises, which it considered too poor to buy equipment from a foreign vendor like Honeywell, according to a manager of the company (interview 2/10/94). He said that the installations by Uniservice were up to two times cheaper than those by Honeywell.

(a2) One energy-service company was under formulation in the Kostroma region in late 1994. This venture was to be a partnership of a bank, the Moscow Center for Energy Efficiency (CENEF), a construction/maintenance enterprise, and an enterprise producing flow meters (gas, electricity, water, and heat). Initial activities for the partnership were to be installation of meters and computer control systems for building heating (interview with the director of the Center for Energy Efficiency, 8/17/94).

(b) Enterprise Associations. An association of enterprises called Thermo-IVS was functionally broader than an energy-service company, although had many similarities (Nagatino case study). Several different enterprises were each able to produce different components for a technically integrated system, and together supply all technical analysis and procurement functions to a customer (except for financing). The association was directed by the equivalent of a general contractor, who was the primary point of contact for customers, and who farmed out appropriate work to each enterprise within the association. In other examples of enterprise associations seen, a bank was often included in the association.

(c) Municipal governments. In the Building-Energy-Efficiency and the World Bank Enterprise-Housing Divestiture case studies, the municipal government was the loan recipient and guarantor. The municipal government was responsible for selecting and approving contractors and the actual work performed, and for recovering costs from tenants to pay back the loan. In both cases the government received technical assistance from NUTEK or the World Bank to accomplish these functions, but the municipal government retained substantial decision-making authority as well as responsibility for the loan, even though energy-efficiency improvements were being made to buildings that were in the process of privatization. The NUTEK Mustamaee project in the Building-Energy-Efficiency case study clearly showed that with capital availability and proper market intermediation, investments that had clear economic paybacks (and even those that were not so clear) would be voluntarily and enthusiastically undertaken by municipal governments. (d) Government ministries. In the World Bank Gas Distribution Loan (World Bank Energy Sector case study), the Ministry of Fuel and Energy's Energy-Efficiency Fund was to play at least a partial intermediary role in soliciting and evaluating projects for financing.

(e) Federal or regional electric utility companies. Two examples were illustrated in the case studies:

(e1) The Russian national electric utility RAO "EES Rossii" played an intermediary role in development of a windfarm in Kalmykia, between the Kalmykia regional electric utility Kalmykenergo, and the production enterprise Radyga, which had begun to produce 1000-kW wind turbines. In this case the intermediation also included financial assistance to both the factory and the utility (Kalmykia case study).

(e2) A program to develop integrated resources planning and demand-side management programs and policies in the North Caucasus region of Russia targeted the three regional electric utilities (Rostovenergo, Stavropolenergo, and Kubanenergo of Krasnodar) as future intermediaries (EPA/NRDC IRP case study). These utilities, while faced with major deficiencies in their ability to play an intermediary role, were nevertheless willing to consider the possibility and actively work towards it (Moscow IRP conference sponsored by U.S. EPA and Russian Academy of Sciences, November 1993). Their enthusiasm stemmed from severe electric power shortages in the region and the strong desire to see positive improvements in the energy efficiency of the region. Some of the deficiencies in their capability to play an intermediary role were lack of capital or even surplus revenue after fuel, operation, and maintenance was paid for; lack of understanding of their customers; lack of a planning department (planning had always been performed by regional technical institutes); and lack of understanding of financial investment decisions and economic payback analysis. Yet according to one researcher of the Moscow Center for Energy Efficiency, Russian electric utilities are really the only agents organized sufficiently to be able to conduct DSM programs, and the only organizations with any money (interview 9/7/94).

(f) Non-governmental organizations. The Center for Energy Efficiency in Moscow was providing many intermediation functions, such as information, literature, seminars, contacts between potential partners, market research (the results of which were sold to interested Western companies), consulting, audits and audit training, policy recommendations, project preparation work, and general education and training. This center was established in 1992 by Battelle Pacific Northwest Laboratories of the United States as an independent Russian organization to promote a wide range of activities related to energy efficiency. The center was also involved with demand-side management and integrated resources planning methodologies, and appliance standards. In late 1993 the center wrote its own proposed draft national law for energy efficiency.

(g) Bilateral aid agencies. In the NUTEK Biomass-Fueled-Boiler Conversion and the Building-Energy-Efficiency case studies, NUTEK played a substantial intermediation role. In the case of the boiler conversion, NUTEK conducted a technical, economic, and financial analysis of the conversion, prepared bidding documents, solicited bids, hired the contractor, supervised installation, and conducted all financial and contractual arrangements. The heating plant would not have been able to perform any of these functions by itself, but <u>was</u> able to make the technical decision for bid award. In Finnish government aid to Russia (OECD case study), the Finnish Ministry of Trade and Industry (Finland's equivalent to a bilateral aid agency) played an intermediary function.

(h) Multilateral agencies. In the World Bank Enterprise-Housing Divestiture and the United Nations ECE case studies, these multilateral agencies played a significant intermediation role. In the case of the World Bank, this role was similar to that of NUTEK just described above. In the United Nations ECE case, the intermediation was primarily information-related and helped Russian enterprises and foreign firms make contact with each other in the context of promoting private business transactions for energy efficiency.

(i) Regional governments. One type of intermediation in Russia that appears unique is intermediation by regional or local governments through a special energy-efficiency tax (on energy sales) supporting an energy-efficiency fund administered by the government. The government then plays an intermediary role with this source of financing in arranging energy-efficiency investments or technology production. Such a special energy-efficiency tax was not apparent in the energy-efficiency literature reviewed, although it could be considered a form of externality tax. As discussed in Chapter 3, these funds were already in operation in a few regions of Russia by 1994, and a federal-level fund was in operation (although empty) since 1992. With this form of intermediation, local and regional governments are likely to play an active role in any foreign technology-transfer that may occur, with implications for the entire technology-transfer process.

(j) Foreign-government sponsored agencies. The Danish government was establishing in early 1994 a Russian-Danish Energy Efficiency Institute near Moscow to promote transfer of know-how and technology in energy efficiency between Danish and Russian companies. The institute will support meetings, exhibitions, contacts with Russian authorities, and assist with preparation and implementation of demonstration projects.

Notably absent from the above list are municipal heat-supply companies. No evidence or case study indicated that municipal heat-supply companies had the interest in playing an intermediary role in improving the heat end-use efficiency of the infrastructure that they served. They received full payment from enterprises or municipalities for heat produced, and sold heat at cost-plus-profit, and so seemed happy with the status quo. Rather, the municipalities desired to play the intermediary role, since they benefitted directly from improvements in heat end-use efficiency.

The Problem of Utility Intermediation and Demand-Side Management

Market intermediation by electric utilities through DSM programs has been emphasized in Western energy-efficiency literature. But this form of intermediation is more problematic in Russia (see Energy Consumption Quota and Demand-Side Management annex, the EPA/NRDC IRP case study, and Schipper and Martinot 1994a).

The justifications and assumptions for DSM programs given in Western literature are of questionable relevance to Russia in light of the research evidence. Some of these justifications and assumptions for Western utilities are (Krause et al 1988): (i) the utility is obligated to serve all future demand, and thus has a direct financial involvement in what the demand is; (ii) the utility has more capital available, lower capital costs, and longer time horizons than its customers; (iii) the utility already has good, established relations with its customers, and therefore is in a good position to market energy efficiency; and (iv) the utility faces true marginal energy costs, while customers typically only face prices representing (lower) average costs. In Russia, electric utilities in general are not obligated to serve all future (or even existing) demand, often do not have enough financial resources even to pay for operating and maintenance expenses (also related to the non-payment crisis described in Chapter 3), have very little contact or understanding of their customers, and have not included long-run marginal capital costs into their analyses.

It is also not clear that Russian utilities are capable of or interested in performing the intermediation functions just described. Regulatory frameworks and institutions are very weak, and it is unlikely that the necessary regulations giving utilities the incentives and mandates to perform this intermediary function will appear. Further, the non-existence or lack of reliable data and unstable economic conditions means that future demand, prices, costs, markets, and other aspects of energy modelling are virtually unknowable and subject to change even if specified. Because of the uncertainties present (many of which were described in Chapter 7), demand-side management and integrated resources planning analyses, calculations, and assumptions that look at the medium and longer terms will not be meaningful.

The reasons that the World Bank (1993a) gives as to why DSM is not prevalent in developing countries correspond quite closely to the problems of DSM in Russia, except that energy prices are not subsidized:

> DSM is not currently pursued with much intensity in most developing countries. The reasons...generally revolve around the facts that: energy prices are low and subsidized; 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 knowledge about and high level support for DSM initiatives on the part of the government. (pp.53-54)

<u>Renewable Energy Intermediation and Independent Power Producers</u>

Grubb (1993) says that probably the most important market obstacle to renewable energy lies in the need for market intermediation. He sees utility regulation fostering independent power producers as critical, since utilities, industries, or fuel consumers by themselves will not be able to understand in sufficient detail the local conditions, resources, and opportunities associated with renewable development, which all vary greatly on a case-by-case basis. This understanding requires a third party who can evaluate opportunities, secure financing, exploit the opportunities, and sell power to a utility or fuel to a consumer. Thus Grubb notes that another key reason why wind-power development in California proceeded so quickly in the 1980s was the quick adoption and implementation of PURPA in California.

Independent power producers do not yet exist in Russia (other than some cases of industrial cogenerators who can sell excess power back to the grid). The policy environment and institutional uncertainties related to electric power system development in Russia (see the Energy Supply Organizations annex) mean that true independent power producers such as those created under the United States PURPA act of 1978 are not likely to appear in the short or even medium term. The implications for renewable energy are that the market demand for renewable energy and its ownership will be by: (1) the regional electric utilities themselves (following the example of the Kalmykia and Windenergo case studies); (2) municipal governments for solar hot-water heaters in residential buildings; and (3) self-generation by industrial enterprises. The lack of independent power producers in Russia who can act as intermediaries in evaluating and understanding resources and financing opportunities leaves these functions to regional utilities, who are generally ill-equipped for such functions.

The need for market intermediation for renewable energy in Russia is similar to that in other countries, and perhaps could better be termed "market building" or "commercialization," since markets for renewable energy in Russia really do not yet exist. There are four factors related to market building for transfer and dissemination of the mature renewable-energy technologies in developing countries, according to Hurst (1990). (1) Demand must exist, with clear financial incentives, and the new technology must replace an existing function with an equivalent function. This demand may be stimulated with tax credits or other tax incentives. Credit must be available, and the reliability must not be a question for consumers. (2) Local manufacturers must be reasonably certain of the market and the opportunities for profit. It is not clear how import tariffs and barriers affect the process; on the one hand competition spurs innovation and efficiency, on the other it increases uncertainty and thus the willingness to participate in a market. (3) Manufacturers must have access to technology, either through licensing agreements or other more passive forms like trade journals, trade fairs, trips abroad, etc. (4) Some type of marketing and distribution system to get the technology to consumers must exist or be created.

Commercialization within a technology-development process requires substantial operating experience over many years, as was the case with U.S. wind-turbine development in the 1980s. The World Bank's earlier characterization (1981) of the problems of renewable energy in developing countries does not correspond with the commercialization problems in Russia. The World Bank wrote that developing countries faced three problems in development of renewable energy: (1) getting on board a rapidly evolving technology; (2) making appropriate technologies choices; and (3) adapting technologies (World Bank 1981). The solution to these problems was seen as more domestic research, development, education, and capabilities for designing, choosing, and adapting technologies. Domestic technology-development for some renewable-energy forms is quite advanced but still lags behind in commercialization.

The case study evidence is also consistent with the understanding from the literature that only the largest, most established renewable energy firms from Western countries in the most mature and profitable markets will be able or willing to transfer technology to a foreign market like Russia. Kenetech Windpower (Windenergo case study), the largest wind-turbine manufacturer worldwide, and Bergey Windpower (Bergey case study), also a world leader in off-grid turbines, have been the firms most active in wind energy in Russia and Ukraine, and their products are some of the most mature and commercialized worldwide of all renewable-energy technologies. One large solar photovoltaic manufacturer has been active in joint venture manufacturing discussions in Russia. In some (off-grid) applications, solar photovoltaics could also be considered a more mature market.

The Importance of Joint Ventures

Julian Cooper (1991) saw the potential for joint ventures to address energy-efficiency technology shortfalls in the Soviet Union:

> In one respect there has been a striking failure in the energy field....energy saving and conservation technologies have been neglected....This is a field that could well offer scope for joint ventures, especially after the price reforms that must be implemented soon. Whereas Western economies have more than fifteen years of experience in adapting to the shock of higher energy prices and have developed appropriate new technologies for enhanced energy efficiency, the pricing practices of the Soviet economy have served to isolate the country's technical specialists and managers from this experience. The joint venture could offer an effective means of reducing this gap within a relatively brief period of time. (p.42)

> [And] the joint venture offers the potential not only of quickly introducing modern technologies absent, or only weakly present, in the domestic economy, but also of exploiting Soviet

> technological strengths that are underdeveloped at present because of the rigidities and counter-innovative qualities of the economic system. (p.48)

The Soviets traditionally engaged in more passive forms of technology transfer, such as equipment purchases and licensing (see Technology Transfer to the Soviet Union annex). More active modes were employed during certain historical periods, but in general they tended to play a secondary role. Yet active technology-transfer has been an important form in the West, especially between affiliates of multinational corporations. Up until 1987, the Soviet Union essentially prohibited most active forms of transfer like joint ventures and wholly-owned subsidiaries, but after 1987 this changed and now "the joint venture is of considerable importance precisely because it offers the possibility of technology transfer of a genuinely active nature" (Cooper 1991, p.49).

The Deputy Secretary-General of the United Nations Conference on Trade and Development, while in Moscow in 1988, said that "joint ventures constitute one of the most important instruments of economic cooperation" (United Nations 1990a, p. ix). The transaction barriers analyzed in Chapter 7 support this statement. These transaction barriers imply that joint ventures are relatively more important for effective technology transfer than other modes of transfer because joint ventures provide a means for overcoming many of these barriers that other modes of technology transfer by themselves do not. In a Russian joint venture, a Western partner can contribute the most essential ingredients that the Russian partner often lacks: managerial, marketing, and financial expertise, and commercial experience ("know-how") with a specific technology. At the same time, existing Russian factories, skilled workers, and secondary supply networks for inputs can be utilized, thus eliminating many transaction barriers that a Western investor would face on its own. This arrangement also promotes learning by Russian managers, accountants, and engineers, who may work side-by-side with Westerners. Joint ventures allow Western partners to benefit from the existing contacts and experience of their Russian partner in overcoming transaction barriers, for example those related to intermediate supplier relationships and networks, financial transactions and regulations, corrupt government officials, and licenses. Joint ventures provide the close working relationships and long-term commitment that are also necessary for overcoming transaction barriers.

This match was seen clearly in the Mosmatic joint venture for industrial control and automation equipment between Siemens and the Moskvich auto factory in Moscow (Mosmatic case study). According to the director of Mosmatic (interview 9/9/94), Siemens supplied capital and know-how in the form of financial, managerial, and marketing expertise. Siemens personnel came to Moscow and worked side-by-side Russian personnel for this training to occur, and Russians were sent to Germany also (this option proved cheaper). At the same time, the Russian partner, Moskvich, provided the joint venture with experience in conducting business in Russia, along with marketing strategies and contacts for getting information about potential markets and customers.

Much of the experience that Honeywell hoped to gain from its Tushino project (Honeywell case study), which was done through a wholly-owned subsidiary, Honeywell Moscow, could perhaps be more readily obtained through a joint-venture partner. From this project, Honeywell hoped to learn how to deliver a successful project on time, how to work with local subcontractors, how to work with a customer who is not interested, how to train maintenance workers, how to get potential customers interested in its products, and how to handle many logistical and financial details (interview with engineer, Honeywell Moscow, 9/20/93).

The factors cited in the international production and joint venture literature as to why multinational corporations have been increasingly choosing joint ventures over wholly-owned subsidiaries bear close resemblance to the arguments just presented based upon the research evidence and logical reasoning (see Multinational Corporations annex). Factors cited in the literature on the supplier side include (1) access to a market frequently requires a domestic partner or having one helps in unfamiliar markets; (2) risks can be shared; and (3) capital requirements can be lowered. "Joint ventures offer a unique opportunity of combining the distinctive competencies and the complementary resources of participating firms" (Datta 1988, p.86). Benefits from joint ventures can be informational, as in knowledge of local market-related information, but "in fact, the biggest set of benefits in a joint venture are often 'political' in nature" (Datta 1988, p.86) in terms of the local partner's relations with local government authorities and institutions. However, the benefits from reduced risk and lower capital requirements with joint ventures may be moderated in Russia by the increased risk of uncertain venture partners, and the inability of Russian partners to contribute generous capital shares. Factors cited in the literature for motivations by the recipient side include: (1) access to capital; (2) access to new technology and brand-names; (3) access to managerial and technical "know-how" and innovation; and (4) opportunities to supply export markets. All of these factors are implied for Russia by the research evidence.

Transaction barriers and transactions costs discussed previously also suggest the importance of joint ventures in a transaction-cost-theory framework. Transaction-cost theory has been used to explain direct foreign investment in all its forms in general, and also the choice of joint ventures over wholly-owned subsidiaries in particular (see the Multinational Corporations annex). If transaction costs are high, and both supplier and recipient firms possess non-marketable knowledge, then a joint venture will be favored. Joint ventures are favored when a firm needs industry-specific information in the host country, when it has little knowledge of the host country, or when it needs resources controlled by local firms. Joint ventures are more likely in cultures radically different from the home country's. Joint ventures are less likely when a firm can acquire through the market or through contracts the assets it needs to operate in the host country (with low transaction costs), or when the assets it is contributing (technology or know-how for instance) have no market price or are difficult to protect through contracts. Many previous empirical studies support the transaction cost theory of the multinational corporation (Datta 1988).

The United Nations and the World Bank both mention encouragement of joint ventures in their literature as means of technology transfer and investment in energy efficiency and renewable energy, but these mentions are brief and do not propose how this is to be accomplished or what specific conditions are most favorable for this option. The World Bank says simply that "joint ventures....can be encouraged" (1993a, p.77), while the United Nations in Agenda 21 says "joint ventures should be promoted between suppliers and recipients of technologies" (United Nations 1993a, p.255; see United Nations Agenda 21 annex).

Corporate executives generally agree that successful transfers of technology through joint ventures require the existence of advanced indigenous technological capability, the availability of a developed infrastructure, reliable local suppliers of intermediate inputs and services, and skilled manpower. These requirements tend to explain why most joint ventures have occurred between developed countries, rather than between developed and developing countries. All of these conditions exist in Russia except perhaps reliable secondary suppliers, which both contemporary experience and historical literature have shown is a problem. The United Nations (1990b) adds the following additional factors: (a) the relative complexity or simplicity of the host country rules and procedures for joint ventures; (b) the potential for repatriation of royalties, profits, and dividends; and (c) the extent to which interests of the foreign partner in producing for the domestic market can be reconciled with the interests of the host country in producing for export markets. These additional factors less clearly support the case of a favorable climate for joint ventures in Russia.

Many of the characteristics, constraints, and barriers to joint ventures during the period 1987-1991 will continue to exist in the future, and the literature for the Soviet Union during this period (see Technology Transfer to the Soviet Union annex) is still very relevant. For example, the fact that the majority of joint ventures before had more than one Soviet partner due to the highly specialized nature of enterprise production, skills, or functions, is still true. It will be a long time before the levels of aggregation of economic agents and units in the economy changes, and associations of enterprises are becoming more prominent (see Decline of Centralized Coordination annex). Joint ventures with these associations are likely to be more common also.

Alternatives to Joint Ventures and Explanations of Foreign Investment

International technology flows have become dominated by multinational corporations (this was argued in Chapter 2). Although technology transfer with Russia can and will occur through many vehicles -- scientific and research exchanges, printed information, conferences and trade fairs, multilateral and bilateral aid programs, etc. -- the literature shows that multinationals occupy the "commanding heights." Multinationals in Russia can transfer technology via sales of equipment, technical assistance, licensing, turnkey projects, or direct foreign investment either as wholly-owned subsidiaries or as joint ventures.

There are reasons why other commercial forms of technology transfer, besides joint ventures, are not as likely to prevail in Russia. To begin with, the transaction barriers imply that long-term commercial relations are important, and this is one factor favoring direct foreign investment over other forms. Other considerations are:

(1) Direct sales and turnkey projects would seem to be profitable for Western businesses, but there is a very limited quantity of capital available for enterprises to outright purchase Western equipment, and a lack of financing by banks. The costs of directly purchased foreign equipment may cause higher-than-acceptable payback times for investments, whereas cheaper Russian equipment will still give reasonable payback times. For example, it appeared that Windenergo-produced wind turbines could produce electricity at near domestic costs of conventional generation. Another bid to work in Ukraine by a Western windpower company in 1992 never got anywhere because the company wanted to import foreign turbines and required electricity prices close to world levels to justify the investment (interview with president of company, 1/18/93). High import duties and rising nationalist protectionism may also limit the amount of equipment that will be imported.

(2) Licensing without a joint-venture is a more risky route, as the Western partner has little control over the development based upon the license, and less stake in the performance of the licensee. The specific shortcomings of Russian technological capability are more likely to prevail

when Russians try to exploit a license by themselves, as was common before the 1960s in the Soviet Union. This is precisely why Soviet policy shifted in the 1960s to longer-term cooperation agreements for technology transfer that included licensing with long-term cooperation. One Russian business analyst said that effective transfer of technology with only a license was "hopeless" (interview 9/6/94).

(3) Foreign subsidiaries will have a more difficult time without an experienced Russian partner negotiating the maze of supplier relationships, corruption, and bureaucratic and legal procedures and uncertainties. Further, because of the large risks and uncertainties present and the transaction barriers described previously, it makes sense to share those risks and uncertainties (and responsibilities) with a joint-venture partner rather than bear them alone, especially if the partner can reduce the risks or improve information. "Recent regulations allow foreigners to form wholly owned companies and subsidiaries, but joint ventures are still the best investment option. Americans can benefit from reliable Russian partners with good connections and access to raw materials and equipment" wrote Kvint (1994, p.70), a Russian economist with extensive practical experience in capitalistic undertakings within the former Soviet economy and since the collapse of the Soviet Union, and a former member of the Siberian School of Economics and the Institute of Economics in Moscow.

Nevertheless, the concept of "power distance" can be used to argue against joint ventures in Russia, and this theory is also consistent with part of the research evidence. Shane (1993) argues that the cultural trait of "power distance" in the supplier country, a measure of the level of interpersonal trust between economic actors, increases the <u>perceived</u> transaction costs and thus increases the preference for wholly-owned subsidiaries over joint ventures in a foreign operation. The lack of attention to power relationships is a common criticism of transaction cost theoretic approaches in general, and in this case as well. As the level of trust and perceived trustworthiness between two potential joint-venture partners declines, transaction costs to the joint venture will increase and the foreign partner will tend to favor a wholly-owned subsidiary. Because of the uncertainties and lack of information in Russia, it is difficult to know enough to trust potential partners and trustworthiness becomes an important issue. Some people interviewed in the course of the research felt that joint ventures were less likely because Western partners could not trust potential Russian partners and were unwilling to relinquish total control of a venture that was risky enough anyway. This view was echoed by the director of Danfoss Russia (Danfoss case study) in explaining why he chose a wholly-owned subsidiary over a joint venture for a new production facility.

Multinational corporations tend to prefer foreign subsidiaries over licensing when transferring technology because of the nature of international technology markets (Vernon 1986). The marginal costs of transfer for a firm that has already developed a technology are assumed to be low, and therefore in the bargaining process with potential recipients, who will have alternative suppliers from which to choose, the gains from licensing will be less than if the firm captures the rents from the technology itself within the recipient country. Another situation favoring foreign subsidiaries is when the value or price of the technology is difficult or impossible to measure and thus licensing becomes problematic.

The market power and collusion theory of firm behavior (see the Multinational Corporations annex) would predict that multinationals will invest in Russia to enter a new market open to the West and develop their market share, visibility and prestige in Russia, if they think they can retain a large market share (technological monopoly) over the longer-term. This was certainly one of Honeywell's interests (Honeywell case study), having been in Russia since 1975, and was a factor in Honeywell's decision to contribute $2 million as a gift towards the Honeywell Tushino project. Kenetech Windpower (Windenergo case study) also saw promising new markets in former Soviet republics and, despite the high cost and hardships involved in their Windenergo joint venture in Ukraine, continued to persist with a longer-term view. Danfoss invested in a wholly-owned-subsidiary production facility in Moscow while acknowledging that the markets for its products did not yet exist in Russia -- but it hoped to create that market itself. All three companies are the world's leaders in their respective technologies.

The traditional neoclassical theory of foreign investment says that foreign investment will flow to Russia, with its high capital costs and low labor and factor costs, from countries with low capital costs but high labor and factor costs. However, the experience since the 1940s has shown that investment does not necessarily follow the pattern predicted by this theory. In fact, much of the multinational investment has occurred between developed countries.

More recent explanations of investment patterns rest on the comparative advantages of different countries with respect to particular technologies in particular stages of maturity, the multinational corporation's motivation to take advantage of technological monopolies in new markets, and trade barriers (Cantwell 1989, Pitelis and Sugden 1991, Brown et al 1993). These explanations for Russia gain tentative support from the case studies in the areas of comparative advantage and technological monopolies in new markets.

Joint ventures are important vehicles for exploiting Russia's comparative advantages. The comparative advantages of Russia related to production of energy-efficiency and renewable-energy technologies are the existence of idle industrial capacity, skilled workers, and potential supplies of cheap raw materials and intermediate inputs close at hand. This would imply that relatively low-technology, high-labor energy-efficiency and renewable-energy technologies would capture this comparative advantage. The case study evidence supports this implication (actually, most energy-efficiency and renewable-energy technologies fall into this category). The 56-100 wind turbine that Kenetech Windpower licensed to Windenergo was a mature, relatively low-tech technology, and had in fact already been superseded in the West by a much higher-tech version with sophisticated electronics (Windenergo case study). The boiler conversions that NUTEK was encouraging for domestic production in Estonia were also explicitly designed to be low-tech, high-labor technologies, both in production and in operation (NUTEK Biomass-Fueled Boiler case study). The radiator-thermostat valves that Danfoss began to produce in Moscow were low-tech, high-labor and material devices (Danfoss case study).

The "new multinationalism" means that competition among both developed and developing countries for capital and technology has intensified (Gilpin 1987). Developing countries have become more differentiated in their ability to attract foreign investment. The host country factors at work here are political and economic stability, surplus and inexpensive skilled labor, large and expanding internal markets, and export-led growth. Corporations are seeing developing countries less as pliable exporters of raw materials, and more as potential markets, industrial partners, and potential future competitors, and the same is true of Russia.

CHAPTER 10

CONCLUSION

As the third-largest producer of CO_2 emissions worldwide, Russia represents a large potential source of the CO_2 emissions reductions needed to mitigate global climate change in the future. Energy efficiency and renewable energy, whether developed and financed domestically, through commercial international technology transfers, or through bilateral and multilateral assistance, are important vehicles for CO_2 emissions reductions. While the reasons for existing inefficiencies and token use of non-hydro renewable energy are well understood (and relate to the former Soviet economic system; see Chapter 3 and the Energy Development Policies in the Soviet Period annex), the situation in post-Soviet Russia and the reasons why investments do not occur today in more efficient energy use and in renewable energy technologies are much less understood in literature and in practice. Further, information about the opportunities for energy efficiency and renewable energy has been scarce in Western literature because of the secrecy and poor quality and quantity of energy consumption data and renewable energy resource assessments in the Soviet period. Even now, much information can only be obtained through personal contacts rather than from printed and published sources; my experience has shown that information in Russia is still a closely-guarded, personal, and costly commodity.

The research evidence acquired in the field for this dissertation -- descriptions of twenty-three case studies, over two hundred interviews, many unpublished documents, and eighteen months of personal experience while resident in Russia and Estonia -- represents a unique in-depth contribution to existing studies, literature, and knowledge. This chapter summarizes the main arguments and conclusions of the dissertation, which are made based upon this evidence and existing literature. First, the main arguments and conclusions from Chapters 3 through 7 and Chapter 9 are summarized. Then, the next section summarizes the contribution of this dissertation to some of the key literatures that were reviewed in Chapter 2 and that were analyzed for relevance to Russia in Chapters 4, 5, and 8. Finally, two arguments that are important to Western policies to promote energy efficiency, renewable energy, and technology transfer are distilled from all of the preceding chapters: first, that the situation in Russia related to energy efficiency, renewable energy, and technology transfer is a complex combination of conditions found in developed countries, in developing countries, and previously in the Soviet Union; and second, that a process of sustainable energy development in Russia must reflect and incorporate this combination of conditions.

Main Arguments and Conclusions

A comparison of energy intensities and the structure and level of energy consumption in Russia with those characteristics in other countries, together with a large body of evidence on technical-economic potential from the case studies, suggest that huge energy-efficiency improvements are possible and economically cost-effective in Russia from technology transfer and investment using both Western and Russian technologies (see Chapter 4). Specific sectors with large potential are the industrial, residential, and heat-supply sectors. Specific technologies with high technical-economic potential for energy-efficiency improvements are: (1) meters, valves, and automated controls for district-heating supply, distribution, and consumption, especially in the residential sector; (2) reduction of heat leakages and better insulation of buildings and heat distribution pipes in the residential and industrial sectors; (3) secondary process heat recovery in industry; (4) variable-speed motor drives in industry and energy production; (5) low-cost measures in industry like boiler tuning, energy monitoring and control systems, and minor industrial process changes; (6) industrial cogeneration with combined-cycle gas-turbines; and (7) municipal lighting.

Russians have themselves developed many renewable-energy technologies but have not deployed them commercially (see Chapter 5). The research evidence showed that economically favorable geographical opportunities exist for renewable energy installations in Russia, particularly for wind, biomass, solar thermal, and geothermal. While wind energy resources are especially plentiful along the northern and eastern borders of the country and in the North Caucasus region, the correspondence of these resources with populated areas and/or electric power transmission capacity is less favorable. The high-population North Caucasus region and populated areas of the Northwest (i.e., Murmansk and Archangel) and Far East (Khabarovsk) represent the best potential for either electric-power-grid-connected wind farms or stand-alone wind-diesel systems for electricity supply to small settlements. 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 year-round solar resources exist only in the most southern regions, summertime-only solar resources for supplemental hot-water heating (potentially an economic addition to existing district heating systems) exist throughout the country. Geothermal resources are concentrated in two small regions, although one of these, the North Caucasus, is heavily populated. Two important motivations exist for renewable energy development in Russia that typically are not seen in renewable energy literature: (1) conversion of existing idle industrial capacity with skilled workers into new productive uses, and (2) increased regional autonomy (economic, political, and technical) from central authorities and national energy supply companies.

Russians have a technological capability that parallels most developed countries. The research evidence showed many examples of existing Russian technologies related to energy efficiency and renewable energy (see Chapter 6). But what was equally clear from interviews is that Russians still lack the associated managerial, financial, legal, and market-transaction skills and institutions to take full advantage of that capability for themselves and in a global economy. They also lack "commercial know-how," which is an innovative, creative, and experience-based (not necessarily technical) ability to turn an idea or design into a reliable, high-quality commercial product or service. A large component of this deficiency is simply the lack of experience in producing for quality. Commercial know-how often can be acquired only through experience, and it is this experience base which the

Russians lack. A common theme expressed by interviewees and seen in research evidence was that "great ideas and opportunities exist if only they could be evaluated and commercialized."

Market-level energy prices, privatization, macroeconomic stabilization, greater institutional efficiency, and national energy efficiency policies, all traditional policy prescriptions for developing countries and countries in transition, were also progressing in Russia from 1992-1995, but are insufficient conditions for exploitation of the technical-economic opportunities outlined above. Energy prices have rapidly been approaching levels found in many developed countries (yet may remain below these levels because of low energy production costs in Russia, cost-based pricing, the "non-payment crisis" of enterprise and consumer indebtedness, and social issues (see Chapter 2)). Unlike energy prices in many developing countries, energy prices in Russia are no longer directly subsidized except for residential heat and hot water. Federal-level government policies for energy efficiency have been few and have not made any real difference. Rather, policies at the local and regional levels (especially by regional energy commissions) are much more likely in the future to have an impact on energy-efficiency and renewable-energy investments, as are fundamental institutional innovations and restructuring at both enterprise and market levels.

The research evidence provided the basis to formulate and catalog thirty-seven transaction barriers to energy efficiency and renewable energy investments and technology transfer (see Chapter 7). Many of these transaction barriers can be seen in literatures on developed and developing countries, while some are unique to post-Soviet Russia. This catalog of barriers supports the central thesis of the dissertation: huge technical opportunities that are economically profitable are not translated into economic activity by domestic enterprises or by foreign entities through technology transfer because of many serious transaction barriers. Chapter 7 groups transaction barriers into several major categories, related to: macroeconomic conditions, lack of information, technical and geographical characteristics of heat-supply infrastructure, institutions, organizational forms, culture and education, and politics. The main influence of a large share of these barriers is greater uncertainty in transactions, either over costs, benefits, opportunities, and/or future actions. Other barriers limit full and correct information from reaching those who need it. Still others are related to legal institutions and 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. Another group of barriers relates to the institutional problems that enterprise managers and apartment owners face even after privatization of enterprises and apartments. The catalog of transaction barriers also serves to highlight the nature of economic activity in post-Soviet Russia (see also the Decline of Centralized Coordination annex), for example that personal contacts and trust are two key ingredients for successful economic activity.

Transaction barriers underscore the importance of market intermediation and joint ventures for energy-efficiency and renewable-energy investments and technology transfer (see Chapter 9). Market intermediation functions provide the information, skills, analysis, market services, project evaluation and specification, and financing necessary to overcome transaction barriers (see Table 7 in Chapter 9 for a list of important market intermediation functions in Russia synthesized from the research evidence). While existing literature does cover market intermediation, as for example by energy service companies, independent power producers, and electric power utilities (demand-side management), applied to Russia it falls short in emphasizing the importance and character of market intermediation in Russia. Strong and pervasive institutionally-related transaction barriers require equally strong and pervasive market intermediaries. Several examples of emerging market intermediaries in Russia were evident in the research, including energy service companies, enterprise associations, municipal governments, regional governments, regional electric utility companies, non-governmental organizations, and bilateral and multilateral assistance agencies. With the exception of electric-power-utility intermediation (demand-side management), which the evidence showed was more problematic in Russia than in developed countries, all of these forms of intermediation represent important institutional innovations for Russia.

Joint ventures with foreign multinational corporations to produce energy efficiency and renewable energy technologies represent another important means for overcoming transaction barriers, one that also takes advantage of Russian technological capabilities. The joint venture, allowed by Soviet law for the first time in 1987, provides a means of active technology transfer, which historical literature on technology transfer to the Soviet Union showed was important. The research confirms a prevailing view in the literature that joint ventures were and are an important instrument for economic development and cooperation in the Soviet Union and post-Soviet Russia. In a Russian joint venture, a Western partner can contribute the most essential ingredients that the Russian partner often lacks: managerial, marketing, and financial expertise, and commercial experience with a specific technology. Joint ventures allow Western partners to benefit from the existing contacts and experience of their Russian partner in overcoming transaction barriers, for example those related to difficult-to-obtain information, intermediate supplier relationships and networks, financial transactions and regulations, corrupt government officials, and licenses. The analysis in Chapter 9 also suggests that other forms of technology transfer, like direct equipment transfers, licensing, and foreign subsidiaries are not as likely to prevail in Russia, although conflicting views in the literature exist on this subject.

Dissertation Contributions to the Literature

Energy-efficiency and renewable-energy technology transfers and investments in Russia reflect a complex combination of elements from the developed country, developing country, and Soviet Union perspectives within energy efficiency and renewable energy literatures, and within literatures dealing with commercial firms, with multilateral and bilateral development agencies, and with international organizations promoting technology transfer for environmental benefits (see Chapters 2, 4, 5 and 8). This conclusion provides a basic framework for understanding the contribution of this dissertation to the literature.

The contribution to the literature also comes in the form of a context-specific, sector-specific and country-specific case added to the multitude that already exist. Very little yet exists in these literatures on post-Soviet Russia, and very little literature on energy-efficiency and renewable-energy technology transfer to formerly planned economies exists. Context is important. For example, many authors have recognized that technology-transfer barriers (or impediments or limiting factors as they are alternatively called) depend very much on the specific context in question:

> The limiting factors for technological transformation are not primarily technological but are instead part of the social, economic, political, and cultural milieus in which technologies are developed, diffused, and used. Market incentives, the structure of regulations, the content and quality of research and education, and social values and preferences all determine technological trajectories. (Heaton et al 1991, p.21)

Finally, the contribution to the literature lies in analyzing the relevance of existing literature to post-Soviet Russia. Below are outlined some of the main literatures reviewed in this dissertation, together with a description of how and where in the dissertation each literature is analyzed for its relevance to Russia:

(a) Energy efficiency. One theme of energy-efficiency literature concerns new technologies for improved energy efficiency and comparative assessments of their technical, economic, and social characteristics. Another theme concerns the reasons why energy consumption is less efficient than a perfect neoclassical economic model would predict -- the reasons for the existence of an "energy efficiency gap." This explanation tends to focus on market failures or market barriers that have caused existing energy inefficiency and that limit further investments or adoption of new technologies. In development literature, macroeconomic structural factors have been emphasized as causes of energy inefficiency (just as for economic inefficiency). Another theme concerns the policy prescriptions recommended to remedy the "energy efficiency gap." This dissertation is relevant to all three of these themes. In Chapter 4, specific technical opportunities and end-use sectors for improved energy efficiency in Russia were analyzed and compared with the literature, taking account of the structure of energy consumption in Russia relative to other countries. For example, Scandinavian literature on district-heating energy efficiency and residential energy efficiency in cold climates is especially relevant to the energy-efficiency opportunities in Russia, while Western electricity-efficiency literature is relevant to a lessor degree. In Chapter 7, market failures were expanded into a more general category of transaction barriers in Russia and these were compared with the literature. Most market failure and barrier literature is very relevant to Russia, while some uniquely post-Soviet barriers are missing from these literatures. Policy solutions were not analyzed in detail for Russia, but rather the importance of policy solutions that provide market intermediation was stressed.

(b) Renewable Energy. Much of the renewable energy literature focuses on technical and economic characterization of different renewable-energy technologies in different applications. Other literature focuses on renewable energy as part of national energy strategies, and the problems of greater adoption. Many characterizations of the barriers to renewable energy "dissemination" are given in the literatures. Another major theme, especially in developing countries, is the creation of new markets for renewable energy, both on the supply and demand sides. In Chapter 5, renewable energy resources, opportunities, barriers, and technological capabilities in Russia were compared with characterizations in the literature for both developed and developing countries. While literatures for both developed and developing countries are partially relevant, a combination of both literatures, along with uniquely Russian elements, is necessary to adequately characterize the problems, opportunities, and capabilities for renewable energy development. In addition, the prospects for building markets for renewable-energy technologies were compared against the literature, especially in light of transaction barriers.

(c) Technology Transfer and Development. Relevant literature on technology transfer could be classified as political-economy-oriented, firm-oriented, and agency-policy-oriented (see Chapter 2). Political-economy-oriented literature is quite diverse, but tends to look at nations as the units of analysis. Government policies, international agreements, and multinational corporate behavior are analyzed in the context of issues like national economic independence and technological competitiveness, economic growth and development, and international trading regimes. The research has not specifically addressed these political-economic issues, although it does have implications for them.

In the firm-oriented international technology transfer literature, four main dependent variables are the subject of research. These are the propensity to transfer (supplier) or seek transfer (recipient), technology choice, and the mode of transfer selected. Independent variables that influence these three dependent variables include economic, political, legal, institutional, cultural, and many other factors. The literature often attempts to place these factors into a conventional cost-benefit economic analysis where the impact of these factors is reduced to their influence on economic costs and benefits weighed by rational economic agents. Chapter 8 analyzed three of these dependent variables in the case of commercial technology-transfers with Russia: the propensity to transfer, the propensity to seek transfer, and the mode of transfer selected. Once again, a combination of perspectives in the literature for developing, developed, and planned economies is relevant to Russia.

Agency-policy-oriented literatures, like World Bank energy-sector lending literature and United Nations literature on sustainable development, attempt to classify the means and barriers to greater improvements in energy efficiency and development of energy supplies, and they specify policies for promoting specific means and overcoming important barriers. The ultimate policy goals associated with these literatures may be different, including, for example economic growth and development, environmental-pollution reductions, or human resource development. Technology transfer is usually treated as a means to greater improvements in energy efficiency and development of energy supplies, and then, within this context, means of transfer and barriers to transfer are analyzed. This literature contains the main policy statements and "blueprints" for sustainable development and technology transfer of environmentally sound technologies, such as the United Nations Agenda 21 and other activities by the United Nations. In Chapter 8, the specific problem conceptions and policy solutions in this literature were held up to Russia to see where there are matches and mismatches. One mismatch is that the conventional development approach of providing capital equipment and technical assistance results in underutilization of the existing technical capabilities and the existing developed infrastructure. Another mismatch is that these literatures tend not to emphasize the level and direction of indigenous technological efforts and potential institutional innovations and reforms in a recipient country, both important considerations for Russia.

Some of the agency-policy-oriented literature does focus on domestic capability (for example "capacity-building" in United Nations Agenda 21; see the UN Agenda 21 annex). A common view in the literature is that the success of technology transfer depends on the recipients' abilities to understand and choose technologies and investments wisely, and on the ability of effective institutional forms to accommodate and guide transfers through conception to operation and beyond. Thus the view by the United Nations and others that domestic capabilities necessary for transfer include the proper institutional mechanisms and capabilities is very relevant to Russia. One aspect of domestic capabilities that the research showed was important, but that is not highlighted in the technology-transfer literature, is the capability for economic and financial analysis of energy efficiency and renewable energy investments. The research evidence and case studies clearly showed that while Russians were interested in technical descriptions of Western technologies, they were more interested in and assisted by descriptions of the economic and financial aspects and analysis of these technologies, basic economic-analysis methodologies and tools, policy-making skills, and business and finance skills.

Russia as a Complex Combination of Developed Country, Developing Country, and Soviet Union

One argument important to Western policies to promote energy efficiency, renewable energy, and technology transfer is that the situation in Russia related to energy efficiency, renewable energy, and technology transfer is a complex combination of conditions found in developed countries, in developing countries, and previously in the Soviet Union. This combination is illustrated here along twelve different dimensions:

(1) Energy system. Russia's energy supply system is comparable in size and sophistication to systems in most developed countries. Nuclear power supplies 10% of all electricity produced, integrated electric power networks reach over 90% of the population, and electricity production and transmission are technically very efficient. Large, centralized heating networks, many based upon cogeneration, supply heat to over 80% of the population, and represent a feature unique to Russia and other former Soviet republics.

(2) Patterns of energy consumption. On a per-capita basis, energy use in Russia is roughly equivalent to that in many developed countries. The industrial and heat production sectors are the largest and most inefficient consumers of energy, while developed country literature on energy efficiency emphasizes electricity in residential and commercial sectors. Levels of economic activity affecting energy consumption, including apartment size, per-capita automobile travel, and per-capita material consumption have not changed appreciably from the Soviet era and are more reflective of developing countries. Energy consumption is currently stagnant, in comparison with high growth rates in developing countries and some growth in developed countries, so future energy-supply capacity-offsets from energy efficiency are more uncertain than in both developing and developed countries.

(3) Renewable energy resources. While many developing countries receive large shares of their energy supply from biomass, and many developed countries receive growing shares of energy supply from high-technology forms of renewable energy, Russia receives practically no share of its energy supply from renewable energy sources other than hydropower.

(4) The meaning, cost, and supply of capital. Capital in the Soviet Union was essentially a free good, allocated on the basis of need and political priorities. This management mentality that one merely "gets" capital, as opposed to having to pay for it or allocate it efficiently, will persist. Capital

markets are weak and long-term capital is in short supply, suggestive of many developing countries. Yet the needs for capital because of the highly developed infrastructure are tremendous and on a par with those in developed countries.

(5) Transaction barriers. Transaction barriers similar to both developed and developing countries include those related to lack of information and uncertainties, institutionally mismatched costs and benefits, market acceptance of technologies, bilateral trade restrictions, and high front-end capital costs. Barriers related to high inflation, currency conversion, corruption and mafia, weak market and legal institutions and lack of enforcement mechanisms, monopoly production, energy quotas and allocations, and State-owned (and "post-State-owned") enterprises are more reflective of developing countries. Many barriers are unique to Russia (inherited from the Soviet Union), including those related to technical and organizational characteristics of district-heating infrastructure (especially lack of regulation-control equipment and meters for billing, building-radiator-network design, and the organizational complexity of supply and distribution); differences in technical standards; highly personalized economic relationships and networks; housing privatization and responsibility; separation of innovation from production; lack of historical experience with cost-minimization, innovation, marketing, financing, negotiating, and competition; and technological pride.

(6) Propensity to transfer technology. Factors affecting foreign firms' propensity to transfer to Russia are similar to those for both developed and developing countries, including repatriation of profits, costs of production, ease of finding partners and ascertaining their reliability and trustworthiness, maturity of markets, costs and uncertainties of transactions, and potential for domestic market exposure. Factors affecting Russian firms' propensity to engage in technology transfer are more reflective of developing countries: availability of capital; desire to acquire management, marketing, and commercial skills; desire for quality that does not exist domestically; and need of products that do not exist domestically. The lack of experience with innovation is a particularly Soviet trait, and also affects Russian firms' propensity to transfer technologies.

(7) Modes of technology transfer. Decisions about the mode of technology transfer by both supplier and recipient are influenced by Russians' technological capabilities and market-oriented deficiencies. The historical Soviet need for more active transfer to ensure successful projects and technology diffusion, together with trade barriers and technological capabilities, all suggest active-transfer modes similar to those between developed countries, like joint ventures and licenses with technical assistance. The need for management, financial, marketing, and commercial experience also suggests more active forms of transfer, and suggests similarities to technology transfer between developed and developing countries.

(8) Choice of technology to transfer. Russia has comparative advantages quite unique among developed and developing countries. The comparative advantages of Russia with respect to production of energy-efficiency and renewable-energy technologies are the existence of idle industrial capacity, skilled workers, and potential supplies of cheap raw materials and intermediate inputs close at hand. This implies that relatively low-technology, high-labor technologies, like many of those for energy efficiency and renewable energy, would capture this comparative advantage, and will be selected in technology-transfer decisions. Markets are still small for these technologies in Russia, and case study evidence shows examples of Western companies establishing market dominance, consistent with recent explanations of multinational investment patterns that take advantage of potential technological monopolies.

(9) Joint ventures. Joint ventures make sense in the context of the intersection of developed country, developing country, and Soviet Union perspectives. The old East-West gap persists in terms of mutual understanding and knowledge about conditions, capabilities, and firms on the other side of the gap. This gap requires the close working relationships and long-term commitment that a joint venture brings for successful projects, as opposed to more arms-length relationships that have worked well in technology transfer between developed countries. Joint ventures work best when the two sides have similar technological capabilities and developed infrastructure, as in the case of technology

transfers between developed countries, rather than between developed and developing countries. Foreign partners can supply capital and business know-how that Russians lack. A Russian partner can get through the maze of conflicting and missing laws, bureaucracy and corruption.

(10) Multilateral and bilateral policies and approaches. Traditional policy recommendations are inadequate for promoting technology transfer, and neglect the importance of institutional innovations and market intermediation. Technical assistance is unnecessary. What is needed is capital and equipment coupled with assistance and capacity-building in evaluating and making investment decisions, and in overcoming transaction barriers related to incentives, institutional structures, information, and uncertainty and risk.

(11) Market intermediation mechanisms. Some of the intermediation mechanisms in developed countries, like energy-service companies and activities by multinational companies themselves, are viable in Russia. Others, like demand-side-management programs by electric utilities, independent power producers, and equipment and appliance labelling, are more problematic in Russia. Intermediation mechanisms unique to Russia include activities by municipal and regional governments (energy-efficiency funds, investment projects, industrial development, and energy efficiency in municipal-owned buildings (even if privatized)), and investments in renewable energy by regional electric utilities.

(12) Market building and commercialization. The building of domestic markets for energy-efficiency and renewable-energy technologies is a key to greater technology transfer and investment in all countries. But in Russia, both market intermediation and joint ventures play an especially vital role in market building because of the transaction barriers present. Market building means development of domestic manufacturers who can produce for these markets, stimulation of demand through incentives, demonstrations, and information, and convincing suppliers that markets are expanding and will pay off their investments in new supply capability and in marketing.

Sustainable Energy Development in Russia

Another argument important to Western policies to promote energy efficiency, renewable energy, and technology transfer is that a process of sustainable energy development in Russia must reflect and incorporate the combination of conditions just described in the preceding section. But before discussing "sustainable energy development" in Russia, this phrase itself needs clarification. Many definitions of "sustainable development" have been advanced, none of them very satisfactory (see Norgaard 1994). "Sustainable energy development" also means different things to different people. One common view is that it means increased economic growth by maximizing the economic benefits of energy use, while at the same time maintaining sound environmental standards (Guertin et al 1993). My definition of "sustainable energy development" is narrower than the general definition of "sustainable development" but is also process-oriented like the more general definitions in the literature. I see sustainable energy development as a four-sided process in which: (1) the environmental impacts, both local and global, of energy production and consumption are continuously reduced on the basis of impact-per-unit-of-good-or-service in the economy; (2) energy-system development contributes to the reduction of poverty and the provision of basic human needs such as food, shelter, transportation, and health, especially of those in the bottom economic brackets; (3) human knowledge, skills, and aspirations are not squandered but channeled into constructive contributions to the above two processes; and (4) new institutions are created or others reconstructed to facilitate the above three processes.

Sustainable energy development in Russia is in many ways similar to that in other developed countries. Examples are coal scrubbers and cleaner forms of coal combustion, improved efficiency of electricity and heat supplies, switching from oil and coal to increased use of natural gas, an honest look at and debate about the future role and costs of nuclear power, and widespread use of renewable energy in the longer term along with existing hydropower and the possibility of fusion. But sustainable energy development means more than just the energy sector. It means modernizing industry while making it more energy efficient and less polluting. It means slowly replacing the car, bus, and truck fleets with more fuel-efficient and less-polluting vehicles while maintaining the existing quality and viability of mass-transit. It means changes in the structure and relationships of economic activity, for example so that materials and goods are not needlessly transported over long distances.

The unique characteristics of Russia in connection with sustainable energy development are the huge inefficiencies in energy use in both existing infrastructure and management practices, few pollution controls on energy combustion, a unique highly centralized heat supply system, the large potential natural gas resources to be tapped and the possibility of converting significant portions of the infrastructure from oil and coal to natural gas, good geographical resources for renewable forms of energy supply, and huge volumes of idle industrial capacity and skilled workers which could be put to work producing the energy efficiency, renewable energy, and clean combustion technologies that Russia, and many other countries around the world, need for sustainable energy development.

If a process of sustainable economic development and reconstruction is to take place in Russia, Western entities must recognize, understand, and make full use of this technological capability. They must also understand the market-oriented shortcomings associated with it, and focus their efforts on overcoming these shortcomings. Russians lack the capital and the market and commercial know-how to use these capabilities fully. Short-term technical assistance will not do much, nor will isolated equipment transfers. Managers and officials in all sectors of the economy need to learn how to reduce costs, how to make economic and financial decisions about capital investments, how to prepare business plans and financing proposals, how to solicit and evaluate bids from suppliers, consultants, and contractors, how to write and enforce contracts, and how to commercialize and market new technologies.

CASE STUDY: BERGEY WINDPOWER WIND-DIESEL SYSTEMS

Bergey Windpower is a U.S. windpower company with expertise in small, off-grid, wind-diesel hybrid power systems, and is considered one of the leading worldwide suppliers of small wind-turbines for village power applications. It has been pursuing business development in the Far East region of Russia because there is a large market potential for this type of equipment there, and the wind resources are excellent. In contrast to most of central Russia and the populated areas of Siberia, many areas of this region are not connected to electric power grids. Rather, diesel generators produce electricity from diesel fuel, which must often be brought long distances by rail, road, or air. In recent years the costs of diesel fuel have risen; the transportation networks, logistics, and payments associated with this diesel fuel supply have broken down; and spare parts for the diesel equipment have been difficult to obtain. Thus electric power shortages have resulted. Wind-diesel systems make sense in the Russian Far East and Far North because the power generated from these systems is cheaper than from pure diesel generation, and because they reduce dependence on outside sources of fuel.

LMW Windenergy of Khabarovsk, Russia was founded in 1992 in a joint venture agreement with a Dutch wind company to develop small wind-turbine applications in Eastern Russia and Siberia. From 1992 to 1994, over 40 installations were completed using Dutch and American equipment. In 1994, LMW Windenergy decided to use exclusively Bergey Windpower equipment. Also in 1994, negotiations took place for Bergey Windpower to license and transfer its technologies to LMW Windenergy for use in producing wind turbines in a former military industrial enterprise in Khabarovsk. The estimated start-up cost for this production was $190,000 for a first phase of production, and the technology-transfer fee was set at $110,000.

LMW Windenergy signed an agreement with the Russian Ministry for Nationalities Affairs and Regional Policy for a project called the Northern Russia Rural Power Project. This is a program to provide rural electrification to 1000 farmers, fisherman, small communities, and medical complexes in the Far North using small wind-turbines and associated equipment. The full project if implemented would provide 17,500 installations and cost $200 million.

In late 1994, the project was on hold pending a source of financing. the United States Export-Import Bank was one potential source of financing, but this bank required a sovereign guarantee for any loan, which the Ministry of Nationalities Affairs and Regional Policy was unwilling or unable to make.

Grant funding of $5 million for a first phase of this project for 100 10-kW wind systems was requested from USAID under its Energy and Environmental Commodity import Program in 1994 (see USAID case study). The project was ranked first technically of all the 40 proposals in the power sector category that USAID received for this program, and was the only renewable energy proposal received. Further, the first round of the Commodity Import Program proposal selection identified only $17-18 million in "worthwhile" proposals for the $30 million in power sector grants that USAID had to give away. But USAID designated the Northern Russia Rural Power Project proposal a "private sector" proposal because LMW Windenergy submitted it, even though the Ministry of Nationalities Affairs and Regional Policy was the official sponsor of the project. Being a private sector proposal, the application was rejected because USAID knew that LMW Windenergy was not able to pay the necessary 70% ruble cost sharing for private sector proposals.

Sources of Evidence

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CASE STUDY: BUILDING-ENERGY-EFFICIENCY RENOVATIONS IN ESTONIA

1. Mustamaee District of Tallinn by Sweden (BITS)

A demonstration project of residential energy-efficiency measures took place in the Mustamaee district of Tallinn during 1991-1993. The project was financed by Swedish bilateral aid agency BITS and conducted by Stockholm Konsult. The project was a combination of before-and-after comparison and side-by-side measurements involving a retrofitted building and a reference building. Technical measures included roof insulation, weatherstripping, a new substation, main pipe-control valves, additional window panes on the top floor, and heat meters. Potential energy savings from this project were initially estimated at 30%.

Two typical nine-story, 72-apartment neighboring buildings were selected, one as the renovated building, and the other as the reference building. Initial energy inspections and measurements were made, followed by renovations in the fall of 1992. During the winter of 1992-93, energy consumption and indoor temperatures were monitored and recorded. The indoor climate was also studied using a questionnaire given to tenants.

An actual energy savings of around 15% was obtained during measurements in the 1992-93 heating season, as compared with the reference building after appropriate adjustments. The researchers noted that because of lower than normal heat supply during this period, the 15% savings was lower than it would be under normal heating conditions. Other results reported were that the building's energy signature showed that the retrofitted building's energy consumption was much more adjusted to the current outdoor temperature than that of the reference building. Tenants also obtained a more reliable supply of hot water and experienced an improvement in air quality.

2. Mustamaee District of Tallinn by Sweden (NUTEK)

In 1994, the Swedish National Board for Industrial and Technical Development (NUTEK) made a Swedish-government loan to the Mustamaee district government of Tallinn, guaranteed by the Tallinn City Council, for renovation of an initial four buildings in 1994. The four buildings selected were typical 5-story buildings, with 80-apartments (approximately 14,000 m2 total floor area each building). The total loan for 1994 was 4.1 million EEK ($340,000), so the total cost per building was about 1 million EEK ($80,000). Loans from NUTEK for an additional 5-10 buildings were anticipated in 1995. The technical measures in this project were very similar to those from the original BITS-financed Mustamaee project of a year earlier:

- new heat meter
- new substation
- new roof insulation
- weather stripping of windows and balcony doors
- replacement of heat and hot-water pipes in the basement
- new main pipe regulating valve
- new front entrance doors and door closers

In the original Mustamaee project a year earlier, ventilation was also included, additional window panes were installed on part of the top floor, pipes in the basement were insulated but not replaced, and the front entrance doors were not replaced.

3. Oeismaee District of Tallinn by Finland

A renovation experiment in one typical 5-story, 60-flat building was conducted in the Oeismaee district of Tallinn in 1994. This project cost a total of 5.8 million EEK ($460,000), 3 million EEK from the Estonian government, and 2.8 million EEK from the Finnish Ministry of Environment and the Finnish Ministry of Trade and Industry. This 2.8 million EEK (1.2 million FIM) went to a Finnish consulting company which did the design, procurement, and construction supervision work, plus paid for Finnish equipment and materials used in the project. The Estonian government's contribution paid for Estonian construction labor and materials purchased in Estonia. The contract was signed in August 1994, and installation was completed by November 1994.

Technical measures for this project included replacement of substations with new heat-exchanger closed-system substations (the old substations were open-system), replacing the radiators with new Finnish radiators with thermostat valves, renovation of the ventilation systems in each of the four entrance sub-sections of the building, replacement of all of the hot and cold water pipes in the building, and wall insulation panels applied to the two opposite sides of the building that contain no windows. The roof of the building had already been insulated in the previous year.

Energy savings were difficult to estimate. A heat meter did exist in the building, so there was historical data for comparison (although only for the last year or two). But in 1993-94 the heat supply temperature was lower than normal to reduce fuel costs, so it was difficult to compare with a "normal" year. Savings of 25-40% were expected.

Sources of Evidence

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CASE STUDY: DANFOSS RUSSIA SUBSIDIARY AND MOSCOW POLYCLINIC RENOVATION

Summary of Danfoss Renovations in the Moskvich Polyclinic: Danfoss of Denmark has been working with the Moskvich auto plant in Moscow and has installed radiator thermostat control valves and a substation regulation system in one large building at this plant, a daytime polyclinic for plant employees. This project was one of the first "experiments" using Western radiator thermostat control valves in Russia. The estimated cost of the installation was $10,000, using exclusively foreign equipment, and in exchange for this installation Danfoss received one car from Moskvich. Measurements of energy savings from this heat control equipment are difficult because heat consumption data about the actual "before" situation do not exist; the "before" situation is estimated using the original heating design parameters for the building when it was constructed.

Danfoss in Russia

Danfoss could be considered the world's leading manufacturer of radiator thermostat valves, having produced more than 50% of all such valves installed worldwide. Danfoss calls their equipment the "answer to modernization of heating systems," and has installed over 350 million of its thermostatic valves in many different countries worldwide.

Danfoss began working in Russia in 1990, and its wholly-owned subsidiary Danfoss Russia was involved in several projects by 1994, as well as construction of a thermostatic valve production facility in Moscow. There are an estimated 150-200 million radiators in Russia, a huge potential market for thermostatic valves, although market demand by private consumers has not yet developed because incentives do not yet exist. Danfoss estimates that no more than 10,000 or 20,000 radiators in Russia as yet have thermostat valves installed. In general, Danfoss estimates heat savings at 20-30% with installation of thermostatic valves. At a cost of $15-$20 per valve plus installation, payback times are on the order of 1-2 years.

In 1983 340 radiator thermostatic valves were installed in the two-pipe heating system in the President Hotel in Moscow. During the 10-year period up to 1993, only 6 valves were replaced, due to broken capillary pipes in bend locations, and the hotel administration has a very high opinion of the reliability and quality of the valves. Other Danfoss projects in Moscow have included a museum and hotel, several individual houses, and three new apartment buildings under construction as of 1993.

Aside from Moscow, Danfoss has begun working in Tatarstan with the republican authorities to install 250 thermostatic valves in one building of a heat supply enterprise, in Taliotti with the city administration to install 200 valves in a school building, in Kemerovo with the city administration to install 4000 valves in commercial and municipal buildings, and in Komi.

Moskvich Polyclinic Renovation

Danfoss installed radiator thermostat control valves and a substation regulation system in one large building of the Moskvich auto plant in Moscow. The building is a daytime polyclinic for plant employees. The installation was completed in October 1993. The polyclinic is a 6-story building of perhaps 5000 m2 total floor area, containing about 350 radiators. In the 1991-92 heating season, due to repair work on the existing (domestic) regulation equipment, a mixing pump in the substation was not working and temperatures inside the building sometimes reached 25-28 degC. The polyclinic heat design load is 0.79 Gcal/hour (design load is always at minus 26 degC).

The total estimated cost of the Danfoss-supplied equipment was $9,500 including about $7500 for the 350 radiator thermostats (slightly more than $20 each) and $2500 for the controller and pressure regulator. In exchange for this equipment, Danfoss received one car from Moskvich (for use by its Moscow office). The plant supplied the installation labor, which totaled about 70 man-days of labor (3-person team installing 15 valves per day, or about 1.5 man-hours per valve). Most of the labor was spent preparing the pipe threadings.

Radiator thermostat valves were added to every radiator in the building. Radiators already had bypass valves installed. Originally the bypass-valves were left as-is, such that occupants could still operate them. This led to problems with heating on one floor being disrupted by the operation of bypass-valves on the floor below. Thus later on these bypass valves were fixed at an approximately half-open position.

The control system operates to regulate the temperature of the water as it leaves the building after circulating through the building radiators, in accordance with the outside temperature and a standard "graphic." The controller varies the position of an automated valve on the return water supply line in the substation. This return temperature varies between 100 degC and 40 degC. If the return temperature is less than 40 degC, the automated valve is opened 100% in order to guard against freezing of the system (which is a problem during nights and weekends if the control equipment fails and no one is around to notice the cold). This regulation is accomplished with an automated valve on the building water output, a pressure regulator (to maintain constant pressure of hot water to the building), and a simple PID controller.

Energy savings come from two main sources: (1) efficient regulation of heat supply and even distribution throughout the building to prevent overheating during working hours; and (2) curtailment of heat supply during nighttime and weekend hours (4 degC setback). Total estimated heat savings are 32% over theoretical heat consumption based upon the original building design parameters. This estimate comes from an experiment carried out over three days from 2/21/94 to 2/24/94, during which time the actual heat consumption as measured by flow, input, and output temperatures was seen to be 68% of the "design" level (average actual heat load was 0.28 Gcal/hr, average outside temperature -5 degC during this time, so average "design" load was 0.41 Gcal/hr). Note that it is not possible to compare with the actual heat consumption before the Danfoss installation, since no meters and measurements existed for heat consumption for the polyclinic. Assuming that the theoretical consumption was the actual consumption prior to the Danfoss installation, and extrapolating to a full heating season, the total estimated savings over one heating season are about 600 Gcal, which when valued at the heat price for February 1994 of 12,840 Rubles/Gcal, and a ruble exchange rate of 1500 rubles/dollar, means that the total annual savings is $5200, and the simple payback time was about two years. Dollar equivalent heat prices had doubled from February 1994 to mid-1995, so the estimated payback time was reduced further, to perhaps one year. Other non-economic benefits include increased comfort in the building (as reported by the occupants, several during my own visit to the building).

<u>Thermostatic Valve Production Facility</u>

Danfoss has also invested in a thermostatic valve production facility in Moscow which is 100% Danfoss owned. While there is no market in Russia yet for the output from this facility, Danfoss hopes to create one. Danfoss hopes the facility will be a market "push," and plans to work with design bureaus and architects to build a market. The Moscow city government said it cannot legislate radiator valves until there are suppliers for them, so he hopes that once the plant is running, legislation will be passed offering incentives or mandating use of the valves, thus creating a stronger market. The Ministry of Construction modified building standards as of June 1994 such that all new and reconstructed buildings are required to have thermal automation.

Danfoss planned to run the factory with only three Danish staff -- the general director, a production manager, and a financial manager -- and planned to replace these last two positions with Russians within two years. The remaining personnel, for engineering, sales, marketing, quality control, production, and administration, were to be Russians. Danish equipment (including test equipment) was installed in the factory, and quality control and test procedures were to be equivalent to those in Danish factories. Quality is of utmost importance to Danfoss, and it emphasized that the experience with Russian equipment operators and production workers thus far had shown them to be highly capable and willing to meet the quality standards required.

The valves produced in this factory are made of brass, and contain about 20 parts, only two of which will ultimately have to be brought in from Denmark. The production cost for these valves is probably not any cheaper than in Denmark, thus the advantage of the plant is primarily the access to and creation of new markets. Labor is definitely cheaper, but materials not necessarily so. Factory space costs 4-5 times more than in rural Denmark, where plants can be located on cheap land. Brass in huge quantities from the London commodities exchange is actually cheaper than what can be bought in Russia.

A plant like this has already built in Poland, so Danfoss already has some experience with installing and operating such a facility in an Eastern European country.

<u>Sources of Evidence</u>

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CASE STUDY: DANISH BUILDING-HEATING-SYSTEM IMPROVEMENTS IN ESTONIA

Summary: In 1992 the Viru region of Estonia obtained financing from the Danish government for district-heating retrofit projects in two small towns (populations 1200 and 3300). Both projects were initiated and completed in 1993 in cooperation with Danish private companies, which supplied the equipment and supervised the construction by local Estonian labor. The three main phases of the projects were (1) to analyze the existing heating facilities; (2) to install energy meters, evaporation meters, and radiator thermostat values in apartments and municipal buildings to provide control and measurement of actual energy savings and to learn about installation and requirements of energy efficient equipment; and (3) to establish Estonian-Danish joint ventures for commercial development of this energy-efficiency equipment. In one town, approximately 2000 radiator valves and evaporation heat meters were installed on individual radiators in virtually all of the apartments in the town and a school. In addition, each building had heat meters, valves, and pressure regulators installed in the main boiler room in the basement. The total cost of this installation was $300,000 (about $100 per capita for the whole town).

Background

In early 1992 authorities of the Viru district of Estonia contacted a Danish engineering firm for assistance in energy efficiency in the Viru region. The Danish company successfully obtained financing for this project from the Danish government, for both auditing and equipment installation. The project began in February 1993 and was completed and handed over to the municipality of Toila in June 1993 and to Haljala in September 1993. Participating in the projects were local administrations, energy experts from neighboring towns, representatives from EU PHARE, Danfoss, and ISS Chlorius.

The three main phases of the project were:

(1) Analysis of the existing heating facilities in two towns in the Viru region, Toila and Haljala. The population of Toila is 1200, and that of Haljala is 3300.

(2) Conduct demonstration projects in these two towns to provide measurement of actual energy savings and learn about installation and requirements of energy efficient equipment. The specific equipment consisted of energy meters, evaporation meters, radiator thermostat values, and pressure regulators for building substations.

(3) Establish Estonian-Danish joint ventures for commercial development of energy-efficiency equipment.

Three Danish individuals participated in the project for engineering, administration, and supervision/execution. All the rest of the labor, including engineers, plumbers, and craftsmen were all Estonian.

Projected energy savings from these projects were approximately 30%, based upon a single pilot installation, and projected water circulation reduction was approximately 40%. Actual measurements of results was to take place during the 1993-94 heating season.

Most of the buildings in Toila and Haljala are served by a central district heating plant, although some of the single-family houses have their own boilers or electrical heating. The boiler plant in Toila is about 30 MW (a lot of the heat from this plant feeds a local health resort, however). According to the manager, this plant is about 90% efficient, but the Danish consultants question this figure. The boiler burns Estonian oil shale and oil imported from Russia. The heat is supplied from the plant as hot water with a supply-pipe temperature of 100-120 degC, and a return temperature of about 70 degC. District heat is supplied to individual consumers with a differential pressure of about 10-20 mVs. The distribution pipes are above ground, and combined with poor insulation result in approximately 20% losses of total energy production. Each of the buildings connected to the network has its own boiler room with pipe heat exchangers for hot water, and all radiator systems are direct with mixing loop. There are no energy or water meters in any of the boiler rooms; all billing is fixed and based upon apartment size. Eighty percent of the radiator systems are 2-string, rather than 1-string, but this is unusual for Estonia.

Project Implementation

A pilot project was conducted in early 1992, and one terraced house was fitted with radiator thermostat valves, an energy meter, pressure difference regulator, and dust collector in the boiler room. All components were supplied free by Danfoss A/S and Tage Schou Nielsen Malerservice A/S. Daily measurements revealed an energy consumption savings of 32% from the radiator thermostat valves alone, and a reduction in water circulation of 40%.

Beginning in February 1993, measurements and "registration" of radiators, boiler rooms, and pressure and temperature conditions were conducted in order to ensure correct dimensioning and fitting of equipment. This process took about 2 weeks. In Toila, a total of 12 apartment houses, 10 houses, several school buildings, a hospital, the town hall, and a tin can factory were registered, in total containing about 1250 radiators. In Haljala, about 2000 radiator valves were installed.

Engineering proceeded and components were supplied by Danfoss A/S (thermostat valves came from the Polish factory because Estonian water quality was questionable), Tage Schou Malerservice A/S (energy meters), and ISS Clorius International A/S (evaporation meters). Also supplied were cutting and drilling machines, hand tools, and work clothes for 8 men.

Total costs of the projects were 3.7 million EEK ($300,000), or about $100 per installed thermostat valve. This broke down into 65% for equipment, 20% for engineering and wages, and 15% for freight, tools, training, and administration. Assuming the average resident pays $150/year for heat, savings are 20%, and each apartment requires three thermostat valves, the simple payback time at these costs is 10 years. Of course the cheaper solution is to simply lower total heat production. If the heat plants in these towns simply lowered heat output to save on fuel costs, usage of the thermostat valves could be minimal; no one will throttle back their heat consumption if inside temperatures are already too low.

Training of Estonian workers took place in March 1993 and lasted several days. It included use of tools, information about the components, and proper installation procedures according to Danish standards. In general the workers were very conscientious and very interested in new products and practical knowledge. Six workers in three teams plus a supervisor were able to install 25-30 thermostat valves each day, about the same rate as a typical Danish team. At first the rate was lower, but then increased as mandatory work schedules were introduced. An installation schedule was very rigorously adhered to, and if installation fell behind schedule, overtime work on weekends was required or longer working days were required. Management techniques such as team meetings every morning to discuss the day's work program were introduced.

Finally, consumer information about the equipment being installed was created in Estonian and distributed to the occupants of the modified buildings.

Problems/Experience in Connection with the Project

In general, the Danish participants found the Estonians to be very productive and cooperative throughout the project. Some of the problems experienced involved language difficulties with an interpreter who was not familiar with the technical terms, gaining access to apartments for initial registration work before an adequate publicity campaign had been conducted, inaccurate drawings which did not portray the heating system as it had actually been built, and various installation problems. Some of the installation problems included lack of pipe fittings locally (a local blacksmith ended up making them himself), replacement of fragile radiators made leaky by the modifications, replacement of radiator bushings damaged during modifications, piping replacement where corroded, and modification of radiator valves to work with the Estonian system (one gateway had to be permanently closed on 3-way valves to make them into two-way valves).

Therefore, some "lessons learned" are: (1) choose a good interpreter; (2) you can never have too much public information; (3) do not rely on existing drawings; (4) components, fittings, valves, pipes, etc. proved almost impossible to get in Estonia, and therefore all components should come from abroad in future projects.

Promotional work by AS ViruDan Engineering followed the project, in several other regions of Estonia, including Rakvere, Kohtla-Jarve, Kohtla-Homme, and Sillamae. AS ViruDan Engineering was established as a legal entity with shareholders from all the other project participants, to continue to carry out this type of work in Estonia, with strong support from Danish companies in both Denmark and Estonia.

Sources of Evidence

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CASE STUDY: DANISH BIOMASS-FUELED-BOILER CONVERSION IN ESTONIA

Summary: In 1993 the Danish government provided a grant to Estonia for installation of a new wood-fueled district-heating boiler to replace an existing oil-fired boiler. The grant came from money that the Danish government had originally earmarked to help Estonia pay for its purchases of foreign oil. The boiler was 5 MW and the estimated cost was close to $300/kW, including a portable wood chipping machine. The boiler was provided and installed by a private Danish company and the whole project took about 6 months from initiation to completion, including a four-month construction period. Wood-fuel costs for the plant were about half the costs of oil-fuel on an energy basis, and wood supply contracts were signed with private companies harvesting state forest lands and with private farmers who sell the timber harvested from their own land.

Project Development

Denmark had pledged emergency energy aid to Estonia in 1992 as part of a program for environmental-related and emergency assistance. By March 1993 the heating season was almost over, and so the Ministry of Foreign Affairs decided that this aid was better spent on a long-term improvement project such as a wood-fired boiler which would displace a continuous stream of oil rather than provide a one-time supply of oil. In June 1993, the project was approved, 18 million EEK were allotted to the project, and the Danish Energy Agency was put in charge.

Construction began in August 1993 and was completed December 1, 1993, for a construction period of approximately 4 months. During this time approximately 25 people worked full time (6 days/week), doing an estimated 14,000 to 15,000 manhours of work for both the boiler and reconstruction of the boiler plant buildings. About 5 to 6 Danish workers participated, particularly in supervision and management. The equivalent of one other person in Denmark did calculations, drafting design and as-built drawings, and provided transportation logistics. Several Estonian companies participated in the construction, including electrical, buildings, foundations, piping, and mechanical work.

Technical Description

The Turi Therme heating plant consists of three DKVR-4 (2.3 MW) boilers and one DKVR-10 (5 MW) boiler, all operated as steam boilers. This project involves adding a brand-new wood-fueled boiler alongside the existing boilers, such that the oil-fired boilers would only be used as standby capacity. It is anticipated that 90% of heat production under normal circumstances will come from the wood-fueled boiler.

The technology selected for this project represents typical boiler technology being installed in Denmark today with one exception: the emissions standards for dust were relaxed from the Danish standard of 40mg/normal m3 to 300mg/normal m3 for the Estonian version. Removal of dust to Danish standards requires a more expensive flue gas washing system or backwash, and requires changing expensive filters. The boiler is 88% efficient, fully automatic, variable from 1 to 4 MW output, and can accommodate wood that is up to 60% moisture content. The boiler is a hot-water boiler which is installed in parallel with the hot-water system at the output of the heat exchanger from the existing steam boilers. Equipment supplied includes wood storage and automatic feeding facilities, a crane, a wood chipper, and spare parts. Service for 5 years is included also.

The plant serves 400 apartments, 15 private enterprises, and 2 schools. Assuming 3 people per apartment, that would be 1200 people total, or approximately 18% of the town population. This is roughly one-third of the population supplied by central heat; approximately half of the population live in private houses not supplied by central heat. In 1990 two-thirds of the heat production went to factories and the other third to residences. Today that split is 50%/50% because industrial production has declined and because enterprises have gone to more self-production as the public supply price has increased.

Heat production in the 1992-93 heating season was 14,000 MWh, although this is much less than prior years. Heat production in 1990-91 was perhaps 1.5 times the production in 1992-93, according to the plant, due to worsening economic conditions, which would be about 21,000 MWh. Oil consumption in a typical year is about 2000 tons. (But assuming 80% boiler efficiency, 2000 tons of oil would produce 18,000 MWh.)

Estimated annual consumption of wood chips is approximately 25,000 chipped-m3 wood, according to the plant. With an 88% efficient boiler, this would produce 29,000 MWh of heat.

Economic Evaluation

The estimated total cost of the installation is about 13.7 million EEK (about $1.1 million). This includes 12.4 million EEK for the boiler and its installation, and 1.3 million EEK for wood chipping equipment. Part of the installation cost includes renovation of the existing boilerhouse building, and part of it includes spare parts and a 5-year service agreement. For a capacity of 4 MW, this comes to approximately 3100 EEK/kW for the boiler itself, plus 300 EEK/kW for wood chipping equipment. About 87% of the boiler and installation cost was for foreign equipment and expenses, while 13% was domestic.

The price of oil paid by the plant averages 1000 EEK/ton delivered. The plant charges 220 EEK/MWh for its heat.

Wood and Peat Fuels

The plant intends to buy wood from two sources. One source is private companies who cut down trees and either pile logs by the roadside within the forest or deliver them to the plant. The price of wood that the plant foresees is 65 EEK/solid-m3 delivered on-site, which would be about 28 EEK/chipped-m3 plus chipping costs. Or cut logs at the roadside within the forest would sell for 40 EEK/solid-m3. Most (60-65%) of the existing contracts are with these types of private companies. The other 35-40% of contracts are with private farmers who harvest the timber on their land. The typical size of contracts with individual farms range from 50 to 500 m3. The plant will only buy wood within a 20-kilometer radius.

The plant has other options for getting wood. It has received the right by the forest district to harvest 26,000 chipped-m3 wood per year on its own directly from the forest, for no charge. Ordinarily, the charge to harvest trees averages 10 EEK/tree. Or the plant might buy a mobile wood chipper and collect thinnings and branches itself in the forest, perhaps 120-150 chipped-m3 per day with a mobile chipper.

Institutional Issues

The plant is a private joint stock company. The town housing authority collects billings from heat consumers and then pays the heating plant. If monthly heating costs for some consumers exceed 25% of their monthly income, or if consumers refuse to pay their bill, the municipality is required to cover the difference. The time lag can be several months between the time when the heating plant produces heat and when it finally receives payment from the municipality in excess of what the consumers pay (the amounts over 25% of monthly income and unpaid bills).

Sources of Evidence

Interview with project manager, Danish Energy Agency (9/7/93)

Interviews with project engineer, Volund Energy Systems, Denmark (9/8/93, 3/9/94)

Interview with chief engineer, Turi district-heating plant (11/26/93)

Interview with Swedish technical advisor, Estonian State Energy Department (8/20/93)

Site visits to Turi, Estonia, 9/8/93 and 11/26/93

CASE STUDY: EPA/NRDC INTEGRATED RESOURCES PLANNING

In 1993, a group of American organizations led by the Natural Resources Defence Council (NRDC) initiated a program to transfer integrated resources planning (IRP) and demand-side management (DSM) planning methods and concepts to Russian electric utilities. Three regional electric utilities in the North Caucasus region of Russia were chosen for this project because of their interest and willingness to participate, and because the North Caucasus region was suffering from severe electric power capacity shortages and energy efficiency was considered a high regional priority. These three utilities are Stavropolenergo, Rostovenergo, and Kubanenergo (Krasnodar region).

In 1993 funding for this project was obtained through the United States Environmental Protection Agency (EPA) from USAID. The Center for Energy Efficiency in Moscow became another key supporter and participant in the project, lending its analytical skills and understanding of U.S. IRP and DSM concepts to translate these concepts into Russian terminology. In late 1993 a kick-off conference was held in Moscow which brought together managers and engineers from the North Caucasus regional electric utilities, together with experts from the United States on IRP and DSM. An elaborate workplan was crafted for the future project, but preparations for the next phases were held up because of lack of sufficient funding from USAID.

The project contained seven major tasks:

(1) Dissemination of IRP concepts and methods, and training of Russian personnel.

(2) Information analysis for understanding energy production, consumption, and decision making in the North Caucasus region.

(3) Development and adaptation of techniques and models for use in Russia.

(4) Intermediation training, education, standards, and joint venture development for production of energy auditing and metering equipment.

(5) Preparation of legislation and regulations, and the institutional transformation necessary to implement IRP and DSM in these utilities.

(6) Creation of program implementation mechanisms, including administrative systems, marketing strategies, consumer contacts and education, program budgets, etc.

(7) Development of pilot programs.

At the conference in Moscow in 1993, the director of the Rostov electric utility felt that integrated resources planning was an excellent mechanism for economic and energy efficiency for his utility and region. He favored the systematic approach it offered, and said that his utility staff were motivated to participate in the IRP project. He hoped that the results from the North Caucasus region would become a model of development for the rest of Russia. One important issue he emphasized was that they would need to develop marketing services, which did not yet exist.

In 1994 and 1995 the project proceeded with training of Russian participants through visits to the United States, audits of enterprises in the region, development of methodologies, and data collection.

Sources of Evidence

Periodic electronic mail reports from the Natural Resources Defence Council concerning the project, sent to all interested participants and observers, 1992-1993.

Interviews with a senior researcher at the Center for Energy Efficiency, Moscow (5/28/93, 7/5/93, 8/9/93, 9/7/94)

Conference on Integrated Resources Planning for utilities in Russia, sponsored by the U.S. Environmental Protection Agency and the Russian Academy of Sciences, Moscow, November 30-December 3, 1993.

Russian-American Working Group on Integrated Resources Planning. 1993. "Development and Implementation of Integrated Resource Planning (IRP) in Russia's Energy Sector." Project proposal for joint Russian-American project for USAID funding, Moscow, June 1993 (draft).

CASE STUDY: EUROPEAN UNION TACIS AND THERMIE PROGRAMS

Summary of THERMIE program: From December 1991 to June 1992, an "Audit-Assistance Crash Program" was carried out. Fourteen audit projects around Moscow were undertaken in the power, industrial, public, and commercial sectors using Western diagnostic and measuring equipment. In general, the audits yielded energy savings between 10% and 30%. Assuming world market prices for energy, the equipment used would have payback times usually less than a year. Measures for heating efficiency improvements in the industrial sector were cost-efficient even at the existing domestic energy prices and foreign exchange rates. The audits also concluded that purchases of Western measurement instrumentation and equipment for diagnostic and tuning purposes could be cost-effective if purchased and shared among several district heating companies.

Summary of TACIS program: The TACIS program in 1993 conducted audits from an "Energy Bus Moscow," energy audits in industry, studies for a comprehensive Russian energy conservation strategy, and training workshops. The Energy Bus audits involved seven projects using Western European measurement and control equipment for diagnostic and optimization purposes. The bus was equipped with a flue-gas analyzer, an ultrasonic leak detector, an infrared camera, ultrasonic heat flow meters, and miscellaneous equipment like thermometers, light meters, wattmeters, etc. The seven projects were: boiler performance at a thermal power plant, audit and tuning of two district-heating boilers, detailed load measurements at two district-heating systems to optimize operations, thermographic inspections of equipment in a power plant, efficiency check of a steam plant of a brick factory, installation of steam traps in Lyubertsy Heat Network, and installation of energy efficient lighting in a school. Based upon the improved management practices that could result from the measurements taken, the audits concluded in four of the seven cases that payback times of less than a year using world energy prices were possible.

EU TACIS

The EU TACIS program in 1993 funded several programs: an "Energy Bus Moscow," energy audits in industry, and studies for a comprehensive Russian energy conservation strategy.

The "Energy bus Moscow" did 7 projects in 1993. "All seven projects assisted the organizations involved by means of in-depth technical audits of their energy conversion processes, i.e., by using Western European measurement and control equipment for optimizing the respective conversion processes." The bus was equipped with a flue-gas analyzer, an ultrasonic leak detector, and infrared camera, ultrasonic heat flow meters, and miscellaneous equipment like thermometers, light meters, wattmeters, etc.

The seven projects were:

(1) boiler performance at a thermal power plant
(2) audit and tuning of two district-heating boilers
(3) detailed load measurements in two district-heating systems to optimize operations
(4) thermographic inspections of equipment in a power plant
(5) efficiency check of a steam plant of a brick factory
(6) install steam traps in the Lyubertsy Heat Network
(7) install energy efficient lighting in a school

The EU TACIS project Energy Bus in 1993 did an experiment at a school, in which existing lights were replaced by energy efficient lighting in two classrooms. The payback period for this investment was calculated at about 6 years using Western electricity prices, but 185 years using existing Russian prices. (However, in the official results table in the report, the payback was listed as 1.5 years, based upon the replacement differential cost of the lamp and a new ordinary lamp at Western prices, and electricity at Western prices.)

"The demonstration of innovative measurement and control technologies is an indispensable step towards joint equipment production, i.e. joint ventures between Russian and Western European manufacturers" the report said.

Payback times for the measurement and tuning equipment itself for these projects is, in the case of five of the projects, less than one year, using Western European prices and assumptions about energy savings resulting from better management practices that were suggested by the results of the measurements.

Audit-Assistance Crash Program 1991/92

An audit-assistance crash program was the first activity of the newly formed EU Energy Center Moscow. The program report summarized the activities as follows:

> In order to get a "feeling" for this market and to gain access to it the Audit-Assistance Crash Program was carried out. Started in December 1991, 14 projects in Moscow and the Moscow region were completed by June 1992. They were selected to cover all important energy carriers and energy sectors and were undertaken in the power, industrial, public, and commercial sectors. The aim was to assess possible energy savings and to demonstrate the performance of European energy technology.
>
> In general, the projects yield energy savings between 10% and 30%. Assuming world market-oriented prices for energy the equipment used would have payback times usually less than a year. The projects for heat-conservation in the industrial sector are cost-efficient even at current prices and foreign exchange rates and orders for the equipment used have already been placed by Russian companies. The same could hold for the measuring and metering equipment in district heating, if the equipment was used at a variety of boiler-houses.
>
> The dissemination of the results of the projects has been an unforeseen success and many requests for Western partners, support and information on technologies reach the Center daily. Private enterprises which are now starting work in the energy market have little interest in working within the old structures of the Soviet Union that are still existing. They are looking for opportunities to get in touch with firms in the West to start cooperation and the Audit-Assistance Crash Program helps to identify possible markets.

Sources of Evidence

Directorate General For Energy. 1992. "Audit-Assistance Crash Program 1991/1992." EC-Energy Center Moscow.

EU Energy Center Moscow. 1994. "Energy Bus Moscow -- Annual Report 1993." Moscow: EU Energy Center. Funded by EU DG I TACIS program, project no. WW91.03/02.01/B015.

Organization for the Promotion of Energy Technology (OPET). 1993. "EC-Energy Center Moscow." Promotional Brochure.

CASE STUDY: HONEYWELL TUSHINO DISTRICT-HEATING EFFICIENCY PROJECT

Summary: This project was one of the largest and most visible of the technology-transfer efforts involving energy efficiency that took place between 1992 and 1994. Honeywell Europe signed a contract with Mosteploenergo, a municipal-owned district-heating supply company in Moscow, to supply and install automated control systems for a 200 MW gas-fired heat-only boiler plant and to the heat distribution network (19 substations) supplied from that plant. The plant and substations provide heat for 50,000 people. Most of the equipment was Honeywell-supplied, but the design and installation was a cooperative effort between Honeywell and several Russian organizations. Total project cost was $3 million in foreign currency plus approximately $700,000 in rubles. The project was not a commercial venture, but rather a "gift" from Honeywell, which paid $1 million directly and $1 million through a joint-venture partner (the Moscow government paid the other $1 million in foreign currency). The project began in 1991, was half-completed by 1993, and was expected to be fully completed by 1994. Total annual gas savings were estimated to be 20% of annual consumption. Based upon these gas savings and domestic gas prices as of January 1994, the simple payback time of the project would have been 12 years. Based upon mid-1995 domestic gas prices, the simple payback time would be 4-5 years. Based upon Western European prices for gas, the simple payback time would be 2-3 years. This project took place within an energy efficiency demonstration zone of the United Nations ECE "Energy Efficiency 2000" framework, although Honeywell did not expect nor receive any actually payback or revenue from this "gift."

(a) Project Development

Honeywell is the world's largest company devoted to control and automation, with 1992 sales of $6.2 billion and R&D investment of $312 million. Honeywell Europe is the largest single contributor to consolidated revenue, with 1992 sales of $1.6 billion. Honeywell developed a small sales presence in East Europe in the 1960s, and opened an office in Moscow in 1974. The early establishment of this representative office in Moscow, according to Alfredo Maselli, Honeywell's vice president of International Marketing, symbolized Honeywell's commitment to a long term presence. When Perestroika began in the mid-1980s, the Honeywell name was already known and accepted in Russia.

In early 1991, Honeywell saw a huge opportunity to improve the efficiency of Moscow's heat supply system through installation of its automatic industrial and building control technologies. Moscow Mayor Luishkov also favored Honeywell's participation -- "we will work with Honeywell and we will pay them foreign currency abroad" he said, according to a Honeywell source (interview 11/11/93). A deal was signed in December 1991 in which Honeywell automatic controls would be installed in one district-heating system by October 1993. The official customer for the project was Mosteploenergo, which was responsible for the target district heating plant, although the Moscow city government (represented by Moscomenergo, the Moscow Power Engineering and Energy Saving Committee) was the real customer. The project was essentially a "gift" to Mosteploenergo: Honeywell contributed $1 million to the project, the City of Moscow contributed $1 million, and Honeywell's joint-venture partner in Russia Sterch Controls contributed $1 million. Sterch was a joint venture between Honeywell and the State Agrochemical Association (Agrokhim), an association representing chemical and agrochemical enterprises with the right to form joint ventures and import and export machinery.

The Tushino project was essentially a demonstration project with no direct economic returns to any of the organizations financing it. As a demonstration, it represented a foot-hold for Honeywell into a huge potential market in residential and commercial building controls. Mosteploenergo, the municipal enterprise that owns and operates the Tushino plant, is the nominal "customer" for this project, and was in charge of project management and coordination. But at least initially the director of Mosteploenergo felt that the project should not occur, and many other people in Mosteploenergo have been against the project, according to a Honeywell source (interview 9/20/93). Mosteploenergo is responsible for production of heat, but has no responsibility for the quantity of heat consumed. The real "customer" is the Moscow city government, which helped initiate the project, funded it, maintained active support for it, and should benefit financially from the fuel cost reduction associated with it.

Why did the Moscow government agree to fund this project? According to the head of the Moscow Government Department of Energy Efficiency and Power Engineering, there are several reasons:

1. Reduction of costs (subsidies) for district heat
2. See what are the possibilities for automation
3. See what is the real potential for savings in a district-heating system
4. See existing Western technology and its capabilities

The previous head of this department had the same view: "to see Western technology in operation in a permanent exhibition."

The Tushino Central Heating District No. 3 was chosen as the project site, a district served by one large 400 MW heat station, and one of 50 such central heating districts in the city (and one of 1500 across all of Russia).

Originally, the project was intended to be conducted in three stages:

Stage I would be installation of a distributed control system, a Honeywell TDC 3000, for automatic control of the boiler plant. The operator control room would be completely renovated (the old control panels removed), and equipped with a control center and integrated operator consoles. Color graphics would display live data on the status of the plant. This stage would cost $2 million.

Stage II would be installation of a heat exchange control system for the 19 heat distribution substations served by the Tushino-3 plant. The system would utilize a Honeywell Excel-EMC/DeltaNet system for local control within each substation and telephone telemetry back to a central console in the plant. The status of substations would be delivered by modems over telephone lines. This stage would cost $1 million.

Stage III would be installation of thermostats for individual room controls and control devices for heat elevators (in the basement) in apartment buildings in the Tushino residential district. This stage would cost $2-3 million.

The project as implemented included both stages I and II together, with stage III postponed indefinitely. The contract between Honeywell and Mosteploenergo covered equipment, engineering, commissioning, training of operation and maintenance personnel, and a supply of spare parts. The contract called for 20% of gas to be saved, out of the approximately 90 million m3/year gas consumption by the plant, although this 20% figure was not a guaranteed minimum. Expectations were that actual savings would be 15-20%. The original 20% estimate included installation of variable speed drives for the heating station water pumps, but this installation was not included in the contract and thus the 20% was not guaranteed in the contract.

The customer, Mosteploenergo, was responsible for installation, and had the right to select the design institute, construction subcontractors, and other project participants. They selected all subcontractors except for the organization doing start-up work for substations, which Honeywell Moscow selected (which was "Viklend," a small father-and-son operation. Viklend did the USAID projects in Kiev, Minsk, and Kostroma).

Honeywell did the engineering management for the project, while a local project design institute, Mosgazniiproyekt, did the project design work. This institute was under the authority of the Department of Energy Saving and Power Engineering of the Moscow government, was engaged in design work and scientific research in the gas and heat supply sphere, and had a staff of more than 400 specialists.

Honeywell Europe contracted with Mosgazniiproyekt as a subcontractor. The design was based upon Honeywell equipment, and this institute sent drawings with temperatures, pressures, and locations of existing control equipment to Honeywell, plus technical and operating characteristics of existing equipment. They also developed a flowchart of automatic operation, and an algorithm according to the existing mechanical equipment. Then Honeywell prepared a complete set of documentation for the new system, with specifications to meet the necessary requirements, including new sensors and valves and their technical requirements, and the software programming with inputs and outputs specified to work with the Honeywell computers. This included electrical drawings and schematics, a complete list of inputs and outputs (temperatures, pressure inputs, valve control outputs, and digital inputs and outputs). This "technology task" by Honeywell was approved by Mosteploenergo. The project institute developed the installation and construction drawings. Overall, the project institute was responsible for design, subcontractors work, project supervision, and construction.

Sterch had a contract with Mosteploenergo for all ruble-value works for the heating station, and paid for local labor, about 2/3 of the whole ruble-value contract, for the work done at the heating station itself: installation, engineering, start-up, and programming. Honeywell Moscow had responsibility for some engineering and for commissioning at the heating substations. Sterch signed several subcontracts with subcontractors for the ruble costs of the project. In order to expedite local work, Mosteploenergo paid directly to subcontractors.

The project institute started their work 6 months late, and design drawings were completed in April 1993. Project work was delayed by late payments by the Moscow government and Agrokhim. Originally the government was supposed to pay its share by January 1992, but a debate within the government about funding the project delayed the money until the summer of 1992.

In 1993, Tushino became an official demonstration zone of the United Nations Energy Efficiency 2000 project in Russia, initiated in 1991 to promote joint ventures and technology transfer of energy efficiency (see UN/ECE case study). As of February 1994 there were eight such zones in Russia, and a total of 27 zones in 15 countries of Central and Eastern Europe. Tushino was the only zone in Russia in which actual investment had taken place as of late 1993. In fact, the Honeywell project engineer said that "this is the first foreign project [in Russia] for supplying equipment for district heating."

In December 1993 an official 72-hour acceptance test was conducted on the two completed boilers and each of the 19 substations (except for the telephone telemetry equipment, which was not yet operational), and all equipment passed these tests. The remaining two boilers were completed in June 1994, and the entire plant and the substations were operational under the new control systems for the 1994-95 heating season.

The official project unveiling ceremony was held October 27, 1993, although the system was not completely operational by that time. At the ceremony, Honeywell Chairman and CEO Michael R. Bonisignore said (Honeywell Europe, 1993a):

> We are firmly committed to expanding our operations in Russia. This project marks an important step in our relationship with our Russian partners, and I would like to stress that the project was completed on time and on budget.... Energy management in all its forms is a key issue for the Russian economy, and I believe that the quality of our products and services, along with our world-class expertise in areas such as district heating and building control systems, will greatly contribute to the prosperity of this country.

In a short speech, First Deputy Minister Nikolsky highlighted the co-operation aspects of the project:

> Honeywell's leading edge technology and worldwide experience are greatly appreciated by us and we are very happy to have established this effective partnership. We are confident that this project will demonstrate the great savings that can be made in energy efficiency.

<u>(b) Project Technical Description</u>

Tushino, one of 33 administrative districts in Moscow, has a population of over 200,000 living in mostly high-rise block apartment buildings built 15 to 20 years ago. Tushino District Heating Plant No. 3 serves one of four heating sub-districts in the district. The heat distribution network from the Tushino-3 plant includes 19 substations with heat exchanges, which distribute heat and hot water via small secondary networks to local buildings. Each substation serves from 2 to 4 buildings, perhaps 500 apartments total. In total, the Tushino-3 station serves 150 residential and commercial buildings of mostly 5, 9, 16, and 22-stories, and about 50,000 people in approximately 10,000-15,000 apartments. There are no industrial customers, just apartment buildings and services.

The Tushino-3 heating station consists of four 100 Gcal/hour (116MW) boilers, type PTVM-100, installed in 1973. Boiler efficiency varies from 88% to 92%, depending on load. These boilers supply hot water to a 2-pipe district-heating network consisting of 20-25 km of primary supply pipe, 29 substations, and over 100 km of secondary pipeline from substations to apartment buildings. This type of system is very typical in Moscow, but with the average length of primary supply pipe typically closer to 30 km. The farthest substation is physically about 3 km from the heat plant. Typical distribution losses in systems of this type are 10-15%, although the exact losses for this system are not known. Seventy percent of the heat produced goes to space heating, and 30% goes to hot-water supply.

In 1993, the plant consumed 87 million m3 of gas, and produced 635,000 Gcal of heat. As of January 1994, prices paid for heat were 17,500 rubles/Gcal by enterprises and industry, and 12,500 rubles/Gcal by residential customers.

Under the old operating regime, operators in the heat station controlled the plant output temperature according to the outside temperature and a standard "graphic," which showed the designed correspondence between these two temperatures. In addition, operators three times per day travelled to each of the 19 substations and adjusted the secondary output temperature according to the graphic for each substation. This process was not very reliable, as the operators would often not make these adjustments and would visit the stations fewer than three times per day. There was no incentive for maintaining peak performance.

This system was very vulnerable to "complaint by the coldest consumer" -- that is, heat output was boosted and regulated in response to complaints of cold apartments from consumers in the least-optimized portions of the system. As a result, many other residents received too much heat and were forced to regulate their comfort by opening windows.

The equipment installed by Honeywell is quite ordinary and straight-forward: temperature sensors, pressure sensors, control valves, value activators, water meters (hot and cold), microprocessor-based controllers, and transducers and relay cabinets. In addition, in the station several other types of components were supplied: TDC3000 computer and control consoles, flue gas analyzer system, control room lighting, air conditioning, uninterruptable power system, fire alarm, and a MS2000 computer and dial-up modems. Almost all of the equipment came from abroad.

This equipment together controls the combustion process, the exhaust gas in the exhaust stack, water treatment processes, and temperatures, pressures, and flows according to outside temperature. In the station, each boiler was outfitted with 100 analog sensors, 20 digital sensors, and 200 digital status lines. About 30 automated control valves were installed by Honeywell, in addition to the 30 that previously existed. Together with the TDC3000 computer this equipment provides four control loops within the station: (1) water temperature input to the boilers; (2) water temperature output from the boilers; (3) gas combustion burner regulation; and (4) water flow through the boiler.

In each of the 19 substations, 6 temperature sensors, 6 pressure sensors, 5 control valves, and one controller were installed together with a modem link back to the MS2000 computer in the station. The control loops within each substation are for secondary heat supply water temperature (which varies according to outside temperature and the "graphic" regime) and hot-water supply temperature (held constant at 60 degC except for night set-back). Eleven of the 19 stations have heat exchangers, while eight of the 19 do not.

The TDC 3000 is a fully-integrated information and control system designed to optimize plant operations. The key elements of the TDC 3000 are distributed process control and data acquisition devices linked by data highways and control networks; communication links that interconnect the system devices and modules; distributed history, application, computing and communication modules connected to the main plant computer network; and a Universal Station to provide a single expert window to all plant operations.

(c) Economic Characteristics

The foreign currency costs of the project were $3 million for hardware, software, and engineering services supplied from Western Europe. The domestic cost of the work was approximately 800 million rubles spent during the period July-November 1993. Seven hundred million of this was for installation and construction, 70 million for design and engineers, and 30 million for electrical cables (14 km total; bought from abroad). The dollar equivalent of 800 million rubles during this period was approximately $700,000, thus making the total project cost $3.7 million, of which 20% is domestic and 80% is foreign.

How much gas will be saved? This question will not be resolved until the Mosgazniiproyekt institute conducts an analysis of the operating data from the 1993-94 heating season (this analysis is expected by December 1994). Mosgazniiproyekt Engineers themselves made the original estimate of 20% savings from heating station and substation renovations combined. However, Honeywell claims 15% savings are possible from the station renovation and an additional 10%-15% for the substation controls (Honeywell 1993a).

There was a measured 1% increase in efficiency of gas burning due to better burner control. The remaining energy efficiency savings involve better matching of the temperature output to the heat load requirements and better distribution of heat, such that less heat needs to be produced in the first place.

Honeywell believed that Stage 1 installation could realistically save 15-20% on gas consumption (30% optimistically); Stage 2 (heat exchangers), 10-15% more; and Stage 3 (thermostats) another 25%. With the gas consumption of the Tushino boilers at approximately 70 million cubic meters per year, and with an export price for Russian gas of $95/tcm, Tushino's annual gas "bill" (at export prices) was about $6.65 million before modernization.

Honeywell, using the Russian gas export price for saved gas, claimed that $2 million worth of gas will be saved annually, for a simple payback time of 1-2 years. Honeywell assumed: (1) maintenance costs of 10% on the TDC and EXCEL equipment (and nothing on thermostats), (2) a conservative, 10-year equipment horizon, (3) nominal gas prices rising 10% annually (in US dollars), (4) a discount rate of 9%, and (5) operation beginning one year after the investment is made. Honeywell estimated a net present value for the Tushino Project as actually built (Stages 1 & 2) of $18 million. With Stage 3 included, the estimated net present value increased to $27 million.

Using the current price for gas that Mosteploenergo paid in January 1994 (25,000 rubles/tcm; January 1994 exchange rate 1400 rubles/$), and an annual savings of 18 million m3, the annual savings would be $300,000, and the simple payback time would be 12 years. With domestic gas prices in mid-1995 rising past $45/tcm, the simple payback time becomes closer to 4-5 years.

<u>Sources of Evidence</u>

Interview with Deputy Head, Moscow Government Department on Power Engineering and Energy Saving (8/12/93)

Interview with Senior Deputy Director, Moscow Government Department of Energy (2/9/94)

Interviews with Engineer, Honeywell Moscow (9/20/93, 11/11/93, 1/20/94, 1/24/94, 9/7/94)

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CASE STUDY: IVO INTERNATIONAL ENERGY EFFICIENCY PROJECTS

Summary: During 1992-1994, IVO International of Finland was conducting a wide range of technical audits in power plants and industries in several regions of Russia. Several commercial projects were being proposed in district heat supply and power plants, but a key problem remained how to receive a return on the investment. One project in Karelia proposed investments in automated control equipment at a combined heat-and-power plant in exchange for the physical transfer of oil from Karelia to Finland. Obtaining an export license for the oil and negotiating a maze of administration and ministerial approvals related to the export proved to be major problems.

IVO International has been active in investments in electric power plants, district-heating systems, and industrial plant renovations in Russia for a number of years, especially investments related to energy efficiency. Its strategy in 1992-1993 was to explore potential projects in several different regions of Russia simultaneously and sign protocol agreements. Then feasibility studies could be conducted and commercial agreements signed for supply and installation of equipment. In 1993, the regions IVO was contacting in Russia were Tver, Moscow City and Region, Cherepovets, Tyumen, Magnitogorsk, Chelyabinsk, Volgograd, Vologda, Altay, and Perm. The range of IVO's contacts in Russia (see table at the end of this case study) represents a good view of all of the different organizations potentially involved or influencing energy-efficiency investments.

The experience of IVO International in developing deals, including innovative financing schemes and "financial engineering," negotiating and obtaining contract and licenses, and other institutional aspects of the process, represents a significant innovative aspect of their activities.

As an example, one of IVO International's more recent efforts in energy-efficiency investments in Russia was in Karelia, at the Petrozavodsk heat and power station. After an IVO-conducted feasibility study in 1992-93, IVO and Kareliaenergo negotiated a purely commercial agreement for automatic fuel burning and optimal boiler combustion equipment, including sensors and fuel and exhaust control of NOx, SOx, and CO. This station has three boilers: 2.5 MW, 2.9 MW, 3.0 MW. In 1993 they signed a deal whereby IVO International would provide and install this equipment, and Kareliaenergo would repay the investment with barter exchange: 15,000 tons of oil. This oil was estimated to be 14-months worth of saved fuel, which was considered the approximate pay-back time of the improvements. At a September 1993 domestic oil price of 36,000 rubles/ton for mazut, this 15,000 tons was valued at about $500,000.

Several institutional hurdles prevented this investment from occurring. After the original contract was signed, a new federal law was passed increasing tax on fossil fuel export from Russia. Since Kareliaenergo receives a quota of oil from the Ministry of Fuel and Energy, it had to first obtain permission to use part of this quota for export. The Ministry of Fuel and Energy did agree to this. But then one of the biggest hurdles in the project was attempting to obtain an export license for export of this oil. An export license was finally obtained after six months elapsed time and after approval from the Ministry of Foreign Economic Relations (Karelia branch). Approval from the Ministry of Economy was also required. IVO then had to find an enterprise in Karelia that was licensed by the government to export oil. Thus not only was a commercial contract required, but also a Western buyer, quota-related approval, agreement from the Ministry of Economy, an oil export license and a contract with a licensed oil export enterprise. Yet after all necessary approvals and arrangements had been secured, the deal was put on hold because at about the same time the Russian government revoked the right to export oil from all previously licensed enterprises except for a few specially designated enterprises. The deal remained, the export licensed remained, but the lack of a new intermediary with rights to export oil threatened to cancel the whole deal.

IVO INTERNATIONAL CONTACTS IN 1993

Ministry of Fuel and Power:
- Department of Technical Policy
- Department of International Relations
- Finnish-Russian Commission for Economic Cooperation
- Department "Northwest Energo"
  - Karelia electric power utility
  - Murmansk electric power utility
  - Novgorod electric power utility
  - Vologda electric power utility
- Department "Central Energo"
  - Moscow electric power utility
  - Tver electric power utility
  - Ryazan electric power utility
- Department "East Energo"
  - Altay electric power utility
  - Tyumen electric power utility
- Department "Volga Energo"
  - Saratov electric power utility
  - Nizhniy Novgorod electric power utility
  - Tatarstan electric power utility

Council of Ministers of the Russian Federation
- Commission for Finnish-Russian Economic Cooperation
- Department of Regional Management (various regions)
- Department of Foreign Trade Management, License Control
- Department of Organizing Management Ministry Council

Ministry of Science, High Education, and Technical Policy
- Department of New Technology in Fuel and Power Complex
- Department of International Scientific and Technical Cooperation

<u>Sources of Evidence</u>

Interviews with Regional Director, IVO International representation in Moscow (9/17/93, 10/1/93, 1/11/94, 1/20/94, 2/1/94)

Interviews with the Director of Energy Efficiency, IVO International (7/7/93, 10/29/93)

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CASE STUDY: KALMYKIA WIND FARM AND OTHER RUSSIAN WIND PROJECTS

In mid-1994, several domestic wind projects were underway in Russia. These are summarized below.

Kalmykia Wind Power Station. The Kalmykia electric power utility, Kalmykenergo, is developing this wind farm along with RAO "EES Rossii." The wind farm, located near the town of Elista, will be 22 MW, with 22 1000-kW turbines produced by the Radyga aerospace enterprise. Total installed cost estimate is about $1000/kW equivalent installed. Wind speeds at this site at a 38-meter height have been measured at 7.6 m/sec annual average, and they anticipate operation 3200 hours/year. Right now Kalmykia must buy electric power from Rostov and Volgograd, but wants to become more self sufficient. Calculations show that a large high-elevation wind zone covers 5000 km2, and could provide 20,000-MW capacity if wind power was fully developed there. The balance-of-plant was completed in September 1994, and the first turbine was scheduled to be erected shortly thereafter. The costs for the balance of plant were estimated at 30%, a high percentage because of the need to build roads and basic infrastructure to serve the plant (nothing was there before).

Maritime Region. A 30-MW wind farm is planned. Design work so far has been by Lengidroproyekt. The installation was ordered by the Maritime region electric power utility because there are good winds on the coast, and the region suffers from an electricity deficit. Two sites are planned, one with 1000-kW turbines, and one with 250-kW turbines.

Radyga aerospace enterprise. For 40 years, all of the work of this enterprise was for the military complex. In 1989 began to think about conversion using wind turbines. Within one year, all design work on prototype wind-turbines was completed, but by 1991 prices began to change, and they had not been able to do much because of high costs. In 1993, with RAO "EES Rossii" and the Kalmykia electric power utility, they began to work in this are again, along with the Tushinskiy enterprise, Samaragidroproyekt, Atommash, and others in St. Petersburg. The 1000-kW machine has two versions of generator: 650 rpm and 2500 rpm, one synchronous with speed control and one with a permanent magnet. Their operating temperature range is minus 50 degC to plus 40 degC. One prototype was built and was to be installed in Kalmykia. They anticipated an production capacity of 12 turbines per year. Radyga was also working on a 250-kW turbine, an exact scaled-down version (2:1) of the 1000-kW turbine.

Saratov Oblast. In a project paid for by the German government, German wind-turbines were to be installed in Saratov Oblast, five 30-kW turbines on the river plain, and five in the hills.

Vetroen association. Vetroen was building two wind stations: a 2.5-MW wind farm near Volgotar (Komienergo, 2 units already installed), and a 2-MW near Novorossiysk, which was 80% complete in 1994. There was a 250-kW design financed by the old Ministry of Energy of the USSR and Yuzhoye, but now everyone is on their own. Vetroen was also gathering arctic application experience, such as tower protection from snow. By the end of 1994, there were to be 4 operating units in Volgotar (250-kW units), and Vetroen expected to be finished by 1995 with all 10 units. Another three stations were planned for Krasnodar (5-MW each). Vetroen quoted typical turbine prices of $800-900/kW, and said that "average payback on Russian territory is 4-5 years." Vetroen was also working on a 100-kW design, and employed 150-200 people in its labor force.

Lengidroproyekt. Feasibility studies were under way for a 25-MW wind station in Leningrad Oblast, and also for stations on Cemi island and in Kaliningrad. Coastal Karelia will be the first installation, with 8 MW planned. A test station and turbine in Ivangorod was testing a 250-kW turbine design in 1994. On Kolskiy island, average daily wind speed has been measured as 8 m/sec at a 10-meter height.

RAO "EES Rossii."   RAO "EES Rossii" was working on 8 wind station projects, totaling 170 MW capacity, in Russia, Ukraine, Kazakhstan, Baltics, and Armenia. The most notable of these projects is the 22 MW wind farm in Kalmykia described above.

Sources of Evidence

Interview with Head of Renewable Energy Department, RAO "EES Rossii" (9/16/95)

Presentations at the Wind Power in Russia conference, Moscow, April 28-29, 1994, sponsored by RAO "EES Rossii" and the EU Energy Center Moscow.

CASE STUDY: MINSK INDUSTRIAL ENTERPRISES

Note: the following two perspectives on enterprise energy efficiency were obtained in mid-1992, when economic conditions had as yet changed little from the Soviet era (with the exception that there were no longer centrally planned dictates for production, prices, inputs, and outputs).

1. Minsk Ceramics Factory

There is a ceramics factory in Minsk that makes high quality and highly desired dishes, teapots, and other domestic ceramics, plus insulators for electronics and other items. The energy engineer at this factory knows very well how he could technically improve the energy efficiency in his factory. And at first glace he has good reason to want to try -- the factory needs 500,000 kWh of electricity per month and only receives a quota of 400,000 from the local utility (any electricity above 400,000 costs ten times as much as normal) -- so the factory makes do with 400,000 by turning off half the lights, reducing the ventilation systems, and generally doing things that reduce plant productivity and make working conditions unbearable. The engineer knows how to invest in new equipment to save 100,000 kWh per month, but if he was somehow able to do this, the utility would then say "you're using 100,000 less, so we can reduce your quota to 300,000." In addition, any additional profit earned by the energy savings gets taxed at 50% (mid-1992; a 28% VAT interwoven with a 30% profit tax give an effective 50% tax on saved energy expenditures given constant revenues[4]), so there is little financial incentive to invest in efficiency. In any case there is no capital available to borrow to invest, and the equipment needed could not be found (due to scarcities and lack of the appropriate personal contacts) even if the plant had the money.

Incentives for the ceramic factory to save 100,000 kWh per month from energy-efficiency investments are reflected in three potential scenarios:

(a) The extra 100,000 kWh per month is used to improve working conditions in the factory by increasing lighting and ventilation. This scenario could only occur if the electric utility did not lower the quota of the factory from 400,000 to 300,000 kWh/month. The energy engineer in the factory thought it was likely that the utility would lower the quota if it learned about the efficiency improvements (and it would be hard to keep them secret, especially with a high-visibility project involving Western partners). From the utility perspective, a decision to not lower the quota in the post-improvement situation would be equivalent to a decision to increase the quota in the pre-

[4] As explained to me by an economist in the Belorussian Academy of Sciences, enterprise revenues in Belorus are subject to both profit and value-added taxes. A profit tax of 30% is applied to the difference between sales revenues and total expenses (which include materials, energy, labor, and value-added tax paid). In addition, a value-added tax of 28% is applied to the difference between sales revenues and non-labor expenses (which include materials and energy). Therefore, if revenue remains constant (no change in price of goods sold) and energy expenses are reduced through energy efficiency improvements, the total amount paid in profit and value-added taxes will increase by roughly 50% of the energy savings, and the net increase in profit is only 50% of the energy savings. This is because the difference between sales revenues and total expenses (in the case of the profit tax) and the difference between sales revenues and non-labor expenses (in the case of the value-added tax) will both increase when energy expenses are lower, increasing the amount subject to tax.

improvement situation from 400,000 to 500,000 kWh/month, since both decisions would involve giving the plant more electricity than it "needs." And because Belarus faces an electricity shortage, the utility cannot justify giving a customer more than it "needs."

(b) The energy demand of the factory is reduced to 300,000 kWh/month, and the energy costs avoided are used to increase worker's salaries. This would occur if the plant management felt the workers were underpaid and felt responsible for their well-being. The factory pays 2.75 rubles/kWh (mid-1992), so the gross increase in salaries would be 275,000 rubles/month. However, the net increase in salaries would be lower by the amount of the value-added tax, or 28%, because the value-added tax applies to (revenue minus non-labor-expenses) and would thus increase as expenses were shifted from non-labor to labor expenses. The profit tax would not change since it applies to (revenue minus total expenses). Therefore, the net increase in salaries would be 72% of 275,000 rubles/month.

(c) The energy demand of the factory is reduced to 300,000 kWh/month, and the energy costs avoided are used to increase profits. Because of the value-added and profit taxes, the net increase in profits would be about 50% of 275,000 rubles/month, while total taxes paid would also increase by 50% of 275,000 rubles/month. While retention of 50% of energy efficiency savings is better than nothing, it should be remembered that in the current situation, profits themselves are not very useful. First of all, with inflation running at very high levels, money that sits around for any period of time becomes worthless. Secondly, the general scarcity of capital and equipment in the economy as a whole has meant that the factory is not able to reinvest profits in new capital or other improvements. The bottleneck for capital improvements is not sufficient money, but sufficient contacts and opportunities to acquire equipment and other goods.

(d) There is a fourth scenario that might be found in the West but is not realistic for this factory. The factory could reduce the price of goods sold to reduce its revenues by the amount of avoided energy costs. This would theoretically put it in a better "competitive" position. But in former Soviet republics, many industries are in a monopolistic or oligopolistic position. Many categories of goods are produced in just one or a few factories, so that even with a "market" and competition among firms, there are no "competitors" except those in other countries. This is true of the Minsk ceramic factory. Its products are well-known and regarded throughout Belarus and Russia, and there is high demand for and chronic shortages of its production.

2. Minsk Building Materials Factory

There is a brick factory in Minsk that makes bricks that are in high demand. Brick making is very energy-intensive and the factory uses a lot of energy. The chief engineer of this factory is very committed to making his plant as energy efficient as possible. This commitment stems not so much from incentives (increased profits do not mean much, and the bricks are in such high demand -- essentially a monopoly situation -- that the factory has no incentive to lower prices either), but rather this commitment stems from the basic values of the engineer that energy efficiency is a "good thing." This distinction is important -- the people who will implement efficiency improvements in the shorter term are those who share this commitment and will push through whatever barriers exist, rather than those who operate strictly on the basis of any economic incentives. This engineer feels he has made his plant as energy efficient as possible given "Soviet" equipment available to him, and now must turn to using Western equipment for more efficiency gains. Because of the high demand for bricks and the political clout of the factory, the factory had the opportunity to buy equipment from Western Europe to improve energy efficiency. A purchase got as far as signed contracts, but the bureaucracy involved in the deal overwhelmed the project and nothing was actually ever bought. The engineer's hope for the future is that the bureaucrats and administrators can be moved aside and the engineers can take actions and make purchases that will improve energy efficiency.

Sources

Interview with Chief Energy Engineer, Minsk Ceramics Factory (6/26/92)

Interview with Chief Engineer, Minsk Building Materials Factory (7/1/92)

CASE STUDY: MOSKVICH AUTO FACTORY

The Moskvich auto factory is one of the largest automobile factories in Russia, and includes several huge buildings (some are 1-2 million cubic meters in volume and over a kilometer long). There are two main plants within the compound. One was built in the 1930s and the second in the 1970s. The design capacity of the two combined is 160,000 cars/year, and the actual production in 1994 was 120,000 cars/year. Even though actual capacity is less than design, no process energy savings are possible through optimizing processes for reduced capacity; the loads exist regardless of plant throughput. For example, building ventilation systems do not depend on production level.

Since the plant can contract relatively easily for the energy it needs, there are no processes that do not receive sufficient energy in general. Therefore, any energy savings would occur in the form of lower energy costs and lower contract amounts, rather than in the form of more production or greater use by currently energy-deficient processes. During peak hours in the winter, when energy allocation limits are reached, the plant manually closes off some non-essential equipment like heating.

Right now control of energy is done manually by human operators, actively from 8 am to 10 pm. Ventilation control, heat flows, building temperatures, etc. are all adjusted manually with meters, valves, controls, regime curves, and telephone calls. But the "human factor" makes operations less than optimal, and each operator has his own idea about operating points, pressure levels, etc.

The peak hours of energy consumption are in the winter between 8 am and noon. Without some type of intervention, the contracted electric capacity of 62 MW would be exceeded for perhaps two hours each day in the middle of the day. But through manual operator intervention and coordination, the plant always manages to stay below 62 MW.

The plant has several buildings with a volume of 1-2 million m3 in which heat consumption is a significant portion of total energy use. The goal is to keep these buildings at 17-18 degC, but sometimes in winter the temperature rises to 20 degC and above. One single building contains 20% of all the interior volume in the plant, and this building has recently been outfitted with variable-speed drives (25 of Ukrainian origin; approximately 250A each; 1-3 years old) on the ventilation systems to allow better heat regulation without having to repeatedly start and stop the ventilation motors (which is wearing on the motors and causes problems to electrical systems from motor starting currents). But control of these drives is still done manually.

These variable speed drives were installed without any control, regulation, or measurement instruments. The plant has investigated mathematical models of this building to perhaps develop some type of open-loop control system, but now feels that closed-loop feedback control of ventilation and heating is preferable. The building is very old, and its hard to adequately model all of the heat sources and sinks. Another complication is that the district heating system water output temperature must be held constant.

The plant uses variable speed drives in other places besides the ventilation systems mentioned above, but these tend to be for low-power pumps, 100-kW and below. About 8-10 new drives are slated for installation on a system of water pumps.

Plant Energy Consumption and Costs

	Quantity	Cost
Electric power capacity	62 MW	840 rubles/KW/mo.
Reactive power capacity	24 MVAR	27 rubles/KVAR/mo.
Electricity	350 million kWh/year	2 rubles/kWh
Reactive power	100 million kvarh/year	0.06 rubles/kvarh
Gas	18 million m3/year	
District Heat	400,000 GCal/year	3000 rubles/GCcal

The plant contracts with Mosenergo for electric capacity, electricity, gas, and district heat (which comes from a plant just a few hundred meters across the street). While Mosenergo is rather lenient about the contracted quantities, they are very strict when it comes to adhering to those quantities: any consumption in excess of contract amounts costs ten times the normal rates. Thus the plant must strictly monitor and control its consumption so that it does not exceed contracted amounts. Contracted amounts are changed quarterly (would be cheaper if changed monthly; with the current system, the contract amounts must be for the worst-case month within a given quarter).

The peak energy demand period is during the winter. The structure of consumption is the same in the summer, but the volume is lower. For example, the summer capacity is only 56 MW (although the June 1993 contracted capacity was 60 MW).

Energy costs as a percentage of total production costs were 6-7% for June 1993. But energy prices change quite often, perhaps every 3-4 months, and this ratio has ranged from a low of 4% to a high of 12% during 1993. Electric capacity charges are approximate half of the total cost of electricity.

The two main factors affecting energy consumption in the plant are (1) outside temperature, and (2) number of cars produced. As one datapoint, 24.4 million kWh were consumed in May 1993, when the average outside temperature was 11.4 degC and the production level was 7500 cars. The plant keeps detailed records of consumption, temperature, and production for daily and monthly periods.

In winter months, electricity consumption in kWh can be broken down approximately as follows:

Ventilation/heating	15-17%
Production of compressed air	12%
Lighting	9%
Services and cafeteria	4%
Production processes	58-60%

Production processes include metal forging, galvanizing, drying, instrument production, and thermal treatments. About one quarter of all process electricity is connected with cutting metal.

I received conflicting estimates of plant lighting; one said 9% while the other said 4%. Non-rotating electric equipment for galvanizing and arc welding uses about 20% of total electricity consumption.

There are some 70,000 motors in the plant, with an average power of 4-5 kW, so total installed capacity is about 300,000 kW. Thirty percent of all electricity consumption goes to motors of 100-kW and below, and if all motors are included, motors represent about 50-60% of all electricity consumption. About half of motor electricity consumption goes to production processes, and half to ventilation, heating, and compressed air.

Proposed Energy Saving Measures

The chief energy engineer was particularly interested in the following themes: (1) Installation of plant energy management and automatic control systems using high-technology Western equipment. (2) Cooperation with Western specialists and experts in doing (1). (3) Automatic building heating systems (control of existing ventilator variable-speed drives) to save energy through reduced and controlled temperatures. He did not seem particularly interested in installing more variable-speed drives in the plant, nor did he seem interested in pursuing other energy saving possibilities immediately. He did emphasize that many plant engineers have been trained in Germany and could work side-by-side with Western specialists. In these areas, the bottom-line savings are electric capacity charges (not consumption of kWh), and district heat consumption.

The plant wishes to optimize energy consumption and reduce necessary contract amounts through an automated system of energy management. With improved measurement and control, a system of "normative minimums" could be established in conjunction with a plant-wide energy policy that would reduce the problems associated with individual operator idiosyncracies, and manual coordination via telephones and human real-time decisions.

To this end the plant lacks computers, software, and mathematical models of energy in the plant to enable efficient control. Automatic control systems would provide the following benefits:

(1) Eliminate the need for manual operator control and coordination, and reduce problems associated with human error and idiosyncracies (or simply being late for work).

(2) Reduce contracted electric capacity by 2-5 MW. Control to smooth out consumption and better regulate supply could allow the plant to contract for a maximum of 60 MW rather than 62 MW, or perhaps as low as 57 MW. The plant conducted an experiment and found that with particularly careful manual intervention, the maximum capacity could in fact be reduced to 60 MW or below.

(3) Allow large buildings (1-2 million m3) to maintain a temperature of 17-18 degC and not higher. Mathematical models of the buildings and/or closed-loop feedback could provide close temperature regulation. Mathematical models actually do not work so well in these buildings because of the different and variable heat sources like vents, the outside temperature, process heat, losses through open doors, etc. It would be better to adjust heat supply every 3-4 hours based upon closed-loop feedback. The economic benefits of these measures need further analysis, but the plant estimated 40 million rubles ($20,000) per year could be saved, based upon turning down the heat by 50% during days off and holidays. Perhaps half of these savings, 20 million rubles, are realized now through manual control.

When I asked the chief energy engineer about the effect on plant operations of a new automatic energy control system, noting that process changes might be required to implement efficient energy management, he replied that no process changes would be required, only changes in the operating times and schedules of various equipment. In general he felt plant senior management would go along with operating schedule changes without any problems. He said the shops most affected by these changes would be energy-intensive areas with few workers, and the workers could be paid more to have them "cooperate."

Some examples of prior energy-efficiency measures taken by the plant include: (1) The plant recently installed compensating capacitor banks which increased the plant power factor to 0.945 and reduced charges for reactive power. (2) A few years ago the plant installed water-heating temperature regulators to provide hot water more closely matched to plant needs. (3) A new closed-circuit water circulating system for drinking water allowed reduction of drinking water by 2000 m3 daily.

Sources of Evidence

Interviews with Chief Energy Engineer, Moskvich Automobile Factory, Moscow (7/6/94, 7/7/94)

Interviews with Energy Engineer, Moskvich Automobile Factory, Moscow (7/6/93, 7/7/93)

CASE STUDY: MOSMATIC JOINT VENTURE

This joint venture is used as an illustration because many of its products and services are similar to those of a venture producing and installing automatic control systems in industry for energy efficiency.

One example of a joint venture producing automatic control systems for industrial process is the Mosmatic joint venture in Moscow. Founded in 1991, the venture provides turnkey projects, sales, and service for industrial process control using Siemens equipment. It is a joint venture between Siemens and the Moskvich auto factory, since the Moskvich plant has been a big customer of Siemens equipment for many years, and the venture can thus continue to provide close-at-hand service to the plant. The manager of this joint venture felt that a local enterprise such as his with primarily Russian staff had a big advantage over foreign companies working in Russia. The knowledge of Russian industrial needs, "psychology," equipment, and overall situation and operation was extremely important to successful business transactions and technically successful projects. This local "know-how" is what he felt provided the great advantages to joint ventures, especially since Russian engineers and specialists were readily available to work in such an enterprise.

Mosmatic produces control equipment cabinets that may contain exclusively Siemens components, or may contain some Russian components, depending on the customers wishes and negotiated price. Simpler components, like relays and cables, can be Russian, while more sophisticated electronic components must be Siemens. Mosmatic offers design, fabrication, installation, maintenance, and guarantee services.

One problem the joint venture faced is that customers were slow to trust it relative to larger domestic and foreign companies offering similar products and services. Especially smaller enterprises were reluctant to entrust their hard-earned foreign currency earnings with a smaller, unknown firm. The joint venture was still struggling to make any profit, but had 93 contracts in 1993. The venture can be competitive with foreign companies because the products involve a large amount of skilled labor beyond the equipment itself, for engineering, design, and programming.

The general director of Mosmatic described four obstacles to the success of his joint venture. His number one problem was finding good, committed people who were willing to work hard. Secondly, problems were financing (obtaining investment capital), and marketing and sales research (developing a marketing department, conducting research to understand customers, developing sales networks). Thirdly, corruption and mafia were ever-present problems, with which every enterprise has to contend. Without the right bribes in the right places, made possible with the right connections, many contracts will be lost even if bids and proposals are high in merit.

In general, Siemens has supplied capital and know-how to the venture. The know-how has been a combination of technical, financial, management, and marketing. Three German specialists were working in the joint venture, and the remaining 30 people (in 1993) were Russians. One German was a technical specialist, one was a marketing engineer, and one was a business specialist. The costs of these specialists relative to the Russian personnel was enormous. One specialist cost \$300,000/year when all costs were included. Russian personnel were trained in Germany for 1-2 months, and additional textbook classes were conducted in-house for more specialized technical details. One of the changes required for the Russian engineers was for them to think in engineering-economics terms, rather than just in technical terms, as they were accustomed.

The general director of Mosmatic referred to the "nuances" of doing business in Russia, and said that these nuances constituted a special form of highly developed know-how. First and foremost he said you need good information about the market and potential customers, and here the know-how is knowing <u>how</u> to get that information in the first place.

Sources of Evidence

Interview with General Director, Mosmatic, 9/9/94.

Mosmatic AO, Moscow. 1994. Promotional brochure.

CASE STUDY: MYTISHCHI DISTRICT-HEATING EFFICIENCY PROJECT

The municipal heat-supply company for the city of Mytishchi, Teploset, has been developing and using an automated system for control of its heat distribution substations for the last 15 years. Originally designed to reduce labor costs, improve reliability, reduce accidents and their consequences, and reduce customer complaints, the system nevertheless has the function of improving energy efficiency at the same time (although energy consumption has not been a concern of Teploset in the past). Over the past 15 years, all substations have been automated using domestic technology and know-how. Now Teploset is concentrating on disseminating its experience to other regions of Russia and entering into joint ventures with other partners for production of heat meters and other equipment for district-heating systems. Teploset is also working with other Russian firms to develop software for monitoring and control of district-heating systems.

Mytishchi is a city of 200,000 people located just north of Moscow. The district-heating network controlled by Teploset contains one 150 Gcal/hr heat plant and 18 smaller heating boilers located throughout the city, along with about 60 heat distribution substations. Total capacity is 270 Gcal/hr. Together this system serves about 300 buildings of 5, 6, 12, and 16 stories through 50 km of primary heat supply piping. Heat is also brought into the network from a TETS plant in Northern Moscow. Teploset supplies 90% of the heat for the residential sector in Mytishchi, produced 655,000 Gcal of heat in 1993, and purchased 91 million m3 of gas from Mosgaz in 1993.

Each substation has a controller that monitors temperature, pressure, pumps, and valves, and controls pumps and valves locally according to the "graphic." This information is transmitted via dedicated telephone lines to the central dispatch center for operator monitoring and control. Each substation sends this information once every two hours. The control of secondary supply temperature does not depend on outside temperature, but rather is based upon the incoming temperature and a look-up table.

The technology used for these automatic controls is very old: 1960s style printed circuit boards with discrete low-level integrated circuits form the control logic. The equivalent of three 8080-microprocessors are implemented with discrete integrated circuits on several boards. All equipment used is domestic.

One of the main advantages of this system is in labor reduction. Before the system was installed, the heat supply system was "unmanaged" in the words of the director of Teploset. Nine people were required for every four substations (or 140 people for all 60 substations), and were supposed to visit each substation once per hour and make adjustments. But the operators did not actually do anything and the system was operated sub-optimally (and the residents complained a lot). With the automatic system, one dispatcher, one operator, and one driver work around the clock servicing the system. The substations are only visited for maintenance or in case of problems. No customers complain anymore, whereas in 1978-80 there were about 600-800 basic complaints per year.

There does not exist any good estimate of the energy savings from these systems, so it is very difficult to do an economic evaluation. The project stands to illustrate that Russians can and have been doing this type of work for a long time already. Total costs for automating one substation were estimated by the Teploset resident engineer to be 2 million rubles for equipment and 5 million rubles for installation, or 7 million rubles total ($5000 equivalent).

Sources of Evidence

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Interview with Engineer, Mytishchinskiy Teploset Heat Supply Company (2/22/93)

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CASE STUDY: NAGATINO DISTRICT-HEATING EFFICIENCY PROJECT

Summary: This project illustrates that domestic technologies and system integration methods exist for automatic heating controls similar to the Honeywell Tushino project, at a fraction of the cost. In 1989, a branch of the Moscow district-heating company serving the Nagatino district of Moscow decided to invest in automatic controls for one 200 MW heat plant and the 32 substations connected to it, which together serve 90,000 people. Because these types of automated control systems require a high degree of integration, this work has been carried out by an association of several different enterprises throughout Russia, each supplying particular components and expertise. While Honeywell was able to provide an integrated system, this association of enterprises demonstrates a successful way that Russian enterprises can do the same thing. The project has been carried out in small stages, with each stage paying for the next stage through energy savings. Energy savings are estimated at 10-15%. Total system cost when completed is estimated at $350,000 equivalent, with a payback time of 1-2 years at mid-1995 domestic gas prices.

Project Development

A project similar to Honeywell's Tushino project at another district heat-only plant in Moscow has been occurring over past several years using mostly domestic technologies and know-how. This project demonstrates that the same type of energy-efficiency improvement can be accomplished domestically at much lower cost.

Enterprise 3, one of 6 regional branches of Mosteploenergo, manages heat supply for 5 districts in South, Southeast, and Central Moscow, serving a total population of 400,000 people in over 1800 buildings (20,000 m2) with 7 heating plants. Total consumption of gas in 1993 by Enterprise 3 was 478,000 tcm. In 1989, Enterprise 3 decided to invest in automatic controls for one of its heat plants (serving the Nagatino district of 90,000 people) and the substations served by it. This work has been carried out by a technical association of enterprises called Thermo-IVS. The project has been carried out in small stages, with a philosophy of each stage paying for the next stage through energy savings.

The association Thermo-IVS has a unique structure that has played a role in its ability to implement a district-heating automatic control system, which, as many associated with the Honeywell project argued, requires an integration of many different products and services. The Thermo-IVS association consists of a loose network of different enterprises with a central "general contractor." The general contractor receives orders from clients and forwards them on to the appropriate enterprise as a "subcontractor." In this way, the network offers a large range of products and services in a coordinated, cooperative manner. No money changes hands between the different enterprises of the association, only between them and the customer. The enterprises associated with Thermo-IVS are located all over the former Soviet Union: Yekaterinburg, Minsk, Kiev, Murmansk, Yakutia-Sakha, and St. Petersburg. This type of association has a strong tradition in Russia, although with Perestroika the influence of these types of associations diminished.

Thermo-IVS was established in 1987 and consists of enterprises producing most of the equipment necessary for district-heating automation: monitoring equipment; combustion analyzers; controllers; heat meters; diagnostic equipment; design and engineering of algorithms, test procedures, and automation; and temperature and pressure sensors.

As of the end of 1993, controls had been installed in the boiler plant itself and in three substations, and plans were proceeding for installation in additional substations. By 1995 all 32 substations were to be automated.

Similar projects were anticipated in three other heat plants of Enterprise 3: Berelova, Kolomenskaya, and Leninadochnaya, once the Nagatino project was completed.

Technical Description

Enterprise 3 operates the Nagatino heat plant, which consists of four 50 Gcal/hr boilers (about 200 MW total). This plant distributes heat to 32 heat distribution substations and services a population of 90,000 people in 225 residential buildings and 90 commercial and industrial buildings. The total area of these buildings is 1.2 million m2, and total designed heat load is 186 Gcal (at -26 degC). Annual gas consumption of the plant is 86000 tcm. Gas costs and heat tariffs are the same as Tushino: gas costs 25,000 rubles/tcm, and heat tariffs are 12,500 rubles/Gcal for residential customers and 17,500 rubles/Gcal for industrial customers (all February 1994 prices).

The systems installed by Thermo-IVS include:

1. Combustion control of the boilers in the heat plant, to maximize combustion efficiency based upon outside temperature, the heat load, boiler efficiency, water temperature, O2% and CO%.

2. Control of the output water temperature according to a 24-hour dispatcher regime, corresponding to heat load and outside temperature.

3. Remote control and monitoring of substation equipment from the main heat plant.

4. Local controllers at each heating distribution substation to control secondary heat supply temperature and hot-water temperature.

In the plant itself, there is no automatic feedback from the control outputs to the equipment. The operators must manually implement the recommendations of the computer. This makes the system less complex, but more labor intensive. The operators, however, have little to do anyway, and this process is not time-consuming. The major drawback is that if the operators ignore the recommendations or are not attentive to timely changes, the efficiency of the system will be reduced. Neither of these situations occurs, according to the director of Thermo-IVS.

The equipment installed includes an EK1101 controller for the plant; an MT-005 controller for each substation; an IBM PC; telephone lines and modems/multiplexers; sensors for temperature, pressure, and water flow; and a flue gas analyzer. Existing control valves and pump controls were used with modification. All equipment used was Russian with the exception of the IBM PC, and these components are available from a variety of firms in any quantity in Russia. The one exception is new automatic regulating control valves installed to replace the existing valves. There is only one firm in Russia producing such valves, and the quality of these valves is not comparable to foreign equipment. So these valves were purchased abroad.

Economic Characteristics

The total costs for the station are estimated at 25 million rubles for monitoring equipment, controller, central computer, and labor to install. The total costs for each substation are estimated at 15 million rubles, including domestic equipment (5 million), imported regulating valves (5 million), controller (2 million), and labor (5 million). Thus the total system cost for one station and 32 substations would be about 500 million rubles, or $350,000 (January 1994 price level).

Nagatino conservatively estimates that 5% of gas consumption can be saved through load control of the heat substations, 1-3% through better gas combustion at the heat station, and a few percent through better matching of heat output with daily fluctuations in heating load, for example hot-water demands. In total, a conservative estimate might be 10% of total gas consumption would be saved.

This station uses 86 million m3 of gas annually. If 10% of this is saved (a conservative estimate), then 8.6 million m3 is saved, valued at $390,000 at domestic gas prices ($45/tcm). Thus the simple payback time would be about one year.

<u>Sources</u>

Interviews with Director, Interregional Energy-Ecology Association Thermo-IVS, Moscow (1/28/94, 2/4/94, 2/11/94, 2/25/94, 8/16/94)

CASE STUDY: NUTEK BIOMASS-FUELED BOILER CONVERSIONS IN ESTONIA AND RUSSIA

Summary: In 1993, the Swedish government through the agency NUTEK (The Swedish National Board for Industrial and Technical Development) began to loan capital to Estonian district heat-supply companies for a series of boiler conversions from oil to wood-chip fuels. The overall goal of this program was environmental: to promote cost-effective projects which reduce CO2, SOx, and NOx on a sustainable basis. The first conversion, a 6 MW boiler in Valga, was completed in December 1993 and began to run successfully. Total time from conception to operation was less than six months. NUTEK assisted the heat-supply company with bidding to both Estonian and Swedish companies and with evaluating bids. A private Swedish company designed and provided the equipment and supervised construction. The estimated conversion costs were about $80-$90/kW, and simple payback time about 3-4, years based upon wood-chip costs that were about half the cost of oil on a per-energy basis. The plant has borrowed capital with a 10-year loan, 3-year grace period and 7-8% interest, similar to World Bank terms. Wood-chip markets were in their infancy in Estonia, but the plant was able to secure a 3-year contract with a sawmill for wood chips. The ultimate goal of the program is to encourage partnerships between Swedish and Estonian commercial firms able to carry out such conversions.

By 1993, NUTEK was lending money to Russia, Poland, Estonia, Latvia, and Lithuania for these types of conversions of heating boilers from oil to wood fuels. In Russia, no loan agreement had yet been signed by the end of 1994, but loan negotiations were underway with a few enterprises in St. Petersburg. Most heating boilers in Russia are larger capacity than in Sweden and the other countries in which NUTEK was working, so that the Swedish boiler conversion technology was not so applicable to Russia. Further difficulties in Russia were that the project economics (domestic oil prices versus domestic wood prices) were not sufficiently favorable for a revenue stream to pay back the capital cost of the loan at domestic oil prices. Investigation was underway to see if export oil prices could be used in valuations of the saved oil. Other difficulties were that it was difficult to make contact with local administrations and local heating enterprises. A form letter mailed out soliciting interest produced no response.

In Estonia, several other boiler conversions were already completed or under negotiation. The first of these was in Valga, and was completed in December 1993. In 1994, 3 more conversions were negotiated and completed in Virsu, Tartu, and Habneimaa. The original Valga project is described in detail below.

Project Development

In early 1993 the Swedish government made available 45 million SEK for loans for environmentally-related energy projects in the Baltic states. The overall goal was environmental: promote cost-effective projects that will reduce emissions of CO2, SOx and NOx on a sustainable basis. Sweden wanted to find out, as part of this program, the costs (per ton) of reducing these emissions in Estonia. As part of this program, administered by NUTEK, boiler conversions from oil to wood fuel were emphasized, with the following criteria: boilers 3-10 MW in size and able to accommodate a pre-oven modification; a "typical" application that can be replicated throughout the region; a nearby source of fuel; and availability of necessary supporting organizations. Another requirement by NUTEK for this project was that at least 70% of the wood fuel needed for the first 3 years be contracted for in advance of project completion.

NUTEK administered financing of the project through a 10-year loan from the Swedish government at 7-8% interest with a 3 year initial grace period. These terms are similar to World Bank loans. The one exception is that a 15% minimum fuel cost reduction is guaranteed to the plant in the contract, no matter what happens to relative wood and oil prices. The interest payments on the loan will be reduced if necessary to fulfil this condition.

In April and May 1993, candidate sites in Estonia, Latvia, and Lithuania were considered for potential investment. By June 1993, the Valga plant had been selected in consultation with Estonian authorities and the plant itself. The selection process was assisted by the State Energy Department, which had solicited proposed from plants over all over the country for its own boiler conversion programs. A call for tenders was issued. Eight bids were received, and four of these were pre-selected by NUTEK for consideration by the plant. In August 1993, a "letter of intent" was written between NUTEK and the plant, specifying roles and conditions for the project. By September, the contract for the prefurnace and other equipment was awarded to KMW, a Swedish company, and construction began. By late October the Swedish equipment arrived and was installed by Estonian workmen under the supervision of two Swedish KMW employees. On December 9 the plant was officially commissioned.

The boiler conversion technology was simple enough that eventually Estonian companies themselves could replicate it. One of the goals of the program was to encourage joint ventures between Swedish and Estonian companies. The program may in the future require Swedish firms to have a local Estonian partner in order to bid on future projects. Estonian companies cannot design a pre-oven (design needs a lot of experience over time), but they can buy a license to produce a pre-oven based upon Swedish designs, according to several sources involved in the project, including Estonia State Energy department officials.

Valga Technical Description

The Valga Soojus heating plant consists of three DKVR-10-13 boilers, originally designed to burn coal but now burning heavy oil (mazut). Standard capacity for each boiler is 9.8 MW when burning oil, so the total boiler plant capacity before conversion was 29.4 MW. In 1993 all three boilers were converted from steam to hot-water operation.

In late 1993 one boiler was converted to wood burning operation using a Swedish supplied pre-furnace, automatic wood feeder, wood storage shed, stationary wood chipper, and automatic combustion control system. The capacity of the wood-fired boiler is 6 MW. The Swedish technology selected is quite basic and simpler than many available technologies in Sweden, according to the supplier. It is not fully automatic and requires manual operation. One of the reasons for this is the physical size constraint for installation within the existing boilerhouse building; a more sophisticated technology would not have fit. The selected technology has been used at 4000 sites in Sweden over the past 25 years, and has also been used in former Czechoslovakia, New Zealand, and other countries. Boiler emissions conform to ordinary Swedish standards.

The residential heating load connected to the plant is given as 18.4 MW. According to the residential load data, there are a total of 1600 apartments in 79 buildings. These apartment buildings are mostly standard 5-story circa 1950, and total heating space is 117,000 m2 (584,700 m3).

Industrial load was 7.9 MW in 1990 and 1991, and 7.2 MW in 1992-93, consisting of 40 enterprises containing 150,000 m3 of space. Other loads total 3.9 MW, for a total load in 1992 of 29.5 MW.

The efficiency of the oil boiler is around 80%, and the losses in distribution pipelines can run as high as 10-20% of heat production. According to Estonian norms, the lowest mean 5-days outdoor temperature of a typical year in Valga in -22 degC. By Estonian norms for Valga, the heating season lasts 220 days and average outdoor temperature during heating season is -1.5 degC. In 1990 the plant consumed 9100 tons of heavy oil and produced 72,700 MWh of heat. In 1991 these figures were about the same: 9200 tons and 72,600 MWh. But in 1992 production dropped to 47,500 MWh from 5500 tons of oil.

With the new wood boiler, the plant estimates annual consumption of wood chips to be 30,000 m3. This would mean that wood would supply 32,000 MWh of the total annual heat production, assuming an 80% boiler efficiency.

Economic Evaluation

Total cost of the conversion, including equipment, installation, the wood storage building, and wood chipper, was estimated at 5.2 to 5.7 million EEK (including 18% VAT and 18% import taxes and customs fees), or about $450,000. This translates into roughly 860 to 950 EEK/KW. About two-thirds of this is foreign cost and one-third domestic cost. Of the domestic cost, the plant estimates this is 60-70% materials, 10-20% labor, 10% transport costs, and the rest miscellaneous and administrative overhead.

The cost of oil delivered on-site is about 1000 EEK/ton, including 18% VAT and transport costs using their own trucks from approximately 15-km away. Preliminary contracts for wood chips show a potential price of 55 EEK/m3 delivered.

The plant charges 258 EEK/MWh of heat. There are no plans to lower this price in the future due to lower fuel costs, as the plant has several loans it must pay back in the future.

Assuming that the 6-MW wood boiler will provide half of all the annual energy supplied by the plant, total annual oil consumption of 7000 tons/year (between the levels of 1991 and 1992; a low income-growth scenario, but higher than 1992 due to the mildness of that winter), total heat production of 64,000 MWh/year (half of this corresponds to 30,000-m3 of wood chips), boiler efficiencies of 80%, no load growth, and stable prices for oil and wood chips, the simple payback time can be calculated as:

Estimated savings based upon fuel costs:
= (3500 t oil/year)(1000 EEK/t) - (30,000 m3 wood chips/year)(55 EEK/m3)
= 1.8 million EEK/year

Estimated savings based upon heat energy:
= (32,000 MWh/year from wood)(1/0.80)(90 EEK/MWh oil - 45 EEK/MWh wood)
= 1.8 million EEK/year

With a total cost of 5.4 million EEK, the simple payback time is 3 years.

Wood Fuel

The plant has a preliminary 3-year contract with a sawmill for 30,000 m3 of wood chips per year. Right now the sawmill sends its waste to a factory that makes particle board and to another wood-chip fired boiler in Parnu. The moisture content of this wood is approximately the same as standing timber, 50-55%. The plant also has plans to purchase a mobile wood chipper and harvest its own wood chips in the forest from clearings, branches, and tops that it would collect itself in the forest. According to the plant, such harvesting can be done free of charge and the only cost of the wood is the labor and transport costs and the mobile wood chipper, with no fee necessary to the forest district.

The plant is exploring other sources of wood, for example buying reject logs from this same saw mill at 15 EEK/chipped-m3 (35 EEK/solid-m3) plus transportation and chipping costs.

Environmental Evaluation

The environmental effect of the project was calculated by AF Energikonsult Syd AB using test results from January 13-14, 1994. The flue gas emissions are:

		Oil fired Boiler	Wood Fired Boiler
Average heat output	MW	8.6	5.0
CO2	%	5.3	10.0
CO	ppm	24	>1000
NOx	mg/MJ	120	48
S	mg/MJ	321	<4.1
Dust	mg/MJ	31.8	31

Based on the results of these tests, the reduction of environmental effects in converting from oil to wood is:

		Oil Fired Boiler	Wood Fired Boiler	Reduction
Average heat output	MW	5.0	5.0	
Annual heat output	GWh	25	25	
CO2	t/y	7650	11360	(*)
S	t/y	33.6	0.4	33.2
Dust	t/y	3.3	3.2	0.1
NOx	t/y	12.6	5.0	7.6

(*) The reduction of CO2 emissions is assumed to be the entire quantity of emissions from burning the oil; sustainable forest growth and harvesting must therefore be assumed.

Comparison of these data with the preliminary estimate made by NUTEK shows that real reduction of emissions is less than estimated. There are two main reasons for this: (1) Real sulphur content in the heavy oil (1.3%) was lower than it was at time of estimation; and (2) Annual heat output assumed in test calculation and in estimation is different.

Institutional Issues

Valga Soojus is a private company that is controlled by the municipality. There is some question as to whether ownership of the plant may revert directly to the municipality in the future. If financial problems arise in the future, the municipality may have to "bail out" the plant from its difficulties.

Indebtedness of the plant may be an issue in the performance of the loan in the future. The plant is owed 1.5 million EEK in unpaid heating bills by its customers, and further it owes money to the World Bank as part of an oil loan and 500,000 EEK to the EBRD for district-heating network improvements.

Sources of Evidence

Interviews with Professor and project advisor, Tallinn Technical University (10/28/93, 1/17/94, 3/10/94)

Interviews with technical advisors, NUTEK (11/18/93, 5/11/94, 5/17/94, 9/7/94)

Interviews with Professor and project advisor, Chalmers University, Sweden (11/16/93, 2/2/94)

Interview with Swedish technical advisor, Estonian State Energy Department (8/20/93)

Interviews with EU PHARE advisor, Estonian State Energy Department (8/4/93, 11/15/93, 11/23/93, 3/16/94)

Interview with Manager of Boiler Conversions, Estonian State Energy Department (5/10/94)

Site visits to Valga, Estonia, 10/23/93 and 12/9/93

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CASE STUDY: OECD MEMBER-GOVERNMENT PROGRAMS IN RUSSIA

In May 1994 in Paris the International Energy Agency held a workshop to review the experience to-date with energy efficiency assistance programs for the former Soviet Union by OECD member countries. This case study description presents the experience from several of these programs that are not described elsewhere in this dissertation, as reported to the seminar by government representatives.

One important conclusion from this workshop was that identification of good project proposals was difficult. The IEA (1994a) said that

> In each [recipient country] different ministries and institutions represent the recipient side. Coordination by the recipient country between different groups does not seem to exist....Scouting for the best grass-roots level project proposals, particularly in Russia, remains a continuing concern of Western donors. In the future it might become easier as Moscow authorities encourage Western donors to make direct contact with local and regional administrations.
>
> The problem is that the enterprises where projects are implemented are preselected by Eastern authorities from a number of privileged geographical, political, and technological subsets.... For lack of a broader information base on Russia's energy using enterprises and institutions, Western donors often make first contacts with potential recipients in international seminars. (p.4-5)

Specific Member Country Assistance Programs and Experience

Canada. Canadian technical assistance to the former Soviet Union was provided with three objectives: to promote transition to market-based economies, to support democratic development, and to increase Canadian trade and investment links with the region. Canada's major program with respect to energy efficiency was an electric utility manager training program. This training included the concepts of integrated resources planning and demand-side management, and environmental analysis in planning. Also financed were various consultancy reports about legislation and regulation in the energy sector, and about institutional restructuring in energy supply industries. Planned are technical and consulting assistance in oil and gas resource management and continued training of energy sector managers.

Denmark. Danish programs in Estonia and Russia have been fully described in the accompanying case studies (Danish Building-Heating-System and Danish Government Boiler Conversion case studies).

Finland. The Energy Department of the Ministry of Trade and Industry has been responsible for Finland's energy sector aid to Russia. Two significant projects financed through this assistance were an Energy Plan for Karelia study, and energy efficiency feasibility studies for nine different industrial and energy utility plants in Russia. IVO International participated in these studies. The Energy Plan for Karelia led to more detailed feasibility plans for commercial investments by IVO International (see IVO International case study).

Italy. An Italian consortium was engaged in a $2 billion gas pipeline repair project with Gazprom that was to improve the efficiency of gas transmission from Siberia and reduce pipeline loses. Private commercial Western European banks put up the capital. Payback of the loan was supposed to be financed with the gas saved as a result of the reduced leakage.

The Netherlands. In 1992-93, assistance was provided for a few energy efficiency projects, including energy efficiency in a Moscow electric power plant, rehabilitation of oil and gas fields, and a study of gas supply rehabilitation.

Sweden. Swedish aid has been focused on the Baltic states, and is described in the NUTEK Biomass-Fueled Boiler Conversion and the Building-Energy-Efficiency case studies.

United Kingdom. Aid from the United Kingdom was targeted towards industrial audit programs and an energy efficiency training program, which trained Russians in basic energy-efficiency technologies and analysis methods, including economic and financial analysis. The training also included management and consulting training, so that graduates of the program could go out and start their own private energy-service companies in Russia if they wished. Trainees spent six months in the United Kingdom working within British energy firms and learned by working on real projects.

United States. USAID initiatives in Russia and Estonia are described in the USAID case study.

United Nations Economic Commission for Europe. The Energy Efficiency 2000 program is described in the United Nations ECE case study.

European Union. The THERMIE and TACIS programs are described in the European Union case study.

EBRD. The EBRD said that it cannot lend money to Russia for energy efficiency because:

> According to present lending rules investment projects proposed to the bank with the principle aim of increasing energy efficiency are not bankable. As distinct from supply side projects there is no collateral cashflow to back up loans. Sovereign guarantees often can not be given either. Preparation and execution of such projects is very labor intensive and can not be carried out by bank staff. Finally, the ownership question of enterprises and municipal housing is unclear and does not allow any recourse on defaulting debtors. (IEA 1994a, p.2)

Sources of Evidence

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CASE STUDY: UKRAINIAN GOVERNMENT WIND TURBINE PRODUCTION

The Ukrainian design bureau Yuzhoye had developed by 1993 a production version of its own 200-kW turbine, of entirely Ukrainian design and manufacture. By 1993, four turbines had been manufactured under contract with the Ministry of Fuel and Energy of Ukraine and were operating in a site in north-eastern Crimea since 1993. The contract was for 24 turbines and serial production was planned for 1994 with a production capacity of 60 turbines per year. The cost of this turbine was given as $70,000, or about $350/kW, which is about a third of the cost of wind turbines in the West (of course quality is a question). At this price wind could be competitive with Ukraine's cost for oil and gas-fired electricity production.

The fact that Ukraine has been developing its own domestic wind-turbine technology may have helped the successful initiation of the Windenergo joint venture (see Windenergo case study). Government officials may have seen this as a way to "diffuse" a foreign technology into Ukraine's domestic effort, and/or spur this domestic effort through greater competition.

The weight of the Ukrainian AVE-250 is about 65 kg/kW, about double that of the Kenetech Windpower 56-100 (33 kg/kW) on a capacity-basis. A comparison of the Yuzhoye turbine and the Kenetech Windpower turbine is shown below:

Yuzhoye AVE-250 compared to Kenetech Windpower 56-100

	AVE-250	56-100
Capacity (kW)	200	110
Wind speed at capacity (m/sec)	13.6	12.0
Working speeds (m/sec)	4.5-25	5-22
Blade diameter (m)	25	18
Turbine weight (tons; less tower)	13.0	3.6
Service life (years)	20	30

Sources of Evidence

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CASE STUDY: UNITED NATIONS ECE ENERGY EFFICIENCY 2000 PROJECT

Summary: The first phase of this program took place from 1991-1993 with the objective of enhancing trade and cooperation in energy efficient technologies and energy demand management practices between former centrally planned economies and the market economies. This objective was to be achieved through enhancing business contacts at trade fair events and meetings and providing participants with a range of information services on policies, technologies, international financing and technical assistance programs. The program has also supported the establishment of domestically-financed energy efficiency demonstration zones as incubators for innovative policies to promote efficiency. In Russia by the end of 1993 there were about six energy efficiency demonstration zones established, mostly in or near the Moscow region. Most of these zones had ambitious plans for projects they would like to conduct with foreign partnership. Some believed that these plans would never happen, or that energy efficiency in these zones is a thin veil for other activities like real estate development of "model villages" affordable only by the wealthy, and industrial renovation. No actual foreign investments in any of these zones had occurred by the end of 1994 except for the Honeywell Tushino project (Honeywell case study). The main results of the program have come from the increased contacts, publications, information exchange, and analysis and identification of technologies that have occurred.

The following is an overall description of the project, from a United Nations press release (United Nations 1993):

> The objective of the United Nations/ECE Energy Efficiency 2000 Project is to enhance trade and cooperation in energy efficient, environmentally sound technologies and energy demand management practices between former centrally planned economies and the market economies. This is achieved through enhancing business contact at trade fair events and meetings and providing participants with a range of information services on policies, technologies, international financing and technical assistance programs.
>
> The three-year Project established by the Ministerial Declaration on Sustainable Development, made at Bergen (Norway) in May 1990, had by 1994 held 30 meetings and trade fair events attended by 2600 participants from 38 United Nations/ECE member states in 221 locations throughout Europe with some 460 participants from central and eastern Europe supported by the Project's Trust Fund. Experts have benefitted from over 68,000 m3 of exhibition space devoted to energy efficient technology at the trade fairs.
>
> A city-scale project, or an energy efficiency demonstration enterprise zone is a town, district, or limited area, in which favorable conditions in every sphere are established to stimulate enterprise and initiative in market approaches to energy efficiency. Such urban or regional economic development zones have already been successfully established in Western countries. On a city wide scale, the combined effect of energy-efficient technology; energy pricing policy; favorable tariff structures; advisory services; information campaigns; metering; monitoring and controls; energy audits; tax incentives, grants and government-guaranteed loan schemes; international technical assistance and trade development programs are demonstrated. The intention is to replicate successful measures nationally, once proven on a limited scale.

The crucial question of financing energy-efficiency improvements had already been the subject of recommendations of a United Nations/ECE ad hoc meeting of experts to the Russian government. Projects of the size and scope proposed in the demonstration zones need to be based on a solid financial foundation. Energy-efficiency improvements can enhance living conditions while using less energy in buildings within a demonstration zone, thus freeing fuels for export. Experts calculate that energy savings could be very large and certifiable by an independent third party.

During the initial phases of cooperation, investments for Western energy efficiency technology could be financed by loans from the World Bank or the European Bank for Reconstruction and Development. These loans could be repaid by the convertible currency earnings from the export of gas or oil to the level of fuel savings certifiably achieved with the demonstration zones.

Government policy reforms and commercial activity are closely linked in the Demonstration Zones. New policy measures for energy efficiency adopted by the Government of the Russian Federation, reflecting recommendations of the United Nations/ECE ad hoc meeting, can establish the conditions needed for foreign companies to introduce energy efficient technology and management practices in Moscow. On the other hand, this participation of foreign businesses can help these new policy measures to become effective more quickly than would be possible otherwise.

A decree in April 1993 by Prime Minister Chernomyrdin established Energy Efficiency Demonstration zones in Moscow as part of the Energy Efficiency 2000 project sponsored by the United Nations Economic Commission for Europe. The decision provides for the repayment of Western energy-efficiency investment in these zones by the export of 50% of the energy savings achieved in a Demonstration Zone within the framework of the United Nations Energy Efficiency 2000 project. Yet by the end of 1994, no specific operational mechanisms or procedures were adopted to implement this decree. While the ultimate actions resulting from this decree were still entirely unclear, the United Nations Energy Efficiency 2000 Project literature has hailed this decree as evidence that the project is achieving its intended purpose: to stimulate innovative policy and economic instruments and mechanisms for encouraging direct foreign investment of energy-efficiency technologies.

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CASE STUDY: USAID ENERGY-EFFICIENCY PROGRAMS IN RUSSIA AND ESTONIA

The four most significant USAID programs related to energy efficiency from 1992-1994 are described here: the Energy Efficiency and Market Reform Project (in Russia), the Emergency Energy Assistance Project (in Estonia), the Commodity Import Program (in Russia), and the Joint Electricity Options Study (in Russia). In addition, USAID helped fund the EPA/NRDC IRP Project (see EPA/NRDC IRP case study).

Summary of USAID Energy Efficiency and Market Reform Project in Russia: In 1992-93, U.S. consultants performed audits in 2 district-heating systems in Russia and 1 system in each of Belarus, Ukraine, and Armenia. They developed recommendations, produced audit reports, and then supplied equipment and training for better energy management. The equipment, about $50,000 worth to each system, included computers; infrared, ultrasonic, and thermocouple measurement and leak detection systems; residential building equipment including heat meters, weatherstripping, insulation, thermostatic valves; and combustion analyzers. Also included in the projects were policy reports on energy pricing and institutional analysis. This project was expanded in 1992 to $45 million and then to $67 million, and then expanded again to $250 million in 1993. The additions included more efficiency components, nuclear power plant safety, and the coal, gas, oil and electricity sectors.

Summary of USAID Emergency Energy Assistance in Estonia: Some of the earliest audits conducted in Estonia were performed by USAID in 1991-1992. The purpose of the program was to combine both technical and management measures for energy savings in industry. Four audits were conducted by a U.S. consulting firm to analyze energy consumption and recommend technical and management changes to improve efficiency. These four were a chemical plant, a fiberboard plant, a boiler house, and a ship repair yard. The audits were followed by provision of approximately $30,000 worth of equipment to each plant consisting of a computer, boiler-tuning and monitoring equipment, combustion analyzers, infrared pyrometers, and other equipment. Training was provided for the use of this equipment. The plant audits all recommended similar measures: computers with spreadsheets to better manage and keep track of energy, combustion analyzers to better tune boilers, and the installation of submeters for fuel inputs. According to the audit report calculations and assumptions, simple payback times for these measures are typically less than one year. The results were mixed; one plant said new economic and management incentives were required before it could use the equipment or implement any of the recommendations, while another was making changes in an "entrepreneurial spirit."

Energy Efficiency and Market Reform Project Background

In 1992, USAID began an energy efficiency project in Russia and other former Soviet republics titled "Energy Efficiency and Market Reform." The project was originally funding at $1.8 million for Fiscal Year 1992. The project purpose was "to improve the efficiency of district-heating systems and to promote energy price reforms" (USAID 1992a, tab A, p.1) Following is the original project purpose and description from USAID (USAID 1992a, tab A, p.1):

> The United States has recognized the independent states of Russia, Belarus, Ukraine, Armenia, Kazakhstan, and Kyrgyzstan, which are part of the new Commonwealth of Independent States. All these states face serious problems this winter in meeting energy needs due to the

disruption of economic and trading relations and the abolishment of the central Soviet government. Power plants, factories and residential energy consumers are experiencing reduced energy supplies due to declining energy production, the switch to foreign currency payments for energy product trade between republics, the collapse of centralized distribution-systems, and the hoarding of supplies in expectation of price increases. Reports indicate that problems with central district-heating systems in a number of cities are resulting in lack of heat for substantial numbers of residential consumers.

This project will focus on two immediate needs: (1) improving the performance of district-heating plants/systems serving residential and industrial consumers in major urban centers; (2) providing technical assistance and training on energy price and market reform, as part of a coordinated effort with the World Bank.

Based on experience under the Emergency Energy Program in Eastern Europe, quick-impact, low-cost energy savings are possible in district-heating plants/systems that can reduce energy consumption. For example, estimated low-cost savings in the Bucharest-South Combined Heat and Power Plant were substantial (nearly 5 million USD equivalent from an equipment investment of 60,000 USD) and had paybacks of less than 3 months. Longer-term measures were also identified that might be included in World Bank or other lending programs.

The project will provide technical assistance and low-cost equipment to improve the performance and efficiency of district-heating plant/systems in all six states and to support the World Bank and International Monetary Fund in promoting rational price and market reforms, especially in Russia.

In District-heating plants, the following activities will be carried out:

1. Reconnaissance to identify district-heating plants in each of the six states and to work out arrangements, including subcontracting for local technical and logistical support;

2. Conduct of energy audits and training in the plants;

3. Procurement of energy efficient equipment;

4. Assistance in implementation of equipment and audit recommendations;

5. Analysis of policy, institutional and investment decision-making processes affecting performance and efficiency of district-heating plants;

6. Wrap-up seminar for management and technical staff.

Regarding energy price reform, the following activities will be carried out in close cooperation with the World Bank, which is beginning pricing discussions in Russia, Belarus, and Kazakhstan. Due to budgetary limitations, the main focus of this initial effort will be on price reform in Russia so as to support fully the World Bank and also because of the critical importance of pricing to production and exports/budgetary revenues as well as efficiency improvement in Russia, which is the predominant producer and consumer of oil and gas.

(1) Key issues in energy price reform will be identified. AID consultants will participate in World Bank missions or follow-up work to implement terms of reference developed by field teams;

(2) A training course on energy/petroleum pricing issues will be developed and carried out for key economic and energy officials;

(3) Technical assistance will be provided to examine such factors as the foreign exchange, end-use consumption, revenue, capital investment and environmental impacts of different energy and energy price scenarios;

(4) Results of these analysis will be reviewed in a workshop and recommendations will be formulated on a program of action, including short and longer-terms studies of critical importance to national economic policy decisions and World Bank energy sector investment planning.

Secretary Baker's December 12, 1991 Princeton Speech highlighted the shortages of food, medicine and energy the former Soviet republic are facing this winter. And the pledged to provide help in addressing these problems and to work with US Businesses to promote economic reform and the involvement of the private sector.

Three sole-source contracts will be concluded with three of the United States private sector companies that have been implementing the Emergency Energy Project [in Eastern Europe, including Estonia]: Resource Management Associates; RCG/Hagler-Bailey; and International Resources Group.

The project was supposed to "support the Energy Roundtable concept which brings together officials from the United States private sector with officials and business people from the CIS states." Thus the idea was to promote business contacts and hopefully catalyze private-sector initiatives as well.

In an interagency government review of this project prior to its approval, the price reform component was questioned, since the International Monetary Fund and the World Bank had the "lead on policy-based lending." But a USAID official defended the price reform component: "Price reform had to be part of this project to insure its success."

There followed four amendments to the project:

Amendment #1, 5/21/92. Increased budget from $1.8 million to $45 million and extended completion date to early 1996. In addition to the two components from earlier, energy pricing and policy and institutional reform and energy-efficiency improvements, the amendment added nuclear power plant safety and regulation, and coal, gas, oil, and electricity production and delivery.

Amendment #2, 8/7/92. Increased budget from $45 million to $67 million to cover increased work in the nuclear safety area.

Amendment #3, 10/16/92. To straighten out interagency problems with DOE and NRC.

Amendment #4, 4/14/93. Increased budget from $67 million to $250 million, and began to plan for significant expenditures in fiscal years 1993, 1994, and 1995.

Audits and Equipment in Kostroma and Yekaterinburg, Russia

As part of the energy efficiency and market reform project, USAID-financed U.S. consultants conducted brief audits of the district-heating systems in two Russian cities, Kostroma and Yekaterinburg (six days in Kostroma and ten days in Yekaterinburg). The audits were followed with audit reports (in English only) with recommendations for specific energy-efficiency measures, and with provision of monitoring, measurement, and tune-up equipment to the district-heating companies in these cities. This process took place from early 1992 until the end of 1993.

The budget of this project illustrates how the majority of the funding went for consulting fees to U.S. consultants. Of the original $1.8 million allocated in 1992, $1.1 million was for technical assistance (U.S. consultants), $0.3 million was for U.S. supplied equipment, and $0.36 million was for pricing policy studies, also by U.S. consultants. The Russian component of the project was $550,000, for RCG/Hagler-Baily, of which $40,000 was allocated for domestic Russian consultants and translators. This made the domestic content of the Russian project about 7%. The RCG Budget was split into $250,000 for district-heating audits (including $50,000 for equipment and $20,000 for local subcontractor/translators), and $300,000 for energy pricing studies and workshops (including $20,000 for local subcontractors/translators).

RCG deliverables were plant audit reports for each city, a policy and institutional analysis report, project plan and trip reports, an Energy Pricing Methodologies and Issues Report, Terms of Reference for a detailed energy pricing study, and Energy Pricing Workshops. The plant audit reports gave short-term energy-efficiency measures and paybacks, implementation priorities and plan, equipment needs, training requirements, capital investment needs, and management improvements. A policy and institutional analysis report provided an analysis of the policy and institutional factors (including financial institutions) influencing energy-efficiency investment decision-making.

RCG was expected to: (a) make site visits and identify target plants; (b) prepare implementation plans and subcontract for local technical and logistical support; (c) conduct energy audits and training in the target plants; (d) procure energy-efficiency equipment; (e) assist in implementing equipment and audit recommendations; (f) analyze policy, institutional, and investment decision-making processes affecting performance and efficiency of district-heating plants; and (g) conduct a wrap-up seminar for management and technical staff.

Approximately $50,000 worth of energy-efficiency equipment was supplied to each city. This equipment included computers; infrared, ultrasonic, and thermocouple measurement and leak detection systems; residential building equipment including heat meters, weatherstripping, insulation, thermostatic valves; and combustion analyzers.

The main recommendations from these audit reports were similar (in fact the language, format, and specific numbers were all practically identical for the two reports). Short-term and medium-term energy efficiency potentials were assessed:

	Kostroma		Yekaterinburg	
	Short term	Med. term	Short term	Med.term
Heat generation	0-1%	0-1%	0-1%	0-1%
Heat distribution	1-3%	2-10%	1-2%	2-5%

Industrial heat use	5-10%	10-20%	5-10%	10-20%
Institutional heat use	5-10%	10-20%	5-10%	10-20%
Residential heat use	5-10%	15-30%	5-10%	15-30%

Specific priority measures and their associated energy savings were identified as:

Short Term, Low-cost: Optimize Operations Management

0.2% Improve control of supply temperature: modulate on hourly basis instead of every 6-8 hours

5% Improve control supply temperature -- optimize the "grafik" based on trial and error procedure

0.5% Improve combustion efficiency in small boilerhouses through proper boiler tuning

0.1% Improve combustion efficiency in heat and power stations through proper boiler tuning

0.3% Improve control of water quality in steam boilers

Short Term, Low-cost: Improve the Standard of Maintenance

10% Test, balance, and clean heat exchangers. Investigate temperature drops and state of flow in piping systems in buildings, and repair as indicated.

5% Plug leaks in windows and install weatherstripping.

1% Use IR scanner to detect excessive heat losses from boilers and piping, and repair insulation as indicated

Medium Term: Metering, Controls, and Tariff Designs

2% Install heat metering at key network points and develop a loss-tracking system

2% Install building-level heat metering and convert to building-consumption-based billing

5% Install evaporative heat meters in individual apartments and convert to individual consumption-based billing

5% Install thermostatic radiator valves in individual apartments

1% Upgrade ability to provide energy services -- organize energy audit service firms and provide them with instruments

1% Upgrade awareness of energy efficiency by organizing education and training programs

In June 1993 there was a series of conferences and exhibitions as part of the project, in Moscow, St. Petersburg, Kostroma, and Yekaterinburg. In Moscow, a 2-1/2 day conference along with an exhibition of U.S. companies displaying their products discussed "how to do business in Russia" for the U.S. companies. The second day was designed (1) to present USAID technical assistance program results, and (2) to provide a forum for business cooperation between U.S. companies and Russian organizations in the energy area. This conference was essentially a forum for Americans by

Americans. The speakers in Moscow included a total of five Russians and 23 Americans, and a panel on "What Next for Russia in Energy Efficiency" included 4 Russians and 8 Americans. The time allocated to project results was 10 minutes for Kostroma and 10 minutes for Yekaterinburg. A similar pattern was repeated in St. Petersburg, Kostroma, and Yekaterinburg, with U.S. company exhibitions, presentations, and business meetings.

Industrial Audits and Equipment in Estonia

Some of the earliest audits conducted in Estonia were performed by USAID under its Emergency Energy Program for Eastern and Central Europe, begun in November 1991. The purpose of the program was to combine both technical and management measures for energy savings in industry. Four audits were conducted by a U.S. consulting firm to analyze energy consumption and recommend technical and management changes to improve efficiency. These four were a chemical plant, a fiberboard plant, a boiler house, and a ship repair yard. The audits were followed by provision of approximately $30,000 worth of equipment to each plant consisting of a computer, boiler-tuning and monitoring equipment, combustion analyzers, infrared pyrometers, and other equipment. Training was provided for the use of this equipment.

The USAID projects were designed to train local people, to include participation of local firms, and to build indigenous capacity. This took the form of involving two local engineering consulting firms, training plant personnel, and additional equipment and training for individuals from Tallinn Technical University. The University was reportedly involved in conducting one-day audits of different enterprises in Estonia and providing its equipment for rent.

The plant audits all recommended similar measures: computers with spreadsheets to better manage and keep track of energy in the plant, combustion analyzers to better tune boilers, and the installation of submeters for fuel inputs. According to the audit report calculations and assumptions, simple payback times for these measures are typically less than one year. Expected energy savings through "better energy management" is given as 5-10% (although only a 1% savings figure is used for calculating payback times). Other measures include better boiler tuning (1-5% savings), better heat recovery (2-7% savings), installing metering to better inform management (1-2% savings), and substitution of electric heating for steam heating. In total, a reduction of 5-20% of energy consumption was deemed feasible at a minimal cost.

In late 1992, the results from these programs were discussed in a seminar. The main changes reported by the Fosforiit plant involved a cleaner, better lit workplace and some equipment repairs and maintenance. It was reported that new laws and management incentives were required before any more specific energy-saving activities could be conducted. No specific energy savings were reported, but this is not surprising. The implementation of management changes and boiler-tuning recommendations is problematic in Estonia for well-known reasons. Where enterprises are still state-owned, there is less incentive to actively reduce costs and energy consumption. In general, energy efficiency gains from boiler monitoring and tuning requires constant (daily and weekly) vigilance to maintain peak operation. Energy consumption can easily revert to previous conditions in a matter of days or weeks without this vigilance. And management attention and motivation is required to maintain this vigilance. In state-owned or even privatized enterprises that are struggling simply to stay solvent, this attention and motivation can be lacking or preempted by more pressing concerns.

The most successful of the four plants seems to have been Baltic Ship Repairs, and this could be attributed to an "entrepreneurial spirit" noted among its management. Baltic Ship Repairs reported that replacement of central heating with electric heaters supplied by the project resulted in significant savings, and more efficient fuel combustion resulted in a 6-7% increase in combustion efficiency and a 2% decrease in loses. One part of the Baltic Ship Repairs improvements also demonstrates the care that must taken in considering local conditions. Fuel oil flow meters supplied to the plant by USAID were never installed because the plant feared problems using these meters with Russian-origin mazut (heavy fuel oil), which contains high levels of particulates and thus could more easily clog meters.

Power Sector Reform and Restructuring

While not directly related to energy efficiency, USAID consultants have also been supporting power sector restructuring and reform in Russia. But this effort was been criticized on several grounds. First, the consultants were working only with RAO "EES Rossii," the monopoly, privatized, national-level electric power utility, and not with members of the government. Second, they have been actually helping to maintain the status quo and bolster the power of RAO "EES Rossii," proposing only long-term ideal solutions, rather than shorter term changes. In this sense they were helping to preserve the unregulated, monopoly, powerful status of RAO "EES Rossii." Thirdly, they have duplicated serious and detailed efforts by EU-funded consultants to do exactly the same work in power sector reform and restructuring. The EU consultants started this work much earlier than USAID, but their effort appeared to have gone unnoticed by USAID consultants.

Commodity Import Program

In 1994 USAID administered its Commodity Import Program, which was a $90 million grant program to the Russian government to assist with energy efficiency and environmental quality. The program was designed to target natural gas transmission, distribution and use; oil production; district-heating systems; power generation, transmission, and use; environmental protection; and coal mining. The grant money was exclusively for purchase of U.S. equipment. Equipment was offered free to government agencies or with 70% cost sharing to Russian commercial enterprises. The grant included equipment, spare parts, freight, insurance during shipment, supervision of installation by the supplier, and training. Customs and import duties were not covered, nor was installation by domestic enterprises. Thus this program had virtually zero percent domestic content, as 100% of USAID money went to American companies and consultants.

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CASE STUDY: WINDENERGO WIND TURBINE JOINT VENTURE IN UKRAINE

Summary: This case study is the most significant example of industrial conversion for renewable-energy technologies to-date in the former Soviet Union. Windenergo is a joint venture established in 1992 between Kenetech Windpower (in 1992 it was called US Windpower), Putnam Hayes and Bartlett, the Ukrainian Ministry of Fuel and Power, and Crimenergo, the Crimean electric utility. Windenergo signed a contract with Crimenergo for 500 MW of wind turbines to be installed in the Crimea by 1995. Windenergo licensed Kenetech Windpower's 56-100 110-kW wind turbine, invested substantial effort in modifying the turbine design to accommodate Ukrainian/Soviet technical standards and materials, and began production of this turbine in a group of over 20 Ukrainian factories (each producing a different component), some of them former defence-related plants. By early 1994, 5 Ukrainian-produced turbines had been installed, and production capacity reached 5-7 turbines per month. Windenergo's selling price for the machine was $30,000, less than a third of the Western price for the "Western" version of the same machine. Estimated electricity cost from the Windenergo turbine is 2.3 cents/kWh, based upon a number of assumptions which are unproven in Ukrainian conditions. By one estimate, conventional electricity production costs in Ukraine were 2.8 cents/kWh on average for imported fuels in 1994. Thus the Ukrainian government has become quite supportive of wind power, and approved a 0.7% tax on electricity sales to help finance defence conversion, environmental projects, and wind turbines.

Project Description

A very significant example of industrial conversion for renewable-energy technologies was the creation of a joint venture in Ukraine, called Windenergo, by the Ukrainian government, Kenetech Windpower, and Putnam, Hayes, and Bartlett in 1993 to develop a wind-turbine manufacturing capacity in Ukrainian factories. Initially a 100-kW Kenetech Windpower turbine was licensed to Windenergo and technology-transfer activities proceeded throughout 1993 and 1994. Production was to be sold to the Crimean electric utility, Crimenergo. The contract between Windenergo and Crimenergo originally called for 500 MW of windturbines to be manufactured in Ukrainian factories and installed in the Crimea by 1995, using Kenetech Windpower technology. Slower project start-up resulted in projections shifting to only 50 MW by that time.

The bureaucracy and approvals for this project were tremendous. In all, 127 separate signatures were required for approval. The project was discussed and approved at the Inter-Ministerial Commission on Allocation of Productive Forces in Ukraine. Local farmers at the Kirov collective farm near the proposed site were contacted, several meetings were held, and their support was obtained. Support was also obtained from the Novoozerninsk and Veselkovsk settlement councils near the proposed wind-farm site in the Crimea.

Windenergo received a license from Kenetech Windpower to manufacture 110-kW turbines. But the "Ukrainian machine" required a lot of work to translate all the Kenetech Windpower documents and to apply Soviet/Ukrainian technical standards to come up with a "Ukrainian design" that could be produced in Ukrainian enterprises. In late 1992, 50 of the best industrial enterprises in Ukraine were gathered together and the turbine was divided into 22 different components, such that each could be produced in a single enterprise. But they tried to have each component produced in actuality by 2 or even 3 different enterprises so as not to be tied to sole-sources. Not all enterprises could meet the quality requirements.

Components for the turbines are produced all over Ukraine: the towers are produced at the Donetsk high voltage tower plant; the generators (synchronous) are produced at the Novokohovka electric power machinery plant of the Ministry of Machine Building; the reduction gears are produced at the Kramatorsk machine building production association of the Ministry of Machine Building. Final construction of all component parts takes place at the Pavlograd machine works.

According to the director of Windenergo, licensing is the only way to go at the present time. Because of the difficult economic situation and lack of capital, a licensed machine is the answer. Its a good way for military factories to convert, provided they can make the grade of the required quality. "Now we are poor and have no money, so we have to produce a licensed machine -- we just can't do it on our own with our technology anymore, like we could have 10 years ago" (Wind Power in Russia conference, Moscow, April 28-29, 1995).

The site chosen for the Crimea wind farm was near Evpatoria, on the shore of Lake Donuzlav. This site is very favorable for wind power, with winds often 7 m/sec or more year round, and that increase up to 10-15 m/sec in the winter. There are no forests or buildings to obstruct the wind, the ground is flat, and there is no need to construct roads to or around the site. The climate is moderate, with rare snow and sleet. To demonstrate its turbines on Crimean soil, in April 1993, Kenetech Windpower provided and installed three US-built turbines on this site, leased to Crimenergo. A year later these were still running and producing power.

By April 1994, Kenetech Windpower had already invested $5 million in technology transfer, technical assistance, contracting, and operation costs of the venture. The results were that Windenergo had produced five U.S.-Ukrainian turbines, three were installed already and two were awaiting the use of a crane to put them in place. Production capacity had developed to about 5-7 turbines per month (6-8 MW/year). Intentions were to increase this capacity to 20-30 turbines per month by the end of 1994, but to do this Windenergo needed more (Ukrainian and Russian) partners; they did not think that they could reach this capacity using only Ukrainian enterprises.

The Ukrainian government approved a 0.7% tax (in 1994 it was set at only 0.2-0.3%) on electricity sales to finance defence conversion, environmental projects, and wind turbine production, although it was not clear where the money was supposed to go and who was supposed to distributes it. This tax represents a government subsidy for wind energy, and the director of Windenergo credits the approval of this tax to "education" about wind energy of government officials.

Economics: The typical selling price for the 56-100 turbine in the West would be $110,000. Windenergo's selling price is $30,000, although this may go up to $40,000. The director of Windenergo estimates an electricity production cost of 2.3 cents/kWh based upon 2000 hours/year, average wind speeds of 6 m/sec in the Lake Donuzlav region, 20 year life, 8% interest rate, 3% O&M costs, and 25% wind availability factor. This includes 2.1 cents for machine cost and 0.2 cents for the balance-of-plant. The director of Windenergo said that the average cost in Ukraine for conventional electricity production was 2.8 cents/kWh, although electricity prices were much less than this because they were subsidized by the Ukrainian government. So the cost of electricity produced by a Ukrainian-version 56-100 wind turbine appeared equivalent to the avoided production costs in Ukraine. All of this translates into a payback time of 4-5 years, the director of Windenergo maintains.

Domestic content: The five turbines produced in 1993 had 87% Ukrainian content and 13% U.S. based upon component costs.

In terms of turbine installation and maintenance in the Crimea, there are many highly qualified technical people in the region, who were formerly with the military and/or navy based there.

Sources of Evidence

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CASE STUDY: WORLD BANK ENERGY-SECTOR LENDING IN RUSSIA AND ESTONIA

Summary of Gas Sector Loan to Russia: In 1993 the World Bank proposed a $425 million loan for investments in gas distribution rehabilitation and energy efficiency in Russia. About $200 million of this would go to energy efficiency, 60% of this for district heating and power plant projects and 40% for industrial investments. As was the case with the first World Bank energy loan to Russia, the Oil Rehabilitation Project, this loan includes provisions to support market-based reforms and privatization in the gas sector. The project would take place in four cities: Volgograd, Saratov, Voronezh, and Ryazan. Technical measures include burner replacement, portable instruments for leak localization and emission control, diagnostics instrumentation, heat recovery systems, reduction of boiler air infiltration by sealing boiler tubes, automated control systems at boiler plants, and installation of control valves and BTU meters in buildings. The World Bank was considering different ways in which to distribute investment capital, including private banks and the Russian Energy Savings Fund. Projects must meet defined criteria of economic and financial feasibility, in particular a minimum of 20%-25% rate of return, and a preliminary list of viable projects was developed. Most of the gas energy-efficiency components showed internal rates of return significantly greater than 20%; one showed a 67% rate of return.

Summary of Estonia Boiler Conversion and District-Heating Loan: The World Bank in 1994 decided to fund a major ($6 million) small boiler conversion program as part of its second loan to Estonia. This loan would fund up to 100 MW of conversions from oil to wood and peat fuels at perhaps 30-40 sites. The Estonian State Energy Department and EU PHARE advisors were managing and administering the candidate project solicitations, evaluations, and selections, as well as bid preparation and awards. By early 1994 34 sites had been evaluated for feasibility and at least four projects were to be completed by the 1994-1995 winter heating season. The domestic content of the projects is supposed to be quite high, at least 50% or more, through selection of domestic Estonian firms capable of carrying out the conversions themselves. Some new boilers were to be installed using exclusively foreign firms.

Russia Gas Distribution Loan

In 1993 the World Bank proposed a $425 million loan for investments in gas distribution rehabilitation and energy efficiency in Russia. The proposed project would fund specific investments with the objectives of (i) freeing up energy for exports by increasing domestic energy-use efficiency; (ii) decreasing the cost of gas supply; (iii) increasing the safety of the operation of the gas networks; (iv) increasing the effectiveness of gas revenue collection by increasing the consumers' ability to pay; and (v) enhancing the global efficiency of the gas distribution utilities towards Western operation standards.

As was the case with the first World Bank energy loan to Russia, the Oil Rehabilitation Project, this second loan was designed to support market-based reforms and privatization in the gas sector. Hence the project is designed to support policy-reform initiatives, including (i) demonopolization of gas distribution; (ii) corporatization/privatization of gas distribution companies; (iii) price reform; (iv) establishment of a satisfactory legal and regulatory environment; and (v) decreased environmental impact of energy use through energy-efficiency investments.

The project would take place in four cities: Volgograd, Saratov, Voronezh, and Ryazan. One main project component (out of four) is investments in end use natural gas consumption efficiency in these cities. Targeted are district-heating systems, power plants, and the industrial sector. Projects must meet defined criteria of economic and financial feasibility. A key component would be a line of credit to be administered by the Russian Energy Savings Fund. The Fund would assist enterprises in evaluating and accessing commercial funding for energy-efficiency measures, and would administer the lending of funds.

Already completed was a preliminary project identification phase and an evaluation of potential projects based on estimated costs and energy savings. A preliminary list of viable projects was developed, using a 20% rate-of-return cut-off for investments by municipal utilities and a 25% return requirement for industry sector projects to reflect the differential risks in these ventures.

The gas conservation measures recommended include:

■ burner replacement at municipal boilers
■ portable instruments for leak localization and emission control
■ diagnostics instrumentation at power plants and municipal boilers
■ heat recovery at power plants and municipal boilers
■ reduction of air infiltration to the boilers by sealing boiler tubes
■ installation of automated control systems at boiler plants
■ installation of control valves and BTU meters in buildings

All of these projects satisfy the criterion of a 20% internal rate-of-return. The projects in this loan range from 21% to 478%, with the majority ranging from 30% to 80%. An assumption in the economic analysis is that the full value of saved gas is $40/tcm, a price level reached in 1995.

Automated controls for district heat-supply companies with heat-only boilers were proposed for Ryazan and Voronezh. In Ryazan, the investment cost is $420,000 and gas savings are estimated at 4.8 million m3/year, for an internal rate-of-return of 59%. In Voronezh, the investment cost is $308,000 and the estimated gas savings are 4 million m3/year, for an internal rate-of-return of 67% (the highest of any of the projects except instrumentation projects). Automated controls are also proposed for several combined heat-and-power plants in these cities, but these projects do not include controls for the district heat networks themselves.

The total cost of the energy-efficiency components of the loan is $206 million, including $122 million for district-heating and power-plant projects and $84 million for industrial investments. Total foreign currency component for the district-heating and power-plant projects would be $55 million, or about 45% of the total cost.

The primary criteria for project viability are:

■ an economic rate-of-return of not less than 20% (real)
■ a financial rate-of-return of not less than 10% (real)
■ demonstrated ability on the part of the ultimate borrower to finance the local portion of project costs from internally generated funds
■ demonstrated ability on the part of the borrower to repay the loan

The funds allocated in the Gas Distribution project for energy efficiency were to be channeled through an intermediary consisting of the Russian Energy Savings Fund (RESF) of the Ministry of Fuel and Energy. This fund was originally set up to collect and disperse financial resources for energy efficiency, although it remained empty as of 1994 (see Chapter 3). However, because of concerns over political manipulation and bureaucratic influences, the World Bank decided to use this fund as an intermediary without actually giving the fund any of the capital itself. Thus the fund was supposed to solicit and evaluate project proposals from potential loan recipients, according to established criteria, and recommend funding of favorable projects to the World Bank. Because of concerns over potential political influences, corruption, and bureaucracy, the World Bank was also supposed to review the proposals itself, and retain a consultant to work with the Ministry officials to monitor the process.

Part of the training and technical assistance component of the loan is to support the RESF staff with: (i) investment appraisal (economic and financial perspectives, discounted cash flow analysis, investment criteria, etc.), (ii) financial planning and control (project financing, pro forma cash budgets, project monitoring and control), and (iii) financial accounting (pro forma financial statements). The training would both assist Fund staff in carrying out their role as an intermediary, and also provide them with skills that they could pass on to utilities and industries to assist the latter in evaluating and obtaining financing for energy-efficiency investments.

Other proposed training and technical assistance measures associated with this loan were:

- update current standards and construction procedures
- consulting support to each GDC for technical, procurement, financial management, project accounting, organizational and operating matters
- ongoing training and support of GDC with foreign twinning arrangements
- finance study of regulatory aspects of third party access to gas industry
- finance an energy pricing study

<u>Estonia District-Heating Loan</u>

As part of its district-heating loan signed in 1994, the World Bank decided to fund a major small-boiler-conversion program, for conversion of heating boilers from oil to biomass fuels. The total loan was $6 million for the boiler conversions, with standard terms (15 years, 5-year grace period, variable interest rate, which was 7.43% in June 1993). After a preliminary screening of candidate boilers, detailed investigation will determine the exact boilers. Then technical specifications will be prepared by World Bank consultants and submitted for international bidding open to both domestic and foreign suppliers. The screening process began in September 1993 and the first boiler conversions were expected to be completed by the 1994-95 heating season. This program was being managed by the Estonian State Energy Department, part of the Ministry of Economy.

Each boiler house would enter into a loan agreement with the Ministry of Finance, which would administer the loans and collect repayment. The risk of non-payment is borne by the Estonian government.

The World Bank loans typically cover the foreign exchange requirements of a project, while the local costs are covered by the recipient boiler enterprises. The Bank expects that 30-50% of the total project cost will be local.

Candidate boilers are proposed to be selected from municipal-owned and private-owned boiler plants that supply a majority of heat to other consumers, based upon technical and economic evaluation criteria:

(i) The equipment for boiler conversion will include a pre-oven, fuel storage and handling equipment, automatic fuel feeding system, automatic combustion control, fluegas cleaning, and ash handling and removal system. Boilers selected for conversion will be DKVR 10, 6.5, 4, or 2.5; Kivioli 80, E1/9, and others.

(ii) The equipment for a new boiler would be the same as for a converted boiler, with the entire boiler supplied instead of the preoven. This boiler should be 0.5 to 3.0 MW in size, and must cover up to 60% of total required boiler capacity.

(iii) The preliminary economic evaluation criteria for selecting candidate projects is based upon such standard measures as simple payback time, economic rate-of-return, net present value, and decrease in present cost of heat production.

Two groups of boilers, conversion of existing and new boilers, will be handled separately.

In addition, a stable woodchip or peat supply must be available by agreement with the local forest district or peat producers, and transport distance should not be more than 40 km.

In preparation for this loan, the World Bank initiated an environmental assessment study to examine the potential impacts of this project, mitigation actions, and develop guidelines for peat and wood use in Estonia.

An initial solicitation was made in September 1993 to municipalities around Estonia for basic proposals and data about district heat plants in those municipalities. These proposals were then screened by the World Bank and the State Energy Department (and its foreign resident-consultants). In December 1993 and January 1994, several local Estonian consulting firms, under the direction of the State Energy Department, evaluated the most promising of these proposals and wrote extensive feasibility reports that analyzed the type of equipment required. Thirty-four of these feasibility reports were prepared.

In March 1994, from these 34 feasibility reports, three boiler conversion sites and one new boiler site were selected for the initial Phase I of the project, which was to be completed by November 1994. Subsequent phases were to follow every two to three months, each phase containing six boiler conversions. The new boiler installations would follow a separate track, as their competitive bidding procedure requires stricter "international shopping" rules.

Sources of Evidence

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CASE STUDY: WORLD BANK ENTERPRISE-HOUSING DIVESTITURE LOAN

Summary: The World Bank in 1994 launched a major loan for energy efficiency in buildings in Russia. The loan's stated goal was to promote housing divestiture from those enterprises that previously had been responsible for residential buildings. The divested buildings were to be transferred to municipal governments, and energy efficiency was seen as the way to make this transfer more palatable to city governments (the buildings are a liability rather than an asset, and neither enterprises nor the city government want to be responsible for them), by reducing heating costs for the buildings (the city governments were typically paying 90-95% of the heating costs of buildings in 1994). The money was to be loaned to city governments, who would contract for building renovations and pass along the costs (minus energy savings) to tenants in the form of increases or decreases (or slower increases) in monthly heating bills. Measures were supposed to pay back in three years or less, and with 15-year loan terms the financial revenue thus generated should allow city governments to come out ahead.

In 1994 and 1995, the Russian Government and the World Bank were preparing a loan to Russia to support divestiture of residential buildings from enterprise ownership to municipal ownership, called the Enterprise-Housing Divestiture Project. In this project, various types of renovations of residential buildings will be considered to reduce the operating costs of these buildings. The primary cost reductions will be achieved by reducing consumption of heat, hot and cold water, gas and electricity. The total value of this loan could be up to $300 million. The project will take place in several cities in Russia, and up to 400,000 apartments with over 20 million square meters of floor space could be affected.

In 1995 in Russia, the true costs of utility services to residential buildings were 5 to 10 times higher than the tariffs paid by the population. For city-owned buildings, city governments had to pay the difference between the true costs and the current tariffs. These subsidies were a heavy burden on cities. Tariffs to the population were expected to rise rapidly over the next few years, and so will become a greater burden on the population as well. City acceptance of buildings that are currently enterprise-owned is easier if the costs of operating and maintaining these buildings are reduced.

The project will target space heating and hot water because these end-uses typically represent 60-70% of the current and true total costs of utility services. The project will also target electric appliances, lighting, and cold water savings, although to a lessor degree because the potential savings from these end-uses are lower. The investments in this project must reduce the costs of utility services to multi-family buildings and apartments. These investments must have a pay-back period of less than five years, and they must be acceptable to building owners and tenants. Some of the technical measures under consideration are heating controls (central heat point, building, and/or radiator thermostats); autonomous hot-water generators and boilers in buildings; insulation of attics, roofs, basements, and pipes; window caulking, sealing, and weatherstripping; hot-water optimization (low flow showerheads, recirculation strategies, faucet aerators); and ventilation control.

Several issues key to implementation of the project include building codes relevant to autonomous boilers or hot-water heaters in buildings; water quality in district-heating systems; the ability of equipment manufacturers to deliver high quantities of equipment quickly; teaming among general contractors, local labor, and domestic vendors; sustainability and lifetime of the technologies after they are installed; and cases where heating deficits mean that buildings currently do not receive adequate heat for indoor comfort.

During a workshop to introduce the project to interested Russians in Moscow in May 1995 at a professional conference of engineers for heating, ventilation, air-conditioning and building thermal physics, a question and discussion period followed the presentations. In the comments and questions by workshop participants, several issues were highlighted: (1) Radiator thermostat valves in one-pipe systems pose special technical problems. (2) Current construction norms and standards make it difficult to install gas-fired boilers and hot-water generators in buildings. (3) There already exist in Russia companies able to provide energy efficiency services and projects, and these companies should be involved in the process to ensure success. (4) Public education should be a key part of the project. (5) Relationships between the different organizations responsible for implementing the project need to be carefully considered. (6) Financial savings that result from energy savings must flow to the organization responsible for repaying the loan. (7) Foreign and domestic equipment must be certified, and there are alternative ways to organize the process of certification. (8) Experience from this project, disseminated through the mass media and other channels, will be very valuable for similar projects elsewhere in Russia.

Sources of Evidence

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ANNEX: COMMERCIAL BUSINESS ENVIRONMENT AND JOINT VENTURES SINCE PERESTROIKA

In 1992, Russia was rated 129th among 169 countries in terms of investment risks by Euromoney Journal, and in 1993 this rating slipped to 149th place, putting Russia soundly in the midst of many much poorer developing countries (Feller and Mikheyev 1994). In 1994 the rating improved to 90th place, but was still on a par with Iraq (Business and Investment in the CIS, 5/94, p.10).

But the perception by potential Western investors of a risky business climate and unstable political and economic conditions has been fueled by Western media reports, which have tended to overemphasize the more extreme situations and events and downplay the normal, strengthening business climate that surrounds the majority of economic activity (interview with director of EU Energy Center Moscow, 9/6/94). The Western perception that it is physically dangerous for Westerners in Russia is also considered exaggerated by many Western expatriots living there.

One significant factor in estimating the economic product of Russia and business activity in general is the so-called "shadow" economy outside of government purview. Transactions in this economy are not taxed, nor regulated, by any ordinary legal means. Once called the black market, this economy includes such things as wage payments to employees that are not reported to avoid taxes, enterprise profits that are not reported to avoid taxes, organized crime activities, and others. Estimates vary as to the size of this "shadow" economy. One estimate put it at 20% of total GDP at the beginning of 1993, and then 40% of total GDP at the beginning of 1994, a doubling in just one year (Business and Investment in the CIS, 3-4/94, p.7).

By 1994 there were many conflicting views about the viability of joint ventures in Russia or the desirability of entering into them on the part of Westerners. More broadly, there was widespread disagreement about the business conditions in general in Russia. Some, like Kvint (1994), a Siberian-born Russian economist, argue that the climate for international joint ventures was never better than in 1994, and Westerners should move fast to get the best deals. According to a study by Kvint, of the joint ventures attempted between 1989 and 1993, between 35% and 38% of those consummated were profitable or would become profitable. An article in the Harvard Business Review ("The Russian Investment Dilemma," May-June 1994) calls that the highest success rate in the world for new business.

According to Kvint, when foreign business ventures do fail in Russia, it is less because of the business conditions and more a function of the planning and preparation on the part of the foreign investor. This planning and preparation includes: (a) choosing the right location, keeping in mind local resources and priorities of local and regional governments and leaders, and essentially ignoring the central bureaucracies in Moscow; (b) choosing the right partner, including as detailed an examination of their financial records as possible, and determining exactly for which functions they possess licenses, and for which ones they do not; (c) understanding cultural differences, including not assuming that the Russian partners know less than the foreigners; (d) designing the deal, especially the division of initial capital investment and thus profits; (e) befriending local and regional leaders, especially working with local leaders (who hold increasing levels of power over their region as time progresses) to actively support and solve local and regional problems, and to learn about local concerns before negotiations are complete; (f) compensating employees properly, including barter payments of valuable commodities, and improved social and living conditions; and (g) anticipating shortages in materials, which may mean including necessary intermediate goods suppliers within the structure of the joint venture itself (as the successful McDonalds venture did).

In the May-June 1994 issue of Harvard Business Review ("The Russian Investment Dilemma"), many executives and academics with experience in Russia agreed with Kvint's assessments. Jean-Pierre van Rooy, the president of Otis Elevator Company, said Otis had invested $50 million and had founded a joint venture in Russia to manufacture, install, and maintain elevators. Otis sees a huge potential market for renovation of the half-million elevators in Russia. Mr. van Rooy agrees with Kvint and sees some of the other major barriers as poor commercial banking facilities and the poor condition of communication and transportation infrastructure. In the same issue, Daniel Yergin and Thane Gustafson, authors of Russia 2010 and What It Means for The World, say that Kvint's optimistic views coincide more with the "miracle" scenario in the book, which is still entirely possible, and see "capitalism, Russian style" as virtually inevitable.

In the same article, others of course also disagreed with Kvint's views. Beyond the obvious problems of political risk, time and distance from home base, and bureaucratic delays, they point out several other significant barriers to foreign investment: government protectionism, lack of a commercial legal code and weakness of contract enforcement mechanisms (which makes borrowing from Western banks on assets in Russia problematic), absence of Western-type accounting practices and standards, organized crime and corruption, and the high costs of maintaining expatriots in Russia. Others blamed the Russian government for inappropriate policies leading to high inflation, bureaucracy in allocation and granting of export rights, and inconsistent and conflicting tax codes among different branches of government and bureaucracies and regions.

One of the significant barriers to joint ventures comes from the institutional, social, and cultural dimensions of the micro-structure of Russian enterprises (lecture by Erickson, 10/14/94). In a joint venture with a Russian enterprise it may be necessary to shut down or eliminate part of the enterprise to make it profitable, and the barriers to doing this are similar to the more general problems of enterprise restructuring: the higher degree of control of the enterprise by labor rather than management, the huge resistance to change, overemployment, and extreme labor specificity which makes change difficult due to retraining costs. Actually, joint ventures through existing enterprise restructuring may not be the best path because of this problem. Rather, entirely new enterprises will need to be formed during joint venture creation or formation of wholly-owned subsidiaries (in Poland, for example, entirely new firms have led the way in changes and new production).

Statistics on joint ventures vary greatly by source. According to statistics by the Russian Ministry of Finance and the Agency for International Cooperation and Development, 12,600 businesses were registered with foreign capital from 1991 to February 1994 (1825 in 1991, 4461 in 1992, 5490 in 1993 and 835 in Jan-Feb 1994). The State Statistics Committee said $2.9 billion had been invested by foreign entities through 1993, $0.3 billion of this as portfolio investment (Business and Investment in the CIS, 5.94, p.9).

Initially, the most successful joint-venture partners were German, Finnish, and Austrian companies, whose members knew the country well and had good relationships with Soviet bureaucrats. By March 1994, of approximately 6600 joint ventures registered, 15% were American, 12% German, 6% British, 6% Italian, and 5% Australian (Business World Weekly, 9/12/94, "Foreign Investments in Russia").

According to Kvint (1994), 18,000 joint ventures existed by 1994, and a total of over $10 billion had been invested by foreign firms in these ventures. By January 1994, this included 2800 U.S. joint ventures, including big corporations like IBM, GE, Ford, Chevron, AT&T, Pepsico, and

McDonalds. About half of total value produced in joint ventures as of November 1993 was in "industry," while 4% was in "utilities and maintenance."

Siemens had 9 joint ventures by 1994, with 4 of these focused in the electric power sector (interview with the director of Mosmatic 9/9/94). Siemens sees these ventures as a "long-term foothold in Russia." One of these ventures is described in the Mosmatik case study. Another was the Interturbo joint venture in St. Petersburg with the Leningrad Metal Plant, which in early 1994 produced its first 150 MW gas turbine in a Russian factory using a Siemens design and Siemens manufacturing technology. The turbine is considered equal to Western quality and performance (Business and Investment in the CIS, 3-4/94, p.16).

Foreign portfolio investment is starting to become a significant factor, according to one investment banker (interview 9/22/94). By 1993, total direct investment in Russia amounted to $2.6 billion, while portfolio investment was only $0.3 billion. But in early 1994, portfolio investment had increased to around $0.5 billion per month. Foreign investment banks were beginning to buy shares of energy companies like RAO "EES Rossii" and Gazprom. The significance of these portfolio investments is that they can lead to management changes in enterprises under the direction of Western investors, and these management changes can lead to improvements in enterprise efficiency, including energy efficiency. In fact, one requirement for Russian companies to sell shares on the New York stock exchange is that they must allow these management changes.

ANNEX: DISTRICT-HEATING SYSTEMS IN RUSSIA

District heat plays an enormous role in Russia's energy system. In 1990, in the residential sector, heat represented 51% of all final energy consumption (Nekrasov et al 1993). In industry, this proportion was 33%, and in agriculture 16%. Over 2 billion gigacalories (Gcal) of heat was produced in 1990 for central heating systems. Another 0.6 billion Gcal was produced by autonomous boilers. Of this 2.6 billion Gcal, about 44% went to the residential and commercial consumers. This 2.6 billion Gcal of heat was produced from large combined heat-and-power plants (co-generation units), dispersed heating boilers serving individual houses, small neighborhoods or groups of buildings, large heat-only boiler plants serving entire city districts, and cogeneration and heating boilers in industrial enterprises. The fuel mix used for co-generation units was 60% natural gas, 15% fuel oil and 25% coal. For large heat-only boilers it was 55% natural gas, 22% fuel oil and 23% coal. About 80% of the Russian population is supplied with heat from centralized district-heating systems, while the remainder receive heat from autonomous building-heating-equipment. About 600 cities in Russia have combined heat-and-power cogeneration, and many more are equipped with centralized heat-only boiler plants. The number of heat-only boilers is 242,000, of which 82,000 are industrial boilers (World Bank 1992c). Nationwide, about half of district heat was produced by cogeneration plants and half by heat-only boilers.

These heat sources supply heat to buildings through extensive networks of underground pipes carrying hot water to distribution substations which then provide lower-temperature water to individual buildings and their radiators. Conflicting data on the total combined length of these pipe networks exist. Figures ranging from 50,000 km of trench length (2 x 50,000 km pipe length) to 300,000 km of trench length (2 x 300,000 km pipe length) have been mentioned. The uncertainty regarding the data reflects the fact that nearly all statistics are based on information covering the former USSR. Furthermore, it is not quite clear if the data only covers length of transmission pipes or also includes the distribution systems (World Bank 1992c).

These systems are designed as fixed flow; heat load control takes place through adjustment of supply temperature at the heat plant, usually depending only on the current outdoor temperature. The typical maximum supply temperature is 150 degC and the design value for the return temperature is 70 degC. Typical pipe networks are steel pipes in concrete ducts. Rockwool is used for insulation, and asbestos cement or bituminous canvas for the outer casing. Design pressure is typically 10 bar. In areas with elevation differences, pressure coverage is obtained through booster pumps and throttling arrangements. From the transmission network heat is supplied to substations, most containing heat exchangers. From substations on secondary lines, heat is supplied to the distribution networks with a typical supply temperature of 95-100 degC.

The typical installation at building level is single string radiator circuits. No valves exist in buildings or apartments, and accordingly the only control of room temperature is performed by opening windows. A number of systems are designed as "open systems," which means that the domestic tap water is supplied by directly taping water out of the district-heating network. Accordingly, water is replenished to the systems by feeding (treated) water into the network at the heat producing units. Heat is metered at substation level or at the production facilities. Residential consumers are charged a flat monthly rate for heat according to the floor area of their apartments. The charge for hot tap water is based on the number of inhabitants in an apartment.

While Moscow is not a typical city by any means, the structure of district-heating can serve as an illustration. Three organizations are primarily responsible for heat supply in Moscow and supply

95% of all heat within the city (Moscow Government 1993). These are Mosenergo, which supplies heat generated from 15 large combined heat-and-power plants that surround the city, Mosgorteplo, which purchases heat wholesale from Mosenergo and is responsible for heating distribution systems from the power plants up to the point of heating substations, and Mosteploenergo, which produces heat in large heat-only power plants and is also responsible for some of the distribution network. Beyond these substations, in smaller secondary distribution networks, local housing administrations are responsible for heat distribution networks up to the buildings and within the buildings themselves. Maintenance of heat systems in buildings is done by the same maintenance teams that work on building water, sewage, and other services.

Most of the heat supply (150 million Gcal annually) in Moscow comes from 15 large combined-heat-and-power (TETs) plants (combined capacity of 28,500 Gcal/hr) and 55 large heat-only boiler plants (combined capacity of 11,000 Gcal/hr; many are 400 Gcal/hr each), all supplied by natural gas. About 50-60% of the annual 30 billion m3 of gas consumed in Moscow goes to supplying these power plants. There are 7,200 substations, 3,000 km of primary distribution lines (1.0-1.2 m diameter, 8-12 mm thick), and 12,000 km of secondary distribution lines (3.5-6 mm thick) which serve 40,000 residential apartment buildings and 6,500 school and hospital buildings. A typical building constructed after 1956 has single-string radiator circuits, and in some buildings radiators have by-pass pipes installed but no control valves. Before 1956, buildings typically had double string radiator systems (World Bank 1992c).

The design of district-heating systems carries back to the era before and after World War II, and has not changed much since. Systems have become very complicated as they have been extended to serve growing cities. Complicated and inflexible systems have been developed that are difficult to control optimally. The only controls in the system are the output temperature of each heating boiler, and the flow of water through distribution substation heat exchangers. There are usually no controls on radiators in individual apartments nor even on the heat entering individual buildings. This lack of control makes it very difficult to properly distribute heat among multiple consumers. Consequently, heat is often supplied to meet the needs of the remotest (or coldest) consumers, and other consumers receive too much heat. The well-known method of heat regulation by opening windows to the outside air is a significant source of energy loss. As system heat output declines in difficult economic conditions in some regions, such "regulation" becomes no longer necessary, although the ventilation afforded by opening windows (even in the middle of winter) is very important to most Russians and is universally practiced, even if comfort is sacrificed.

Maintenance is another special problem of district-heating systems, partly because of the vastness and complexity of the systems, partly because poor quality materials were used in many systems, and partly because of the way systems are operated. Circulating water is not treated, and pipe corrosion is a major problem. Heating pipes designed to last 20-30 years may fail after only 10 years due to corrosion. Accidents and supply disruptions to these systems are thus major concerns. Necessary expenditures for maintenance are large, and add to the economic costs of district-heating as compared to other decentralized forms of heating.

Another problem in heat supply is that different technical parts of the system fall under the administration and responsibility of different organizations, and this leads to difficulties in addressing energy efficiency in an integrated fashion. For example, several different organizations may be involved in the production and distribution of heat within a common physical network of heat production stations, combined-heat-and-power plants, and distribution pipes and substations. Industrial enterprises may produce heat and supply it to the public network as well. Local district administrations are responsible for the heating infrastructure within the buildings of their individual districts. A city may contain many different district administrations, and thus new building heating equipment is not the responsibility of any one agency even if the buildings are still state owned. Smaller scale local systems for providing heat to just a few or several buildings may exist side-by-side larger district-heating networks, and the smaller systems are maintained by separate organizations again.

The organizational complexity of district heat management led to poor performance and management of the systems. Dispersed responsibility led to inaction in planning, upgrading, maintenance, and optimization of these systems. In the words of one noted heat supply specialist, "the system of heat supply has practically vanished from national economic planning" (Chistovich 1990, p.37).

ANNEX: DECLINE OF CENTRALIZED COORDINATION AND MINISTRIES: ENTERPRISES ON THEIR OWN

The former system of economic planning and management is presented in some detail here to illustrate just how much change enterprises are having to undergo in adjusting to market-economy conditions, and thus how long (if ever) it is going to take for "Soviet management culture" (see Soviet Management Culture annex) to change.

In some ways the former Soviet economy could be viewed as one large corporation, "USSR Ltd.," with the Politburo as its board of directors (Nove 1986). Gosplan and other central planning agencies developed detailed plans specifying the production quantities of all goods and services in the economy, and used massive input-output tables to determine the quantities and flows of raw resources, intermediate goods, and final goods. These plans also specified research and development innovations to be carried out by separate research organizations, and specified how these innovations were to be distributed to enterprises. And the plans specified what technologies, equipment, and materials should be imported from or exported to foreign countries to balance everything. The plans were not strictly "top-down" however, but also "bottom-up"; enterprises and ministries had a significant input into their formation.

Central ministries were responsible for fulfilling plans on a sectoral or branch level. Ministries in turn dictated plan targets to the enterprises under their control, and allocated material inputs to these enterprises according to what the ministry and central planners determined were required. Thus enterprises had little freedom or need to make decisions of any kind: they were told how much to produce, they were allocated the materials deemed necessary to produce the target, they were told who to get their inputs from and where to ship their output, the prices they paid for inputs and charged for outputs were fixed by the state, and their accounting was done on a simple cost-plus-profit basis. Performance and bonuses of enterprise managers (and ministry officials on a branch level) were based primarily on meeting plan targets, rather than profits, quality, innovation, or efficiency.

One fundamental flaw in the system was that it was simply impossible for central planners to understand the detailed needs of sub-sectors, consumption, and production, and to include these levels of details in their plan. Another flaw was that no matter what indicators were used as plan targets, problems would arise. For example, a plan might call for a certain quantity of shoes to be produced, but it could not specify the distribution of sizes. The shoe enterprise might then make lots of smaller-sized shoes because they required fewer hard-to-obtain materials and could still fulfill its plan obligations without any reprisals from the authorities (only from large-footed people). Or if the plan specified the output of shoes in tons rather than quantity, a shoe enterprise could make a smaller quantity of large-sized heavy shoes to reduce the work required to meet the plan, leading to a deficit of shoes in general and smaller sizes in particular. And it would be difficult for central planners to know how many tons of shoe laces to specify for how many tons of shoes, so that many shoes might be produced without corresponding shoe laces.

Another flaw was a gross waste of energy and materials. Thousand-pound chandeliers, thick-walled pipe when thin-walled would do, and thick concrete fences when thin would do were just part of the responses to the system. An enterprise would request a certain quantity of energy or raw materials to meet output targets, and then be obligated to use the energy or material even if it was not needed, just to ensure that future allocations would not be reduced. At extremes this even meant needlessly burning energy (simply to waste it) and dumping materials.

The economic mechanisms were sometimes bizarre. For example, an enterprise could also be judged on the ruble value of its output, which was proportional to the ruble value of its inputs because prices and profits were fixed. In this situation, the higher the price of an item the greater the demand arose for it. Inputs with higher prices were in greatest demand by enterprises, as they allowed ruble values of inputs (and thus outputs) to increase.

The level of re-work and resourcefulness that the system required was staggering, and enterprises became highly skilled at making do with what they were given in order to meet plan targets. Monthly production quotas meant that no one wanted a car produced on the last day of the month. In a somewhat absurd but illustrative example, if a ball bearing plant was required to produce X tons of ball bearings in a given month but did not receive its allotted supplies of steel until the last day of the month, it could produce one giant ball bearing weighing X tons on the last day of the month and meet its target. Recriminations for the ball bearing factory would be few, but the tractor factory receiving this single X ton ball bearing would have to melt it down and make their own proper-sized bearings in make-shift production facilities. But the bearings thus made would be poor quality and farmers receiving these tractors would be accustomed to and capable of replacing the bearings or fixing other problems. In fact the "breaking-in" period of most new equipment usually involved some degree of rework or remanufacturing. This phenomenon also applied to larger construction projects. In the electric power industry, power plants were constructed by a separate ministry from the one that would operate them. One Western observer reported that some large (900 MW) power plants took up to three years after their "acceptance" from the construction ministry to get them on-line and functioning properly (interview 10/5/94).

Production in the Soviet era was characterized by highly segmented and monopoly production, in which many enterprises produced only one very specialized or narrow range of products, and the output was used by the entire economy. Thus enterprises not only had a market monopoly, but also a technological monopoly (Erickson lecture 10/14/94). Lack of flexibility, specialization, single-source or single-customer procurement and sales, and no requirements for marketing characterized production. Thus the problems facing Russian industry are not simply those of greater enterprise efficiency through privatization, as perceived by Western economists and multilateral agencies (see Chapter 2). Rather, the "monopoly" problem is also highly significant, and the need to reconstruct the whole system of economic relationships between enterprises (in something of a Schumpeterian perspective), and for sectoral reconfiguration (product assortment, location of activities, mechanisms of intermediation, etc.) is also great. This second aspect has been relatively neglected by Westerners (Erickson lecture 10/14/94).

The "monopoly problem" and the institutional structure of production in Russia that it points to mean that large transaction barriers exist within the economy generally, and market intermediation is critical. Because of the monopoly and highly segmented nature of production described above, with many enterprise producing a highly specialized and narrow class of products, and often the only production of its kind in Russia, the need for market intermediation becomes of critical importance. Whereas before, Gosplan provided all intermediation for at least official transactions, enterprises themselves or third parties must now provide intermediation. This process of intermediation is not easy precisely because of the highly specialized and fragmented nature of production. Unofficial black-market networks which existed before 1991 have played an increasing role after 1991 in intermediation and transactions. Financial services are another open field for intermediation; enterprise associations (see below) have also been incorporating banks along with groups of enterprises.

Within enterprises, significant restructuring must also take place if privatization and macro-reforms are to have any impacts (Erickson lecture, 10/14/94). But institutional, cultural, and social constraints make such restructuring problematic. There is a much higher degree of control of the enterprise by labor rather than management than in Western firms, and consequently huge resistance to any types of change. Overemployment and extreme labor specificity make changes difficult due to retraining costs and cultural attitudes about the enterprise as security and protector of its workers. Further, any attempt to redirect or adjust the enterprise product mix to respond to market conditions comes up against the inter-enterprise barriers discussed before: the difficulty to obtain entirely new and reliable sources of materials and supplies, new customers, etc.

With the demise of central planning, economic relations have changed in several fundamental ways, and enterprises have found the conditions they face very different from before. Of great importance is that looser, multi-node horizontal "networks" of enterprises appear to be replacing the previous central coordination. Larger "associations" of enterprises are allowing individual enterprises to continue to receive inputs and sell outputs under conditions in which an enterprise "on its own" would face great difficulty. These associations are viable institutions for responding to the extreme segmentation and specialization characterizing enterprises mentioned before, and the lack of intermediation. A group of enterprises, each with a special function, can provide more flexible and broader production, especially when coupled with intermediary entities within the association itself, like banks and marketing functions. These change are happening.

Payment and price continues to take a back-seat to production and material availability, leading to the huge "non-payment problem" of interenterprise debt described in Chapter 3. This means enterprises do not stop shipping just because they are not being paid; other enterprises are counting on their output for their own production. Much of these changes have been brought about simply by enterprises struggling to survive under the new conditions. The role of ministries in directing economic activities of their (previously) subordinate enterprises and associations has been greatly diminished. In fact, ministries are now more likely to "serve" enterprises, in the form of coordination requests from below, or access to networks and contacts of ministry officials for markets and inputs.

Some of the broad changes that have been taking place are: (a) Most prices, except those for energy and natural resources, are no longer under administrative control. (b) There has been a transition from producing for superiors under administrative orders to producing for customers under contracts. (c) Managers have received greatly increased status and responsibility over the affairs of their enterprises, and are no longer merely executing orders from above. (d) Innovation to reduce input requirements and costs has become a higher priority. (e) Many enterprises in different branches now have direct horizontal relationships and contracts with one another, whereas before all relations were vertical through the central ministries and planning agencies. For example, marketing departments are now appearing within enterprises attempting to broaden these networks. (f) A sellers market, in which most any good was in great demand and could readily be sold, has changed into a buyers market. Increased domestic and foreign competition and no administratively-mandated buyer-seller relationships mean the buyer, especially one with money, calls the shots. (g) Relationships among different economic actors are becoming more anonymous based upon contracts, but are still highly influenced by the personal relationships (or lack thereof) between contracting parties. (h) A Soviet-era expectation that production and technology levels next year will be pretty much like last year has been replaced by an acknowledgement that everything should be (if ever so slowly) inching towards "world levels" and "world standards," and must face "world competition."

ANNEX: ECONOMIC DEVELOPMENT LITERATURE AND THE TRANSITION TO A MARKET ECONOMY

From a political economy standpoint, there are three main perspectives on economic development (Gilpin 1987): the liberal perspective, the classical Marxist perspective, and the underdevelopment perspective. In the classical Marxist perspective, capitalism is an inexorable global force for development that will spread until it encompasses the entire world. After capitalism reaches its "limit," socialism will emerge as the next stage. But the spread of capitalism is not without its frictions, as political conflict erupts over divisions of labor and capital. Marx saw the struggle of different countries to develop under the capitalist system as essentially one of inequality and politics.

The underdevelopment perspective sees the international capitalist system as one that systematically underdevelops the less developed countries. Structuralist theories of underdevelopment focus on the structure of the global economy and how it limits prospects for developing countries, especially how it tends to preserve or increase the inequalities between developed and developing countries. Developing countries become caught in a vicious cycle of poverty. The key to this problem is the gains from technological progress, which flow mainly to the developed countries. Structuralists argue for trade protectionism and an import-substitution strategy of domestic industrial development. "The poor are poor because they are poor." Dependency theory, on the other hand, sees developing countries as dependent on developed countries, through which they have lost control of their domestic economies to multinational corporations and interests of developed countries -- in essence a form of economic colonialism. The solution for advocates of dependency theory is nationalism and autonomy from the capitalist system. "The poor are poor because they are powerless or exploited."

In the liberal perspective, the most important factor affecting economic development is the efficient operation of markets, and the policies required to best achieve development are those that remove political and social obstacles to free markets and free trade. As viewed from theories of international trade and comparative advantage, free trade serves as an "engine of growth" as less developed countries gain access to capital, technology, and export markets. Liberal economists see the obstacles to development as a reliance on subsistence agriculture, a lack of technical education, a low propensity to save, a weak financial system, and inefficient government policies. "The poor are poor because they are inefficient."

Thus in the neoclassical, liberal view, growth contributes to economic and social development by providing higher levels of production and income, which automatically trickles down so that rich and poor alike benefit. The primary policy goal then becomes reducing government intervention and interference in markets. Thus:

> the neoliberal recommendations for less developed nations in Latin American, Africa,and the ex-Soviet Union and Eastern Europe has been the rapid and radical dismantling of the state apparatus and an augmented reliance on the spread and operation of markets. (Hodgson et al 1994, Vol.1, p.140)

Development economics had its origins in a dissatisfaction with orthodox neoclassical theory in the context of the highly imperfect markets in developing countries. As with the neoclassical perspective, the aim of development was economic growth. But the policy problem of how to achieve that growth was the point of departure for development economics. It shared with

Keynesians the belief that the problems of growth and structural change required state intervention. It was influenced by a progression of theories and models of economic growth which served as the basis for economic development policies over the past forty years. Three early prominent models were (Riddel 1987):

(1) The Harrod-Domar long-term growth model took the neoclassical emphasis of capital as important for growth and made it accessible to policy analysis. The model very simply equated the rate of growth to the proportion of income saved divided by a relatively constant capital-output ratio. Thus a higher domestic savings rate and external investment capital were seen as the crucial elements.

(2) Rostow's stage theory supposed that countries go through a logical sequence of different stages of growth, much like a process 'law' in a physical system. The most important phase of this process was a 'take off' into a stage of self-sustaining growth. Rostow's theory supposed that this 'take off' depended on certain economic and social preconditions. These included a critical minimum level of capital investment, which could be brought about through inflows of foreign capital which would raise the domestic savings rate. Coupled with these capital inflows, a transfer of knowledge and skills was required to make effective use of the capital.

(3) In the 1960s, Chenery and Strout's "two gap" model influenced development by supposing that two different bottlenecks inhibit development. The first bottleneck is a shortage of capital and skills in which growth is investment-limited, and the second is a shortage of foreign exchange in which growth is trade-limited. Thus the policies associated with these gaps are: provide more capital and skills, and restructure the economy towards exports in order to earn foreign exchange.

Consistent with these models, in the 1950s, the critical factors in accelerating economic growth in developing countries was seen as capital investment and technology, to create the preconditions for "take-off" to long term self-sustaining growth. But to make use of this investment capital for the necessary advanced technologies (for example industrial factories, power plants, dams, and communications), a transfer of technical skills and knowledge was required for societies with relatively smaller technological capabilities. Technology and infrastructure development was commonly done through turnkey projects, subsidiaries, and/or equipment transfers with technical assistance, as whole technological infrastructures were transferred. The selection and specification of technologies was often made for the developing countries by the developed countries, who presumably knew best.

In the 1970s, as development thinking turned to ideas of local self-reliance, appropriate technology, and regional economic planning and development, attempts were made to develop and transfer many small-scale renewable-energy technologies like biogas, cooking stoves, wind turbines, and solar heaters. Many of these efforts failed due in part to a failure to understand local needs and conditions.

By the 1980s it was clear that development had slowed down or was not responding, foreign debts were accumulating, and domestic investment was not forthcoming. Structural rigidities seemed to be norm and economies had not adjusted by themselves to market and price changes as had been expected. Thus the primary development goal of growth gave way to one primarily of adjustment. Structural adjustment policies were promoted as ways of changing the fundamental structure of economies to make markets work properly. Technology transfer then became an instrument for re-orienting the economy towards structures that would promote growth (for example new livestock species or crop strains suited for export production).

Development economics as a field was seen by many, including its own practitioners, to be in serious decline in the 1980s, as the failures of development become more obvious and as production of new theories to explain these failures dried up. In fact many have all but pronounced it "dead" (Leeson and Minogue 1988).

Another view of the role of technology transfer for development was advanced by Schultz (1964). He saw economic growth (in both rich and poor countries) coming not from the traditional economic inputs, but rather arising from human capital -- skills and abilities -- and from technology.

Alternative views of the development process have come from schools of institutional economics (Hodgson et al 1994). Schumpeter in his Theories of Economic Development makes a distinction between economic growth, which is essentially a quantitative change in economic activity, and economic development, in which qualitative changes brought about by innovations interrupt the normal "circular flow" equilibria of economies. The entrepreneur as "creative destructor" is the primary agent of development, through innovations that can be of three basic types: new products and processes, access to new markets, or implementation of new organizational structures. Veblen saw development as "a cumulative sequence of economic institutions stated in terms of the process itself." Thus institutions are not only a precondition for human action, but constitute the major result of those actions, and

> development occurs when individual actions generate instrumental institutions that support the dynamics of those actions cumulatively reinforcing the circular consequences. Underdevelopment occurs in this framework when institutions fail to provide an adequate instrumental framework for human action and are degenerated to mere "ceremonial institutions." (Vol. 1, p.149)

Thus in the institutionalist view, the state should intervene actively to shape public and private institutions in attaining specific goals of development. In this view, the state is not a barrier to development as in the neoclassical, liberal view, but rather is the agent ultimately responsible for social and economic development. Inherent in these views is the process of development as a coevolution of economic activity and institutions. This is similar to other views of development in the social sciences, of which Norgaard (1994) provides a good account.

As environmental issues became more important in the 1980s, and with the recognition that many environmental impacts of development were irreversible, the term "sustainable development" came into fashion, and there have been many calls for elaborations and operational definitions of this term. However, Norgaard (1994) argues that this term is impossible to put into an operational definition. While many people may agree that current policies are unsustainable, the wide variety of competing interests, preferences, and aspirations that exist (including those of future generations) make a common definition of "development" impossible, and thus it is not clear what is to be sustained or for how long or for whom.

The most commonly cited definition of sustainable development from the Brundtland report emphasizes intergenerational equity:

> development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (World Commission on Environment and Development 1987, p.43)

In relation to Russia and Eastern Europe, economic reform and restructuring have been primary "development" goals (Ellman 1994, Aslund 1994, Yavlinsky and Braguinsky 1994). The ideology and theories underlying reform have tended to come from the liberal neoclassical perspective discussed above. Policies advocated by Western economists and multilateral institutions have been to dismantle the old state institutions and let market forces take over. These goals were to be accomplished by price freeing, elimination of state subsidies, and enterprise privatization, while at the same time stabilizing macroeconomic indicators through fiscal and monetary restraint. The structural adjustments that would take place and the necessary institutional changes "were treated as secondary issues, to be resolved semiautomatically by capital markets and liberalization" (Yavlinsky and Braguinsky 1994, p.89). Some of the greatest debates have been primarily those of speed and sequence: "shock therapy" versus gradualism, the timing of price liberalization and privatization, etc. Yet critics of these conceptual approaches say that no replacement institutions were created to support newly emerging markets, and that insufficient understanding of the institutions of the formerly planned economies accompanied these prescriptions. "Eastern Europe is not well served by straight textbook advise" said a former head of the World Bank's East European Department (Ellman 1994, p.2).

Yavlinsky and Braguinsky argue that this liberal neoclassical approach to transformation has been inefficient and ineffective:

> 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. These coexist today in the Russian economy with a relatively small number of purely private undertakings, mostly in retailing, services, and banking, and what are still more or less state-owned enterprises, mostly in defence industries and in infrastructure......[Managers of these new post-state-owned enterprises have not had time to adapt to market conditions], and managers who recognized new opportunities nevertheless failed to change over to normal market behavior because of a tremendously high switching cost.... To enter the market economy, [these enterprises] would have to pay for market research, create an after-service network, develop new marketable products, establish a system of quality control, shape a new network for distributors, and retrain the labor force. (pp.92-93)

That is to say that the transaction costs of participating in the market economy in Russia, as well as the R&D and retraining costs, are high compared with the costs of continuing to do the same business with the same products and the same suppliers and customers as previously, including formerly black-market suppliers and customers and formerly state-mandated suppliers and customers.

Competition and cost-minimization constraints have been slow to develop in Russia because of the monopoly and specialized nature of production. The Soviet needs to minimize on planning costs and the belief in large economies of scale led to the one-factory, one-product approach to production, where many enterprises are monopoly producers of a single, specialized intermediate good for all of Russia. Thus costs are simply passed on to customers, and the incentive to minimize them is essentially absent still, even if an enterprise is privatized. The decreased demand resulting from higher prices is seen not as an opportunity to cut costs, but rather necessitates the need to raise prices still further.

ANNEX: ELECTRIC POWER SYSTEMS IN RUSSIA

Aggregate electricity production in Russia is 67% thermal (half of which is combined heat and power), 22% hydroelectric, and 10% nuclear (Wilson et al 1994). The capacity mix varies substantially across Russia's many zones, from the Northwest region (almost 40% nuclear) to the Center and Urals (mostly natural gas with some nuclear and hydro along the Volga river) to Siberia (mostly hydro and coal) to the Far East (almost exclusively coal). On average, over half of all electricity generation from fossil fuels comes from natural gas. Independent power generators (mainly industrial co-generation) generated 37 billion kWh in 1993, or 4% of the total. As electric demand fell in 1993-1994, it was for the most part absorbed within the large fraction of thermal generation. However, in 1994 hydroelectric and nuclear generation also dropped, nuclear in part because of nuclear fuel shortages due to electricity debt non-payments (see Chapter 3). The previous trend was an increasing use of natural gas at the expense of oil and coal, but this trend stopped in 1993. Additions to total electric power capacity also stopped in 1992, having increased steadily through the 1980s but slowing down in the late 1980s and early 1990s due to construction, economic, and environmental problems. Electric power shortages exist in Buryatia, Chita, and the North Caucasus regions due to a shortage of generating capacity, and in some areas of the Far East due to fuel shortages.

Russian electricity demand is characterized by an unusually high proportion of industrial demand (over 50%) and low residential and service sector demands (each historically under 10%). This reflects both the historical structure of the Russian economy, with an emphasis on heavy industry, and also the well-known inefficiency of Russian energy use. The structure of demand varies substantially across the many regions of Russia, which have very different climate and patterns of economic development. The share of household electricity use varies, for example, from less than 10% in industrial regions to 50% in Kalmykia and 70% in Kamchatka. Electrification is high in just about all populated areas of the country, as even in the sparsely populated areas the majority of the population tends to be concentrated in towns and settlements. After growing steadily for several decades, electricity demand fell for the first time in 1991, by 1%, and then by 5% in 1992, and by another 5% in 1993. Most of the declines occurred in the industrial sector; household electricity use stayed constant. Regions with high concentrations of industry have seen the biggest declines; for example 25% in Vladimir and 19% in Vologda. Wilson notes that the declines in electricity demand are much lower than the declines in major economic indicators (GDP, industrial production), and are also much less than would be expected based upon the experience in other reforming economies. Total consumption of close to 1000 billion kWh in 1993 gave a per-capita electricity consumption of 6000 kWh.

A variety of forecasts places electricity demand in the year 2010 at anywhere from 80% to 140% of 1990 levels. Wilson notes that future growth in electric demand is still highly uncertain:

> Forecasts of future electricity demand reflect enormous uncertainty and a wide range of opinions. As one indication, results from a 1993 delphi-type study in which forecasts of future electricity demand were collected from 30 power industry specialists showed a 20% range in the forecasts for 1995. The specials disagreed even more about the year 2000: the range was over 40%. Another indication is the fact that the Russian official forecasts for 1995 electricity demand have dropped by about 15% in 1994 compared to the forecast for 1995 prepared in 1993. (p.2-2)

Geographically, the electric power system of the former Soviet Union consists of eleven district regional electric grids that interconnect to form one large Unified Power System (Central Intelligence Agency 1985, Martinot 1991 and 1992). The UPS spans eight time zones, covers a west-to-east distance of over 80000 kilometers, and includes over 98% of the generation capacity of the former Soviet Union. The UPS serves very diverse territories, from the norther Arctic taiga forest, to Central Asian desert areas bordering the Middle East, to European-style cities nearer Scandinavia. There is a general (although by no means perfect) territorial correspondence between the regional grids and the territories of the former Soviet republics. Map 2 shows the geographic coverage of the different regional grids. Figure 2 shows a schematic of the topology of the system.

The several characteristics of the electric power system that have relevance to renewable energy and energy efficiency are: (1) the large expanse of territories not served by any power grid, (2) the difficulty in transmitting power over long distance because of transmission-line loses, (3) the relative autonomy of each regional grid and low capacity for transfers between grids, (4) close territorial correspondence between regional grids and former Soviet republics, and (5) severe electricity power capacity shortages relative to demand in some regions.

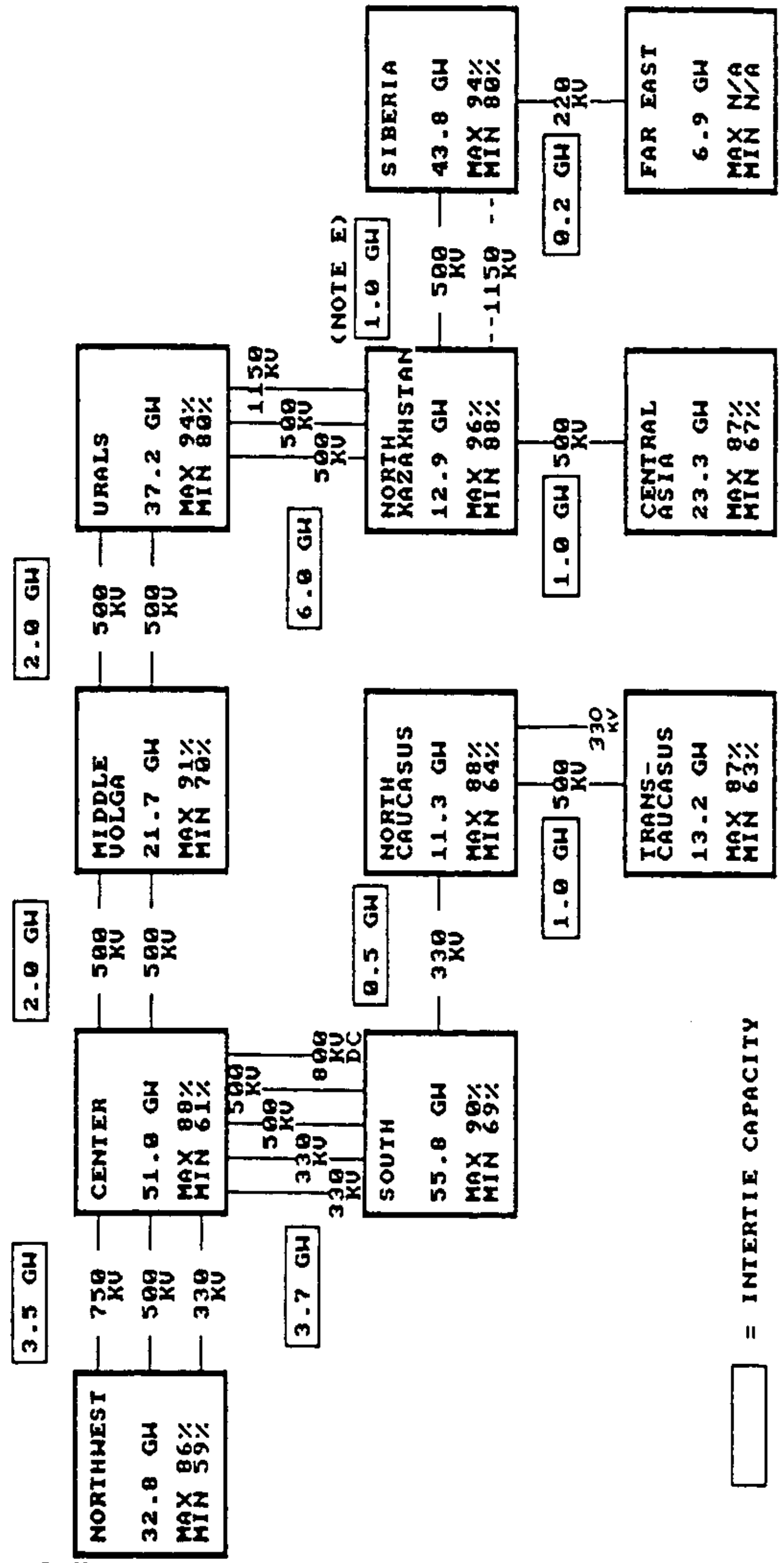

Figure 2: Topology of the Electric Power System of the former Soviet Union

Notes: (a) Maximums and minimums represent average daily demand as percentage of capacity; (b) transmission intertie data as of 1989, capacity and demand data as of 1985; (c) intertie capacities are author's estimates; (d) the 1150 KV line from North Kazakhstan to Siberia was under construction (1988). Source: Martinot 1992.

ANNEX: ENERGY CONSUMPTION QUOTAS, THE OBLIGATION TO SERVE, AND DEMAND-SIDE MANAGEMENT

In the former Soviet system, a complex series of energy consumption "norms" for production of specific goods, or for energy consumption by specific types of equipment were developed by several scientific institutes. These norms were often unrealistic, but nevertheless represented "actual energy consumption" in many official statistics. The central planning authorities allocated energy supplies to enterprises on the basis of these norms and planned production. Enforcement of these norms was the nominal responsibility of an "energy officer" in each enterprise, but in reality the energy officer was merely an energy accountant. A national energy inspectorate -- "Energonadzor" -- was responsible for monitoring energy consumption in enterprises and reporting this consumption to central authorities. If energy consumption was greater than the norms, fines could be imposed, but enterprises had no budgetary constraints so fines did not create any hardship for enterprise managers. This national energy inspectorate, comprising over 4000 people in 1994 (interview with the head of the energy efficiency department of the Ministry of Fuel and Energy, 2/26/94) was previously part of the Ministry of Fuel and Electric Power, which then became the Ministry of Fuel and Energy.

While central planning authorities no longer exist, one significant way in which the old system has not changed is that allocation of some energy supplies was still taking place under an administrative system. Individual enterprises and utilities sign contracts for specific monthly quotas of electricity consumption, and stiff penalties (like 10 times the normal rate) are imposed for purchases above the quotas. Allocation of gas occurs on an enterprise, municipal, and regional level. This allocation system has its origins in the centrally planned system, where central authorities instructed energy suppliers how much to produce, and then allocated this production among the enterprises according to need. This "need" was also determined by central planners, often based on past history and norms, although enterprises were able to influence the plan.

Gustafson et al (1993) described the process of gas allocation:

> The process by which gas is allocated to consumers is still essentially that of the command economy. Gazprom's basic picture of gas demand is built up through an elaborate statistical exercise that adds up the known requirements of past customers and the prospective needs of new ones. Computer models then factor in the impact of weather, changes in the expected output of gas-intensive commodities, improvements in technological process, and other variables. Toward the end of every year, gas users submit allocation requests to Gazprom; Gazprom tallies them up, compares them with its own projections, and informs each consumer how much it can expect to get. Following a stage of vigorous bargaining, these allocations become official... Thus Gazprom builds up a synthetic picture of gas demand. This picture is based on technology, past history, administrative rules and norms, and politics -- but not yet....on price or cost. (p.13)

Energy suppliers are now on their own in terms of deciding how much energy to produce and how much investment in new capacity to make. By controlling allocations they can wield considerable political power. And unlike Western public utilities, Russian energy suppliers are under no legal or moral obligation to serve all existing or future demand. Rather, their obligation is to increase supply as they think necessary and then allocate that supply.

In this situation the prospects for demand-side management and integrated resources planning for electric utilities are not as good as in the West. The question of how to serve "future demand" at the lowest possible cost including both supply-side and demand-side options, which is at the heart of these approaches, is not as relevant without an obligation to serve. The option of "doing nothing" may be the cheapest of all, and the option of increasing supply provides the most direct benefits to the utility in terms of jobs for workers and more political influence. Legislative attempts to provide incentives for utilities to invest in efficiency may cause problems. If profits are based on ruble investment values, efficient investment decisions may not be made. If profits are based upon actual saved energy, measurement of the saved energy is likely to be difficult or open to corruption or manipulation. The whole question may be mute for most regions of Russia, which face electric power capacity surpluses for the near future because of the decline in industrial demand.

The system of quotas has several implications. It means that demand is not simply a function of needs and energy prices, but contains an administrative and political component to it. In some cases it means that demand simply equals supply, supply being determined by whatever the supplying organization has available or chooses to make available. This is directly opposite from Western experience, where supply usually equals or exceeds demand. In regions or districts with severe energy shortages, the allocation system has the potential to reduce incentives for energy efficiency, since any savings can simply result in a lower quota.

ANNEX: ENERGY DEVELOPMENT POLICIES IN THE SOVIET PERIOD

Following is a brief history of energy policy in the Soviet Union from 1970 to 1990, with an emphasis on energy efficiency and renewable energy. However, nothing so brief can do such a complex subject justice. Gustafson (1987) provides a very comprehensive treatment, and most of the material below comes from this source. Overall, energy development has been characterized as "technocratic monopolism" by one researcher (interview 9/21/94) because large scale technical systems were designed and developed by a technocratic elite.

The Soviet energy picture in the early 1970s looked rosy. With the opening of large oil fields in Western Siberia in the 1960s, energy was plentiful, cheap, and of little concern to political leaders. But by the mid 1970s, signs were appearing that the growth of oil production in Siberia was declining, just as oil export prices to the West increased dramatically in 1973 and caught the attention of Soviet political leaders. In 1977 the warnings became plain that Siberian oil output was declining, and Brezhnev instituted a crash program to meet 1980 oil production targets by significantly increasing investment in oil mid-way through the Tenth (1976-80) Five-Year Plan (FYP). This program did pay off, and the 1980 oil target was met.

In 1980 energy policy began to emphasize gas. It was clear that some other fuel would have to make up for the oil shortfalls. Coal was becoming more expensive, and Gosplan studies in the late 1970s showed that gas transmission via pipeline from Siberia would be more efficient than coal-generated electric power transmitted from Siberian coal fields. So Brezhnev instituted another energy crash program to increase gas production by 150% by 1985 and to construct six massive gas pipelines from Siberian gas fields the to European part of the Soviet Union.

Both the oil and gas crash programs were successful from the point of view of maintaining or increasing output. But the cost of these crash programs was that energy investment became a much greater share of total industrial investment, from 28-29% during the 1970s to 38.6% by 1985 (Gustafson 1987, p. 25). And during the 1981-85 Eleventh FYP, energy investment used 90% of the total industrial investment growth increment for the entire country, leaving other industries with essentially no investment growth (Gustafson 1987, p. 39). And the effects of the "technocratic" approach were that environmental degradation and resource depletion were not included in decisions and consequently adversely impacted resource reserves and environmental conditions.

Underlying these policies has been the fact that Soviet energy costs were rising sharply after the late 1970s, with clear signs of diminishing returns, as the following figures show (Gustafson 1987, p. 40):

Years	Growth in Energy Output	Growth in Investment
1975/70	28%	38%
1980/75	21%	41%
1985/80	13%	48%

By 1980, nuclear power was also receiving emphasis, with the expectation that all new generating capacity in the European part of the Soviet Union would be nuclear. This emphasis was successful until 1988, with rapid capacity installation throughout the 1980s. However, in 1988 and 1989, the nuclear program ran into public opposition, and the number of plants coming on-line dropped dramatically in those years (Sagers 1989 and 1990).

Much of the coal in the former Soviet Union is located in the Ekibastuz and Kuznets regions of Central Siberia. In 1976, Prime Minster Aleksi Kosygin advocated a so-called "coal-by-wire" strategy, in which electric power would be generated close to coal fields in Siberia and transmitted over long distances to the European part of the Soviet Union. This strategy never really received strong emphasis, although work on it has progressed. The electric transmission lines have been difficult to build, and the coal plants under construction in Siberia are years behind schedule and plagued with environmental concerns and modifications (Sagers 1990).

When Gorbachev came to power in 1985, energy policy was still very much fixated on supply, with little action towards conservation or energy-efficiency improvements (intensive development versus extensive development). The link still held firm between gross national product growth and energy growth. In 1985, as part of his modernization and efficiency platform, Gorbachev called for emphasizing conservation and efficiency, and shifting investment priority away from energy towards the machinery and food sectors. Nevertheless, the Twelfth FYP that emerged in 1985 included very substantial increases in energy production targets, especially in gas and nuclear power, and Gorbachev's calls for increased energy efficiency were largely ignored in practice.

It was during the years of Glasnost that public opposition to nuclear power gained momentum and construction of many nuclear power plants was halted. Plant construction was delayed or canceled in several locations in the Russian Federation, including Rostov, Saratov, Karelia, and Perm.

It was also during Glasnost that calls for renewable energy and energy efficiency were increased, particularly among the environmental activist and anti-nuclear citizens groups that formed in this period, like the Socio-Ecological Union. While renewable energy was never taken seriously by most Soviet officials, especially those in the energy supply ministries, there was recognition of the potential role of renewable energy at even the highest levels of the Communist Party. In a meeting of the Central Committee of the Communist Party (CPSU) in June 1988, issues associated with scientific, technical, and economic problems of developing renewable energy sources were discussed:

> Ye. K. Ligachev, member of the Politburo and Secretary of the CPSU Central Committee, [pointed out that] the promise of the broad use of energy from the sun, the wind, geothermal, water, and...biomass is confirmed by the operation of individual facilities and installations in a number of areas of our country and abroad... It was pointed out at the meeting that work to develop nontraditional power engineering is progressing very slowly, and the volume of organic fuel replaced is still insignificant... The main reason for this situation is the lack of discipline among executives of a number of ministries and departments, research organizations and local agencies in carrying out adopted resolutions to develop and utilize nontraditional energy sources. (Current Digest of the Soviet Press, vol. 40, no. 23, p. 21, citing Pravda, 6/9/88)

1989 was a turning point for the energy sector. Oil output fell by almost 3%, and coal output fell also by more than 4%. Gas and electricity production continued to increase, but electric power capacity increased by only a third of plan target, and no nuclear capacity came on line at all. With the breakup of the Soviet Union, energy problems took a back seat to more pressing social, political, and economic concerns, and energy production stagnated or declined. Oil output continued to fall in the early 1990s, and by 1993 even gas and electricity production were declining.

Energy policy in the early 1990s was cast adrift with the breakup of the Soviet Union. Several competing groups offered suggested policy and development directions, including the Russian Academy of Sciences, but no coherent energy policies or legislation yet emerged at the national level, and the prospects appeared uncertain that anything would. Rather, each ministry has pursued its own policies and activities without the central coordination and direction that once existed, a reflection of the operation of the Russian economy in general during the early 1990s.

ANNEX: ENERGY SUPPLY AND REGULATION ORGANIZATIONS IN RUSSIA

Before 1990, the leading energy policy-makers in the Soviet Union were the Communist Party (CPSU) Central Committee Politburo and the General Secretary, consistent with the party's "leading role" in all matters of policy. A number of other bodies were also been involved with energy planning and policy, including the State Planning Committee (Gosplan), the USSR Academy of Sciences, the State Committee for Science and Technology (GKNT), the Council of Ministers, and individual energy-related ministries. Often these bodies formulated policies and plans and then submitted them to the Politburo and General Secretary for approval. Ministries especially could influence state plans because the ministries would often furnish the original plan drafts and the assessment of resources and capabilities that went along with the plans. But the final decision always rested with the Politburo and General Secretary.

Nevertheless, energy policy had a pluralist nature which could be characterized using Almond and Roselle's "interest group model" of politics (Almond and Roselle, 1989), in which different groups and their policy ideas competed with each other for policy-maker recognition. Gustafson (1989) notes that debates over energy policy frequently involved coalitions that cut across institutional lines and whose main objective was to win the ear of influential leaders.

Another feature of decision-making and implementation in the energy field was the division of responsibilities among many different organizations, which was in part due to the vertical nature of the ministerial structure (Gustafson 1989, pp. 292-301). Each ministry was responsible for development, maintenance, and operation of the enterprises under its vertical sector. In general there was poor horizontal cooperation among ministries. A ministry may have depended on other ministries for machinery, construction, roads, etc., but obtaining the aid of these supporting ministries was difficult. Often an operating ministry could not influence the priorities of a construction ministry on which it depended.

Yet despite this fragmentation, another feature of energy policy was centralized management. The primary energy-related ministries were all-union ministries, meaning they exerted centralized control over all activities throughout the entire country related to their particular branches. Furthermore, the party Central Committee until 1988 also exerted centralizing influence on energy policy implementation through the departmental structure of the secretariat, which duplicated at union, republic, oblast, and local levels the government ministerial structure for the purpose of monitoring and control.

After Gorbachev came to power in 1985, a number of shifts occurred in economic decision-making power and thus in energy decision-making power. One of the first such shifts began in 1988, as a result of decisions made at the 19th Party Conference in June-July 1988. All Central Committee departments responsible for monitoring specific industries were eliminated, with the exception of defence and agriculture. According to Aslund (1990), "Essentially, departments in the economic sphere were abolished, and the Central Committee apparatus lost more power in matters related to the economy than in any other field" (p.79).

At a Supreme Soviet meeting in June 1989, Prime Minister Ryzkhov announced a reorganization of the government ministries in which the total number of ministries was reduced from 82 to 57 (Current Digest of the Soviet Press, vol. 41, no. 33, pp. 18-19, citing Pravda, 6/11/89). Two changes specific to energy were affected by this reorganization. The former Ministry of Atomic Power (which had run civilian nuclear power plants) and the former Ministry of Medium Machine Building (which had run military nuclear activities) were combined to form one Ministry of Atomic Power and Industry. The former Ministry of the Oil Industry and the former Ministry of the Gas Industry were also combined to form one Ministry of the Oil and Gas Industries.

Later reorganizations took place in the energy sphere, both before and after the breakup of the Soviet Union. In 1991, Gazprom was formed from the Ministry of the Oil and Gas Industries. Then in 1992 RAO "EES Rossii," the national electric utility, was split from the Ministry of Power and Electrification, and was created as a joint-stock company with a government majority ownership. Also, the Ministry of Fuel and Energy was created from the Ministry of the Oil and Gas Industries and what was left of the Ministry of Power and Electrification.

By 1992, the two big players in Russia's energy sector were Gazprom and RAO "EES Rossii," both now private joint-stock companies. The oil industry, because of declining output and fragmentation, represents much less of a political influence than these two giants. These large monopolies have been essentially unregulated since their creation (but see discussion below on energy commissions).

Gazprom has been and will continue to be a very powerful organization in Russia. It has a monopoly on all gas production and transmission in Russia, as well as all gas exports to Europe. Gazprom's natural monopoly makes sense from several technical and organizational viewpoints, according to a U.S. consulting company studying the gas industry in Russia (Gustafson et al 1993), and will likely continue to exist. Gas exports represent a sizable share of Russia's foreign currency earnings, and these earnings flow through Gazprom to the government. Gazprom was originally created as a state-owned enterprise in 1991 with a monopoly on all gas production and transmission, out of a ministerial reorganization that saw other energy industries become fragmented. Gazprom became a joint-stock company in 1993 with the government retaining partial ownership.

The World Bank (Energy Sector case study 1993 document) had this to say about Gazprom:

> The natural gas industry in Russia is dominated by Gazprom. Gazprom has a monopoly on non-associated gas production, gas transmission, and gas exports, making it the largest gas company in the world. In addition, through the system of gas allocation, it strongly influences the whole of the Russian gas market. The scale of Gazprom's operations, its financial strength, its place in the provision of energy to a wide range of customers throughout Russia and its access to foreign currency, combine to make Gazprom a formidable entity. Its contribution to economic stability in a turbulent period of economic restructuring is an important factor which is well recognized. Taking the whole range of its activities, together with its direct access to the Council of Ministers, it is able, in practice, to strongly influence national policy for the sector, encroaching significantly on the role of the Ministry of Fuel and Energy and probably other branches of government as well. (p.9)

The Russian national electric utility RAO "EES Rossii" parallels Gazprom in its monopoly status, large resources, and influence (Wilson et al 1994). RAO "EES Rossii" became a joint-stock company in 1992 split off from the Ministry of Fuel and Energy via a surprise decree by President Yeltsin. Many officials of RAO "EES Rossii" came from the Ministry of Fuel and Energy. The ownership of half of all electric power generating resources in the country was given to RAO "EES Rossii," although some of these transfers remain in doubt or have been reversed and the real fraction is somewhat less. Although this "confiscation" of regional property was later ruled unconstitutional by the Russian constitutional court, RAO "EES Rossii" still exists. Seventy-two individual regional electric utilities retained the other half of the generation resources. RAO "EES Rossii" owns 589 thermal power plants, 102 hydroelectric power plants, and 2.5 million km of power lines. With 1.3

million employees, it is the largest electric utility in the world. Original plans called for the breakup of RAO "EES Rossii" into smaller companies after its consolidation, but the political influence of RAO "EES Rossii" makes this event very unlikely. Rather, RAO "EES Rossii" will continue to remain a strong monopoly of electric power generation and transmission. Relations between RAO "EES Rossii" and the Ministry of Fuel and Energy are understandably strained; as a private company RAO "EES Rossii" wants no interference, yet the Ministry wants to keep its influence in the power sector. A federal energy commission is responsible for regulating electricity tariffs, but this commission was unsalaried, lacked any support staff, and contained several RAO "EES Rossii" employees. RAO "EES Rossii" is essentially an unregulated, private, natural monopoly (Wilson et al 1994, interview with USAID energy consultant in Moscow, 9/1/94).

Since 1992, RAO "EES Rossii" has been involved in many political struggles with the government and with industry. Many regional electric power companies and governments did not accept its formation. Regions in Siberia especially challenged it, and in fact retained some of the generation capacity that was supposed to go to RAO "EES Rossii." Several special deals transferring property back to the regions were completed. RAO "EES Rossii" continues in political struggles with regional energy companies. RAO "EES Rossii" also struggles with the nine operating nuclear power plants and the Ministry of Atomic Power, which is responsible for these plants. While RAO "EES Rossii" does not control these nuclear power plants directly, it does control their dispatch. Thus RAO "EES Rossii" can schedule its own plants instead of the nuclear plants even if the nuclear plants are cheaper to operate; by running its own plants RAO "EES Rossii" can make a profit, but by running the nuclear plants it does not (interview with USAID energy consultant in Moscow, 9/1/94).

The power struggles, unclarities about ownership and responsibility, non-payments of energy bills by final consumers and also by RAO "EES Rossii" to the nuclear industry, meant that by 1994, construction in the electric power industry had virtually ground to a halt. Regional utilities and RAO "EES Rossii" alike could hardly finance operations and maintenance, let alone new construction (interview with USAID energy consultant in Moscow, 9/1/94).

Due to the enormity and conglomerate nature of RAO "EES Rossii," its costs and cost structure are virtually unknown and unknowable. Therefore, it is difficult to form a sound basis for electric power tariffs, and this has opened the way to disputes and politization of the tariff-setting process. Battles were continual over electric power tariffs, and it was not clear how to account for regional variation (interview with USAID energy consultant in Moscow, 9/1/94).

District heating is supplied through combined-heat-and-power plants run by RAO "EES Rossii" or regional electric utilities, or by municipally-owned district-heating companies. For example in Moscow, two organizations are primarily responsible for heat supply in Moscow: Mosenergo, which supplies heat generated from 15 large combined heat-and-power plants, and Mosteploenergo, which produces heat in large heat-only power plants. Both feed heat into the heating distribution-system. In general, Mosenergo and Mosteploenergo supply heat up to the point of heating distribution "substations." Beyond these stations, in smaller secondary distribution networks, local housing administrations are responsible for heat distribution networks up to the buildings and then within the buildings themselves. Maintenance of heat systems in buildings is conducted by the same municipal maintenance administrations that work on building water, sewage, and other services. Tariffs for Mosenergo and Mosteploenergo are approved by a regional energy commission, taking into account costs of operations, maintenance, and capital equipment.

By 1994 all major oil producers were joint-stock companies (AO), although the government still owned large shares of these companies (30-51%), and municipal governments also owned small shares in some companies (interview with investment banker, 9/22/94). Thus the oil producers still have obligations to the government, under the directives of the Ministry of Fuel and Energy. These directives, or required contracts, are specified by the Ministry of Fuel and Energy for supply of oil to municipal or regional heat or electric power plants. These directives may come through representation by the government federal property committee (Goskomimushestva), which represents the government's shares of the AO oil companies, or by local property committees, which exert an influence on the local activities of oil companies. These local property committees, rather than local governments or federal government agencies, will ensure that a certain amount of oil is allocated to local enterprises (interview with investment banker, 9/22/94).

Regional energy commissions had formed in many regions of Russia by 1994 to regulate local and regional energy monopolies and tariffs, but such commissions were quite weak politically, lacked experience, a professional paid staff and funding, and were often partly staffed and controlled by representatives of the energy companies they were supposed to be regulating. A federal energy commission was formed in 1992 under the Price Committee of the Ministry of Economy but suffered the same problems as the local commissions (Wilson et al 1994, interview with USAID energy consultant in Moscow, 9/21/94). In 1995 these commissions may have started to become stronger, because of a government law allowing them to become legal entities with budgets and staffs.

Government involvement in renewable energy is primarily by the Ministry of Fuel and Energy and the Ministry of Science, with perhaps secondary involvement by the Ministry of Environment and Natural Resources and the Ministry of Economy. Utilities involved have been those most interested in renewable energy in their service territory (Murmansk, Komi, Kalmykia, Dagestan, Yakytia, Leningrad, Khabarovsk, Maritime, Sakhalin, Stavropol, Krasnodar), and the national electric utility RAO "EES Rossii." In fact it appears that RAO "EES Rossii" is taking the lead in renewable energy development. This is understandable, as few other organizations have the combination of both the resources and the interest. RAO "EES Rossii" is funding the 1-MW photovoltaic plant in the North Caucasus, eight wind farm projects totaling a planned 170 MW using Russian designed and manufactured turbines, micro-hydro, and geothermal development projects (Wind Power in Russia conference, Moscow, 4/28/94-4/29/94). Research institutes involved include the Khrzhizhanovskiy Power Engineering Institute, Moscow Energy Institute, the Northern Energy Institute (Kola), VNIIKTEP, and the State Central Aviation Institute. And many state-owned enterprises, design bureaus, science-production associations, and private enterprises are involved in development and production of solar hot-water heaters, solar photovoltaics, wind turbines, and small geothermal plants.

ANNEX: INTERNATIONAL TECHNOLOGY TRANSFER MODELS AND FRAMEWORKS

Sagafi-nejad (1991) characterizes the literature on technology transfer into four distinct clusters of variables: technology characteristics, transfer modes and approaches, organizational parameters, and a broad set of environment characteristics of both home and host countries. Much of the literature could be viewed as an attempt to explain the impact that these variables have on the transfer process (for example on decisions to transfer or to seek transfer, and the impacts on the supplier and receiver), as well as the links and dependencies between the variables themselves. Technology characteristics can be measured on scales like capital-intensive versus labor-intensive, proprietary versus public domain, complex versus simple, and product versus process. Common transfer modes and approaches are direct sales of equipment and services, technical assistance contracts (consulting), turnkey projects, wholly-owned subsidiaries, joint ventures, license-only agreements, license-plus-technical-assistance agreements, co-production, R&D agreements, personnel-exchange agreements, and simple information transfers (documents, conferences, etc.). Organizational parameters include the attributes of supplier and recipient entities, like management structures, decision-making processes, and whether they are public (governments, municipalities, state-owned enterprises, multilateral and bilateral agencies), private (multinational corporations or single firms), or other (NGOs, educational institutions, media, etc.). Environment variables include a wide range of economic, cultural, political, administrative-legal, and infrastructure conditions and factors.

Robinson (1991) presents a general model of technology transfer, which he hopes will provide the basis for unifying future research and empirical studies. The three main decisions (dependent variables) that a supplying entity makes about technology transfer are the choice of technology, the mode of transfer (decision to transfer externally or internally), and the decision to transfer (propensity to transfer). These decisions are dependent on four main groups of independent variables: perceived costs, perceived risks, anticipated benefits, the cost of modifying the technology, and supplier government and recipient government policies and regulations. These independent variables can be resolved into many economic, organizational, legal, and administrative factors. On the recipient side, the decision to seek foreign technology, the mode of transfer desired, and the choice of technology are the dependent variables, which are also related to the same types of independent variables as the supplier side. A comprehensive list of transfer mechanisms and organizational links completes Robinson's model (Table 8).

Reddy and Zhao (1990) provide a very comprehensive review of the work on international technology transfer over the past three decades, with a bibliography listing over 200 entries, much of this from business and management schools. They provide an organizing framework for the literature that includes three main perspectives: the home country perspective (also called the "supplier" or "sender" by some), the host country perspective (also called the "recipient" or "receiver" by some), and the transaction perspective. Issues in the home country perspective include impacts on the home country, government policy, and multinational corporations strategies and decisions. Issues in the host country perspective include impacts on the host country, government policy, technological capability and appropriate technology, and technology acquisition and adaptation. Issues in the transaction perspective include the role and nature of technology transfer, costs and benefits, conflict and codes of conduct, modes, effectiveness, and pricing. The important factors, according to the studies reviewed by Reddy and Zhao, for the determinants of transfer mode, effective transfer, technology choice, and transfer mode, are shown in Table 9.

Many other technology-transfer models have been advanced over the previous 20 years, but after reviewed them, Yager (1991) concludes that the Robinson model is arguably the most comprehensive in an international context. However, the Robinson model lacks an ex-post element; that is, it represents the process only up to the decision (contract) to transfer technology. One other notable model is that of Samli (1985), which includes five key components: the sender, the technology, the receiver, the aftermath, and the assessment. The principal independent variables are the needs and willingness of the sender and receiver to engage in transfer, barriers caused by sender or receiver, characteristics of the receiver in terms of markets, raw materials, labor, know-how, and ability, and the supplier's knowledge of these characteristics. The aftermath includes questions of whether transferred technology "works," contributes to continuing innovation, and meets the original objectives of both sides. The assessment relates to the longer-term process of technology diffusion and how that relates back to future transfers.

McIntyre and Papp (1986) define the international technology process according to six main elements: (1) the transfer item and its characteristics; (2) the supplier; (3) the recipient; (4) the transfer mechanism or channel; (5) the rate of diffusion (both to a specific recipient and also to the larger society as a whole); and (6) the absorptive capacity of the recipient. For them, the choice of transfer mechanism is critical. Some mechanisms are more active or effective, while others are more passive or ineffective. Different mechanisms will involve different agents with different legal rights and responsibilities, and will affect the costs and benefits to both supplier and recipient, the externalities generated through the transfer, the actual amount of technology transferred, and the levels of control on both supplier and recipient sides. For example, in direct equipment transfers, the knowledge transferred is slight, the control primarily on the supplier side, and the benefits greater to the supplier (in accordance with the high value-added and the monopolistic returns of technology). They conclude that the choice of transfer mechanism is not merely a "value-free" (after Goulet 1977) technical or economic one, but rather one with political implications for the distribution of externalities, costs and benefits of the transfer.

TABLE 8:
INTERNATIONAL TECHNOLOGIES TRANSFER ENTITIES, MECHANISMS, AND LINKS
(ROBINSON 1991, P.16)

Supplier and Recipient Entities

Public:	Regional or global authority
	National government, agency, or enterprise
Public/ private:	Non-profit organization
	Educational institution
	Professional organization
Private:	Single firm or national joint venture
	Partnership
	Consortium (national or multinational)

Transfer mechanisms

General information flow
Teaching/training
Sale and purchase of good or services
License
Technical assistance contract
Contract manufacturing
Production sharing
Co-production
Architecture and engineering
Consulting
Research and development
Construction supervision
Construction
Turnkey contract
Turnkey-plus

Organizational links (related transfers; unrelated can be anything)

Agent
Branch
Subsidiary
Equity joint venture
Partnership
Strategic alliance

TABLE 9:
FACTORS FROM THE INTERNATIONAL TECHNOLOGY TRANSFER LITERATURE
(REDDY AND ZHAO 1990)

1. Determinants of transfer mode

■ competition faced by the supplier firm
■ age of the transferred technology
■ nature of the transferred technology
■ importance of the technology to the supplier firm
■ industry characteristics
■ size of the supplier firm
■ supplier firm's foreign manufacturing experience
■ strategy of the supplier firm
■ supplier's technology-transfer experience
■ public policy of host country
■ recipient firm's characteristics
■ characteristics of the host country
■ bargaining power between the two contracting parties

2. Determinants of effective transfer

■ commercial experience of supplier firm in host country
■ degree of technological competition among supplier firms
■ willingness and ability to transfer technical knowledge
■ supplier firm's organizational structure
■ absorptive capacity of the recipient firm
■ level of technological development of the host country
■ characteristics of the host country
■ mode of transfer
■ relationship between interacting firms and countries
■ training

3. Determinants of technology choice by supplier

■ cost / microeconomic determinants
■ maturity and characteristics of the technology
■ nature and degree of competition faced
■ characteristics of supplier firm

4. Determinants of technology choice by recipient

■ costs / microeconomic determinants
■ nature and degree of competition faced
■ degree of new technological knowledge gained
■ macroeconomic conditions
■ prestige of supplier in the host country and in international markets

TABLE 9 CONTINUED

5. Determinants of transfer costs

- size and nature of demand
- production costs
- institutional differences between home and host countries
- labor-intensive (higher) versus capital-intensive (lower)
- learning curve (higher when lower on learning curve)
- size of supplier firm
- age of the technology
- degree of the technology diffusion
- understanding of the transferred technology
- recipients' R&D capacity
- recipients' general manufacturing skills
- levels of the host country's development

ANNEX: MAFIA AND CORRUPTION IN RUSSIA

A presidential report issued in January 1994 to President Yeltsin claimed that 70-80 percent of private enterprises and commercial banks in Russia pay 10-20 percent of their turnover to mafia, in the form of payoffs, kickbacks, blackmail, embezzling, and monopoly pricing (Handelman 1994). In return these businesses receive protection, loans, and debt collection and contract enforcement services. According to the Russian Ministry of Internal Affairs, organized crime controlled as much as 40 percent of the turnover in goods and services by 1993. In the absence of government regulation, criminal cartels have infiltrated banks, real estate markets, stock exchanges, and even the rock music industry.

Facts and data about organized crime in Russia are understandably hard to obtain. Stephen Handelman (1994) compiled some of the best material on organized crime while he was Moscow Bureau Chief of a Western newspaper from 1987 to 1992, through private interviews with leading police officials, politicians, and gangsters themselves. He estimates that between 3000 and 4000 gangs operate in Russia. A senior official in the Interior Ministry, responsible for crime prevention in Russia, put this figure at 4500 (Business World Weekly, 5/14/93, "Racket in Russia"). While total active membership may be below 100,000, "the hazy boundary between criminal and legal business activity has allowed mafia groups to penetrate most areas of the Russian economy, giving them disproportionate influence" according to Handelman (p.83).

Published sources suggest that the mafia in fact provides an indispensable service for many businesses: protection of property rights. In Western countries, this service is provided by government and associated police forces, the courts, and a strong "rule of law." In Russia these elements are much weaker and less able to provide property-right protection. If a contract is broken there is usually no recourse in the courts. Delinquent debtors can be sued in arbitration court, but this involves great expense and long delays. Therefore, property rights are enforced by the physical power of individual gangs, codes of conduct between gangs, and a "rule of murder" where those who do not follow the rules are executed. Many Western businessmen accept the mafia as a necessary cost of doing business, and even appreciate the stability it provides (Business World Weekly, 5/14/93, "Racket in Russia"). One businessman said the mafia was there the day he opened a retail store. They estimated his expected turnover and profits in a very professional manner and asked for their share. Yet by making his payments he does not receive any trouble from them or anyone else.

The word "mafia" general encompasses a wide range of activities: businesses that sell stolen goods, street thugs who control and protect retail businesses, white-collar business crime, organized crime syndicates, and corrupt government officials. Much of the "white-collar" crime involves illegal financial transactions (bank transfers, stocks, bonds), privatization fraud or abuse, and illegal real-estate deals. Such crime is prevalent because of the absence of any laws or regulations governing these types of activities. Other forms of criminal activity include property theft (cars, military arms, raw materials, and commodities including oil, gas, and gasoline), narcotics, prostitution, kidnapping, and extortion.

More than half of all criminal groups have ties to the government bureaucracy itself, which greatly extends their power and also provides a way for government officials to practice "politics by other means" by using criminal activity for political purposes. The former nomenklatura of the Communist Party, who had vast power and privilege in the old system, use links to organized crime to perpetuate this power: "Mounting evidence indicates that nomenklatura capitalists use organized crime groups as instruments in the fierce struggle over the spoils of the former Soviet Union: the industries, banks, defence facilities, port and factories once exclusively controlled by the Communist Party" according to Handelman (p.84).

The criminal groups and their ties to government did not appear overnight with the collapse of Communism, but have deep roots going back decades in the Soviet Union. The word "mafia" originally described the networks of corruption within government ministries themselves and within the supposedly pure Communist Party under the old Soviet system. Yet "Perestroika was the real beginning of organized crime," commented a Ministry of Internal Affairs official (p.86). The secret wealth accumulated by underground tycoons and party barons found a legitimate outlet when the government expanded the permissible area of private commerce. Black and grey money poured into the stock exchanges, joint ventures, cooperatives, banks and joint stock companies that were otherwise celebrated abroad as harbingers of economic reform.

And for Western business interested in Russia? Handelman continues, "If the obstacles in the Russian marketplace hamper Russian entrepreneurs, they have a chilling effect on foreigners, for whom the nexus between organized crime and politics exacerbates the cultural barriers between the ex-socialist East and capitalist West. Bribery was always a hidden cost of doing business in the Soviet era. Today, the hapless foreign businessman can find himself the target of extortion demands or worse" (p.94).

Most evidence of organized crime must come of necessity from anecdotes. One press report said that in mid-1993, police in Toliatti in the Volga region arrested a gang who had demanded that the management of a local auto plant producing Lada cars pay them for the "privilege" of safely transporting its cars to other regions of Russia. The payment demand was every tenth car sold (Business World Weekly, 5/14/93, "Racket in Russia"). Another report claimed that Moscow's Sheremetevo International Airport had been "taken over" by Mafia gangs, who now controlled all commercial activities at the airport, including cargo handling, ticket selling, aircraft maintenance, and even the airport security service itself (Business World Weekly, 4/25/94, "Mafia Takes Sheremetevo Airport in Hand?"). In 1992 Chechen gangs attempted to swindle about $350 million from private banks in Moscow using false promissory notes. Some believed the gangs were being used as an instrument of the Ministry of Finance to undercut newly emerging private banks (Handelman 1994).

In the context of technology transfer and energy efficiency, the mafia is important for several reasons. Criminal activity, to the extent that it affects activities like private business investments, government investment decisions or priorities (and even policies), energy supply price or availability, and import/export conditions, will affect technology transfer. Any special incentive plan or policy must be viewed in the context of the potential for corruption and crime. For example, attempts to pay for foreign investment in energy efficiency through export of the "saved energy," as advocated by the United Nations ECE "Energy Efficiency 2000" program, are wide open to corruption. Large, central energy-efficiency investment funds are prime targets for corruption and behind-the-scenes control of how the money is spent and where, especially when the sums are large and when foreign currency is involved. On a smaller level, any profitable venture to produce or provide energy-efficiency related products is subject to a cut of the profits by the mafia, and/or payoffs to make it viable in the first place. These cuts add to the cost of doing business, and are often distasteful to Western businessmen, who would just as soon go elsewhere.

ANNEX: METHODOLOGICAL APPROACHES TO THE RESEARCH

This dissertation has taken methods from several of the literatures it addresses: energy efficiency, renewable energy, and technology transfer. These methods range from technology assessment, comparative assessment, and empirical and comparative economic analysis, to simple inductive reasoning and argumentation.

Since part of the research involved interviews and social-science data and explanations, several different social-science (sociology and anthropology primarily) methodological literatures were consulted in the course of conducting this research. I reviewed literature on traditional social science research methods (Baily 1987, Selltiz 1962, Hoover 1992), comparative methods (Smelser 1979), and interpretative social science methods (Rabinow and Sullivan 1979). Case study methods were also very useful (Yin 1989, Burawoy et al 1991). Originally I intended to collect most case study data as a participant observer in a few selected case studies, and so reviewed this literature (Jorgensen 1989). But once in the field I realized that most of the data I needed could be collected through interviews and site visits as an outside observer, and direct participation was too limiting and time consuming to allow the breadth of information I required from a multiplicity of case studies and subjects. Literature on ethnography (Burawoy et al 1991) and cultural interpretation (Geertz 1973) proved useful for trying to think about and describe cultural differences between "Russian" and "Western" culture. Czarniawska-Joerges (1992) provided useful insights on the process and methods of understanding the anthropology of organizations, and the differences in research methods between sociologists and anthropologists.

Social-science related methods used in this research were in the interpretive tradition typified by Weber -- interpretation of specific historical processes, often through unstructured interviews, participant-observation, ethnography, document study, and in-depth analysis of specific cases -- rather than in the positivist tradition typified by Durkheim -- generalizable laws uncovered through surveys, experiments, and quantitative techniques and analysis. The extended case method, described by Burawoy et al (1991), provides a basis for the analysis here. The purpose of the extended case method is to "reconstruct theory out of data collected through participant observation" (p.271), according to Burawoy. With the extended case method, each case is analyzed not for the generalizations possible to other similar cases (statistical generalization to a larger population), but "looks for specific macro determination in the micro world" (p.279):

> In the genetic mode [of the extended case method] the significance of a case is related to what it tells us about the world in which it is embedded.

While statistical generalization from a multiplicity of cases is a traditional positivistic approach, generalization through the extended case method is validated by reconstructing existing generalizations.

The interpretive case method (typified by Geertz, 1973) is also relevant to my research. This method looks for the inherent social and cultural meaning in a particular case. In contrast to the extended case method, the interpretive case method collapses the general and particular, such that each particular case is seen as an expression of the general. "It is as if the whole lodges itself in each part in the form of a genetic code, which has to be uncovered through a process of hermeneutic interpretation" (Burawoy et al 1991, p.272). Geertz called the process "thick description" and wrote:

> Believing, with Max Weber, that man is an animal suspended in webs of significance he himself has spun, I take culture to be those webs, and the analysis of it to be therefore not an experimental science in search of law but an interpretive one in search of meaning." (p.5)

The case studies presented here are particular instances of historical events (specific activities taking place between 1992-1994), analyzed within a larger historical background and context (the Soviet Union's planned economy over 70 years and the transition and transformation of that economy after 1991). I use the case studies to illustrate and build generalizations about the macro world (for example, technical-economic potential and transaction barriers), and also to reconstruct existing perspectives (actually, to construct a "hybrid" Russia with elements from developed country, developing country, and Soviet Union perspectives). Social and cultural meanings within particular cases, following Geertz, also have been extracted, as for example in culture-related transaction barriers like technological pride, and in the meaning of renewable energy as a source of jobs and autonomy.

Part of my approach fits the metaphors and characterizations of anthropological field research put forth by Czarniawska-Joerges (1992, pp. 186-225). She calls the process of data collection "gathering insights," and likens the process to traveling:

> Some people will not depart without complete knowledge of the place they are going. I usually know the name of the place and the plane departure time. After having returned, I begin to devour information that helps me make sense of my experience. When all is said and done, anthropology might, after all, be seen as a frame of mind. (p.193)

It was true that part of my literature review and study of contemporary Russia occurred after I returned from tours of field research, as I attempted to "make sense" of the data I had collected. It was a very iterative process. In this sense my approach shared attributes with that of grounded theory, in which field data are not collected to support a pre-established hypothesis, but rather are collected according to some particular conception of "relevance" and then compared for generalizations present, in order to construct new theories.

Czarniawska-Joerges' strategy for data analysis is what she calls an "account of accounts" in which explanations of a complex situation are attempts to account for the accounts of others (as understood from interviews, documents, statements, etc.) and to tie these accounts into a meaningful story. This story should make sense even (and especially) where different accounts contradict each other. In the end she believes that "truth is in experience fit." In the end I have tried to ground my arguments in their fit to the experience from the case studies, while bolstering them with views and theories from the literature.

Interviews and document study provided a wealth of data about the case studies. Of course interviews are prone to bias from lying, unconscious mistakes, accidental errors, memory failures, and interviewer errors. Interview subjects may respond to please the interviewer or to make their situation or subject appear in a favorable light for reasons of self-promotion. Document study is prone to problems like bias (from the goals and purpose of a given document), selective survival (only some documents survive), incompleteness (no chance for follow-up), and is limited to written (primary analytical) expression. As much as possible I attempted to gather more than one opinion (interview response) and to "triangulate" from different interview responses, document sources, or published articles in newspapers and journals. Often interviews simply highlighted the importance or existence of one factor or another, and I was able to follow up and verify a particular area once highlighted with more detailed and reliable printed sources and other interviews. Some people I interviewed several times over the course of weeks and months, which led to much greater rapport, correction of prior misunderstandings and misinterpretations, and an in-depth understanding of key issues. Interviews were often dialogues or conversations with considerable time spend on conceptual understanding and clarification, rather than question-and-answer sessions. As an interviewer I was fairly neutral in terms of my demeanor, dress, attitude, and who I represented. Interviewees were generally cooperative, unthreatened, and interested in helping a "scientific investigation." As I represented the University of California, my interest was considered neutral and not in conflict with any interests that the interviewees had. In particular, I had nothing concrete that they wanted (except perhaps greater contacts with the West that could mean trips abroad) that might bias their response.

Reliability and validity were constant concerns during the research (preferable terms to me have been cited by Czarniawska-Joerges: reliability and validity are better expressed as "truth value" (internal validity), "applicability" (external validity), "consistency" (reliability), and "neutrality" (objectivity)). Reliability is especially difficult in this type of research because the results are extremely dependent on the specific researcher's actions and experiences. The lists of documents, material sources, conferences, and persons (positions) interviewed documented here would help to establish the reliability of further or parallel inquiries.

Internal validity is bolstered by the large number of interviewees, documents, and case studies, which taken together provide a fairly robust picture of existing conditions, circumstances, and views. One problem related to internal validity is the absence of case studies that were never realized and thus were not amenable to identification and investigation. But many of the case studies included here do in fact contain elements or projects that were not realized. By focusing on the main organizations working in Russia during this period, both commercial and public, I was able to learn of their realized successes, and partly of their unrealized or abandoned work. Literature sources have supplemented the case studies, and helped to fill the gap represented by those Western organizations that never even started working in Russia, and thus whose attempts are not represented in the case studies.

External validity must be appraised in the context of the overall arguments of the dissertation, and ultimately the robustness and plausibility of these arguments gives an indication of the external validity.

ANNEX: MULTINATIONAL CORPORATIONS LITERATURE, JOINT VENTURES, AND FOREIGN INVESTMENT

The traditional neoclassical approach to foreign investment and trade is that capital and goods move from countries with surplus capital and deficit labor (low capital and high labor costs) to countries with scarcities of capital and surplus labor (high capital and low labor costs), either as export of capital-intensive goods or as capital transfers to countries with comparative advantages in cheap labor. In this traditional view, final goods, labor, capital, and technology are all simple commodities that are produced and consumed according to comparative advantage. After the 1940s, as the bulk of international investment occurred between cheap-capital and expensive-labor developed countries, it was clear that new explanations were needed. While international theories of trade have remained rooted in this neoclassical view, new theories of foreign investment, production, and the multinational firm have emerged.

According to Gilpin (1987), "although a unified theory that explains all cases of foreign direct investment has yet to be developed, the principal factor explaining the multinational corporation is the increased importance of oligopolistic competition as one of the preeminent features of the contemporary world market economy" (p.234). Two of the more recent theories on multinational corporations are the "product cycle" theory and the "industrial organization theory of vertical integration." In the product cycle theory, international trade and investment results from the development and evolution of technologies through innovative, maturing, and standardized stages. The comparative advantage of individual countries well-suited to particular stages of certain technologies means that as technologies mature or as comparative advantages change, technological production will shift from country to country. The industrial organization theory of vertical integration says that corporations will transfer investment abroad internally to take advantage of some firm-specific advantage in the foreign country, such as technical or managerial skills or economies of scale. According to this theory, firms integrate vertically in order to reduce transaction costs, then attempt to exploit their technical knowledge, and then expand this vertically integrated structure through production in locations where they possess an advantage.

Aside from comparative advantage, technology, and vertical integration, trade barriers can also explain patterns of foreign investment. "The dramatic rise of trade barriers around the globe.....has become the most important determinant of foreign investment in both developed and less developed economies. Corporations have learned that they must establish foreign subsidiaries in a growing number of countries or enter into joint venture or other arrangements with local firms in order to reach protected markets" (Gilpin 1987).

According to Cantwell (1991), international production and multinational corporations can be analyzed at three levels: macroeconomic (national and international trends), mesoeconomic (interactions of firms at an industry level), and microeconomic (growth and decisions of individual firms). At the macroeconomic level, theories of trade, location, and balance of payments and exchange rate effects apply. Theories of industrial economics, games, and innovation apply to the mesoeconomic level, and theories of the firm apply at the microeconomic level. There are two dominant micro-level theories. One view sees the firm as an agent of market power and collusion, in which investment is a means of further extending collusive networks, reducing competition, and by increasing barriers to entry in their industry. Another is the so-called internalization approach based upon a Coasian view of the firm as a means to raise internal efficiency by replacing markets.

Hennart (1991) demonstrates that a wide variety of the types of foreign direct investment undertaken by multinational corporations can be explained with transaction cost theory. "The existence of [multinational corporations] puzzles traditional microeconomists" (p.82) because in a perfect market the extra costs of doing business abroad usually would put the firm at a disadvantage. If a firm possess advantages abroad (resources, technologies, distribution systems, etc.), why not sell or rent them to a local firm? Many have pointed to market imperfections in exploiting these advantages which can lead to gains for multinational corporations. Transaction cost theory of the multinational corporation maintains that these market imperfections are inherent (in fact "natural") attributes of markets and that multinational corporations are institutions for bypassing these imperfections. Instead of price signals performing the three essential economic functions -- informing actors of others's needs, rewarding them for productive behavior, and curbing bargaining -- the hierarchy of a multinational corporation can perform these functions more efficiently if market transaction costs are present or market prices are flawed due to "bounded rationality."

This strand of theory sees multinational corporations as a response to imperfect markets for technology transfer, and their decisions on the forms of transfer depend upon the transaction costs involved (Safarian and Bertin 1987). If transaction costs are high, then an internal transfer is preferred (Contractor 1991), but in general "transaction costs may in fact be low and not pose a large barrier in many cases" (p.63). These transaction costs include the direct costs of negotiating and transferring the information and capability to the other firm and training their personnel. They can also include the potential costs of creating future competitors with the technology past the term of the agreement or through diffusion effects.

While wholly-owned subsidiaries have traditionally been the dominant modes of foreign investment, international joint ventures have been growing in number throughout the 1980s. Three reasons for this trend advanced by Datta (1988) are that host governments are increasingly requiring foreign investment in the form of joint ventures (India for example), multinational corporations began to realize that the knowledge of complex and volatile local business environments by local partners can be a significant asset, and the growing trend to internationalize business to reduce costs. Gilpin cites increasing requirements by host countries for local participation and more joint ventures, export of local production, increased local content in final products, and restrictions on the repatriation of profits as indicators of developing countries' will to increase their own benefits from foreign investment (p.251). Gilpin goes on further:

> The shift from wholly owned subsidiaries abroad to joint ventures and other forms of intercorporate alliances has been accelerated by a number of political, economic, and technological factors: (1) access to a market frequently requires a domestic partner; (2) the rapid pace and cost of technology necessitates that even large corporations spread the risk; (3) the huge capital requirements of operating globally and in all major markets; (4) for American firms, the loss of technological leadership; (5) for Japanese firms, to forestall protectionism. (p.254)

Datta (1988) outlines a framework of issues related to international joint ventures. These include environmental factors influencing the feasibility and desirability of joint ventures; joint venture objectives by supplier, recipient, and host government; strategy alternatives; the benefits from ventures; and issues of implementation and management, including cultural and administrative impediments. Environmental factors can be reflected in perceived opportunities: some "see joint ventures as providing competitive advantages through the realization of potential synergistic benefits in situations that allow the sharing of complementary skills and resources" (Datta, p.80). Supplier objectives can be: reduction of economic and political risks, reduced capital requirements, entering new unfamiliar markets, etc. Recipient objectives are much more likely to be related to access to new technologies and brand-names or trademarks of the foreign partner and capital. "Transfer of technology probably constitutes the single most important reason why firms in developing countries seek joint ventures with organizations in technologically-advanced countries" (p.82). And "joint ventures offer a unique opportunity of combining the distinctive competencies and the complementary resources of participating firms" (p.86). Benefits from joint ventures can be economic, such as economies of scale and cost reductions, informational, as in knowledge of local market-related information, but "in fact, the biggest set of benefits in a joint venture are often 'political' in nature" (p.86) in terms of the local partner's relations with local government authorities and institutions.

Contractor (Rosenberg and Frischtak 1985) looks at corporate selection of either direct foreign investment or licensing (arms-length or joint venture) as primary strategies (modes) of transfer. He finds that generally licensing is a substitute rather than a compliment to direct foreign investment. Through a statistical analysis of U.S. investments and licensing abroad with 30 other countries, half industrial countries and half developing countries, he concludes that the ratio of licensing to direct investment increases with technical capability in the recipient country (as measured by research expenditures and research population normalized by population), a restrictive investment environment, and less research-intensive technologies. Licensing is negatively related to higher per-capita GDP and level of industrialization in the recipient country.

Kogut (1988) provides three explanations for joint venture motivations. In addition to the traditional two -- the transaction cost and strategic behavior (which parallel the internalizing and market power theories discussed above) -- he adds a third, joint ventures as a vehicle for transfer of organizational knowledge and learning. In this third perspective, some forms of tacit knowledge can only be transferred through a joint venture because the knowledge is organizationally embedded and not conducive to licensing or other forms of transfer.

ANNEX: REGIONAL VARIATION OF TECHNOLOGY-TRANSFER PROPENSITY

The following factors were evaluated for each of Russia's 89 regions to determine in which regions future technology-transfer and cooperation in energy efficiency and renewable energy is more likely to occur. This information is summarized in Table 10 below, and is organized according to three groups of regions according to the likelihood of international technology transfer and cooperation occurring in that region. Map 7 shows the most likely regions as implied by this analysis.

A. Very high or high electricity prices
B. Very high or high heat prices
C. Energy shortages
D. Local energy or raw material resources that can pay for investment
E. Foreign representatives/business/projects underway in efficiency or renews
F. Close proximity to other countries (road, rail, water, international airport)
G. Good wind or solar energy resources available
H. Especially pro-free-market by administration and/or "Free Economic Zone"
I. Especially high unemployment regions seeking to create jobs
J. Defense/industrial infrastructure with highly skilled workers available
K. Strong political desire for increased political and/or economic autonomy
L. Demonstrated interest in energy efficiency or renewable energy (projects, funds)
M. Public support of alternatives to nuclear power and/or conventional energy
N. Designated by expert opinion as favorable
O. High share of foreign investment and/or joint-ventures
P. Ministry of Fuel and Energy proposed Russian-American efficiency projects
Q. Economic and financial stability

These factors are discussed individually and analyzed for Russia's 89 regions below (results summarized in Table 10). The analysis is a composite of many sources, both printed and personal.

A. Very high or high electricity prices. Three regions had very high average electricity tariffs (as set by regional energy commissions) above 100 rubles/kWh in June 1994 (above 5 cents/kWh): Kamchatka, Sakhalin, and Magadan. Industrial tariffs in these three regions were 160-220 rubles/kWh (8-11 cents/kWh). Eleven more regions had high average tariffs of 60-100 rubles/kWh (3-5 cents/kWh): Amur, Buryatia, Chita, Chelyabinsk, Kalmykia, Kaliningrad, Karachay-Cherkessia, Komi, Kurgan, Tver, and Yakutia-Sakha. Industrial tariffs are significantly higher than these average rates (up to 160% higher in 1993 on a nationwide average), and the highest industrial tariffs, those above 70 rubles/kWh in June 1994 (above 3.5 cents/kWh) were found in the above regions plus Vladimir, Ivanovo, Voronezh, Tambov, Kabardino-Balkaria, Archangel, Stavropol, Kirov, and Altay. (Wilson et al 1994)

B. Very high or high heat prices. Fourteen regions had average heat prices (as set by regional energy commissions) more than twice the national average in June 1994 of 125 rubles/Gcal. Regions with heat prices above 250 rubles/Gcal (12.5 cents/Gcal) were Vladimir, Voronezh, Kaliningrad, Karelia, Murmansk, Kirov, Kurgan, Tomsk, Amur, Maritime, Kamchatka, Sakhalin, and Khabarovsk. In heat supply, as opposed to electricity supply, industrial heat tariffs are not substantially greater than average tariff levels. (Wilson et al 1994)

C. Energy shortages. Electric power capacity shortages are especially acute in the North Caucasus regions (Rostov, Krasnodar, Stavropol) and in the Far East regions (Maritime, Khabarovsk, Amur, Chita, Sakhalin). Electricity and heat shortages in the Far East regions and in some Siberian regions are acute because of fuel delivery problems. The Far East regions, aside from one hydroelectric plant, must import all fuels for electricity and heat production from elsewhere.

D. Local energy or raw material resources that can be used to pay for investment. Significant oil resources exist in Komi, Perm, Bashkortostan, Tatarstan, Samara, Orenburg, Volgograd, Stavropol, Dagestan, Tyumen (including Khanti-Mansi A.R. and Yamal-Nenets A.R.), and Tomsk. Significant gas resources exist especially in Yamal Nenets A.R. Gold, platinum, diamonds, and other high-value commodity resources exist in Yakutia-Sakha, Magadan, Archangel, and Chelyabinsk.

E. Foreign representatives/business/projects already underway in energy efficiency or renewable energy. Danfoss Russia has been active in several regions, including Moscow, Kemerovo, Tatarstan, and Samara (Toliatti). Honeywell so far has concentrated primarily in Moscow and St. Petersburg, and also Yekaterinburg. USAID conducted district-heating system audits in Kostroma and Yekaterinburg, and awarded a major district-heating commodity import grant to Vladimir. A joint German-Russian project to install wind turbines has been occurring in Saratov. IVO International has been working on projects in Karelia, Tver, Moscow, Tyumen, Chelyabinsk, Volgograd, Vologda, Altay, and Perm. A U.S. EPA financed project for developing integrated resources planning for regional utilities is underway in the North Caucasus regions (Rostov, Stavropol, and Krasnodar). The World Bank gas distribution rehabilitation and end-use efficiency loan in 1994 provides capital to the regions of Volgograd, Saratov, Voronezh, and Ryazan.

F. Close proximity to other countries (road, rail, water, or international airport). Proximate road and rail transportation to Finland and the Baltics is from Karelia, Leningrad, Pskov, Novgorod, Tver, Smolensk, Moscow, Yaroslavl, Kaliningrad, and Vologda. Proximity to Japan and the Pacific Ocean is from Kamchatka, Khabarovsk, Maritime, Sakhalin, and Magadan. Proximity to China is from Gorno-Altay, Tuva, Irkutsk, Buryatia, Chita, Amur, and Jewish AO. International airports exist in Leningrad, Moscow, and Vladivostok. The Mediterranean via the Black Sea is proximate to Krasnodar, Rostov, Stavropol, and to a lesser extent Volgograd and Kalmykia. The Baltic Sea via inland waterways is accessible to Yaroslavl, Kostroma, Ivanovo, Nizhniy Novgorod, and Tatarstan. In terms of existing joint ventures, "regions of concentration of joint ventures (are especially located in the) frontierside, seaside and riverside territories" (Popova 1993a).

G. Good wind or solar energy resources available. Good wind resources may be found in the North Caucasus regions (Rostov, Krasnodar, Stavropol, Kalmykia, Astrakhan', Dagestan), along the lower Volga (Volgograd, Saratov), along the Pacific Coast regions (Sakhalin, Maritime, Kamchatka, Khabarovsk, Magadan), near the Gulf of Finland (Leningrad, Karelia), and in the far north (Murmansk, Archangel, Nenets AO, Komi). (Martinot 1992, interviews with head of renewable energy department of national electric power utility RAO "EES Rossii," 4/28/94 and 9/16/94). Solar resources may be found in some southern regions, particular the North Caucasus regions (Rostov, Krasnodar, Stavropol, Kalmykia, Astrakhan', Dagestan), Volgograd, and Altay.

H. Especially pro-free-market by administration and/or "Free Economic Zone." The leaders in this category are Nizhniy Novgorod and Samara. Free Economic Zones are Altay, Kemerovo, Leningrad, "Nakhodka" (in Maritime), Novgorod, Sakhalin, and "Yantar" (in Kaliningrad) (US Department of Commerce 1993).

I. Especially high unemployment regions. Unemployment in 1994 was expected to grow in all regions. Regions with high current and future projected unemployment include Ivanovo, Yaroslavl, Kirov, Vladimir, Pskov, and Kostroma, as well as Dagestan, Udmurtia, Kalmykia, and Mordova. Other regions with large potential unemployment numbers in the future are Kurgan, Archangel, Murmansk, Tambov, Chuvashia, Komi, Chechenia, and Ingushetia.

J. Defense/industrial infrastructure with highly skilled workers available. Such areas include Novgorod, Kaluga, Voronezh, Udmurtia, Novosibirsk, Omsk, and Magadan, all of which are estimated to have 40 percent or more of total industrial employment in the military-defense sector. The military-defense sector also has a large presence in Leningrad, Mari-El, Moscow, Mordova, Nizhniy Novgorod, Saratov, Samara, Perm, Pskov, Yekaterinburg, Tatarstan, Tula, and Novosibirsk, although these regions are more diverse than the first group. Other highly industrial regions are also likely. (Sagers 1992)

K. Political desire for increased political and/or economic autonomy. This could be said of most of the ethnic republics. But only in those regions with political and social stability and few separatist tendencies can this characteristic be viewed positively. Stable republics include Tatarstan, Buryatia, Karelia, Kalmykia, Yakutia-Sakha, Gorno-Altay A.R, and Jewish A.R. Questionably stable republics, which do not have separatist tendencies but which still may experience ethnic strife include Komi, and the smaller republics in the Volga-Vyatka region -- Chuvashia, Mari-El, Udmurtia, and Mordova. Unstable republics tending towards separation from the Russian Federation especially include those in the North Caucasus -- Chechenia, North Ossetia, Ingushetia, Abkhazia, Adyge, Karachay-Cherkessia, Kabardino-Balkaria, and Dagestan. Another unstable situation exists in Tuva, which borders Mongolia, Among ordinary regions, Yekaterinburg and Maritime Territory have both been vocal in desires for greater autonomy.

L. Demonstrated interest in energy efficiency or renewables (projects, funds). Energy-efficiency funds have been established in Moscow, Chelyabinsk and Khabarovsk. Karelia has shown explicit interest in energy efficiency, having held a major conference on energy efficiency in 1994. A center for energy efficiency exists in Moscow and Chelyabinsk. The first-ever energy-service company outside of Moscow was established in Kostroma. Domestic renewable energy projects, demonstrations, and/or research facilities are located in Leningrad, Kalmykia, Astrakhan, Dagestan, Stavropol, Rostov, Komi, Karelia, and Maritime. Wind projects with foreign participation have occurred in Saratov, Crimea, and Maritime, with some activity in Leningrad. (Wind Power in Russia Conference, Moscow, 4/28/94-4/29/94, Moscow International Energy Club meeting, 2/26/94, interviews with senior researcher and director of Moscow Center for Energy Efficiency, 9/7/94 and 8/17/94).

M. Public support of alternatives to nuclear power and/or conventional energy. Regions where additional nuclear power is planned, disputed, or already canceled include Maritime, Tomsk, Krasnoyarsk, Chelyabinsk, Rostov, Kostroma, Saratov, Tatarstan, Bashkortostan, and Nizhniy Novgorod. Public environmental movements are also especially strong in Tver and Perm. The governor of Nizhniy Novgorod is a very progressive, young mayor with roots in environmental movement. (Interview with head of Socio-Ecological Union energy group, 9/7/94, Sagers 1992, Martinot 1992)

N. Designated by expert opinion as favorable. Staff of the Moscow Center for Energy Efficiency have offered their assessments, which provide a general agreement on the following twenty regions in terms of a combination of different factors: Moscow, Leningrad, Kostroma, Vladimir, Samara, Tatarstan, Kamchatka, Khabarovsk, Maritime, Sakhalin, Chelyabinsk, Yekaterinburg, Nizhniy

Novgorod, Karelia, Tula, Yaroslavl, Omsk, Stavropol, Krasnodar, and Rostov. (interviews with senior researcher and director of the Moscow Center for Energy Efficiency, 9/7/94 and 8/17/94)

O. High share of foreign investment and/or joint ventures. For 1993 the regions with the highest foreign investment per-capita included Moscow, Krasnoyarsk, Omsk, Archangel, Jewish AR, Belgorod, Mari El, and Komi. Together these eight regions absorbed over 70% of total foreign investment in 1993, which was $2.9 billion (Business World Weekly, 9/13/94, "Foreign Investments in Russia"). Another source gave the top ten regions for foreign investment in the first quarter of 1994 as Moscow, Archangel, Tomsk, Novosibirsk, Irkutsk, Leningrad, Sakhalin, Karelia, and Vladimir (Business World Weekly, 8/8/94, "Foreign Investment in Russia"). The German government was to loan 1 billion German marks to enterprises in the Chelyabinsk region for capital investment purposes in late 1994, and Ernst & Young in late 1994 considered the investment climate in Chelyabinsk to be favorable. In terms of joint ventures established, the leading regions are Moscow, Leningrad, Kaliningrad, Samara, Sakhalin, and Karelia (Popova 1993a).

P. Ministry of Fuel and Energy proposed Russian-American energy efficiency projects. One hundred projects for joint Russian-American implementation for energy efficiency were proposed by the Russian Ministry of Fuel and Energy in late 1993. The projects were of all types, from equipment production to demonstrations to final installations in industry and buildings. The regions included in these proposals were Buryatia, Chelyabinsk, Kostroma, Krasnodar, Kurgan, Leningrad, Moscow, Nizhniy Novgorod, Novgorod, Novosibirsk, Perm, Rostov, Ryazan, Samara, Saratov, Smolensk, Tula, Tver, Tyumen, Vladimir, and Volgograd (Ministry of Fuel and Energy 1993).

Q. Economic and financial stability. Regions judged to have good stability, with high proportions of profitable, successful enterprises are Yekaterinburg, Murmansk, Samara, Kursk, Kirov, Vladimir, Vologda, Leningrad, and Moscow (Business World Weekly, 6/4/94, "Investment Risks by Russia's Regions: Enterprises Financial Standing").

TABLE 10: REGIONAL PROPENSITIES FOR TECHNOLOGY TRANSFER

GROUP I: Very high likelihood
GROUP II: High likelihood
GROUP III: Lesser likelihood

All regions are oblasts unless otherwise designated. "Ter." = Territory (Kray), "Rep." = Republic, "A.R." = Autonomous Republic.

GROUP I	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.	Q.
Archangel	X			X			X		X						X		
Chelyabinsk	X			X	X							X	X	X	X	X	
Kalmykia Rep.	X						X		X		X	X					
Kamchatka	X	X				X	X							X			
Karelia Rep.		X			X	X	X				X	X		X	X		
Khabarovsk Ter.		X	X			X	X							X			
Kostroma					X	X			X			X	X	X		X	
Krasnodar Ter.				X		X	X	X						X		X	
Leningrad					X	X	X	X		X		X		X	X	X	X
Maritime Ter.		X	X			X	X	X				X	X	X			
Moscow					X	X				X		X		X	X	X	X
Nizhniy Novgorod						X		X		X				X		X	
Perm				X	X					X			X			X	
Rostov			X		X	X	X					X	X	X		X	
Sakhalin	X	X	X			X	X	X		X				X	X		
Samara				X	X			X		X				X	X	X	X
Saratov					X		X			X		X	X			X	
Stavropol Ter.	X		X	X	X	X	X					X		X			
Tatarstan Rep.				X	X	X				X	X		X	X			
Tver	X				X	X							X			X	
Vladimir	X	X			X				X					X	X	X	X
Yekaterinburg					X					X				X			X

GROUP II	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.	Q.
Altay Ter.	X				X		X	X									
Amur	X	X	X			X											
Buryatia Rep.	X					X					X					X	
Chita	X		X			X											
Ivanovo	X					X			X								
Jewish A.R.						X					X				X		
Kaliningrad	X	X				X		X									
Kirov	X	X							X								X
Komi Rep.	X			X			X		X			X			X		
Kurgan	X	X							X							X	
Magadan	X			X		X	X			X							

Murmansk		X					X		X								X
Novgorod						X		X		X						X	
Novosibirsk										X					X	X	
Omsk										X				X	X		
Pskov						X			X	X							
Tomsk		X		X									X		X		
Tyumen				X	X											X	
Volgograd				X	X		X									X	
Vologda					X	X											X
Voronezh	X	X			X					X							
Yakutia-Sakha Rep.	X			X							X						
Yaroslavl						X			X					X			

GROUP III	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.	Q.
Adyge A.R.																	
Aga Buryat A.R.																	
Astrakhan							X					X					
Bashkortostan Rep.				X									X				
Belgorod															X		
Bryansk																	
Chechenia Rep.									X								
Chukchi A.R.																	
Chuvashia Rep.									X								
Dagestan Rep.				X			X		X			X					
Evenk A.R.																	
Gorno-Altay A.R.						X					X						
Ingushetia Rep.									X								
Irkutsk						X									X		
Kabardino-Balkaria Rep.																	
Kaluga										X							
Karachay-Cherkessia A.R.																	
Kemerovo					X			X									
Khakassia A.R.																	
Khanti-Mansi A.R.			X														
Komi-Permyak A.R.																	
Koryak A.R.																	
Krasnoyarsk Ter.															X		
Kursk																	X
Lipetsk																	
Mari-El Rep.										X					X		
Mordova Rep.									X	X							
Nenets A.R.							X		X								
North Ossetia Rep.																	
Orel																	
Orenburg				X													
Penza																	
Ryazan																X	
Simbirsk																	

Smolensk			X				X
Tambov	X			X			
Tula						X	X
Tuva Rep.			X				
Udmurtia Rep.				X	X		
Ust'Orda Buryat A.R.							
Yamal-Nenets A.R.		X					

Map 7: Favorable Regions for Technology Transfer from an Integrated Perspective

ANNEX: REGIONAL VARIATION OF ELECTRICITY PRICES

Below are electricity prices for all of Russia's regions, as of June 1994 (Wilson et al 1994). Regional geography and political factors play a strong role in the regional variations observed in energy prices, rather than any type of operating markets (interview with director of Center for Energy Efficiency, 8/17/94).

ELECTRICITY PRICES BY REGION (Average regional tariff; June 1994 rubles/kWh)

Kamchatka	15.6
Sakhalin	12.6
Magadan	11.6
Amur	8.0
Kalmykia Rep.	7.5
Tver	7.1
Komi Rep.	7.0
Karachay-Cherkessia A.R.	6.9
Chelyabinsk	6.7
Kurgan	6.7
Yakutia-Sakha Rep.	6.6
Kaliningrad	6.6
Chita	6.3
Buryatia Rep.	6.2
Pskov	6.0
Kirov	5.9
Vladimir	5.9
Voronezh	5.9
Kabardino-Balkaria Rep.	5.6
Krasnodar Ter.	5.5
Ryazan	5.5
Kaluga	5.5
Kursk	5.4
Tambov	5.4
Omsk	5.3
Smolensk	5.3
Altay Ter.	5.2
Simbirsk	5.1
Perm	5.1
Ivanovo	5.1
Samara	5.0
Archangel	5.0
Udmurtia Rep.	5.0
Novgorod	4.9
Orel	4.9
Tatarstan Rep.	4.9
Yekaterinburg	4.8
Tomsk	4.8
Yaroslavl	4.7
Astrakhan	4.6

Moscow	4.6
Kostroma	4.5
Belgorod	4.5
Nizhniy Novgorod	4.4
Stavropol Ter.	4.4
Mari-El Rep.	4.4
Tyumen	4.1
Bryansk	4.1
Leningrad	4.0
Vologda	4.0
Mordova Rep.	4.0
Maritime Ter.	4.0
Bashkortostan Rep.	4.0
Khabarovsk Ter.	4.0
Saratov	3.9
Murmansk	3.8
Novosibirsk	3.7
Rostov	3.6
Orenburg	3.5
Lipetsk	3.5
Penza	3.4
Tula	3.3
Karelia Rep.	3.1
Dagestan Rep.	2.5
Volgograd	2.3
Krasnoyarsk Ter.	2.2
Chuvashia Rep.	2.2
Khakassia A.R.	1.8
Irkutsk	1.6

ANNEX: REGIONAL DIVISIONS AND POTENTIAL BREAKUPS IN RUSSIA

Radvanyi (1992) provides a good analysis of the regional and ethnic divisions within the Russian Federation and how the Federation could split into more distinctive politically and economically autonomous areas. If this happens, each of these new regional entities will pursue their own policies with respect to energy efficiency and renewable energy, and the characteristics of each of these regional entities will become even more important to questions of energy efficiency and renewable energy. The regional entities that Radvanyi explores have been modified slightly here to allow for other information since then and my own opinions. The names of the entities have been unchanged from those that Radvanyi put forth. These entities are described below and shown in Map 8.

Northern Forest Peoples. This includes Karelia, Murmansk, Vologda, Archangel, Nenets, and Komi. Forest products are a major industry, and the population densities of these regions are low. National identity is strong in Karelia and Komi, both with republican status. Resources for biomass (both harvesting and wood and paper industry waste) and wind are exceptionally good, and energy efficiency has also received attention, especially in Karelia.

Great Volga Association. This includes Volgograd, Samara, Saratov, Penza, Simbirsk, and Nizhniy Novgorod regions, and a "sub-association" of ethnic republics including Tatarstan, Chuvashia, Mordova, Udmurtia, and Bashkortostan. It is not clear whether the republics will remain a distinct grouping, or whether some, such as Bashkortostan, will be more strongly associated with the Greater Urals Association. Renewable resources are poor in these regions, except perhaps for wind energy in Volgograd and Saratov. Plentiful hydropower and oil resources mean that alternatives will not be as critical for regional autonomy. These republics may favor energy efficiency as way of boosting regional revenues through exported oil resources as such resources become more locally controlled.

Greater Urals Association. This includes Kurgan, Orenburg, Perm, Yekaterinburg, Chelyabinsk, and Tyumen. Renewable resources are poor. Pollution from heavy coal-burning industries in these regions may give energy efficiency extra priority. Yekaterinburg and Chelyabinsk are already active with policies devoted to energy efficiency.

Siberian Charter. This includes Omsk, Tomsk, Novosibirsk, Kemerovo, Irkutsk, Krasnoyarsk, Altay, Khakassia, Tuva, and Gorno-Altay. Plentiful and cheap coal, oil, and hydropower in this region make both energy efficiency and renewable energy much less likely. Renewable resources other than biomass are small, except perhaps for solar in Gorno-Altay which is at the southern border of this association. Energy efficiency may play a significant role in Krasnoyarsk and Tomsk, where nuclear power facilities connected with Russia's signing of the international nuclear non-proliferation treater are under pressure to be shut down.

Far Eastern Association. This includes Amur, Sakhalin, Kamchatka, Magadan, Chita, Khabarovsk, Maritime, Buryatia, and Yakutia-Sakha. Wind energy resources are excellent in some of these regions, solar is marginal but possible, and biomass resources are also good. Energy efficiency will be especially important and cost-effective in these regions, energy prices are among the highest in Russia, remote diesel generators are prevalent, and fuel supplies from Russian are difficult and more expensive to obtain. Much of the technology transfer and trade will likely occur with Japan and Pacific Rim countries, as well as China.

Association of Cities of the South of Russia. Nineteen cities in the south of Russia, located in the regions of Stavropol, Krasnodar, Rostov, Kalmykia, Astrakhan, and the ethnic republics near the

Caucasus mountains. Wind, solar, and geothermal resources are excellent in these regions. Wind could be used for electricity generation, while solar could be both for electricity and for heat and hot water, especially during the summer. Many of the historical and recent renewable energy research and commercial installations are located in these regions. Electricity efficiency will be particularly important relative to heat efficiency in these regions, because of the decreased need for heating and because of severe under-capacity of electricity generation and electric power shortages in the region generally.

The Center. This includes all those regions in the central European part of Russia not included in the other regions. Prospects for renewable energy are few in these regions, but energy efficiency is especially important and large opportunities exist. Several regions have been active with energy efficiency, including Tver and Vladimir. A highly developed gas distribution infrastructure in these regions gives added potential to such technologies as gas-turbine industrial cogeneration, fuel switching from oil to gas, replacement of large inefficient district-heating systems run by large gas-fired heat-only boilers with more dispersed apartment-level, building-level or apartment-complex-level boilers.

Some regions like Tyumen could go either way, and Radvanyi had put Tyumen with the Siberians rather than the Urals Association. Tatarstan and Chechenia had declared their independence from the Russian Federation in 1991 and pose special problems, as the recent war in Chechniya showed.

In 1992, nearly all of these regional entities had developed some types of political institutions (Council or Committee of Coordination, Parliament, General Department) and economic institutions (e.g., Urals Bank of Foreign Commerce, Bank of Information, Economic or Financial Union, Reserve Fund to Guarantee Foreign Commerce), according to Radvanyi. The Siberian Charter received official government support, including the right of direct barter agreements with third parties and the granting of privileged licenses for foreign commerce and creating foreign joint ventures.

Map 8: Possible New Regional Entities within the Russian Federation

ANNEX: SOVIET MANAGEMENT CULTURE

While central economic planning and Gosplan are gone forever, their legacy lives on in the form of the mentality and thinking of those who worked in the old system. I will call this mentality "Soviet management culture." While diminishing over time, it will continue to persist in Russia until new generations take full charge of economic and political affairs. This culture is well documented in the literature (see for example Nove 1986), and was related to me in various forms by interviewees trying to emphasize the way things were historically and the "mentalities" involved. It arose from the old system of central planning and was a natural, rational response to the prevailing system. Poor energy efficiency was just one dimension of overall poor economic efficiency. The system was not structured to encourage managers to economize on inputs, reduce costs, or innovate; in fact the incentives faced by managers often encouraged them to waste energy and materials. Some of the aspects of this culture could be characterized as follows:

- Lack of incentives or ability to innovate
- A view of capital as essentially free, allocated politically from above
- Emphasis on quantity, not quality
- Vertical hierarchical relationships with few horizontal ties
- Lack of skill or motivation at cost reduction and material input efficiencies
- Performance incentives unrelated to profits
- Arbitrary prices without inherent meaning
- Interest in high-tech as a novelty, not a competitive factor

And some of the learned behaviors within this culture were as follows (presented here as an archetype of extreme behavior):

- do not rock the boat; do not make changes
- Follow orders from above
- do not be creative
- Make do with what you have
- do not make independent decisions
- do not worry about production costs
- do not worry about delays (there are a thousand ready excuses for everything)
- Inflate your requests of what you want so you'll get what you need
- Report progress even when there isn't any

It should be emphasized that these were not "bad" people, but the values and ways of thinking are the product of the particular system and environment under which they lived. They were behaving perfectly rationally and logically given the system. In fact, enterprise managers had many different and often conflicting directives to follow and many different and often conflicting incentives to contend with. Negotiating this maze of directives and incentives to maximize personal gain was performed with the utmost skill, cunning, and rational self-interest.

Studies of enterprise manager incentives in the Soviet period showed that there was little to induce management to be concerned with profit levels, and the evidence "suggests that, on the whole, profit seeking is not important to managers or enterprises in the Soviet Union" (Stubbs 1991, p.8).

The barriers to innovation and diffusion of innovations in the old Soviet economy were well known and discussed. These included lower investment in general for technical improvements, the difficulty in changing investment allocations over time to respond to new needs, lack of competitive or cost-management pressure on managers, and lack of horizontal sharing and coordination among different enterprises and research bureaus belonging to different ministries. The same barriers for enterprise managers also applied at the ministerial level for ministry officials responsible for fulfilling plan targets based upon an aggregate of enterprises. Six key factors were at work (Nove 1986):

(a) The separation of R&D from production. Research and development was typically performed in centralized research facilities that worked under the directives of the central ministry for that branch. The ministry was responsible for disseminating R&D to individual enterprises as it saw fit. Consequently, there was little direct contact between design bureaus and production enterprises, the R&D was often unsuited to the needs of production, and little revision of research based upon production results occurred. These research facilities were often "monopolists" in their particular branch.

(b) The chronic shortage of material inputs and the personal nature supplier relationships. Because of the shortage of goods in the economy, good personal relationships with suppliers were important for securing deliveries of scarce supplies, in a sense "friends get theirs first." This was especially true because shortages were partly caused by illicit stockpiling of supplies by many enterprises for trading with other and for selling on the black market. Innovations that might call for new materials or equipment were risky because they could require new and unfamiliar suppliers. An enterprise might not have the close working relationships with new suppliers necessary to secure deliveries of scarce supplies. And if innovation required unexpected changes or unforeseen inputs, it would be hard to modify the supply plan dynamically. These risks meant that any innovation jeopardized plan fulfillment.

(c) Wholesale price policy. The traditional (deliberate) Soviet pricing policy of production cost plus a standard markup meant that innovations that lowered production cost simply lowered revenues and left profits unchanged. The consumer received the full cost-reduction benefits of the innovation.

(d) Emphasis on quantity of output. The system of performance indicators and bonuses emphasized output above all else -- costs, profits, capital, labor productivity, quality, and innovation. Given the risk-reward relationship, most enterprise managers preferred to avoid innovation. The rewards from "business as usual" were almost as great as new technology bonuses, and by innovating the manager incurred substantial risks that the innovation would not perform as expected, would cause reductions in output, increases in costs, or longer introduction times than planned.

(e) Lack of competitive pressure. A chronic shortage of goods in the economy, as well as a monopoly position of many enterprises in the specific goods they produce, meant that everything produced could be sold. Soviet industries faced no competition from each other. And because all import-export decisions were initiated and made by Soviet central authorities, industries faced no competition from foreign businesses. Thus there was little competitive pressure to innovate.

(f) Outside organizations might delay projects. Construction and installation work might proceed slowly due to shortages of materials, equipment, and labor. Construction organizations received bonuses based on the value of work done, not on timely completion.

(g) Engineers themselves were highly specialized in their training, leading to a loss of the innovative and creative human potential that can come from a broader perspective. Students in Soviet engineering institutes did not major in general fields like electrical or mechanical engineering, but rather in one of hundreds of subspecialties (Graham 1993). All aspects of engineering, including engineering-economic analysis, were buried under one overriding mandate: increase production. Graham interviewed an engineer in 1960 who insisted that her engineering degree read "ball-bearing engineer for paper mills" (p.30), and that "each commissariat sought to train its own staff in specialties so limited that they bordered on the absurd" (p.30). The reasons for this specialization, as Graham notes, were that

> After 1930 engineers in the Soviet Union turned away from the broad social and economic questions...One reason...was fear. Stalin made it clear to Soviet engineers that if they wanted to stay out of trouble, they must concentrate on the narrow technical tasks that party leaders assigned them...[and] their ability to increase output was constantly judged. (pp.29-30)

(h) If an enterprise desired to produce a new product, it had to convince Gosplan to "create a market" for the new product and specify who would "buy" the new product.

Where innovation was successful, as for example in the military and space sectors, one advantage of the Soviet system came into play. New innovations could be disseminated wherever desired by bureaucratic decision, and this provided some advantages compared to innovation and dissemination in the West.

The inability to exploit scientific and technical progress to produce innovations in industry was thus a key problem in the Soviet Union. But the ability to innovate is likely to become stronger now for a few reasons. As direct ties between scientific and design organizations and enterprises form, and as enterprises develop their own research capabilities either individually or in larger associations, R&D activity is likely to become much more responsive and accountable to the needs of production than it was under the old system. It has become common for enterprises to contract directly with design bureaus for technical services, rather than go through respective ministries. These contracts represent a very important source of income or "business" for the design bureaus, and mean that accountability, feedback, and cooperation will more likely occur in the process.

ANNEX: STRUCTURE OF ENERGY SUPPLY AND DEMAND IN RUSSIA

In 1990 Russian primary energy production consisted of oil (40%), gas (39%), coal and other solid fuels (16%), hydroelectricity (3%), and nuclear (2%) (Nekrasov et al 1993). Renewable energy contributed practically nothing, except for less than 1% from fuel wood (Batenin 1990). Of this energy production, three-fourths was consumed in Russia and one-forth was exported to other former republics and abroad. Final energy consumption (electricity, heat, gas, oil, coal) in Russia in 1990 was 23% residential, commercial and municipal, 49% industry and construction, 7% agriculture, and 22% transport (Nekrasov et al 1993), although these figures can be somewhat misleading because of the energy accounting practices inherited from the former Soviet Union; "transport" for example, includes the energy use in buildings associated with transport, residential consumption of transport workers, etc., while "industry" includes some transport energy consumption associated with industry. From 1990 to 1993, because of the economic depression and fall in industrial output, energy consumption and production of all energy forms fell dramatically, and the consumption share of industry fell as well.

Centrally-supplied heat consumption was greater than or equal to electricity consumption on an energy basis in three major sectors: in the residential sector heat represented 50% of total consumption while electricity was 16%, in the commercial and municipal sector heat was 33% of total consumption while electricity was 25%, and in industry and construction both heat and electricity were 33% of total consumption. These figures for heating do not include the heat consumption from non-central heat sources such as individual boilers and process furnaces, which make heat consumption an even greater share of total final consumption in these sectors. (Nekrasov et al 1993)

Gustafson (1993) stated that "natural gas is the key to Russia's economic future. As oil and coal production decline, gas is increasingly the mainstay of the energy balance. Once Russian economic growth resumes, it will be fueled and financed above all by gas." "This statement was clear to Russians long before Gustafson said so" said a researcher at the USA-Canada institute in Moscow (interview 9/21/94). But investments in new gas production and transmission infrastructure were severely reduced in 1992-1994 because of a lack of capital, reduced demand, and non-payments by consumers. So there is a real question now about how much gas Russia will need in the future and how much money Gazprom should invest in additional gas production and transmission. Connected with this are questions of how fast European gas demand will increase, and how much Ukraine will be able to pay for its gas in the future. Another important question is the structure of local gas distribution companies.

Because of the misleading nature of Soviet energy consumption categories (see Schipper and Cooper 1991), and the questionable integrity of Soviet-style energy data, the figure above for Russia must be considered with caution. A Western-style analysis of Estonia (Schipper and Martinot 1994b) provides greater insight into one particular region of the former Soviet Union. In 1990 in Estonia, residential and services represented about 25% of final energy consumption, industry and construction about 40%, and agriculture and transport about 35%. Thus residential was about the same, industry was less, and agriculture more than in Russia. By 1992 these proportions had shifted to more like 30% residential, 35% industry, and 35% agriculture and transport, reflecting the drop in industrial production. Heat in Estonia in both 1990 and 1992 represented close to 50% of <u>all</u> final energy consumption across all sectors, and over 60% of residential heating on an energy basis was supplied from district-heating systems.

ANNEX: TECHNOLOGY TRANSFER TO THE SOVIET UNION BEFORE 1991

There was always something of an ambivalence towards imports of foreign technologies in the Soviet Union. On the one hand, the Soviet Union needed Western technology, and this drove much of the transfer and cooperation that did occur. But on the other hand, there was a desire to remain economically self-sufficient and isolated from the influence of capitalist countries, corporations, and market fluctuations. In general, the need for Western technology arose for two main reasons: the fundamental inability of the Soviet administrative/planned economy to produce the innovations required for continued progress, and the need to fill short-term gaps in production when plan targets were not met or when special requirements called for extra equipment.

The availability of Western credit, foreign-exchange earnings, and/or counter-trade possibilities was often a limiting factor in technology transfers and cooperation agreements. Nevertheless, Soviet officials did have a high degree of control over this availability, through control of exports and trade policies. The credit worthiness of the Soviet government was always considered good by Western banks (especially because of oil exports), and much of the technology transfer and trade that occurred up through the 1970s was financed by credit from Western banks. Or else imports were financed by export earnings or through "counter-trade" agreements (barter, counterpurchase, or compensation). With these agreements the Western supplier had to agree to buy certain Soviet exports, either related or unrelated to the original imports (Western firms tended to see this as a nuisance, especially if they had to resell the Soviet goods on Western markets).

During the 1920s and into the first Five-Year Plan (1928-32), foreign technology was seen as key to economic development (Zaleski and Wienert 1980). A number of cooperation agreements were completed with Western countries. These agreements included provisions for foreign technicians and skilled workers to enter the Soviet Union and supervise construction of plants and installation and operation of equipment; by 1932 some 6,800 foreign specialists, mostly U.S. engineers, were working in Soviet heavy industry. Although a number of technical assistance agreements still prevailed in the 1930s, many of these foreign specialists returned home in the early and mid-1930s as Soviet trade declined and the ideology within the Soviet Union's industrial policy swung towards technological self-sufficiency.

During World War II and immediately afterward, trade with the West came to a standstill, but American industrial technologies were still injected into the Soviet economy via the Lend-Lease agreement. Further, confiscation of ex-German assets after the war provided the Soviet Union with a large number of industrial plants that were moved to Soviet territory. Stalin himself acknowledged U.S. technical assistance before and during the war, saying that two-thirds of all large Soviet industrial enterprises had been built with U.S. help or technical assistance. With the formation of the CMEA in 1949 and the passage of the United States Export Control Act of 1949, the Soviet Union resumed its policy of economic independence from the West, and Western countries began to curtail certain exports to the Soviet Union for strategic reasons. Yet by the early 1960s foreign trade again increased. Food, fuels and raw materials left the East and steel, machinery and industrial equipment entered. Since the 1960s, this pattern has persisted, and Soviet leaders generally acknowledged the importance of international economic relations, and even a "critical role" of Western technology in improving Soviet technological performance.

A significant shift in the forms of transfer occurred in the 1960s. Before 1965 many technology transfers were equipment purchases through trade and counter-trade agreements or the purchases of licenses without accompanying know-how (non-active, disembodied, or "one-shot" transfers). But after 1965 Soviet policy acknowledged the importance of longer-term (5-15 years) "embodied" technology transfer, including licenses with technical assistance, longer-term industrial cooperation agreements, and turnkey plants. License agreements, typically 5-10 years in length, were seen as especially effective as quick and cheap ways to narrow the "technology gap" between East and West, although in the years it took to negotiate and exploit an agreement, technology had once again leaped ahead. Turnkey plants were also regarded as an effective channel of technology transfer, although were rarer than other modes of transfer. Within the Soviet system it was much easier and faster to put in an entirely new plant with Western technical and managerial expertise than to force radical innovations on existing plants where management and workers were resistant to changes. Direct foreign investment, a common and effective form of technology transfer in the West, was not permitted. Joint ventures were extremely rare before Perestroika, reflecting the Soviet leadership's aversion to foreign (or any private) ownership of property.

In terms of sectors involved, key transfers of technology took place especially in the automobile, oil and gas, machine-tools and chemicals sectors. And the impact of these transfers was often very significant. For example in chemicals, 72% of the increase in production capacity from 1971-1975 was due to Western equipment, and over $5 billion worth of Western equipment was imported in the 1960s and 1970s (Zaleski and Wienert 1980). Western technology was crucial in development of the automobile sector. Major industrial agreements were completed between Fiat and the Volga Automotive Factory (VAZ) for production of the Zhiguli car in the 1960s and between Renault and the Moskvich auto plant for production of the Moskvich car in the 1980s. The agreement with Fiat was considered a successful one and lasted several years and involved several hundred millions dollars; over 1,500 Fiat specialists went to work in the Soviet Union and an equal number of Soviet technicians were sent to Italy.

The ability of the Soviet system to absorb and diffuse Western technologies has been much studied but few concrete conclusions have been reached. To quote Hanson (1985, p.12) "the only honest conclusion that can be drawn about the contribution made in the past by Western technology-transfers to the USSR....is that the importance of that contribution is unknown, probably not dominant but possibly appreciable." But there have been case studies that have documented absorption of complete plants in the chemicals and machine tool industries from West European firms (Bornstein 1985). Project commission leadtimes tended to be 2-3 times longer (6-7 years compared to 2-4 years for equivalent plants in the West); the main reasons given were shortages of construction labor, transportation, and complementary inputs, and a lack of relevant manufacturing know-how. Knowledge of plant performance after commissioning was difficult for Western partners to obtain, but often survey respondents judged performance to be less than guaranteed or less than comparable above-guarantee levels in the West. Reasons included non-completion of related upstream and downstream plants, shortages of materials and transport, and use of unsuitable materials.

Surveys of technology transfer in the 1970s show some of the more significant problems experienced by transfer partners. For example, Swedish firms consistently reported quality problems and slow delivery and delays. Soviet partners found it difficult to effectively manage projects and control their own subcontractors within the Soviet economy (Bornstein 1985).

One important aspect of Soviet technology-transfer was that all transactions were conducted through the Ministry of Foreign Trade and controlled by central planning authorities (Nove, 1986). Although enterprises could make proposals concerning imports (or exports), central planning authorities, together with the Ministry and other authorities concerned with technical progress, made the decisions over what and how to import. According to a researcher at the USA-Canada Institute in Moscow (interview 9/21/94), the information systems used by central authorities were tailored to select and present the best technological achievements from the West. Thus enterprise managers themselves were far removed from foreign markets, rarely traveled abroad, and had little experience in evaluating, understanding, and selecting foreign technologies. If they perceived a need for capital equipment or innovation, it was only their job to propose, and they would either "get" this capital or they would not. Under this system they would naturally want the latest and most sophisticated technologies, even though cheaper, older or less sophisticated technologies might be adequate (and in fact some regulations existed that forced managers to accept only the "best available technologies").

Another notable aspect of Soviet technology-transfer was that formal cost-benefit calculations played a small role in import decisions (Nove 1986). Soviet internal prices and costs did not reflect relative scarcities or the real economic "value" of goods, nor did foreign exchange rates correspond to the relative purchasing power of the ruble compared to other currencies. Thus a true comparison of import costs with what the equivalent domestic cost would be was impossible. Soviet authorities were never able to make a true cost-benefit analysis based upon the true economic value of foreign technologies and imports compared with domestic products. Rather, imports depended on technical and material needs and priorities, and the availability of foreign exchange from exports, barter, and Western credits.

With the coming of Perestroika and Gorbachev's attempts to modernize, reform, and open the economy, two legislative acts were passed in 1987 that made joint ventures possible for the first time (United Nations 1990a). These acts spelled out the rules and rights of joint venture activity, which included all of the rights of a "juridical person" within Soviet law, as well as the right to own property, sign contracts, hire workers, and manage its affairs independent of state agencies and plans. The goals of these joint venture acts were spelled out clearly: to help meet the country's needs for equipment, raw materials, and foodstuffs; to attract advanced foreign technology and managerial experience; to facilitate exports; and to reduce "superfluous imports." Joint ventures after 1987 were slow to start. Yet by the end of 1993, there were 6400 foreign joint ventures registered in Russia with 112 different countries, according to one source (Business World Weekly, 6/27/94, p. 7 "Russia to Stimulate Foreign Investments"). The United States was the leader (1100), followed by Germany (1000), China (500), Finland (500), and Britain (400). But the huge discrepancy between registered and operational joint ventures, together with conflicting estimates by different sources, mean that the actual number of working joint ventures could be anywhere from 3000 to 15,000.

In 1990 a survey was conducted on 48 U.S.-Soviet joint ventures to explore the motivations for entering into a joint venture, problems in negotiation, problems in operations, and views of future prospects (Artemova and Sherr 1991). These ventures were selected to be representative of the whole field of U.S.-Soviet ventures, of which there were 172 at the time. Just a few of these ventures were engaged in goods production, while 16 were engaged in R&D, engineering, intermediary consulting services, and marketing. Soviet partners were very diverse and included industrial giants, rank-and-file enterprises, scientific research institutes in industry and academia, universities, foreign trade organizations, department stores, and public organizations.

Significant barriers to joint venture formation at the time were seen as currency inconvertibility, lack of charter capital by Soviet enterprises, lack of incentives (demand) for new technologies and innovations by Soviet enterprises, and no profit incentives. From early on, risk was a central factor in Western partner willingness to enter into these ventures, as even in the late 1980s political instability was growing (Artemova 1991).

Motivations by Soviets to enter into joint ventures were acquisition of foreign currency, access to modern technology, improvement in the quality of goods produced, participation in a favorable high-status type of economic organization, obtaining technological know-how, obtaining managerial know-how, and increased worker pay over jobs available in non-joint ventures (Artemova and Sherr 1991).

Export of goods to world markets was not a significant factor in motivations to enter into joint ventures. While exports were necessary for foreign currency, they primarily served to maintain the ventures primary goal of serving domestic markets.

Important negotiating issues seen by Western partners were problems of currency conversion, quality control, obtaining office and work space, management control and decision-making, and financing from Western sources. Other important issues were not seen as difficult to resolve, including agreement on business objectives, valuation of contributions, protection of intellectual property, financing from Soviet sources, figuring input prices, and figuring output prices.

Western partners did not see identification of the proper partner as a significant issue, perhaps because most matches were arranged by a central ministry, and Western partners were too daunted by the complete lack of information about potential partners and the difficulties in communication to be choosy.

One very interesting observation from this survey was that joint ventures tended to have multiple Soviet founders, but usually only one American founder. Artemova and Sherr explain this phenomena by saying that because several factors, including the high degree of enterprise specialization, the separation of research from production, and the lack of marketing functions in enterprises, "a single enterprise is often unable to cope with the tasks confronting joint ventures" (p.179). So for example, a scientific research institute and an industrial enterprise might be co-founders of a joint venture.

In the late 1980s and early 1990s, there was a growing gap in the perceptions of joint ventures on the Russian and Western sides. While Westerners were becoming increasingly skeptical of joint venture involvement in the Soviet Union as the perceived risks were increasing, the Soviets were taking an increased interest in these types of ventures, and joint ventures had "become fashionable, and there were references to joint ventures in virtually every spoken or written comment by economists who are lobbying for a radicalization of economic reform and who view them as one of the main ways to achieve the desired goal of activating foreign economic ties" (Artemova and Sherr 1991, p.178).

ANNEX: TRANSACTION COST ECONOMICS AND INSTITUTIONAL ECONOMICS LITERATURE APPLIED TO RUSSIA

Transaction costs are externalities associated with negotiating, completing, and enforcing transactions (contracts) between economic actors. They are often non-trivial, as Norgaard (1994) so well conveys:

> economic theory....ignores the costs of knowledge, information, and skill acquisition, decision-making, contracting, and enforcement. One does not have to look very hard at the industrialized economies to see that most people are engaged in learning, thinking, contracting, and enforcement.... (p.118)

From the perspective of the firm, technology transfer is both a contracting problem leading up to a formal agreement between supplier and recipient, and a management problem of implementing whatever agreement is forged. Oliver Williamson (1985, 1989, 1991), a leading "new institutionalist" and best known for his work on transaction cost economics, states that "any issue that arises as or can be reformulated as a contracting problem can be usefully examined in transaction cost economizing terms" (1989, p.9). And several studies of international joint venture formation highlight avoidance of excessive transaction costs (real or perceived) as a primary motivating factor (Kogut 1988, Hennart 1991).

In Common's concept of a "transaction" (Hodgson et al 1994) as the "ultimate unit of economic investigation," economic activity consists of groups, rather than individuals, engaging in transactions with one anther according to a set of rules. In this conception, market mechanisms are patterns of behavior that economic actors adhere to, a set of "working rules" that specify what actors must do, must not do, may do, and are expected to do in their transactions with one another. These working rules are partly defined by culture, by laws, enforcement mechanisms, institutions for resolving conflicts, and in some cases reference to "standard practice" of one trade or another. The development of these working rules and institutions has taken place in the United States over decades and centuries, for example as the Supreme Court has built a "business law" through their decisions. In Russia these concepts of transaction and working rules are especially relevant to the "transition to a market economy" being promoted by multilateral and bilateral agencies. As will be seen, working rules of the Soviet-era included both the official rule of "do as you are instructed from above" and unofficial rules of personal-relationship-based barter exchanges, deceit, waste, and corruption to smooth production. New working rules and institutions, including contract and business laws and regulation, property rights delineation and protection, enforcement mechanisms, a strong judiciary for conflict resolution, financial and banking services, and others, are evolving slowly. The evolution, speed, and form of these new rules and institutions will play a dominant role in the shape and structure of economic activity in Russia, as viewed from Common's perspective.

North (1990) and others represent the "new" institutionalism, in which institutions are created and modified in pursuit of economic goals by "economic man." This conception of "economic man" remains similar to that used by neoclassical economists. The "old" institutionalism as typified by Veblen, in contrast, sees institutions shaping individual behavior (preferences are endogenous), not just vice-versa (Hodgson et al 1994).

North (1990) sees institutions as powerful determinants of markets in situations where transaction costs are not trivial. There is no reason to believe that institutions necessarily shape markets in an efficient manner, and in fact many "inefficient" institutions have persisted for millennia. The distinction between institutions and organizations is that institutions are the rules of the game, while organizations are the "players" with certain goals, strategies, skills, and resources that are influenced by the rules. North sees institutions and organizations co-evolving, as each needs and shapes the other. He uses institutions to explain the relative differences in patterns of economic development and growth in different countries in different time periods. According to North, the primary role of institutions is to reduce uncertainty, by providing a stable (but not necessarily efficient) structure to human interaction and a set of rules, either formal or informal with which to guide actions. Formal rules encompass laws and regulations; informal rules encompass cultural conventions, codes of behavior, and norms.

Enforcement of these rules is a critical component of institutions, for without enforcement and punishment, compliance with the rules can break down, leading to more inefficient transactions or losses from potential gains in trade. In North's view, "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 the Third World" (p.54). "In developed countries, effective judicial systems include well specified bodies of law and agents such as lawyers, arbitrators, and mediators, and one has some confidence that the merits of a case rather than private payoffs will influence outcomes. In contrast, enforcement in Third World economies is uncertain not only because of ambiguity of legal doctrine...but because of uncertainty with respect to behavior of the agent" (p.59).

The role of institutions in economic activity is summarized by North as:

> Institutions affect the performance of the economy by their effect on the costs of exchange and production. Together with the technology employed, they determine the transaction and transformation (production) costs that make up total costs. (p.5-6)

These transaction costs are dependent on both the costs of measurement, determining or knowing the values and attributes of what is being exchanged in a transaction, and the costs of monitoring, policing and enforcing agreements after transactions have occurred. Policing and enforcement can come from a third party like the state, internally enforced codes of conduct, and second-party retaliation. "Because of the costliness of measurement, most contracts will be incomplete; hence informal constraints will play a major role in the actual agreement. These will include reputation, broadly accepted standards of conduct (effective to the extent that the conduct of the other parties is readily observable), and conventions that emerge form repetitive interactions" (p.61).

In Russia, the institution of free-market transaction is relatively new. Aside from the (still significant) transactions on the black market in the former Soviet Union, all transactions were regulated and specified by the central planning authorities. Now, analysis of many of the problems of Russia's economy in the post-Soviet era would be enhanced if conducted within the frameworks of institutional economics and transaction cost economics. Due to the vacuum left by the demise of central planning, which essentially had prescribed practically all transactions within the formal economy, non-trivial transaction costs are one of the principal features of the Russian economy. The economy was originally one large corporation "USSR Inc." (after Nove 1986) with a fundamentally hierarchial mode of transaction. It is now in transition to an economy in which some transactions remain hierarchical, while others now take place within markets. The balance between these two modes is now in flux. It is precisely this division of hierarchical versus market transactions that transaction-cost economics tries to explain, by postulating that institutional and organizational forms evolve to minimize transaction costs ("economizing" behavior). Williamson himself (following Coase) frequently asks the rhetorical question "why isn't the economy one large corporation?" The Russian economy is moving away from just that, and having to evolve new organizational and institutional forms in the process. Indeed, one could argue that the greatest problem facing the Russian economy is an institutional one in the Schumpeterian sense (Erickson lecture, 10/14/94; Schumpeter saw the process of economic development as a process of innovation, whether innovations are new products and processes, access to new markets, or implementation of new organizational structures). Yet the lack or weakness of newly developing market institutions, along with the highly specialized and vertical nature of inter-organizational linkages existing from Soviet times, and corruption at all levels (including activities of the Mafia), make for large transaction costs. The "friction" in the economy (to use the physics analogy) is enormous.

The transitions and changes taking place could also be viewed as a transition from "institutional man" towards "economic man." The participants of "USSR Inc." had previously behaved with an institutional rationality, that is, consistent with the constraints and demands of the system. Economic rationality played a minor role, especially insofar as prices and costs did not reflect true value. In this sense the concept of bounded rationality is also useful, as a hybrid of economic man and institutional man. Williamson's concept of opportunism is especially appropriate for Russia as well, since deceit was and still is culturally considered "normal" economic behavior.

ANNEX: UNITED NATIONS AGENDA 21

In Agenda 21, the "blueprint for sustainable development" agreed upon by 178 countries at the United Nations Conference on Environment and Development in June 1992, technology transfer is seen as a significant potential instrument of sustainable development (United Nations 1993a). Technology transfer is included under Section 4, "Means of Implementation," as Chapter 34 titled "Transfer of environmentally sound technology, cooperation and capacity-building."

Five main objectives are given in Chapter 34. The document calls for the promotion, facilitation, financing, and support of: (1) access to scientific and technical information; (2) conduct of actual transfer projects; (3) maintenance and promotion of indigenous technologies, (4) capacity-building for human resource development, institutional capacities for R&D and implementation, and integrated sector assessments of technology needs; and (5) long-term technological partnerships between potential suppliers and recipients of technology. The chapter recognizes that technological knowledge exists in both the public domain and as proprietary information. These five objectives are to be realized through seven proposed mechanisms. Funding, supporting, and facilitating these mechanisms is estimated in Chapter 34 to cost $450-$600 million on grant or concessionary terms, although these are unreviewed order-of-magnitude estimates.

1. Information networks and clearinghouses that would not only disseminate information but provide advice, referrals, and training and technology assessment services

2. Government policies creating favorable conditions for both public-sector and private sector transfers, and reducing barriers

3. Institutional support and human resource development for assessing, developing, and managing new technologies

4. Collaborative networks of technology research and demonstration centers

5. International programs for cooperation and assistance in R&D and capacity-building for training, technology assessment, environmental impact assessments, and sustainable development planning

6. Technology assessment capabilities among international organizations

7. Long-term collaborative arrangements between private businesses direct foreign investment, and joint ventures

Chapter 34 acknowledges that "international business is an important vehicle for technology transfer" and that facilitating these transfers is an important priority. It recommends that:

> Long-term collaborative arrangements should be promoted between enterprises of developed and developing countries for the development of environmentally sound technologies. Multinational companies, as repositories of scarce technical skills needed for the protection and enhancement of the environment, have a special role and interest in promoting cooperation in and related to technology transfer, as they are important channels for such transfer, and for building a trained human resource pool and infrastructure....Joint ventures should be promoted between suppliers and recipients of technologies.....Together

> with foreign direct investment, these ventures could constitute important channels of transferring environmentally sound technologies. (p.255)

The financial resources and mechanisms for funding the components of Agenda 21, including Chapter 34, are outlined in Chapter 33. Sources of funding include:

multilateral development banks and funds
specialized United Nations or other international agencies
multilateral institutions for capacity-building, like the UNDP
bilateral assistance programs, like USAID
debt relief by public and private creditors
private funds (10%)
private investment, including foreign direct investment and joint ventures.
innovative financing (debt swaps, economic incentives, tradeable permits, etc.)

Chapter 37 discusses "capacity building," which it defines as developing a country's "human, scientific, technological, organization, institutional, and resource capabilities" to "enhance the ability to evaluate and address the crucial questions related to policy choices and modes of implementation" for sustainable development, "based upon an understanding....of needs as perceived by the people of the country concerned" (p.270).

The overall objective of capacity building is to improve and develop these abilities. One of the specific objectives is given as:

> Reorienting technical cooperation and, in that process, setting new priorities in the field, including that [sic] related to transfer of technology and know-how processes, while giving due attention to the specific conditions and individual needs of recipient [countries].... (p.270)

Several activities are recommended in Chapter 37 to achieve this capacity building. Capacity building strategies include identification of "the requirements for technical cooperation, including those related to technology transfer" for each country. Then individual countries should assemble requests for technical cooperation to the international community based upon long-term sectoral capacity building strategies. These strategies should address policy adjustments, budgets, institutional coordination, training, and science and technology needs. A review mechanism for technical cooperation is recommended, and includes five aspects: (1) evaluation of existing capacities and capabilities; (2) assessment of the contribution of existing activities towards capacity building; (3) a re-orientation of existing programs to a capacity building viewpoint; (4) greater use of long-term cooperative arrangements between a wide variety of institutions (i.e., municipalities, universities, public utilities, research centers, private foundations); (5) inclusion of environmental sustainability and capacity building in project designs.

The United Nations Commission for Sustainable Development was formed in 1992 and given the responsibility to monitor progress in implementing Agenda 21 by the United Nations system, national governments, multinational agencies, non-governmental organizations, and others, and to make recommendations to the General Assembly for future actions. The formation of the United Nations Commission for Sustainable Development was hailed as one of the achievements of the UNCED conference (French 1992), although the Commission's exercise of power appeared limited to "peer pressure and publicity" at that time. Within the United Nations, many other existing agencies are involved with technology transfer and sustainable development. The General

Assembly of the United Nations is the highest policy-making and appraisal organ. The Economic and Social Council coordinates the work of all the agencies within the system. The Conference on Trade and Development (UNCTAD) had traditionally dealt with trade, technology transfer, and development issues, and continues to play a leading role within the United Nations system in this respect. Other United Nations agencies, like the Environment Program (UNEP) and the Development Program (UNDP), are also significantly involved in implementation.

The Commission's first session was in 1993 and the second session was in 1994. In the second session in May 1994 (United Nations 1994c), the Commission reviewed recent experiences and programs related to technology transfer of environmentally sound technologies in developed, developing, and transitional countries. Absent was any specific experience from the countries in transition report. For specific action proposals, the Commission then referred to the Ad Hoc Working Group on Technology Transfer and Cooperation (of environmentally sound technologies).

The Ad Hoc Working Group saw the problem as one of inadequate financial resources and limited human and institutional capacities (United Nations 1994d). To address these problems, governments and international organizations should provide more financing, "improve access" to environmentally sound technologies, provide inventories on public and private domain technologies, promote research efforts, facilitate the greater availability of technologies that exist in the public domain, ensure adequate coordination among different agencies, and consider innovative mechanisms for promoting technology transfer and cooperation. The working group said that countries should have the capacity to maintain their own R&D in the areas of environmentally sound technological innovation. It also recognized that private sector activity was key to technology transfer, and advocated favorable market conditions to encourage profitable business development and linkages between research and industry. In this respect governments and financial institutions should create appropriate regulatory frameworks, environmental quality standards, enforcement practices, and pricing policies to promote a "more demand-driven approach in the development and commercialization of environmentally sound technologies" (p.5).

The Ad Hoc Working Group discussed three main aspects of technology transfer: access to information about these technologies, institutional capabilities and capacity-building, and financial arrangements (or "financial engineering"). The first aspect related primarily to clearinghouses, information and database systems for technologies and their suppliers and potential applications, as well as country and sector-specific information (policy environments, regulations) and case studies of successful modes of transfer, and creating institutional linkages for greater information transfer and sharing.

Capacity building for technology management was considered a pre-condition for assessing, adapting, using, managing, upgrading, and developing technologies. Capacity building should focus on developing existing knowledge and infrastructure, and strengthening the ability to plan, monitor, and stimulate programs for technical innovation. A number of mechanisms for capacity-building were proposed, including case studies on needs assessment at the national level (including institutional, legal, knowledge, financial and other barriers that influence the effective and efficient development of technologies), environmental technology centers, "one-stop shops," and teaming or twinning at firm, research, and government levels to enhance learning and cooperation.

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Belarussian Electric Utility Company (Deputy Director, Assistant to Director)

Center for Energy Efficiency, Moscow (Director, Senior Researcher, Researcher)

Chalmers University of Technology, Sweden (Professor)

Committee for Productive Forces and Natural Resources, Russian Academy of Sciences (Senior Research Fellow)

Danfoss Russia AO (Managing Director, Engineer)

Danish Energy Agency, Ministry of Energy (Head of Section, Head of Section)

Dansk Energi Management A/S Copenhagen (Consultant)

Design Institute Mosgazniiproyekt, Moscow (Engineer)

EU Energy Center Tallinn (Director, Deputy Director)

EU Energy Center Moscow (Director, Deputy Director)

Eesti Energia (Manager of International Relations)

Electric Power Research Institute, Moscow (Head of Laboratory)

Embassy of Finland in Moscow (Commercial Secretary)

Energy Research Institute, Russian Academy of Sciences (Deputy Director)

EnPro Engineers, Ltd., Tallinn (R&D Manager)

ESKOM Energy Savings Association and Bank, Moscow (Manager)

ESTIVO Ltd., Tallinn (Project Manager)

Estonian State Energy Department (EU PHARE Energy PIU Director, Deputy)

Estonian Building Research Institute (Researcher)

Estonian Ministry of Industry and Energetics (Energy Adviser)

Estonian State Energy Department (Project Manager, General Director)

Estonian National Housing Board (Counsellor)

Estonian Ministry of Environment (Vice-Chancellor)

Haabersti Real Estate Maintenance Enterprise, Tallinn (Director)

Honeywell Moscow (Engineer)

Institute of Electrodynamics, Ukrainian Academy of Sciences (Head of Renewable Energy Department, Researcher)

Institute of Economics (Economics Researcher, Lecturer)

International Clearinghouse on the Environment, Moscow (Director)

Interregional Energy-Ecology Association Thermo-IVS, Moscow (Director)

IVO International Representation in Moscow (Regional Director)

IVO International, Finland (Director of Energy Efficiency and Conservation)

IVO Group, Finland (Manager, Project Development Energy Efficiency)

Kenetech Windpower (Project Manager, Project Manager, General Council)

KMW Energi, Norrtälje, Sweden (Engineer)

Khrzhizhanovskiy Power Engineering Institute, Moscow (Head of Laboratory, Head of Solar Energy Laboratory)

Lithuanian Energy Institute (Head of Laboratory)

Luikov Institute of Belarussian Academy of Sciences (Researcher, Head of Laboratory)

Minsk Ceramic Factory (Chief Energy Engineer)

Minsk Machinery Building Factory (Chief Engineer)

Minsk Building Materials Factory (Chief Engineer)

Mytishchinskiy Teploset Heat Supply Company (General Director)

Moscow Aviation Institute, Wind Energy Department (Director)

Moscow Government Department of Finance (Deputy Director)

Moscow City Council (former) (Deputy and Chairman of Ecology Committee)

Moscow Government Department of Energy Efficiency (Director, Senior Deputy Director)

Moskvich Automobile Factory, Moscow (Energy Engineer, Chief Energy Engineer)

Mosmatic Joint Venture, Moscow (Director)

NedWind Windturbines, The Netherlands (President)

RAO "EES Rossii" (Head of Renewable Energy Department)

RAO "EES Rossii" (Chief Expert on Heat Supply Science and Technology)

Rockefeller Foundation Global Environment Program, Moscow (National Program Director)

Rozhdestvenskiy Investment Company, Moscow (Deputy Director)

Russian Center of Economic Analysis (Vice Director)

Russian Ministry of Economy, Institute of Price Formation (Deputy Director)

Russian State Committee on Renewable Sources of Energy (Chairman)

Russian Socio-Ecological Union (Director of Energy Program)

Russian Ministry of Fuel and Energy (Head of Department of Energy Efficiency)

SeaWest Power Systems, United States (President)

State Energy Agency "Ukrenergoresursy," Ministry of Energy, Kiev (General Director)

Swedish National Board for Industrial and Technical Development (NUTEK) (Head of Energy Efficiency Department, Senior Advisor, Engineer)

Tallinn Technical University, Thermal Engineering Department (Assistant Professor)

U.S. Agency for International Development, Moscow (Deputy Chief of Energy and Technology, Senior Energy Advisor)

U.S. Embassy Moscow, Foreign and Commercial Service (Commercial Assistant)

United Nations Economic Commission for Europe Energy Division, Geneva (Energy Efficiency 2000 Project Director)

US-Canada Institute, Moscow (Senior Fellow)

Uzbekistan Academy of Sciences (Wind Energy Researcher)

Valga RAS Soojus (Heat Supply Company), Estonia (Technical Director)

Windenergo Ltd., Kiev (General Director)

World Bank (Task Manager, Task Manager)

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Zhukovskiy Central Institute of Aerodynamics (Researcher)

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