Russian Business Opportunities in Energy Efficiency and Renewable Energy

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M. Evans

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Executive Summary

Russia consumes two to three times more energy per unit of production than Western Europe. This high energy intensity is like a weight, slowing down economic growth in Russia. Under a Memorandum of Cooperation on Energy Efficiency and Renewable Energy, the U.S. Department of Energy (DOE) has provided assistance to the Russian Government to help Russia increase its energy efficiency and use of renewables. Both the Russian and U.S. participants realize that the lack of well-written business plans created an obstacle. To help alleviate this problem, the Pacific Northwest National Laboratory (PNNL) organized a DOE-sponsored workshop in July 1995 on developing business plans for Russian energy efficiency and renewable energy projects. DOE and PNNL have also individually helped several Russian businesses write and promote business over the past two years.

The business plans described in this paper received assistance under the Memorandum of Cooperation. These projects include:

- A geothermal power project in Kamchatka
- A project to improve residential energy efficiency in Lytkarino, a Moscow suburb
- An energy efficiency project at Polimer, a chemical manufacturer in central Russia
- Projects initiated by the Cheliabinsk Energy Savings Fund
- Two projects to use the pressure differential in gas pipelines to generate power
- A project for small-scale power supply to oil and gas fields in Siberia
- A project to build a small-scale district heating system and efficient housing in Samara.

The project descriptions include information on the opportunities available for foreign firms, financial and technical aspects of the projects, the risk involved in each project, marketing strategies of the Russian firms, and the benefits of the projects, including the environmental benefits. Opportunities for foreign businesses range from selling energy efficiency equipment to investing equity in a Russian firm in order to build a geothermal power plant, and much in between.

Each of these projects differs in content and in stage of development. The descriptions attempt to provide a fair assessment of all the projects, including their advantages and disadvantages. This analysis, therefore, provides both the key details of potential opportunities, and a look at some of the problems frequently encountered in Russian energy efficiency ventures. In this sense, this paper attempts to serve as a guide to foreign businesses that are interested in the Russian market for energy efficiency goods and services.

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**Introduction**

Russia ranks among the world's most energy-intensive countries. As a result, its environment is burdened with comparatively high levels of pollution, while its economy is weighed down by inefficient energy use. Increased use of energy efficiency and renewable energy promotes sustainable economic growth. The environmental benefits include reduced greenhouse gas emissions, decreased acid rain, urban smog and associated health problems, and lowered environmental impact of oil drilling, coal mining, and fuel transportation. In certain areas, such as Cheliabinsk, energy efficiency and renewables can also help replace the power supplied by aging nuclear reactors.

Energy efficiency can promote economic development in Russia in several ways. If industry reduces its energy costs, it can produce goods more competitively. Efficiency can free up resources for capital investment, which stimulates economic growth. In addition, many industrial enterprises in Russia are finding it difficult to pay energy bills. These non-payments have led to industrial stagnation. Energy waste also creates problems in the residential sector. The government subsidizes up to 60% of residential energy costs, creating a burden on the state. This burden puts added pressure on the state to solve its budget problems by issuing more currency, an inflationary policy. Yet even with subsidies, many residents are struggling to pay their utilities bills. Energy efficiency could help such residents lower their energy bills, which in turn could help raise their standard of living. In this way, energy efficiency can ease the pain of market reforms.

**Russia's Economic Climate**

Russia has undergone a profound transformation in the last several years. Only a few enterprises were privatized in 1991, but 85% of the economy had been privatized by 1995. Russia is now more “capitalist” in this respect than Italy. Even heavy industry--metallurgy, machine building, chemicals--has been privatized. This is important for energy efficiency because industry accounts for the majority of energy use in Russia, and heavy industry is particularly energy intensive. Privatization should provide incentives for industrial firms to improve their energy efficiency. In fact, 11% of all upgrades to industrial plants in 1995 were energy efficiency measures and another 12% of the upgrades were for automation, which can also help save energy.¹

Despite its successes, the economic transformation has brought much hardship. The inflation rate has been over 100% every year since 1991, official unemployment reached almost 8% in 1995, the income gap between the rich and the poor has grown, and the economy has yet to stabilize from the transition.² Non-payments are common: consumer debts for energy stood at $4.8 billion in September 1995, a 15% increase in real terms from just three months earlier. Non-payments can also lead to bankruptcy. Only a handful of Russian firms have filed for bankruptcy because Russian law does not contain feasible bankruptcy provisions; the Russian Government is currently drafting bankruptcy provisions and when these are implemented, there may be a flood of bankruptcies. The transformation has also caused government budget crises, as the state shifts from owning the economy to regulating portions of it. This has led to a decrease in funding for infrastructure, just at a time when infrastructure is needed to help the economy grow.
In Russia in the last few years, the most common form of share expropriation is when a firm’s management unilaterally takes over or dilutes the firm’s stock. The weak Russian investment laws contribute to this problem: the only legal proof of ownership are often the stock registries maintained by enterprises. Finally, the faulty Russian infrastructure will have a negative impact on virtually all projects in Russia. Poor telephone lines, roads, and shipping networks make doing business in Russia more difficult and expensive. Many of the projects in this report, however, can also benefit from the lack of infrastructure. The geothermal and small-scale power projects would create energy infrastructure. Thus the need for energy infrastructure provides an opportunity, particularly in remote areas and in Russia’s Far East, where energy prices are very high.

Russia’s Investment Climate

Risk, taxation, low liquidity and lack of financing all affect Russia's investment climate. There are several types of risk influencing projects in Russia, including macroeconomic risk (as described above), political risk, and risk of share expropriation. Taxes are a problem in Russia not only because they are high, but even more so because they are constantly changing and they are not always transparent. The Russian profit tax was 35% in 1995, the excess wage tax was also 35%, and the value-added tax (which covers most goods and services) was 21.5%. There are many exceptions to these rates and additional taxes apply in certain circumstances. Foreign firms that want to sell goods or invest in Russian projects should be sure to determine their tax liability before getting involved. Low liquidity will also affect project participants who invest in a Russia company. If the foreign participant decides to get out of a deal involving equity, it can be difficult to sell Russian stock. Foreign investors should be sure to work out an exit strategy in advance, even if they plan to be involved in a project for a long period of time.

Lack of financing is probably the most troublesome of all the investment obstacles in Russia. Russian commercial banks usually shy away from providing project financing. When they do provide financing, the interest rates are extremely high and the terms are usually very short—a matter of months at best.

In recent years, Russian firms have begun using a structure called a financial-industrial group, or FIG, to finance investments. A FIG is a consortium of companies and other organizations which put their resources together to work on a specific project or set of projects. FIGs can include industrial enterprises, banks, insurance companies, government entities, research institutes, etc. FIGs can affect the projects below in two ways. First, several of the Russian companies are creating FIGs to help

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1 In Russia in the last few years, the most common form of share expropriation is when a firm’s management unilaterally takes over or dilutes the firm’s stock. The weak Russian investment laws contribute to this problem: the only legal proof of ownership are often the stock registries maintained by enterprises. Since the reforms began in the late eighties, the Russian government has not expropriated any shares (or nationalized any enterprises), although a few officials have threatened to do this.

2 The economic climate of Russia will influence the projects described in this report in many ways. Inflation makes it imperative that foreign firms either export their earnings quickly, or put them in inflation-proof investments. Inflation also makes it difficult to assess potential returns and future costs. Non-payments increase the risk of all ventures. Non-payments can particularly affect any supply-side projects, including the geothermal and small-scale power projects. Finally, the faulty Russian infrastructure will have a negative impact on virtually all projects in Russia. Poor telephone lines, roads, and shipping networks make doing business in Russia more difficult and expensive. Many of the projects in this report, however, can also benefit from the lack of infrastructure. The geothermal and small-scale power projects would create energy infrastructure. Thus the need for energy infrastructure provides an opportunity, particularly in remote areas and in Russia’s Far East, where energy prices are very high.
finance their projects. In this way, a foreign firm may find an opportunity for sales, paid for with the resources of members of a FIG. The most important caveat in such cases is that the foreign firm should have a clear understanding of who will make payment; payment responsibility should not be left up to the FIG as a whole without more concrete guarantees. Second, Russian companies may want a foreign firm to become part of a FIG. This generally means purchasing shares in the FIG. There are few laws regulating FIGs, and those which do exist contain major gaps, such as lack of clarity on how FIGs should issue and register securities. The large number of entities involved in a FIG may also make it difficult to come to agreement on a deal.

Many Russian firms rely on self-financing, exports or counter-trade to pay for foreign purchases. Self-financing means that a firm pays with its profits either directly in Russia, or through a letter of credit from a bank holding its profits. This is one of the least risky types of deals possible, particularly if the foreign firm can obtain advance payment for its goods. Some Russian firms prefer to pay for foreign purchases with export earnings because it eliminates the need to exchange and export the payment. Counter-trade, on the other hand, is similar to barter, but usually a middleman is involved who sells and buys the goods. By working through a counter-trade organization, a foreign company can sell its goods to a Russian enterprise and get paid in hard currency.

Foreign banks will finance Russian energy efficiency and renewable energy projects in certain cases, although usually only development or export finance banks are willing to get involved in Russian projects directly. Development banks, such as the World Bank, the International Finance Corporation (IFC) and the European Bank for Reconstruction and Development (EBRD), will loan money for very large projects after a full feasibility study is completed. To date most of their energy sector loans have been for supply-side projects, such as oil field rehabilitation and new fossil power plants. The World Bank will only work on projects which have been negotiated with the Russian Government, and the World Bank requires a loan guarantee from the Russian Government for all projects. The IFC is the private-sector counterpart of the World Bank. It also requires some form of guarantee, although, unlike the World Bank, it will consider outside proposals and usually only finances 30-40% of a project.

The EBRD has both public and private sector branches. The public sector branch works much like the World Bank, but it will consider proposals from many sources, not just the Russian Government. Because the EBRD requires sovereign guarantees for public-sector projects, and these projects are not negotiated in advance with the Russian Government, it can be very difficult to get the guarantees. (The Russian Government is very cautious about guaranteeing loans for fear that it will incur too much debt.) The private sector branch of the EBRD is similar to the IFC. For example, it will only finance up to 35% of a project, though it can help find financing from other sources. Likewise, it can provide either equity or debt financing. The EBRD has established an Energy Efficiency Unit, which finances both public and private-sector energy efficiency and renewable energy projects.

*Commercial banks will generally only get involved with the backing of an export or development bank.
Each of these organizations goes through a bureaucratic, time-consuming process before lending money. To expedite the process for small projects, these banks have set up credit lines at Russian banks, but they are rarely used, mainly because of high interest rates, strict lending requirements at the Russian banks, and lack of advertising. Another issue to consider when working with development banks is that they or their agents must conduct competitive procurement bids in all public-sector projects. Thus a foreign firm cannot usually put a public-sector deal together and expect to get financing from a development bank.

Export finance banks, instead, cater to firms who need financing in deals to sell their goods. The U.S. Export-Import Bank welcomes applications for export financing from private U.S. firms. U.S. ExIm requires guarantees from the Russian Government for virtually all projects. It is also a rather bureaucratic organization and can take quite a bit of time to review projects. It often prefers large projects, although it has more flexibility with environmentally-beneficial projects such as energy efficiency and renewables. The U.S. Overseas Private Investment Corporation (OPIC) also provides financing for foreign ventures. OPIC is much smaller than U.S. ExIm and will only provide financing for long-term projects; OPIC also sells risk insurance.

Other sources of foreign financing are private investment and equity funds, such as the U.S.-Russian Investment Fund. These funds will generally only consider relatively small private-sector projects. The funds are less bureaucratic than the development and export finance banks and can usually review a project in a matter of weeks, rather than months or years. They do not require feasibility studies for most projects, although they do require solid business plans. Many such funds, particularly equity funds, have very high minimum rates of return which they will accept. Equity funds provide financing by purchasing a stake in a Russian firm, which gives that firm cash for capital investments and upgrades. Some Russian firms will reject this form of financing because they do not want to give up management control.

**Business Plan Training**

In an effort to overcome some of the barriers to energy efficiency projects, The U.S. Department of Energy has sponsored training and a workshop on developing business plans for energy efficiency and renewable energy projects. The idea was to help Russian business people understand the type of planning necessary to successfully carry out energy efficiency projects, and to capture this in a business plan which could help attract financing and foreign business partners. This assistance began in 1994 under the Memorandum of Cooperation on Energy Efficiency and Renewable Energy between the U.S. Department of Energy and the Russian Ministry of Fuel and Energy. The Pacific Northwest Laboratory provided the technical support for this work by assisting a number of Russian firms, including Criocor, in developing and marketing their business plans. In July 1995, PNNL hosted a workshop on business plan development to help eight Russians with their business plans. Seven of these projects are described in this report. (The Russian working on the eighth project asked that his project be excluded because of business sensitivity.) This report also includes a project developed by the Russian firm Criocor. The Department of Energy plans to sponsor another business plan workshop in 1996, as well as individualized follow-up with the Russian participants.
Potential for Return

While the difficulties of doing business in Russia are daunting, there are many good opportunities. Russians have large appetite for Western goods and services, and this demand is likely to grow as the economy stabilizes. Energy efficiency is a good example of this. Because Russia uses energy so inefficiently, most of the cost-effective opportunities for efficiency remain. Likewise, Russia has not invested much money in renewables to date, so cost-effective opportunities for renewable energy abound.
Geothermal Energy in Kamchatka

Geoterm, an innovative new Russian company, is developing a new geothermal power project in Kamchatka. The project will involve three stages, bringing on line a total capacity of 112 MW of electricity and 728 GJ per hour of heat. The first stage of the project is a 12-MW plant called Verkhne-Mutnovsky, which will be completed by October 1996. While the first stage will be financed entirely by Russian companies, Geoterm is lining up support from multilateral development banks and Western companies to complete the second and third stages. Geoterm itself has done extensive feasibility and planning work on the project and its business plan demonstrates an understanding of its markets, strengths and limitations.

Opportunities for Foreign Businesses

There are two main ways in which foreign companies can participate in this project. First, Geoterm is considering buying equipment from foreign suppliers. It is especially interested in purchasing foreign air condensers. Geoterm would also consider buying other types of foreign equipment, including turbines, depending on the price, the transport logistics and whether the supplier would be interested in taking an equity stake in the project. Second, Geoterm is actively seeking a foreign partner willing to take an equity share in the second and third stages of the project. Such a partner would most likely be a key equipment supplier or a company that builds geothermal power plants. The terms of the investment would need to be worked out on a case by case basis.

Project Description

Kamchatka is a large peninsula in the Pacific Ocean, north of Japan. It has the potential to produce about 2000 MW of geothermal energy. The only operating geothermal power plant in Kamchatka now is an 11 MW plant called Pauzhetsk. The current electricity demand in Kamchatka is 400 MW, although there is also great unmet demand off-grid and in other areas of Russia's Far East. Kamchatka electricity prices are among the highest in Russia because most of Kamchatka's power is generated from fuel transported great distances.

The first stage of the project, the 12-MW Verkhne-Mutnovsky Plant, will cost $16.5 million to construct; Russian enterprises such as RAO EES Rossii (the Russian Joint-Stock Electric Company and Joint Energy System of Russia) are providing all of the financing. The company sent the first shipments of modular plant equipment to Kamchatka in the summer of 1995 and the project is proceeding on schedule. The geothermal field for the plant has already been drilled and the price of electricity in the region is high, which makes the project look economically promising. Geoterm has an agreement to sell the electricity to Kamchatskenergo, the electric utility for Kamchatka. The average wholesale electricity price in Kamchatka is 7.4 cents per kWh. The cost of electricity

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produced from the Verkhne-Mutnovsky Plant will be only 2 cents per kWh, so the pay back time on this project is short for a power plant--four to six years.\textsuperscript{7}

Geoterm has planned two additional stages of the project beyond the 12 MW plant. The second stage would bring on line an additional 100 MW of capacity, at a cost of $150 million. The third stage would involve developing a geothermal heat network, producing 728 GJ per hour, at a cost of $150 million. This would increase the efficiency of the existing complex by using the hot water from underground for a district heating system. (The first stages of the project would use only geothermal steam, discarding the hot water.) This geothermal field is near Petropavlovsk-Kamchatsky, a city of 500,000, so there is local demand for the hot water; the city would use the water to heat buildings.

Geoterm has tried to plan these stages so that it can use the implementation of each stage to gain experience and the trust of financial institutions. It needs partial foreign financing for the second and third stages. The European Bank for Reconstruction and Development (EBRD) and other financial institutions have expressed an interest in financing these stages; Geoterm is also considering equity investments from foreign firms. The following analysis focuses on the first stage because it will be realized in the short-term, and because Geoterm's planning to this point has focused on the 12 MW plant.

Geoterm

Geoterm Company Limited was established in the summer of 1994. Its headquarters are in Petropavlovsk-Kamchatsky, and it has a subsidiary in Moscow called Geoterm-M. Geoterm was founded by RAO EES Rossii, Kamchatskenergo, Nauka Company (a scientific firm) and Kamtek Company Limited (a company of the Kamchatka Administration).

<table>
<thead>
<tr>
<th>Founder's Name</th>
<th>Role in Geoterm</th>
<th>%</th>
<th>Private or State</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAO EES Rossii</td>
<td>capital</td>
<td>45</td>
<td>mixed</td>
</tr>
<tr>
<td>Kamchatskenergo</td>
<td>electricity sales; capital</td>
<td>28</td>
<td>50/50</td>
</tr>
<tr>
<td>Nauka</td>
<td>technical expertise</td>
<td>12</td>
<td>private</td>
</tr>
<tr>
<td>Kamtek</td>
<td>exclusive license to use site</td>
<td>15</td>
<td>state</td>
</tr>
</tbody>
</table>


Geoterm is a joint stock company of the closed type, which means that Geoterm does not issue public stock, so the only shareholders are the founders. The company has hard budget constraints and does not get direct subsidies from the government. Geoterm does get indirect subsidies in that it has access to a state-owned license and to capital from RAO EES Rossii, which is partly state owned.
By including Kamchatskenergo, the local power utility, as a founder and owner, Geoterm ensures that it will get a fair price for its electricity.

Geoterm is run by a Board of Directors. The Board members include O. Britvin, the President of Geoterm and Vice President of RAO EES Rossii, O. Povarov, the Vice President of Geoterm and a professor, Ye. Klochkov, another VP of Geoterm and the General Director of Kamchatskenergo, and V. Luzin, General Director of Geoterm. Grigory Tomarov and S. Trofimchenko manage Geoterm-M.

There are 15 employees of Geoterm and Geoterm-M. Grigory Tomarov and Professor Povarov have a great deal of experience in putting together geothermal power plant projects, including projects in Nicaragua, Yugoslavia and Russia. Geoterm has already built a 100-MW geothermal plant in San Jasinto, Nicaragua. Klochkov and Luzin have worked for many years in power plant construction in Kamchatka. Geoterm also employs up to 100 subcontractors. The company prefers to work with many subcontractors so that it can pool the knowledge of numerous experts and because much of the work is seasonal in nature.

**Technical Plan and Characteristics**

The Verkhne-Mutnovsky Plant, which is the first stage of Geoterm’s plans for the Mutnovsky geothermal field, will be finished in October 1996, and has a projected useful lifetime of 30 years. The plant will produce 90 million kWh of electricity per year. Kaluga Turbine Plant, which is located a few hundred miles south of Moscow, is making three 4-MW turbine generators for the plant.\(^8\)

Geoterm has designed the Verkhne-Mutnovsky plant in modular pieces which can be manufactured in Western Russia. These pieces are then airlifted to Kamchatka, where they are assembled. While modular design is common in geothermal plants, it is particularly important in Kamchatka because of the harsh climate in Kamchatka that limits construction to four months a year. It also preserves the local landscape by minimizing on-site construction and assembly.

The Mutnovsky geothermal field is located at a point where two deep faults intersect, making the geology of the site very favorable for geothermal energy. The geothermal reserves at this site are quite large and will provide more than enough steam to generate the anticipated power and heat.

<table>
<thead>
<tr>
<th>Table 1-2: Geothermal Reserves of the Mutnovsky Field</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reserves</strong></td>
</tr>
<tr>
<td>Steam Flow</td>
</tr>
<tr>
<td>Electrical Capacity</td>
</tr>
</tbody>
</table>

Several years ago, the Soviet Government began developing another power plant at the site called the Mutnovsky Geothermal Power Plant. The government drilled bore holes and set up the grid connections. At that point, the government ran out of money for the project and dropped it. Thus, much of the work necessary to complete a plant has already been done. Geoterm has an agreement with the government that if the government begins to build the Mutnovsky Plant again, Geoterm will drill new bore holes. In the meantime, Geoterm can use the existing bore holes without reimbursing the government. Geoterm includes the cost of drilling new bore holes in its financial assessment of the project.

**Financing**

Geoterm anticipates that an initial investment of $16.5 million for the 12 MW power station will pay for itself in just over 6 years. In addition to the $16.5 million for the construction of the plant, Geoterm has estimated that drilling new bore holes would cost $13.4 million. Because these bore holes will not be drilled for some time, Geoterm will finance them through electricity sales. Table 1-3 breaks down the costs of building the power plant.

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Field</th>
<th>Power Plant</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Work</td>
<td>3.3</td>
<td>1.6</td>
<td>4.9</td>
</tr>
<tr>
<td>(including land)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>0.2</td>
<td>7.9</td>
<td>8.1</td>
</tr>
<tr>
<td>Engineering</td>
<td>0.5</td>
<td>1.4</td>
<td>2.0</td>
</tr>
<tr>
<td>Contingency</td>
<td>0.4</td>
<td>1.1</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4.5</td>
<td>12.0</td>
<td>16.5</td>
</tr>
</tbody>
</table>


The annual operating costs of the plant will be approximately $1.7 million in 1995 dollars. This will cover maintenance, depreciation, and the salaries of 34 plant employees.
<table>
<thead>
<tr>
<th>Criterion</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Rate of Return</td>
<td>percent</td>
<td>19.8</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>Million $</td>
<td>10.3</td>
</tr>
<tr>
<td>Payback Time (with 8% discount rate)</td>
<td>Years</td>
<td>6.3</td>
</tr>
<tr>
<td>Capital Cost/kW</td>
<td>$/kW</td>
<td>1375</td>
</tr>
</tbody>
</table>


Geoterm assumes that it will have continuous revenue until 2026 from electricity sales to Kamchatskenergo. Its revenue estimates are based upon current electricity prices and price trends. Geoterm assumes that electricity prices will rise in real terms by 3% per year, as will the cost of producing electricity at Verkhne-Mutnovsky. Actual energy prices have risen much faster than this in recent years, so the revenue may be higher than anticipated.

To build the Verkhne-Mutnovsky Plant, Geoterm originally anticipated that it would need to borrow $5.5 million in financing from the European Bank for Reconstruction and Development. However, Geoterm has found financing for the entire venture from its owners, RAO EES Rossii and Kamchatskenergo.

For the larger stages, Geoterm would need up to 50% outside financing. To finance these later projects, Geoterm is exploring financing options with several institutions, including EBRD, the International Finance Corporation (IFC) and the Russian-American Investment Fund. EBRD is very interested in the project. In fact, EBRD has already committed feasibility study money for the two larger stages of the project. EBRD financing would most likely cover 32% of the project costs, with 8% interest and a four-year term. Geoterm is also looking into equity financing from foreign companies and has held discussions with some geothermal energy companies. California Energy and ORMAT have been particularly interested in the project. The remaining 15% would come from the Russian Ministry of Finance or foreign equity investors.

**Marketing Strategy**

Geoterm has agreements to sell all its electricity to the Central Region of Kamchatskenergo. The Central Region of Kamchatskenergo is the largest of three energy regions in Kamchatka, generating about 90% of the Kamchatskenergo's electricity. Kamchatskenergo serves 435,000 residential customers, as well as many industries and commercial installations. The largest power-consuming industries in Kamchatka are fish and timber processing, agro-industry and military suppliers. Both...
fish and timber processing have significant hard currency earnings from exports. The 12 MW Verkhne-Mutnovsky plant would generate about 3% of Kamchatskenergo’s electricity. This electricity would be sold primarily to industrial customers.

Kamchatskenergo is interested in purchasing this energy because it is cheaper than bringing in fuel from other areas of Russia and because Kamchatskenergo owns part of Geoterm, so it will profit if Geoterm profits. Kamchatskenergo is also anticipating a rise in electricity demand that the new geothermal plant will meet. When the Verkhne-Mutnovsky Plant first comes on line, Kamchatskenergo is planning to reduce power generation at two other large power plants to reduce fuel costs.

A larger problem that Geoterm has to face is ensuring that Kamchatskenergo’s customers pay for electricity. If electricity customers default in large numbers, Kamchatskenergo will be hard pressed to pay Geoterm in full. Non-payment, as it is called in Russia, has greatly affected the power sector in recent years. To address this concern, Geoterm is looking at the possibility of entering into special agreements with industrial enterprises, particularly those with hard currency earnings. The enterprises would benefit by being guaranteed more reliable power supply and Geoterm would benefit by ensuring that it gets paid. To date, Geoterm does not have any agreements with enterprises, but does have contacts with those that would use its electricity. These agreements would not, however, be sales agreements, because currently Geoterm has an agreement with Kamchatskenergo to sell all its energy through that utility.

Geoterm has also done sensitivity analyses to test the return on the project if electricity prices drop. Geoterm feels that if prices drop from 7.4 to 7 cents per kWh, the project is still cost-effective. In all likelihood, electricity tariffs in Kamchatka will not decrease significantly any time soon, and are actually likely to rise because fuel subsidies are being eliminated.

Kamchatka’s economy is doing well in comparison to other regions of Russia. Kamchatka is one of the leading Russian regions in attracting foreign investment: in the first six months of 1995, the region attracted $21 million of foreign capital. The fishing industry, gold mining and tourism have the best economic prospects. The Gore-Chernomyrdin Commission has even established an Ad Hoc Working Group on U.S. West Coast-Russian Far East Commercial Relations. According to this working group, the Russian Far East is one of the most dynamic commercial regions of the Russian Federation, with major opportunities in the energy sector. In fact, there was a major international conference on renewable energy in Vladivostok in November 1995.

**Environmental Benefits**

Kamchatka is one of the cleanest, most pristine northern environments on Earth. This makes environmental protection and reductions in emissions particularly important.

The Verkhne-Mutnovsky Geothermal Plant will reduce emissions from electricity generation, and will also reduce the environmental impact of extracting and transporting fuel over long distances.
According to Kamchatskenergo data, every kilowatt of electricity produced at its power plants on average creates 5.4 grams of anhydride sulphide, 0.33 grams of ash, 3.8 grams of nitrogen oxides, and 850 grams of carbon dioxide.\textsuperscript{11} This does not take into account emissions at the source of extraction or from leakage during transportation.

When the Verkhne-Mutnovsky Geothermal Plant goes into operation, Kamchatskenergo plans to reduce power generation at thermal power plants in the Pavlovsk Region of Kamchatka by 9 million kWh per year, an amount equivalent to that generated at Verkhne-Mutnovsky. The chart below shows the net effect this will have on decreasing harmful emissions.

<table>
<thead>
<tr>
<th>Table 1-5: Expected Emissions Reductions with 12 MW Verkhne-Mutnovsky Geothermal Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Pollutant</td>
</tr>
<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>Anhydrous Sulphide</td>
</tr>
<tr>
<td>Ash</td>
</tr>
<tr>
<td>Nitrogen Dioxide</td>
</tr>
</tbody>
</table>


Based on this, the 100 MW phase of the project will probably reduce carbon dioxide emissions by 530,000 tons per year.

According to Geoterm, the Verkhne-Mutnovsky Power Plant is not likely to significantly damage the environment in other ways. The concentration of harmful gas in the Mutnovsky geothermal field is small, making up 0.5\% of the output by weight. Two important environmental concerns at geothermal sites are carbon dioxide and hydrogen sulfide emissions from the Earth. These emissions are low at the Mutnovsky field; for example, the field emits 55-97 g of carbon dioxide per kWh of electricity generated, which will equal about 9 tons per year. Emissions of other pollutants, such as mercury, ammonia, boron and radon are also low. Another concern is residual water. Geoterm plans to reinject these waters underground, which will dispose of most of the toxic substances in the water, and partially recharge the geothermal reservoir.\textsuperscript{12}
Residential Energy Efficiency Near Moscow

Lytkarino is a Moscow suburb of 53,000 that is trying to increase residential energy efficiency and improve the living space of its residents. It houses several industrial and research enterprises, a construction company, and more than thirty building maintenance organizations. The city is unlike most Russian cities in that 98% of the housing is now owned by the city and not by industrial enterprises. Most Russian enterprises are still struggling to divest employee housing. Very little of Lytkarino’s housing is privatized. Given that the city owns most of the housing stock, and subsidizes residential energy bills, the city has an interest in improving the energy efficiency of these buildings. Like most Russian cities, however, Lytkarino does not have much money to make such changes, although the city is trying.

Opportunities for Foreign Businesses

The Lytkarino City Administration would welcome foreign participation in joint ventures, in investments in various areas of the town’s economy and infrastructure, and in construction contracts. The City Administration would like to discuss new solutions to its housing and energy problems with foreign firms.

Lytkarino has developed a new scheme for financing residential energy efficiency. The city administration attracts construction companies, especially foreign ones, to the city to install residential energy efficiency measures and reconstruct the housing. Instead of paying the firms directly, the city administration allows them to build additions on to the existing apartment buildings and to then sell the new apartments. It has already attracted several construction companies to the city, but it would like to attract even more in order to renovate additional buildings. This scheme can provide opportunities for construction companies and for companies which would like to partner with or supply equipment to construction companies working in Lytkarino.

The Lytkarino City Administration is also working with the Russian Center for Energy Efficiency to develop other mechanisms for financing projects on district heating efficiency. If these mechanisms prove successful, they will provide further opportunities for firms selling energy efficiency products.

Project Description

Lytkarino is located between the Moscow River, recreational forest parks, and a children’s camp. These physical features limit Lytkarino’s growth outward. Five-thousand Lytkarino families are waiting for apartments. As a result, the City Administration would like to renovate existing buildings, both to include more living space and to increase energy efficiency. The city has developed a business plan for renovating the Fifth Ward, which contains particularly old and decrepit buildings. It estimates that these renovations will cost 96.2 billion rubles, or $21.6 million. Renovation of the Fifth Ward would be the first step in a larger overhaul of the city. Two gas-fired boilers that the city owns supply the Fifth Ward with district heat. These boilers burn 39.2 million cubic meters of gas per year.
In renovating the Fifth Ward, the city plans to:

- Increase energy efficiency by insulating buildings and installing modern controls;
- Renovate the existing housing stock;
- Increase the residential living space by adding new stories and annexes to existing buildings.\(^\text{15}\)

The efficiency measures will include insulating the building exteriors, installing weatherstripping around windows, and placing heat meters and thermostats in apartments. The city administration also plans to install windows and doors with aluminum frames in many of the ward’s apartments. A local private manufacturer called LZOS will produce the windows and doors, which it asserts are efficient.

The city would also like to install hot and cold water meters in the apartments, which it estimates will save 60% of the water used in these apartments. Based on the experience of other cities, this estimate may be overly optimistic. Water efficiency is important in Lytkarino because the town gets its water from artesian wells that are running dry. Saving water will allow the town to avoid constructing costly new artesian wells, and will also save electricity and gas, which are used to pump and heat water.

For now, city officials are focusing on 14 buildings which need renovation. When these buildings are finished, the city will consider other buildings as well.

In addition to this project which focuses on heat-use in buildings, the Russian Center for Energy Efficiency, CENEf, is working with the city on a more comprehensive plan to improve the efficiency of the district heating system.\(^*\) This plan would include measures to improve supply-side, demand-side and distribution efficiency, for example, boiler house combustion controls, variable speed drives on pumps, heat exchangers to capture waste heat, insulation on heat pipelines and building pipes, ultrasonic cleaning of pipe inner surfaces, and automated controls for heat supply.\(^\text{16}\)

**Financing**

The city seems to have found a creative solution in the “real-estate-for-efficiency” exchange it has set up with private companies. The city has found companies which are willing to finance renovations including efficiency upgrades of the first 14 buildings. In exchange, the companies are allowed to add floors and wings to the buildings, and they can then sell the additional apartments to the highest bidder. Viacheslav Shubin, the Deputy Mayor of Lytkarino, estimates that the companies involved are making a 15% profit. A Slovak company called Stavokonsul, and a Scottish firm called the Miller Group are both working on the reconstructions. The Weimar University in Germany is providing

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some technical support, and Russian firms are conducting feasibility work on the project. Under this scheme, the city has not had to pay anything, which is making implementation much easier.

### Table 2-1: Scope and Costs of Fifth Ward Reconstruction

<table>
<thead>
<tr>
<th>Item</th>
<th>No. of Buildings</th>
<th>Cost (US$ mill)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design/Planning</td>
<td>not applicable</td>
<td>0.04</td>
</tr>
<tr>
<td>Residential Apt. Houses</td>
<td>14</td>
<td>12.48</td>
</tr>
<tr>
<td>Children Service Center</td>
<td>1</td>
<td>4.46</td>
</tr>
<tr>
<td>School</td>
<td>1</td>
<td>4.46</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>21.40</td>
</tr>
</tbody>
</table>


While this source of financing works very well for renovating a small numbers of building, the city may need to look for other sources of financing if it wants to undertake a larger project focusing on district heating. CENEf is helping the city to assess its options for more comprehensive heat efficiency measures and believes the most promising of these options are:

- Financing the project from the city’s capital budget;
- Financing the project from the regional administration’s capital budget, through interest-free loans or a revolving loan fund;
- Using money originally allocated for heat subsidies;
- Obtaining debt financing;
- Using performance contracting, such that a private company would arrange the financing; and
- Using a combination of financial instruments.

More work is needed to determine which of these options, if any, is most suitable for Lytkarino.

**Environmental Benefits**

Because the city does not know how many buildings or other facilities it will be able to upgrade in the end, it is difficult to estimate the environmental benefits. The Russian Energy Efficiency Center, CENEf, is conducting energy audits which will determine the amount of emissions reductions which can be expected from various measures. In rough terms, the city anticipates that it will save 20% of the heat and gas currently used in the Fifth Ward buildings slated for renovation; this in turn will reduce emissions by 20%.
Energy Efficiency at a Chemical Manufacturer

Industry accounts for the majority of energy use in Russia and is key to increasing energy efficiency. Fortunately, improving energy efficiency in industry is often much simpler than improving efficiency in other sectors. Industrial enterprises receive few energy subsidies, which means that industry has a financial incentive to cut energy costs by investing in efficiency. Furthermore, industrial enterprises can often afford energy efficiency: these enterprises may have special accounts for capital improvements in their plants, or have hard currency from sales abroad.

Polimer is a large chemical enterprise near Samara in Central Russia. The general director, Evgeny Panov, realized that the company’s energy costs were hurting profits and the enterprise’s long-term viability. The company studied the problem and would like to cut its energy costs in several ways. For example, the company would like to purchase U.S. steam traps, to cut its heat expenditures.

Opportunities for Foreign Businesses

Polimer would like to reduce its energy bills by purchasing energy efficiency equipment and upgrading its power production facilities. In particular, the enterprise is considering buying steam traps, energy controls, a gas turbine, and equipment to recover hot water so that it can be used for heating. It may also need to purchase a new gas heating system in the near future, as its current steam heating system is old and inefficient.

Evgeny Panov is also interested in installing pollution control systems, although he did not say that he had immediate plans to buy them. Polimer does have pressure to reduce its pollution. Russian Prime Minister Chernomyrdin issued a decree requiring enterprises, such as Polimer, to cooperate with federal and local authorities to improve the environmental situation in Chapaevsk, Samara Region.\textsuperscript{17}

Project Description

Polimer hired a local engineering company called Tekhenergomashservis (Technical Energy Equipment Service) to study the plant’s use of heat. Tekhenergomashservis found that the enterprise was not collecting condensate return and recommended that Polimer install high-quality steam traps. It estimated that for a $200,000 investment in approximately 170 steam traps, the company could save $800,000 per year in energy costs. The energy savings would also decrease emissions of carbon dioxide, sulphur dioxide and nitrous oxides by 25\%.\textsuperscript{18} When Evgeny Panov was in the United States for the Business Plan Workshop, his main objective was to meet with a steam trap supplier.\textsuperscript{19} Panov signed a contract with Armstrong International to purchase $25,000 worth of steam traps. The deal is stalled, however, because Polimer is not able to export hard currency for the payment.

Based on Tekhenergomashservis’ recommendations, Evgeny Panov would also like to make other energy efficiency improvements to reduce Polimer’s heat use. He is particularly interested in
regulating the hydraulic regimes, installing other energy efficiency equipment, and using excess hot water in heating systems.\textsuperscript{20}

In addition, Polimer is assessing its electricity costs. It is considering generating all of its electricity on site to avoid high electricity tariffs by purchasing an efficient 24 MW gas turbine station from a U.S. turbine manufacturer. According to Panov, natural gas is cheap in Samara and is likely to stay that way because Russia is a major producer of natural gas.\textsuperscript{*} However, the company is still willing to consider end-use electrical efficiency. Polimer is hiring an engineering firm to study solutions to its electricity problems.

Polimer has a small combined heat and power plant, a steam boiler and a hot water boiler. This equipment is in bad condition and needs to be modernized. Similarly, the enterprise has a problem with its water pumping system, which it plans to fix when it has money. Polimer uses 100,000 cubic meters of water a day, which it gets from a nearby river. The enterprise has to pay for the electricity to pump this water, and for sewage charges to dispose of this water.

\textbf{Polimer}

Polimer is a large, privatized enterprise that formerly produced chemicals for the defense industry. It now produces industrial and consumer chemical products such as industrial explosives, household and industrial detergents, varnishes, and other chemicals. Polimer sells all of its goods are within the former Soviet Union, so it does not earn hard currency. Evgeny Panov said he would like to find new, foreign markets for Polimer’s goods.

Polimer is a joint stock company of the open type, which means it can issue public stock. The State Committee for Property owns 38\% of the enterprise, a local commercial bank called Samaraagrobank owns 22\% and the rest of the shares have been sold on the stock market.

The firm now employs 5,000, down from 11,000 before privatization. Most of the employees work in the production processes and the energy system; 1,000 work in administration, accounting, sales, and R&D. Polimer has annual sales of $20-25 million and a profit margin of about 12\%. Last year the company made $3 million in profit. Polimer has annual independent audits of its finances. Panov said that the 1994 audit showed that the enterprise’s accounts were in good order, except for a few mistakes.

The enterprise has already divested itself of most of its “social” property, such as worker housing and health clinics. This is important for the enterprise’s finances and energy use. Worker housing and other social holdings were very costly for Polimer to maintain, particularly after government subsidies to support the housing were cut off.\textsuperscript{21} Part of the cost of maintaining these buildings was paying utility bills, so knowing what the enterprise was responsible for was important to understanding how they used their energy.

\textsuperscript{*}Nonetheless, prices for natural gas have gone up significantly since 1991.
The main heat consumers at Polimer are the shops that produce formalin, pitch, varnish, enamel, and dye. The company’s boilers and combined heat and power plant supply the chemical plant with heat and some electricity; Polimer must purchase most of its electricity from the grid. The boilers and CHP plant at Polimer run on natural gas and fuel oil. Polimer’s peak use of steam is 333 GJ/hour. Of this, 100 GJ/hour is for technological processes and 230 GJ/hour is for heating and other non-process needs. According to Panov, much of this steam is wasted because of inefficient energy conversion processes.

**Financing**

Polimer had planned to pay for the steam trap project directly from profits, without having to look for outside sources of financing. The advantage of this approach is that it would have made the project much simpler and cheaper by avoiding large interest payments and the time necessary to arrange the financing. However, because Polimer does not earn any of its profits abroad in hard currency, it has found it difficult to make payment in hard currency.

Polimer’s options now are to look for new foreign markets, so that it can pay hard currency, to sell its goods abroad through a counter-trade organization, or to continue looking for means to exchange and export its profits. Polimer may also be able to take out a Russian commercial loan in hard currency, but the problem of getting the money out of Russia remains. If Polimer did take out a loan to finance upgrades, it most likely would be from its investor, Samaraagrobank. The fact that a bank owns part of Polimer gives Polimer a strategic advantage: Samaraagrobank will give the enterprise favorable loan conditions and will guarantee loans from other banks, including foreign ones. Polimer is unlikely to find financing from Western banks because it will have the same difficulties exporting hard currency for loan payments.

Polimer may in the end turn to Russian suppliers who will accept payment in rubles or in kind. It will probably not, however, buy Russian steam traps because of their poor quality.

**Environmental Benefits**

Improvements to the enterprise’s system of heat use and distribution would decrease its carbon dioxide emissions by 25 to 40%, according to Panov’s estimates. Installing steam traps alone decreased carbon dioxide emissions by 25%, and additional measures such as installing controls and using excess hot water for heating would save an additional 15%.

Polimer is also a significant polluter in the Volga region of Russia, polluting the air and the Volga River. Pollution is so serious in Chapaevsk that there is no clean drinking water in the city. Polimer has considered renovating and upgrading its water pumping facilities, which Panov feels will decrease the plant’s water emissions.

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*There is not a large difference between peak and off-peak demand at Polimer, as at most Russian industrial facilities, in part because equipment is often left running when not in use.*
Cheliabinsk Energy Savings Fund

The Cheliabinsk Regional Administration has enthusiastically embraced energy efficiency. For example, the regional administration set up an energy savings fund, with the help of the Russian Center for Energy Efficiency (CENEf), to pay for energy and energy efficiency projects.

The regional administration decided to establish the energy efficiency fund because much of the region’s energy is wasted through a lack of meters, pipe insulation and steam traps. Local power and heat producers are also serious polluters, and efficiency will reduce their emissions.

The main source of financing for the Fund is a 1% tax on energy sales which it collects monthly from energy producers. The Fund received almost $430,000 in 1993 and its funding went up to $535,000 in 1994. Recently, the regional administration has also adopted a Law on Energy Efficiency, which provides further political support for the Energy Savings Fund's work.

Opportunities for Foreign Businesses

This Fund creates opportunities for foreign companies in two ways. First, the Fund is implementing energy efficiency projects and may need to purchase foreign equipment or seek foreign investments in implementing these projects. Currently, the Fund would like to acquire equipment from foreign companies, including energy and water controls and meters for residential buildings, hot water heaters, localized boilers, and a fluidized bed combustion power plant that could cleanly burn brown coal. It is also interested in having foreign firms reconstruct housing and train local specialists in energy efficiency techniques. In some cases, the Fund may be willing to purchase the equipment outright; in others, particularly for large projects, it would like foreign suppliers to invest in the venture as well.

Second, the Fund promotes energy efficiency in the Cheliabinsk Region, raising awareness of energy efficiency’s benefits. This could create a secondary stream of investment and sales opportunities from other sources, such as local industrial plants. One particularly interesting proposal which the Fund has developed is to set up a revolving loan fund that would finance energy efficiency projects; such a revolving loan fund would create many opportunities for energy efficiency sales in the Cheliabinsk Region.

The Energy Situation in Cheliabinsk Region

The Cheliabinsk Region produces gas, coal, and a small amount of fuel oil. Currently, gas is the main fuel produced in the region, but gas production is expected to drop, so that in 15-20 years, coal will be the predominant fuel produced in the Cheliabinsk Region. As in many regions of Russia, the non-

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*Cheliabinsk region has a population of 3.6 million. The main industries are metallurgy, machine building, transportation, communication and energy.
payment crisis lies at the heart of the area’s serious energy problems. Customers do not always pay their energy bills, so energy producers do not have money to maintain and improve production and distribution facilities. In Cheliabinsk, coal production is lagging, and the region’s gas pipelines and energy production equipment are in need of repair. By January 1995, the energy producers and distributors in the Cheliabinsk Region had accumulated debts of 1.536 billion rubles (380 million). The region is also a net importer of energy. For example, it needs to bring in about 15% of its coal from elsewhere in Russia. Natural gas is the least expensive fuel in Cheliabinsk.

<table>
<thead>
<tr>
<th>Type of Energy</th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>MW</td>
<td>4,300</td>
</tr>
<tr>
<td>District Heat</td>
<td>GJ/hour</td>
<td>23,902</td>
</tr>
<tr>
<td>Heat (total)</td>
<td>GJ/hour</td>
<td>60,697</td>
</tr>
</tbody>
</table>


Cheliabinsk’s power and heat plants are running below capacity because of economic and financial problems. The region’s power plants are running at 40-60% of capacity, and the heat plants are running at 70% of capacity. In part because of the low production, the Cheliabinsk Region must buy most of its electricity from other areas. For example, in the fourth quarter of 1994, the region used 5.1 billion kWh of electricity, and of this, it purchased 3.9 billion kWh from outside of the Cheliabinsk Region.

The Cheliabinsk Fund

The regional administration set up an energy efficiency fund in 1993. Its official name is the Regional Extra-budgetary Fund of Energy Savings and it is under the control of the Committee on Energy, Transportation, Communication and Housing, which reports to the Deputy Head of the Regional Administration for Industrial Policy and Infrastructure Development.

At the same time that the Cheliabinsk Regional Administration set up the Fund, it announced an Energy Efficiency Program for the region. The program serves as a guideline for the Fund’s activities. The main goal of the program is to ease the energy deficit in Cheliabinsk Region by implementing energy efficiency projects and creating legal and economic stimuli for efficiency. The provisions of the program include:
1. Creating economic mechanisms to promote energy efficiency;
2. Installing energy meters and controls on a large scale;
3. Realizing energy saving projects in industry and residential buildings;
4. Reducing losses from district heating systems, and using waste heat;
5. Increasing the energy efficiency of buildings by using more efficient building materials, insulation, and modern heating systems;
6. Using local boilers for heating, particularly in rural areas and in urban single-family homes; and
7. Installing variable-speed electric drives for motors.

The Fund also pays for research projects, including feasibility studies. It has undertaken projects to build or study the feasibility of efficient heat and power plants, including a feasibility study for a 100-MW fluidized bed combustion plant the Fund would like to build. It has also helped finance research and development to promote the manufacture of energy buses* and equipment to reduce heat losses from pipe joints. One of the Fund’s goals is to develop a manufacturing base to produce energy efficiency equipment in the Cheliabinsk Region. For example, a group of regional companies now jointly produces heat meters with help from the Fund. The Fund has also done work to introduce energy efficiency into building construction. In addition to supporting specific energy efficiency projects and research, the Cheliabinsk Fund is involved in developing legislation, standards and tariff policy which promote energy efficiency.

Sample Projects and Initiatives

Revolving Loan Fund for Energy Efficiency

The Cheliabinsk Energy Savings Fund collects taxes and spends its money through grants. With the help of the Russian Center for Energy Efficiency (CENEf), the Cheliabinsk Energy Savings Fund is now proposing a revolving loan fund which would lend money instead of providing grants, and would thereby create a sustainable source of capital for energy efficiency projects in the Cheliabinsk Region.

The revolving loan fund could get its initial capital from a variety of sources, including money which the local public utilities collect from energy tariffs, public bonds, or regional budgetary funds. It would be established as an independent government agency and would serve not only as a source of financing, but also as an initiator of energy efficiency projects.

The revolving loan fund would require feasibility studies before it would consider projects for financing; it would also require guarantees that the money would be repaid, and as with any financial institution, it would charge interest on the money it lends. Loans would be repaid based on the money saved through the projects’ energy savings. The money repaid would be divided between the

* Energy buses are vehicles which transport energy audit equipment to audit sites, such as industrial plants, schools or homes.
revolving loan fund, the Regional Administration and the municipal housing authority. The Regional Administration would receive the largest share of the repayment revenue to reimburse its initial investment and create government revenues. After a specified period in each project (two years in one example), the revolving loan fund would no longer receive a share of the savings. It would, however, continue to receive revenue from other, newer projects. This is similar to the way an energy service company receives a portion of the savings for a set number of years in a performance contract. The revolving loan fund would appeal to the regional government because it saves energy, easing the local energy shortage, and it earns a significant return for the regional government’s budget.26

This revolving loan fund can help Western suppliers and investors because it will provide a source of financing for local projects, and because it will stimulate awareness about the benefits and importance of energy efficiency.

*Energy Efficient Housing Demonstration Projects*

The Energy Savings Fund is considering two housing demonstration projects in Cheliabinsk. One would involve an industrial neighborhood of the city; the other would involve a single building in the center of town.

In the larger project, the government would like to privatize former enterprise housing, enticing residents to privatize their apartments with efficiency improvements and building repairs. The neighborhood is home to 15,000 people. The buildings in the neighborhood consume 0.5 PJ of energy per year, which creates 14,400 tons of carbon dioxide emissions, 5,190 tons of sulphur dioxide, and 3,800 tons of nitrous oxides. The chart below describes the energy use and anticipated savings.

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*The formula for how to divide the repayments between these organizations is somewhat complex, and probably will be refined as the concept of the revolving loan fund is further developed.*

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The Cheliabinsk Energy Savings Fund proposes to improve the energy efficiency of the residential and commercial buildings in this neighborhood by:

- installing thermostats and meters for heat, water, electricity and gas ($1.25 million),
- bringing in foreign water heaters and furnaces ($3 million), and
- reconstructing the buildings so they can be sold as condominiums ($2 million).

The total project will cost an estimated $6,250,000. The local public company which owns and manages the buildings would contribute much of the funding, including money for the building repairs, and for some of the heat and water meters. The Fund is also planning to attract investments from local private equipment manufacturers, the regional administration, and foreign companies. The Fund is particularly interested in attracting foreign companies that have experience in:

- designing and installing turnkey heating boilers;
- reconstructing housing;
- manufacturing automated metering systems and controls for gas, electricity, heat and water; and
- training specialists in energy efficiency and small energy systems.

The Energy Savings Fund would like to begin the project as soon as possible, and to complete it by 1998.

The second demonstration project would be much smaller, addressing one ten-story building. The building currently has its own heat-only boiler. The Fund would like to add a foreign water heater, controls, meters and thermostats, and to repair some apartments. These measures will cost approximately $100,000, and will have a two-year payback time. The Energy Savings Fund and the Cheliabinsk regional housing authority, Cheliaboblzhilkomkhoz, plan to pay for the project. The project will save about 25% of the energy used, or 422,000 kWh of heat and hot water and 144,800 cubic meters of gas per year. The purpose of this project is to save energy and to demonstrate the benefits of energy efficiency technologies to contractors and builders of the region, as well as the general public.

**Environmental Benefits**

Because each project which the Cheliabinsk Energy Savings Fund undertakes will entail different environmental benefits and costs, it is difficult to discuss the environmental benefits of the Fund as a whole. An example of the potential environmental benefits can be found in the two housing projects described above. The first, larger project will result in 20% energy savings, which should reduce carbon dioxide emissions by 2,880 tons, sulphur dioxide emissions by 1,038 tons, and nitrous oxide emissions by 760 tons annually. The second project would reduce annual carbon dioxide emissions by over 400 tons, as well as reducing emissions of other substances, like nitrous oxides and sulphur dioxide, by small amounts.
Kaluga Turbine Factory

Kaluga Turbine Factory is one of the premier steam turbine manufacturers in Russia. Before military conversion, Kaluga produced mainly defense-related turbines, although it has now adapted its production lines to civilian products. The company currently produces turbo-generators, and is also developing a line of gas expansion turbines based on its steam turbine technology.\(^*\) Kaluga has received German certification that it meets the International Standard Organization's manufacturing quality standards.\(^27\)

Kaluga Turbine Factory and its subsidiary Turbocon have developed two plans to build and install turbo-generators at industrial enterprises in Russia. These projects are alike in that they generate electricity efficiently. In addition, one of the projects will involve a gas expansion turbines to generate electricity from the energy in pressurized gas, without burning the gas itself.

Kaluga has already leased several turbo-generators to industrial enterprises. In both projects, Kaluga and Turbocon are looking for outside investors to contribute to the initial costs.

Opportunities for Foreign Businesses

Kaluga would like to buy high-quality, foreign equipment to complement the turbogenerator sets they are leasing. In particular, Kaluga would like to be able to offer its customers foreign automatic controls for the turbines and explosion-proof generators for the gas expanders.\(^*\)

Turbocon and Kaluga are also seeking foreign investors for their projects. Turbocon and Kaluga are particularly interested in finding a U.S. partner who could provide advanced controls, design, packaging expertise, and/or financing. Investment would most likely involve taking an equity stake in the project. This scenario is risky because the foreign firm would not have majority ownership of Turbocon or Kaluga to ensure that the project went smoothly. Furthermore, Kaluga’s gas turbine expanders are still in the design stage, so this venture has relatively high technical risk.

Project Descriptions

One Kaluga project is to lease 150 turbo-generators with a total capacity of 75 MW.\(^28\) Turbocon will set up most of the turbines at industrial plants in areas where power is expensive or in short supply, such as Kamchatka and Sakhalin Island. Turbocon will attach the turbo-generators to existing heat-only boilers to generate both heat and power, increasing the efficiency of energy production.

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\(^*\)Presently, Kaluga’s gas expansion turbines are in the design stage. According to Vladimir Zhuze, at the Russian Center for Energy Efficiency (CENEF), Kaluga is making progress in designing the new turbines, but their current design may contain some flaws. For example, Kaluga does not make provisions for pre-heating the gas.

\(^*\)Kaluga does not build generators, but rather purchases them, generally from Russian suppliers, and then packages them with its own turbines.
For every kilowatt hour of electricity generated in the first project, Kaluga estimates that its turbo-generators will consume 90 grams of boiler fuel and 41 MJ of heat. In comparison, Kaluga’s condensation turbines consume 230 grams of boiler oil per kWh.

The project will cost $30 million. When all the turbines are set up, they will generate more than 375 million kWh per year. This is worth $22.5 million annually, assuming an average price per kWh of 6 cents. Because Kaluga’s technology consumes less fuel than existing power generating equipment, the project would save 45,000 tons of boiler fuel, with a value of $4.5 million.²⁹

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unit for Boiler</th>
<th>with Gas Expansion Turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Power Capacity</td>
<td>kW</td>
<td>500</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
</tr>
<tr>
<td>Voltage</td>
<td>V</td>
<td>400</td>
</tr>
<tr>
<td>Expected Lifetime</td>
<td>years</td>
<td>25</td>
</tr>
<tr>
<td>Service Life</td>
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</tr>
<tr>
<td>Required Floor Space</td>
<td>meters</td>
<td>6x12</td>
</tr>
</tbody>
</table>


A second project which Kaluga is planning is to lease 35 turbo-generators with gas expansion turbines with a total capacity of 63 MW. Manufacturing these units will cost $18.9 million. Annual revenues from this project will be $11.34 million. Each of these turbo-generator sets will produce 10.8 million kWh of electricity per year, saving 3,500 tons of fuel annually. Since Kaluga does not currently manufacture gas expansion turbines, this project is farther from implementation than the first.

Turbo-generators are industrial turbines attached to generators which produce electricity. The turbines for Kaluga's first project burn boiler fuel and consume a small portion of steam generated at the boiler to which they are attached.³ The real efficiency gains with Kaluga’s projects come when gas expansion turbines are added because gas expansion turbines generate power and cold air without burning the gas. Instead, when the gas expands as it goes through the gas expansion turbine, the gas flow turns the turbine shaft, much like wind turns the blades of a windmill. This turning generates

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³For every kilowatt hour of electricity generated in the first project, Kaluga estimates that its turbo-generators will consume 90 grams of boiler fuel and 41 MJ of heat. In comparison, Kaluga's condensation turbines consume 230 grams of boiler oil per kWh.
electricity. The temperature of the gas falls as its volume increases, and it can then be used to cool air for air conditioning or for producing cryogenic products.

Financing and Risks

To finance the projects, Kaluga and Turbocon are leasing the turbo-generators to industrial enterprises for twenty years, after which time, the turbo-generators will belong to the enterprises. The lease payments range from 50-70% of the price of purchasing electricity from the grid at that site. Under the lease agreement, Turbocon installs the units and services them under warranty. Kaluga and Turbocon originally wanted to either finance the project themselves, or have enterprises purchase the turbo-generators outright. They found that these options were not realistic, so they began to lease the turbo-generators to build a customer base.

While leasing is a more realistic option to get projects started, it is also a riskier option because of the possibility that enterprises will not make their lease payments. The risk is particularly high because the leases are very long-term. The crisis of non-payments affects most industrial sectors. The lease agreements give Turbocon the right to withdraw money from the leaseholder’s account in case of non-payment, or if the leaseholder does not make payment for six months, to take the equipment back. Repossession involves costs and losses, so it does not solve the problem of risk, although the threat of higher energy bills if the equipment is taken away may stimulate enterprises to make payments.

Another risk involved with these projects is the fluctuation in the price of electricity. Turbocon has targeted areas where electricity prices are high because of high fuel costs. While over the next few years, these electricity prices will probably continue to increase, they may decrease over the longer term. Many Russians have realized that generating electricity in remote areas where prices are high is profitable; with time, this influx of entrepreneurs should increase the supply of electricity and decrease the cost. This needs to be taken into account because the term of the investment is 20 years. One solution might be to insert a clause into the lease agreement that the lease payments should not drop below a certain level, with that level being pegged to a foreign currency.

Turbocon and Kaluga have structured the lease to avoid the technical risk that the turbines will not produce as much electricity as planned. The formula they use for the lease payments is based on the numbers of hours the Turbo generators are in operation, not the number of kilowatt hours of electricity they produce. This means that they do not need to measure the electricity produced, which avoids disputes, but it also means that if the turbines are not as efficient as they should be, the leaseholder loses.

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*The cooled air could also be supplied to a combustion gas turbine to maximize capacity or could be used to cool the air entering the turbine which can help increase output. Currently, the Kaluga technology is not set up for these applications.*
Turbocon and Kaluga are also exploring other financing options, such as receiving credits from the federal and local governments, receiving investments from a financial-industrial group, or receiving a bank loan, although it has not secured any financing from these sources yet. Government credits are becoming increasingly scarce and thus are not a stable source of financing. Russian bank loans are exceedingly difficult to obtain, particularly for more than a few months, as these projects would require. Foreign bank loans and investments from financial-industrial groups are very cumbersome to arrange. Turbocon does not appear to have put much effort into obtaining financing from these sources, which is probably a wise decision.

Project Implementation

Kaluga is a joint stock company and is one of the only enterprises in the former Soviet Union that produces turbines for small-scale power generation. It makes steam turbines, back pressure turbines (which are used in the boiler project), driving turbines, geothermal steam turbines and turbo-generators. Kaluga created Turbocon specifically to implement the projects described here. Turbocon has about ten employees who identify customers, investors, and outside sources of financing. They also design and install turnkey facilities. Kaluga employees maintain the turbo-generators, while boiler workers at the enterprises leasing the units operate the turbo-generators.

In the project involving 150 turbo-generators, Turbocon is setting up six daughter companies, each of which would be responsible for maintaining and selling electricity from 25 turbo-generators. The daughter companies would each employ 12 Russians, and would also pay salaries to boiler workers at the enterprises. According to Turbocon’s estimates, installing each turbo-generator will cost $200,000. Turbocon and Kaluga would implement the project over five years, setting up ten to thirty new turbines each year. Turbocon has calculated the overhead expenses for this project as follows:

Thus far, Kaluga has sold four power units for boilers. Kaluga and Turbocon have attracted investments for this project from Kaluga Innovation Bank, Transnational Bank and Energogarant Insurance Company. Kaluga and Turbocon have also signed an agreement with an Icelandic firm called Virkir Orkint to collaborate on this project.
Table 5-2: Annual Overhead Expenses for Kaluga Steam Turbo-Generator Project

<table>
<thead>
<tr>
<th>Expense Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Salary and Payroll Taxes</td>
<td>$230,740</td>
</tr>
<tr>
<td>Office Expenses</td>
<td>$50,000</td>
</tr>
<tr>
<td>Auxiliary Materials</td>
<td>$50,000</td>
</tr>
<tr>
<td>Amortization (5% from Outlays)</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>Property Taxes and Land Payments</td>
<td>$900,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$2,730,740</strong></td>
</tr>
</tbody>
</table>


*Note: Based on the information in Turbocon’s business plan, these costs do not appear to take inflation into consideration.*

In the gas expansion turbine project, Kaluga and Turbocon’s customers will include Izhorsky Industrial Plant in St. Petersburg and Samaraenergo (the electric utility serving Samara Oblast). The rental payments will only cover 50-65% of the costs of generated electricity, which is fair because Kaluga and Turbocon do not pay for all the generation expenses. Energogarant, the largest Russian insurance company, and Transnational Bank have both invested in the project.33

Turbocon estimates that the gas expansion turbine project, when implemented, will bring in $11.3 million per year from the rental payments at electricity prices averaging around 6 cents per kilowatt hour. For the first three years that the project makes money from rental payments, Turbocon and Kaluga will use the earnings to expand production.

**Environmental Benefits**

Because the type of fuel saved will vary depending on the site, it is not possible to calculate emissions reductions without detailed information on each site. Turbocon and Kaluga were not able to provide this information at the time of publication.
Criocor Stock Company

Criocor is a private joint stock company established in 1991 which specializes in using the pressure differential in gas to generate power and obtain cryogenic products. Its project is like Kaluga’s gas expansion turbine project in that it relies on similar technology to generate electricity, but Criocor’s technology combines the gas expansion turbines with air separation equipment. Criocor packages these enhanced power generation units and installs them at gas distribution substations. Unlike Kaluga, Criocor does not manufacture turbines but rather purchases them from a Ukrainian plant. The units generate power by using the pressure difference in natural gas as it is expanded to enter distribution systems. Criocor is currently operating a demonstration unit in Moscow, and a second unit in St. Petersburg will soon be on line.

Criocor’s target is to produce 400 million kWh annually with its technology, which will result in a savings of 100,000 cubic meters of gas per year. Each of Criocor’s units will have a capacity of between 2 and 30 MW. About 8.4 billion kWh of potential electricity are lost annually at gas distribution stations and gas reducing points at heat and power stations when traditional technologies are used. Traditional technology simply expands gas so it can enter local distribution systems and does not capture the energy used to keep the gas under pressure.

Criocor’s technology will simultaneously produce air products, such as oxygen and nitrogen in an inexpensive and environmentally-sound manner. Producing cryogenic products, such as liquid oxygen, is usually expensive because it requires much energy. Because Criocor’s technology separates these air products cheaply using the cold temperature of the expanded gas, these products can be sold to increase the economic return of the project. The entire project will cost $18.7 million, based on calculations made in January 1994. The pay back period is approximately five years.

Opportunities for Foreign Businesses

Criocor is looking for foreign partners to help commercialize its technology in Russia. The company is looking for a long-term relationship that would complement, not duplicate, its capabilities as a packager and marketer of small power systems. In particular, Criocor would like to attract a partner or partners who could provide:

- advanced controls, including environmental controls;
- cryogenic equipment;
- grid interconnections;
- expertise in production and use of liquid gases; and/or
- financing.

It is important to note that Kaluga is currently designing its gas expansion turbine, whereas Criocor is already producing and installing its units.

A 6 MW prototype cost $2 million to build and install.
The General Director of Criocor, Alexander Stepanets, believes that the best approach to cooperation would be to start small, possibly by collaborating on one or two near-term projects, and to develop a broader partnership as the working relationship progressed.

Two specific projects which Criocor would consider implementing with a foreign company are installing cryogenic air separation equipment at the demonstration site in Moscow, and setting up a joint venture to create a similar system at one of several potential sites identified in Criocor’s ongoing market studies. Criocor would like to cooperate on these projects with a foreign company through a joint venture which would either own and operate the systems or provide turnkey installations.35

**Criocor’s Market**

There is a growing market for on-site power production in Russia because of regional power shortages, escalating electricity prices, and uncertain grid reliability. Stepanets said there were 26 potential sites for gas expansion turbines within Moscow, and over 1000 throughout Russia. Criocor is comparing electricity prices and other regional factors at these sites to assess the true market potential for the technology.

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| Table 6-1: Average Russian Prices for Products of Criocor’s Technology (in USD) |
|-----------------------------------------------|---------|---------|
| Product           | Unit               | Price  |
| Electricity       | kWh                | .03-.20* |
| Natural Gas       | 1000 cubic meters | 61      |
| Liquid Argon      | ton                | 200     |
| Liquid Oxygen     | ton                | 55      |
| Liquid Nitrogen   | ton                | 55      |

Source: Criocor; CENEf

According to Criocor, growth in Russian demand of cryogenic gases is expected to significantly outpace current domestic supply in the near future. The cryogenic gases have several uses. Metallurgical and chemical plants use cryogenic products, primarily liquid oxygen, for their industrial processes. Hospitals use liquid oxygen to chill organs before transplants. The agricultural and food industries use liquid nitrogen for fast freezing and for cold storage and transportation. Liquid nitrogen is also used to recycle rubber and plastic, and can replace freon as a cooling agent.36 Criocor has a great deal of information on the performance and condition of existing cryogenic plants and

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*There is a wide range of electricity prices because Criocor will sell its technology in many areas of Russia, and electricity prices vary greatly in Russia.
markets within the former Soviet Union. Many on Criocor’s staff came from the premier Soviet cryogenic institute, and Criocor has good relations with other cryogenic organizations. Because the air products market is highly specialized, enterprises with no experience in this area will probably want Criocor to own and operate the cryogenic equipment.

Criocor has entered into agreements with Gazprom, the Russian gas monopoly, and a number of regional electric utilities to invest jointly in this venture, or to sell its technology, electricity and air products. Dr. Vilen Shpak, Deputy Director General of Criocor, stated that Criocor has an agreement with Gazprom to place a unit on one of Gazprom’s lines; the two companies are now jointly seeking additional financing for the project. The Gazprom project will be Criocor’s largest, when it is implemented. Criocor is also marketing systems for gas expansion turbines and gas turbines to other countries, primarily those of the former Soviet Union and developing countries. Ekaterina Gretchneva, Head of the Power Systems Department at Criocor, was recently in Colombia to discuss potential gas turbine system sales.

The table below describes the sites where Criocor would like to install its equipment in Russia.

<table>
<thead>
<tr>
<th>Site</th>
<th>Capital Expenditure (mill. $)</th>
<th>Simple Payback Period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Izevskaya CHP-2</td>
<td>2.24</td>
<td>4.1</td>
</tr>
<tr>
<td>GRS Gus’-Khrustalny</td>
<td>1.25</td>
<td>5.8</td>
</tr>
<tr>
<td>Nizhnekamskaya CHP-1</td>
<td>3.04</td>
<td>4.3</td>
</tr>
<tr>
<td>Volzhskaya CHP-1</td>
<td>4.36</td>
<td>4.6</td>
</tr>
<tr>
<td>GRS Permtransgas</td>
<td>3.35</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>14.25</td>
<td>4.9 (average)</td>
</tr>
</tbody>
</table>


Notes: CHP means a heat and power station; GRS means a gas reducing station; the dollar values are calculated using the exchange rate from June 1994 (1961.8:1), as listed in Russian Economic Trends.

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* According to Vladimir Zhuze at CENEf, Criocor has signed contracts with utilities in the Tatar Republic and in Nizhny Novgorod.

** Criocor has preliminary orders from companies in Belarus, Moldova, Kazakhstan, Turkmenistan, Colombia, Mexico, and Bangladesh.
Financing and Risk

Criocor would like to market its technology in one of two ways: as an owner and operator, or as a turnkey supplier. In the first case, Criocor would sign a rental or investment agreement with the owner of a given facility on the use of space and the gas lines, but would retain ownership of the Criocor power units themselves. In the second case, Criocor would sell and install its equipment, but would not get involved in electricity production. The exact nature of these agreements will be key to marketing the technology. Criocor has not yet resolved issues regarding the ownership and finances of the demonstration unit at Moscow’s CHP-21 power plant, according to Igor Bashmakov, Director of the Russian Center for Energy Efficiency (CENEf). The Moscow Heat and Electric Utility that owns CHP-21 has surplus capacity and currently exports power. Consequently, the utility and Criocor are still negotiating acceptable tariffs and/or the sales price of the unit.39

There are several risks involved in these projects of which potential investors should be aware. Criocor has not completely worked out the scheme under which it will operate (i.e. leases, sales, joint investment). No investments should be made until this is well defined and written into contracts because the risk involved in each scheme is different. Kaluga has found that leases are the only practical way to go because of market conditions. Leases, however, hold great risk because they stretch payments out over 10-20 years, and it is almost impossible to determine the credit worthiness of Russian entities over such a long period. Energy prices may come down in some regions when competition increases, so it is possible that a customer will try to get out of the lease if s/he sees that it is no longer advantageous. Relying on sales is risky because the market may not bear the large up-front cost of purchasing the equipment. There is also risk of default if payment cannot be made after delivery of the equipment. Joint investment (involving the Russian customer, Criocor, and other entities) entails the risk of fraud or default on the part of the Russian partners. Criocor itself is a risky partner in that it has few assets which it can use as collateral. There is also technical risk with these projects because the equipment which Criocor produces has not been on the market long and may still have flaws; furthermore, some of Criocor’s equipment is still under development. In fact, when Bruce Hedman of PNNL toured the Criocor demonstration site, the equipment was down for repairs. The turbines for the equipment come from Ukraine, which may make it more difficult to ensure a steady supply of the end product.

Criocor

Criocor was established in Moscow in 1991. Initially, the company was owned by a broad spectrum of stock holders, including banks, stock exchanges, research institutes, enterprises and potential customers. Now Criocor is a public stock company and its stockholders include Stolichny Bank, several Ukrainian enterprises and companies, the Irish company Irlasto PLC, Russian research institutes, investment companies, engineering companies and customers such as Mosenergo, the Moscow electric utility. Each of the stock holders has a key role to play in Criocor, from conducting
feasibility studies to manufacturing turbines and cryogenic equipment and providing financing. In 1994, the company had $21,400 in fixed assets.  

Criocor’s Board of Directors is made up of four engineers, a lawyer and a finance expert. The board members are relatively young, ranging in age from 30 to 46. Criocor employs 30 people. The company has also established ten affiliates throughout Russia and the former Soviet Union.

Criocor won the Euromarket Award-94 for business success, and development and assimilation of power-saving, environmentally-friendly technologies. The company also won a prize at the Arc of Europe Gold Star Convention in Madrid in 1994. This prize is awarded for business success, image, and high-quality products.

Criocor has gained the support of many Russian government institutions. The Ministry of Fuel and Energy, including the Minister, has actively promoted Criocor’s products at home and abroad. Criocor has also obtained the backing of the Council of Ministers, the Minister of Environment, the Russian Industrial Investment Fund, and the Moscow City Government.

The Technology

Criocor packages and sells technology to generate electricity from the pressure differential which exists in gas at distribution stations. When natural gas is transported through pipelines, it is compressed, but the pressure of the gas must drop before the gas can enter distribution lines. Usually when gas is expanded at distribution points and stations, the energy potential from the gas compression dissipates. However, if gas is expanded in a special installation called a gas expansion turbine, this energy can be used to generate electric power. Criocor’s technology also collects cryogenic products, such as liquid oxygen by using the cold obtained through operation of the gas expansion machine. This cold is obtained without burning fuel; cooling is generally an energy-intensive process.

The Criocor system is based on turbines produced by the Nikolaev Turbine Plant in Ukraine. Nikolaev is designing two gas expansion turbines for Criocor:

<table>
<thead>
<tr>
<th>Low Pressure Unit (demonstration system)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressure Reduction:</strong> 12 atmospheres to 2 atmospheres</td>
</tr>
<tr>
<td><strong>Flow:</strong> 100 to 165 cubic meters/hour</td>
</tr>
<tr>
<td><strong>Output:</strong> 4 to 7 MW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Pressure Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressure Reduction:</strong> 55 atmospheres to 12 atmospheres</td>
</tr>
<tr>
<td><strong>Flow:</strong> 150 to 350 cubic meters/hour</td>
</tr>
<tr>
<td><strong>Output:</strong> 8 to 18 MW</td>
</tr>
</tbody>
</table>

*Criocor has 42 million in rubles. The dollar value was calculated at 1962 rubles/dollar, the exchange rate in June 1994, as listed in *Russian Economic Trends*, Vol 4 (2), 1995, p. 159.*
Criocor purchases the Nikolaev turbines, and packages them with air separation units, controls, and other equipment. Its core business is thus packaging (including engineering and design) and marketing; in this sense, Criocor is very similar to Turbocon. Criocor has patented its technology in Russia.

Demonstration Project

In 1994, Criocor set up its first cryogenic power installation at a combined heat and power station in Moscow called CHP-21. Criocor has set up two units; each unit expands 150,000 cubic meters/hour of gas from 12 atmospheres to 2 and generates 5 MW net power (6 MW gross). Steam from the CHP is used to preheat the natural gas before it enters the expanders in order to prevent overcooling of the expanded gas. The system is designed to handle the entire natural gas input to the plant, and a by-pass system with conventional pressure reduction valves is in place for routine maintenance or emergency shut-down situations. Criocor’s installation produces 80 million kWh of electricity per year, saving 30 million cubic meters of gas per year. In the future, Criocor will add air separation equipment to the site.

According to CENEf’s calculations, the demonstration project will cost a total of between $5.5 and 6.7 million, or between $550-680 per kilowatt installed. Criocor projects that the payback period for this demonstration project will be two years, which matches calculations based on current Russian electricity tariffs. In the future, Criocor’s production costs should go down because it will have lower design costs, and the return should go up when cryogenic products are produced.

Bruce Hedman of PNNL toured the demonstration units in January 1995 to see first-hand how they worked. Only one unit was fully installed at the time of his visit. The second unit was down for generator repairs. The control system was antiquated, and required two operators per shift. The system that was running was extremely noisy, but most of the noise appeared to come from the gas flow in the inlet and outlet piping and not from the expander itself. The demonstration units were housed in a concrete block building, which contained the noise. Hedman felt that Criocor was adequately maintaining the installation.

Environmental Benefits

Criocor’s equipment will reduce air emissions significantly because it produces electricity and air products without burning fuel. Criocor estimates that its 10 MW demonstration project in Moscow will save 30 million cubic meters of natural gas per year. Based on standard emissions in Russia, this project will reduce emissions by 64,400 tons of carbon dioxide, 1.2 tons of methane, and 140 tons of nitrous oxides. If Criocor is able to meet its goal of producing 400 million kWh annually with its
technology, it will save of 110,000 cubic meters of gas per year.\textsuperscript{*} The table below describes the impact these gas savings would likely have on pollution.\textsuperscript{**}

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Units</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>tons</td>
<td>236,200</td>
</tr>
<tr>
<td>Nitrous Oxides</td>
<td>tons</td>
<td>521</td>
</tr>
<tr>
<td>Methane</td>
<td>tons</td>
<td>4.2</td>
</tr>
<tr>
<td>Toxic Waste</td>
<td>tons</td>
<td>15</td>
</tr>
</tbody>
</table>


In addition, Criocor’s technology will produce liquid nitrogen, which can replace freon as a refrigerant. Freon is a chlorofluorocarbon (CFC) which damages the Earth’s ozone layer. According to Criocor, the emission levels from its installations will meet existing Russian environmental standards: for example, nitrous oxide emissions will be 150 mg (dry) per cubic meter of gas, or 75 mg per cubic meter with steam injection.\textsuperscript{43}

\textsuperscript{*}This includes the energy savings from the production of air products.

\textsuperscript{**}The emissions reductions for all Criocor installations are based on natural gas savings from power production and production of air products.
Power Supply for Oil and Gas Fields in Siberia

In remote regions of Siberia, the price of electricity is very high: diesel, the fuel of choice in the Russian wilderness, is hauled over thousands of miles, making the fuel a very precious commodity. Gas and oil fields, in particular, are located in some of the most remote areas of Siberia, so ironically, these energy-rich locations sometimes have very pricy power.

Malaya Energetika, a private Russian venture, is seeking to promote decentralized power for such areas, using high-efficiency U.S. gas turbines. The company would like to start with a project in Evenkia,* Siberia, where it claims there are significant oil and gas deposits.

The most important potential problem with this project is that it is not clear that there are significant oil deposits at Evenkia, and even if there were, the local and Federal governments disagree over who owns them. Such disagreements over ownership have stopped many oil deals in Russia. This project also has major environmental weaknesses. The idea of the project is to promote efficient generation of electricity—in order to extract oil from a pristine area and ship it thousands of miles to population centers. In many locations with small reserves, extracting oil and gas would not be economically feasibly without power production based on indigenous fuels.

Nonetheless, Malaya Energetika itself is an interesting company, which can help energy efficiency companies market their goods and services in Russia. While the Evenkia project may not succeed, Malaya Energetika probably will, and in so doing, will develop many other energy and energy efficiency projects. Malaya Energetika’s management is very interested in attracting U.S. technology and support; this interest may create opportunities for U.S. firms in a number of areas.

Opportunities and Risk for Foreign Businesses

The Evenkia project is a risky investment. Foreign companies interested in this project should get complete information on the oil reserves and the structure of the oil deal before they proceed.

Malaya Energetika, however, has many other interesting projects and capabilities. The company can probably be most useful to foreign firms which want to market their goods in Russia, and which do not have their own representatives in the country. Malaya Energetika can provide information on potential customers and can help foreign companies make initial contacts. It can also help foreign firms learn about the economic and market conditions in particular areas of Russia.

In this way, Malaya Energetika can help reduce the risk of getting one’s feet wet in the Russian market by reducing the initial investment required. Because of Malaya Energetika’s focus on energy supply, energy efficiency companies will need to make their requirements very clear. Over the long-

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*Evenkia is an autonomous district (okrug) of the Krasnoyarsk Krai.
term, Malaya Energetika may not serve the needs of energy efficiency companies well because they may overlook potential energy efficiency opportunities.

**Evenkia Project Description**

Malaya Energetika has developed an energy supply plan for each population center in Evenkia, taking into account climatic, geological and hydrological aspects of the locations. This plan is driven by the idea of using local fuel, particularly oil and gas, to satisfy local energy demand. These plans are part of a feasibility study Malaya Energetika completed in 1993 on power supply to the Evenkia Autonomous Region.

The Evenkia administration has approved of this strategy as a basis for planning the development of energy supply to Evenkia’s towns and villages. The regional administration has decided to begin implementing the plan in one of the most remote towns, Yessei, by building a mini-nuclear power plant. (Malaya Energetika does not explain why an area so rich in fossil fuels needs a nuclear power plant; mini-nuclear power plants are, however, one of Malaya Energetika’s areas of specialization.) At the regional administration’s request, Malaya Energetika has also solicited proposals from Western European firms to barter mini-CHP plants in exchange for local Evenkia goods, and to purchase oil refining equipment.

According to Alexei Andreev, Evenkia has one of the largest inland oil fields in the world and this oil is very high quality. However, he could not produce documentation to support this. Andreev went on to explain that this large field went unnoticed in the West because it was discovered by Russian specialists, and Westerners were worried about becoming involved before the ownership questions were resolved. The Russian Federal Government and the Evenkia Administration disagree on who owns the fuel reserves and who has the right to tax them.

Another related issue is financing. Thus far, no Western companies have expressed serious interest in investing in the Evenkia oil and gas fields. The local government is poor, and Moscow has little money to invest in oil and gas development. Russian companies have shown an interest in the fields, but not enough to invest in them. If Evenkia can demonstrate that its oil reserves are indeed substantial, and works out ownership and taxation issues with Moscow, then foreign and Russian investors may flock to the project, and the proceeds from oil drilling can be used to build small-scale heat and power plants. Until then, though, any major plans for developing energy supply in Evenkia will probably sit on the shelf.

**Malaya Energetika**

Malaya Energetika’s 1994 annual report begins by pointing out the importance of small consulting and engineering firms, like itself, in Russia’s current economic development: “These types of firms in particular are able to adapt themselves most easily and quickly to changes in the economic
As of January 1, 1995.

Malaya Energetika’s 1994 Sales by Type

Source: Promotional Brochure, 1995

The company specializes in energy research and small-scale power development in remote areas of Russia, particularly in Siberia, although it also has a network of researchers on contract throughout the former Soviet Union. Malaya Energetika’s main business areas are research (on energy markets and for feasibility studies), management of industrial and public power supply projects, and sales of energy equipment.

As of January 1, 1995.
Table 8-1: Ownership of Malaya Energetika, 1995

<table>
<thead>
<tr>
<th>Shareholder</th>
<th>Private or State</th>
<th>Notes</th>
<th>Approx. % Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Various (Sold on Stock Market)</td>
<td></td>
<td>held mainly by AO METR</td>
<td>30</td>
</tr>
<tr>
<td>Rosenergoatom State Concern</td>
<td>state</td>
<td>nuclear power company; main founder</td>
<td>20</td>
</tr>
<tr>
<td>Energy Russian Company (ERCO)</td>
<td>mixed (majority private)</td>
<td>sells energy sector securities</td>
<td>20</td>
</tr>
<tr>
<td>Beloyarskaya Nuclear Power Station</td>
<td>state</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Moskovsky Zavod Polimetallov</td>
<td>mixed (majority state)</td>
<td>metal factory</td>
<td>15</td>
</tr>
<tr>
<td>Institute of Energy System Projects</td>
<td>state</td>
<td>small</td>
<td></td>
</tr>
</tbody>
</table>

Source: Meeting with Alexei Andreev, Washington, DC, July 28, 1995

Malaya Energetika has an Information Research Center, which maintains databases on the market for energy services, commercial proposals for energy projects, and sources of financing, including interested investors. This information is focused primarily toward energy supply, although Malaya Energetika also collects information on potential energy efficiency projects, and on the market conditions for energy efficiency in various regions and economic sectors of Russia. Malaya Energetika has technicians in many regions who can perform energy audits, and engineers who can recommend energy efficiency measures at factories and utilities. It can also arrange the transport and installation of energy efficiency equipment. In this sense, Malaya Energetika can act as an energy service company.46

Malaya Energetika does work on renewable energy, including solar thermal, photovoltaic, wind, and biomass. It has information on Russian and foreign suppliers and communities which would like to invest in renewable energy. Malaya Energetika is also working to promote renewable energy investment projects for several clients. One such client is a timber processing plant in the Russian Far East which would like to use its wood waste to generate heat and power.

Malaya Energetika’s clients include regional and local administrations, municipal utilities, nuclear power stations and various private enterprises. These clients are located throughout Russia—from Yakutia to Chita, and from Moscow to Arkhangelsk. Malaya Energetika also helps many foreign firms, such as Allison Engine and the Czech firm, Skoda, to market their products in Russia, and is
an authorized dealer for Kraftwerks und Anlagenbau (Germany) and Wartsila Deisel (Finland). The Kazakh Ministry of Fuel Resources and a Lebanese firm, TECMO Industries, have also used Malaya Energetika’s services. In addition, Malaya Energetika has three service centers in Germany. The company imports and exports energy equipment for both its foreign and domestic clients.

**Environmental Impact**

Malaya Energetika is undertaking many projects, not all of which benefit the environment. Thus, it is difficult to determine the net environmental impact of the company’s activities. As noted previously, the proposed project in Evenkia would likely increase harmful emissions both from fossil-fuel burning on site, and from extracting, transporting and consuming previously inaccessible fossil fuels.
Energy Efficient Neighborhood in Samara

The City of Samara would like to build a new energy efficient neighborhood called Sport Center. The neighborhood would be primarily residential, and the buildings would contain many efficient measures such as controls and insulation. This city has hired two local companies, Energoprogress and Energoperspektiva, to build this neighborhood and an efficient district heating plant that would serve the neighborhood.

While the ideas behind this project are good, its planning and organization warrant seem problematic. Consequently, this section briefly describes the project, then explains some problems with the project. I believe that including a description of this project is useful for two reasons: first, it demonstrates many typical problems of Russian business plans, and second, if the project is realized, there may be some opportunities for U.S. companies to supply equipment such as controls, insulation and gas turbines.

Opportunities for Foreign Businesses

Despite the uncertainties involved in this project, it may, nonetheless, create opportunities for foreign companies to supply equipment. This equipment might include construction materials, controls, insulation, hot water piping, gas turbines and plant controls.

It is also important to mention that several German companies are already discussing the project with Samara officials, although it is not clear exactly what role they will play. The business plan frequently compares Samara to Germany, indicating that the officials involved are interested in copying German technology and policy. This may become an obstacle to non-German firms that would like to get involved in the project.

The Combined Heat and Power Plant

Samara city officials would like to build a small combined heat and power station (CHP) to supply a new neighborhood of the city, called Sport Center. The station will consist of two gas turbines, each with a 4.9 MW electric power capacity and an 8.5 MW heat capacity. It will also include two peak hot water boilers, each with a 9 MW capacity. In all, the station will have a heat capacity of 35 MW, or 126 GJ/hour. The station will cost $25 million, which includes station design, equipment, and building construction. The City has set up a company called Energoperspektiva to organize the construction of this plant.

The heating season in Samara is 182 days long. Most of the heat produced at the Mini-CHP will be for hot water, not space heating.

Energoperspektiva hopes to receive $15 million in financing for the CHP project, which is equal to 60% of the project costs. The company would like to repay the loan over seven years with the money it receives from energy sales. The business plan does not provide details about how
Energoperspektiva plans to raise the money. Energoprogress, a related company, mentioned that it had approached Western banks for financing for the entire Sport Center project, and had been unequivocally refused on each occasion. In another part of the business plan, Energoprogress mentioned that it expects the local administration and the Federal Government to provide most of the funding.

Table 7-1: Projected Energy Inputs and Outputs at the Samara Mini-CHP

<table>
<thead>
<tr>
<th>Energy</th>
<th>Units</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Power Production</td>
<td>MWh</td>
<td>58,000</td>
</tr>
<tr>
<td>Annual Heat Production</td>
<td>MWh</td>
<td>120,000</td>
</tr>
<tr>
<td>Total Annual Consumption of Natural Gas</td>
<td>1000 m³</td>
<td>25,000</td>
</tr>
<tr>
<td>Total Annual Consumption in Coal Equivalent</td>
<td>tons</td>
<td>34,000</td>
</tr>
<tr>
<td>Annual Fuel Savings in Coal Equivalent (compared to Samaraenergo average)</td>
<td>tons</td>
<td>5,900</td>
</tr>
<tr>
<td>Percent Fuel Savings</td>
<td>percent</td>
<td>21</td>
</tr>
</tbody>
</table>


Building Sector Efficiency

The City hired Energoprogress to draw up plans for this neighborhood. The City will have ultimate authority and responsibility over the project. The neighborhood will include 250,000 square meters of floor space for apartment buildings, shops, schools, banks, and various commercial offices. In all, there will be about 4,000 apartments. Each building will have heat and gas meters at the building boundary and some heat controls. In addition, the German firm Ruhrgas has already built one very efficient building, and another building is planned. The two buildings have or will have meters, controls, insulation, Western windows and efficient lighting and appliances. These efficiency measures in both sets of buildings will reduce energy consumption by 18-20% in comparison to the average energy consumption in Samara. Because of these savings, a smaller CHP can effectively

* According to Energoperspektiva, the average fuel use per energy output in Samaraenergo is 280.5 tons of coal equivalent per kWh, and 42.2 tons of coal equivalent per GJ, whereas the same figures at the Mini-CHP will be only 161.6 and 43.7 respectively.
serve the entire neighborhood. Eventually, the City of Samara would like the UN to include its demonstration neighborhood is the list of UN EE-2000 demonstration zones.\textsuperscript{*} The major drawback of this plan is that Energoprogress does not identify who will finance construction of the neighborhood, nor what the demand is for this new residential and commercial space.

**Energoperspektiva and Energoprogress**

Energoprogress is a small research company in Samara. Energoperspektiva is a private joint stock company of the closed type. Its shareholders include Energoprogress, the Samara city and regional administrations, Samaraenergo and several German firms. Both Energoperspektiva and Energoprogress are managed by the same individual, V.A. Simonov.

Understandably, the companies have strong ties with the city administration, the main heat purchaser in Samara. They also have good relations with Samaraenergo, which is key because Samaraenergo provides electricity to the city and could stop the project if it felt threatened by it.

**Problems and Risks**

The main risk with this project is that, as of yet, the new Sport Center neighborhood does not exist, aside from one German-built apartment building. Energoprogress has plans to build the second highly efficient buildings with German firms. It also has drawn up some rough plans for the rest of the neighborhood, but it is not clear who would actually build the neighborhood.

Potential problems could also arise because of flaws in the project design and preparation. For example, the business plan for the Mini-CHP includes minimal information besides technical data on the amount of energy to be produced. There is virtually no information on the market, competitors or the implementation plan (who will do what and how). Much of the information included is contradictory. In one place, Energoperspektiva’s business plan states that the company will keep costs competitive by using only Russian equipment, but in other places, Energoperspektiva states it has no competitors and that it would like to involve foreign suppliers.

The documents refer to two companies, Energoperspektiva and Energoprogress, which are both led by the same person. The documents do not, however, provide a good description of either of these companies: when were they established, what their main business is, how many people they employ and so on. In fact, Energoperspektiva’s business plan included a page with most of these questions, but the company had not filled in the answers.

The lack of market data is particularly troubling. Building a whole new section of a city is a large undertaking. Samara is a big city, with over 1.3 million residents, but its economy has been shrinking

\textsuperscript{*}The Samara City Administration decided to create this demonstration zone in Resolution 430, dated 25 March 1994.
because it is based on heavy industry. The demand for such a demonstration neighborhood may be small. Without in-depth market research studies, investing in such a large venture is very risky.

Likewise, there is little information on financing the neighborhood construction, other than vague references to the municipal and federal budgets. These are not realistic sources of funding. The City has failed in several attempts to attract financing from foreign banks, and Russian banks charge prohibitively high interest rates. The only other option is to assemble a coalition of stakeholders, such as industrial enterprises, companies, banks, and individuals, each of whom will finance a portion of the project. Neither the City nor its contractors seem to have put much emphasis on this last option.

**Environmental Benefits**

Because the Sports Center and its combined heat and power plant represent additions to the City of Samara, they do not reduce emissions or otherwise improve the natural environment. The district heating plant, for example, will probably create 54,000 tons of carbon dioxide emissions and almost 120 tons of nitrous oxide emissions per year. The one environmental advantage of the small-scale CHP is that it is more efficient than most such plants in the Samara Region. In comparison to other plants, its annual emissions of carbon dioxide are about 10,000 tons less per unit of heat or power and its other harmful emissions are also less.
Contact Information

Geothermal Energy in Kamchatka

Geoterm-M:
Evgenii Vasilchenko, General Director
Grigory Tomarov, Director (participated in Battelle business plan workshop)

Address: 2-21 Aviamotornaya St.
E-251 Moscow
Russia

Tel.: 7-095-918-1996
7-095-918-1561
7-095-361-2321
7-095-361-5476

Fax: 7-095-918-1560

Geoterm (in Kamchatka):
Oleg Britvin, President (also Vice President of RAO EES Rossii in Moscow)
Oleg Povarov, Vice President
Viktor Luzin, General Director

Address: 19 Krasintsey St.
Petropavlovsk-Kamchatsky
683000 Russia

Tel.: 7-41500-25026
Fax: 7-41500-25025

Energy Efficiency at a Chemical Manufacturer

Evgeny Panov, General Director of Polimer (participated in Battelle business plan workshop)

Address: Chapaevsk, Samara Oblast
446100 Russia

Tel.: 7-84639-23257
Fax: 7-84639-25522
7-84639-23614
Residential Energy Efficiency Near Moscow

Alexandr Zakharov, Head of Lytkarino City Administration

Viacheslav Shubin, Deputy Mayor of Lytkarino
(participated in Battelle’s business plan workshop)

Address: City Administration of Lytkarino
7/7 Pervomayskaya ul.
Lytkarino, Moscow Region
140061 Russia

Tel.: 7-095-552-6837
7-095-555-3009
Fax: 7-095-552-8618

Cheliabinsk’s Energy Savings Fund

Igor Osipov, Director
Viacheslav Galanov, Deputy Director (participated in Battelle Business Plan Workshop)

Address: Cheliabinsk Regional Energy Savings Fund
pr. Pobedy, 168
Cheliabinsk
454084 Russia

Tel.: 7-3512-136429
7-3512-666800
Fax: 7-3512-666800

Kaluga Turbine Factory

Vladimir Fedorov, Director of Turbocon and Deputy Director of Kaluga Turbine Factory
(participated in Battelle Business Plan Workshop)

Address: Turbocon
A/Ya 771
Kaluga
248021 Russia

Tel.: 7-08422-67193
Fax: 7-08422-72290
Valery Pryakhin, General Director of Kaluga Turbine Factory

Address: Kaluga Turbine Factory
        ul. Moskovskaya, 237
        Kaluga
        248006 Russia

Tel.: 7-08422-73056
Fax: 7-08422-72290

Criocor Stock Company

Alexander Stapanets, General Director
Dmitri Oliunin, Deputy Director

Address: Criocor
        Third Parkovaya St., 8/19
        Moscow
        105043 Russia

Tel.: 7-095-367-8845
    7-095-367-6909
    7-095-367-8872
Fax: 7-095-367-6918

Power Supply for Oil and Gas Fields in Siberia

A.K. Polushkin, General Director
Alexei Andreev, Head of Investment Project Department
(participated in Battelle Business Plan Workshop)

Address: Malaya Energetika
        ulitsa Tkatskaya, 1
        Moscow
        105058 Russia

Tel.: 7-095-962-9412
    7-095-962-9440
    7-095-962-9441
    7-095-962-9442
Fax: 7-095-964-1900
Energy Efficiency Neighborhood in Samara

Valery A. Simonov, Head of Energoperspektiva and Energoprogress

Address: ul. Galaktionovskaya, 132
Samara, Russia

Tel.: 7-8462-334761
7-8462-396228
Fax.: 7-8462-323248

Oleg N. Syusyev, Mayor of Samara

Address: City Administration
ul. Kuibyshev, 137
Samara, Russia

Andrey Simonov, Specialist, Volgoenergo's Investment Department
(attended Battelle business plan workshop)

Tel.: 7-8462-396128
7-8462-396328
Fax: 7-8462-396166
Notes


5. Conversations with Grigory Tomarov, Director of Geoterm-M, the Moscow branch of Geoterm, in July and September 1995.

6. Conversations with Grigory Tomarov, Director of Geoterm-M, the Moscow branch of Geoterm, in July and September 1995; Memo from Grigory Tomarov, October 26, 1995.


12. ibid.


18. Letter from Evgeny Panov, General Director of Polimer, to Igor Bashmakov, Executive Director of the Russian Center for Energy Efficiency, April 18, 1995.


20. Letter from Evgeny Panov, General Director of Polimer, to Igor Bashmakov, Executive Director of the Russian Center for Energy Efficiency, April 18, 1995.


22. Letter from Evgeny Panov, General Director of Polimer, to Igor Bashmakov, Executive Director of the Russian Center for Energy Efficiency, April 18, 1995.


35. ibid; Bruce Hedman’s Trip Report (Moscow, January 1995), dated February 22, 1995 (unpublished). Note: Bruce Hedman was a Program Manager at PNNL at the time.


38. Memo from Vladimir Zhuze, Deputy Director of the Russian Center for Energy Efficiency, CENEf, dated January 30, 1996.


42. Criocor Stock Company. *Information Packet.* Moscow, 1994; Criocor. *Expander Generating Unit DGA-5000.* Moscow, no date.


55. Memo from Vladimir Zhuze, Deputy Director of the Russian Center for Energy Efficiency, January 22, 1996.