*Fueling Reform: Energy Technologies for the Former East Bloc*

July 1994

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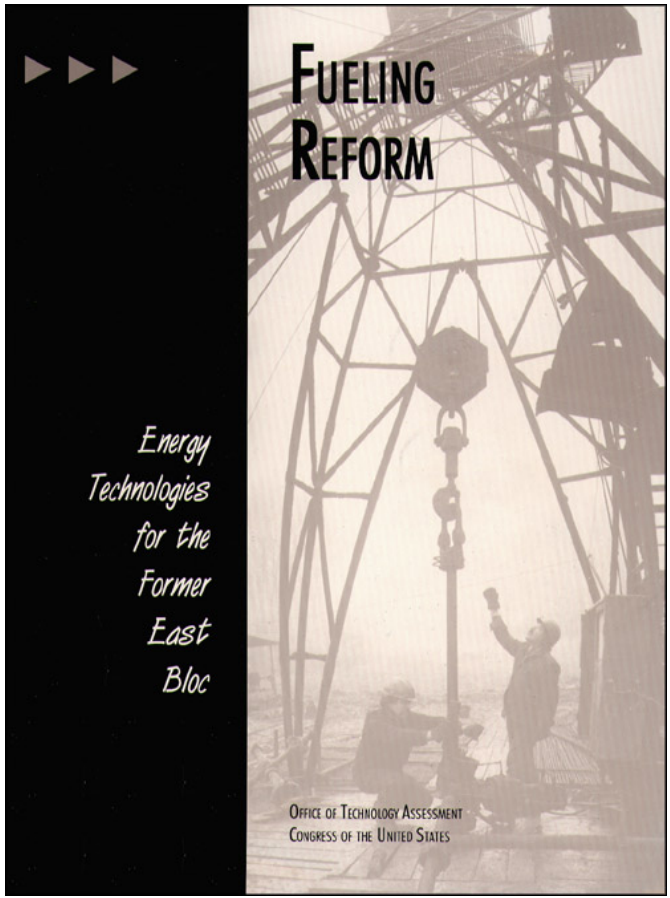

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# Foreword

The Senate Committee on Environment and Public Works, the House Committee on Foreign Affairs, the House Committee on Energy and Commerce, the Senate Committee on Foreign Relations, and the House Subcommittee on International Development, Finance, Trade, and Monetary Policy requested an assessment of energy and environmental technology transfer to Central Europe and the former Soviet Union. The intent was to determine how U.S. energy technology can help resolve the economic and environmental problems in the region.

This report is the second of two produced during this assessment. The first, *Energy Efficiency Technologies for Central and Eastern Europe* (released May 1993), focused on ways to reduce waste in the use of energy.

The present report focuses on technologies to improve energy supply in Central Europe and the former Soviet Union. The report is divided into two parts. The first part reviews energy supply technologies for fossil–fuel and nonfossil–based energy resources. In addition, it reviews the environmental consequences of energy production and consumption. The report highlights specific needs for U.S. technology and opportunities for U.S. business. The second part of the report is devoted to policy considerations. It describes the highly varied political, economic, and social context of reform. Next, it analyzes and catalogues Western energy–related assistance and investment programs for the region. The final chapter of the report presents policy options relating to energy supply and efficiency that will promote the achievement of U.S. political and economic goals.

Energy is a key factor as the former East Bloc countries struggle toward stability and economic recovery. The issues raised in both these reports are therefore timely for congressional deliberations on assistance to the region, on how to increase U.S. exports, and on how to reduce environmental problems.

OTA appreciates the invaluable advice and assistance of the many people who contributed to this project, including the advisory panel, contractors, and reviewers.

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**Note:** OTA appreciates and is grateful **for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.**

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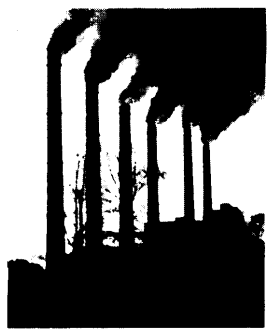
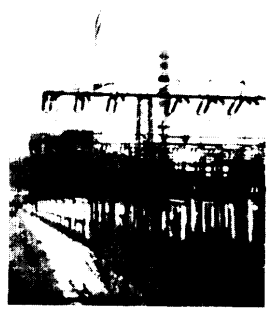




# Introduction and Summary 1

Encouraging the successful transition of the former East Bloc into prosperous, market-oriented democracies is the most important long-term foreign policy issue facing the United States. A successful transition can convert former enemies into friendly trading partners and allow reductions in U.S. defense spending. Failure of the transition could have very undesirable implications for the United States, including the rise of nationalistic, authoritarian regimes, the possible resumption of the Cold War, and dangerous international instability. [1]

Reforming and revitalizing the energy sector will be a critical factor in the overall transition, and energy technology transfer will be one of the most influential tools the United States can use in support. Russia and several other republics of the former Soviet Union (FSU) have extensive reserves of oil, gas, coal, and uranium that can generate the hard-currency export earnings needed to finance reform in all sectors. Tapping that potential will entail adoption of market-economy business practices as well as the modernizing of facilities, technologies, and techniques in the production and consumption of energy. The result will be a reduction in the present wasteful use of energy and an enhanced ability to develop and produce energy. Most importantly, successful reform in the energy sector can make systemic reform easier by raising

BILL WESTERMEYER

*St. Basil's Cathedral, Red Square, Moscow.*

[1] The former East Bloc is made up of Central/Eastern Europe and the states of the former Soviet Union (FSU) as shown in figures 1-1 and 1-2. This report will focus on former East Bloc countries with significant energy supply and processing industries. In Central Europe, this includes Poland, the Czech Republic, and Hungary. In the FSU, this includes Russia, Ukraine, Azerbaijan, Kazakhstan, Uzbekistan, and Turkmenistan. Other countries, especially Romania, also produce significant amounts of energy, but were beyond the scope of this study.

levels of economic well-being and by providing a model for transition.

At present, almost the entire energy sector faces serious problems. Technology is years behind that of the West. Production facilities and the transportation infrastructure are deteriorating and require massive upgrading. Management frequently is unfamil iar with concepts basic to market economies, such as minimizing costs, finding markets, financing, and customer service. In all countries, energy is an unnecessarily great economic cost because it is used so wastefully. Moreover, pollution from energy production, transportation, and consumption is a large factor in the environmental devastation that affects much of the region.

Revitalization of the energy sector will depend primarily on changes in political and economic decisionmaking in each country. It will involve appropriate pricing of energy and the elimination of subsidies so that proper cost signals are sent to consumers and adequate investment capital is made available to the energy industry. It will entail fair and responsible treatment of both domestic and foreign investors who can bring desperately needed investment, technology, and expertise. This is already happening in some of the Central European countries, especially Poland, the Czech Republic, and Hungary. There, economic recovery is occurring, and people see their economies and political systems increasingly linked to the West.

In the FSU, however, the present economic depression precludes instant reform. People earning $30 per month simply do not have enough money to pay world market prices for the energy required to stay alive. Many people have yet to see any benefit to reform and, in fact, are starting to blame it for the steep drop in their standard of living. The December 1993 parliamentary election in Russia raised considerable doubt about future political and economic directions.

The spread of corruption and racketeering also seriously undermines prospects for reform, fanning popular discontent over declining living standards and the inequitable distribution of wealth. Corrupt practices pervert efforts to rationalize systems of pricing, supply, management, and economic policymaking.

The West cannot force economic and political reform and revitalization, but it can play a vital role. In the energy sector, the United States can provide advice on sorely needed changes in institutional structures and economic policies. U.S. governmental assistance programs can provide information, training, technology, and direct assistance to energy-related enterprises trying to modernize. Multilateral development banks can stipulate that loans be made only to enterprises and governments that make decisions on a more rational basis. Private industry can provide modern technology through products and services as well as investment in new facilities. Policy advice, financing, and technology can help build a rational, productive, and noncorrupt system of energy supply and consumption that will be a model of economic transformation for other sectors.

The potential benefits to the United States of assisting in FSU energy sector reform are many. Foremost is the reduction in future conflict and geopolitical competition that should redound from political stability and economic prosperity in the former East Bloc. Modernizing energy-related facilities and technologies through technology transfer should also advance U.S. energy and environmental business interests, open up vast new resources of fossil fuels to the world fuel supply, and reduce pollutants that contribute to global warming.

OTA has previously examined the importance of improving the efficiency of energy use in its companion report of 1993.[2] This report explores the role that the United States can play in revitalizing the energy supply sector. Chapters 2 through 5 examine the need for modem energy technology, especially for oil and gas, coal, nuclear energy,

[2] U.S. Congress, Office of Technology Assessment, *Energy Efficiency Technologies for Central and Eastern Europe, OTA-E-562* (Washington, DC: U.S. Government Printing Office, May 1993).

electric power, renewable energy, and pollution control. Chapters 6 through 8 review the political and economic problems that inhibit reform, U.S. and other Western programs intended to overcome these barriers, and possible modifications to U.S. policy to enhance support of national goals. The remainder of this chapter summarizes the report. Figures 1-1 and 1-2 show the region and its major energy resources.

## ENERGY TECHNOLOGIES

### I Oil and Natural Gas

A major strength of the FSU is its abundant oil and gas resource base. The FSU contains about 7 percent of the world's proven oil reserves and has immense potential for new discoveries. Russia has the lion's share of proven reserves, about 85 percent. Kazakhstan accounts for much of the rest. The gas reserves of the FSU are even more abundant—almost 40 percent of the global total. Russia again has the lion's share. Khazahkstan, Azerbaijan, and Turkmenistan, though less explored, are also well endowed.

The oil and gas sector is critical for the FSU. In individual exporting and importing countries alike, oil and gas are key inputs to economic growth and stability. However, despite abundant resources that supported the growth of the world's largest integrated oil and gas industry, the sector is encountering severe problems. Oil production has fallen by 40 percent over the past 5 years, and gas production has stagnated, in sharp contrast to previous rapid rates of growth. There is little indication of an early recovery in production. This drop, and the resultant drop in exports, is a major economic disaster for Russia. Rehabilitation and development of the oil and gas industry is crucial to the economic recovery of many of the FSU countries, Russia in particular.

The failure of the oil and gas sector is in part due to outdated technology and inadequate investment. Underpinning both is an economic and institutional regime that does not offer adequate incentives to either domestic or foreign investment or encourage the rapid adoption and diffusion of improved technology.

The need for extensive technological upgrading has created expectations among Western companies that the FSU will be a large export market. Oil and gas technology is a generation out of date, and inadequate to meet the challenges of future development. In exploration, seismic equipment is bulky and of low quality. The Russian industry has not benefited from recent improvements in drilling technologies that reduce the cost or risk of exploration. Excessive and premature use of water flooding during recovery has damaged reservoirs. Lack of deep-water offshore technology holds back the development of rich offshore deposits. Pipeline infrastructure faces major problems of technical performance, and equipment is frequently in short supply. Refinery technology is chronically outdated, and does not match current and 1ikely future demands for petroleum products.

However, economic and political factors in the FSU will limit the role of imported technology. The FSU has a comprehensive supply industry that can produce most equipment, often more cheaply, even if inferior to Western technology. Russia in particular has a distinct preference for domestic development and an acute shortage of foreign exchange. There are some areas in which foreign technology has compelling advantages. These include technologies connected with workovers and rehabilitation of existing wells, advanced drilling systems, offshore technologies, improved compressors, refinery upgrading, and technology transfer to improve the production of oil and gas field equipment currently produced in FSU countries.

The adoption and diffusion of improved technologies will depend on economic and institutional reforms. Until incentives are in place to ensure that technology is correctly and efficiently used, even the best technology will not be effectively deployed.

A major handicap to oil and gas development (especially oil) has been the lack of funds for sector rehabilitation and expansion. After many years of favored status in the investment budget, capital expenditure in oil and gas has been sharply cut in recent years. In principle, the shortfall in central government expenditures was to be met from for-

FIGURE 1–1: Selected Energy Sources in Central Europe


SOURCE Dewed from "Atlas of Eastern Europe," Central IntelligenceAgency, August 1990.

FIGURE 1-2: Selected Energy Resources in the Former Soviet Union


SOURCE: Derived from "Energy in the Newly Independent States of Eurasia," Central Intelligence Agency, August 9[illegible]2

eign investment and from the surplus revenues of the new operating entities, particularly the production associations. In practice, domestic industry resources have been squeezed by changes in pricing policies. With the continued control of domestic oil prices and the decontrol of other prices, added to higher taxes, production association costs have risen much faster than revenues, thus compressing the surplus available for investment. Moreover, production associations have limited access to hard-currency earnings from their oil exports.

In addition to domestic investment, external financing requirements are also substantial-estimated at between $5 billion and $7 billion annually. Although major public sector commitments have been made (through the multilateral development banks and the U.S. Eximbank Framework Agreement), the bulk of the resources for foreign investment in oil and gas must come from the private sector.

Recognizing the need for foreign direct investment and its accompanying technology transfer, Russia made major changes to its rules governing foreign investment. Joint ventures were authorized in 1987, and later changes permitted foreign companies to take majority ownership ‘and control. In response, the international oil industry has shown a high level of interest. There are currently over 100 projects in FSU countries with foreign participants. The projects cover all branches of the sector, all of the oil and gas producing republics, and different sizes of companies of many nationalities. Over half of these projects had U.S. joint venture partners. However, many projects have been making modest progress.

The attractions of FSU countries to foreign investors are strong. Immense resources offer a wide range of opportunities, at low geological risk. Most republics have a trained work force at all levels of expertise, from scientists to oil field workers.

On the other hand, important obstacles block foreign investment. Beyond the high level of political uncertainty, there is as yet no legal and regulatory framework governing oil and gas leasing, exploration, and development. Ownership rights are hotly contested between the central federation, local governments, and the production associations themselves, causing uncertainty among potential foreign investors about the legality of their agreements and contracts.

Taxes are high compared with those of alternative areas, such as those near the North Sea, and are based on revenues rather than profitability. These taxes are also subject to retroactive change.

Differences in perception between Russian hosts and foreign investors are a significant obstacle to foreign participation. To the Western eye, the need for modem technologies throughout the oil and gas industry is obvious and represents a large export market. The Russian industry and government have different views. Some parts of the industry are eager for new technologies, but others exhibit deep opposition to the involvement of foreign capital in the oil and gas sector. Joint ventures are viewed as necessary only to produce oil that cannot be produced with current Russian technology—hence the offering of depleted or technically difficult oil fields to foreign investors. Many of these perceptual differences stem from differences in business practices. Russians are generally unfamiliar with basic Western business terms and concepts such as accounting, profit, depreciation, risk, market pricing, accountability, quality control, contracts, and liability.

In sum, the rehabilitation of the FSU oil and gas industry offers a tantalizing but challenging prospect for the foreign investor. FSU countries offer exciting, rich possibilities for oil and gas development, but many obstacles threaten these mutually beneficial outcomes. Overall, the picture is mixed, showing some improvement of late but suggesting that the rehabilitation of the oil and gas sector will take more time and care than originally thought.

## | Coal

Coal is an abundant resource in Russia, Ukraine, Kazakhstan, the Czech Republic, and Poland. In recent decades, coal has declined in importance in the Soviet economy, but it is still the major national energy resource (and source of employment) in

Poland, Hungary, and the Czech Republic. For example, in Poland, more than one-half of the residential/commercial sector's energy needs are derived from coal.

In the FSU, the coal industry is in crisis. Coal production has been declining since 1988 and will probably continue to decline for the near future, owing to equipment shortages, inefficient technologies, labor unrest, and a lack of capital investment in new mine development. Environmental concerns further cloud the industry's future. Coal production has had serious harmful environmental effects, some of which linger long after mines have closed. The widespread burning of low-quality coal is largely responsible for environmental degradation.

Some restructuring of the coal industry has begun in former East Bloc countries, including closure of inefficient mines, price increases, and reduced subsidies. However, the industry is still far from competitive.

Modem Western mining technologies may provide short-term improvements in productivity, efficiency, safety, and environmental impacts. However, Western assistance alone will not reverse the coal industry's downward slide. In the long term, the success of the coal industry will depend on the success of economic reforms. Capital must be invested in mine development and modernization, and labor and transportation problems must be resolved.

Thus far, the U.S. coal industry has not actively pursued former East Bloc markets. The characteristics of the region's coal industry and related problems have hampered foreign investment. Also, differences in mining techniques render much U.S. underground equipment unsuitable for FSU mines. Longwall mining is the principal underground mining technique used in the FSU and throughout Europe. Germany, a leader in longwall mining R&D, is actively marketing its equipment in Central Europe.

The biggest U.S. effort in the FSU has been part of a much larger humanitarian program, Partners in Economic Reform (PIER). With U.S. government funding and coal industry and labor support, PIER administers the Coal Project, which provides technical assistance and training in health, safety, efficiency, and productivity throughout the coal regions of Russia, Ukraine, and Kazakhstan. This focus is unlikely to change unless former East Bloc countries make a successful transition to a market economy and coal industry problems are resolved.

SPEARS AND ASSOCIATES, INC.

*Idle drilling rig, Raduzhney Siberia,*

As reforms are implemented and the coal industry stabilizes, transfer of U.S. coal mining technology may become significant. In the near term, however, U.S. companies might focus on opportunities after the coal is extracted, such as coal cleaning. There has been little cleaning of coal in former East Bloc countries, but U.S. companies have extensive experience in this technology. Over 200 million tons of coal are cleaned each year in the United States to remove ash and sulfur impurities and to increase coal's heating value. Cleaning also reduces transportation costs by removing significant quantities of noncombustible material from raw coal before shipment. Because coal cleaning is relatively labor intensive, new or

expanded coal-cleaning facilities could provide jobs in areas where mass unemployment looms.

In April 1993, a U.S. firm (Custom Coals Corp.) announced that it was seeking to design, construct, and operate three coal cleaning plants in Poland. One facility will serve three mines, with a capacity of 25 million tons. Another facility will be a fine-coal cleaning plant to produce ultra-clean coal products for home and district heating systems in Krakow.

## I Nuclear Energy

The Chernobyl accident demonstrated that Soviet reactors had serious safety deficiencies. Subsequent analysis and inspection by Western experts have confirmed that major accidents are far more likely in these reactors than those of the West because of design problems and poor operation. The greatest concerns are over the graphite-moderated RBMK reactors, such as at Chernobyl, and the oldest pressurized-water reactors, the VVER 440 Model 230. These reactors lack basic safety equipment such as a containment vessel. The RBMK, unlike Western reactors, is vulnerable to an uncontrolled nuclear accident, as happened at Chernobyl.

A nuclear accident could harm millions of people and contaminate vast regions of Europe. As the world's leading manufacturer and operator of nuclear powerplants, the United States has the expertise and a particular responsibility to help reduce this risk. U.S. involvement can also mean U.S. exports, such as the $434 million sale of equipment and fuel by Westinghouse Electric Corp. to the Czech Republic announced in 1993.

Ideally, the riskiest plants should be closed. However, the power they produce is greatly needed, and none of these countries can afford to build and fuel replacement powerplants. Even Ukraine has decided to defer closing the Chernobyl station on the grounds that the economic necessity outweighs the risk.

It should be noted that the actual level of risk is not well understood. Soviet reactors have some safety advantages, such as a large water inventory in the VVER 440 that slows core heating following an accident and allows more remedial action than that of Western reactors. Some experts believe that the newer reactors can be upgraded to safety levels near Western standards. The uncertainty over risk complicates decisions over how soon reactors should be closed. Nuclear assistance is controversial because some critics believe that none of these reactors can be made sufficiently safe and that all should be shut done as soon as possible.

U.S. nuclear assistance funding is rising from $30 million in fiscal year 1993 to $100 million in fiscal year 1994. The program has focused primarily on information transfer (e.g., training in operations, regulations). The increase will allow some physical improvements at nuclear power stations. Most attention has been paid to the newer plants on the assumption that the riskier ones would be shut down soon. However, since it appears that these plants will be operated for a substantial period, they will present a disproportionate threat unless near-term safety upgrades are supported. Nevertheless, it also is important not to upgrade them to the point that they are kept operating longer than necessary. No funds are yet being allocated for replacing any nuclear powerplants.

Western companies are concerned that their assistance could lead to liability if an accident occurs at a reactor despite upgrades. This concern is a significant impediment to assistance. Recipient countries may have to limit liability, as have many in the West, because the potential consequences of a major accident are so great.

Concerns about nuclear weapons proliferation have increased because of political and economic instability in the FSU. Analysts fear that with the weakening of central control over weapons and associated facilities, nuclear weapons or materials could be stolen and sold to an irresponsible country or terrorist group. Alternatively, FSU weapons experts could work for other countries.

The United States has already taken steps toreduce this danger, as discussed in other OTA reports. The key issue in this report concerns the use of FSU weapons experts in the civilian nuclear power industry. Many have a technical back-

ground suitable for conducting research and analyzing nuclear reactor safety. Using them for this purpose would serve the dual purpose of increasing safety and reducing proliferation risks.

International science and technology centers have been proposed for Moscow and Kiev. Both have been delayed because of difficulties in getting legislative approval. The Russian institute was started in December 1993 by Presidential proclamation, but it is uncertain how permanent this arrangement will be. An alternative approach would be to increase collaborative R&D activities with existing institutions.

## I Electric Power

All countries in the former East Bloc have a substantial and sophisticated electric network. In some countries, electricity is more available than oil and gas because it can be generated from nuclear energy or local coal. Nevertheless, the electric power industry faces many problems, including decrepit generating stations, expensive fuel, poor operations, and massive pollution.

Modernization is badly needed to improve operations, reduce costs, and reduce pollution. In addition to physical plants, utility management and government regulators need training to understand how to operate in a free market environment. Particularly in the FSU, rates are subsidized heavily, so neither utilities nor users see incentives to make optimal decisions.

Several U.S. technologies would be of considerable benefit. Burning coal cleanly will be important in reducing pollution. Flue-gas desulfurization, fluidized-bed combustion, and integrated gasification combined cycle are ways to use coal much more cleanly. These and other technologies may be used widely as the electric sector modernizes, if financing is available.

Demand-side management (DSM) could also become important in countries that base rates on costs. Utilities work with their customers to reduce waste so that the construction of new plants will be minimized. Since capital is scarce and demand for electricity will soar as economies rebound, DSM may be critical in preventing shortages.

The U.S. assistance program has created partnerships between U.S. utilities and their Central European and FSU counterparts. The partners exchange information and expertise. The program has been so successful that U.S. utilities are finding that the demands on their time are getting too great, since they are reimbursed only for travel and other expenses. The U.S. Agency for International Development (AID) is adding a supplementary program to pay for intensive projects such as large training courses.

The major barrier to modernization is financial. Many power companies in the region lack funds for investment, and their borrowing capability is limited. Export financing will be essential for wide-scale sales. Present U.S. export financing policies may not be adequate to support the electric equipment industry's unusual opportunity. Central European countries may open up new markets and opportunities for American companies for investment and sale of electrical equipment-opportunities that have been limited by protected domestic industries elsewhere in the world.

Cooperation in electric technology should also result in technology transfer to the United States. Russia pioneered high-voltage transmission and has built lines at twice the voltage of any in the United States. Super-critical boilers are another area where U.S. manufacturers and utilities can learn valuable lessons.

## I Renewable Energy Technology

Solar and other renewable energy technologies contribute only a small share of total energy production in the former East Bloc, and that is unlikely to change soon. Nevertheless, the potential is significant.

Soviet scientists conducted extensive research on renewable resources over the last several decades, resulting in sophisticated technologies and well-developed science, but few commercial successes, with the exception of hydroelectric power

FRANK ZOLLI, NEW ENGLAND POWER SERVICE

*Vertes Powerplant, Hungary New England Power Service is paired with Hungarian Electric Companies, Ltd. under the Utility Partnership Program.*

projects. Russia inherited much of this technology and expertise, although Ukraine has substantial technical know-how in windpower and solar thermal areas. Little expertise, however, has emerged over the years regarding project planning, development, and management.

The potential for renewable development varies since geography, climate, and weather patterns largely determine prospects. For example, wind energy potential is enormous in Russia, Kazakhstan, and Ukraine. The U.S. Windpower project in Ukraine, which calls for the installation of 500 MW (megawatts) by 1995, typifies the country's potential. Moreover, the southern areas of Ukraine, Russia, and the Central Asian republics are well suited to solar use. Solar water heating already is used in some areas. Also, Russia has significant amounts of hydroelectric capacity and experience in developing its resources. Hydroelectric power contributes about 19 percent of total electric power capacity.

Other republics are pursuing renewable energy projects out of economic necessity and to become more self-sufficient. Estonia, which has extensive forests, is taking the lead among former republics in biomass development. Lithuania is exploring its geothermal potential. Hungary is a leader in geothermal use for horticultural purposes.

However, significant obstacles interfere with renewable development and use. These include artificially low conventional fuel prices, limited capital, and the lack of political and institutional commitment. For example, Russia's institutional structure is geared to producing fossil fuels, not renewable. These obstacles are significant and will hinder development in the near term.

In several countries, the situation is somewhat different. The need to develop indigenous energy resources, reduce dependency on foreign imports and related costs, and address environmental concerns is creating niches for renewable, such as the wind energy project in Ukraine. Defense conversion and the availability of idle or underutilized industrialized plants may provide an added incentive to develop indigenous renewable resources.

Assistance from Western countries could improve the prospects for renewable development, especially in those countries that have limited or no indigenous fuel supplies. Technology transfer is one avenue for developing these resources at a more rapid pace. It can take many forms, including engineering and design expertise, management and training programs, licensing foreign manufacture of technologies, and equipment sales. Wind turbines, photovoltaic cells, and solar thermal collectors could be manufactured under joint ventures with the West.

Even if assistance is forthcoming, former East Bloc countries must develop a favorable climate for renewable development. Economic reform and the development of domestic markets are essential to renewable use in the long term.

## ENVIRONMENTAL TECHNOLOGIES

Uncontrolled production and use of energy has been a leading cause of environmental degradation in the former East Bloc. The area's centrally planned economies placed a higher priority on the quantity of industrial production than on economic efficiency, environmental protection, or consumer demands. They provided cheap, state-subsidized fuels, which encouraged very high consumption of energy relative to that of other in-

dustrialized countries. The nature of major fuel resources, such as the high-ash coal used in power generation, has further increased pollution.

Environmental problems due to energy use vary across the region. Programs to alleviate environmental damage from energy use must therefore consider the problems of each region individually. For example, regional air pollution patterns vary. In Estonia, more than two-thirds of the emissions of particulate, sulfur dioxide ($S0_2$), and nitrogen oxide ($NO_x$) come from just three sources. In Poland, fuel use at a large number of small, decentralized boilers and home heating units is a major source.

Solutions to environmental problems must also address a variety of institutional constraints. An ineffective regulatory structure is a prime impediment. Contrary to Western perceptions, all of the countries in the region have stringent environmental standards. However, regulatory enforcement of these standards has been lax. Without enforcement of regulations, there has been little incentive to install, operate, or produce emission-abatement equipment. Doubts about future environmental standards have also discouraged local entrepreneurs and potential foreign investors.

Lack of public and private capital also delays the installation of pollution control equipment. Public budgets are under extreme pressure to meet a variety of investment, restructuring, and social safety net costs, severely limiting the amount of public money available for environmental purposes. While foreign sources of public and private financing can provide some interim funds, these sources are relatively small. This renders local private sector capital markets essential, since most environmental expenditures will ultimately be made by privatized companies. But these markets barely exist now. A number of AID and other assistance programs are aimed at developing local capital markets.

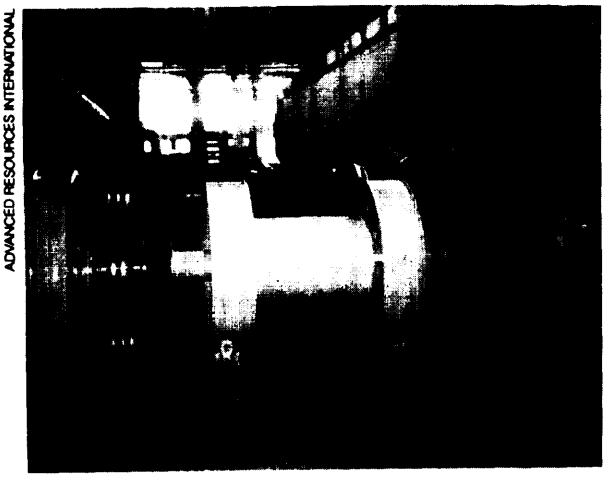
Coordinating environmental assistance with larger economic and social reforms can maximize overall effectiveness. Assistance should also target those energy plants and sectors that can withstand the economic reforms, and not those that will probably be shut down. The structure of the energy industry itself is an impediment to environmental reform. Public utilities and industries are overstaffed and inefficient. Until they restructure and downsize, they will not be able to afford pollution control.

All of these factors will constrain the market for energy-related environmental technologies. Nevertheless, the United States, through its public programs and private business activity, can help upgrade environmental protection in the former East Bloc. Opportunities for technology cooperation are excellent because the United States has a commercial and technical advantage in several areas.

One of the strongest areas of U.S. technological expertise is in coal cleaning. U.S. firms are also well positioned in emission-abatement equipment. One area of particular strength is in low $NO_x$ combustion reburn technologies. Other technologies include flue-gas desulfurization units, electrostatic precipitators, and baghouse filters for powerplants; lean-bum technology for mobile sources; and desulfurization equipment for refineries.

U.S. companies can also help reduce the environmental impact of energy production. For example, as Russia expands gas production further north, the sensitive tundra ecosystem would benefit from some of the lessons learned in Alaska. U.S. mining firms are the world's most experienced in dealing with acid mine drainage and have extensive experience in land reclamation.

However, prospects for U.S. business may suffer because European Union emission standards are generally stricter than U.S. standards. Countries aspiring to join the EU will need to meet these standards with higher efficiency abatement systems than U.S. companies produce. Moreover, since pollution coming from the region affects Western Europe more than the United States, European countries might be more motivated to give more financial and technical support to address these issues. Thus, additional government efforts are likely to be necessary to assure that U.S. environmental equipment is competitive.




*Drilling equipment manufacturing* plant in Kazakhstan.

## THE POLITICAL, ECONOMIC, AND SOCIAL CONTEXT FOR EFFECTING CHANGE

The modernization of the energy sector of the former East Bloc is only one facet of a much larger set of reforms that involve fundamental changes in the political and social orders of these societies. Energy sector reforms depend on the larger set and will also contribute to it. This transition involves several distinct but closely interrelated processes, the most important of which is the establishment of a new political order that embodies a popular consensus about the need for economic reform. Those countries where there is less popular consensus about reform and that have yet to enact new political structures have moved much more slowly and less successfully to stabilize their economies and lay the foundations for a new economic system. The energy-producing countries analyzed in this report fall into three groups: those in the vanguard of reform, those slow to reform, and those lagging in reform.

### I Countries in the Vanguard of Reform

Poland, the Czech Republic, and Hungary occupy the first tier of reform. They were the quickest to establish a political consensus on the need for democratic and market transformations and to translate this political will into effective mechanisms for the implementation of reform programs. Poland launched the earliest, most radical, and, to date, the most successful reform program. Although recent electoral gains by former Communists highlight the need to pay greater attention to social protection during the period of transition, Poland has been the first post-Communist country to experience economic growth and is solidly on the road to reform. The Czech Republic has pursued a more cautious approach toward economic transformation and as a result has not experienced the expansion that Poland has seen. Nevertheless, the Czechs have weathered the breakup with Slovakia and made substantial progress in introducing structural and institutional change, stabilizing the economy, and laying a firm basis for future growth. Hungary pursued a deliberately more cautious strategy, hoping to minimize the social costs of change. As a result, although Hungary remains in the vanguard of reform, the costs of reform have been strung out and even accentuated.

Despite problems, all three countries have freed most energy prices, started privatizing state industries, and welcomed foreign investment. Because of this, Western assistance programs are producing promising results, especially for improving energy efficiency. There is also solid ground for American trade and investment programs. U.S. exports and investments can support reform and development in Central Europe.

### | Countries Reforming Slowly

Russia and Kazakhstan occupy the next tier of reform. Both countries have yet to undertake the types of domestic price, legal, and regulatory reforms that would make energy-efficiency projects profitable, stimulate more extensive and efficient energy production, and make it easier to structure bilateral and multilateral lending for energy-sector modernization.

Since the coup attempt of August 1991, Moscow has been in the throes of a multifaceted struggle over fundamental questions of power, sovereignty, property, and the nature of the future socioeconomic order. The most prominent aspect of this struggle has been the debate by political and social constituencies over the nature and

course of economic reform. These debates are anchored in Russia's uniqueness. Russia's size, as well as its much larger, more complex, and more deeply troubled economy, render the country less amenable to the types of Western-sponsored aid and trade programs that have been instrumental in the transformation of the economies of Central Europe. Although impressive strides have been made in price reform and private sector growth, the Russian economy is still contracting. Unless Russia resolves its crisis of authority so that it can pursue consistent and coordinated monetary and fiscal policies, it will not achieve the type of solid economic stabilization that is an absolute prerequisite to economic reform and growth. Until then, Russia will at best flounder or muddle through reform.

Under these conditions, an increase in U.S. trade-promotion programs may stimulate near-term sectoral stabilization and provide opportunities for American firms. But without strong conditional it y, both aid and trade programs are unlikely to promote long-term, self-sustained, systemic reform.

In contrast to Russia, Kazakhstan has opened its doors to foreign investment, providing potentially mutually beneficial opportunities for American energy companies and the Kazakhstani government. But the country is suffering from the dissolution of economic ties with the FSU and the strains of being a multi-ethnic state. Although Kazakhstan's current energy bonanza provides grounds for optimism, oil development will be limited in the short term by lack of export pipeline capacity and the immense need for capital renovation and exploration. As a result, the Kazakhstani economy is not likely to start growing substantially until the second half of the 1990s. In the interim, the United States can reward Kazakhstan's openness to foreign investment and encourage further systemic reform through expansion of American aid, trade, and investment programs.

## I Countries Yet To Reform

Ukraine, Turkmenistan, Uzbekistan, and Azerbaijan occupy the final tier of reform. Despite the profound economic and political changes occurring in the FSU, these countries have barely taken even the first steps down the road of economic reform. The reasons they lag so far behind are fundamentally political—in these states, Soviet-era bureaucrats remain entrenched in power and cling tenaciously to the tenets of the old system. As a result, most of the distortions and inefficiencies of the Soviet-era energy production, consumption, and pricing system remain in place, and opportunities for Western investment and trade promotion remain murky.

In Ukraine the debilitating competition for internal political power and continuing squabbles with Russia over the legacy of Soviet-era property and nuclear weapons have resulted in the neglect of economic reform. Analysts warn that the consequences of this neglect-economic collapse and hyperinflation-could lead to economic and political disintegration.

Since 1991, economic conditions in Uzbekistan have also deteriorated, but state policies have maintained many of the characteristics of the Soviet-era economy, such as subsidies and price controls. Economic reform will likely proceed slowly in Uzbekistan under the official goal of "market socialism. " Political reform may be even slower. Uzbekistan's president has suppressed almost all political parties, jailed opposition activists, enforced press censorship, and stifled the development of democratic politics.

The reins of economic and political power are also held tightly in Turkmenistan by an authoritarian ruler who has created a Stalin-like "cult of personality" and suppressed potential political opposition. Although Turkmenistan's vast gas and oil wealth offers excellent opportunities for development, potential revenues from energy development are likely to be squandered through corruption.

Finally, in Azerbaijan, the continuing war with Armenia over Nagomo-Karabakh, and attempts by Russia, Turkey, and Iran to influence domestic politics, have diverted attention from economic reform. Despite the proliferation of small-scale capitalism and negotiations with foreign compa-

TABLE 1-1: Selected FY 1994 USAID Program Budget Allocations
(Italics indicate energy sector-specific items)[a]

| Program type | FSU (millions) | Central Europe (millions) |
|---|---|---|
| **Policy and market reform assistance** | | |
| *Pricing policy and institutional reform* | 22.0 | |
| *Energy sector restructuring and privatization* | | 8.0 |
| Rule of law | 25.5 | 2.8 |
| Commercial law reform | | 11.3 |
| Local governance | 9.5 | |
| Democratic governance and public administration | | 23.0 |
| Privatization | 115.0 | 44.3 |
| Business development | 75.0 | 30.0 |
| Banking sector reform and bankers training | 12.6 | |
| Fiscal sector reform | 15.5 | |
| Financial and monetary sector reform | 10.7 | 18,1 |
| Training and macroeconomic advice (Dept. of Treasury) | 2.1 | |
| Market environment | 14.4 | |
| **Business and organizational training** | | |
| Short- and long-term training | 91.5 | |
| US/NIS partnerships | 5.0 | |
| Exchanges (USIA) | 128,0 | |
| SABIT Program (DOC) | 2.0 | |
| CAST Program (NAS) | 2.0 | |
| Eurasia Foundation | 12.0 | |
| **Energy efficiency** | | |
| *Efficiency & performance improvement* | 35.0 | 9.0 |
| *Production and delivery systems* | 39.0 | |
| *Special earmarks (lab-to-lab, etc.)* | 33.0 | |
| **Nuclear power** | | |
| *Nuclear power plant safety and regulation* | 85.0 | 5.0 |

Continued next page

nies to develop the Caspian Sea's energy resources, there has been no systematic program of economic reform. Instead, corruption and a highly lucrative illicit trade in oil and other valuable raw materials have proliferated.

Given the leadership's lack of interest in reform in these countries, the most effective form of assistance to spur progress may be U.S. policies to promote energy efficiency and training in market skills. As in Russia, an increase in American trade and investment support programs may do little to promote market reform.

## I Problems Common to All Countries

Despite their differences, the countries of the former East Bloc share a similar set of problems in the transition from Communist authoritarianism to market democracy. All need to minimize unemployment and other social disruption during the transition period while fighting inflation and maintaining budget discipline. These states must also overcome a broad lack of understanding of market principles and the mindset of the old system. This challenge is complicated by the charac-

TABLE 1–1: Selected FY 1994 USAID Program Budget Allocations (cont'd.)
(Italics indicate energy sector–specific items)[a]

| Program type | FSU (millions) | Central Europe (millions) |
|---|---|---|
| **Technical assistance** | | |
| *Russia Energy & Environment Commodity Import Program* | 125.0 | |
| *Krakow Power Project* | | 4.5 |
| **Environment** | | |
| Policy and institution building | 21.9 | |
| Technology cooperation | 36.5 | |
| Local NGO support | 14.6 | |
| **Trade and investment promotion** | | |
| Transfer payments to DOC and TDA | 8.5 | |
| American business initiative | | 3.0[b] |
| **Enterprise funds** | | |
| Russian-American Enterprise Fund | 120.0 | |
| Western NIS Enterprise Fund | 45.0 | |
| Central Asian Enterprise Fund | 30.0 | |
| Fund for Large Enterprises in Russia | 100.0 | |
| EBRD Small Business Fund | 15.0 | |
| Multi-Lateral Equity Fund | 21.0 | |
| Central European Enterprise Funds | | 55.8 |

[a] This table is *not* a comprehensive listing of USAID former East Bloc programs. It includes only those programs that are either specifically targeted at the energy sector or that address general areas of economic and systemic reform that are important for energy-sector development,
All figures represent original appropriations
- They do not reflect recisions under way in February 1994
- They do not reflect considerable carryover of funds appropriated m fiscal year 1992-93

[b] ABI terminated after fiscal year 1994
SOURCE U S Congress, Office of Technology Assessment, 1994

ter of newly emergent market relations, which often create a negative image of capitalism and highlight its very worst aspects. These factors complicate the efforts of American companies to conclude investment and purchase agreements and render even more imperative U.S. government efforts to promote the principles of market reform.

But even more important, the huge drop in living standards and the political chaos of the post-Communist era have led to a crisis of identity in many areas of the FSU, especially Russia. With Russia and the other FSU countries now in a weak position on the world stage, with economies in collapse, with crime on the rise, and with citizens earning paltry incomes, nostalgia for the old system has grown. Unless these countries start achieving economic and political progress soon, the social consensus needed for the transition to democratic politics and market economics will not emerge.

## CURRENT U.S. PROGRAMS PROMOTING COOPERATION

The United States supports a wide range of programs designed to promote energy and environmental technology cooperation (see table 1-1.) Bilateral aid programs operated by AID, the U.S.

Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and others include technical assistance, training, provision of information, policy advice, R&D, and technical cooperation. Other bilateral programs managed by the Export-Import Bank of the United States (Eximbank), the Overseas Private Investment Corp. (OPIC), and the U.S. Department of Commerce (DOC) provide backing to the U.S. private sector, which can play a key role in the rehabilitation of the former East Bloc energy sector. As the largest shareholder in the multilateral development banks (MDBs), the United States also actively exercises influence over their large project lending programs. MDB lending has emphasized the oil and gas industry and the power sector, but there are also active programs for environmental improvements and energy efficiency. Most of the programs surveyed for this report are quite recent in origin, but even on the basis of limited experience, their strengths and weaknesses have become apparent.

## I U.S. Program Evaluation

The U.S. government moved with exemplary speed to develop assistance programs for the Central European countries and later the FSU. The energy sector has been an appropriate part of these programs. Within overall 'budget constraints, the existing programs are comprehensive in coverage and address the main issues identified in OTA's technical analysis-capital constraints for both energy supply and conservation projects, energy sector and macroeconomic reform, and technical assistance. Particularly strong efforts have been made to include the U.S. private sector in these efforts.

In addition, U.S. programs have shown considerable flexibility and responsiveness to changing conditions, even over the short time they have been in operation. There has been a clear shift from the early emphasis on providing energy and environmental technologies directly to building underlying policy and institutional capacity. Efforts have been made to respond to early criticisms of the U.S. effort, including too many temporary consulting missions, lack of in-country expertise, slow procurement, and confusion over country needs due to a regional approach to aid disbursement.

Moreover, these programs have been developed and implemented under difficult circumstances, including budget constraints. Considerable political pressure was put on agencies to disburse quickly to give visible evidence of Western support for the new regimes. All agencies have experienced difficulties recruiting permanent staff with the necessary area expertise.

An additional problem is that many programs are lodged in institutions that were designed for different types of operations. The World Bank and AID were designed for projects in developing countries, whose capabilities and needs differ considerably from those of the former East Bloc. The primary mission of Eximbank is to support U.S. exports, but Eximbank's Framework Agreement is both a major support to U.S. exports and a cornerstone of U.S. financial assistance to the FSU countries.

Moreover, unstable political and economic conditions in some recipient countries have hampered program development. Several U.S. agencies report a shortage of viable projects in the FSU, either because of unwillingness to accept conditions attached to financial assistance or lack of interest. In several countries, notably in the Russian oil and gas sectors, foreign investment is viewed with deep suspicion.

Several specific weaknesses of U.S. assistance have emerged over the past several years. The large number of U.S. agencies offering broadly similar services raises issues of coordination and duplication. Officials in the former East Bloc complain that they are swamped by visiting missions and that the funds are going largely to foreign consultants rather than to the countries themselves.

Coordination among the various donors, reportedly fairly low during the first years of assistance, has apparently improved as the energy and environmental assistance efforts proceed. Even so, there are several examples of lack of donor

coordination, which seriously weakens the entire effort. For example, while the World Bank insists on conditionality in its loans, the Eximbank Framework Agreement contains no conditionality, thus weakening World Bank requirements.

Underpinning these weaknesses in implementation is a more fundamental uncertainty over the best means to achieve U.S. policy goals. The optimal scale of U.S. assistance and its distribution between the many countries of the region have not been defined. Allocations of assistance within the energy sector are open to question, particularly the emphasis on supply expansion, given the immense potential for energy conservation. The reluctance of some host countries, notably Russia, to cooperate in key parts of the assistance program raises questions about the wisdom or feasibility of the present approach.

These mixed experiences suggest that the time is opportune to reexamine the totality of U.S. efforts in the light of original U.S. policy objectives and to suggest ways in which the programs that support U.S. policies can be improved.

## US. POLICY GOALS AND OPTIONS

### | U.S. National Goals

The primary U.S. goal is to promote the transition of formerly hostile East Bloc countries to democratic, market-oriented trading partners. Some countries are well on their way to a successful transition, but others face a much more uncertain future. Energy technology transfer supports the transition, but will have only modest impact unless accompanied by market reform measures such as the elimination of subsidies, privatization, and new legal structures.

U.S. goals toward the former East Bloc with specific energy implications include the following:

#### *10 Support Market Reform in the Energy Sector*

Modernization is unlikely without reform, and the energy sector can lead the way for other sectors.

#### *To Modernize Energy Sector Facilities and Technologies.*

Improving the technology of supply and use of energy can have major economic advantages by increasing exports of oil, providing new options, and reducing unnecessary costs to the economy.

#### *To Advance U.S. Energy-Related Business Interests.*

U.S. companies have many products and services appropriate for export to the energy sector of the former East Bloc.

#### *To Reduce Energy-Related Pollution and Threats to the Environment.*

Local and global pollution can be significantly ameliorated with modem technology.

#### *To Augment World Fuel Supplies.*

Increased exports of oil and natural gas from the former East Bloc because of increased production and reduced consumption will mean less strain on world energy markets.

### I Policy Options

Policymakers have a variety of options to support the goals discussed above (see ch. 8 for a more extensive discussion). As listed in table 1-2, policy options are available in the following areas:

#### *U.S. Bilateral Development Assistance*

U.S. development assistance to the FSU is intended to increase the flow of information and skills needed to operate a modem, environmentally acceptable energy system; to assist in building needed facilities; and to reduce the risk of nuclear weapons proliferation. AID is the primary agency for development, and it funds many of the programs run by other agencies. A large fraction of U.S. assistance funding is spent in the United States, and the assistance is delivered in the form of goods and services. The activities listed (and discussed under Element 2 in the following section) are those selected by this study as particular

TABLE 1-2: Policy Options

*U.S. Foreign Development Assistance*
Increase funding for the following areas:
- Policy assistance
  - Price reform, privatization, regulation, and policy training
- Training in market activities and skills
- Energy efficiency improvements
  - Demonstrations and assistance
  - Efficiency centers and information
- Nuclear safety and proliferation control
- Environmental information and assistance
- Specific technology transfer programs
  - Utility Partnership Program
  - Powerplant renovations
  - Clean-coal demonstrations and assistance
  - Coal mine safety
- Energy research and development

*U.S. Export Promotion*
Increase flexibility of financing
Increase feasibility studies
Direct Small Business Administration to create programs assisting small businesses
Enhance Foreign Commercial Service and other information programs
Upgrade visibility of exports within U.S. diplomatic policy
Remove barriers to exports

*Multilateral Development Banks*
Encourage smaller- scale loans
Make energy efficiency a higher priority

*Investment Promotion*
Raise limit on Overseas Private Investment Corporation insurance for oil and gas projects

*Program Management and Coordination*
Improve procedures to expedite activities
Improve coordination among agencies

**SOURCE.** Office of Technology Assessment, 1994.

ly effective. All could be considered for increased funding if it is available.

### *U.S. Export Promotion*

DOC, Eximbank, and the Trade and Development Agency (TDA) have useful programs that support U.S. businesses. Increased funding for export financing (e.g., through guarantees for commercial bank loans that otherwise would not be available,) feasibility studies, and information programs would assist U.S. industry and contribute to economic modernization.

### *Multilateral Development Banks*

Loans from The World Bank and the European Bank for Reconstruction and Development (EBRD) are major vehicles for development. Congress could influence the MDBs to give a higher priority to energy efficiency and smaller projects that cumulatively can have a greater impact.

### *Investment Promotion*

Foreign investment will be one of the prime forces for development. OPIC provides project finance and insures against political risk.

TABLE 1–3: Low Cost Improvements for U.S. Programs

**AID**
Streamline and accelerate the grants and procurement process.
Lift the hiring celling and require AID to hire more personnel with regional expertise.
Coordinate AID programs more closely with DOC to ensure maximum benefit to U.S. business

**Eximbank, OPIC, TDA**
Increase operating budgets to
Permit the hiring of personnel with regional expertise.
Speed processing and improve monitoring of credit, insurance, and other applications.

**Commerce and State Departments**
Upgrade status of the Foreign and Commercial Service to ensure maximum coordination between trade promotion and diplomatic efforts.

**DOE**
Provide more direct funding for international programs,

SOURCE Off Ice of Technology Assessment, 1994

### *Program Management and Coordination*

Even at the current level of funding, programs can be made more effective.

* * * *

Most of these options are for changes in programs already in effect. They are listed because the programs could usefully be enhanced with increased funding or a change in emphasis. Funding has risen sharply in recent years, but the need for assistance and financing remains enormous. Doing business as usual will mean relatively slow progress at best and a substantial risk of serious political instability, especially in Russia and other countries in the FSU. U.S. budget problems suggest that additional funding can come only at the expense of other priorities; however, measures to restore economic growth in the region could, in the long term, prove highly cost-effective if they succeed in creating friendly, prosperous trading partners.

## | Policy Strategy

Some policy options (e.g., development assistance) support all U.S. policy goals simultaneous] y in all areas of the former East Bloc. In other cases, priorities must be set and choices made. The United States must ensure that goals and initiatives are sufficiently flexible to account for differing local conditions. The options discussed above fall into three groups, each of which can be considered separately or as elements of an overall strategy: low-cost changes to maximize the effectiveness of current U.S. programs; additional funding for effective programs; and options that support some goals but can conflict with others in some countries. A complete strategy to support U.S. goals might consist of the low-cost changes (which are largely noncontroversial), some additional funding for effective programs (depending on the priority accorded energy revitalization in the former East Bloc), plus whichever elements of the last group support the highest priority goals.

### *Element 1: Maximize the Effectiveness of Current US. Programs*

Changes that could improve the effectiveness of U.S. activities and programs for all countries in the former East Bloc are listed in table 1-3. Improvements in program effectiveness should be considered whether or not any further options are entertained because they support all goals without penalizing other national priorities.

### *Element 2: Expand the Most Effective Assistance Programs*

Reform and modernization of the FSU energy sector are clearly in the U.S. national interest, espe-

AIRPOL, INC

*The early stages of assembly at the Skawina plant site. In the background is the thickener with preassembled sections of the absorber vessel in the foreground. The absorber vessel sections are ready to be placed in position*

cially if accompanied by overall economic and political reform. As noted throughout this report, there is a great need for assistance, and U.S. programs can have considerable impact in supporting reform. The steps that could be taken if Congress is willing to allocate more funding to enhance the U.S. role, as listed in table 1-2, include the following:

*Emphasize Government-to-Government Policy Assistance*—U.S officials can supply information and encouragement for policy makers in the former East Bloc to take the painful steps involved in economic transformation and help them design realistic reform programs that meet the need to maintain domestic political and social stability. Total additional costs might be $1 million per agency-e. g., DOE, NRC—for time and travel.

*Expand Business and Organizational Train*ing—One of the most effective U.S. initiatives to promote change is providing training in general business-related skills—a transfer of the knowledge and skills necessary to support the development of new modes of economic organization and technical processes. This type of technology transfer promotes domestic reform while supporting U.S. economic interests. It provides former East Bloc firms with the skills to organize their work and efficiently employ advanced technologies from the West. Additional costs would depend on the level of activity. Several million dollars would allow a significant amount of additional training.

*Expand Energy-Efficiency Programs—Ameri*can demonstration projects and information programs (especially the efficiency centers) area vital component of technology transfer in the energy sector. Energy-efficiency projects can promote reform by demonstrating that it is possible to cushion the effects of raising energy prices and introducing market-based economic relations. An additional $2 million to $5 million could easily be justified simply on the basis of energy savings.

A more activist approach, at least for Russia, where domestic oil is still subsidized, would be to persuade the Russian government to commit to raising energy prices to world levels over several years. In the meantime, enterprises would be guaranteed their current quota of energy, but the state would buy back at near-world prices all that was not needed. This would provide a revenue stream for investments in improved efficiency. The EBRD could finance initial improvements based on anticipated revenues. AID and DOE could provide training to create an energy service and equipment industry. There should also be many opportunities for American businesses which could be funded by Eximbank. Such a program would call for an unprecedented amount of planning and coordination, but it offers a way around the problems (inadequate incentive, information, and capital) that inhibit the reduction of energy waste. Additional costs for the U.S. government might be several tens of millions of dollars over 3 years for U.S. energy auditors and service companies to get the process moving and to start joint ventures for investments in equipment manufacture and directly in efficiency improvements.

*Expand Technical Assistance Programs*—Technical assistance programs provide access to technologies essential to short-term stabilization and long-term modernization and economic growth. Since U.S. firms are leaders in several areas, an expansion of technical assistance programs, consistent with an activist program of U.S. policy, would provide benefits for U.S. business. Priority projects, as listed in table 1-2, include

additional assistance in installing nuclear safety equipment, additional assistance in pollution control, an expanded utility partnership program, powerplant renovations, more clean coal demonstrations, additional coal mine safety activities, and R&D cooperation. Several of these initiatives (nuclear safety, powerplant renovations, clean coal demonstrations) could entail costs of several tens of millions of dollars, depending on how much activity is wanted.

### *Element 3: Select Priorities for Trade and Development*

In the case of conflicting goals, policies must be tailored to each country or region to ensure their appropriateness and consistency, especially where economic reform is tenuous. This is most important in the area of export- and investment-promotion programs.

The key question for Congress is how actively to promote market reform and long-term sectoral modernization versus short-term economic stability and U.S. economic interests. The most important vehicle for expressing this policy preference is the conditionality provision of export credits and insurance.

Government financing of exports to modernize the energy sector benefits U.S. business and jobs, and it can stimulate increased energy production. However, these credits may simultaneously harm other American interests by discouraging Russian firms from accepting Western firms as investors, a potentially much larger, though more costly, source of the enormous amounts of capital needed for energy sector modernization. The availability of public-sector financing may even inhibit reform by removing the incentive for firms to restructure their operations to attract commercial credit and cooperation.

Nevertheless, there is good reason for the United States to maintain its export-credit programs at a level sufficient to keep American firms competitive with their Western rivals and to provide afoot in the door to potentially lucrative markets. The political importance of foreign assistance and trade-promotion programs should also not be underestimated. Thus, reconciling trade and aid programs with one another and with the larger goal of promoting market reform will prove difficult, if not impossible.

The differing conditions among the former East Bloc countries suggest two approaches for U.S. policy, depending on which goals are to be supported:

**1. Support near-term economic stabilization through expansion of energy production. This** option seeks to support former East Bloc countries by maximizing energy output to provide foreign exchange, regardless of their progress on economic reform. It also aggressively emphasizes U.S. exports.

**Policies:** Expand export-credit and MDB programs to ensure that financing is not a major constraint; provide minimal conditionality and restrictions on loans. Higher subsidies might be necessary for OPIC and Eximbank to cover increased losses on bad debt.

2. **Support long-term energy sector modernization and systemic market reform.** This approach may entail further declines in oil and gas production in order to achieve long-term gains.

**Policies:** Expand export-credit programs only insofar as they can support reforms and can be effectively used. Impose maximal conditionality on credits: export-credit and investment assistance would go only to firms actively engaged in a real transition to market functions.

It is possible to satisfy these dual priorities only in countries that have embarked firmly on a course of economic reform. A balanced approach is appropriate for Poland, the Czech Republic, and Hungary because their progress toward economic reform makes it possible to promote both trade and reform simultaneously. This option may also be appropriate in Kazakhstan. Although market reform has been limited there, Kazakhstan is open to foreign investment and trade.

In other countries of the former East Bloc, the choices are not so easy. Declining oil production is a serious threat to Russia's weak economy. Bolstering that economy may be essential for preventing social and political instability. The United

States has the technology and the resources to provide significant help, and U.S. industry would benefit from supplying it. However, if the help is provided without insisting on continued reforms, U.S. long-term interests and Russia's long-term economic health could be damaged. Selecting the appropriate balance depends on one's views of the urgency of Russia's short-term energy problems and the importance of U.S. equipment exports vis-a-vis long-term development.

## CONCLUSION

Improved energy technology will be a critical factor in modernizing the economies of the former East Bloc, and the transfer of energy technology will be an important asset in achieving U.S. national goals. However, financial and institutional constraints in these countries will limit Western investment and sales of equipment and services. A strong and active U.S. government role is necessary to expedite the transition to market economies and democracy and to assure that export markets are available for U.S. industry. The policy options discussed above, if implemented skillfully and with adequate funding, can help very significantly. Congress will face the issue of whether increased efforts are warranted in light of other U.S. national priorities and uncertainties over progress toward reform in Russia and other countries of the former East Bloc.

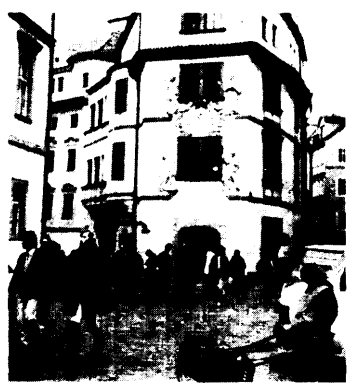
# Overview of Energy Supply and Demand

2

Energy resources differ significantly among countries of the former East Bloc. Russia and the Central Asian countries have substantial energy resources, Central Europe has limited resources, and the Baltics are resource poor. Patterns of energy use differ as well. For example, Russia and Romania use a high percentage of natural gas in their respective fuel balances; Poland and the Czech Republic rely extensively on coal; and Ukraine, Lithuania, Bulgaria, and Hungary generate substantial amounts of electricity from nuclear powerplants. Even so, two common threads are evident in the energy picture of these countries: much of the energy consumed is wasted, and numerous cost-effective opportunities exist for improving energy efficiency. This chapter discusses the role of energy in the economy and provides a broad overview of energy resources, energy consumption, and the potential for improving efficiency.

## ENERGY'S ROLE IN THE ECONOMY

Energy has played and continues to play a crucial role in the economies of former East Bloc countries. In the past, centrally planned economies relied on abundant and easily accessible energy supplies to foster rapid industrialization, particularly of heavy industries. Between 1950 and 1989, energy production fueled an impressive economic growth rate in the former Soviet Union (FSU), averaging 5.8 percent annually.[1] Energy supplies increased sixfold during this same period (averaging 4.7 percent annually).



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[1] United Nations Economic Commission for Europe, *Energy Reforms in Central and Eastern Europe—The First Years*, ECE Energy Series, No. 7 (New York, NY: United Nations Publications, 1991), p. 5.

Instead of becoming more energy-efficient as they grew, however, centrally planned economies experienced higher growth rates in energy consumption than did OECD (Organization for Economic Cooperation and Development) countries.[2] Heavily subsidized energy prices, the lack of market incentives, and the importance given to fulfilling quotas and achieving state plans contributed substantially to the high energy requirements and corresponding production in the region.

In recent years, the energy picture has changed somewhat. Energy production, particularly of oil and coal, is falling, largely due to inadequate investment in exploration, the use of outmoded technologies, the lack of spare parts, and poor maintenance. The dissolution of the Soviet Union and the resultant political and economic changes further limit output. Energy demand has declined because of reduced economic activities and higher energy prices, although energy consumption as a percent of GDP (gross domestic product) is still high.

Increasing or stabilizing energy production is critical to the economic well-being of former East Bloc countries. Recent energy shortages have constrained economic activities and slowed reform. Moreover, revenues generated by energy exports are essential for financing reform initiatives and modernizing industries, buildings, and transportation networks.

Even more important to the economic health of these countries may be improvements to energy efficiency. The past neglect of energy conservation and efficiency practices resulted in extensive energy waste and contributed to high operating costs, energy shortages, loss of foreign exchange, and environmental damage. Improving energy efficiency can reduce energy waste and provide additional fuel supplies for export, thus spurring economic growth. Additional revenues will benefit exporting nations, especially Russia and Kazakhstan. Efficiency improvements also will benefit Ukraine and the oil-importing countries of Central Europe and the Baltics by reducing expenses and improving their balance of payments.

With energy prices still below market levels, there is little incentive to improve energy efficiency. However, as these countries move to market economies, energy prices will continue to rise until they reach world market levels, making energy-efficiency measures more attractive.

Finally, a decrease in fossil fuel combustion will reduce air pollution and $C0_2$ emissions, providing significant environmental benefits.

## ENERGY SUPPLY

Russia, an energy giant, has the world's largest natural gas reserves and immense oil and coal reserves. How these supplies are developed and utilized will influence global markets for years to come. Of the Central European countries, only Poland has large energy resources, mostly coal. The following brief overview describes the energy resources in the former East Bloc in terms of reserves, production, and exploration.

### I Oil Supply

#### *Oil Reserves*

Several FSU countries are rich in oil reserves: Russia, Kazakhstan, Turkmenistan, Azerbaijan, and Uzbekistan. Russia alone has proven reserves of about 50 billion barrels (Bbbl), which is about double that of the United States, though dwarfed by Saudi Arabia's resources. The largest oil fields are located in Western Siberia and the Volga-Urals. The U.S. Geological Survey estimates that Russia has additional oil reserves[3] in the range of

[2] A Report to the U.S. Working Group on Global Energy Efficiency, *Energy Efficiency, Developing Nations, and Eastern Europe* (June 1991), p. 2.

[3] These include discovered and undiscovered resources. Discovered resources are defined as reserves not ready for immediate production; undiscovered resources are those that take into account more remote geological probabilities.

40 to 171 Bbbl, with the most likely amount set at 60 Bbbl.[4] The wide range indicates the high degree of uncertainty attached to these estimates. The eastern regions of Siberia and the offshore areas are relatively unexplored by international standards. Future exploration and production of these resources will be technically challenging and more expensive because they are in remote areas with harsh climates.

Most of Kazakhstan's oil reserves (estimated at 16 Bbb1[5]) are located in the northwestern region near the Caspian Sea. The Tenghiz oil field may add another 3.3 Bbbl to Kazakhstan's oil reserves, according to one estimate.[6] However, development of this field has been hampered by technical challenges, enormous financial requirements, and the difficult y of transporting the oil to internationnal markets.

Turkmenistan's oil fields are located in the Cheleken Peninsula and in the eastern part of the country. According to Turkmen authorities, the country may have oil reserves close to 5.1 Bbbl.[7]

Azerbaijan and Uzbekistan also have significant oil reserves. Most of Azerbaijan's 1.2 Bbbl reserves are located offshore in the Caspian Sea.[8] Western companies are eager to exploit these resources, but the need for massive infrastructure development hinders energy sector investment. Other former republics have only small amounts of oil. Romania is the only Central European country that has significant oil reserves.

## Oil *Production*

Major oil production activities are centered in Russia, Kazakhstan, and Azerbaijan. Until recently, Russia was the world's largest oil producer, but production has been on a downward slide since 1987, when output peaked at 11.44 million barrels (MMbbl) per day.[9] In 1992, Russia produced 7.95 MMbbl per day, a drop of more than 30 percent. (See table 2-l.) Oil output declined further in 1993. The greatest losses in output have occurred in Western Siberian oil fields due to policy decisions that favored short-term production goals at the expense of exploration and discovery, depletion of old giant fields, inefficient production practices, and the lack of capital for more sophisticated drilling and export operations.

Future oil production in Russia is likely to occur in remote, inaccessible fields, entailing huge capital investment and access to Western technology and expertise. Assistance from Western companies can improve future development prospects and increase production of old fields. Technology transfer, one avenue for developing resources, is discussed in detail in the oil and gas section in chapter 3.

Unlike Russia, Kazakhstan's oil production has been increasing steadily since the early 1980s. In 1992, Kazakhstan produced about 552,000 barrels per day.[10] Future increases in production will depend on development of oil deposits in the remote and inhospitable Guryev region in northwest Kazakhstan, particularly the Tenghiz field. Development will be expensive because of the technically challenging nature of the oil deposits. The great depths, high pressures, and high sulfide content of the Tenghiz field will require using advanced technologies not yet available in the FSU. Moreover, Kazakhstan's lack of domestic infrastructure, such as pipelines to transport oil through neighboring countries, will require mas-

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[4]Estimates are derived from U.S. G[eol]o[gic]. and Oil and Gas Journal estimates as reported in Joseph p. Riva, Jr., *Oil and Gas in the Russian Federation,* CRS Report for Congress, 3-732 SPR (Aug. 9, 1993), p. 4.

[5]"Kazakh Liquids, Gas Reserves Tallied," *Oil and Gas Journal*, vol. 91, No. 31, July 26, 1993, p. 35.

[6]Matthew J. Sagers, "The Energy Industries of the Former USSR: A Mid-Year Survey," *Post-Soviet Geography,* vol. 34, No. 6,1993, p. 364.

[7]Nancy Lubin, "Fueling Reform: Central Asia," OTA contractor report (January 1994), p. 15.

[8]Joseph p, Riva, *Russia and the Commonwealth of Independent States: Oil Resources,* CRS Report for Congress, 92-78 SPR (Jan. 16, 1992).

[9]Sagers, "The Energy Industries of the Former USSR," p. 344.

[10]Ibid.

TABLE 2-1: Oil Production in the Former Soviet Union and Romania, 1980-92 (million barrels per day)

| Country | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1985 | 1980 |
|---|---|---|---|---|---|---|---|---|
| Russia | 7.949 | 9.260 | 10.362 | 11.144 | 11.423 | 11.437 | 10.891 | 10,979 |
| W. Siberia | 5.537 | 6.603 | 7.536 | 8.135 | 8.336 | 8.224 | 7.392 | 6.280 |
| Kazakhstan | 0.552 | 0.534 | 0.518 | 0.510 | 0.512 | 0.492 | 0.458 | 0.376 |
| Azerbaijan | 0.221 | 0.235 | 0.251 | 0.265 | 0.275 | 0.277 | 0.263 | 0.295 |
| Turkmenistan | 0.106 | 0.108 | 0.112 | 0.116 | 0.114 | 0.116 | 0.120 | 0.161 |
| Ukraine | 0.088 | 0.098 | 0.106 | 0.108 | 0.108 | 0.112 | 0.116 | 0.151 |
| Uzbekistan | 0.062 | 0.056 | 0.056 | 0.052 | 0.048 | 0.046 | 0,040 | 0.026 |
| Belarus | 0.040 | 0.042 | 0.042 | 0.042 | 0.042 | 0.040 | 0.040 | 0.052 |
| Other republics | 0.006 | 0.008 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 |
| Total FSU[a] | 9.027 | 10,342 | 11.463 | 12.198 | 12.537 | 12.535 | 11,955 | 12.114 |
| Romania | 0.138 | 0.140 | 0.163 | 0.180 | 0.193 | 0.215 | 0.220 | 0.238 |

[a]Data exclude condensate, Which accounted for 37 percent of FSU total production in 1992 Sum of components may nOt equaltotal due to rounding.

SOURCE Matthew J. Sagers, "The Energy Industries of the Former USSR. A Mid-Year Survey,'*Post-Soviet Geography*, vol. 34, No 6, 1993, p 344; Energy information Administration, *International Energy Annual 1992*, DOE/EIA-0219(92), January 1994, p 6, and *International Energy Annual 1983*, DOE/EIA-0219(83), November 1984, p 16

sive capital investment. Western companies are intensely interested in developing Kazakhstani resources, and the Kazakhstani government has welcomed foreign interest quite openly, which contrasts sharply with Western experience in Russia. Deals with Chevron, British Gas, Italy's Agip, and France's Elf should bring about $38 billion in foreign investment in Kazakhstan's oil industry over the next 40 years. [11] Kazakhstan hopes to use oil revenues to finance development and modernization of the rest of its economy.

Azerbaijan has been producing oil since the 1870s. Most of its output comes from offshore fields. Soviet development practices, which favored oil field investment in Siberia over that in the Caucuses, left Azerbaijani exploration and production inefficient. Consequently, output has been declining since 1980, falling to 221,000 barrels per day. [12] Pervasive corruption and the lack of economic reforms in Azerbaijan have dampened Western enthusiasm for development and leave open to doubt the degree to which these resources will be used to support economic and political modernization.

Other former republics—Turkmenistan, Uzbekistan, Belarus, Kyrgystan, Tajikistan, and Georgia—are also oil producers, but their contributions are small compared with those of Kazakhstan and Azerbaijan.

## Exports

Within the FSU, only Russia and Kazakhstan are currently net oil exporters, mostly to European Countries. Exports are transported by pipeline to Central and Eastern Europe and by tanker to Western Europe. Oil supplies are critical to economic recovery in both exporting and importing countries of the former East Bloc.

In recent years, Russian oil exports have declined, mostly due to a decline in production. For example, 1991 exports averaged about 1.4

[11] "Tomorrow's *Gusher," The Economist,* vol. 324, No. 7769, Jul. 25, 1992, p. 72.

[12] Sagers, "The Energy Industries of the Former USSR," p. 364.

MMbbl per day, a 33-percent decline from 1990, with shipments to FSU countries registering the biggest decrease. Exports to OECD countries remained fairly constant. To maintain export levels to Western Europe, and thus hard currency payments, it is likely that Russian exports to the former republics of the Soviet Union will further decline, at least in the near term.

## I Natural Gas Supply

### *Natural Gas Reserves*

Russia has the world's largest gas reserves-about 1,626 trillion cubic feet (Tcf). Undiscovered gas reserves are estimated to range from 927 to 4,083 Tcf, with 1,569 Tcf the most likely amount.[13] Western Siberia has the largest gas fields, and vast amounts of natural gas are also thought to lie beneath the Arctic Ocean. Foreign companies are very interested in developing Russia's large gas reserves, particularly those in the Far East region. It is clear that Russia's huge resource base can support increased production, but new infrastructure and markets are needed to make this happen.

Other former republics that have gas resources are Turkmenistan, Uzbekistan, Kazakhstan, and Ukraine. Much of Turkmenistan's enormous gas reserves (96 Tcf) are located along its border with Iran. Kazakhstan's gas reserves are estimated at 64.6 Tcf. Its main gas field, Karachaganak, is located on its northern border with Russia. Both exploration and development of this field have been challenging because of the highly corrosive characteristics of the gas and the location of the deposits (4,000-5,000 meters deep).[14] Ukraine's sizable untapped reserves (37.8 Tcf) have been uneconomical to explore and produce, but given its hard currency shortage, the country will be forced to reduce imports and maximize domestic production.

Poland also has natural gas reserves, estimated at 12 Tcf. Much of its highly dispersed reserves have low Btu (British thermal unit) value. To date, the lack of capital has hampered the exploration and development of this resource.

### *Natural Gas Production*

Natural gas production in the FSU declined in 1992 for the second year in a row. This is in sharp contrast to the growth rates of 6 to 8 percent annually in the 1980s. Despite the decline, the natural gas industry is in better shape than its oil counterpart-it is relatively young, requires less sophisticated technologies, and may not need huge amounts of capital to maintain present production levels.

The largest declines in 1992 output occurred outside Russia. (See table 2-2.) For example, Turkmenistan's production dropped by almost 29 percent in 1992. Its main fields have peaked, and newer, smaller fields could not offset the drop in output. In addition, the loss of its traditional export markets, particularly to Ukraine, contributed to the decline. Even so, Turkmenistan remains the second largest gas producer in the FSU and the third largest in the world.

Also, Ukraine's output declined by 14 percent. Its heavy reliance on Russian gas imports has forced Ukraine to seek alternative suppliers such as Iran. In 1993, Ukraine, Iran, and Azerbaijan formed a joint venture to build gas pipelines through Azerbaijan to Western Europe.[15]

Unlike the other former republics, Uzbekistan's natural gas production continues to rise. Due to expanded exploration and development, 1992 production increased by 2.1 percent. Uzbekistan is the third largest natural gas-producing country in the FSU.[16]

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[13] Riva, *Oil and Gas in the Russian Federation,* p. CRS-6.

[14] Sagers, "The Energy Industries of the Former USSR," p. 377.

[15] Ibid., pp. 387-88.

[16] Ibid.

TABLE 2-2: Natural Gas Production in Selected Former East Bloc Countries, 1980-92 (trillion cubic feet)

| Country | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1985 | 1980 |
|---|---|---|---|---|---|---|---|---|
| Russia | 22.616 | 22,704 | *22.623* | 21.747 | *20.829* | 19.222 | 16.316 | *8.970* |
| W. Siberia | 20.292 | 20.271 | *20.105* | 19,056 | 18.039 | 16.414 | 13.271 | *5.523* |
| Turkmenistan | 2.122 | 2.977 | *3.101* | 3.175 | *3.118* | 3.111 | 2.938 | *2.490* |
| Uzbekistan | 1.511 | 1.480 | 1.441 | 1.451 | 1.409 | 1.406 | 1.222 | 1.229 |
| Ukraine | 0.738 | 0.858 | 0.992 | 1.088 | 1.144 | 1.257 | 1,515 | **2.002** |
| Kazakhstan | 0.311 | 0.279 | 0.251 | 0.237 | 0.251 | 0.222 | 0.194 | **0.152** |
| Azerbaijan | 0.275 | 0.304 | 0.350 | 0.392 | 0.417 | 0.441 | 0.498 | **0.494** |
| Other republics | 0.014 | 0.018 | 0.018 | 0.021 | 0.018 | 0.025 | 0.025 | **0.025** |
| Total **FSU**[a] | 27.588 | 28.619 | 28.775 | 28.114 | 27.193 | *25.688* | *22.704* | *15.369* |
| Romania | 0.78 | 0.88 | 1.03 | 1.13 | 1.28 | 1.32 | *1.27* | 1.20 |
| Hungary | 0.17 | 0.18 | 0.16 | 0.22 | 0.22 | 0.22 | *0.26* | 0.21 |
| Poland | 0.14 | 0.15 | 0.14 | 0.19 | 0.20 | 0.20 | *0.23* | 0.22 |

[a]Sum of components may not equal total due to rounding.

SOURCE. Matthew J. Sagers, "The Energy Industries of the Former USSR. A Mid-Year Survey," Post-Soviet Geography, vol. 34, No. 6,1993, p. 378; Energy Information Administration, *International Energy Annual 1992, DOE/EIA-0229(92)*, January 1994, p. 10; and *International Energy Annual* 1983, DOE/EIA-0219(83), November 1964, p 20

For the first time ever, natural gas production declined slightly in Russia. The fact that output decreased by only 0.4 percent[17] is remarkable given recent institutional changes in the gas industry and the country-wide economic crisis.

In Russia, future natural gas production, like oil production, is likely to come from remote areas. Extraction and transmission costs will increase. Major investments in exploration, development, and transmission will be necessary to increase production, and financial resources may not be available.

Transport of gas to markets maybe even more problematic than increasing production. Many pipelines and compressors are in dire need of repair. Losses from leaky transmission and distribution lines are a serious problem. In the last years of the Soviet empire, over 900 miles of pipeline were replaced annually, but the need for pipeline replacement was double that amount. Today, capital constraints dictate that only badly deteriorated sections be scheduled for replacement. Natural gas transmission systems in Kazakhstan, Uzbekistan, and Turkmenistan are particularly bad and in dire need of repair/replacement. 18

## *Natural Gas Exports*

Russia exports about 3.8 Tcf of natural gas annually, mostly to Western Europe.[19] The need for hard currency may ensure that Western European exports will be maintained at the expense of Central European customers. However, maintaining the flow to Western Europe may be complicated by Russia's dependency on pipelines that cross several former republics, particularly Ukraine, Belarus, and the Baltics. Ukraine's periodic stoppages of Russian gas exports to Europe are already a

[17]Ibid, p. 378.

18 Mikhail Korchemkin, "Oil and Natural Gas Systems of the Former Soviet Union," OTA contractor report (July 1993), p. 13.

[19]Riva, *Oil and Gas in the Russian Federation*, p. CRS-6.

bone of contention between the two countries. This and other factors have prompted Central European customers to look elsewhere for gas supplies. Ukraine, which is very dependent on Russian gas supplies, is building closer ties with Iran, partly to diversify energy sources. Recently, Ukraine and Iran agreed to build gas pipelines through Ukraine to connect Iran to Western Europe.

Turkmenistan exports natural gas to other former republics, particularly Ukraine and Azerbaijan, and to Western Europe. Ukraine is the largest single market for Turkmenistan natural gas. In 1993, Turkmenistan negotiated the sale of 1 Tcf to Ukraine and 622 billion cubic feet (Bcf) to Azerbaijan.[20] Most of Turkmenistan's hard-currency earnings come from its natural gas exports. Like Ukraine, Turkmenistan is planning to build export pipelines through Iran and Turkey. This should lessen Turkmenistan's frustration over Russia's ownership of transmission pipelines and consequent control over lucrative Western markets.[21]

## Coal Supply

### Coal Reserves

The FSU's substantial coal reserves, estimated at 266 billion tons,[22] are scattered throughout the former republics. A large portion of its coal reserves comprise less desirable deposits because of location and geological characteristics. Russia, Ukraine, and Kazakhstan are the three major coal producing countries.

Much of Russia's immense coal reserves are located in Siberia. Kuznetsk, Kansk-Achinsk, and South Yakutia are the major coal-producing regions in Siberia. Other major coal basins are located in western Russia and the Urals.

Ukraine's coal reserves are estimated to be about 44.1 billion tons.[23] There are three major coal fields in Ukraine: Donets Basin, located in the eastern region; the L'viv-Volynsk Basin, located in the western region; and the Dnieper Basin. The Donets Basin is the major coal producer and one of the oldest sites of underground mining. Donets coal seams are very thin (many are less than 1 meter thick) and steeply pitched, making it difficult for miners to work. Over the years, the quality of Donets coal has decreased: the ash and moisture content has risen, whereas the energy content has fallen.

Kazakhstan has substantial coal reserves—about 55.1 billion tons[24]—making it one of the largest coal-bearing countries in the world. Its three primary coal basins, Ekibastuz, Maikyubensk, and Karaganda, are located in eastern and central Kazakhstan. Coal quality varies from subbituminous in the Maikyubensk basin to anthracite in the southern part of the Karaganda basin to poor quality in the Ekibastuz. This coal is exportable only to Russia because it is too abrasive and contains high-ash components, making it uneconomical to transport.

Poland's recoverable reserves are estimated at about 45 billion tons.[25] Substantial hard coal reserves are found primarily in the Upper Silesian Basin in the South, while lignite reserves are scattered throughout central and western Poland.

The Czech Republic and Hungary have sizable coal reserves, but far less significant than that of Poland, Russia, and Ukraine. Nevertheless, coal is

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[20] Sagers, "Energy Industries of the Former USSR," p. 385.

[21] "Turkmenistan Moves Closer to Building Gas Export Pipeline," East European Energy Report, *Financial Times*, Issue 26, Nov. 19, 1993, p. 7.

[22] Department of Energy, U.S. Department of Energy, *Annual Energy Review 1992*, DOE/EIA-0384(92) (Washington, DC: U.S. Government Printing Office, June 1993), p. 297.

[23] U.S. General Accounting Office, *Ukraine Energy Issues Affecting U.S. Trade and Investment*, Report to the Chairman, Subcommittee on European Affairs, Committee on Foreign Relations, United States Senate, GAO/GGD-92-129 (August 1992), p. 7.

[24] Charles Bingman, "Economic Development and Privatization in Kazakhstan," *Central Asian Monitor*, No. 4, 1992, p. 27.

[25] EIA, *Annual Energy Review 1992*, p. 297.

TABLE 2-3: Coal Production in Selected Former East Bloc Countries, 1980–92 (million tons)

| Country | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1985 | 1980 |
|---|---|---|---|---|---|---|---|---|
| Russia | 371.775 | 389.526 | 435.832 | **452.040** | 469.129 | **457,222** | **435.722** | 431.533 |
| Ukraine | 147.740 | 149,504 | 181.698 | **198.677** | 211.356 | **211.687** | **208,379** | 217.310 |
| Kazakhstan | 140.022 | 143.330 | 145.094 | **152.591** | 157,773 | **156.670** | **144,212** | 127.233 |
| Uzbekistan | 5.182 | 6.505 | 7.166 | 6.836 | 6.064 | **5.513** | **5.513** | 6.284 |
| Kyrgyzstan | 2.426 | 3.859 | 4.079 | 4.410 | 4,410 | **4.410** | **4,410** | 4.410 |
| Tajikistan | 0.221 | 0.331 | 0.551 | 0.551 | 0.772 | **0.662** | **1,103** | 1.103 |
| Georgia | 0.551 | 0.882 | 1.103 | 1.323 | 1.544 | **1.764** | **1,874** | 2.095 |
| Total FSU[a] | 667.916 | 694.046 | 775.413 | 816.207 | 851.047 | **837.707** | **800.882** | 789.857 |
| Poland | 227 | 231 | 237 | 275 | 294 | **290** | **275** | 254 |
| Czechoslovakia | 102 | 111 | 119 | 130 | 137 | **137** | **140** | 136 |
| Romania | 38 | 36 | 42 | 68 | 58 | **50** | **51** | 39 |
| Hungary | 17 | 19 | 19 | 22 | 23 | **24** | **27** | 28 |

[a]Sum of components may not equal total due to rounding

SOURCE Matthew J Sagers, "The Energy Industries of the Former USSR A Mid-Year Survey," *Post-Soviet* Geography, VOI 34, No. 6, 1993, p. 392, Energy Information Administration, *International Energy Annual 7992, DOE/EIA-0219(92)*, January 1994, p 12, and *International Energy Annual* 1983, DOE/EIA-0219(83), November 1984, p 22

an important national energy resource and source of employment in both countries.

## Coal Production

The first mined coal fields in the FSU were located in the west, near population centers. Some of these deposits have been mined since tsarist times and have thus become depleted. The industry was forced to open new mines in Siberia and the Arctic, far from major population and manufacturing centers and subject to harsh weather.

In 1992, coal production declined in all the former republics. (See table 2-3.) The decline can be attributed to several factors, including the lack of investment in mine development, equipment shortages, and labor unrest. Low morale, poor salaries, and wretched working and living conditions have led to several crippling miners' stikes in the FSU in recent years.

Coal production activities have had serious harmful environmental impacts. These include land disturbances, saline water discharge, sewage problems, methane emissions, and inadequate and inappropriate storage of mine and coal washing/cleaning wastes. Even after mines close, some of these effects linger. (For a discussion on the extent of environmental damage, see chapter 5.)

Russia produced about 371.8 million tons of coal in 1992, a decline of 4.6 percent from the previous year.[26] Because of declining production, Russia is a net importer of coal. The bulk of Russia's production comes from Siberian basins, where coal is mined in both open pit and underground mines. The Kuznetsk Basin, located in the southern part of Western Siberia, has been the largest coal producer in Russia for years. It produces many grades of high-quality coal, with low ash, moisture, and sulfur content. The next largest producing basin, the Kansk-Achinsk, has a large share of low-quality, high-moisture coal that tends to self-combust during transport, making this coal uneconomical to transport over long distances.

[26]Sagers, "Energy Industries of the Former USSR," p. 391.

Ukraine is still the second largest coal producer in the FSU, but Kazakhstan is a very close third. Ukraine's coal production has been on a downward slide since 1988. The biggest drop in output occurred in 1991, when production decreased by almost 18 percent. In 1992, Ukraine produced 147.8 million tons.[27] Ukraine, too, is a net importer of coal.

Kazakhstan's energy production and exports are dominated by coal. Recent oil and gas discoveries are expected to change significantly the country's energy balance. In 1992, Kazakhstan produced 140 million tons, a slight decline of 2.3 percent. Miners' strikes in May and June 1992 and the mutual indebtedness of the Kazakhstani coal industry and its customers are largely responsible for the decline.

Poland is a major coal producer, ranking seventh in the world. In 1991, Poland produced 231 million tons.[28] Its economy is heavily reliant on coal; for example, more than one-half of the residential/commercial sector's energy needs are derived from coal.[29] In recent years, coal output and exports have been declining. Despite the decline, Poland remains a major coal exporter.

In the Czech Republic, coal is the leading domestic energy resource. Brown coal provides the bulk of production in recent years. Much like other former East Bloc countries, output has declined in recent years, and the Czech government intends to phase out one-third of its coal production by the late 1990s.

Coal is also a major domestic energy resource in Hungary, accounting for about 36 percent of total energy production in 1990.[30] Production has been declining since 1983. Hungary's coal mining industry is reorganizing, and mines are being privatized. Contraction of Hungary's coal industry is inevitable.[31]

## | Coalbed Methane

Russia is likely to have significant coalbed gas resources. Three basins, located east of the Ural mountains, contain most of Russia's resource: Pechora, Kuznetsk, and Tungusk. The Pechora basin's coalbed methane resource is estimated at 80 to 120 Tcf, but the area's harsh climate may limit exploitation of this resource. The Kuznetsk basin's estimated coalbed gas resource is 350 to 500 Tcf. There is no reliable estimate of coalbed gas resources in the remote Tungusk basin.[32]

Ukraine and Kazakhstan, which have significant coal resources, boast estimated coalbed methane resources of 60 and 40 Tcf, respectively. Poland also has significant coalbed methane resources, and Western countries are interested in developing this resource. For comparison, table 2-4 highlights major coalbed methane resource countries.

Although the resource base is high in this region, development potential may be weak because deposits are often located in remote areas with harsh climates. Also, these remote areas may lack the essential infrastructure to produce and transport this resource. Moreover, local markets may not be well established. Currently, about 50 Bcf of methane are produced in FSU mines.[33]

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[27] Ibid.

[28] EIA, *Annual Energy Review 1992,* p. 209.

[29] U.S. Agency for International Development, Office of Energy, *Poland: An Energy and Environmental Overview,* prepared by Argonne National Laboratory (October 1990), p. 19.

[30] Richard Browning, "Current Energy Economic Structure," OTA contractor report, "Hungary profile."

[31] Organization for Economic Cooperation and Development, *Energy Policies—Hungary, 1991 Survey* (Paris: 1992), p. 53.

[32] Jonathan R. Kelafant, Scott H. Stevens, and Charles M. Boyer 11, "Vast Resource Potential Exists in Many Countries," *Oil and Gas Journal,* vol. 90, N(). 44, Nov. 2, 1992, pp. 82-83.

[33] Ibid.

TABLE 2-4: Major World Coalbed Resources

| Country | Coalbed methane resources (trillion cubic feet) |
|---|---|
| Russia | 600-4,000 |
| China | 1,060-1,240 |
| United States | 400 |
| Canada | 200-2,700 |
| Australia | 300-500 |
| Germany | 100 |
| Poland | 100 |
| Ukraine | 60 |
| United Kingdom | 60 |
| Kazakhstan | 40 |

SOURCE Vello A Kuuskraa, Charles M Boyer II, and Jonathan A Kelafant, "Hunt for Quality Basins Goes Abroad," *Oil and Gas Journal*, VOI 90, No 40, Oct 5, 1992, p 51

## Nuclear Power

Nuclear power is an important source of electricity in Lithuania, Hungary, Slovakia, Bulgaria, Ukraine, and the Czech Republic. Nuclear power supplies 80 percent of Lithuania's electricity and nearly half of Hungary's and Slovakia's. Moreover, the Czech Republic has one of the largest nuclear industries in Central Europe and is the only non-Soviet country to build Soviet-designed nuclear reactors.

At the end of 1992, there were 65 operating nuclear power reactors in the former East Bloc. (See table 2-5 for a breakdown of the number of plants and capacity, by country.) Russia has a heavy concentration with 28, and Ukraine has 15.34

About 40 percent of these reactors present serious safety concerns. Nevertheless, these plants continue to operate for a variety of reasons, including the need for power supplies to fuel economic growth and the desire to reduce air pollution. Also, the days of cheap Soviet energy exports are gone, and some countries believe they have no other choice but to pursue nuclear power. Many of these countries have energy supply deficits, and nuclear energy helps fill the gap. Russia, Ukraine, and the Czech Republic plan to increase their nuclear capacity in the near future. Ukraine also has postponed the closure of the Chernobyl nuclear powerplant, a reflection of the desperate situation the country now faces regarding energy supplies. Other countries, including Poland, have halted nuclear power development plans for the time being. The safety problems of East Bloc reactors and what the United States and other Western countries can do about them are discussed in detail in chapter 4.

## Renewable Energy

In former East Bloc countries, renewable resources contribute only a small share of total energy production. In Hungary, for example, renewable contribute only about 1 to 2 percent to total energy supply,[35] compared with 9 percent in the United States. Also, the use of renewable is relegated to a minor role in Poland's and Russia's current and projected energy supply scenarios. The Russian Ministry of Fuel and Energy has indicated that by the year 2010, nontraditional energy resources are expected to provide only about 2 to 3 percent of total fuel supply and 2 to 5 percent of electricity output. However, this small contribution could save 50 million tons of conventional fuel per year.[36]

Hydroelectric power is the most developed renewable. In 1991, the FSU had 64.1 gigawatts of hydro capacity, which is about 19 percent of total installed capacity.[37] Over the last several decades, Soviet scientists have conducted research on other renewable technologies, resulting in well-developed science and a few test installations scattered

[34] International Atomic Energy Agency, "International Data File," vol. 35, No. 4, December 1993, p. 60.

[35] Hungarian Energy Policy, Ministry of Industry and Trade, Budapest (June 1991).

[36] "Russia Should Use New Energy Sources," *Interfax Business Report*, May 3, 1993, p. 4.

[37] EIA, *Annual Energy Review 1992*, p. 305.

TABLE 2-5: 1992 Nuclear Power Reactor Capacity

| Country | Operable | | Under construction | | Nuclear share of electric generation |
|---|---|---|---|---|---|
| | Units | MWe | Units | MWe | percent of total |
| Bulgaria | 6 | 3,538 | 0 | 0 | 32.5 |
| Czech Republic | 4 | 1,632 | 2 | 1,784 | 20.7 |
| Hungary | 4 | 1,729 | 0 | 0 | 46,4 |
| Kazakhstan | 1 | 135 | 0 | 0 | 0.6 |
| Lithuania | 2 | 2,760 | 1 | 1,380 | 80.0 |
| Russia | 28 | 18,893 | 18 | 14,175 | 11.8 |
| Slovak Republic | 4 | 1,632 | 4 | 1,552 | 49.5 |
| Slovenia | 1 | 632 | 0 | 0 | 34.6 |
| Ukraine | 15 | 13,020 | 6 | 5,700 | 25.0 |
| Total | 65 | 44,193 | 31 | 24,591 | |

**KEY** MWe=megawatts **of electricity**

**SOURCE IAEA Bulletln,** "International **Data File," VOI 35, No 4, December 1993, p** 60

throughout the former republics. Today, the Russian national electric utility (RAO) is taking the lead in the future development of renewable. RAO, which is a private joint stock company, is currently funding a solar photovoltaics project in the northern Caucasus region. RAO has also encouraged joint ventures with Western renewable energy companies.[38]

Of course, the potential for renewable development differs by country-with c1imate, weather patterns, and other geographical factors largely determining the prospects. Wind energy potential is enormous in Russia, Kazakhstan, and Ukraine (but most often is inaccessible). These countries are now seeking joint ventures to help develop their wind energy resources. The most impressive joint venture for renewable technologies so far is the U.S. Windpower project in Ukraine. Plans call for 500 megawatt (MW) wind turbines to be manufactured in Ukrainian factories and installed in the Crimea by 1995.

However, the usual obstacles to renewable development interfere with joint ventures sought by these countries and Western companies: artificially low prices for conventional fuels, capital constraints, and the lack of political and institutional commitment. These obstacles are significant and will continue to hinder renewable development and use in the near term.

With huge fossil fuel resources, Russia has had little incentive to develop renewable. Also, Russia's institutional structure is geared to producing fossil fuels and not renewable. In other former republics, the situation is somewhat different. The need to develop indigenous energy resources, reduce dependency on foreign imports and related costs, provide decentralized power to rural areas, and address environmental concerns have spurred some interest in renewable technologies. Defense conversion and the availability of idle or underutilized industrial plants may provide added incentives to develop renewable.

[38] Eric Martinot, "Renewable Energy i, Former Soviet Republics: An Informal Report to the OTA," Nov. 8, 1993.

TABLE 2-6: Energy Consumption by Fuel Type for Selected Countries (percent of total)

| Country | Oil | Gas | Coal | Electricity | Total[a] |
|---|---|---|---|---|---|
| Azerbaijan | 47.77 | *45.89* | 0 | 6.34 | *26,59* |
| Kazakhstan | 16.81 | *14.86* | 59.11 | 9.23 | *100.55* |
| Russia | 26.77 | *39.32* | 25.01 | 8.90 | *964.37* |
| Ukraine | 15.48 | *37.37* | 38.70 | 8,45 | *247.43* |
| Poland | 11.77 | *8.20* | 69.75 | 9.50 | 114.70 |
| Czech Republic | 16.30 | 13.63 | 62.65 | 7.42[b] | 43.97 |
| Slovak Republic | 32.62 | 21.90 | 27.86 | 17.25[b] | 18.21 |
| Hungary | 31.61 | 33.20 | 22.62 | 12,57 | 27.05 |

[a]Totals in million tons of oil equivalent

[b]Czech and Slovak Republics' totals include nuclear- and hydro-generated electricity only.

**SOURCES: For 1992 FSU data,** PlanEcon, Inc., *PlanEcon Energy Outlook for the Former Soviet Republics* **(June 1993); for Czech and Slovak Republics (1991 data) and Hungary (1990 data), International Energy Agency,** *Energy Statistics and Balances of Non-OECD Countries 1990-1991*

Technology transfer from the West could assist in developing renewable at a more rapid pace. Russia and Ukraine have substantial technical know-how but little expertise in project planning, development, and management. Wind turbines, photovoltaic cells, and solar thermal collectors could be manufactured under joint ventures with the West. The potential for and impediments to U.S. renewable technology transfer to the former East Bloc are discussed in chapter 4.

## ENERGY DEMAND

The countries of the former East Bloc vary in their patterns of energy use. Poland, the Czech Republic, and Kazakhstan, for example, rely on indigenous coal for a large percentage of their energy needs. Ukraine relies extensively on indigenous and imported natural gas and coal, and Russia uses considerable amounts of natural gas and oil to fuel its economy. Although Hungary's energy use is more diversified than that of other former East Bloc countries, nuclear energy supplies nearly half of its electricity needs.

The Baltics are quite dependent on energy imports, particularly from Russia. Latvia imports almost all of its electricity and fuel, and Lithuania imports almost all of its primary energy. Lithuania's oil-fired and nuclear powerplants generate a surplus of electricity for export. Estonia uses indigenous oil shale to satisfy half of its energy needs.

Much of the energy used in former East Bloc countries is wasted. The old economic system focused on quantity of production rather than quality or cost, resulting in an astonishing waste of inputs, such as energy, and a near total disregard for the environment. Although energy consumption has declined in recent years, further improvements are possible. The following provides a brief overview of sectoral energy use in the former East Bloc and of opportunities for improving energy efficiency. Table 2-6 shows 1992 energy consumption by fuel type for selected countries.

### Energy Demand by Sector

The three major energy-consuming sectors—industry, buildings, and transportation—are diverse and large. Industry is the single largest energy user in the former East Bloc, accounting for almost half of the energy used in the FSU and about 40 percent in Hungary and Poland. The industrial sector uses energy for a wide variety of purposes, such as direct heat, steam generation, machinery operation, and feedstocks.

Energy used in buildings accounts for about one-fourth to one-third of all energy used in the former East Bloc. Most urban and suburban housing consists of large, multifamily apartment buildings. Single-family homes are common in rural areas. This contrasts sharply with the United States, where single-family homes are the predominant housing type. Commercial buildings are much less common in the former East Bloc. According to one estimate, the FSU has less than one-fifth as much commercial building floor space per capita as does the United States.[39]

In the buildings sector, energy is used to heat and cool homes and offices, cook, and power appliances and lights. Space heating dominates sector demand. Sources include district heat, direct fuel use, and electricity. In the FSU, space heating accounts for over 75 percent of all building energy use. Onsite fuel use provides the bulk of energy used for space heating (about 60 percent), with the remaining coming from district heating plants. Coal provides a large share of home and district heating needs in Poland, the Czech Republic, Slovakia, and Hungary. Water heating is a significant energy user too. Hot water is often supplied centrally by district heating plants. Buildings with access to natural gas service use this fuel to heat water. Most household lighting is supplied by incandescent lamps, and lighting levels are often relatively low.

In the transportation sector, freight accounts for the largest share of total energy use. In the FSU, long-distance rail and pipeline dominate, but truck use is slowly rising. Passenger mobility is very low compared with that of Western countries. The bus is the most frequently used mode of passenger travel, followed by rail. However, travel by private auto has been rising and probably will continue to rise, particularly in urban areas.

In the FSU, the transport sector accounts for about 16 percent of total energy use, compared with nearly 27 percent in the United States. In Poland, the sector's share is even lower—l 3 percent. These comparatively lower numbers are directly linked to limited automobile ownership in former East Bloc countries. However, over the last decade, modal shifts in transportation use have occurred, the most prominent being an increasing reliance on autos and trucks.

Transport sector fuel use has changed over the years. For rail transport, electricity and diesel have replaced coal and residual oil. Diesel fuel is slowly replacing gasoline use in trucks and buses.

### *Energy Efficiency*

Artificially low energy prices and the emphasis placed on large-scale industrial development resulted in high energy requirements in the former East Bloc. Furthermore, past capital investment strategies that favored energy production over efficiency further contributed to a technically outdated and energy-inefficient industrial infrastructure.

Former East Bloc countries are among the most energy intensive in the world. In 1990, the FSU's energy intensity was 70 percent higher than that of the United States and about 2.5 times that of Western Europe.[41]

Industries in the former East Bloc typically require more energy to produce one unit of output than do industries in Western Europe, Japan, or the United States. Among the most energy-intensive industries are iron and steel, chemicals, and petro-

[39] L. Schipper and R.C. Cooper, *Energy Use and Conservation in the U. S. S. R.: Patterns, Prospects, and Problems,* LBL-29830 (Berkeley, CA: Lawrence Berkeley Laboratory, April 1991), p. 23.

[40] Energy intensity is defined as the ratio of primary energy consumption to GNP.

[41] Igor Bashmakov, Moscow Center for Energy Efficiency, Visiting Scientist, Pacific Northwest Laboratory, Battelle Memorial Institute, "Energy Conservation Costs and Benefits for Russia and the Former USSR" (April 1992), p. 6.

leum refining. The iron and steel industry, for example, requires about 50 percent more energy per ton of iron output than is required in the United States. Open hearth furnaces still produce the bulk of steel in the FSI.

The energy intensity of buildings is also quite high. Buildings in the FSU use about 50 percent more energy to heat one square meter of floorspace than do buildings in the United States.[42] Common inefficiencies found throughout the former East Bloc include the lack of building insulation, energy-inefficient lighting, poor-quality motors and appliances, and inadequate construction. For example, in Poland, typical apartment building walls have less than half the insulating value of walls in typical U.S. houses, and new refrigerators use about 40 percent more energy than is allowed by the 1993 U.S. appliance standard.

In addition, automobile and truck fuel efficiency is below Western standards, primarily because of the use of less technically advanced equipment. Other factors that affect efficiency include poor vehicle and infrastructure maintenance, poor fuel quality, traffic congestion, and cold weather conditions. For example, FSU automobiles averaged about 20 miles per gallon (mpg) in 1985, compared with 27.5 mpg in the United States. Also, Aeroflot aircraft use 50 percent more energy per seat per kilometer than those in Western countries.[43]

## Opportunities for Improving Energy Efficiency

Few of the many opportunities to improve energy efficiency have been exploited to date. Identification of the most promising energy-saving technologies, projects, and policies has just begun. OTA's report, *Energy Efficiency Technologies to Central and Eastern Europe,* discusses these opportunities in detail. They range from simple and inexpensive measures, such as fixing steam leaks and radiator valves, to more capital-intensive investments, such as new boilers, electric motors, and process control systems. In many cases, these technologies offer paybacks of two years or less.[44] New processes and facilities will improve energy efficiency throughout the economy, but replacement is likely to take many years to accomplish. One estimate indicated that replacing energy-using technologies in the FSU with Western European models could lower intensity by 25 to 40 percent.[45]

Continued price subsidies and inadequate capital resources will limit implementation of these measures. In addition, industries may recognize the energy savings potential and have a financial incentive to make the investment, yet not have the needed capital. Other factors also impede energy efficiency improvements, including management practices and the lack of consistent and reliable information on energy use. Many factory managers ignore energy-efficiency investments for various reasons, including institutional obstacles. For example, managers who save energy fear that they might be penalized by having their allocations reduced. Today, managers are most concerned about keeping the business/plant open and workers employed. Profits are given little consideration because taxes and inflation are so high.

Assistance from Western countries could accelerate efficiency improvements and contribute to the economic transition in former East Bloc countries. The following briefly discusses sectoral opportunities.

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42 Schipper and Cooper, *Energy Use and Conservation in the U. S.* S.R., p. 58.

43 L. Schipper and E. Martinot, Lawrence Berkeley Laboratory, "Energy Efficiency in Russia, Ukraine, and Belarus: Opportunities for the West," draft report prepared for the U.S. Department of Energy, January 1993, pp. 4-5.

44 The amount of time required for the value of the energy savings to exceed the initial cost.

45 Lee Schipper, "Improving Energy Use in the Soviet Union: Opportunities for the West?," paper prepared for the Fritjiof Nansen Institute, Oslo, Norway, January 1992, p. 4.

### Industrial Sector

The industrial sector is especially suited for rapid efficiency gains. Four categories of generic technologies could be used to improve industrial energy efficiency: housekeeping, improved measurement and control, improved steam system, and improved motors. Simple, low-cost housekeeping measures, such as insulating pipes, plugging leaks, turning off equipment when not in use, and maintaining equipment can result in large energy savings. Of course, energy savings and paybacks will vary according to specific measures and applications.

Improved measurement and control also offers large potential energy savings. Examples include energy management systems to operate equipment automatically and improved sensors and controls to allow for fine-tuning of the temperature. Savings are site-specific but generally considerable.

Steam systems can be improved through housekeeping measures and the installation of sensors and controls and improved burners.

Electric motors account for the bulk of industrial electricity use in the former East Bloc. Replacing standard motors with high-efficiency motors will result in substantial savings. Although high-efficiency motors typically cost about one-third more than standard motors, this investment often pays back rapidly, depending on usage, electricity rates, and other factors.

In the short term, the first priority for industry is to implement the numerous low-cost/no-cost measures noted earlier. The use of these technologies is usually straightforward and does not require a highly trained engineer to install. In the long term, major energy efficiency improvements will come not just from retrofits but from replacement technologies and new facilities. Investments in new technologies and facilities will most likely be made for reasons other than efficiency; nevertheless, efficiency and environmental benefits wil1 accrue from these investments. The capital requirements to rebuild industrial facilities will be enormous. Industries may recognize the energy-saving potential and have the financial incentive to make the investment, but not have the needed capital.

Also, structural changes are likely to make a big difference in industrial energy use. Moving away from heavy industry to less energy-intensive consumer products will do much to reduce energy use.

### Buildings Sector

In the buildings sector, low-cost measures can provide significant energy savings. Installing thermostats to regulate heat and sealing windows properly are two examples. Other measures, such as fuel switching and making improvements to building shells, appliances, and district heat delivery systems will require more capital but will improve energy efficiency significantly. Behavioral changes can also save energy.

A number of factors will almost certainly lead to increased energy use in buildings in the former East Bloc. These include large increases in the size of commercial buildings and residential housing; growth in population; increased demand for energy-intensive services in the commercial sector, such as air conditioning; and growing demand for energy-intensive residential appliances, such as color TVs, clothes dryers, and larger refrigerators. The challenge will be to moderate this increase in energy demand below what it would otherwise be.

Although much housing is in relatively poor condition, the shortage of housing means that very few residential buildings will be replaced in the near term. Therefore, low-cost investments can be justified even in older buildings. Properly designed and constructed new buildings are much more efficient than even well retrofitted old buildings[46] Even though relatively few new *buildings* will be constructed, they will be used for many

[46] See U.S. Congress, Office of Technology Assessment, *Building Energy Efficiency*, *OTA-E-518* (Washington, DC: U.S. Government Printing Office, May 1992).

years. Hence, developing new technologies and standards should have a high priority.

### *Transportation Sector*

Improving efficiency in the transportation sector depends on the replacement of existing vehicles and on upgrading major infrastructure and transportation networks. There is great potential for growth in the transportation sector, particularly personal travel. Car ownership levels are rising, and reliance on truck transport is increasing. Demand for automobiles in Central Europe is expected to grow by 133 percent in the 1990s. This compares to an OECD rate over the same period of just 10 percent.[47]

An increase in automobile use will drive gasoline demand up, unless fuel economy increases faster. New demand will require additional refining capacity or greater capital expenditures for imports. Thus, the efficiency of new automobiles is critical. For example, replacing the existing FSU fleet with new automobiles that get 20 percent better fuel economy would save about 50 MMbbl of oil per year. However, this will take many years to accomplish and require enormous amounts of capital.

Public transport systems are extensively developed and have prospered in former East Bloc countries. Continued government support and increased investment in public transport systems could help mitigate the expected surge in car ownership.

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[47] Y. Karmakoleas, International *Finance* Corp., The World Bank, "Automotive Industry Trends and Prospects for Investment in Developing Countries" (1990).

# Fossil Fuel Technologies

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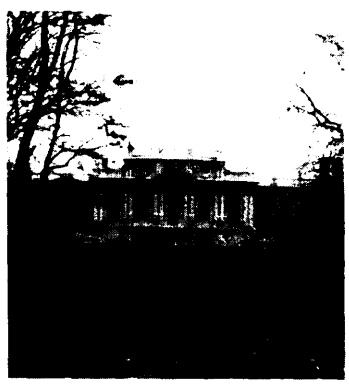
The energy sector was a cornerstone of the East Bloc system. Cheap and abundant fossil fuel resources underpinned industrialization strategies, and fossil fuel exports to the West provided the substantial hard-currency earnings needed to import capital equipment, food, and consumer goods. [1] With the dissolution of the Soviet Union and the restructuring of East Bloc trade ties, the region has now differentiated into two groups-countries that are substantial net exporters of energy (e.g., Russia and Kazakhstan) and those (e.g., Ukraine, Hungary, and the Czech and Slovak Republics) that are dependent, often heavily, on imports for their energy supplies.

Supply problems in the resource-rich countries—the focus of this chapter-concern the revival of flagging production through renovation of existing facilities and the efficient exploitation of new resources. This involves the acquisition of improved technologies, major efforts to mobilize capital resources, changes in sector organization and management, radical revisions of the policies and regulations governing energy development, and immediate attention to the environmental damage associated with energy use.

The pressing need to revitalize the energy sector of these countries could offer good opportunities for U.S. energy companies, which are world leaders in most branches of oil, gas, and coal technology, with extensive experience in working abroad. How-



ALAN T CRANE

*Marinsky Palace, Kiev, Ukraine.*

1 For the energy-exporting countries of the region-notably Russia—revenues from oil and gas provide 80 percent of convertible currency earnings. U.S. International Trade Commission, *Trade and Investment Patterns in the Crude Petroleum and Natural Gas Sectors of the Energy-Producing States of the Former Soviet Union,* investigation No. 332-338, Publication 2656 (Washington, DC: June 1993), pp 2-8.


**Wetl** *site quarters for drilling crew in Kazakhstan.*

ever, only a small faction of the full potential will be realized unless political and economic barriers to energy technology transfer are removed.

## OIL AND NATURAL GAS

Rehabilitation of the oil and gas industry is crucial to the economic recovery of the former Soviet Union (FSU) countries. The FSU oil and gas sector has major strengths that could stand it in good stead as it seeks to revitalize. These include a rich resource base, long experience as a major energy producer, and technically skilled personnel. At the same time, the industry is presently facing critical problems—poor technology; lack of capital, largely related to inadequate economic incentives and inappropriate legal and institutional frameworks; economic instability and political uncertainty; and a shortage of management skills. The solution of these problems will require wide ranging energy sector reform. A start has been made, but there is still a long way to go.

Western technology and resources have the potential for making an important contribution to the solution of these problems. However, the FSU is unlikely to attract western private sector capital on the scale needed unless stronger assurances and incentives governing foreign investment are forthcoming. Major problems for the foreign investor, particularly in Russia, are the lack of a legal framework governing oil and gas investment, a cumbersome decision- making process, and the current tax regime that is, compared with competing provinces, high, poorly structured, and unpredictable.

## | Oil and Gas Industry Problems

Signs of trouble in the oil sector appeared in the 1980s when recorded production,[2] which had been expanding rapidly, peaked at about 12 million barrels per day (MMbbl/d) and subsequently fell sharply, by almost 40 percent. Virtually all of this decline took place within Russia, by far the largest producer among the FSU countries. Hence the emphasis in this sector on revitalization of the Russian industry.

The decline in oil production is attributable largely to the maturing of two super-giant fields in Western Siberia and, despite immense development expenditures until the mid- 1980s, lack of adequate exploration. Resources were funneled into increasing production rather than developing an adequate portfolio of new projects to take up the slack as older fields matured.

The impacts of economic crisis and political dislocation were superimposed on this longer term stagnation. Shortages of capital and foreign exchange prevented replacement and repair of existing equipment. Insurrection in Azerbaijan (which provides almost 40 percent of the equipment needed by the oil and gas sector)[3] disrupted deliveries of essential oil field equipment to Western Siberia. Further delays have been caused by intermittent stoppages of railroads, highways, and Caspian Sea transportation. The changing, often confrontational, relationship between central, re-

recorded production data do not take into account underreporting production or capacity, or deliberately holding back Production in antic ipation of future price increases. These factors could moderate the extent of the decline.

[3] A. Konolplyanik, Former Deputy Minister, Russian Federation Ministry of Fuel and Energy, in "Russia Struggling to Revive Production, Rebuild Oil Industry," *Oil and Gas Journal*, *vol. 91, No. 31,* Aug. 2, 1993, p. 44.

gional, and local authorities discouraged orderly development. Strikes and the introduction of short working weeks because of lack of cash to pay salaries have held back production.[4]

On the demand side, the sharp contraction of the economy, and the rapidly declining number of customers able and willing to pay fuel bills has reduced oil consumption. Refineries, for example, are not being full y paid for their deliveries, which leads them to reduce crude oil orders from producers, or not pay for them.[5] Strict export quotas limit foreign sales, already suffering from the breakdown in the traditional East Bloc oil trade and the disruption of the oil transmission system.[6]

Gas has avoided the sharp production decline experienced by the oil sector. FSU production rose sharply in the 1980s before leveling off toward the end of the decade and subsequently declining moderately (by about 5 percent).' The failure of the gas sector to continue expanding after 1989 is associated with many of the factors causing the decline in oil output—poor technology, the fall in investment, declining domestic demand, and export disruptions,

Given the problems facing the gas industry, it may be surprising that production has not declined more. One reason is that the investment needs are much less than for the oil industry. Reserves are still plentiful, easier to access, and therefore cheaper to develop. The gas sector infrastructure is relatively new, and the industry requires less sophisticated technology to maintain current levels of production.[8] Another reason could be institutional. Though an organization the size of Gazprom (a joint stock company owned by the Russian government) may not be compatible with longer term plans to liberalize and decentralize the industry, its sector-wide, integrated structure may have been able to provide greater stability during the recent turbulent years.

## | Opportunities for Technological Upgrades

Poor technology is considered to have played a major role in the decline of the oil and gas industry in recent years. It is widely agreed that oil and gas technology used in the FSU is far behind the technology currently being used by the international oil and gas industry and that it must be upgraded if production is to recover and new fields are to be explored and developed. As the following survey shows, opportunities for technological upgrade are present in all stages of the oil and gas industry-exploration, drilling, production, transportation, refining, and offshore activities. The large number of efficiency-enhancing, cost-saving innovations in the international oil industry in recent years has largely bypassed the FSU industry.

### *Exploration*

The exploration stage identifies promising areas for subsequent drilling. Because drilling is expen-

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[4]Financial Times, *East European Energy Report,* Issue 30, March 1994, p. 27.

[5]Igor. K Lavrovsky, "A Case Study of Joint Ventures in the Oil Sector of Russia," OTA contractor report (September 1993), p. 4.

[6]The Druzhba (Friendship) pipeline, for example, built to deliver crude oil to the former COMECON and the FSU republics of Lithuania and Latvia, was divided at the time of the dissolution of the USSR into nine enterprises belonging to five independent states—Russia, Belarus, Ukraine, Latvia, and Lithuania-each introducing its own hard-currency transit tariff. The governments of the 15 new states also took control over the sections of railroad (major carriers of petroleum products) situated in their territories.

[7]The decline in 1992 production was attributed almost entirely to a sharp fall in Turkmenistan production, largely due to the loss of markets in the other republics. Matthew J. Sagers, "The Energy Industries of the Former USSR: A Mid-Year Survey," *Post Soviet Geography, vol. 34,* No. 6, June 1993, p. 384.

[8]Sagers "The Energy Industries of the Former USSR," p. 377; and U.S. International Trade Commission, *Trade and Investment Patterns*, pp. 22-30


*Truck-mounted drilling rig used for oil well drilling at Langepas, Western Siberia.*

sive, accounting for 15 to 40 percent of offshore development costs and up to 80 percent of land development costs, careful exploration is essential for minimizing project costs.[9]

The first stage in the exploration process is the identification of promising oil regions by measuring changes (by aircraft, satellite, and ground observations) in magnetic fields and variation in the Earth's gravity. Once promising regions have been established, seismic surveys are performed to identify exploratory drilling sites within the region. These surveys provide detailed maps of underground structures through information derived from artificially generated shock waves. The detail of the maps depends on whether the seismic survey is two or three dimensional. A two-dimensional (2-D) seismic survey (based on observations along single lines) maps vertical slices of the subsurface. A three-dimensional (3-D) survey, based on grid pattern observations yields more accurate and detailed information of underlying structures. Both systems are currently used by the international oil industry. The advantage of 2-D technology is its lower cost, but 3-D technology is increasingly used because it permits more efficient field development. Both types, but especially 3-D, require advanced computer capability to process and interpret the large amounts of information produced.

Russian seismic technologies have not benefited from recent innovations. Equipment is bulky, difficult to transport, and low quality, yielding information that is inadequate for the complexity of the structures. The quality and availability of minicomputers to produce a rough picture of the area, large computers to further refine the information, and the necessary software, is limited. In the past, the abundant, easily accessible, and low-cost reserves may not have required sophisticated seismic technology. But future development is likely to take place in more costly, technically difficult environments, such as permafrost, that require advanced exploration technologies.

### *Drilling*

Once promising reservoirs have been identified, drilling for exploration and subsequent production takes place. Drilling involves a number of components. The drill bit performs the boring action at the rock face. It is powered by either a turbo or rotary action motor, and connected to the surface rigs, hoists, and derricks by drill pipe. The borehole itself is lined with cement to anchor the casing and stop corrosion and leakage. Chemically designed mud is used for lubrication. The debris in the mud as it returns to the surface provides valuable information on the geology of the drilling area. Blowout preventers at the surface prevent sudden explosive escapes of gas or liquids caused by high pressure. Computers to monitor progress and interpret the information obtained from the drilling operation are an essential part of the drilling process.

Major innovations in Western technologies over recent years have vastly improved drilling precision and lowered drilling costs. A wide range of advanced drill bits has been developed to match specific site conditions. The quality of drill pipe, cement, and chemical muds has been improved

[9] Shell Briefing Service, *Producing Oil and Gas* (London: Group Public Affairs, Shell International Petroleum Company, Ltd., 1989), p. 2.

and refined. Reductions in the size of the drilling hole (slim-hole drilling) has yielded cost savings of 25 to 40 percent over conventional drilling because they permit reductions in rig size, casing, drilling muds, and cement. Slim-hole drilling also results in less waste mud and debris than conventional drilling. [10] Automated drilling rigs reduce manual labor requirements and are therefore inherently safer. Measurement while drilling (MWD), where measurement instruments are incorporated into the drill string (or pipe) above the bit, transmit information to the surface while the drill is in operation. MWD permits continuous drilling, which reduces costs, and provides more information than conventional wire line surveying (where drilling must be stopped while measurements are taken). New technologies allow for controllable directional drilling, particularly useful for tight, low permeability reservoirs and for improving production potential.

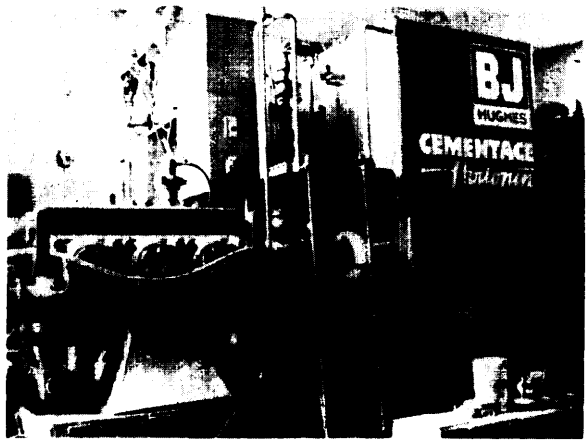
The Russian industry has limited access to these innovations. Drill bits and muds are of poor quality. Drill pipe has low tensile strength and is prone to corrosion. Defective connections do not withstand the range of temperatures, torque, and bending experienced in Russian conditions. Unresponsive fishing tools, used to retrieve broken equipment downhole, lead to excessive downtime in drilling operations. Worker safety is threatened by lack of blow out preventers, including ancillary equipment such as effective rubber seals, and remote control devices. The Russian industry has lagged in MWD, slim hole, and accurate directional drilling techniques. There is inadequate use of computers to optimize drilling programs and equipment maintenance schedules. The reasons for this lag in technological development is not primarily a lack of technical knowledge, but rather the incentive system, which in the past put priority on achieving short-term volumetric goals and emphasized quantity rather than quality.

The development of drilling technologies in Russia has differed from those used in most of the rest of the world. There are two main types of drilling technologies, rotary and turbo. The rotary system, used by most of the international oil industry, is powered from the surface, whereas the turbo drill, widely used in the FSU, is situated down hole, close to the bit. The widespread use of turbo drilling in the FSU was largely due to the Soviet inability to provide the high-quality steel drill pipe necessary to withstand the torque of rotary drilling, especially at greater depths. Turbo drilling thus allowed the Russian industry to dig farther and deeper than would otherwise have been possible with rotary drills. However, turbo drilling cannot be used in conditions of high stress, and requires frequent maintenance, thus adding to drilling time. It also requires high pressure pumps, not currently available domestically in sufficient supply. Though adequate for the past, this technology may not be suitable for future developments in more difficult geological environments.

Turbo drills are, however, essential for directional drilling because they allow the bit to take a predetermined direction. The concept behind Positive Displacement Motors—a highly successful directional drilling technology widely used by the international oil industry—apparently originated in Russia but was developed and commercialized largely outside (by Drilex Services of Scotland and the United States). A comment of John Forest, president of Drilex Services, illustrates both the strength and weakness of Russian petroleum technology, “The design idea was brilliant, the industrial engineering poor, and the materials totally unacceptable.”]

[10] Shell Briefing Service, *Research and Development in the Oil Industry, No. 4* (London: 1991) p. 4

[11] J. Karpeisky-Ryan, “Energy and Environmental Technology Transfer from the Former Soviet Union to the United States,” OTA contractor report, November 1993.



ADVANCED RESOURCES INTERNATIONAL

*U.S. manufactured pumping equipment, Ostrava, Czech Republic.*

### Production

The production process consists of drawing the underground deposit to the surface. Efficient production requires careful reservoir modeling and management. Oil and gas flow from a reservoir at varying rates, depending on natural reservoir pressures. Well stimulation technologies, such as hydrofracture stimulation, can enhance the natural drive. This technology involves cracking the rock by forcing fluid into the well at high pressures and rates, thus increasing the permeability of the formation. The cracks are propped open with material such as gravel, to keep the channels to the well open. This technology could be of growing importance to the Russian industry in the future because an increasing share of recoverable oil reserves is located in reservoir rocks with low permeability.[12] The domestic industry cannot provide the necessary equipment. The only manufacturer of hydrofracturing technology "Krasnyi Molot" (Red Hammer) enterprise in the Republic of Chechnya, has virtually stopped production. Domestic capability of acidizing, another form of well stimulation is also limited.

At some point during production, primary recovery mechanisms, depending on natural pressures, become insufficient and must be supplemented by secondary and tertiary recovery technologies. Secondary recovery involves direct displacement of oil by water flooding (the most usual method) or gas injection. Tertiary recovery consists of treating reservoir rock with chemicals or heat and is not often used, especially at current low oil prices. In all recovery techniques, artificial lifi-reinfecting oil or gas into the oil flow-enhances drive.

Water flooding, the injection of water into a well to supplement the natural pressures, is a widely used recovery technology throughout the world. In Russia, however, water flooding is both excessive and implemented in an arbitrary manner, regardless of the individual characteristics of the oil field. Wells are drilled and water injected according to prescribed rules based on hectare of field area. Russian oil field technologists believe that early water flooding increases ultimate recovery rates. If arbitrarily used, however, water flooding runs the risk of breaking through the oil bearing formations and damaging the producing well, thereby reducing total output over the life of the field.

In addition, excessive water flooding entails enormous costs and raises major environmental water disposal problems. The water cut in the Russian industry—the percent of water in total well output—is high (75 percent) and rising. This means that enormous amounts of fluid have to be pumped from the wells, using either sucker rods (situated on the surface and working like a plunger) or the higher precision electric submersible pumps situated at reservoir depth. Russian domestically manufactured electric submersible pumps are, however, of poor quality and prone to frequent breakdown.

As a result of poor reservoir management and production practices, a substantial number of wells in Russia are now idle. Almost 28,000 wells in the Russian Federation are officially listed as

[12] According to Russian experts, hydrofracturing should be introduced at Yuganskneftegaz, Nizhnevartovskneftegaz, Tomskneft, Surgutneftegaz, Varyeganneftegaz, Noyabrskneftegaz, Kondpetroleum, and Permneft associations.

idle, but potentially productive following repair (in addition to 26,000 classed as abandoned or awaiting abandonment). However, a much smaller number of these wells (between 5,000 and 8,000) are attractive candidates for rehabilitation, especially at present world oil prices, largely because of demage to the oil fields by poor management.

### Offshore Operations

Offshore operations differ from onshore mainly in the need for platforms for drilling equipment. Here again, there have been many innovations in recent years. In deeper waters, rigid platforms attached to the seafloor have been replaced by lighter platforms, floating on the surface and held in place by cables fastened into the sea floor. Simplified deck or "top sides" reduce costs and complexity of operations. Temporary drilling rigs, packaged rigs, or semi-submersible tenders can reduce capital costs by up to 25 percent and operating costs by up to 40 percent. ]  [4]Greater automation is reducing costs and environmental damage while improving safety.

This area of technology is of particular interest for the FSU where promising areas of future development have been identified in offshore Arctic, Baltic, Black, Caspian, and Okhotsk Seas. Russia has relatively little capability in this area—most Russian production has taken place onshore—and has in the past depended on technology directly purchased from the West or reproduced from Western designs. Because of the high technology content, offshore projects may be particularly suited to joint ventures with foreign partners.

### Pipelines

Crude oil and gas are usually carried in pipelines. Both oil and gas pipelines are equipped with devices—pumps in oil pipelines, and compressors in gas pipelines—to maintain pressure and flow.

Due to the size of the country and the distance between producing areas and markets, the FSU has a vast network of oil and gas pipelines. Future development of remote resources of oil and gas, and rerouting of lines in accordance with new political alignments following the dissolution of the Soviet Union, imply that considerable additions will be needed to the pipeline network, requiring large quantities of large-diameter pipe for gas transmission.

The pipeline infrastructure already faces major problems of technical performance. Domestically made pipe is defective in wall thickness, insulation, resistance to corrosion, and general workmanship. Welding procedures are not adequately controlled; diagnostic and inspection technologies are poorly designed. Problems of pipeline quality are particularly acute in the Central Asian gas system, where a combination of poor anticorrosion treatment and the high electrochemical activity of the soil results in accelerated deterioration. Leaks, especially in gas pipelines, are frequent and difficult to detect, leading to catastrophic explosions.[15] pipelines can be under repair up to 20 percent of the time.

Essential pipeline components such as excavating and pipe laying equipment and modem pipeline inspection and monitoring equipment are in short supply, especially since the dissolution of the FSU, and variety is limited. The FSU frequently relied on imported supplies of large-diameter pipe, mainly from Germany and Japan. Pipeline management, including maintenance and leak detection, is hindered by the lack of modem computer diagnostics.

Quality and performance of compressors are acute problems. These machines, fueled by gas

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[13]Troika Energy Services, for th U.S. Department of Energy, reported in "Restoring Idle Russian Oil Capacity" *Oil and Gas Journal*, May 17,1993, vol. 91, No. 20, pp. 30-31.

[1]@he]] Briefing Service, *Producing Oil and Gas*, p. 3.

[15]The worst was an explosion of a liquified petroleum gas pipeline in June 1989 that killed 575 and injured 623 passengers on two trains that were in a station a few yards from the pipeline.

from the pipeline itself, push the gas through the pipeline. A system of well placed, efficient compressors can substantially increase pipeline capacity. Since domestically manufactured compressors were of poor quality, the Soviet Union imported Western compressors, one of the few areas where the Soviet Union relied on imports. However, much of this capacity is now outdated or worn-out. For example, the pipeline from Orenburg to the western border of the FSU, built in 1976-1978 with Cooper-Bessemer and Italian Nuovo Pignone compressors, now loses 25 percent of transported gas through compressor consumption and corroded pipes. The latest export pipeline, built from Yamburg to the western border in 1987-1988, loses "only" 14 percent of the gas, despite being longer and having much bigger compressor capacity.

Gazprom is attempting to remedy compressor problems by developing domestic compressor manufacturing capacity, based on Russian aero derivative turbines, at factories in Perm and Yekaterinburg. Gazprom also plans to boost efficiency through the manufacture of recuperators. Recuperators, not widely used in Russia, can raise pipeline efficiencies from 20 percent up to 33 percent. But Gazprom still needs to import Western compressors. In 1992, the company signed a $1.46 billion contract to purchase compressors from Nuovo Pignone. The United States lost the Russian compressor market to Europe in the late 1970s and early 1980s, when an embargo was introduced. However, this loss is not final, and U.S. firms are well placed to increase sales in the FSU since the majority of imported compressors (typically 25-, 16-, and 1O-MW capacity) are of General Electric design.

## Refining

Refineries transform crude oil into products (such as gasoline, diesel, kerosene, and residual fuel oil) for use by the final consumer. Virtually all areas of the former East Bloc have some refining. But here again, this sector's activity encounters major difficulties, in part due to lagging capital investment, even in the days when upstream oil and gas were being highly favored. [16] Since the dissolution of the FSU, the regional refinery situation has become increasingly complex. Deliveries of crude oil from Russia to some of the other republics have fallen sharply: deliveries to Ukraine and Belarus, for example, are running at one-half previous levels. [17]

Refinery technology is chronically outdated throughout the region. Much of the refinery capacity was built in the 1960s. It is estimated that between 60 and 80 percent of refinery fixed assets are worn out. [18] In addition, existing equipment not well used and losses are exceptionally high. [19] Product quality is low.

A basic problem is that current FSU refinery technology (which maximizes heavy fuel oil output) does not match current and likely future demands for petroleum products (lighter products such as gasoline and kerosene). Secondary refining technologies (such as hydrocracking and catalytic cracking) that permit a wider range of product output and a larger share of light products in the total account for a much smaller share of refinery capacity in the Former East bloc compared with North America (see table 3-1 ). Consequently, heavy products, such as residual fuel oil, account for 36 percent of total output of refined petroleum products in the FSU, compared with 6

[16] In the early 1980s, when capital budgets for oil and gas rose by over 100 percent, budgets for refineries rose by only 34 percent.

[17] Mikhail Korchemkin, "Oil and Natural Gas Systems of the Former Soviet Union, OTA contractor report, October 1993, p. 28

[18] Konolplyanik, "Russia Struggling to Revive," p. 44.

[19] According to Russian estimates, the same amount of refined products could be produced out of three-quarters Of the current input Of crude if refineries were reconstructed.

TABLE 3–1: Share of Selected Upgrading Technology in Total Refinery Capacity (percent of total distillation capacity[a])

| | Former East Bloc | Us. |
|---|---|---|
| Vacuum distillation | 27 | 44 |
| Catalytic reforming | 3 | 24 |
| Catalytic hydrorefining | 9 | 12 |
| Catalytic cracking | 5 | 34 |
| Catalytic hydrocracking | negligible | 8 |

[a]Figures reflect maximum percentage of crude that may be converted by each refining method

SOURCE "Worldwide Refining Report, " *Oil and Gas Journal, VOI* 91, No 51, Dec 20, 1993, pp 37 and 49

percent in the United States. The more valuable lighter products such as gasoline, 46 percent of petroleum product output in the United States, represent less than 20 percent in the FSU.[20]

In the Soviet Union, the strategy used to meet the rising demand for light products was expansion of output rather than technology: that is, increasing refinery throughput to the point of adequate production of light products. This strategy had several drawbacks. Even when the crude was available in sufficient quantities, there was an oversupply of heavy products, notably residual fuel, that was passed on to power stations (which would have preferred to use natural gas) or to the export market, frequently at unremunerative prices. When production fell, crude was no longer available in sufficient quantity, and acute shortages of light products, especially gasoline and jet fuel, developed.

## *Critical Technologies*

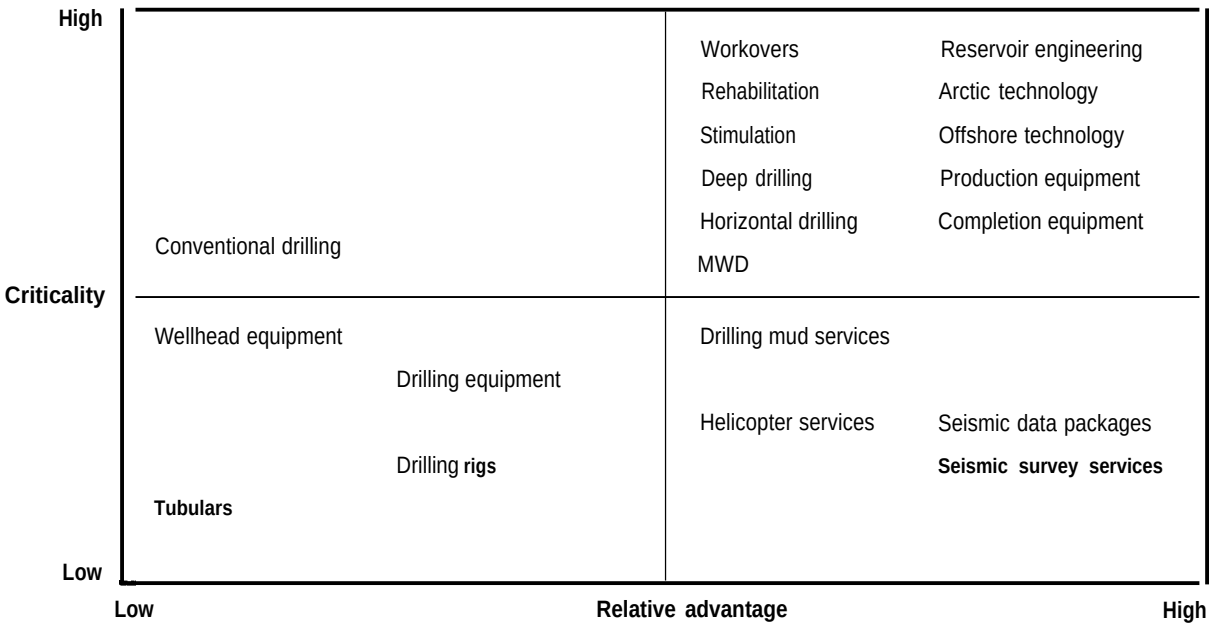
OTA's survey of the state of technology in the oil and gas sector yields a list of technologies that could substantially increase FSU oil and gas output over both the short and long term. Those countries, such as Turkmenistan, Kazakhstan, and Uzbekistan, that do not have domestic equipment supply industries, will rely largely on imported technology, especially in the near future. As their oil and gas sectors develop, however, they may wish to initiate domestic production of some items of equipment. For those countries with substantial supply equipment capacity, such as Russia and Azerbaijan, the situation is different. They are likely to be more selective in their choice of imported technology, taking only those technologies that cannot be provided by the domestic industry. Taking this into account, the technologies identified here fulfill two criteria—they are critical to FSU oil and gas sector rehabilitation and development, and they have a relative advantage overdomestic Russian technologies (see figure 3-1 ).

Technologies are needed both to rehabilitate existing idle wells and to explore undeveloped resources. Technologies that could rejuvenate idle wells at relatively low cost include advanced drill bits, fishing and downhole tools, sucker rods, and submersible electric pumps. Because of their durability, advanced drill bits could speed the drilling process and reduce downtime. Improved fishing tools would have the same effect. Water flooding on the scale practiced in Russian fields necessitates more efficient electric submersible pumps to lift large amounts of fluids. Improved gas lift equipment is also needed for wells using gas injection as a secondary recovery technique. These items are all produced in the FSU, but the need appears to be for a higher quality and larger range of model and size than are immediately available.

Also, existing wells can benefit from well stimulation technologies, such as fracture stimulation, which enhances the natural reservoir drive by increasing the average permeability of the formation and therefore increases recovery rates. This technology is likely to be of continuing impor-

[20]Energy Information Administration, U.S. Department of Energy, *International Energy Annual 1992* (Washington, DC: U.S. Government Printing Office) p. 42.

FIGURE 3-1: Opportunity Segments in the Oil and Gas Industry




SOURCE: Etienne H Deffarges et al., "E and P. Opportunities for Service Firms Abound in the C I S ," *Oil and Gas Journal, VOI* 90, No 38, p. 61

tance as an increasing share of new oil and gas reserves are found in less permeable structures. Local availability of this technology is limited but it is currently being provided by foreign firms.

Additional technologies will be highly beneficial to the longer term exploitation of oil and gas reserves. Many of these are not currently available in the FSU. Advanced seismic technologies such as 3-D systems, by providing more detailed information than alternative technologies, shorten the exploration process, enable improved reservoir development, and minimize expensive drilling. These considerations are particularly important in developing resources in remote or hostile environments. The FSU could also benefit greatly from new drilling technology. MWD improves the precision of the drilling process and reduces drilling time—again, important factors in exploitation of new resources. This technology is apparently not available from local industry. Improvements in deep drilling and horizontal drilling technologies will increase the resource base and improve recovery rates.

As much of the most attractive new petroleum potential in the FSU is offshore, the FSU could benefit from the major improvements in offshore technologies that have taken place in recent years. There is little experience with these technologies because much FSU production takes place on shore or in relatively shallow water.

Moving downstream, oil and gas transmission systems will require compact, efficient compressors and higher quality pipe. The local industry could benefit from recent advances in anticorrosion and seamless pipe, and in compressor design. These technologies are likely to be increasingly important as the pipeline network is expanded and penetrates further into hostile environments. Refinery upgrading, including residual fuel oil conversion capacity, will be required to improve system efficiency and meet current and expected demand for petroleum products. These technolo-

gies are good candidates for technology transfer since they are now standard, mature, and predictable in operation. Moreover, the FSU is accustomed to importing refinery technology.

Information technology underpins many of these technical improvements, making possible the greater precision, speed, and efficiency that has been the hallmark of technological development in this and other industries over the past 20 years. Advanced computers process geophysical data quickly and provide high-quality interpretation, thus reducing the risk, time, and cost of exploratory drilling. Computer diagnostic equipment can improve safety and reduce losses in both pipeline and refinery operations. Although computers are produced in the FSU, they do not have the range of Western models and lack the software.

However, as with all technologies, effective deployment depends on incentives. Until economic and institutional incentives are in place to ensure that technology is correctly and efficiently used, even the best technology will not be used efficiently. The reform of the FSU energy sector is critical to technology upgrading.

## I Energy Sector Reform

The rehabilitation and development of the FSU oil and gas industry will require massive investments. One estimate suggests that to achieve Russian oil production levels of about 7 MMbbl/d) through the year 2000 will require external financing of about $3 billion annually, and double that amount in domestic (ruble) financing. Increasing production to the 1990 level of about 10 MMbbl/d would require a doubling in external financing, as well as substantial increases in domestic financing.[21] In addition, substantial capital investments will be needed in gas development, oil and gas transmission systems, and refinery upgrading. An added complication is that these sums must be mobilized from unaccustomed sources-domestic producers rather than the central government, and external sources including the international oil companies. The scale of this effort implies major reforms to the energy sector.

The shortfall in domestic capital investment, previously provided by the central government, was presumably to be met from the surplus revenues of the new operating entities, particularly the production associations. This strategy depended, however, on changes in pricing policies and investment laws that would provide the necessary incentives.

While changes have been made, they have so far been inadequate to revive domestic investment. On the contrary, industry resources available for investment have, if anything, been reduced by changes in pricing policies introduced since the breakup of the Soviet Union. Prices of virtually all of the materials and equipment purchased by the oil and gas sector were freed from government control in 1992, and rose sharply. Prices of all energy products, however, were exempted from decontrol. They have been raised several times by decree, but the rise in nominal prices has been offset to a considerable extent by high rates of inflation and the depreciation of the ruble. Oil prices in Russia and other parts of the FSU are still under one half the level of comparable world prices, and gas prices are even lower. Since the oil and gas industry's costs rose faster than its revenues, the funds available for capital investment were therefore compressed. In addition, taxes increased in number and complexity.

Finally, there are reports that the foreign exchange holdings of several production associations, which had been earmarked for imported equipment, were frozen in government accounts, or held in the foreign commerce bank, which subsequently went bankrupt. All these factors have made it difficult for the production associations to

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[21] Y. Bobylev and A. Chernyavsky, "The Impact of the Oil Industry Crisis on Russia's Economy," *FBIS Report, Central Eurasia, FBI S-USR-93-006-l*, July 151993, quoted in the Atlantic Council, *Energy Policies for Russia and Ukraine*, Policy Paper (Washington, DC: November 1993), table 6.

take up the slack in capital investment from the central government.

It is difficult to overestimate the importance of price reform in the oil and gas sector. Raising oil and gas prices not only creates the resources available to the production associations for investment, but also makes the sector attractive to other domestic investors. Economic oil and gas pricing as part of a broader program of macro economic reform could encourage the return of the substantial amounts of capital presently being held outside Russia.[22] (The importance of capital repatriation in economic recovery has been amply demonstrated in Latin America in recent years.) Higher energy prices would also encourage efficient energy use and therefore confer an important environmental benefit. Foreign exchange earnings would be augmented by increased exports.

However, raising energy prices, especially to residential consumers, can cause considerable hardship. The question for the future is how to reduce the still substantial gap between domestic and international prices currently being maintained by a system of export taxes and quotas. The attainment of international parity by gradual reductions in controls and taxes may take unacceptably long. This could be the moment to consider new approaches to price reform. One approach would be to combine higher prices with increased efficiency in energy use so that total energy bills do not rise, or at least increase by less than the rise in prices.

Though correct energy pricing is a necessary condition for energy sector reform, it is frequently not sufficient because institutional and market imperfections can weaken or negate the signals being provided by higher prices. For example, many consumers in the FSU, particularly the large, energy-intensive, industries, and the regional importing countries, do not pay their oil and gas bills, so the specified price is an administrative fiction that does not provide incentives to producers. Effective energy pricing will require additional supporting actions.

Many of these can be achieved by moving toward a market system, through restructuring the industry, and by setting up the necessary legal and institutional framework. Some progress has already been made in industry restructure. The Ministry of Gas Production was transformed into the giant, government-owned joint stock company, Gazprom, in 1988. Beginning in 1992, a series of decrees converted oil sector enterprises, formerly under the jurisdiction of the energy ministries into joint stock companies as a first step toward corporatization and eventual privatization. The oil industry is to be divided into three integrated holding companies, all of world-class size (Yukos, Surgutneftegaz, and Lukoil), each of which includes exploration, production, refining, and distribution activities similar to the large vertically integrated, international oil companies. At a lower level in the organizational structure are a number of production associations, some of which would rank among the world's largest oil companies on the basis of their annual oil production. In all cases, the state retains a controlling interest, but there are plans for some private investment.[23]

This new structure, though introducing elements of corporatization and privatization, still bears some common characteristics with the old including the prominent position of large units with considerable monopoly power, which are frequently staffed by top officials of the old regime—the so called "oil generals." On balance, centralized political control of the industry has

[22] The Institute of International Finance has estimated the current scale of capital flight from Russia to be at least $1 billion a month, although this will include foreign currency legally deposited by Russian companies into Russian banks that place it overseas.

[23] For further description of the structure of the oil and gas industry in the Former Soviet Union see U.S. International Trade Commission, *Trade and Investment Patterns*, pp. 2-1 and 2-2; and Anthony Reinsch, Igor Lavrovsky, and Jennifer Considine, Canadian Energy Research Institute, *Oil in the Former Soviet Union*, Study #48 (Calgary, Alberta: October 1992), pp. 22-30.

been considerably weakened. However, the last word on the centralization/decentralization struggle has not yet been said, and it may be many years before a stable reorganization of the industry is achieved.

There has been less progress on the other institutional underpinnings of the market economy. The countries of the FSU lack a body of commercial law that spells out the rights and responsibilities of commercial enterprises and their accountability to their shareholders, whether government or private. Bankruptcy legislation is ineffective. Private property rights and contracts are still insufficiently protected. The land title system is unclear, and the decisionmaking process is clouded by a multiplicity of authorities all of whom have effective veto power.

The privatization of the energy sector is also hampered by unfamiliarity with basic Western business practices and concepts such as profit, the time value of money, depreciation, risk, quality control, contracts, and liability. Management skills are weak, and there is little experience in project evaluation. However, Russians appear to be well aware of these limitations and are eager to acquire management skills.

## I The Role of Foreign Investment

Anticipating the difficulty of raising adequate capital resources, especially foreign exchange, from domestic institutions during a transitional restructuring period, there was considerable interest in attracting external financing from both the international public and private sector.

The public sector responded promptly (see ch. 7). The Group of 7 (G-7)[24] put oil and gas at the top of its assistance agenda for the FSU. As part of this effort, the United States is developing bilateral programs in the U.S. Agency for International Development (AID), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA) programs; the Export-Import Bank of the United States (Eximbank) Framework Agreement, and expanded investment guarantees from the Overseas Private Investment Corp. (OPIC). Other G7 members are also providing bilateral support. The Japanese Eximbank, for example, is negotiating a $1.5-billion export credit for oil and gas equipment. The European Energy Charter, which provides a government-sponsored framework for energy investors in the region, is nearing completion. In addition, the multilateral development banks (MDBs)—the World Bank, the International Finance Corp. (IFC), and the European Bank for Reconstruction and Development (EBRD)—have made major new loans to FSU countries. These loans have the potential for leveraging much larger sums through cofinancing with the private sector.

It is assumed, however, that the bulk of the external financing of FSU oil and gas will come from the private sector, notably in the form of foreign direct investment. This is a particularly attractive form of investment (compared with portfolio, licensing, and even MDB lending) as it provides not only capital, but also management and technology. Most public sector commitments are explicitly designed to supplement and encourage rather than supplant private capital, though some observers (see ch. 8) consider that these programs have failed to achieve this aim. Moreover, the international oil companies have large development budgets that dwarf the resources available from public sector institutions. They are reported to foresee spending $30 billion to explore and produce oil in Russia over the next decade, but only if conditions are favorable.

Recognizing the need for foreign direct investment and its accompanying technology transfer, the Russian government introduced major changes to rules governing foreign investment. Previously, foreign investment was discouraged, if not forbidden, and technology imports were kept to a minimum. The first change was made in

[24] The Group of 7 is the term applied to the group of large industrial economies (United States, Canada, Japan, France, Germany, United Kingdom, and Italy) that meet regularly to consider the state of the global economy.

1987, when the Soviet Union authorized joint ventures and allowed foreign companies to own up to 49 percent of the equity. Later changes permitted foreign companies to take majority ownership and control. This liberalization was reinforced by Russia's membership in the International Monetary Fund, which promised additional financial assistance and the creation of a ruble stabilization fund. Legislation specific to oil and gas ventures is, however, still lacking.

In response to these initial changes, the international oil industry showed a high level of interest in the FSU. A recent compilation of projects with foreign participants listed over 100, including all branches of the sector, all of the oil and gas producing republics, and different sizes of companies of many nationalities.[25] Over one-half had U.S. joint venture partners. Two-thirds of the projects are in Russia itself, mainly in the oil sector, but many of the Russian projects are small in scope and investment.[26] planned investments in Kazakhstan on the other hand, if they materialize, could amount to many billions of dollars.[27] (Box 3-1 describes the main forms of investment to date.)

Despite the large number of projects, progress on the ground has been modest to date. Agreement had been reached on only one-third of the projects, mainly contracts to bring idle wells back into production.[28] Joint ventures currently produce about 4 percent of Russian oil production, accounting for 15 percent of Russia's hard currency crude exports. This combination of a high level of interest from the international oil company, and their relatively small commitments, reflects the balance between the attractions and problems attached to foreign investment in the FSU (see appendix 3-1 to this chapter on Dresser Industries' experience with joint ventures).

### Attractions to Foreign Investors

On paper, the attractions of foreign investment in FSU countries are strong. As Jonathan Stem puts it:

> It is hard to think of a previous situation where such an immense and potentially promising set of oil and gas provinces, denied to foreign investors for many decades has been suddenly opened up.[29]

The FSU countries have immense resources offering a wide range of opportunities at low geological risk. Inefficient production practices in existing fields initially held out the promise for quick and easy projects—the deployment of improved production techniques in a short timeframe and a consequent quick return on investment. Early optimism regarding the rehabilitation of idle wells has since been dampened, though opportunities still exist. In addition, there are projects involving the exploration and development of new fields. Russia, Kazakhstan, and Azerbaijan offer the unique opportunity of a new area with known and proven oil reserves, thus minimizing the geological risk of opening up promising but unknown areas, like those in countries of Africa, or the Antarctic. Turkmenistan and Uzbekistan are amply endowed with gas reserves. Though many of these new areas will be in hostile climates, U.S. and other oil companies can adapt, given their long experience in a wide variety of countries and climatic conditions.

FSU countries offer other advantages to the foreign investor. Most republics have a trained work force at all levels of expertise, from scientists to oilfield workers. Though many of the sites are remote, they generally have abetter infrastructure of roads, air service, trains, and telephones, than that in many of the other countries competing for oil

[25] U.S International Trade Commission, *Trade and Investment Patterns,* appendix E.

[26] Jonathan P. Stern, *Oil and Gas in the Former Soviet Union* (London: Royal institute of International Affairs, 1993), pp. 30, 31.

[27] 1 bid., p. 30.

[28] 1 bid., p. 31.

[29] 1 bid., p. 53.

## BOX 3–1: Main Forms of Investment in the FSU Oil Industry to Date

**Joint Ventures**

Until now, joint ventures between foreign firms and local partners have been the main form of foreign investment in the FSU Industry, The advantages for the host country partners (typically, production associations) are seen to be the halting of production declines, an increase in convertible currency revenues, and the acquisition of technical and management skills. Foreign investors in joint ventures gain access to local information and expertise and assistance in dealing with FSU bureaucracies.

The major joint venture activities are fields with technical problems, well stimulation (including hydraulic fracturing), drilling of horizontal wells, idle well reactivation, oil spill cleaning, and separation of liquid hydrocarbons. Well stimulation and reactivation of idle wells is the leading activity, as the service contract for idle well reactivation (a Russian decree—1 Or of January 1992-entitles Western companies to receive contractors' margins of up to 25 percent of the total cost of the workover) is the best developed instrument in legal terms, In April 1993, 12 production associations had signed 34 contracts with foreign partners to repair 7,407 wells with estimated production potential of 1.7 MMbbl/d. The Western companies, mainly small to medwm-sized, receive about 15 percent of this volume as payment. They are to ship an estimated $800 million of equipment, mainly service rigs and auxiliary equipment. The host production association pays for much of the down hole equipment, pipes, materials, and chemicals. The production associations receive about 40 percent of the export price for 011, with the rest retained by central and local fiscal authorities. A new decree envisages the transition to a system of payments in kind. There is less interest in natural gas because investment is needed primarily for rehabilitation of existing infrastructure rather than in-increased production

**Production Sharing Agreement**

At present, there is no legislation governing production sharing agreements, and each agreement is settled on a case-by-case basis. Russia's first agreement was approved in early 1993 between Elf Neftegas (a subsidiary of the French company Elf Aquitaine) and Interneft, a Russian company. This agreement calls for Elf to bear the full financial risks for exploring a tract in Volograd and Saratov estimated to contain 100 to 500 million tons of crude. Elf is committed to revest $500 million over a 9-year period. Elf will be repaid in petroleum in terms of specific formulae designed to protect Elf against changes in legislation, particularly taxation Elf has also signed a similar agreement with Kazakhstan.

**Equity-Sharing Agreements**

These will depend on the effectiveness of the privatization programs. Russia plans to privatize 60 percent of state property in the near future. The state will retain a controlling share in privatized petroleum companies whose dividends will be plowed back into the companies for investment in production facilities and the provision of social services. Foreign investors may acquire up to 15 percent of the shares auctioned. Kazakhstan and Azerbaijan also allow foreign equity participation.

**Tenders and Auctions**

Several international tenders and auctions have been held in Russia, largely covering the Sakhalin province, for exploration and development rights. A notable example is a consortium of Marathon, McDermott, Mitsui, Shell, and Mitsubishi to undertake an $80-million feasibility study to explore and develop a tract offshore Sakhalin. At the conclusion of the feasibility study, the consortium will negotiate a final agreement on development rights, though the original agreement did not guarantee the consortium development rights.

**SOURCE U S International Trade Commission, Trade and Investment Patterns in the Crude Petroleum and Natural Gas Sectors of the Energy Producing States of the Former Soviet Union, Investigation No 332-338 Publication 2656 (Washington, DC June 1993), pp 3-8 to 3-10, and Igor K Lavrovsky, "Case Study of Joint Ventures in the 011 Sector of Russia, " OTA contractor report, (August 1993)**

company investment. Finally, these opportunities are becoming available at a time of U.S. spare capacity, which reduces the opportunity cost of going abroad. However, the FSU republics are not the only investment opportunities in the world. The oil companies will weigh the overall environment for investment in FSU countries with possibilities in other parts of the world.

### *Obstacles to Foreign Investment*

On the other hand, there area number of obstacles to foreign investment. These include a high level of political uncertainty, lack of a legal and regulatory framework, a poor economic environment, and different perceptions of the role of foreign investment.

## | Political Uncertainty

Political uncertainty, especially as it affects the sanctity of contracts, is of prime concern to prospective investors. The history of the international oil industry has shown that perceptions of political uncertainty are not consistently associated with any one type of political regime. Gulf Oil (now part of Chevron) continued production in Angola throughout its civil war, and many foreign oil companies continue to be interested in Azerbaijan, despite a recent unilateral cancellation of all previous agreements with foreign companies. The perception of stability is important however, and may explain the particular interest in Khazakhstan, despite major logistical problems in oil transport. In Russia itself, where production potential may from many points of view be more attractive, there is considerable uncertainty over the political environment.[30] Programs such as OPIC and the Multilateral Investment Guarantee Agency (see ch. 7), which offer—at a cost—insurance against political risk, help reduce exposure.

## I Lack of Legal and Regulatory Framework

In addition to general political uncertainty, there are more specific aspects of particular concern to foreign investors in the oil and gas sector. There is as yet no legal and regulatory framework governing oil and gas leasing, exploration, and development, and current draft laws do not resolve many of the issues that foreign oil companies cite as limiting their greater participation. Nor is there legislation defining the rights and responsibilities of the foreign investor. Each project must negotiate its own terms, a long and complex business. For example, it took Chevron over 3 years to negotiate its agreement with Kazakhstan. There is also concern over the consistent application of laws and decrees. According to Exxon:

> "Laws and decrees are promulgated, discounted, ignored, exceptions are promised, granted and revoked. There are also great voids where no Russian legislation exists at all."

Issues of owning and disposing of private property, intellectual property, due process in cases of expropriation, and environmental liability have not been addressed.

#### Unclear rights of ownership

In Russia, as in many other countries, oil and gas resources are owned by the government. This, in itself, is not a serious obstacle to investors. However, in Russia it is not clear how to obtain rights to develop these resources, especially as surface property rights lie within the jurisdiction of the regional and local governments. Ownership rights are hotly contested between the central federation, local governments, and the production associations, causing uncertainty among potential for-

30A recent ranking of countries by country risk (a weighted average of 11 factors, including indebtedness, current account position, and political stability) in *The Economist,* Aug.21, 1993, p. 84, ranked Russia as the second most risky country in the world, a few points behind Iraq, and both just under 100, the highest number on the index.

TABLE 3–2: The Current Russian Tax Regime

**Export tax:** Levied at the rate of 30 ECUs per ton ($5.15/bbl) on crude oil sold abroad.

**VAT:** Twenty percent of the cost of all inputs (domestic and imported) at the time of purchase, but refunded in full after 24 months if production stream is for export.

**Profits tax:** Levied at 32-percent rate on taxable income, but with straight-lme depreciation of most capital expenditures, expensing of certain outlays (but not interest), full loss carry-forward provisions, and deduction for reinvested earnings (limit 50 percent of taxable income).

**Production royalties:** Combined state and federal assessment equal to 16 percent of the gross value (world price) of production,

**Currency exchange:** Fifty percent of hard currency receipts from exports to be exchanged for rubles at market rates. We presume that the unstable value and inconvertible status of the rubles acquired via such transactions constitutes an implicIt tax of 25 percent on the value of currency so exchanged,

**Social reserve fund:** A levy equal to 37.5 percent of total wages, collected for the purpose of rebuilding social Infrastructure.

**Repatriation tax:** In the case of U.S. Investors, 5 percent of remitted dividends, Could be higher or lower for legal residents of other jurisdictions,

SOURCE James L Smith, Department of Economics, "Poor Economic Prospects Face Investors in the Russian 011 Industry" (Houston, TX University of Houston, April 1993), p 2

eign investors about the legality of agreements and contracts. Some U.S. companies sign contracts with all three levels of government. Even within each level of government, there is an absence of established lines of decisionmaking. Some recent improvement is reported. Relationships between the center and the provinces, a serious problem in the past, appear to be stabilizing, with regional authorities receiving more freedom in equipment procurement and searching for investment sources.

### Poor economic environment

The economic environment is crucial for foreign investors, who need to be assured of their ability to make profits and their freedom to remit them. Foreign investors, whose earnings are derived from oil exports rather than from sales to the much lower priced domestic market do not suffer directly from oil and gas price controls as do their Russian counterparts. However, foreign investors are subject to a multiplicity of taxes (see table 3-2), which taken together are seen by U.S. investors to represent an unrealistic and unstable tax regime.

Taxes are high compared with competing provinces, such as the North Sea, and based on revenues rather than profitability, a great disadvantage when costs vary greatly between areas.[31] Under this tax regime, oil produced in Russia would have to sell for nearly twice the price of oil produced in the United States or Australia for a project to be economically viable.[32] This punitive tax situation exists not so much by design, but because many of the jurisdictions that have the authority to impose taxes fail to realize the cumulative impact of their tax decisions.

Taxes are also subject to change. An export tax of $6 per barrel was imposed in 1992 to bridge the great differences between domestic and export prices. The tax virtually eliminated the profit of one U.S. venture. Although some companies managed to be grandfathered into the export tax exemption, negotiating the exemptions took valuable time and energy and often tied up tax payments until a decision was reached.

One of the attractions of investment in oil and gas, over other branches of industry in the FSU is

[31] In most Countries, the investors are first allowed to recover their costs from the initial revenue streams of the project. Higher tax rates are imposed only after costs have been recovered. In Russia, under the present regime, high taxes are imposed before cost recovery.

[32] James L. Smith, Department Of Economics, "Poor Economic Prospects Face Investors in the Russian Oil industry" (Houston, TX: University of Houston, August 1993).

the ready ability to earn the hard currencies necessary to cover the cost of imported equipment and to remit profits.[33] For this purpose, it is necessary to have clear title to the oil (which is sometimes in doubt) and the freedom to export it. However, the freedom of foreign investors to export oil is subject to changing regulations. In 1991, central control over oil exports was loosened, and joint ventures were given the right to export a share of their production. In December 1992, however, controls over oil and gas exports were reinstated because of suspected illegal sales. In 1993, the 80 licensed exporters were cut to 30, and further cuts are contemplated. In the same year, Decree715 (of July 23) specified that joint ventures involved in incremental production projects would not own the additional crude they produce but would instead work on a contractual basis for cash.

These measures have increased central government control over Russian oil exports, including those of joint ventures. However the situation is still fluid and may change again especially as increased central control over exports is strongly opposed by many of the regional and local associations. In theory, joint ventures should be able to export oil under any combination of centralized/decentralized governance; but in practice, constant changes in administrative systems can be time consuming, costly, and destabilizing for the foreign investor. A further cause for concern is the possible unwillingness of third parties to allow transit of oil and gas across their territories.

### Different perceptions of foreign investment

One obstacle becoming more apparent as experience with joint ventures and other foreign investments grows is the difference in perception about technology transfer and foreign investment between the Russian hosts and the foreign investors. Views are not consistent among participants on either side. In Russia, for example, the oil sector shows more interest than the gas sector in foreign investment. Within the oil production associations, views also differ over the merits of foreign investment. And views vary among countries of the FSU. Kazakhstan and Turkmenistan, with little indigenous technical capability, encourage foreign investment. Russia, which has considerable technical capability, is more ambivalent.

U.S. companies, too, have different perceptions. Several oppose public sector programs, such as those implemented by the World Bank and the EBRD, on the grounds that they supplant rather than supplement the private sector, and thus discourage Russia from making necessary reforms, including granting access to Russian hydrocarbon resources. Other companies, and suppliers of oil equipment, on the other hand, support such programs on the ground that they help share the risk of doing business with FSU countries.

Despite all the differences, some generalizations can be made. To the Western eye, the need for up-to-date technologies throughout the oil and gas industry is obvious and represents a large export market. In influential parts of the FSU government and industry, however, there is a deep-seated opposition to the involvement of foreign capital in the oil and gas sector. This suspicion toward international oil companies is a common phenomenon in many countries of the world but is particularly acute in Russia, a pioneer in the oil industry and, for much of its history, the world's largest oil producer.

Part of the opposition is based on Russia's disappointment with foreign oil company performance so far. They regard the international oil companies primarily as bankers and have been disappointed at the sums actually forthcoming. They feel that much foreign investment to date has mainly benefited Western companies.

[33] In 1992, the ruble was made internally convertible and convertible for current account transactions. But the shortage of foreign currency has limited the practical operation of full internal and current account convertibility, and foreign investors in the oil sector seek to obtain foreign currency through oil exports for payment for their services and investment.

More fundamentally, influential elements of both the Russian government and Russian industry do not consider Western technology to be a key element in petroleum industry rehabilitation, but rather, as in the past, a supplement or temporary substitute for domestic technology. The new producing regions, like Turkistan, Kazakhstan, and Uzbekistan that do not have a domestic equipment supply industry, may be eager, or have no alternative than to encourage foreign investment if they wish to develop their petroleum resources. Russia, however, is likely to want to preserve its domestic equipment supply industry, especially because the development of oil and gas technology is considered a fruitful area for defense industry conversion.

### U.S. Regulations Governing Private Sector Participation

For many years, U.S. trade and investment with the Soviet Union was prohibited or very strongly controlled. The major legal obstacles (the Byrd Amendment to the Trade Act of 1974, and the Stevenson Amendment to the Export-Import Bank Act of 1945, both restricting U.S. Export-Import Bank operations in the FSU) were repealed by Joint Resolution of Congress on April 1, 1992. Since then, U.S. firms have been able to export equipment freely. However, industry considers that restrictions remaining in the National Security Controls Act could constrain use of some recently available technologies, particularly seismic or computer equipment.[34]

New bilateral tax and investment treaties (eliminating double taxation on interest and royalties and defining the conditions of international investment) have also been concluded with Russia and several other republics. An exception to these new initiatives to encourage foreign direct investment in the FSU is the case of Azerbaijan, where U.S. aid is specifically prohibited except for nuclear weapons disarmament until Azerbaijan ceases uses of force against Armenia and Nagorno-Karabakh.[35] As a result, the International Trade Commission reports that the government of Azerbaijan has delayed signing a contract with a U.S. firm for the development of an Azeri petroleum field, while negotiations continue with non-U.S. companies interested in the same project.[36]

Though much of the legal legacy of the Cold War has been dismantled, U.S. industry still feels at a competitive disadvantage with oil and gas companies of other nations. (In addition to oil companies based in Western Europe and Japan, companies from the Middle East and Latin America are also active in the FSU.) This competitive disadvantage is based on 3 factors. First, U.S. companies lack the long experience of other Organisation for Economic Cooperation and Development (OECD) countries in conducting business with the FSU. Contacts and knowledge of trading conditions were not readily available to the industry in the early days, adding to the frustrations, costs, and complexity of early initiatives. As time goes by, and U.S. efforts to disseminate information about Russian trading conditions improve, this initial disadvantage will be overcome, but in the important early days it could have disadvantaged U.S. firms.

Second, there is widespread belief among U.S. companies and policymakers that other governments provide much greater financial and diplomatic support to their national companies, many of which are nationalized companies, than does the United States. This issue has been a long standing bone of contention between the United States and its competitor allies in the OECD.

Third, U.S. business practices may differ in important respects from those of other countries. U.S. companies, for example, maybe held by public opinion in this country to higher standards of environmental practice than are the companies of

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[34]U.S. International Trade Commission, *Trade and Investment Patterns*, pp. 4-1 and 4-2.

[35]Section 907 of title IX of the Freedom Support Act of 1992.

[36]U.S. International Trade Commission, *Trade and Investment Patterns*, p. 4-3.

other countries. Also, U.S. companies, which are forbidden by U.S. law to engage in bribery, must compete with companies domiciled in other countries that lack similar legislation. This factor could be of particular importance during the inevitable disruptions occurring during the transition from a state-owned to a market economy.

## | Conclusions

The rehabilitation of the FSU oil and gas industry through U.S. investment and technology offers a mixed prospect. On the one hand, these countries offer exciting and rich new possibilities for oil and gas development and a well educated work force. U.S. participation in the oil and gas sector could provide benefits to both partners. It could contribute to the establishment of political and economic stability in the FSU and provide a major area of growth for the U.S. industry.

On the other hand, there are several obstacles to these mutually beneficial outcomes. Some of the more important have been outlined here. They include a severe lack of investment funds (largely related to political uncertainty, insufficient economic incentives, and inadequate legal and institutional frameworks); economic instability, including the disruption of the previously important energy trade that took place before the dissolution of the Soviet Union; a shortage of management and some technical skills and information; and the frequently differing agendas of the host country, foreign investors, and aid donors. The U.S. industry may be disadvantaged by its unfamiliarity with this particular market and a tradition of less aggressive government backing.

These are formidable barriers. Some progress has been made in the past few years, but much remains to be done to help the energy sector of the FSU attract domestic as well as foreign capital. Despite a distinct cooling of the early euphoria, the FSU energy industry is still regarded in the West as the single most promising area of joint business activity, and some companies have been able to achieve considerable success in their Russian undertakings. Another good augury for the future is the greater spirit of realism in Western companies about the amounts of money, time, and effort needed to succeed. On the Russian side, the perception of whether foreign investment is needed is still a key issue. Eventually, the continuing shortage of capital investment and technology may make the foreign investment option more attractive—many other countries have changed their views about foreign investment as the need arose.

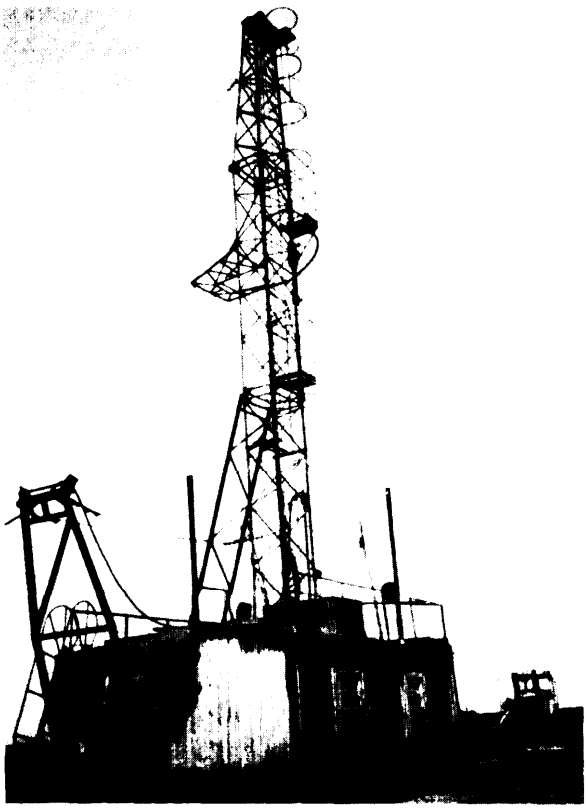
But the actual path of development has been slow, lagging early expectations. The experience of the past few years suggests that there is no quick fix for either side. Overall, the picture is mixed, showing some improvement of late, but suggesting that the rehabilitation of the oil and gas sector will take more time and care than originally thought.

## COAL MINING AND BENEFICIATION

Coal is an abundant, widely distributed resource in Russia, Ukraine, Kazakhstan, and Poland. Coal deposits vary in geologic composition and quality. For example, the geologic characteristics and location of some of Russia's coal deposits—very deep or thin, and located in areas far from consumers—make it difficult and expensive to mine. Deposits also range from high-quality hard coal to lignite. In the former East Bloc, most coal is mined underground using a variety of mechanized equipment. Railroads are the dominant means of transportation to markets.

Prior to World War II, coal was the dominant fuel in the Soviet Union, as it was elsewhere in the world. In 1940, coal supplied 75 percent of Soviet energy needs.[37] Since then, oil and natural gas use has increased significantly, and today, coal ac-

[37] U.S. Congress, Office of Technology Assessment, *Technology and Soviet Energy Availability*, OTA-ISC-153 (Washington, DC: U.S. Government Printing Office, November 1981), p. 82.




*Coal coring exploration rig, Kuznetz Basin, Kazakhstan,*

counts for only 14 percent of energy use in Russia.[38] Coal, however, is still widely used in the Far East and Siberia for industry and as a household fuel in rural areas. Poland also relies on coal for a large percentage of its energy needs. This reliance is unlikely to diminish before the end of the century.

The coal industry in the FSU is a multifaceted enterprise. In Russia, for example, the coal industry consists of more than 1,500 associations, enterprises, and structural units. The industry not only mines coal but is responsible for mine construction, mineshaft equipment production, and geological surveys. The industry also provides housing (some 35 million square meters), health care, children's schools, and other facilities for its employees.[39] This situation is similar to the coal company town that existed in the United States 70 years ago. Today, the coal industry is trying to divest itself of some of these community/social activities, which have proven to be a tremendous burden on resources.

In the FSU, the coal industry is in crisis. Production has been steadily declining since 1988, and that will likely continue for the near future. Moreover, production costs are escalating rapidly, and transportation costs are high when compared with that for natural gas. Continued government management and control, environmental concerns, and labor unrest cloud the industry's future. Reasons for the decline in output are outlined in this section, followed by a discussion of the potential for U.S. mining and beneficiation technology transfer to former East Bloc countries. Reclamation technologies are examined in chapter 5.

## Declining Coal Production

In former East Bloc countries, coal production's downward slide is directly linked to the lack of capital investment in new coal mines and in upgrading old, established ones. In recent decades, government strategy dictated that the coal industry take a backseat to oil and gas development. Thus, over the past 15 years, no new mines have been opened in Russia. Moreover, over one-half of the operating mines are at least 30 years old and in poor working condition; few of these mines have been upgraded.[40] In Ukraine, no new mine

[38] "Rosugol" Malyshev: Coal Industry Privatization 'Problematic,'" June 16, 1993, in *FBIS Report, Central Eurasia,* July 23, 1993, p. 90.

[39] Yuriy Malyshev, "Coal: Uphill or Downhill?," *FBIS Report, Central Eurasia;* and "Rosugol's' Malyshev Analyzes Deep Crisis of Coal Industry," FBIS-USR-93-079, June 25, 1993, p. 52.

[40] Yuriy Malyshev, *FBIS Report, Central Eurasia,* June 25, 1993, p. 53.

construction has occurred in the last 10 years, according to the Minister of Geology.[41]

Equipment shortages have also contributed to the decline. The failure to produce suitable equipment and spare parts in the required quantities has been a longstanding problem in the FSU. Critical equipment is idled because spare parts are not available, and some equipment simply does not exist; e.g., methane gas detectors and other safety equipment.[42] More recently, the dissolution of the FSU has further aggravated the situation. Economic ties between various sectors in former republics have been disrupted. For example, Ukraine produced about 60 percent of the underground excavation equipment, as well as the face cleaning machinery, mine rescue equipment, and electric locomotives; Kazakhstan provided the copper for the electric locomotives.

The uneven quality of equipment also contributed to the decline. Some mines have to make do with old, decrepit machinery, while others command better, more sophisticated equipment. Improper maintenance and repair, and the lack of spare parts, make a bad situation even worse.

Furthermore, the thickest coal seams closest to the surface are now depleted, and miners must work thinner seams at greater depths, making extraction slower, more difficult, and more expensive. This is particularly true in Ukraine. In Russia, new mines located in the east are considerable distances from population centers. Moreover, several of the Siberian basins have lower quality coal, which is uneconomical to transport. Cold climes further limit extraction and transportation.

Labor unrest adds to the problem. Wretched working and living conditions and low salaries have led to miners' strikes. For example, many miners work without safety equipment, such as hand-held methane detectors. Methane gas explosions are the number one cause of death in underground mines. Also, medical facilities are inadequate, and consumer goods are scarce, particularly in remote areas in Siberia and the Arctic.

Finally, the mutual financial indebtedness among related industries has resulted in production decline. At the heart of this situation is the coal industry's indebtedness to the railroads. Recently imposed higher shipping rates and fines for late payments have further strained relations. As a result, coal is being stockpiled in storage areas, where it is subject to degradation and spontaneous combustion.

## Coal Mining Technologies

About 50 percent of coal output in the FSU is mined underground, a decline of 13 percent since 1980.[43] This decline reflects the former Soviet government's view that surface mining must expand to ensure the coal industry's success. Of course, there are differences between countries as well as regions. Underground mining is still the predominant coal extraction method in Ukraine.

Underground mining is more complex than surface mining. Instead of scraping away the overburden (overlying soil and rocks), miners must work underground, connected to the outside world by shafts and passageways sometimes thousands of feet long. Roof support, ventilation, drainage, and lighting are some of the factors that complicate underground mining.

Equipment used in underground mining ranges from relatively simple to highly automated machinery. The oldest method, hand labor, is still used occasionally in small mines.

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41 U.S. General Accounting Office, Report to the Chairman, Subcommittee on European Affairs, Committee on Foreign Relations, United States Senate, *Ukraine Energy-Conditions Affecting U.S. Trade and Investment*, GAO/GGD-92-129 (Washington, DC: U.S. Government Printing Office, August 1992), p. 7.

42 Dolores Kern, "Melting the Ice," *Coal Voice*, vol. *16, No. 3* (May/June 1993), p. 14.

43 Richard Levine, U.S. Bureau Of Mines, personal communication, Sept. 13, 1993; and the Office Of Technology Assessment, *Technology and Soviet Energy Availability*, p. 82.


*Coal mine entrance in Upper Silesian Basin, Poland.*

Longwall mining is the principal underground mining technique used in the FSU and throughout Europe. In the FSU, longwall mining accounts for about 85 percent of total underground output.[44] It involves the creation of interconnected corridors that are 300 to 600 feet apart. The long wall of the interconnection is mined in slices, using a rotating cutter that moves back and forth across a coal face. As the machinery moves, it cuts the coal, which falls onto a conveyor belt. The roof is held up by steel jacks while the cutter makes a pass across the face. The roof jacks are advanced with the shearer to make a new pass. The roof collapses in the mined-out area behind the jacks. Almost all of the coal can be extracted by this process.[45]

In recent years, open pit mining in the FSU has become more important, increasing from 35 percent of coal output in 1980[46] to 50 percent in 1992. Surface mining is used extensively in the Czech Republic and Estonia (see table 3-3). Surface mining equipment includes bulldozers, draglines, excavators, and large-capacity trucks.

## Potential for U.S. Mining Technology Transfer

The FSU designs and manufactures coal mining equipment. Although adequate, FSU equipment is heavier and somewhat less sophisticated than that of the United States and other western countries. Shortages of equipment, such as draglines and large-capacity excavators have been met in the past by Central Europe, particularly Poland and the former East Germany. Western imports provided only a small share.

Germany and Britain are leaders in longwall mining research and development. Because of this expertise and their proximity to former East Bloc markets, German and British companies are in a strong position to transfer technology. Germany is now actively marketing its equipment in former East Bloc countries.

The preferred method of underground mining in the United States (down to 700 meters) is the room and pillar with roof bolting system. Thus, opportunities for U.S. export and technology transfer of underground mining equipment largely hinge on a change in mining techniques, i.e., from single-entry longwall mining to roof bolting techniques. Changes in mining techniques are unlikely to occur in the near future. Moreover, geologic differences render much U.S. equipment unsuitable for the narrow seams of many FSU mines. Modifications must be made to U.S. equipment prior to export, a major market disadvantage.

However, the United States is a leader in surface mining technology and equipment. Examples of equipment that might increase productivity are large-capacity draglines and excavators. While these technologies are not unique to the United States, U.S. companies do produce equipment that typically have larger capacities than

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[44]Central Intelligence Agency, *USSR Energy Atlas* (Washington, DC: U.S. Government Printing Office, January 1985), p. 32.

[45]For an in depth discussion of mining processes, see U.S. Congress, Office Of Technology Assessment, *Direct Use of Coal—Prospects and Problems of Production and Combustion, OTA-E-86* (Washington, DC: U.S. Government Printing Office, April 1979).

[46]OTA, *Technology and Soviet Energy Availability, p. 82.*

TABLE 3-3: The Role of Surface Mining

| Country | Surface mined (percent) |
|---|---|
| Russia | 55 |
| Ukraine | 4 |
| Kazakhstan | 70 |
| Estonia (shale) | 50 |
| Poland | 70 |
| Czech Republic | 75 |
| Hungary | 32 |
| Slovak Republic | 0 |

SOURCES Przemysl (Warsaw 1992), p 20, Iparstatisztikai Evkonyv (Budapest 1989), p 301, Statistiska Rosenka (Prague 1992), p 388; Okhrana okrushaiushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov (Moscow Goskomstat, 1991), pp 202-203.

their Western European and Japanese counterparts.

To date, the U.S. coal industry presence in the FSU has been part of a much larger humanitarian effort, Partners in Economic Reform (PIER). With U.S. government funding and coal industry and labor support, PIER administers the Coal Project, which provides technical assistance and training in health, safety, efficiency, and productivity throughout the coal regions of Russia, Ukraine, and Kazakhstan. Technical assistance includes demonstrations of U.S. mining technology and equipment, as well as management, engineering, and safety techniques. The Coal Project also funds the purchase of safety equipment, such as methane detectors, for FSU miners. The Coal Project has liaison offices in Moscow, Kiev, and Almaty and regional training centers in the Donbass, Kuzbass, Karanganda, and Vorkuta mining regions.

## | Coal Beneficiation

Coal beneficiation (cleaning) is done at the mine prior to transport. Cleaning improves the quality of coal so that it can be used more cleanly and efficiently and offers significant savings in transport fees. Coal cleaning also reduces handling and storage, and maintenance costs for pulverizers because of lower volume. Furthermore, pre-combustion cleaning can result in environmental benefits; e.g., cleaning removes ash and some of the sulfur[47] found in coal, thus reducing particulate and sulfur dioxide, which are emitted during combustion.

It is important to note that the benefits of coal cleaning will vary among East Bloc countries and will largely depend on the characteristics of the coal. For example, in Ukraine, where coal is high in pyritic sulfur, cleaning will offer significant reductions (up to 50 percent) in sulfur emissions. In Poland, the primary benefits are reduced transport costs and particulate emissions, especially in urban areas where a large percentage of households use high-ash coal for heat. (See chapter 5 for a discussion of the environmental benefits and potential impacts of coal beneficiation.)

There has been little cleaning of coal in former East Bloc countries. For example, during the 1970s and 1980s, only about 15 percent of coal was cleaned in the FSU, mostly for coking coal. Coking coal typically receives cleaning because of the technical requirements of metallurgical operations. Polish coal is cleaned for the export market.

### *Potential for US. Technology Transfer*

The United States has extensive experience with coal beneficiation. About one-third of U.S. steam coal (over 200 million tons) is cleaned to remove ash and sulfur impurities and to increase heat value.[48] This experience and technological expertise could both benefit the coal industry and mitigate the air quality impacts of coal combustion in several countries.

But before U.S. and other Western companies invest in coal cleaning projects, coal data must be collected and evaluated to determine appropriate

[47] Two types of sulfur are found in coal: pyritic and organic. Traditional coal cleaning methods can only remove the heavier, pyritic sulfur.

[48] Thomas C. Elliott, "Coal Handling and Preparation," *Power*, January 1992, p. 17.

cleaning techniques and to ascertain the level of newly generated wastes resulting from beneficiation. In most cases, such data are not available and must be assembled by U.S. companies interested in doing business in former East Bloc countries, a major financial undertaking for small- and medium-sized firms and a significant obstacle.

Although few U.S. firms are involved in coal cleaning technology transfer to this region, Custom Coals is actively pursuing opportunities in Poland. The U.S. company is planning to build three facilities near Krakow, Poland. These plants will have the capacity to clean 10 million tons of coal annually for powerplant use. Appendix 3-2 details Custom Coals' experience in Poland and provides some perceptions of federal government efforts to assist U.S. businesses.

## Conclusions

The coal industry in former East Bloc countries continues to experience serious problems including declining output of mines near population centers, few additions to mine capacity, declining coal quality, and labor unrest. The low priority given the coal industry in the past has contributed significantly to present-day instability. For example, capital investment decisions in the 1970s and 1980s favored oil and gas development and starved the coal industry. Moreover, government strategy to mine the thickest seams closest to the surface quick] y depleted high-qua] it y, economical coal. What is left is coal of poorer quality that is located far from consumers. Production costs are rising rapidly, and transportation costs are high, when compared with those for natural gas.

The shortage of capital also hindered the development and production of coal mining technologies. The use of old, inefficient technologies is commonplace. In addition, equipment manufacturers historically have been reluctant to develop and produce new technologies. Fear of jeopardizing output plans and risking related bonuses are at the root of this fear. Moreover, the reliability of equipment has been a longstanding problem. Infrequent repair and maintenance, the lack of spare parts, and the use of equipment that is unsuitable for the conditions aggravate the situation. Equipment failure results in work stoppages, and poorly maintained equipment results in an increased rate of accidents and injuries in the labor force.

Some restructuring of the coal industry has begun in Russia, Poland, Hungary, and the Czech Republic. Recently, Russia announced the closure of 41 underground mines and one open pit mine by 2000. These mines produce about 3 percent of total output but account for 26 percent of all coal industry accidents.[49] Also, a new entity, Rosugol, was created in 1993 to administer the coal industry. However, principal responsibility still resides with the 28 coal associations that oversee production and transport. In other countries, restructuring is further along. Hungary, for example, has closed several mines, raised coal prices, and reduced subsidies. In Poland, the Hard Coal Agency, a state-owned, joint stock company, was formed to encourage privatization and to close inefficient mines. Also, prices have been raised, subsidies have been reduced, and some mines have become independent entities. However, the coal industry in former East Bloc countries is still far from being a competitive structure of private producers, distributors, and traders. Legal and regulatory issues are two of the many concerns that must be addressed before a truly competitive industry emerges.[50]

Associated environmental problems further cloud the outlook for the industry. The widespread burning of low-quality lignite is largely responsible for the alarming degradation of the environment in the region. Cleaning up the pollution will require many years of effort and large infusions of capital. The Polish government, for example, esti-

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49 Radio Free Europe/Radio Liberty Daily Report, "Forty-Two Mines to be Closed," Oct. 29, 1993.

50 Energy Sector Management Programme, *Poland—Energy Sector Restructuring Program, vol. 2: The Hard Coal Subsector*, Report No. 153/93 (Washington, DC: World Bank, January 1993).

mates that $260 billion will be needed to attain European Union environmental standards and reach sustainable economic development.[51] Hence, technological advances in clean coal burning and pollution control equipment will not only provide environmental benefits but also may help stabilize coal output and use.

Modem coal mining technology offers short-term improvements in productivity, efficiency, and environmental impacts. It also buys time while the transition is made to a market economy. However, Western assistance alone will not reverse the coal industry's downward slide informer East Bloc countries. Efforts must be made by Central European and FSU governments to solve the variety of problems now facing the industry. To stabilize output and reverse the decline, capital must be invested in mine development and modernization. Manufacturers must be able to produce the required equipment and get it to the miners. Western imports and joint ventures in production facilities could provide some relief in this regard. The industry's social/community activities, such as health care, housing, wages, taxes, and pensions, must also be addressed.

In the final analysis, however, the long-term survival of the coal industry will depend on how well governments make the transition to a market economy. Economic reform is the key.

The U.S. coal industry has not thus far actively pursued technology transfer to former East Bloc markets, as compared with the oil industry. The characteristics of the region's industry and related environmental impacts, labor, and transportation problems have not been conducive to foreign investment. Furthermore, mining techniques and geologic characteristics of coal deposits differ from those found in the United States. Because mining is generally done at deeper levels and on thinner seams, U.S. companies would have to modify their equipment for export to former East Bloc countries, a major market disadvantage. As reforms take hold, and the coal industry stabilizes, there may be more interest in coal mining technology transfer to that region. One near-term possibility for U.S. companies might be to focus on opportunities for U.S. technologies and expertise after the coal is extracted, such as coal beneficiation. The United States is a leader in coal cleaning technologies and project development and management. This expertise could provide significant energy efficiency and air quality benefits. However, the lack of accurate coal data will present a challenge to Western companies interested in technology transfer. Accurate data are essential to the success of coal beneficiation projects.

In sum, there are many opportunities to rejuvenate the coal industry in former East Bloc countries and make it financially healthy. Whether U.S. companies jump in will depend on the region's and coal industry's success in making the transition to a market economy and addressing the myriad of problems it now faces.

## COALBED METHANE

Methane gas is often associated with coal. Generally, the amount of methane stored in a coal deposit is related to the quality and depth of a coal deposit. Higher quality and deeper coal seams have greater capacity to hold methane.

Large amounts of methane can be released during the mining process. For example, coal mining operations in Poland release about 4.8 trillion cubic feet (Tcf) annually, most of which is vented to the atmosphere.[52] Unutilized methane is a potent greenhouse gas and a safety hazard. Methane is estimated to be about 25 times more effective in

[51] Stanley J. Kabala, "The Environmental Morass in Eastern Europe," *Current History*, vol. 90, No. 558, November 1991, p. 388.

[52] U.S. Environmental Protection Agency, *Assessment of the Potential Economic Development and Utilization of Coalbed Methane in Poland*, EPA/400/1-91/032 (Washington, DC: U.S. Government Printing Office, August 1991), p. ii.

TABLE 3–4: Methane Degasification Emissions, Selected Countries

| Country | Total recovered (bcf) | Total used (bcf) | Total vented (bcf) |
|---|---|---|---|
| FSU | **43.4** | **9.8** | **33.6** |
| Czechoslovakia | 4.9 | 4,4 | 0.5 |
| Poland | 10,0 | 7.0 | 3.0 |

**SOURCE Charles M Boyer, II, and Jonathan R** Kelafant, **and** Dina **Kruger,** "Diverse Projects Worldwide **Include Mine, Unmmed Coals,"** *Oil and Gas Journal,* **VOI** 90, **No 50, Dec 14, 1992, p 40**

trapping heat than carbon dioxide ($CO_2$) on a weight basis,[53]

Methane gas explosions are the number one cause of death in underground mines in the FSU. In the past, miners took canaries down into the mine with them as a warning that methane was present. Gas detection equipment and mine ventilation systems are now used.

The methane can be captured and used instead of being released. Coalbed methane is essentially identical to natural gas and can be transported by pipeline to households and industries. Extracting and using coalbed methane improves mine safety and provides environmental benefits. Its use could thus reduce pollution in the heavily industrialized areas of southwestern Poland, where adverse health effects have been associated with high levels of sulfur dioxide emissions. There is great potential for methane recovery and use in Poland, Russia, Ukraine, and Kazakhstan. They are among the major coal bed methane resource countries in the world.

## I Coalbed Methane Technologies

In gassy coal seams, ventilation systems are inadequate, and degasification technologies must be used. These technologies can recover methane before, during, and after mining, and can be used inside the mine or from the surface. Degasification systems have become more important in light of growing concerns about greenhouse gas emissions. Methane degasification emissions for several areas are highlighted in table 3-4.

The four principal methods of degasification are surface pre-mining drainage, in-mine drainage, surface gob recovery, and cross-measure boreholes. Several factors, including the characteristics of the coal deposit, mining methods employed, and surface conditions, determine which degasification technology is used.

Surface pre-mining drainage uses vertical wells that are drilled from the surface to recover the methane before mining activities commence. Drilling can occur from 2 to 15 years prior to mining. This method is used exclusively in the United States, but can be used in other countries as well.[54] Poland has expressed interest in surface pre-mining drainage.

In-mine drainage is preferable in areas where surface mining is impractical because of land use patterns and where immediate drainage is required. Boreholes are drilled into the coal seam where they can be connected to the mine's piping system, which transports the gas out of the mine.[55]

Surface gob recovery is used after a coal seam is mined. Wells are drilled to within a few feet of the top of the coal seam. As mining is completed underneath, gas is produced from the fractures

[53] US Congress, Office of Technology Assessment, *Changing by Degrees: Steps to Reduce Greenhouse Gases*, OTA-O-482 (Washington, DC: U.S. Government Printing Office, February 1992), p. 59.

[54] Charles M. Boyer, II, Jonathan R. Kelafant, and Dina Kruger, "Diverse Projects Worldwide Include Mines, Unmined Coals," *Oil and Gas Journal*, vol. 90, No. 50, Dec. 14, 1992, p. 39.

[55] Ibid.

created by the caved-in areas. Surface gob recovery often produces large quantities of methane. However, the gas is not pipeline quality because it has been contaminated by mine air.[56]

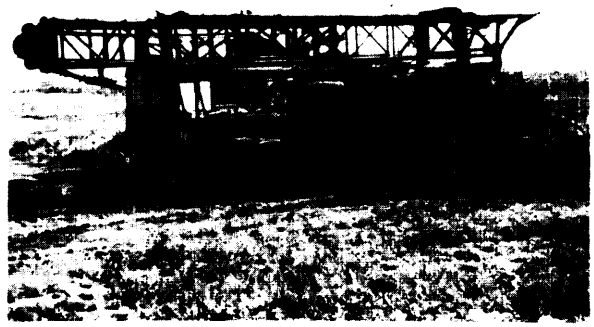
In many countries, including the FSU, Central Europe, and the United States, cross-measure boreholes are the principal recovery method. Boreholes are drilled at an angle into the strata above or below the coal seam being mined. Like other in-mine recovery systems, the boreholes are connected to the mine's piping system.[57]

## | Potential for U.S. Methane Technology Transfer

The desire to reduce greenhouse gas emissions and become energy self-sufficient has spurred interest in developing coalbed methane resources worldwide. Poland, for example, is actively seeking Western assistance to explore and develop its resources.

The United States has done extensive research on coalbed methane exploration and development technologies. This research paved the way for successful U.S. projects, such as that in the San Juan Basin in Colorado and New Mexico and the Warrior Basin in Alabama. With a vast resource base (400 Tcf) and production experience (over 1 billion cubic feet per day), the United States is a recognized leader in coalbed methane development.[58] U.S. technologies and project management expertise can help expedite coalbed methane development in former East Bloc countries.

Recently, two U.S. companies, Amoco and McCormick Energy, have been awarded contracts to extract coalbed methane in the Upper Silesian coal fields in southern Poland. Most of the methane will be compressed and transported by pipeline. It is expected that the recovered methane will replace about 7 percent of Polish gas consumption, or 1 percent of the country's total energy demand.[59]



ADVANCED RESOURCES INTERNATIONAL

*Truck mounted drilling rig typically used for coal and coalbed methane explorations in the former Soviet Union,*

U.S. and European companies are also pursuing coalbed methane exploration and production projects in the Czech Republic, Hungary, Romania, and Bulgaria. Additionally, the EPA is actively promoting expanded coalbed methane recovery and use in several countries, including Poland, Russia, Ukraine, and the Czech Republic. Thus far, EPA has funded resource assessments and established a coalbed methane information center in Katowice, Poland. EPA also has established a U.S./Poland working group to encourage projects to reduce methane emissions from mines.

While interest in commercial coalbed methane projects is growing, several factors have dampened Western enthusiasm for market development in former East Bloc countries. The lack of appropriate regulations and the legal uncertainties that relate to ownership and granting concessions have hindered development. Also, the poor condi-

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[56] Ibid.

[57] Ibid.

[58] Jonathan R. Kelafant, Scott H. Stevens, and Charles M. Boyer, II, "Vast Resource Potential Exists in Many Countries," *Oil and Gas Journal*, vol. 90, No. 44, Nov. 2, 1992, p. 80.

[59] "Flaring Coal," *The Economist*, vol. *328, No. 7820,* July 17, 1993, p. *65.*

tion of many coal mines and the continuation of subsidized energy pricing have further reduced the economic attractiveness of coalbed methane projects.

Available and accurate geologic data, a fully integrated natural gas pipeline system, and tax incentives are also needed. Most of these conditions do not exist in former East Bloc countries, making coalbed methane development riskier. These countries must address these legal, financial, and political issues to attract Western investment and fully realize their coalbed methane resource potential.

## APPENDIX 3-1: EXPERIENCE WITH JOINT VENTURES-DRESSER INDUSTRIES

### Background

Dresser Industries is a full-spectrum oil and gas production equipment manufacturer that has been selling oil- and gas-related equipment to the Soviet Union since 1936. Dresser began doing business with Moscow when Soviet Russia was rapidly expanding its petroleum production capabilities to fuel the huge spurt of economic growth that took place under the state-sponsored industrialization program of the 1930s. Dresser has remained in Russia ever since, selling a full spectrum of highly engineered upstream and downstream oil- and gas-related equipment. Dresser's business intensified in the early 1970s, and the company established an officially accredited office in Moscow in 1979. With almost six decades of experience in the Soviet market, Dresser is one of the most experienced American exporters to the FSU.

### Present Activities

The company is currently working on two large projects in the FSU. In St. Petersburg, Russia, Dresser is in the process of setting up a joint venture with the Kirovskii Zavod, a former military enterprise, for the manufacture of oil and gas pipeline turbine compressor sets. This will be the company's first manufacturing operation in Russia. In Uzbekistan, Dresser has signed a $200-million agreement to build a gas injection condensate recovery project.

### Doing Business in the FSU

Dresser officials who have worked recently in Moscow note that many of the skills that the company learned in the Soviet era are still vital for doing business in the FSU. Of particular importance are the company's wide range of contacts within the FSU oil and gas industry and the understanding that doing business in the FSU requires a long-term commitment and perspective. Moreover, since Dresser's activities have been almost exclusively commercial in nature and have not involved resource extraction, the company has not been greatly hampered by the legal and ownership uncertainties that have affected oil and gas exploration ventures since the breakup of the Soviet Union.

But there have been substantial changes in the way business is done and in the types of problems Dresser has encountered since the Soviet Union split apart. Whereas before 1991 the company dealt almost exclusively with ministries and foreign trade organizations, it now sells directly to end-user organizations such as enterprises, production associations, and refineries. This can be a double-edged sword. Although it is easier to deal with end-users than third parties, Russian enterprise directors have had little experience negotiating major purchases with foreign contractors. Managers are often unfamiliar with Western price norms, warranty standards, and other trade-related matters previously handled by professional negotiators in Moscow. As a result, the customarily long Soviet-era negotiation process is often further attenuated in the FSU.

Moreover, the Soviet Union was such a reliable creditor that Dresser never needed to require a letter of credit. Now, the need to obtain financial guarantees from enterprises in the post-Soviet states can create confusion and misunderstanding. Post-Soviet enterprise managers are unfamiliar with Western financial requirements and have been slow to appreciate the need for confirmed letters of credit and other guarantees. Dresser thinks

that a U.S. government sponsored training program to teach basic business management and marketing skills to FSU energy sector managers could improve understanding of the mechanics of market economies and foreign trade. But the need for such training is so great that company officials wonder whether any foreseeable American training program could have a significant impact.

## | U.S. Government Role

According to Dresser, recent U.S. government activity in the commercial sector has had a positive impact on energy-sector exports to the FSU. The relaxation of COCOM has been of particular help to the company, allowing it to sell its high-technology nuclear logging equipment and other computer-driven systems to markets from which they were previously prohibited. The company also notes that the U.S. government has shown greater interest in promoting American exports over the past four or five years. This includes not only greater coordination between agencies such as DOE and Commerce, but also encompasses changes in other aspects of U.S. government policy. For example, the easing of visa restrictions for Russians to visit the United States may not have been seen as a commerce-enhancing step, but it greatly eased Russian frustration at what was perceived to be unequal treatment: Dresser officials could visit the Soviet Union, but Soviet citizens could not come to the United States. Dresser notes that the easing of these restrictions and the placing of former Soviet citizens on a more equal footing with Americans in the business process has eased relations with Dresser's Russian partners and made it easier to do business.

Nevertheless, company officials maintain that without substantial United States government assistance in the area of finance, Dresser and other equipment supply companies will be unable to expand their export activities to the FSU. They say that given the acute need for FSU countries to raise hard currency, the U.S. government should give greatest priority to promoting investment in those FSU sectors, such as oil and gas production, that will provide the quickest and most lucrative hard-currency exports. But given the region's economic and political instability, Western banks will not lend money on an unsecured basis. Western resource extraction ventures such as Chevron can afford to risk investing their own money because the potential rewards are so great. But in the equipment export sector, where the returns are much smaller, Western firms such as Dresser cannot risk investing hundreds of millions of dollars of their shareholders' money in the turbulent conditions of the FSU. Accordingly, Dresser advocates a large expansion of Eximbank guarantees (at the standard 85 percent rate) for energy sector investment projects. In his view, Eximbank guarantees (coordinated with similar guarantees by other Western nations) will prove much more effective and will promote investment much more quickly than other efforts currently under consideration, including the European Energy Charter and attempts to set up escrow accounts or funnel investment funds through multilateral organizations such as the World Bank.

## APPENDIX 3-2: CASE STUDY: CUSTOM COALS CORP.

Custom Coals Corp. is an Arizona corporation headquartered in Pennsylvania and founded to market a recently developed technology to reduce the pre-combustion sulfur content of coal. According to the company, its cleaning process removes sulfur more economically than flue gas desulfurization (scrubbers), the most widely used post-combustion process. Company data show that in many cases the Custom Coals process, which employs physicial benefication and limestone and hydrated sorbent additives, reduces sulfur emissions at half the cost of scrubbers. The company's products are designed for electric utilities and for the district and home heating markets.

The company recently won a $76-million contract under the U.S. Department of Energy's Clean Coal Technology Program to construct and operate a demonstration coal cleaning plant in Somerset County, Pennsylvania. After this project goes on line, Clean Coals plans to develop 9 to 10 full-scale plants in the United States.

## I The Project

In addition to U.S. markets, Custom Coals is seeking to sell its technology overseas in countries that depend heavily on coal but lack effective and cost-efficient pollution-control technologies. At the present time, the company's most active project is in Poland, though it is also working in China and Mexico. Poland is a particularly attractive prospect because of its huge coal reserves, its dependence on coal for power generation and heating, and the need to curtail the emissions of sulfur that have contributed to the country's nearly catastrophic levels of pollution.

Ideally and in the long term, the best way for Poland to reduce toxic emissions is to convert its powerplants to gas-fired operations. But conversion to gas would demand a great deal of capital, which the country cannot afford. Coal cleaning provides a good short-to medium-term solution to Poland's problem. It demands much less capital investment and results in significant pollution reduction. Custom Coals estimates that its clean coal product will contain 75 percent less particulate and heavy metals and 50 percent less sulfur than raw Polish coal. In addition, the coal cleaning technology will offer Poland the ability to clean its high-sulfur coals and export the product to Western Europe.

The company has proposed an initial project involving three coal cleaning plants, which would process about 10 million tons of Polish coal annually for sale on the domestic and export market. It sees the potential for 25 plants, to process around 100 million tons (75 percent of Polish annual coal production). The company has already spent one year working on the project, in consultation with government officials, as well as the managers of coal mines, power generation plants and the electric grid. The company is presently studying the technical characteristics of Polish coal; evaluating project sites, supplies, builders, and operators; and developing a detailed project for submission to international lending agencies. It hopes to have a financeable project ready for presentation to the World Bank and the EBRD by the second quarter of 1994, with groundbreaking set for the fourth quarter of that year.

## I Doing Business in Poland

Custom Coals reports a warm reception from Polish government and enterprise officials because it actually proposes to build a project. Poles have told Custom Coals officials that they feel "studied to death" by fly-in, fly-out Western consultants who spend a great deal of money identifying problems but do very little about solving them.

However, business negotiations have not been problem free. The Poles' lack of background in free market economics and lack of knowledge about the rates of return needed to attract investment capital has impaired their ability to evaluate potential business deals. Polish managers have difficulty judging whether they are receiving reasonable terms, in the context of the international economy, and they worry about being taken advantage of by more knowledgeable Western business people. The lack of a consistent and reliable system of cost accounting often makes it difficult for Custom Coals to generate the types of data needed to satisfy financial requirements. And the many unusual attached costs borne by Polish enterprises (everything from bowling alleys to day care centers) have to be taken into account in computing total project cost.

Nevertheless, Custom Coals has had few major problems setting up its business. This is in large part because the company has been able to find professional service providers who are fluent in U.S.-Poland business issues, the technical questions of coal production, and the English 1anguage. Beyond management training for future senior Polish managers of Custom Coals projects, the company does not foresee a need for substantial investment in training.

Custom Coals' German competitors have been active in the same market. German companies enjoy an advantage over Custom Coals because their domestic operations are subsidized by the German government. However, the German firms rely on conventional pollution-control technologies, not

the advanced, pre-combustion technologies developed by Custom Coals. The German companies are also seeking direct financing or sovereign financial guarantees from the Polish government to underwrite their proposed projects. Custom Coals is structuring its project proposals so that the Polish government will not have to provide financing, making their proposal potentially much more attractive from the Polish point of view.

## | International Lending Agencies and the U.S. Government

Since commercial banks are still extremely reluctant to lend to projects in Central Europe, the success of Custom Coals' Polish project depends on funding from multilateral lending agencies such as the World Bank and EBRD. Custom Coals officials have been solicitous of advice from representatives of both institutions and have remained in continuous contact with them as they develop their funding proposal. World Bank officials are particularly enthusiastic about coal cleaning as a more cost-effective answer to Poland's pollution problems than the installation of highly expensive scrubbers. Custom Coals is optimistic about prospects for long-term project financing from these institutions.

Custom Coals' experience with U.S. agencies has been more mixed. The company applied for and received a $375,000 matching grant from the AID to conduct feasibility studies for its Polish project. But the application process was extremely slow. AID took 7 months to review the project before approving it in May 1993, and another 7 months to disburse the funds.

In the company's view, the World Bank and EBRD are fulfilling their missions as multilateral lenders financing development projects. The company is therefore less concerned about project funding than with financing the feasibility studies and other initial costs involved in putting together a project proposal. The company notes that these initial costs can be quite high—around $2 million to $3 million simply to put together a project financing proposal suitable for submission to a multilateral lender. For a large corporation, this is not a big expense, but for a relatively small business like Custom Coals, these development costs constitute a considerable sum. The company's AID grant is designed to meet part of these costs, but the AID application process is too slow.

The company would therefore like to see a new and more timely way of providing development assistance for U.S. firms, especially for small companies, in the form either of loans or grants. (Custom Coals would gladly take a commercial loan to cover these costs if it could obtain one for its Polish project.) The company points to the DOE Clean Coals Technology Program as a model. The DOE program provides startup monies on a timely basis, requires company matching funds (which eliminates spurious projects), and requires repayment to replenish the revolving fund. Unfortunately, these DOE funds cannot be used for projects abroad. The company thinks that something like this would be ideal for projects in Central Europe.

## | The International Perspective

Custom Coals notes one larger philosophical issue. The company sees coal cleaning not as a national issue, but as a global one. American firms and the U.S. government have spent large sums of money developing domestic technologies for coal cleaning and for the reduction of sulfur dioxide and particulate emissions. Domestically, where all powerplants and industry are already meeting previously established standards for pollution control, recent investments in coal cleaning technology will yield significant, but relatively marginal improvements in pollution control. But applying these technologies elsewhere, where the basic technologies in use are far below the U.S. standard or where no pollution-control technology exists, could yield much larger results in terms of reducing worldwide sulfur emissions. In essence, $2 billion spent worldwide would have a much greater impact on reducing pollution levels than the same money spent in the United States.

Overseas projects thus offer a much greater environmental ‘*bang” for the investment buck. Accordingly, the company advocates a shift in U.S. government focus and a more global approach to coal cleaning as a way of obtaining greater results from technologies already developed at home.

# Non-Fossil Fuel Technologies

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Fossil fuels dominate energy supply in the former East Bloc, just as they do in the West. Some of the major energy issues, however, concern non-fossil technologies. Nuclear safety and proliferation issues could pose global risks. Electric powerplants are key elements in the energy picture, requiring major modernization to meet environmental standards. Renewable energy is promising in the long term.

## NUCLEAR POWER TECHNOLOGIES

Nuclear energy was a high priority in the Soviet Union. It was seen as an advantageous spinoff from the necessary development of military nuclear capability, an alternative to fossil fuel resources, and a symbol of modernity. The role that nuclear energy plays in each country is listed in chapter 2.

This report discusses two major considerations relating to nuclear energy. The first is safety. Soviet reactors have proved to be substantially less safe than Western reactors. As Chernobyl has shown, a major nuclear accident can threaten millions of people, even hundreds of miles away. However, improving safety is difficult, complex, and often expensive.

The second is nuclear weapons proliferation. Soviet weapons, materials, or expertise could become available because of potentially inadequate control in the former Soviet Union (FSU). Analyzing that risk is beyond the scope of this report. However, research and analysis on nuclear safety in the civilian sector is a logical area for employing former weapons designers, thereby reducing the danger of proliferation.

There are other nuclear power issues such as economics, public acceptance, and nuclear waste. Nuclear waste is already a subject of technological cooperation between the United States and Rus-

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sia but is beyond the scope of this study. Some critics believe that nuclear power should be phased out as quickly as possible, and that any cooperation that will tend to prolong its use here and in the former East Bloc is undesirable. This section neither accepts nor rejects that view. It merely lays out the issues related to nuclear reactor safety and weapons proliferation and discusses what can be done to address them.

## Nuclear Safety

The pattern of nuclear power technology development in the Soviet Union was similar to that of the United States: maritime and small power reactors were constructed in the 1950s; pressurized water reactors (PWR) and boiling water reactors (BWR) were tested in the 1960s; and widespread deployment occurred in the 1970s. However, Soviet nuclear designs were largely indigenous, unlike almost all other reactors in the world that were derived from U.S. technology. Therefore, Soviet reactor designs, although based on similar concepts, evolved quite differently from those in the West. Furthermore, the institutional environment for designing, constructing, and operating nuclear powerplants was completely unlike anything in the West.

Western observers have generally concluded that the reactors in the former East Bloc are significantly less safe than Western reactors. The explosion at Chernobyl and other accidents have reinforced this view. The disruption from the breakup of the Soviet Union and the economic crisis affecting the entire region have aggravated the problems as Russian operators and engineers have returned home and spare parts have become unavailable.

Since the Chernobyl accident in 1986, Western countries have increased efforts to reduce the risk of another major accident, particularly one on the scale of Chernobyl. Even an accident that disabled a reactor with very little offsite contamination, such as at Three Mile Island, would be a major economic blow to a region the United States is trying to help.

Some reactors had been scheduled to be shut down, largely for safety reasons, but economic realities have made this difficult. All these countries suffer from severe energy shortages, and nuclear reactors have been an essential element in keeping electric power available. As noted in chapter 2, in six of these countries, nuclear is a higher fraction of the power supply than in the United States (about 20 percent). Shutting reactors down without adequate alternatives (new generating capacity or improved efficiency of electricity use) would aggravate the economic crisis. None of these countries can afford to replace all operable but risky plants with new ones. Even Ukraine, with its special sensitivity toward nuclear safety, has deferred the planned shutdown of the two remaining Chernobyl reactors and may consider repairing the Unit 2 reactor, which was severely damaged by fire in 1990 (the 1986 explosion destroyed the Unit 4 reactor). In addition, Armenia is giving serious consideration to rehabilitating two reactors shut down because of safety concerns following a major earthquake in 1988.[1] The only other recent shutdowns for safety reasons have been in the former East Germany.

Nuclear safety is a complex subject. Accidents can arise from a variety of faults involving design, construction, operation, and maintenance. While there is no consensus in the United States about how safe reactors are, or how safe they should be, regulation and public involvement has been much stronger than in the former East Bloc. There has been exhaustive analysis of reactor designs here

[1] The damage then was slight, and the reactors were still operable. However, the powerplant was not very close to the earthquake epicenter. Apparently, it was decided then to close the reactors because they might not ride out a stronger earthquake. More damage has occurred from subsequent deterioration, and seismic resistance must be upgraded.

and in other Western countries, a process for learning from mistakes, and considerable incremental improvement.[2] Operations and maintenance have also improved, as evidenced by the greatly improved performance of U.S. reactors.[3]

Evaluation and comparison of reactors based on different technology and under different regulatory and institutional systems are much less certain. However, it does appear that the evolutionary improvement experienced in the West was not duplicated in the Soviet Union. Reactor designs were improved, but not as rapidly. There does not appear to have been an organized policy for backfits to address safety deficiencies as they were identified,[4] or even a strong regulatory authority. Operations and maintenance were never held to high standards, and are actually slipping, in part due to the economic crisis.

However, the situation is not entirely grim. The Soviet-built plants in Hungary and Finland have been among the most reliable in the world.[5] Furthermore, there are different approaches to safety. Soviet reactors have some advantages and can, at least in theory, achieve safety levels equivalent to Western reactors. Except for basic items such as containment vessels and emergency core cooling systems, the presence or lack of a specific safety feature does not necessarily greatly affect overall safety. Each reactor must be analyzed in its entirety. U.S. assistance must be designed to account for specific technological needs, for the recipient's ability to make use of the assistance, and for the role that nuclear energy plays in each country.

Improving safety in operating reactors requires a variety of activities:

- identifying and fixing specific problems on individual reactors,
- enhancing analytical skills and regulatory expertise and authority,
- upgrading operations and maintenance of reactors,
- infusing the entire enterprise with a commitment to excellence.

This section reviews the safety problems of reactors in the former East Bloc and what can be done about them by the United States and other Western countries. It identifies specific technologies and expertise that would be useful in reducing risks and the current activities to transfer them.[6]

## Design Safety Problems

Two main types of reactors were produced by the FSU—the RBMK and the VVER (both are Russian acronyms). The RBMK is graphite moderated and water cooled. Its fuel assemblies are in tubes inside graphite blocks, somewhat like the high-temperature gas reactor (HTGR). Water flows up through the tubes and emerges as a steam/water mixture. The steam is separated and drives a turbine, as in a BWR. Spent fuel is re-

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[2] These issues were discussed in: U.S. Congress, Office of Technology Assessment, *Nuclear Power in an Age of Uncertainty*, OTA-E-216 (Washington, DC: U.S. Government Printing Office, February 1984). Subsequent developments have largely confirmed that analysis. Also see: U.S. Congress, Office of Technology Assessment, *Aging Nuclear Powerplants: Plant Life and Decommissioning*. OTA-E-575 (Washington, DC: U.S. Government Printing Office, September 1993).

[3] Institute Of Nuclear Power operations, *Annual Report 1993,* " 1993 Performance Indications for the U.S. Nuclear Utility Industry," March 1994.

[4] U.S. Department of Energy, *Department of Energy's Team's Analysis of Soviet Designed VVERs*, DOE/NE-0086 (Washington, DC: ~t- ber 1988).

[5] Reliability and safety are not equivalent. A reactor can achieve high reliability if i! is operated despite safety problems—until an accident occurs. However, under a stringent safety regime, (here is a significant correlation between the two because many of the measures needed to improve safety (e.g., intensive operator training and scrupulous maintenance) also improve reliability.

[6] Further detail is included in Richard Wilson, "Nuclear Power Safety in Central and Eastern Europe," OTA contractor report, (September 1993).

TABLE 4-1: RBMK Reactors in the Former East Bloc

| Russia | Model | start operation | MWe |
|---|---|---|---|
| Kursk 1 | 1 | 1976 | 1000 |
| Kursk 2 | 1 | 1978 | 1000 |
| Kursk 3 | 2 | 1983 | 1000 |
| Kursk 4 | 2 | 1985 | 1000 |
| Leningrad 1 | 1 | 1973 | 1000 |
| Leningrad 2 | 1 | 1975 | 1000 |
| Leningrad 3 | 2 | 1980 | 1000 |
| Leningrad 4 | 2 | 1981 | 1000 |
| Smolensk 1 | 2 | 1982 | 1000 |
| Smolensk 2 | 2 | 1985 | 1000 |
| Smolensk 3 | 3 | 1990 | 1000 |
| **Ukraine** | | | |
| Chernobyl 1 | 1 | 1971 | 1000 |
| Chernobyl 2 | 1 | 1971 (shutdown) | 1000 |
| Chernobyl 3 | 2 | 1975 | 1000 |
| Chernobyl 4 | 3 | 1983 (destroyed in 1986) | 1000 |
| **Lithuania** | | | |
| **Ignalina 1** | 2 | 1983 | 1500 |
| **Ignalina 2** | 2 | 1986 | 1500 |

SOURCE: Richard Wilson, '(Nuclear Power Safety in Central and Eastern Europe," OTA contractor report, September 1993.

placed while the reactor is operating, unlike U.S. reactors, which must be shut down for refueling.

The RBMK design evolved from early plutonium production reactors. It was never built outside the Soviet Union, possibly because of concerns that it could be used to generate weapons-grade plutonium. The reactors at Chernobyl in Ukraine are of this type. The design has no direct counterpart in the West. RBMKs exist in Russia, Ukraine, and Lithuania. In addition to these operating reactors, construction has ceased or slowed at Kursk 6, Smolensk 4, and Ignalina 3, in part because of public opposition following the Chernobyl accident.

The second type, the VVER, is similar conceptually to the PWR, the dominant reactor of the West. It is water moderated and cooled, and evolved from reactors used for icebreakers and submarines. This reactor has been exported, including to Finland, Hungary, and Bulgaria. The former Czechoslovakia later assimilated the design and constructed several independently. Several models are extant. The oldest is the 440/230, which was followed by the 440/213, both at 440 megawatts of electricity (MWe). The latest model is the 1000 MWe VVER-1OOO.

Tables 4-1 and 4-2 list the reactors of greatest concern. These tables do not include other types of reactors, such as the Canadian-built heavy-water reactors in Romania.

There are two main areas of concern with the RBMK: core neutronics and the hydraulics of the pressure tubes. The first refers to the nuclear reactions in the core. The RBMK has a positive void coefficient, meaning that if water is lost from the core, the reaction tends to speed up. Both water and graphite are moderators (which slow neutrons so that they will be more likely to cause another fissioning when they strike a uranium atom), but water also absorbs some neutrons. Western reactors are designed so that water must be present for the reaction to continue. If some is removed from the core, either through excessive boiling or a loss-of-coolant accident, the reactor will shut down (a characteristic known as a negative void coefficient). This is an inherently stable design, and such stability was a prime criterion in the early days of nuclear energy, when many different reactor concepts were investigated.[7] In the RBMK, graphite provides all the necessary moderation. As water is lost, the number of neutrons increases

7 U.S. reactors are inherently safe in terms of the chain reaction; the reactor will automatically shut down the chain reaction If coolant is lost. The major safety problem following a loss-of-coolant accident comes from decay of the fission products—the highly radioactive waste from the chain reaction. Fission products produce sufficient heat as they decay that the reactor fuel can melt (as at Three Mile Island) unless cooling is maintained.

TABLE 4-2: Older VVER Reactors in the Former East Bloc

| | Unit | Model | Start operation |
|---|---|---|---|
| **Armenia** | | | |
| Armenia | 1 | 230 | 1977 |
| | 2 | 230 | 1980 |
| **Bulgaria** | | | |
| Kozloduy | 1 | 230 | 1974 |
| | 2 | 230 | 1975 |
| | 3 | 230 | 1980 |
| | 4 | 230 | 1982 |
| **Czech Republic** | | | |
| Dukovany | 1 | 213 | 1985 |
| | 2 | 213 | 1986 |
| | 3 | 213 | 1986 |
| | 4 | 213 | 1987 |
| **Hungary** | | | |
| Paks | 1 | 213 | 1983 |
| | 2 | 213 | 1984 |
| | 3 | 213 | 1986 |
| | 4 | 213 | 1987 |
| **Russia** | | | |
| Kola | 1 | 230 | 1973 |
| | 2 | 230 | 1974 |
| | 3 | 213 | 1982 |
| | 4 | 213 | 1984 |
| Novovornezh | 3 | 230 | 1972 |
| | 4 | 230 | 1973 |
| **Slovakia** | | | |
| Bohunice | 1 | 230 | 1978 |
| | 2 | 230 | 1980 |
| | 3 | 213 | 1984 |
| | 4 | 213 | 1985 |
| Mochovce | 1 | 213 | 1994 |
| **Ukraine** | | | |
| Rovno | 1 | 213 | 1980 |
| | 2 | 213 | 1981 |

SOURCE Richard Wilson, "Nuclear Power Safety in Central and Eastern Europe, " OTA contractor report, September 1993

because absorption decreases, thereby increasing the chain reaction. Under some conditions, such as occurred at Chernobyl Unit 4, this is an inherently unstable design: the chain reaction can multiply rapidly, leading to an explosion. This accident might have been prevented had the design precluded too many control rods from being withdrawn from the core, or if operators had been thoroughly trained to recognize the risk.[8]

The obvious solution is to remove enough graphite so that the reaction shuts down if water is not present. However, this would be extremely difficult in an existing reactor that is structurally dependent on the graphite and where all work would have to be done by remote control. Fixed neutron absorbers (to supplement the movable control rods) are being installed in the cores instead, and the operational reactivity margin is being increased. Improved monitoring and controls would also be beneficial.

Two other weaknesses are already being corrected. First, each control rod had a graphite tip to match the surrounding moderator below the core when fully inserted. Unfortunately, control rods are reinserted from the top, and this graphite tip adds to the core reactivity as it passes through, apparently the proximate cause of the Chernobyl explosion. These rods can be modified to remove the extra graphite, but it has not yet been confirmed if all RBMKs have been modified.

The second correction was to add a fast-acting scram system to all RBMK reactors. The original shutdown rods were suspended by a cable that winds around a drum. About 20 seconds were required to insert the rods. The new system will allow a much faster shutdown in case of emergency, possibly forestalling a major accident.

The major hydraulic concern is over the possibility of fuel channel rupture. These tubes are at high pressure, and rupture can have serious consequences. Reactivity increases, as discussed above; and, if several tubes rupture simultaneously, pressure in the cavity below the reactor cover can increase enough to lift the head off, breaking all the tubes and lifting out the control rods, as happened at Chernobyl. Additional pressure relief capacity is being added to reduce, though not eliminate, this risk. Russian RBMK specialists

[8] Richard Wilson, *Nuclear Power Safety*, pp 7-8,

contend that there are no mechanisms by which several tubes could rupture simultaneously (common mode failure). Detailed analysis is required to verify this conclusion, since the consequences of such a failure would be catastrophic. Only three tube ruptures have occurred in the entire operating experience of RBMKs, indicating that a multitube rupture is a low-probability event. The U.S.-pioneered probabilistic risk assessment (PRA) could be very useful in quantifying this risk. In addition, steps to reduce the risks that any tubes will rupture are warranted. Improved testing, monitoring, and valve systems are under consideration.

The oldest VVER reactors, the 440-megawatt model 230, lack some of the basic safety features of Western reactors, in particular, emergency core cooling systems (to keep the core from melting after a loss-of-coolant accident) and containment vessels (to prevent the escape of radioactive materials after a severe accident). Pipe breaks that could be handled easily by a Western reactor would cause a serious accident in one of these reactors. It is not practical to install these safety features on an existing plant. Furthermore, the reactor vessel is susceptible to radiation-induced embrittlement, introducing the risk of a fracture in the vessel such that any core cooling would be impossible. Finally, these reactors were not designed for the level of seismicity that exists at some sites, including Armenia (especially the older Unit 1 ) and Bulgaria.

However, it also should be noted that even the older Soviet reactors have some positive features, including a large water inventory and a low power density. These features can help them ride out problems such as "station blackout" (extended loss of power to run the pumps that cool the core) that could cause accidents at U.S. reactors. In addition, while lacking a containment vessel, the model 230 has an "accident localization system," which condenses steam and reduces the release of radioactivity following the break of most pipes in the reactor system.

The newer model 213 included an emergency core cooling system and an improved accident localization system, but not a full containment except when sold abroad to Finland and Cuba (construction of Cuba's two reactors has been suspended). This reactor could withstand a considerably larger pipe break than the model 230. The reactor vessel was also improved.

A comparison of key features of the 440 with standard U.S. PWRs is shown in table 4-3.

The VVER-1OOO design incorporates a full containment vessel and rapid acting scram systems. In other ways it is also more like a Western PWR. With some modifications, such as increased fire protection and improved protection of critical instrumentation and control circuits, this design might approximate Western safety standards.

### *Other Safety Issues*

Even well-designed plants can be risky. Sloppy construction can result in unexpected weak points or in unexpected behavior. Poorly trained operators can turn a minor mishap into a major accident. Inadequate maintenance can allow deterioration of critical systems. Safety is primarily a function of people—people operating and maintaining the plant well and being prepared to catch problems before they become serious, people analyzing plants to recognize a deficiency before it causes any problems, and managers farsighted and tough enough to insist that their organizations do things right. Not only are well-operated plants safer, but they can function more smoothly, producing more power, which can be critical during this period of energy problems.

In this regard, most Soviet nuclear plants appear to have significant problems. Quality control was weak in many industries in the Soviet Union, and nuclear plants do not appear to be the exception. Construction was poor, regulation almost nonexistent, and no one seems to have been in charge of ensuring that safety was paramount. Although less easy to document than design problems, operating problems can present even greater safety risks. Russian plants operated at a consis-

TABLE 4–3: Summary Comparison of VVER–440 with Typical U.S. PWR Accident Mitigation Features

| System or function | VVER-440 model V230 | VVER-440 model V213 | Two IOOP U.S. PWR |
|---|---|---|---|
| Reactor Protection System | 4 systems | Same as model V230 | *2* independent, multifunction systems. Ten separate trips input to an interlock for additional reactor trip. |
| Emergency Core Cooling System (ECCS) | No Emergency Core Cooling System. Periodic water makeup system provides limited replenishment of primary coolant emergency. | Three high-pressure injection pumps. Three low-pressure shutdown cooling pumps. | Safety Injection (S1) system. Two high-pressure, two low-pressure pumps. |
| Emergency Feed-water (EFW) System | None. | Two pumps. Two supplementary EFW pumps. | Two subsystems |
| Emergency Power Sources | Two 6kV diesel generators, One is assumed to run continually. | Three 6 kV diesel generators. One is in hot standby, one in cold standby, and one in reserve. | Two emergency diesel generators. |
| | Two 220V DC station batteries. | Three 220V DC station batteries. | Two fully redundant 125V DC systems and station batteries. |
| Localizatlon/Contain merit System | Accident localization system. Pressure suppression by means of spray system, | Accident localization system. Pressure suppression by means of bubbler tower and spray system. | Full containment for primary system. |
| Spray System | Spray pumps discharge into the accident localization system. | Three spray pumps. | Two pumps. |
| Missile Barriers | None. | None. | Concrete missile shields. |
| Combustible Gas Control | None. | None. | A hydrogen gas control system. |
| Post Loss-of-coolant Accident (LOCA) Decay Heat Removal | Decay heat removal heat exchangers in spray systems. | Decay heat removal heat exchangers in ECCS/spray system. | Decay heat removal using reactor heat removal system with containment spray system. |

**SOURCE** Derived from **U S Department of Energy (DOE),** *Department of Energy's Team's Analysis of Soviet Designed VVERs, DOE/NE-0086,* **October 1988**

tently high level from 1990 through 1993.[9] However a good operation record is no guarantee against operating failures (as at Chernobyl).

An essential element in assuring safe operation is instilling a culture of excellence in the entire enterprise in each country. Unfortunately, this is the most difficult form of technology transfer to define and to transfer. Yet it is critical because nuclear plants have to be built and operated to the highest standards to be both productive and safe.

[9] *Nuclear* Engineering *International*, vol. 39, No. 478, May 1994, p. 15.

Such standards cannot be imposed solely by regulations; they require a voluntary commitment by everyone involved. The U.S. industry has made great improvements in achieving this dedication, but continuing poor performance at some U.S. nuclear stations indicates that the lessons have not been fully assimilated here.

Assimilation of a culture of excellence will be even more difficult in the former East Bloc. To some degree, the commitment will be encouraged by the previous activities. It can also be promoted by frequent contacts between individuals in various Eastern and Western nuclear enterprises, especially at the powerplants. Encouraging visits of operators to U.S. nuclear powerplants for training and exposure to U.S. procedures will be a significant help.

## Safety Assistance

U.S. safety assistance comes both directly from the Federal Government and through other agencies and private organizations. The U.S. Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) got involved after the Chernobyl accident with a review of reactor designs to identify safety deficiencies and discussions with Soviet nuclear officials. This activity has continued with the VVER reactors.

A Joint Coordinating Committee for Civilian Nuclear Reactor Safety (JCCCNRS) was established in accordance with a 1988 memorandum of cooperation between the United States and the Soviet Union. NRC and DOE are the main U.S. members. Following the breakup of the Soviet Union, this agreement was redirected to both Russia and Ukraine and extended for 5 years. There is no agreement with Armenia, Lithuania, or Kazakhstan, which has an experimental liquid metal reactor and a nuclear desalination plant. Negotiations are currently under way. The NRC has agreements with Hungary, the Czech Republic, and Slovakia.

The JCCCNRS has established a variety of working groups, which met with their Russian counterparts for information exchanges. The four current groups address:

- radiation embrittlement, structural integrity and life extension of reactor pressure vessels,
- severe accidents,
- health effects and environmental considerations,
- plant aging and life extension.

The U.S. program shifted from cooperative exchanges to specific assistance after the May 1992 conference in Lisbon on assistance to the New Independent States. The "Lisbon Initiative" includes:

- operational safety improvements for the VVER-440/Model 230 reactors, including training and emergency procedures,
- establishing a regional training center in both Russia and Ukraine, including computer-based simulators,
- modifications to reduce risk at selected RBMK and Model 230 reactors,
- fire safety, starting with two plants in Russia and Ukraine, and
- improving regulation and safety standards.

Improved training, maintenance, and other procedures can partially compensate for equipment and manufacturing deficiencies. Well-trained operators can avoid damaging mistakes and can react appropriately to incipient accidents. The NRC is providing advice and assistance to the emerging regulatory agencies, while DOE has focused on activities to assist operations. The U.S. program includes training of operators and regulators, exchanges of information and people, including a program with U.S. utilities coordinated by

10 Similarly, a properly designed and built reactor is less likely to suffer a major accident even if operated ineptly. However, because of the potential consequences of a major accident, all reactors should be designed, built, and operated to the highest standards. Unfortunately, most Soviet reactors fail all three of these standards.

the Institute for Nuclear Power Operations (INPO), an entity organized by the U.S. industry following the accident at Three Mile Island. These programs have brought Russian and Ukrainian operators to this country to visit U.S. powerplants and vice versa. Recently, equipment to enhance safety has been purchased.

One of the largest and most useful U.S. financial contributions to date has been for reactor simulators. These devices are extremely helpful in training reactor operators by simulating normal and accident conditions. Operators can practice and become proficient in handling events only rarely experienced at actual reactors. Soviet simulators had been for routine operations only. Abnormal events are much more complicated to simulate. U.S. assistance was important in the construction of an RBMK simulator now at Smolensk (Russia) and a VVER 1000 simulator at Zaporozhye (Ukraine).

Regional training centers now being established will be at Balakovo in Russia and Khmelnitskiy in Ukraine (both sites operate VVER- 1000 reactors). The United States is funding the development of training programs and simulators at the centers. Both should become operational by early 1996.

U.S. help is also important in preparing a manual for emergency operating procedures for the Novoronezh VVER 440/230 reactor. This is intended as a prototype for other reactors in Russia.

Inadequate fire protection is a major deficiency. The Soviets had not paid much attention to fire safety, and even systems that were supposed to be fireproof turned out to be flammable (a problem not unknown in the United States). There have been several serious fires in Soviet reactors. U.S. personnel have inspected Russian and Ukrainian plants and made recommendations for upgrades, some of which are surprisingly basic, such as replacing wood fire doors at Smolensk with steel doors.

Total funding supplied by the U.S. Agency for International Development (AID) for nuclear safety assistance was $25 million in fiscal year 1992 ($22 million for DOE, the rest for NRC) and $19 million in fiscal year 1993 ($14 million to DOE the rest for NRC). In addition, reactor simulators cost $11 million in fiscal year 1993 (funds supplied by the Department of Defense). Congress has appropriated $100 million for fiscal year 1994. This funding should permit some limited safety upgrades at reactors.

The regulatory assistance by the NRC is designed to fill a major void. None of the East Bloc countries had a strong, independent regulatory agency that had the authority to shut down unsafe plants unilaterally. However, Hungary, Bulgaria, and the Czech Republic have regulatory bodies sufficiently strong to get high-level government attention paid to safety concerns. For example, the Bulgarian regulatory body has twice been able to get reactors shut down.

In May 1993, Presidents Clinton and Yeltsin agreed to establish the Joint Commission on Technological Cooperation in Energy and Space. The commission is chaired by Vice President Gore and Prime Minister Chernomyrdin of Russia. Improving nuclear plant safety and regulation will be major interests of the commission. The commission has agreed to a joint study on Russian energy alternatives (funded by AID) to set the context for decisions on reactor safety.

The United States has supplied only a small part of the total assistance. The International Atomic Energy Agency (IAEA) provides active help. An IAEA inspection team alerted the West to the very dangerous situation in the older Bulgarian reactors in 1991. It is analyzing other former East Bloc reactors to determine the need for upgrades. However, the IAEA does not have the resources or mandate to supply more than advice. Moreover, the United States has opposed giving the IAEA a more forceful regulatory role on the grounds that safety regulation is a national role.

The European Union has allocated a total of about $500 mill ion for nuclear safety teams to visit reactors and install equipment to improve safety, including $13 million for upgrading Bulgarian reactors.

The Group of 7 Industrialized Nations (G-7) agreed in March 1992 on an action plan to upgrade the safety of Soviet-designed reactors. In Decem-

*The Temelin Nuclear Powerplant, a VVER-1000 under construction in the Czech Republic with major assistance by Westinghouse Electric Corp.*

ber 1992, (after extensive negotiations) the G-7 agreed to establish a fund for upgrading reactors in the former **East Bloc. A total of 118.4** million ECU ($136 million) has been contributed so far, led by Germany (ECU 31.4m), the European Union (ECU 20m), and France (ECU 15m). The United States has contributed ECU 2m.[11] The fund, called the Nuclear Safety Account (NSA), is administered through the European Bank for Reconstruction and Development (EBRD). The first grant (about $28 million) has gone to Bulgaria for upgrades to the Kozloduy reactors. The grant was contingent on Bulgaria indicating its intention (but not pledging) to close units 1 and 2 by 1997 and 3 and 4 by 1998. Reliable alternative power should be available by then, including Kozloduy units 5 and 6. This grant will pay for fire protection, inspection equipment, safety valves, electrical components, a new emergency feedwater system, and control room equipment. The second grant, $38 million in February 1994, was for Lithuania to upgrade the Ignalina RBMK plant with new instrumentation, fire protection, and a training simulator.

The World Association of Nuclear Operators (WANO), essentially an international INPO, is also encouraging the exchange of safety information and expertise. WANO's U.S. office is co-located with INPO.

## I Nuclear Weapons Proliferation

One of the most serious threats to international stability resulting from the breakup of the Soviet Union is the possibility that nuclear weapons may fall into the hands of irresponsible, hostile nations, or even terrorist groups. Even if the weapons themselves are adequately safeguarded, special nuclear material (plutonium or highly enriched uranium), parts, or expertise for weapons manufacture may become available.

As weapons are dismantled, large amounts of plutonium and highly enriched uranium (HEU) are removed. This material must either be protected or burned up in a reactor. HEU can be used as fuel in conventional reactors by blending it with ordinary uranium, resulting in low-enriched uranium. HEU has substantial value since its use replaces the normal enrichment process. The United States has offered to purchase such uranium from the FSU, in part to encourage the dismantlement of weapons. However, some details of the agreement still need to be resolved. Plutonium is more difficult to use in commercial reactors because its use changes the fuel cycle and requires stringent safeguarding. If it is not used to generate power, it must be indefinitely stored and carefully guarded. Russia plans to build a large storage facility for both HEU and plutonium from weapons and is studying options for plutonium disposal. These issues, including cooperation with Russia on dismantlement, are discussed in a recent OTA report. [12]

Much smuggling has been reported from the FSU, including some nuclear materials, though no

11 E@ *European Energy Report*, "Nuclear Safety Account Grants Lithuania's Ignalina Leeway" Issue 29, February 1994, pp. 4-5.

12 U.S. Congress, Office of Technology Assessment, *Dismantling the Bomb and Managing the Nuclear Materials*, OTA-O-572 (Washington, DC: U.S. Government Printing Office, September 1993).

significant transactions of nuclear weapons or weapons-grade materials have been documented. Many observers are very concerned because the economic and political disruption may have reduced the effectiveness of controls. Military personnel, civilian workers in arms plants, and nuclear weapons scientists are suffering from the overall economic problems as well as the partial demilitarization. It is possible that someone may be tempted to sell out to a renegade nation engaged in a clandestine nuclear weapons program.

Russia has inherited the nuclear weapons state status of the Soviet Union, but three de facto weapons states (Ukraine, Belarus, and Kazakhstan) have been created, at least temporarily. Leaders of these three have promised to turn their weapons over to Russia, but this agreement has proved difficult to put into practice, especially in Ukraine. This diffusion of authority further complicates control.

Ukraine's large civilian nuclear infrastructure presents an additional complication. To become a nonweapons state, Ukraine must not only give up its weapons but place its civilian nuclear plants under international safeguards to ensure that nuclear materials are not diverted. Ukraine's large civilian nuclear program will place an additional burden on the IAEA.

In Russia, the military and civilian nuclear sectors are both within the Ministry of Atomic Energy, and some nuclear facilities have dual purposes. For example, the Tomsk reactors were built to produce plutonium, but they also supply steam for the city's district heating plant. Russia no longer needs the plutonium but hasn't yet closed the reactors because the heat is still needed.

Using unemployed weapons scientists and engineers in the nuclear power industry could be a constructive way to reduce the likelihood that they may contribute to proliferation. Improving nuclear safety will entail considerable research and analysis. Many of the weapons scientists and engineers have expertise that would be useful in reactor safety. However, it is not clear how many can make the transition to an enterprise with very different objectives and constraints. Developing an industrywide commitment to excellence may be easier with new employees than with retrained weapons experts. Using the weapons experts in research and development may be the best solution.

The United States and several other countries have agreed to fund two international science and technology centers, in Moscow and Kiev, to provide constructive work for former weapons scientists and engineers. Ratification of the agreement stalled in the Russian Parliament, but President Yeltsin promulgated it in December 1993. Ratification is even less advanced in Ukraine. If this center cannot be maintained, alternative mechanisms could be considered, such as direct R&D cooperation with existing institutions.

A forthcoming OTA report, *Proliferation Issues and the Former Soviet Union, will* discuss these issues in more detail.

## | Considerations for the Future

Current activities will help reduce nuclear safety risks, but they are not proceeding as rapidly as desirable. Recipients have generally praised the United States for the effectiveness of its assistance. However, coordination among multilateral donors could be improved. Funding for projects to improve safety, especially for expensive plant modifications, has been slow. In fact, nuclear officials in the former East B1OC reportedl y are getting quite tired of visits that seem more intended to procure information than to supply help.

The first question is how hard to push for the closure of the oldest, riskiest reactors (RBMKs and VVER/230s). It is clear that these reactors are well below Western safety standards. However, the actual level of risk is not well enough understood to permit an analytical comparison of the costs and benefits of shutting them down. The countries that operate them are reluctant to close them because they see the energy as vital until replacement power is available. Chronic energy

shortages are very debilitating for an economy and pose their own risks to public health and safety. '3 A case can be made that the nuclear risks must be high before a responsible government should close plants and thereby subject its people to a significant, long-term shortage.

No one really knows if the risks of another Chernobyl accident are that high. Chernobyl Unit 4 was grossly abused during a unique test. Such conditions are unlikely to be repeated. Thus, this one accident is not necessarily a guarantee that others will follow. The first PRA is only now being done for the RBMK, but it probably will be years before the data are adequate for an overall risk evaluation. PRAs are useful only if they consider the design, the quality of the components, and the behavior of the operators. The latter two factors require extensive databases for valid analyses.

However, there is no controversy over the conclusion that the RBMKs are much more prone to accidents than Western reactors, and that such accidents are more likely to turn into catastrophes because of the lack of containment and the limited accident mitigation capability. **If** the risk of a major accident is one in a thousand years of operation (a very high risk level, which is assumed here for illustrative purposes), then the 15 RBMKs collectively present a risk of 1.5 percent per year. If they are operated for another 10 years, there is about a 14-percent chance that one of them will suffer another major accident. While that means that there is better than a five out of six chance that an accident won't happen, the risk is much too high by Western standards, especially if the consequences of the accident would be equivalent to that of Chernobyl. More accurate risk analysis is important for improving our understanding of the problem. However, analysis should not be a substitute for action in making needed improvements in reactors that are likely to continue operating.

Replacement power would probably involve either natural gas or coal or the completion of newer, safer reactors currently under construction. Building new powerplants, even gas turbines, is very expensive, and none of these countries has the funds to do that. The World Bank suggested that $18 billion would be required to replace the plants by 2000, exclusive of fuel costs. None of the gas-importing countries can afford to pay for the gas they already need, and Russia would prefer to export the gas for hard currency rather than bum it at home. Coal plants are much more expensive to build than gas plants, and would require additional funds for the pollution control systems (e.g., flue gas desulfurization) necessary to avoid worsening the environmental devastation in the region.

An alternative would be to emphasize energy efficiency to reduce the demand for electric power. As discussed in a prior OTA report", the potential for efficiency gains is huge in all the formerly centrally planned economies. Aggressive efficiency programs almost certainly could reduce demand for electricity significantly, at least until economic growth resumes. With a surplus of generating capacity, local policy makers can decide which plants to shut down, based on economics, safety, public concern, environmental considerations, and national priorities. When all these factors are taken into consideration, nuclear plants might or might not be the highest priority to shut down. They are generally cheaper to operate than fossil-fuel plants, and pollution from coal and some oil-fired plants is very damaging. The risk of a nuclear accident at any individual reactor site must be weighed against the costs of closing it. Although

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13 U.S. *Congress,* Office of Technology Assessment, *Physical Vulnerability of Electric Systems to Natural Disaster and Sabotage*, OTA-*E-453* (Washington, DC: U.S. Government Printing Office, June 1990).

14 U.S. Congress, Office of Technology Assessment, *Energy Efficiency Technologies for Central and Eastern* Europe, OTA-E-562 (Washington, DC: U.S. Government Printing Office, May 1993).

the collective risk appears high, the risk entailed by anyone plant may not appear unreasonably high to its operator.

For the time being,it appears likely that most or all of these reactors will continue to operate unless the West contributes far more assistance than it has yet considered. Upgrading thereto Western safety levels would be even more expensive than replacing them—$24 billion, according to the World Bank. One possible compromise may be to provide grants to upgrade the newer plants and correct the worst problems in the older plants, with closure of the latter as soon as practical, as is planned for the NSA grant to Bulgaria. Until recently, it had been assumed that several of the riskiest plants, such as the two operable reactors at Chernobyl, would be shut down soon. Thus, little has been done to upgrade their safety. The recent Ukrainian decision to continue operations results in the worst possible situation, at least until the modifications at other RBMKs are implemented there, too. Ukraine has agreed to shut the reactors down when the power is no longer needed but has not committed to a firm schedule.

Increased assistance would have several advantages, most obviously in reducing the risk of a serious nuclear accident. It would also provide business opportunities for the U.S. nuclear industry, possibly leading to even greater sales later. The sale of instrumentation and control systems and nuclear fuel for two Czech reactors by Westinghouse Electric Corp. is an example of the type of business that may emerge (see box 4-1). For Westinghouse, the Temelin project represents not only a foothold in the market, but also a demonstration project to convince other countries in the region, most notably Russia and Ukraine, of the effectiveness and need for such comprehensive modernization programs.

The market in the West for nuclear power generation technology is flat, but the former East Bloc, which includes 25 percent of the world's pressurized light water reactors, represents a potential multibillion-dollar market. Supplying equipment and services to foreign reactors helps U.S. companies remain in business, which would help keep U.S. reactors on line and increase the possibility of a nuclear revival later. Whether this is an advantage or a disadvantage depends on one's views of nuclear power.

One barrier to material assistance in the FSU is the concern of companies installing safety upgrades that if an accident happens despite the upgrade, the Western company could be held liable for all damages. Since the cost of the damages could far exceed the value of the business involved, companies will insist on limiting their liability. This has been done in the United States with the Price-Anderson Act, which also provides a no-fault mechanism for reimbursing those hurt by a nuclear accident. Negotiations are underway with Russia, Ukraine, and the Baltics to address this issue, and some agreements have been reached on liability provisions for U.S. companies providing assistance.

Increased assistance could also provide opportunities for former weapons scientists and engineers to work on constructive projects using their expertise. If these experts can be employed in nuclear reactor safety efforts, proliferation risks will be reduced. The creation of one or several centers for nuclear safety analysis could provide the double benefit of producing useful information and contributing to international stability.

There are two main disadvantages to increased assistance. First, the cost would increase commensurately at a time of serious U.S. budget constraints. Second, some people believe that no amount of improvement can make these reactors sufficiently safe and advocate shutting down at least the riskiest ones in the very near future; any remedial measures could prolong their operation and thus be counterproductive. Some critics object to assistance because it would support the industry in this country or promote its prospects. Thus, any proposal to increase support is likely to be controversial.

Opposition emerged to the Westinghouse sale to the Czech Republic, in particular to Eximbank (the Export-Import Bank of the United States) financing. The Austrian government prepared and

## BOX 4-1: The Temelin Nuclear Powerplant

After the collapse of the Communist government in 1989, the Czech Power Co. (CEZ) had to decide whether to complete construction of a Soviet-designed WER 1000 nuclear powerplant at the village of Temelin. Units 3 and **4 were canceled because** the power was not needed, but units 1 and 2 were more than 50 percent complete. A safety review determined that modifications were necessary to upgrade the plant to Western standards. CEZ decided that the cost of modifying and completing the two reactors was reasonable. Furthermore, the plant would have environmental advantages since up to 2,000 MWe of coal-fired capacity in Bohemia could be closed, eliminating a major source of pollution in a heavily polluted section of the country.

The utility solicited competitive bids for new instrumentation and control (I&C) systems and nuclear fuel. Westinghouse Electric offered the West's most advanced technology at competitive prices and won the contract. In May 1992, the company signed a $419-million contract to provide new I&C and Western-manufactured fuel for the Temelin plant. Westinghouse applied for a $31 7-million Eximbank guarantee for a loan from a consortium of commercial banks.

Opposition to the project developed, primarily over safety concerns. The government of Austria protested the sale on the grounds that the original Soviet design was unsafe and that melding Western technology onto a half-finished plant would not adequately improve it. A U.S. interagency technical review concluded that Temelin would meet standards. Eximbank approved the application in January 1994, subject to congressional review. Congress took no action by the deadline in March 1994, which was tantamount to approving it.

### Safety Issues

According to a International Atomic Energy Agency review, the WER 1000 design has both deficiencies and advantages compared with Western standards. The modifications address the deficiencies. However, as Austria points out, ' some concerns (e.g., protecting key components against Internal missiles that might be generated by an explosion) may not be addressed because critical structures are already built. Furthermore, a major effort is required to integrate the Westinghouse modifications, and much information will be needed from the original Soviet designers. It is not clear if all the necessary data and assumptions will be available. Finally, problems in quality control of the construction to date leave concerns that hidden problems may compromise safety.

CEZ responds that adequate data are available from Russia and that the upgrades wiII be shown to make the plant meet high standards of safety.[2] Furthermore, the US. participation (several U.S. companies besides Westinghouse are involved) will assure high-level designs and workmanship. In fact, one of the major reasons Westinghouse got involved was to promote nuclear safety, especially since a major accident in the former East Bloc could have negative consequences for the nuclear industry in the United States and elsewhere.

### U.S. Government Role

Financial guarantees have proved crucial to this project. Political risks and economic uncertainties limit commercial banks' willingness to lend capital for projects in the region, and nuclear power projects are generally viewed as especially risky. Westinghouse believes that U.S. government involvement is vital in facilitating the upgrading of the nuclear power sector in the former East bloc and that a systematic overall strategy is required rather than an ad hoc approach focused only on short-term repairs to the most dangerous facilities.

Critics of nuclear power prefer to end government export support. However, the public has few opportunities to intervene on exports, unlike domestic nuclear power actvities. Export financing is an indirect route for expressing concern. The U.S. government has taken the position that nuclear safety is a sovereign issue, to be determined by individual countries.

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1 **Advisors on the** SpecialDelegation **of the Government of** Austria, **"Technical Memorandum regarding the** Temelin **Nuclear** Power **Plant "**

2 CEZ, *Information on the Temelin NPP,* **unpublished** report

delivered a list of concerns,[15] based largely on deficiencies in the design identified by the IAEA and a review by a U.S. consultant. Austria was unable to obtain all the reports needed for its evaluation, and the concerns listed generally stem from unanswered questions on how the deficiencies identified earlier will be handled. In this case, Eximbank decided that the interagency review was sufficient y positive and approved the loan. Temelin will be a new nuclear powerplant and can be expected to operate for many years. Thus it is particularly controversial. Assistance to existing powerplants maybe less controversial, especially because they are likely to operate whether or not they are improved.

DOE and NRC would be the agencies most appropriate for enhanced assistance programs for direct improvements in safety since they are already involved. If new energy supplies to replace the most dangerous reactors are considered, funding will have to be increased, probably to well above the $100 million level for the next decade. Much of this might be funneled through AID. DOC and Eximbank would have a major role. The Department of State also has an important role with overall strategy and coordination with other countries.

One factor that needs to be addressed, whatever level of assistance is selected, is coordination with other donor countries and multilateral organizations. There have been many complaints of redundant visits and discussions. When the needs are so great and the resources so limited, it is important not to waste efforts. This need is widely recognized, and steps are being taken. In particular, the Group of 24 Nations (G-24) has set up a Nuclear Safety Committee in Brussels to coordinate assistance. This is an area that will require continued oversight.

Two final areas of cooperation should be mentioned because they have the potential for providing very useful information to the United States. The first is on health effects of radiation. The Chernobyl accident and other nuclear catastrophes have exposed a great many people to radiation. Studies of public health effects could be expanded with additional funding. Collecting and analyzing this data will improve U.S. understanding of this important area of science. The JCCCNRS has a working group on the subject, but funding is very limited. In January 1994, Russia and the United States signed an agreement for the exchange of information on health and environmental effects of radiation, which should be useful.

The second, annealing of reactor vessels, is of interest as U.S. reactors age.[16] Neutrons generated in the core impinge on the reactor vessel and gradually embrittle it. After many years, the vessels become so brittle that they could crack under certain conditions and lose their ability to maintain cooling in the core, leading to a meltdown. If the lifetimes of the current generation of reactors are extended, reactor vessels may have to be annealed to reduce the brittleness. Russia has already done this on several reactors because their design and materials leave them more subject to embrittlement. This has been an active subject of discussion (including a working group of the JCCCNRS), and Russia has already provided considerable information to American researchers. Further cooperation could be valuable.

## ELECTRIC POWER TECHNOLOGIES

Unlike fossil energy supply discussed in chapter 3, electric power is well developed in every country of the former East Bloc. Generating capacity (but not fuel supply) is adequate almost everywhere, if only because demand has dropped with economic decline. Transmission and distribution

15 Advisors on the Special Delegation of the Government of Austria, "Technical Memorandum regarding the Temelin Nuclear Power Plant," unpublished document February 1994.

16 Annealing involves heating the reactor vessel to a high temperature, which repairs damage to the metal. It is difficult to do because the reactor vessel is very large, and both geometry and radiation limit access.

TABLE 4–4: Electric Power Capacity and Production

| Country | Capacity Gwe | | Production billion kWh | | |
|---|---|---|---|---|---|
| | 1991 | 1990 | 1992 | 1991 | 1990 |
| Russia | 213.0 | 213.3 | 1018.0 | 1072 | 1082 |
| Ukraine | 54.4 | 55.6 | 253.0 | 279 | 299 |
| Kazakhstan | NA | 17.9 | 81.0 | 86 | 87 |
| Moldova | 3.7 | 3.7 | 11.0 | NA | NA |
| Belarus | 5.8 | 5.8 | 37.6 | NA | NA |
| Kyrgyzstan | NA | 3.7 | 11.8 | NA | NA |
| Turkmenistan | NA | 3.2 | 13.1 | NA | NA |
| Uzbekistan | 11.6 | 11.3 | 50.9 | NA | NA |
| Tajikistan | NA | 4.6 | 16.8 | NA | NA |
| Armenia | NA | 3.8 | 6.8 | NA | NA |
| Georgia | NA | 4.2 | 11.5 | NA | NA |
| Azerbaijan | 5.8 | 5.8 | 19.8 | NA | NA |
| Latvia | 2.1 | 2.1 | 8.5 | NA | NA |
| Estonia | NA | 3.5 | 15.9 | NA | NA |
| Lithuania | 5.1 | 5.1 | 28.2 | NA | NA |

**NA = Not Available**

**SOURCE Matthew J. Sagers, *PlanEcon Energy Outlook for the former Soviet Union*, (Washington, DC June 1993)**

systems are largely equivalent, or even superior, to those of the West. Lenin asserted that "Communism is Soviet Government plus the electrification of the whole country."[17] Electric power thereafter had a high priority among the central planners.

Nevertheless, the sector has severe problems. In particular, many fossil fuel-generating plants operate poorly and are among the worst sources of pollution in the region. Furthermore, a high fraction are nearing the end of their expected lifetimes and must be replaced. Finally, as in other sectors, management is unfamiliar with the concepts of operating under a market economy, such as finance, customer relations, pricing, and regulation.

Reliable, high-quality, electric power is essential for any modem economy. Upgrading electrical systems will make an important contribution to realizing the U.S. goal of revitalizing these economies. The surge in retrofitting old plants and building new ones that must occur with revitalization should provide many commercial sales. U.S. electrical equipment manufacturers could have an unusual opportunity to export, unlike in Western Europe, where markets are largely closed to foreign companies.

## I Status of the Electric Power Sector

Generating capacity and recent production are shown in table 4-4. Production has declined in all these countries because of reduced demand and sometimes fuel and parts shortages.

These statistics depict a relatively well-endowed sector, especially in comparison with other energy sectors. In fact, in some countries, such as Lithuania and Ukraine, electricity is much

17 Leslie Lamarre, '*connecting With Russian T& D," *EPR/ Journal*, Jan/Feb1992, p. 28.

less subject to interruptions than are oil and natural gas, which must be imported from Russia. Many countries have indigenous sources of coal and hydroelectricity, and nuclear fuel is relatively cheap even if imported. In other areas, including Georgia, Armenia, and Eastern Siberia, severe shortages of electricity have occurred because of fuel shortages, mostly due to ethnic struggles or delays in construction.[18]

However, as in so many other sectors of these economies, much equipment is old and in poor condition. As discussed above, over 20,000 MWe of nuclear capacity are likely to be shut down over the next decade. Most fossil fuel technology (though not all) is also well below Western standards. As Central European countries move toward integrating their economies (and their electric grids) with Western Europe, they will have to meet much higher environmental standards. Some powerplants can be retrofitted with pollution control equipment, but others will have to be replaced.

The major problem inhibiting rehabilitation is the lack of capital. Powerplants are expensive. None of these countries can afford to rebuild their electric power systems with so many competing needs for very limited capital. Electricity can still be produced, and the inefficiency and pollution of current facilities seem like minor problems compared with massive unemployment and lack of heat.

The power companies themselves are unable to undertake costly construction because their revenues are still based mostly on what users can pay and generally do not cover costs. Only in the Czech Republic has any significant move toward privatization of the electric sector taken place. In general, market reforms in the electric utility sector depend on market reforms in the country as a whole, and these have not been progressing very rapidly anywhere. The status of market reform in various countries is detailed in the country -specific discussions below and is summarized in table 4-5. Countries are listed in order of progress in electric sector reform. Note that in the case of utilities, privatization is not a prerequisite for market reforms. Many utilities in Western Europe and the United States are government-owned, but still operate effectively in a market economy.

### Russia

The Soviet Union controlled its entire electric system from Moscow through the Ministry of Energy and Electrification. Eleven Regional Unified Energy Systems were responsible for generating and delivering the power within their jurisdictions. Three main transmission networks—the "national" integrated power grid extending over 3,000 miles from the border with Poland to Lake Baikal in central Siberia, the Central Asian grid, and the Far East grid-cover most of the FSU. After 1991, ownership of the various components devolved to the new republics, but the national grid is still operated as an integrated unit, much like the main U.S. grids.

In 1993, the first step toward privatization was taken when the Russian Joint Stock Company for Power and Electrification (RAO ESS) was created. It owns and operates the51 largest powerplants and the transmission grid. The plan is to sell 20 percent of the company to Russian citizens for vouchers that already have been distributed. Thirty percent will be assigned to regional development organizations, and the remaining 50 percent will be retained by the Federal government, presumably temporarily.

### Poland

Poland has reorganized but not privatized its power industry. Formerly, almost all activities—mining, power production, transmission, and distribution—were centralized in the Union of Power and Brown Coal. This inefficient structure

[18] Matthew J. Sagers, "The Energy Industries Of the Former USSR: A Mid-Year Survey," *Post-Soviet Geography*, vol. 34, No. 6, 1993, pp. 403-407.

TABLE 4–5: Status of Reforms Affecting Electric Power

| Country | General market reforms | Power sector reforms | Comments |
|---|---|---|---|
| Czech Republic | yes | yes | Generating utility already partly private. |
| Hungary | yes | plans | Moving to mixed private/ govt ownership. |
| Poland | yes | plans | Variety of ownership structures possible. |
| Slovenia | yes | plans | |
| Slovakia | yes | plans | |
| Russia | some | plans | May use Czech-type vouchers, |
| Ukraine | some | no | |
| Bulgaria | yes | no | |

SOURCE Office of Technology Assessment, 1994

has been split up. Power is generated by 28 enterprises, which sell their power to the Polish Power Grid Co. There are 33 distribution companies that buy power from the grid and sell to final consumers. Poland has embarked on a considerably more radical reorganization than has been attempted in the United States, though several European countries, such as the Netherlands, are following a similar scheme. An earlier OTA report analyzed such a plan.[19]

## Czech Republic

The Czechoslovakian government had carried out a reorganization of the state power industry similar to that of Poland. The former power company had owned and operated almost all powerplants, the transmission and distribution grids, and some electrical equipment manufacturing plants. Following the national and industry breakups, The Czech Power Company (CEZ) controls only generation and transmission, and eight regional distribution utilities deliver the power to customers. CEZ has been organized as a private corporation, and one-third of the stock has been sold publicly. The distribution utilities are expected to be fully privatized by the end of 1994.

## Hungary

The Hungarian Electricity Board (MVMT) maintains central control. Subsidiary companies are responsible for power generation, transmission, and distribution. The subsidiary utilities are nominally independent, but MVMT regulates revenue flow between producers and distributors. A plan for privatization has been announced, but little progress has yet been made. The government is likely to retain up to 50 percent of the shares in the companies.

Hungary has insufficient generating capacity for its own needs and imports about 30 percent of its power from Ukraine. This will conflict with joining the Western European power grid because

19 U.S. *Congress,* Office of Technology Assessment, *Electric Power Wheeling and Dealing: Technological Considerations for Increased Competition,* OTA-E-409 (Washington, DC: U.S. Government Printing Office, May 1989).

individual members are expected to generate most of their own power or import it from other members. New facilities and transmission lines would have to be built.

## | Technology Needs and Cooperation

Many technologies used for generating electric power are behind Western standards, in large part because relatively few new plants have been constructed in recent years. Modernization is required across the region. The most pressing needs for non-nuclear technologies involve clean coal, gas turbines, and demand-side management. In addition, expertise in operating and regulating market-based utilities is almost completely absent.

There are many opportunities for Western investment and cooperation in the FSU electric power sector. Russia and Ukraine are actively seeking joint ventures and cooperative agreements to modernize their electric power industries. But Western involvement has been limited by sector restructuring and political and economic uncertainties. To date, Western companies have focused their efforts on data collection and market evaluations. Nevertheless, several joint ventures have been established and more are sure to follow.

### *Clean Coal*

Coal is the major domestic energy resource for many countries, and wide-scale use is inevitable. However, a large fraction of the pollution in Central Europe results from the uncontrolled combustion of coal in powerplants. These plants will have to be either replaced or upgraded with environmental protection equipment such as flue gas desulfurization (FGD) systems (pollution control technologies are discussed in the following chapter). The market for replacement and refurbishment of coal-fired powerplants could be very large.

Coal can be burned quite cleanly (except for carbon dioxide emissions) with the proper equipment. The United States has pioneered clean-coal technologies with a large program at DOE. Some of this expertise has already been made available to Poland (see box 4-2). Coal cleaning, an attractive option for near-term reduction of pollution, was discussed in chapter 3. Fluidized-bed combustion (FBC) and integrated gasification combined cycle (IGCC) are relatively new technologies that can be employed in new plants, resulting in efficient power production and very low levels of emissions. FBC and IGCC technologies are emerging as competitors to conventional coal-fired plants, particularly in areas where high-sulfur coals are used and emissions are strictly limited. Moreover, the IGCC technology requires less land and water than conventional scrubber-equipped coal-fired powerplants.

The United States is highly competitive in these new technologies and in conventional, pulverized-coal combustion with FGD. Westinghouse Electric Corp. formed a joint venture with a Polish partner in 1992 to retrofit seven power stations with new control and desulfurization systems. The contract will be worth about $2 billion.

### *Gas Turbines*

Shifting to the use of natural gas instead of coal or heavy oil in electric power stations is an option for Russia and other gas-producing countries. However, gas is also a major earner of foreign exchange, and burning it at home will reduce exports. Hence, its use must be as efficient as possible. Modem, high-efficiency gas turbines, introduced recently by American manufacturers, are based largely on aircraft engines. They are rapidly becoming the technology of choice for new generating capacity in this country because the captital costs are much lower per kilowatt than coal or nuclear plants, they can be installed quickly in small quantities as demand grows, they bum natural gas, which is still quite plentiful, and they produce only low levels of pollution.

Russian and Ukrainian military aircraft engine factories, currently largely idle, could convert to the production of turbine generators. Western finance and technology are needed to set up the new assembly lines that would allow rapid production. Several recent joint ventures illustrate the potential for gas turbine production in Russia. Siemens,

### BOX 4–2: DOE's Retrofit Of A Coal-fired Powerplant

Krakow, Poland, suffers from severe air quality problems, due largely to the burning of coal for electricity production and space heating. In 1989, President Bush visited Krakow and pledged U.S. support to help clean up the air. The Support for East European Democracy (SEED) Act of 1989 authorized $10 million for DOE to retrofit a coal-fired powerplant there. This section of the Act was intended both to help cleanup Krakow's air and to promote U.S. clean coal technology, by specifying that the retrofit "shall be carried out by one or more United States companies using United States technology and equipment manufactured in the United States."

In 1990, DOE and Polish officials signed an agreement establishing a Bilateral Steering Committee to oversee the retrofit. The committee selected the Skawina Power Station near Krakow, for the retrofit. Skawina has 11 boilers of 50-MWe each. In August of 1990, DOE requested proposals from U.S. companies for clean coal technologies that would reduce sulfur dioxide ($SO_2$) emissions from one boiler by 65 percent.

The legislation left the definition of "U.S. companies" to DOE, and it proved difficult. DOE's initial definition was a company incorporated under U.S. laws and with at least 50% of the voting stock held by U.S. citizens or firms. However, this definition would have excluded all but a very small number of firms. Furthermore, determining stock ownership, especially if the stock was held by mutual funds, would have been difficult. DOE dropped the stock ownership requirement. By one estimate, this change allowed an additional six companies to be eligible for the project.

In May 1991, DOE awarded a $7.8 million contract to AirPol Inc., of Teterboro, New Jersey, a subsidiary of FLS miljo of Denmark, to design and install a flue-gas desulfurization unit. AirPol then showed that an additional boiler could be easily retrofitted by simply enlarging the size of the desulfurization unit. The Polish government agreed to cover the additional $3.9 million to extend the system to a second 50-MW boiler. Airpol worked closely with several Polish companies, including Mostosal and Elektrim. The modification will allow the boilers to meet Poland's stringent 1998 $SO_2$ emission limits.

In November 1993, the new system was dedicated. Testing is under way and the system is expected to be fully operational by Spring 1994.

a Germany company, and St. Petersburg Metallic Plant formed a joint venture to produce gas turbines. Asea Brown Boveria (ABB), an international company with a 20-percent U.S. component, is also very active in the Russian market. One of ABB's most recent activities is the formation of ABB Uniturbo, a joint venture to produce gas turbines.

The advantages for Russia would be improved technology that could replace polluting and unsafe generating stations and meet new needs at low cost. In addition, production of advanced turbines could become a major economic asset, helping in stabilization. For the West, participation in the form of investment and licensing would create an economic opportunity not otherwise available. The U.S. national interest would also be served because international stability will improve if military factories are redirected to civilian goals instead of selling arms.[20] Russian-made turbines need not be directly competitive with U.S.-made models if the technology keeps improving, as appears possible.

## Demand-Side Management

Many U.S. electric utilities promote energy efficiency by their customers. They provide information and sometimes financial support for customers to install equipment that reduces their

20 Robert H. Socolow, *Conversion to Electric Power Objectives of the Russian Production Lines for Gas Turbines for Military Aircraft*, unpublished notes from conversations in April 1992 with academicians Oleg Favorsky and Alexander Sheindlin.

TABLE 4-6: Potential U.S. Results from Electricity-Savings Technologies

| | Electricity savinga | |
|---|---|---|
| | Low ease | High case |
| **Residential end uses sector** | | |
| Space heating | **32.2%** | 54.8°A |
| Water heating | **32.3** | 66.2 |
| Central air conditioning | **29.1** | 34.4 |
| **Room** air conditioning | 18.5 | 32.3 |
| Dishwashers | 5.2 | 26.3 |
| Cooking | 7.9 | 18.2 |
| Refrigeration | 22.1 | 48.0 |
| Freezer | 24.0 | 32.4 |
| Residual appliances | 27.8 | 40.0 |
| Total residential* | 27.1% | 45.5% |
| **Industrial end uses** | | |
| Motor drives | 28.5% | 45.0% |
| Electrolytic | 18.8 | 29.7 |
| Process heating | 7.9 | 13.3 |
| Lighting | 16.7 | 33.3 |
| Total industrial* | 23.7% | 38.3% |
| **Commercial end uses** | | |
| Heating | 12.7% | 23.6% |
| Cooling | 30.0 | 70.0 |
| Ventilation | 30.0 | 50.0 |
| Water heating | 40.0 | 60.0 |
| Cooking | 20.0 | 30.0 |
| Refrigeration | 12.2 | 34.1 |
| Lighting | 22.2 | 55.6 |
| Miscellaneous | 18.2 | 36.4 |
| Total commercial* | 22.5% | 48.6% |
| Total* | 24.4% | 43.9% |

● Totals are weighted averages

SOURCE: U S Congress, Off Ice of Technology Assessment, *Energy Efficiency Challenges and Opportunities for Electric Utilities* OTA-E-561 (Washington, DC: U S. Government Printing Office, September 1993)

use of electricity.[21] Over the past 15 years, **public** utility commissions and utilities (realizing that prices will stay lower with lower growth because new plants have become so much more expensive than existing ones) have pioneered the concept of demand-side management (DSM), where electric utilities help their customers improve efficiency. Utilities have been given incentives to ensure that their interests correspond to their customers' interests.

Power companies in the former East Bloc are also accustomed to managing their customers' consumption, but their approach used directives, not incentives. Until the late 1980s, demand grew rapidly, and construction did not always keep pace. Shortages often developed, and large customers had to be rationed. Sometimes residential areas were blacked out or, as in Romania, restricted to a very limited number of light bulbs and appliances. Over the past several years, demand has dropped with economic activity. Restrictions have been minimal in most areas, though fuel shortages for powerplants are increasingly likely to revive them in some countries.

Interest is growing in ways to reduce demand to minimize the new plants that must be built and to reduce pollution. DSM and the closely related concept integrated resource planning (IRP)-a planning process that evaluates both supply and demand options to determine the most economical and reliable system—have largely been developed in the United States. Applications for efficient technologies and the range of savings that could result in the United States are shown in table 4-6. Savings in Central Europe and the FSU should be even higher because efficiency has been ignored for so long.

DSM techniques include information programs to alert customers to potential energy savings measures, rebates or loans to help finance improvements, and performance contracts with energy service companies to install energy-saving equipment at customers' facilities. Implementation of these techniques depends primarily on utility management understanding of the opportunities available and having the appropri-

21 The u.s. experience with DSM is described in detail in a recent OTA report: U.S. Congress, Office of Technology Assessment, *Energy Efficiency: Challenges and Opportunities for Electric Utilities,* OTA-E-561 (Washington, DC: U.S. Government Printing Office, September 1993).

TABLE 4–7: Utility Partnerships Under the AID/USEA Programs

| U.S. partner | East Bloc Partner |
|---|---|
| **Central and Eastern Europe** | |
| Houston Power and Lighting | Czech Power Works |
| Southern Electric International | Slovak Power Enterprise |
| Commonwealth Edison | Polish Power Grid |
| Central Maine Power | Bulgarian Power Authority |
| New England Electric Company | Hungarian Electric Companies, Ltd. |
| Boston Edison | Rumanian Electric Co. |
| Central Vermont Public Service | Latvenergo (Latvia) |
| **FSU** | |
| **Pennsylvania Power and Light** | Kievenergo (Ukraine) |
| **Cincinnati Gas & Electric** | Kazakhstananegro |
| **National Hydropower Association** | State Energy Co. of Kirgizstan |
| **Edison Electric Institute** | RAO EES Rossii (Russia) |
| **American Gas Association** | Gasprom (Russia) |
| **American Gas Association** | ROSGAZIFIKATFIA (Russia) |
| **City of Anaheim Power Utility, Southern California Edison, and City of Pasadena Water & Power** | Ministry of Energy and Fuel (Armenia) |

**SOURCE U S Energy** Association, **March 1994**

ate incentives and resources. Western encouragement can involve policy advice (to get pricing, regulations, and incentives correct), utility management advice (to improve understanding of cost minimization and financing), advice on specific DSM/IRP techniques, and assistance in manufacture of energy-efficient products. Regulatory agencies have played an essential role in instituting DSM in the United States, and assistance in setting up effective, cost-based regulation and pricing is likely to be critical in the former East Bloc.

## Electric *Power Company Management*

The power industry is one of the few that has valued efficiency, at least in some ways. As noted below, the Soviet Union pioneered supercritical boilers and ultra-high-voltage transmission because they reduce energy losses. However, this thinking did not permeate utility operations. U.S. utilities operate with far fewer personnel and use more modem technology.

Managerial skills and operating procedures are being upgraded by an intriguing program-the Utility Partnership Program (UPP)--funded by AID at the U.S. Energy Association (USEA). In this program, U.S. utilities form partnerships with counterparts in Central and Eastern Europe. A similar program for FSU utilities—the Energy Industry Partnership Program (EIPP)—has been created more recently. Partnerships are shown in table 4-7.

The UPP and EIPP pay for visits in each direction to exchange information on engineering, finance, marketing, planning, plant operations, and other aspects of utility operation. The types of activities are described in box 4-3. The program appears to be working well. Participants report that the exchanges are fruitful.

The contacts developed have led to commercial contracts. Part of the purpose is to introduce the partners to U.S. vendors. For example, the Southern Company received a large contract from its Slovakian partner to refurbish a power-plant.

Demands on the time of the U.S. partners has grown, and they are hesitant to deepen their role because of their accountability to their stockholders and Public Utility Commission. Only travel

## BOX 4–3: Eastern Europe Utility Partnership Program

The U. S.-Eastern Europe Utility Partnership Program, was implemented by AID and USEA in October 1991 to "provide a mechanism which enables the experience of U.S. electric utilities to be transferred to Eastern European electric utilities, thereby helping address institutional Issues, including free-market managerial challenges and technical, financial, economic, regulatory and environmental issues. "[1,2]

Central and Eastern European power companies are paired with an American utility and participate in a variety of activities, including executive exchanges and seminars on topics such as customer service, environmental issues, and rate regulation. An Information exchange program provides general support for the partnerships by supplying resource material, technical reports, and funds for utility officials to attend industry conferences in the United States. Industry groups such as the Edison Electric Institute, the Electric Power Research Institute, North American Electric Reliabilty Association, and American Public Power Association are often Involved in UPP activities,

The UPP has been mutually beneficial. Professionals at Central Maine Power (CMP) taught courses in accounting and customer service practices to individuals at Bulgarian NEK. CMP participants gamed valuable managerial experience and learned from the technical expertise of the Bulgarians, s Overseas contacts established through the UPP offer U.S. utilities the possibility of future business,

As the program progresses, interactions have become focused on specific problems of the East European utlilties, demanding more of the U.S. partners, A seminar on financial management, for example, provided a general perspective on the field, but not the time and expertise necessary to develop and implement a corporate financial plan, In response, more intensive training activities are to be incorporated into the UPP in 1994.

The UPP has grown in size as well as intensity Increased activity has required additional funding, Originally, the program was projected to cost $4,8 million over 3 years, A subsequent amendment to the agreement, signed in October 1993, estimated $226 million over 6 years (1992 to mid-1997).

Both sets of partners are enthusiastic in their support of the UPP, During a strategic planning session held in Budapest in November 1993, representatives showed strong interest in integrated resource planning, demand side management, and environmental issues for future topics for cooperation,

[1] Amendment to USEA Cooperate Agreement EUR-0030-A-00-1085-03

[2] A more recently established program, the Energy Industry Partnership Program (EIPP), funded through AID and administered by the USEA, arranges similar partnerships in the former Soviet Union

[3] Phone conversation with Connie Irland of Central Maine Power, Dec 28, 1993

and incidental costs (not labor) are covered by the AID grant. AID has introduced a consultancy grant program for projects that require considerable time by the U.S. partner (e.g., intensive training) to encourage continued participation. This grant program, open to all utilities, provides an alternative to UPP funds. Utilities can propose specific projects. Some utilities have created subsidiaries to participate in the consultancy grant program.[22] The first round of proposals is now under evaluation.

## Reverse Technology *Transfer*

In some cases technology in the former East Bloc is superior; therefore the United States can also

[22] Phone conversation with Eric Haskins, manager, Utility Partnership Program, USEA, Dec. 28, 1993.

TABLE 4-8: Technology Interchange Between Electric Power Research Institute (EPRI) and the Former Soviet Union (FSU): Plant Demonstration Projects

| Topic | Brief description | EPRI interest |
|---|---|---|
| Supercritical Powerplants | Boiler and turbine temperature and flow conditions for low power operation. | Data on how to slide pressure through the critical point. New approach for Us. |
| Boiler Efficiency and Emissions | New combustion air admission methods. | Efficiency and NOx improvements. |
| Adjustable Speed Drives(ASD) | Assessment of EPRI guides. | Validation of EPRI ASD guidelines. |
| Thyristor Steam Turbine Startup | Reduced temperature variation in steam turbine. First of a kind for steam turbine startup. | |
| Gas turbines | New water cooling scheme for high temperature blades. | Step improvement in blade cooling over current methods. |
| Steam turbines | Titanium blades for high back-pressure turbines. | Possible solution to higher back pressures. |
| Electric Generator | New design with water-cooled rotor and stator. | Elimination of hydrogen, more efficient generator, better reliability. |
| Superconducting Electric Generator | 300-MW design already built. | Reduces R&D costs. |
| Modified Oxygenated Chemistry | Improved oxygen treatment for steam chemistry control. | Reduction of blade corrosion. |
| Coal Refinery | Liquefaction and gasification of coal. | Use of low-rank coals for gasification, smokeless fuel. Wide application in Eastern Europe, China. |
| Slagging Boiler Studies for Lignite | New modifications to reduce slagging. | Non-slagging boiler for high-moisture, high-ash coals. |
| District Heating Studies | Optimization of cogeneration turbine operation. | Modification of existing plants for district heating. |
| Ash Metals Extraction | Ash melting and metals extraction. | Key elements of a coal refinery. |
| Oxygenated Hot Water Cleaning of Boilers | New application for boiler cleaning and reduction of waste disposal. | Reduced tube failures and less chemical cleaning. |
| Component Life Assessment | Life extension of power plant components. | Validation and updating of EPRI life assessment tools. |

**SOURCE Adopted from Tony Armor,** Director, **FossII Power Plants Department,** EPRI, **fax** communication, Oct **12, 1993**

profit from technological exchange. The highest voltage transmission line in the world is in Russia (1,150 kilovolts vs. a maximum of 700 kilovolts in the United States). Furthermore, Russia has far more experience with supercritical steam turbines (which are more efficient than conventional turbines because they operate at higher temperatures and pressures). U.S.-Russian cooperation in such areas has already started, in particular at the Electric Power Research Institute. Table 4-8 lists some recent fossil fuel technology interchanges with the FSU. Joint R&D cooperation could be very beneficial.

## Barriers to Technology Cooperation and Sales

As in all other areas, the two major constraints to rapid increases in activity are the political situation in these countries and the limited financial resources. Other factors are also relevant, some of which are peculiar to the electric power industry.

### *Political Constraints*

Western electric utilities, whether private or government owned, operate in a very different milieu from enterprises in the former East Bloc. There, electricity is considered to be part of the social safety net as well as a key industrial input. Prices have been determined more on the basis of what the customer could afford than the cost of the power.

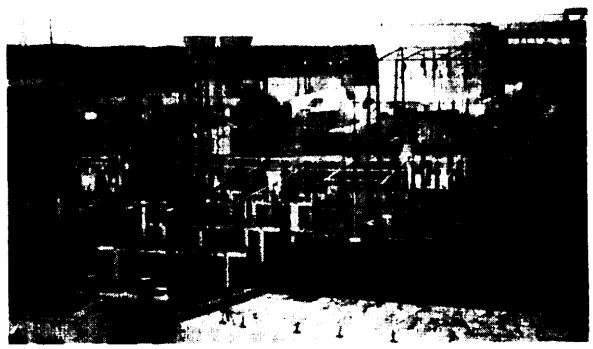
These countries are devising energy and regulatory policies but often do not have a clear concept of the role that pricing, or the utilities themselves, could play. Former regulations are no longer enforced, and agreements for power limitation are often ignored. In theory, state-owned utilities can easily implement national policies, but the practice will be difficult. The abolition of central planning could have a perverse impact on the rational allocation of power. Considerable help-both advisory and material—will be needed to rationalize energy policy and institute realistic pricing.

### *Financial Constraints*

Technology and engineers are sufficiently good in the former East Bloc that, given unlimited financial resources, power companies could construct systems largely equivalent to those in the West. However, few of these companies have the resources to buy much from the West, and few equipment manufacturers can afford to modernize their facilities and products.

Substantial equipment and service sales are possible in this sector, but only if adequate financing is made available. Since many power systems will eventually be integrated with the Western European grid, there will be a natural tendency toward Western European equipment unless U.S. firms can offer favorable terms.

LARRY MARKEL



*Holesovice Electric Substation, Prague Electric Distribution Utility.*

### *Institutional Constraints*

In some of these countries, the structure of the electrical power industry is changing. This introduces uncertainty into their planning, even though the intent is to make the utilities more responsive to market forces. In Russia, generation may be divided into 70 utilities. In some countries, generation, transmission, and distribution are being separated, a process that is difficult even in countries without economic chaos in other sectors. Utility restructuring will remove some incentives since decisionmaking will be divided between utilities that sell to end users and utilities that generate power and build powerplants. These changes will take time and considerable care to ensure that reliability of power supply is not jeopardized.

Foreign investors have expressed considerable interest in building independent powerplants. Although this would solve financial constraints and upgrade technology, investors must see political, legal, and regulatory stability before they invest.

DSM is even more uncertain. Low rates do not justify efficiency investments by customers, and low revenues do not permit utilities to invest. The structure of electricity demand is also less favorable than in the United States. Residential and commercial customers have proven more amenable to DSM than has U.S. industry. In the former East Bloc, the residential and commercial sector consumes one-third of the electricity, half the frac-

tion in the United States and thus a smaller target. In addition, some industrial customers will close, but it is not always easy to tell which. Obviously, it is not worth improving the efficiency of plants about to close.

Russia has a complete equipment supply industry, which in some ways rivals that of the West. Therefore, it is unlikely that Russia will buy large quantities of electric power equipment from the West. Other countries are better prospects for sales.

### Potential Policy Improvements

Steps that the United States could take to help modernize the electric power industry are similar to those for other sectors. High-level policy advice and encouragement to introduce market reforms and realistic pricing is essential. Enactment of legal protections and currency stabilization will be needed to encourage foreign participation. Technical assistance is likely to be important. AID programs can be strengthened and expanded. UPP and EIPP appear to be particularly attractive candidates for expansion.

On the commercial side, additional financing will be essential to assure that U.S. firms remain competitive. Eximbank loan guarantees and Overseas Private Investment Corp. insurance are vital parts of a U.S. presence there. Trade Development Agency feasibility studies are also working well and could be expanded.

## RENEWABLE ENERGY TECHNOLOGIES

A vast array of technologies is used to capture and convert wind, sunlight, geothermal heat, falling water, and organic biomass into energy. Renewable energy sources can heat homes, supply electrical power and process heat, and fuel cars. Some renewable sources can be converted to feedstocks for producing chemicals. In general, renewable resources are inexhaustible and widely, but irregularly, distributed. Because of the latter, storage is very important.

The potential for renewable is enormous, but only a small amount of the resource is economically recoverable at the present time. In the United States, for example, renewable provide about 9 percent of the total energy used annually, mostly from hydroelectric power.[23]

Over the last two decades, significant advances in renewable energy technologies have been made. Many systems have reached either prototype or commercial development. Performances have improved and costs have declined. Hydropower is the most developed renewable and enjoys widespread use. Windpower is competitive or near-competitive with other sources for bulk power production. Flat-plate solar collector systems for space heating and hot water are economically viable in some parts of the world, e.g., Israel, Australia, and Cyprus. Photovoltaic systems command an increasing number of market niches, particularly for telecommunications and space, but require further development before they will be economically competitive for bulk power production. Biogas production in some locales is viewed as an important energy source and is ecologically sound, as well. Geothermal resources are enormous, but the amount that can be recovered economically is small.

Environmental concerns and increased demand for electricity have stimulated some interest in renewable resource development in former East Bloc countries. The use of renewable can reduce regional air pollution and mitigate global climate change, environmental impacts to which former East Bloc countries contribute substantially. Moreover, renewable development can reduce dependence on foreign energy supplies (and thus improve a nation's balance of payments), provide decentralized power sources for rural areas, and address nuclear safety concerns. These issues have become more prominent since the dissolution of the FSU. Each country now requires independence and control over its energy resources

[23] Robert L. San Martin, "Renewable Energy—Power for Tomorrow," *The Futurist, vol. 23, No. 3,* May-June 1989, p. 40.

and production. Renewable resources can play a vital role in realizing these goals.

Through technology transfer, the United States can help these countries develop their renewable resources. Under the terms of a recent energy agreement, the United States and Russia will cooperate on energy efficiency and renewable energy research and will exchange technology and information. The United States is a leader in developing and manufacturing most renewable energy technologies and is experienced in bringing projects on line. It has the largest installed geothermal-, hydro-, and wind-generated electricity capacity in the world. Additionally, several U.S. renewable companies are serious] y pursuing former East Bloc markets. For example, U.S. Windpower recently signed a joint venture agreement with Ukraine to develop a 500-MW wind farm in the Crimea.

This section discusses the potential for U.S. renewable technology transfer to the former East Bloc. But first, it examines the obstacles to renewable development in this region. Brief descriptions are provided of specific technologies and their applications. For further information, the reader is referred to the forthcoming OTA report *Renewing Our Energy Future.*

## I Barriers to Renewable Development

As noted in chapter 2, renewable contribute only a small share of total energy production in the former East Bloc, but there is potential for growth, and interest is rising in several countries. However, there are significant obstacles to renewable development, and competition from conventional fuels will be stiff.

Past energy pricing policies discouraged the introduction of renewable energy technologies and the efficient use of energy. Conventional energy sources were priced so low that renewable could not compete. In some countries, this is still the case. Fuel prices, particularly of oil and natural gas, will continue to have an enormous influence on renewable development. As conventional energy prices rise, alternative sources will become more attractive.

The lack of political and institutional commitment to renewable development is another barrier. Over the years, a strong institutional structure developed to support the production of oil and gas, while little attention was paid to renewable. Successful U.S. experiences confirm that policies and institutions are crucial to renewable development.

Funding priorities are also an important factor. Over the last two decades, capital investment in the FSU favored oil production over other energy resources and other sectors of the economy. Moreover, foreign assistance programs also focused on large-scale conventional energy projects, particularly bulk power and oil and natural gas. Renewable projects tend to be smaller and more dispersed than conventional energy projects, thus making them less attractive for traditional aid. In addition, severe constraints on capital investment will further limit investment in renewable.

Lack of accurate data is yet another barrier. With wind energy, for example, simply measuring annual average wind speeds may not indicate the amount of power that can be generated; distribution of wind speeds over time must also be measured. Accurate data are essential to the success of a renewable project.

The lack of technically trained personnel could also bean obstacle to renewable development, as well as for the staffing of local facilities and plants. In all East Bloc countries, scientific and technical training were directed at conventional energy exploration and production, thereby exacerbating the personnel problem.

Finally, some alternative energy technologies are viewed as immature and unrel iable, presenting yet another obstacle to renewable development. Because some renewable technologies are still relatively new, long-term experience is scarce. Reliability is a major concern for countries that have neither the capital nor human resources to spend on unproven technologies. These countries are more likely to consider traditional, proven technologies.

## I Potential for U.S. Renewable Technology Transfer

### *Wind''wer*

Wind turbines convert energy of the wind to electrical energy. All former East Bloc countries have at least a few good wind sites. Several regions in Russia, Ukraine, and Kazakhstan are very favorable to wind power development, but the bulk of these are extremely remote and sparsely populated, i.e., the Far East and northern arctic coast in Russia and central Kazakhstan. Others on the northern and eastern shores of the Black Sea in Ukraine and the North Caucasus area are more accessible. [24]

There has been little wind power development in the former East Bloc. In Russia, for example, small wind turbines are used primarily for water pumping in agricultural applications, although interest in wind energy development is growing. Construction of Russia's first wind power station has begun near Novorossisk.[25] Several factors created a favorable climate for wind power development in this area, including the shortage of electricity in the Novorossisk area, termination of construction of the Rostov nuclear powerplant, and promising wind sites.

Also, prototype 100-kW (kilowatt) and 10-kW turbines are being developed at several facilities throughout Russia. Russia's aerospace industry has tremendous turbine manufacturing capability and is actively seeking Western production partners. Dutch and German companies have established joint ventures in Russia to manufacture small wind turbines.

Wind turbine R&D is being done in Ukraine, as well. The Ukrainian Institute of Electrodynamics, which has primary responsibility for renewable energy research, is working on 1.5-kW and 100-kW turbine designs. The Institute is also collaborating with a former defense factory to manufacture 250-kW turbines, several of which have been sold to the Ukrainian Ministry of Energy to construct a wind farm in the Crimea. The Ministry is also pursuing wind power joint ventures, which will convert Ukrainian factories to wind turbine and photovoltaic facilities. German, Norwegian, and U.S. firms have been contacted in this regard.[26]

In March 1993, California-based U.S. Windpower and a Ukrainian utility formed a joint venture to supply 500 MW of wind power by 1996.[27] When completed, this will be the second largest wind power facility in the world (Altamont Pass in California is the largest). Under the agreement, Ukraine is licensed to manufacture turbine parts. As payment, U.S. Windpower will receive components to service its turbines in the United States and Europe.

Poland and the Czech Republic also manufacture wind turbines for export, primarily to Denmark. Polish and Czech domestic markets cannot support wind turbine manufacturing capacity.

U.S. technology and extensive project development and management expertise could benefit wind power development in former East Bloc countries. The U.S. wind power industry is a leader in wind power technology and development. Its technologies, particularly small wind machines (under 50 kW), are the most advanced in the world, according to DOE. The industry also has tremendous site validation capabilities: our instrumentation for measuring and evaluating

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[24] Eric Martinot, "Wind-Generated Electric Power in the Former Soviet Republics: Geographical Prospects," *Post-Soviet Geography*, vol. 32, No. 4, 1992, p. 229.

[25] The first of si, 250-kW wind turbines has been installed, and testing is under way. Together, the turbines, which were developed and manufactured in Russia, will generate a total of 15 MW. See "Wind Power Station Construction Begins," in FBIS, *Central Eurasia*, FBIS-USR-93-112, Aug. 27, 1993, p. 84.

[26] Eric Martinot, "Wind Energy in Russia and Ukraine," summer 1992 research trip excerpts, Lawrence Berkeley Laboratory, no date.

[27] "Venture Plans 500 MW Wind Project in Ukraine," New *Technology Week, vol. 7, No. 14,* Apr. 5, 1993, p. 16.

wind data is the most advanced in the world.[28] Furthermore, U.S. companies have crucial experience in developing, financing, and managing large wind energy projects. U.S. Windpower, for example, is a major wind turbine supplier and wind farm developer.

In recent years, the U.S. wind power industry has suffered setbacks from changes in the tax code and opposition to wind power projects, but is now making a comback. In Europe, wind energy development has made steady progress since the 1980s. If development continues at the present pace, European wind energy development will equal California's present capacity by the year 1995. (California's 1992 installed wind power capacity is 1,690 MW.)[29] Moreover, Europe has significant manufacturing capacity with over 25 wind turbine manufacturers. *30 Because of these* recent developments and proximity to former East Bloc markets, European companies are in a strong position to compete. Even so, U.S. companies have a long record of involvement in wind energy development and should be competitive.


*Small U.S.-made wind turbines.*

### Photovoltaics

Photovoltaics (PVs), or solar cells, convert sunlight directly into electricity. Although PV energy is more expensive than conventional energy for most uses, costs continue to drop. It is expected that PV systems will produce electricity for 10 to 20 cents/kWh (kilowatt-hour) by 2000.[31]

The FSU has done extensive R&Don PVs for use in spacecraft and ground installations. PVs are used as a power source for navigation signal installations and UHF relay transmitters, and are used in cathodic protection systems for pipelines in Central Asia and Azerbaijan.[32]

Russia has begun to commercialize its PV technology. It is a large supplier of crystalline wafers to India and is trying to market its products in other countries.

U.S. and European companies are interested in marketing their PV systems in the FSU. Integrated Power Corp., for example, has had some success in Kazakhstan. It has developed a PV power system for telecommunications in that country. British Petroleum also sells PVs to the FSU to monitor oil and gas pipelines.

Engineering and designing PV systems may present technology transfer opportunities for U.S. companies. Russia has manufacturing capability but little experience in marketing and developing commercial projects. The United States has extensive experience in these areas. Joint ventures that

[28]Personal communication, Dan Acona, Department of Energy, June 8, 1993.

[29]Paul Gipe, "Windpower's Promising Future," *Independent Energy*, vol. 23, No. 1, January 1993, p. 67.

[30]George Stein, "Big Plan in Ukraine to Harvest the Wind," &~ *Francisco Examiner*, Business Section, &c. 11, 1992, p. B-1.

3] Forthcoming OTA report Renewing *Our Energy Future*, Ch. 5: "Renewable Energy Resources and Technologies."

[32]"Alternative Power Sources in Use in the USSR," *Ambio*, vol. 19, No. 4, July 1990, p. 222.

incorporate indigenous manufacturing capacity with U.S. engineering, design, and project development expertise may make the most sense.

### Solar Thermal Electricity

Solar thermal electric plants use mirrors or lenses to concentrate sunlight, heating a fluid which is then used to produce electricity. The FSU has done R&D on solar thermal systems, including work on coatings, collector manufacturing technology, plant reliability, and interseasonal storage of solar heat and solar salt ponds. However, research activities tended to focus on large centralized facilities, with few practical results.

As of 1990, there were a little over 50,000 square meters of solar collectors in the FSU, producing the heat equivalent of about 5,000 tons of fuel per year.[33] The Crimea republic in Ukraine is well suited to solar use. Solar water heating is used in major hotels in this area. The Crimea is also the location of a 5-MW experimental solar power station which began operation in 1985. The republic plans to build solar power stations with a total capacity of 50 MW in the near future.[34]

The United States has substantial experience with solar thermal systems. Today, there are 354 MW of installed solar thermal powerplant capacity in California's deserts. However, the United States has lost its leadership position to European countries. U.S. solar thermal development was seriously damaged by the bankruptcy of Luz, Inc., in 1992. Today, European companies are actively marketing their solar thermal technologies worldwide, and the Israelis are pursuing the FSU market.

### Geothermal

Natural heat below the Earth's surface can be used directly for space and process heat or converted to electricity. Geothermal energy is commonly referred to as a renewable energy resource, but it can be depleted if oversubscribed. Also, geothermal energy production can cause environmental damage; i.e., when hot brines are released from wells.

Hydrothermal energy has been used in a wide variety of markets: power production, district heating, greenhouses, and therapeutic pools and spas. There are 11,300 MW of installed geothermal capacity worldwide for direct-heat applications, and 20 countries generate 5,700 MW of electricity.[35] The United States has the largest installed capacity in the world, with about 2,700 MW.[36]

Estimates of total hydrothermal water reserves in the FSU are equivalent to over 200 million tons of fuel per year. There are more than 200 wells located throughout the FSU, and extraction exceeded 20 million cubic meters in 1990.37 Much of the geothermal heat is used in greenhouses. There is only one operational hydrothermal power station in the FSU, located in Kamchatka.

The Kamchatka area, in far Eastern Russia, shows the most promise for geothermal development. Japanese companies have shown interest in developing geothermal power stations there. Geothermal resources are also located in Central Russia, particularly in the Nizhny Novgorod and Yaroslav regions.

The FSU has continued its R&D work on hot dry rock (HDR) geothermal energy resources, but financial difficulties have slowed progress. Ac-

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[33] Ibid, pp. 221-222.

[34] "Southern Republics Draw Up Their Own Programs," *Interfax Business Report,* May 3,1993, p. 6.

[35] Statement of the National Geothermal Association for the Hearing of the Subcommittee on Energy and the Environment of the House Committee on interior and Insular Affairs, Jan. 23, 1992.

[36] Ronald Dipippo, "Geothermal Energy: Electricity Generation and Environmental Impact," *Energy Policy,* vol. *19,* October 1991, *pp.* 798-807.

[37] "Alternative Power Sources in Use in the USSR," p. 223.

cording to one expert, HDR technology transfer would benefit both the United States and Russia. The United States has more sophisticated instrumentation, such as microseismic monitors, while the Russians have an edge in rock mechanics and thermal physics in geothermal resource development.[38]

Lithuania also has some geothermal resources, located in the western part of the country. The Lithuanian government, with help from Denmark, is exploring geothermal potential in this region. Currently, several wells are producing hot water. The Ministry of Energy indicates that geothermal energy will be used to heat resorts in the future .39

In Central Europe, Hungary is a leader in geothermal use for horticulture. About 2 million square meters of greenhouses are heated by geothermal water.[40] Poland is interested in developing its geothermal energy resources for space heating and hot water, particularly in those areas having high pollution or a long heating season. Low-energy resources are located throughout the country; the Podhale field in Southern Poland is the most developed. Several wells are producing hot water for greenhouse use, and an experimental district heating system is in the design phase.[41]

U.S. drilling and site validation technologies can help expedite the development of geothermal resources in former East Bloc countries. However, drilling and extraction costs continue to be a major constraint to greater geothermal energy development in this region.

### *Biomass Technology*

Biomass refers to materials from biological sources that can be used directly as a fuel or converted to other forms for use as a fuel or feedstock. The principal energy use of biomass is the production of heat, via direct combustion, for use in process heating, space heating, and cogeneration systems. The use of biomass for electricity production is usually uneconomical because the dispersed production and low energy content make transportation costs high.

Biomass may be a significant energy resource in rural areas. Consumption, however, is difficult to measure because so much of it never enters the commercial market. Wood, for example, is gathered by individuals and families as the need arises.

Among former Soviet republics, Estonia appears to be taking the lead in biomass development. Estonia's large fuel wood resources, plus the escalating costs of oil and gas imports, have spurred interest in converting heating boilers from oil to wood. Several projects are now under way, using both foreign and domestic technology, and many more are planned. In 1994, the World Bank will begin a large-scale boiler conversion investment program; total converted capacity may reach 200 MW. However, questions have been raised about the sustainability of Estonia's forests.[42]

There is some interest in the FSU in utilizing organic wastes from industry and agriculture for biogas production. This interest is spurred by the need to manage waste and improve sanitary conditions primarily at large livestock complexes. However, the potential contribution of biogas to FSU's total energy supply is insignificant (about 1.5 percent) and will probably remain so in the near future.[43]

A variety of liquid fuels can be produced from biomass, including ethanol and methanol, syn-

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38 Testimony of Professor Paul Kruger, Oversight Hearing on Hot Dry Rock (HDR) Geothermal Energy, before the House Committee on interior and Insular Affairs, Subcommittee on Energy and the Environment (Washington, DC: Jan. 23, 1992), pp. 4-5.

39 "Minister Assesses Lithuania's Energy Options," in Vilnius *Tiesa*, Mar. 12, 1993, p. 5, in FBIS, *Central Eurasia*, FBIS-USR-93-049, Apr. 21, 1993, p. 95.

40 World Energy Council, *Geothermal Energy: Status, Constraints and Opportunities*, Geothermal Chapter (9th Draft) April 1992, p. 17.

41 Biyakowski Wieslaw and Dlugosz Piotr, "Geothermal Energy Utilization in Poland, State of Development," n.d.

42 Eric Martinot, ."* Renewable Energy in Former Soviet Republics: An Informal Report to OTA," unpublished document Nov. 8, 1993.

43 '' Alternative Power Sources in Use in the USSR," p. 224.


PAUL MAYCOCK

*Photovoltaic array*

thetic gasoline, jet, and diesel fuel. These fuels have the potential to address some environmental concerns, such as urban ozone and greenhouse gas emissions. However, there are substantial barriers to the introduction of liquid biofuels into transportation markets. These fuels cost more to produce than gasoline and lack the highly developed and massive infrastructure that already exists to support the production, distribution, and use of gasoline. The financially strapped countries of the former East Bloc do not have the substantial capital needed to build new production and distribution networks. There are far more pressing considerations, such as upgrading existing transportation infrastructure and systems and improving vehicle energy efficiency.

## Hydroelectric Power

Hydroelectric facilities use the energy in flowing water to turn a turbine connected to a generator. Hydropower is considered a clean energy source that can respond quickly to utility demand. But large hydroelectric projects can be very expensive, construction times can be long, and environmental costs can be high. The development of this resource can flood large tracts of land, displacing people and leading to loss of forests and wildlife. It can also disrupt the flow of rivers.

The FSU has substantial hydroelectric capacity and expertise in developing the resource. In 1991, the FSU had 64,100 MW of hydroelectric power, which is about 19 percent of total installed capacity.[44] Russia has more than two-thirds of the FSU's installed capacity.

In Poland, hydroelectric resources are very limited and are not expected to be significant in the future. As of 1991, Poland had 1,900 MW of hydroelectric capacity, or about 6 percent of total installed capacity.[45] In the former Czechoslovakia, hydropower provides 2,900 MW of installed capacity, or about 16 percent of the total.[46]

Hydroelectric technologies are considered mature, with efficiencies greater than 90 percent. Nevertheless, several technological developments offer improvements in hydropower economics and environmental impacts. These include new ultralow-head turbines designed for use at sites with elevation differentials of less than 10 feet; cross-flow turbines that improve efficiency; and improvements in dam design, construction techniques, and materials. U.S. work on these and other hydroelectric technologies can help former East Bloc countries fully realize their hydro potential.

There is some interest in the use of small hydroplanes in areas where ample water resources exist. Microhydropower (less than 100 kW) could make a contribution in rural areas that have no access to the power grid. Microhydro electric plants are common in China and India. Although initial cap-

[44]Energy Information" Administration, Department of Energy, *Annual Energy Review 1992*, DOE/EIA-0384(92) (Washington, DC: U.S. Government Printing Office, June 1993), p. 305.

[45]Ibid.

[46]Ibid.

ital costs can be high,[47] these systems can be installed quickly and do not entail flooding large areas.

## Potential for Development of Renewable

Although there has been little renewable development in the former East Bloc, there is considerable potential. The usual obstacles to renewable development interfere, however: artificially low conventional fuel prices, capital constraints, and the lack of political and institutional commitment. These and other obstacles may prove to be insurmountable in the near term, but ongoing economic reform and price restructuring should enhance renewable development and use in the long term.

Several factors argue for renewable development in former East Bloc countries. These include the need to develop indigenous energy supplies, provide decentralized power to rural areas, and address environmental concerns. Also, the modular nature of some renewable technologies allows for shorter construction time, and they can be targeted at specific needs. Wind turbines and PV systems, for example, can be sized to fit any application.

Moreover, the availability of idle or underutilized industrial plants and defense facilities provides opportunities for renewable technologies production, especially wind turbines, PV cells, and solar collectors. Several aerospace factories in Russia and Ukraine are now manufacturing or planning to manufacture wind turbines. However, the lack of domestic markets means that production must be oriented toward exports.

Assistance from Western countries could improve the prospects for renewable development in former East Bloc countries, especially in those countries that have limited or no conventional energy resources. Technology transfer provides an important avenue for developing indigenous alternative energy resources at a more rapid pace.

U.S. firms are world leaders in developing and manufacturing renewable technologies, but other countries have expertise, as well. European renewable energy companies continue to grow and are aggressively competing with U.S. firms for global markets. U.S. renewable R&D funding is dwarfed by EU spending: the EU spends about $170 million per year on wind energy compared with $24 million per year in the United States.[48]

Even so, U.S. photovoltaic and wind technologies are among the most advanced in the world. The United States "wrote the book" on PV technology for terrestrial applications, and today, U.S. industry accounts for about one-third of total world PV production. Seventy percent of domestically manufactured PVs are shipped overseas.[49] U.S. small wind machine technology (under 50 kW) and wind site validation capabilities are the best in the world. Finally, the United States has tremendous renewable project planning, development, and management expertise. This experience is derived from having the largest installed geothermal and wind-generated electricity capacity in the world.

To compete in a significant way, U.S. firms must overcome several obstacles. The first is the cost disadvantage of some U.S. technologies relative to foreign competitors. Second, U.S. machines, such as wind turbines, must be adapted to the metric system to compete in European markets. According to DOE, this is a major disadvantage for U.S. companies, and conversion to the metric system would be a tremendous boost to U.S. industry. Third, the U.S. renewable industry, much like the energy efficiency industry, is composed primarily of small- and medium-sized firms. These companies do not have the financial

[47] Typical costs range from $1,000-$2,000/kW. For further information, see U.S. Congress, Office Of Technology Assessment, *Fueling Development: Energy Technologies for Developing Countries*, OTA-E-516 (Washington, DC: U.S. Government Printing Office, April 1992).

[48] NUTEK, *IEA Wind Energy Annual Report 1992*, (Stockholm 1993), p. 43.

[49] Jim Reynolds, International Solar Program, U.S. Department of Energy, personal communication, June 21, 1993.

resources to deal with the political uncertainties and financial risks associated with doing business in former East Bloc countries, risks that are intimidating even for the largest corporations.

Demonstration programs could bean effective way to penetrate former East Bloc markets and build confidence in unfamiliar technologies. Because some renewable technologies are perceived to be unreliable and very expensive, decisionmakers would see first-hand how the technology works, how to compile data, and how to develop operating experience.

Even if assistance is forthcoming, former East Bloc countries must provide a favorable climate for renewable development. The energy sector is currently undergoing restructuring, including privatizing industries and market pricing, but with varying degrees of success. Energy sector reform is a very important step to enhancing renewable development. As conventional energy prices rise and the cost of power production increases, renewable energy resources will become more attractive.

Because some of the renewable technologies are relatively new and/or commercial experiences are limited, political and institutional support will also be required. For example, wind energy development requires cooperation among equipment manufacturers, electric power producers, and land resources ministries. Without political commitment, small alternative energy projects will receive little or no financial support.

In the near term, renewable resource development will take a back seat to conventional fuels, particularly oil and gas. Russia has tremendous reserves and will continue to develop them in order to fuel its own economy and to obtain the hard currency so desperately needed. However, the desire and economic necessity to become self-sufficient will drive some countries to develop their renewable; for example, Ukraine's efforts in wind energy.

# Energy-Based Environmental Technologies

5

The extent of the staggering environmental problems facing many former East Bloc countries is finally apparent. In Poland, 65 percent of rivers are unfit even for industrial use. Inversion layers over Prague result in concentrations of sulfur dioxide ($S0_2$) 10 times the World Health Organization's (WHO) recommended standards for peak concentrations. High levels of $S0_2$ have been linked to increases in respiratory disease, particularly among school children in the most polluted areas of the Czech Republic. One powerplant in Kazakhstan emits almost four times the amount of particulate released by all powerplants in the United States. The examples go on and on. ]

Environmental damage comes from a variety of sources, including industrial processes, agriculture, and municipal waste. Insufficient or nonexistent pollution abatement equipment further contributes to environmental damage.

Energy production, transportation, and consumption play major roles in the environmental problems in former East Bloc countries. Growing domestic energy needs were met by increased fuel production rather than fuel conservation or efficiency. State subsidization of fuels and raw materials further stimulated energy consumption levels far higher than that in other industrialized countries. Exacerbating the problem, many of the fuels produced in the region were of low quality and thus more polluting. Although the countries of the region had strong environmental laws

DANIEL TALMO

*Parliament Building, Budapest.*

[1] For example, Hilary French, "Green Revolutions: Environmental Reconstruction in Eastern Europe and the Soviet Union," *Worldwatch Paper, No. 99,* November 1990; Murray Feshbach and Alfred Friendly, Jr., *Ecocide in the USSR (New* York, NY: Basic Books, 1992).

and standards (more stringent than WHO recommendations), enforcement was weak. As a result, emission abatement equipment (installed or produced) was insufficient to address pollution problems.

Although environmental activism played an important role in the overturn of Communist governments, the transition from environmental activism to action has not been easy. There are many obstacles to cleaning up the environment, many of which are imbedded in issues of economic reform. Little money is available to pay for mitigation equipment or regulatory enforcement. Also, since closing polluting facilities will exacerbate unemployment and reduce municipal revenues, many regulatory agencies have found themselves powerless to stop pollution.

Nevertheless, reducing pollution is an essential part of economic modernization. In many areas, a cleaner environment will directly increase economic well being because the benefits (e.g., improved human health, reduced corrosion of materials, and greater availability of usable water) will outweigh the costs. In addition, pollution control is a promising area for U.S. exports.

This chapter examines the possibilities for using U.S. equipment and expertise to reduce the environmental effects of energy production, transportation, and consumption in this region.[2] With the recent slowdown in economic activities, all former East Bloc countries have experienced an overall decline in pollution. However, it is extremely important that abatement equipment be in place before these economies turn around. If not, air quality problems will be magnified in the future.

## REGULATORY FRAMEWORK

Given the region's severe environmental problems, many Westerners were surprised to learn that the former East Bloc countries have very stringent standards for air and water quality, legislated many years ago, and that in some countries mining reclamation laws were on the books before similar regulations in the United States. In fact, almost all ambient standards were much stricter than U.S. standards or WHO recommended standards. Lack of enforcement rendered the standards meaningless, however, Even when exercised, enforcement depended on a system of fines. Communist industries were much less responsive to financial incentives than to production quotas.

Standards themselves have also been a problem. Environmental regulations focused almost exclusively on ambient standards rather than unified source standards.[3] Specific site emission limits were generally determined by local authorities, based on modeling practices that allowed for regional air or water quality standards to be met, but there were no national targets for abatement. This complicated the design and manufacture of abatement equipment. Focusing on ambient rather than source standards is at odds with environmental regulation in Western industrialized countries, where source limits to both air and water pollution have been implemented in the past 20 years.

Every country in Central Europe and some former Soviet republics aspire to membership in the European Union (EU). As a result, they favor establishing environmental standards consistent with existing and anticipated EU standards.[4] Much work must be done, however, to bring pol-

[2]This study does not examine the human health and environmental impacts of the nuclear fuel cycle, nuclear accidents, or problems that result from past practices; e.g, toxic waste dumps.

[3]Ambient standards generally set maximum concentrations of a targeted pollutant in a particular media (air, water, soil). Compliance requires that pollutant levels do not exceed this maximum. Source standards specify a maximum level of a pollutant that can be discharged over a given period of time from a regulated source (smokestack, well, factory) into the air or water.

[4]Margaret Bowman and David Hunter, "Environmental Reforms in Post-Communist Central Europe," *Michigan Journal of International Law*, *vol. 13, No. 4,* summer 1992, p. 970.

luters into compliance. Many countries are debating whether to phase in strict EU standards quickly or institute weaker transitional standards, to be revised after economic recovery. This debate has been strongest in the Czech Republic.

Although environmental activism played a major role in the revolutions in Central Europe and fanned dissatisfaction with centralized authority in the former Soviet Union (FSU), the environment has taken aback seat to the present economic dislocations. In Poland, for example, although environmental regulations were off to an impressive start in 1989, economic troubles in the following years took their toll on environmental law reform.[5]

Another legacy of the previous systems is the reluctance and skepticism of local officials and industry toward regulatory enforcement. Many of the old, centralized bureaucratic structures remain, especially at the local and regional levels. Decentralization may create opportunities for improved environmental decisions since local offices should have better knowledge of local environmental concerns. Unfortunately, local authorities are also more susceptible to strong local pressures not to enforce regulations that may increase local unemployment and economic hardship. Moreover, local and regional environmental agencies are often understaffed, underfunded, and underequipped.

Reliable environmental data are critical for determining the scope of environmental problems, setting priorities for pollution abatement, and understanding the impacts of new regulations, but the data for many environmental problems are questionable. Due to the lack of monitoring equipment, most data are not determined through measurement of actual emissions. Instead, analysts make calculations based on assumptions that have not been rigorously scrutinized, or that are derived from data such as the sulfur content of fuels, rated efficiencies of engines, abatement equipment, estimates of average distance driven, and mobile source emission factors.[6]

## ENERGY PRODUCTION, PROCESSING, AND TRANSPORTATION

The production, processing, and transportation of fossil fuels (oil, natural gas, and coal) can have significant negative consequences for the environment. The following section examines the effect of these activities on the region's environment and the opportunities for U.S. technology and expertise to address these problems.

### Oil and Natural Gas

As noted in chapter 2, most of the oil and gas activities in the region are centered in the FSU, specifically Russia, Kazakhstan, and Azerbaijan. Romania is the only non-FSU country with notable oil and gas production. All countries in the region, however, have refining capacity, pipelines, and other forms of oil product transport that can have environmental consequences.

#### *Production*

The drilling and production of oil and natural gas includes many activities with potentially harmful direct and indirect results for the environment. The main direct environmental concerns during drilling of oil and natural gas involve the proper handling of fuels and chemicals (including drilling mud) at the drilling site, which, if spilled or leaked, can contaminate groundwater and riverways.

Oil production activities pose a greater direct environmental threat than gas production. Faulty valves, well casings, and collection facilities can leak oil to the ground, forming large pools (such as at Baku) or traveling to streams and rivers. In Russia, discharges resulting from waterflooding pro-

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[5]Ibid., p. 930.

[6]R.C. Cooper, "Environmental Problems and Pollution Abatement in Central and Eastern Europe, "contractor report prepared for the Office of Technology Assessment, Aug. 6, 1993.


**Typical *field* flares.**

duction techniques have caused oil to enter waterways. The Ob river, which flows through the oil-producing region of Tiumen north to the Arctic Ocean, has been especially affected by all of these problems. Environmentalists have said that millions of barrels of oil in Tiumen Oblast are spilled through pipeline ruptures or lax production controls, resulting in the death of bottom fisheries.[7]

The indirect environmental impacts of oil and gas drilling and production include the consequences of construction activities and human settlements. In Russia, the climate adds additional concern. The largest oil- and gas-producing areas of Russia are in Western Siberia. Western Siberia is frozen in winter, but the spring thaw causes the land around the rivers to become waterlogged or flooded, drawing pollutants from areas contaminated by oil. As drilling and production have moved further northward, the industry has entered areas of permafrost that require stringent practices for sensitive ecosystems preservation. But no areas in the oil or gas regions of Western Siberia have been protected through the establishment of nature reserves (zapovedniki) or national parks. Given the present economic crisis and pressures to increase fuel production, it is unlikely that new areas will be protected in the immediate future.

In the major gas-producing region of Western Siberia, future production will be found beyond the Arctic Circle, at Yamburg and the Yamal Peninsula, in areas of continuous permafrost. Pipelines must be cooled and buildings must be raised off the permafrost to avoid melting the frozen soil beneath. If trees are cut away, forests that overlay permafrost can be turned into irreversible marshes.[8] While the development of the Yamal Peninsula was put on hold by the Soviet government in 1989 (the same year that travel across the bare tundra was prohibited), the Russian government has recently permitted the work to resume.[9]

Offshore oil and gas drilling also present a number of environmental concerns, most importantly, leaks or spills of oil and chemicals that can harm marine life. The major offshore producing area has been the Caspian Sea, where drilling and production has taken place since the 1920s, in the shallow waters off the coast of Azerbaijan. Minor oil spills and slicks are noted periodically off this coast, '" but the specific reasons for these accidents are unclear. Offshore drilling and production activities have occurred to a lesser extent in the Black Sea (near Romania), the Baltic Sea, off Sakhalin Island, and the Barents Sea.

## Environmental technology options

Market incentives, combined with increased regulatory enforcement, may redress some of the environmental problems presently found in oil production. For example, when oil has a real market price for the producer, increased economic efficiency will result in less oil on the ground and more in the pipeline moving to consumers. Foreign equipment does not appear to be needed for such efforts, only the adaptation of the Russian (or

[7]Mike Edwards, "Siberia: In From the Cold," *National Geographic,* vol.177, No. 3, March 1990, p. 35.

[8]Philip R. Pryde, *Environmental Management in the Soviet Union* (Cambridge, MA: Cambridge University Press, 1991), p. **203.**

[9]Matthew Sagers, "News Notes," *Post-Soviet Geography, vol. 34, No. 6,* April 1993, p. 383.

[10]Pryde, *Environmental Management in the Soviet Union,* p. **88.**

Azerbaijani) and other equipment manufacturers to address market needs.

In several specific areas, such as offshore and arctic operations, Western environmental technologies and expertise are needed. While the Russians have had more experience in arctic oil and gas operations than any other country, their efforts have not focused on mitigating environmental hazards. Western technologies (such as transport vehicles or equipment that can withstand saline or arctic conditions) and field management expertise are needed to reduce the impact of operations.

#### U.S. opportunities to transfer technology

U.S. firms have had many years of experience in the Alaskan oil fields that would be applicable to the needs of Western Siberia. For example, in Alaska, workpads were built along pipeline ditches to protect the tundra from the wear and tear of construction, and crossings were provided for the caribou migration. [11] Also needed are vehicles that do not damage the sensitive tundra.[12] U.S. firms will compete in this area with manufacturers from other countries, particularly Canada.

U.S. firms also have a great deal of experience in offshore oil and gas operations, although the market advantage for U.S. firms is not clear. With the development of North Sea fields, some European firms have developed expertise that would readily apply to regions such as the Barents and Baltic Seas. U.S. firms would have a logistical advantage if drilling and production activities are to take place in the East Siberian Sea region, due to its proximity to Alaska. But given the great distances from markets, it is not clear whether this region will be exploited in the near future.

### *Processing*

Refineries are generally located in market areas, with crude oil del ivered by pipeline. At oil refineries, the major air pollution concerns stem from hydrogen sulfide ($H_2S$), which is formed in hydroprocessing (catalytic reforming, hydrotreating, and hydrocracking) and cracking (catalytic and thermal) and from CO (released primarily during catalytic cracking) and hydrocarbon vapors. Given the relative importance of primary distillation technology in the region, refinery emissions are probably determined by the sulfur content of fuels consumed, rather than from technical processes. Waste waters from refineries, without sufficient processing, may contain oil or other byproducts of the production process. The discharge of oil products in refinery effluent to waterways has been a significant problem in Russia (where 29,000 tons entered waterways in 1989) and Uzbekistan (24,000 tons in 1989).[13] Petroleum discharge into rivers appears particularly troublesome along the Tom river (a tributary of the Ob), where petroleum product concentrations exceed standards by 8 to 10 times because of point sources at Mezhdurechinsk, Novokuznetsk, Kemerovo, and Tomsk.[14]

Gas processing, on the other hand, occurs at or near gas production sites, since the gas must be processed before entering transmission pipelines. Environmental problems resulting from natural gas processing are mainly the result of insufficient controls at sulfur-removing facilities. North Caspian Basin fields and all significant fields of Central Asia suffer from high sulfur content. The only notable environmental problems in the gas processing industry have occurred at the Astrakhan

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[11] John Fowler, *Energy and the Environment*, 2d ed. (New York, NY: McGraw-Hill, 1984), p. 210.

[12] Edwards "Siberia: In From the Cold," p. 39.

[13] Goskomprioda, *Sostoianie prirodnoi s„d„v i prirodookhrannaia deialel'nest' v SSSR v 1989 godu (The* State of the Environment and Environmental Protection Activities in the USSR, 1989) (Moscow: Goskompriroda, 1990), p. 68.

[14] Ibid.

complex in Russia, where there have been repeated leaks of $H_2S$ and $S0_2$.[15]

### Environmental technology options

The most immediate problems in the oil and gas processing sectors are water purification and emission abatement. Simple effluent treatment plants for oil and suspended solids removal and neutralization are greatly needed. Those facilities with secondary refining processes would benefit from $H_2S$ treatment, while more traditional sulfur-scrubbing units are needed at facilities burning high-sulfur residual fuel oil.

Given the archaic refinery structure that is found in most East Bloc countries, refinery upgrades are likely in the coming years. Upgrades are needed not only to produce more of the lighter fractions, such as gasoline, but also to produce unleaded fuels and to desulfurize residual fuel oil. Environmental technologies will be needed for these projects.

### U.S. opportunities to transfer technology

U.S. firms are certainly experienced suppliers, manufacturers, designers, and constructors of advanced oil refineries. However, they face significant competition from other suppliers, primarily the Japanese. U.S. firms have a clearer advantage in the area of gas processing, especially for high-sulfur (sour) gases. While U.S. firms did not play a large role in the Astrakhan gas complex, they are active in the development of gas processing facilities at the Tenghiz (Kazakhstan) field.

## *Transportation*

Accidents during transport of crude and refined oil products to market can result in severe environmental consequences. In the region, crude oil transport depended largely on pipelines, while railroads have played a major role in product transport. Inland waterways-in particular, the Volga river system—are also used for product shipments. Small tankers ply the Caspian Sea to link the oil-producing regions of Baku, Turkmenistan, Emba, and Mangyshlak, with refineries, regional markets, and the Volga river system.

Many concerns have been voiced about the reliability of both crude oil and natural gas pipelines in the region. The greatest direct environmental consequences come from leaky oil pipelines. Natural gas leaks present safety more than environmental concerns. In 1989, an explosion of escaped gas from a natural gas liquids pipeline killed hundreds of people on a passing train.[16]

There are indirect environmental impacts from pipelines. When constructed above ground (as they must be in areas of permafrost), pipelines can inhibit the migration of wildlife. For example, in the Siberian city of Norilsk, when major pipelines were built to supply natural gas, insufficient provisions were made for reindeer crossings along migratory routes. Reindeer became trapped between parallel pipelines, and whole herds were funneled into downtown Norilsk, where they became the victims of cars and poachers. *7

Because a large share of FSU oil exports went to Central Europe through pipelines, oil tankers have played only a minor role in crude oil and petroleum product transport. Shipments of oil and petroleum product by sea accounted for only 8 percent of oil shipments for the Soviet Union as a whole. [1]8 Tanker transport has been used primarily for shipments to countries outside continental Europe (Cuba, the United Kingdom, the Scandinavian countries, and others). The main crude oil and petroleum product export ports have been Ventspils (Baltic Sea) and Novorossisk (Black

[15] D.J. Peterson, *Troubled Lands: The Legacy of Soviet Environmental Destruction* (Boulder, CO: Westview Press, 1993), p. 255.

[16] Pryde, *Environmental Management in the Soviet Union,* p. 98.

[17] 1 bid., p. 174.

[18] Goskomstat, *Narodnoe khoziaistvo SSSR* v 1990 (The National Economy of the USSR in 1990) (Moscow: Finansy I Statistika, 1991), p. 577.

Sea). Several notable tanker accidents have occurred in the Baltic Sea and the Volga River. Given the inherent risks of oil transport, it is not clear if the frequency or magnitude of these accidents is worse than industry averages elsewhere.

#### Environmental technology options

As noted earlier, if market incentives and regulatory enforcement were adequate, domestic equipment could address some environmental problems, such as oil pipeline leaks. But new problems and new technology needs may arise. As trading partners diversify, so might fuel transport activities. If Russian oil and product exports shift away from Central Europe, and these countries diversify their petroleum suppliers, tanker traffic could increase dramatically in the region. Increased spill protection and spill response equipment would then be needed to match the increased risks.

With extensive reserves of natural gas in Russia, and significant resources in Uzbekistan and Turkmenistan, gas exports are likely to increase. Gas pipeline construction will increase in the coming years, with extensive construction in Arctic areas if the gas fields on the Yamal Peninsula are exploited. In the long term, liquefied natural gas (LNG) tankers could provide an expanded market for Russian gas. Since LNG is flammable and heavier than air, a tanker collision would be disastrous.

#### U.S. opportunities to transfer technology

U.S. firms have a limited advantage in oil and gas transportation technologies. Given the economics of shipping pipe long distances and the previously established ties with West European pipeline manufacturers, U.S. firms will not be able to compete in the pipeline market. However, U.S. firms with experience in pipeline construction might be able to provide expertise and services in upcoming pipeline projects. The only other major market for U.S. suppliers is likely to be control equipment for pipeline operations, both in the field and in long-distance transport.

U.S. firms have a great deal of experience in spill response equipment and technologies. Nevertheless, given the location of ports and shipping patterns, it is not clear whether or not U.S. firms will have a market advantage because of the transboundary nature of oil spills and the European response capabilities.

### *Conclusions*

A mix of technologies, expertise, market reforms, and regulatory enforcement is needed in the region to reduce the impacts of oil and gas operations. The highest priorities for Western equipment and expertise would be in arctic operations, oil separation equipment, refinery equipment (both water and air purification systems), and offshore operations.

One difficulty in assessing future needs for environmental equipment is the uncertainty about what impacts might arise from the disruption of historic trading relationships or the influx of Western oil exploration and service companies. Changes in export patterns could result in increased use of tankers, which might increase the likelihood of oil spills. Since it is unclear if domestically produced tankers would be involved, the most important technology transfer opportunities may lie in American experience in rapid response to oil spills. Also, the entrance of Western firms could expand the reach of the oil and gas industries to previously unexplored or produced regions, particularly in offshore areas and remote locations, resulting in unforeseen environmental problems.

## | *Coal* and Shale

The initial effects of mining are land disturbances. In surface mining, huge shovels remove the soil above the coal or shale seam, causing the most visible environmental damage. In underground mining, waste is deposited above the mine, causing land degradation at the surface. The environmental impacts of both methods of mining, however, extend beyond the initial extraction process. Mining can lead to the disruption of hydrologic cycles, pollution of surface and groundwater by acidic or


*Strip mining site outside Pees, Hungary*

saline discharge, and sedimentation of rivers by the runoff from barren or sparsely vegetated sites. Even after mines are shut down, these environmental problems linger.

### Surface Mining

As noted in chapter 3, surface mining is used extensively in the Czech Republic, Kazakhstan, Russia, and Estonia. In the Czech Republic alone, surface mining of lignite results in 500 million tons of mining waste each year.[19] Associated environmental problems include soil erosion, loss of vegetative cover, and water pollution (through sedimentation and acid mine drainage). The natural revegetation of mined areas is a very slow process, due to low levels of soil nutrients in the disturbed areas.

Reclamation efforts attempt to return mined areas to biological productivity. During reclamation, excavated areas are refilled and regraded, then fertilized and seeded. It is sometimes necessary to create a drain with a culvert to carry the water away quickly, before it can form sulfuric acid. Successful reclamation depends on fertile soils and local climatic conditions (e.g., elevation, rainfall). The conservation of fertile soil is extremely important to reclamation efforts. Topsoil must be removed and stored as part of the mining process, and replaced after the coal (or shale) has been extracted.[20]

Starting with Poland, all of the countries in the region implemented legislation in the 1960s, 1970s, and 1980s requiring reclamation of mined areas.[21] It is difficult to judge the past success and current needs of reclamation because detailed data are not readily available. Secondary literature, however, suggests that reclamation laws are not sufficiently enforced and that reclamation efforts are much needed in the region.

### Underground Mining

Mine spoils and water discharge from underground mining can result in environmental problems. Underground mining—the main form of coal extraction in Ukraine, Slovakia, and Hungary-accounts for a large share of coal mining in Russia and shale production in Estonia. Mine wastes, piled up around the mine entrances, create unfavorable conditions for revegetation: altered soil texture and structure, high or toxic concentrations of sulfates, inadequate levels of plant nutrients, and low pH levels.

Mine wastes have created significant environmental problems in Ukraine. At the Donets Basin, piles of overburden have created mounds on the surface up to 100 meters high. Ukrainian coal enterprises have almost 1,200 waste dumps (370 presently in use), occupying an area of over 5,000 hectares and containing nearly 1.4 billion cubic

[19] Stanley J. Kabala, "The Reform of Environmental Policy," *Report on Eastern Europe,* vol. *2, No. 8,* Feb. 22, 1991, p. 11.

[20] Fowler, Energy *and the Environment, p.* 199.

*2 I* M.J. Chadwick, N.H. Highton, and N. Lindman (eds.), *Environmental Impacts of Coal Mining and Utilization* (Oxford: Pergamon Press, 1987), p. 35.

meters of barren rock.[22] Vegetating these waste piles has been difficult because the material is generally infertile.[23]

Another problem associated with underground mining is fire. In operating mines, fires result from accidents. At waste dumps, fires result from spontaneous combustion (a noted problem in Ukraine). Despite a program to reduce these fires by switching to flat dumps insulated with inert materials, spontaneous combustion has occurred at 15 of the flat waste dumps now in use.[24]

### Mine Discharge

A major problem associated with underground mining is the discharge of polluted waters to ground and surface water. When water reaches the coal seams, from either producton or natural seepage, it can react with the sulfur-containing pyrites or other minerals and form very destructive pollutants, such as sulfuric acid. Mine drainage also contributes increased amounts of sediments, sulfates, iron, and salts. Acid or saline discharge can affect both surface and underground mines, depending on the mineral content of the coal seams, overburden, and groundwater. Polluted mine discharge is a particularly tenacious problem because it can occur at abandoned mines as well as surface-mined areas that have not been reclaimed for hydrologic features.

In Poland and Ukraine, most of the problems with mine drainage have occurred from underground mines and runoff from tailing piles. Water draining from underground Polish mines is largely saline which has increased the salinity of the two major rivers, the Vistula and the Ordra, rendering the water too corrosive even for industrial consumption.[25] In Ukraine, saline discharge is also a problem, caused principally by suspended substances, mineral salts, organic ingredients, and trace elements. According to Ukrainian sources, water purification systems still leave about 10 percent of intake water polluted.[26] In Russia, where the sulfur content of mined coal is lower, acid mine drainage has been less significant (with the possible exception of the high-sulfur Kiselovsk field in the Urals region).

Special measures must be taken in mining areas where acid-producing substances are present. The main techniques rely on isolating the acid-forming materials and preventing contact with oxygen, by either water or overburden. Unfortunately, both options have limitations, and if they cannot prevent acidification, then the only recourse is treatment of the mine discharge.[27] Commonly, after mining operations have stopped, the mine is sealed and water allowed to fill the mine shafts. This method works as long as there is no "breakout" of the acidic water filling the mine. Unfortunately, when a breakout occurs, it is often difficult to detect and respond to before significant damage has occurred to water bodies .28

### Processing

As noted earlier, there is relatively little processing of energy coal in the region, and therefore the environmental consequences of coal processing has been limited. However, the introduction of additional coal cleaning capacity, although reducing pollution at the point of use, will produce significant amounts of waste that are difficult to

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[22] "Ukraine: Environmental Protection Needed in Coal-Producing Regions," *Ugol Ukrainy* 1993, *No. 1,* as translated *in JPRS Environmental Series,* May 21, 1993.

[23] Pryde, *Environmental Management in the Soviet Union,* pp. *205-206.*

[24] "Ukraine: Environmental Protection Needed in Coal-producing Regions."

[25] World Bank, *Poland Environmental Strategy,* Apr. 24, 1993, p. 3.

[26] "Ukraine: Environmental Protection Needed in Coal-Producing Regions."

[27] James M. McElfish Jr. and Ann E. Beier, *Environmental Regulation of Coal Mining* (Washington, DC: Environmental Law Institute, 1990), pp. 138-39.

[28] 1 bid., p. 139.

dispose of or reclaim. In the United States, for example, coal mining is the third-ranking industrial producer of mineral waste; 90 percent of this comes from the washing of coal to remove impurities.[29]

### Environmental technology options

Technical expertise more than specific equipment is needed to remediate environmental problems at coal and shale mines. Hydrologic expertise is needed to deal with mine discharge and to reduce the formation of acidic or saline discharge. Water purification systems and expertise are needed to clean up existing sites. Attention should be given to incorporating reclamation (such as grading, soil, and substrata separation and storage) into production. But reclamation of previously mined areas will likely be too difficult to attempt in the short term, unless it becomes economical to reprocess mine tailings.

### U.S. opportunities to transfer technology

The United States has had significant experience dealing with problems similar to those found in the coal and shale sectors of the former East Bloc, in particular, land reclamation efforts and the reduction of acid mine discharge. The need for assistance in the reclamation of surface-mined areas appears greatest in the Czech Republic and Estonia. Problems in tailings reclamation and polluted water discharge from underground mining are greatest in Ukraine and Poland.

While the United States does not have a clear advantage in the desalinization equipment needed in Poland, there are many opportunities for firms with experience in mine hydrology.

## THE ENVIRONMENTAL IMPACTS OF FUEL CONSUMPTION

When fuels are burned, minerals within are released in either particulate or gaseous forms. Thermal $NO_x$, hydrocarbons, CO, and carbon dioxide ($C0_2$) are also formed during the combustion process. In sufficient quantities, many of these compounds can affect human health, damage the economy (e.g., corroding structures and stunting crop growth), and cause transboundary pollution.

High energy use combined with lax enforcement of env ironmental standards resulted in widespread air quality problems in the region. Acid rain exists in all countries of Central Europe and most of the FSU. In the Czech Republic, there is evidence that soil acidity has increased significantly since the 1960s, representing one of the few examples of large-scale soil acidification caused by acid deposition.[30] This increase in soil acidity could be contributing to problems in soil toxicity, because aluminum, zinc, and beryllium are liberated from soil primarily under extremely acidic conditions.[31]

Smokestacks historically have been used to reduce pollution problems from stationary sources such as powerplants by elevating emissions above the ground where they may be more effectively dispersed. However, other environmental problems are aggravated by tall stacks. In particular, tall stacks release pollutants at a sufficient height to allow chemical transformations and precipitation as acid rain. Increased mobile-source activities—in particular, private car use-create a host of other pollution problems (such as lead emissions, CO, and hydrocarbons that react to form

[29] Fowler, *Energy and the Environment*, p. 202.

[30] Bedrich Moldan and Jerald Schnoor, "Czechoslovakia: Examining a Critically Ill Environment," *Environmental Science and Technology*, vol. *26*, No.1, *1992, p.* 16.

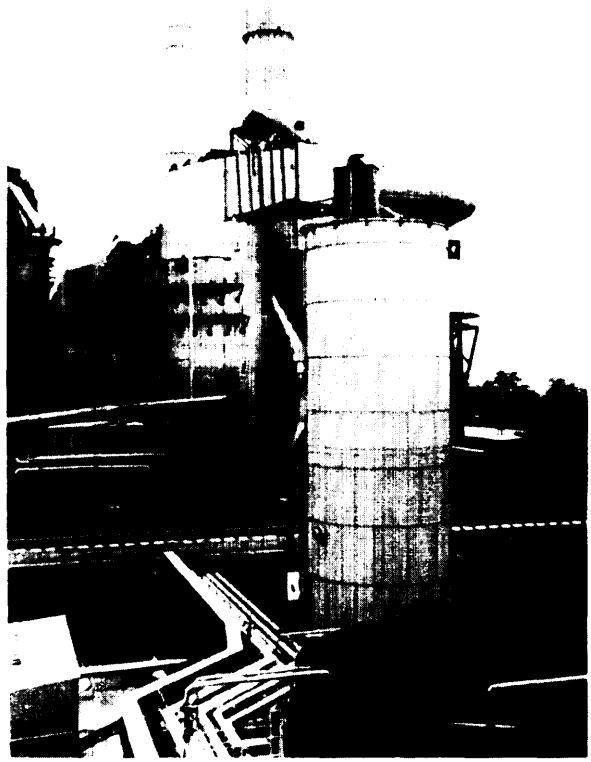
[31] Ibid.

ozone) at ground level. Therefore, in the last decade, many technologies have been developed for the control of emissions from fossil fuel use through pre-combustion fuel cleaning or processing, combustion modifications, and post-combustion cleaning of flue gases for both stationary and mobile sources. In former East Bloc countries, however, the lack of regulatory enforcement resulted in a lower level of technology (and applications) of abatement equipment than that in the West. Existing abatement equipment appears inefficient compared with Western models and is based on particulate removal, rather than gaseous components such as $S0_2$.

The following section examines problems arising from fuel use in former East Bloc countries. The focus is on particulate, $S0_2$, and $NO_x$ because there is insufficient data about emission patterns of other pollutants (e.g., CO, hydrocarbons, lead) for a comparative analysis. The reader is cautioned that the following analysis is based on official data, which might contain errors.

## I Particulate

Particulate matter is composed of dust, mist, ash, smoke, and fumes. Fuel burning, industrial processes (particularly smelting), and waste incineration are the major sources of manmade particulate emissions. The smaller particles (from 0.1 to 1 micron) are mostly combustion-related, and consist of particles of tar (heavy hydrocarbons) and soot (carbon) that escape unburned in the exhaust gas. **32 In the cyclone (or wet-bottom)** furnaces 'hat dominate capacity in the region, as much as 70 percent of the incombustible material in coal leaves with combustion gases as fly ash, and the remainder is collected at a bottom grate as slag, or bottom ash.[33]



AIRPOL, INC

*Wet flue gas desulfurization system for the Skawina Power Plant in Krakow, Poland: completed absorber vessel with lime silo and hold tank in foreground.*

The size of these particles largely determines their effects. Large particles are the most visible pollutants and can carry damaging materials, such as sulfuric acid, to the surfaces they strike. Smaller particles, however, present a greater health threat because they can evade the human respiratory system's defense mechanisms.

### Regional *Issues*

Particulate emissions in the former East Bloc area much more significant problem than in the United States, where they have been substantially re-

32 Fowler, *Energy and the Environment*, p.161.

33U.S. Department of Energy, *Energy Technologies and the Environment* (Washington, DC: *1988),* p. *29.*

duced through the installation of abatement equipment.[34] In 1989, particulate emissions from fuel use and industrial sources[35] in Russia (7.8 million tons) were 75 percent higher than in the United States (4.5 million tons). Particulate emissions in Poland and Ukraine were less than 2.4 million tons. High levels of particulate emissions are due to the use of high-ash coal, lignite, and shale without pre-combustion cleaning and without sufficient post-combustion abatement equipment.

Table 5-1 shows the major sources and densities of regional particulate emissions measured as kilograms per capita. (Note that this measurement does not reflect health risks; instead, it is a general indicator of the intensity of emissions in the various economies.)[36]

### Environmental technology options

For large sources, two very efficient (99+ percent) types of post-combustion cleaning are now commonly in use in the West: electrostatic precipitators (ESP) and baghouse filters. The decision to use ESPs or baghouse filters is largely determined by the coal type used at the boilers; low-sulfur coals of the Western United States have had resistivity problems with ESPs.

No comprehensive statistics exist on the type of particulate abatement equipment installed in former East Bloc countries. While Soviet sources have referred to the use of ESPs at large powerplants, there is little information about their effectiveness. The Polish environmental handbook provides some background information on pollution control equipment installed in the region.[37] In 1991, 88 percent of stationary particulate emission sources had some sort of particulate removal system in place, but most used cyclone technology which is much less effective than ESP and baghouse filters. Only 20 percent of all equipment was rated above 90 percent efficiency. Only half of the relatively few ESP units were rated above 95 percent efficiency, although the standard in the West is generally higher than 99 percent.[38]

A different approach to particulate emissions in this region would be cleaning coal to remove some of the ash matter before combustion (see also chapters 3 and 4). Because the coal burned in this region tends to be of high ash content, simple coal cleaning could provide a significant reduction in particulate emissions, especially for smaller fuel consumers, where post-combustion cleaning would not be feasible. In Katowice, Poland, tall powerplant and industrial stacks account for only 55 percent of particulate emissions, with the remainder coming from low stacks associated with households, district heating plants, and small industry.[39] cleaning would also reduce particulate emissions in the Czech Republic, Slovakia, and Hungary whose home heating needs are largely met by coal. Coal cleaning also provides benefits to large coal consumers by reducing the wear on ESPs, baghouse filters, and sulfur removal systems.

### U.S. opportunities to transfer technology

As noted in chapter 3, U.S. firms have a significant advantage in hard-coal cleaning technologies. However, U.S. experience in cleaning lignites does not provide a good match for the needs of former East Bloc countries. Since the sul -

[34] U.S. Environmental Protection Agency, *National Air Pollutant Emission Estimates /940-1989* (Triangle park, NC: 1991).

[35] Particulate emission data from mobile sources, solid waste burning, and forest fires are not available for the Central and East European countries noted here.

[36] Many analysts use the measure Of pollution per dollar of GNP. Given the problems of GNP accounting and dollar conversion rates among the countries in this region, the pollution-intensity of economic output has not been calculated. It can be said, however, that given the large disparities in per capita economic output, the emission intensities of this region are much higher than the case in other European countries.

[37] *Ochrona Srodowiska* 1992 (Warsaw: Glowny Urzad Statystyczny, 1992), p. 152.

[38] Ibid.

[39] World Bank, *Poland Environmental Strategy, p. 4.*

TABLE 5–1: Emissions of Particulates

| Country | Kg/per capita | Main sources |
|---|---|---|
| Estonia (1989) | 162 | Use of locally produced shale and industrial facilities,<br>Shale-fired powerplants 55%<br>Cement plants 35% |
| Kazakhstan (1989) | **122** | Use of high-ash Ekibastuz coal |
| Czech Republic (1988) | **81** | Use of locally produced lignite (primarily powerplants) and industrial facilities:<br>Powerplants 50%<br>Industrial sector 35% |
| Russia (1 989) | **57** | Coal use, **industrial sources**<br>**Powerplants 50%**<br>**Metallurgy 25%.** |
| Poland (1990) | **55** | Industrial sector, coal use<br>Industry 40%<br>Residential/commercial 30%<br>Powerplants 30% |
| Slovak Republic (1988) | 51 | Lignite use, industrial sector |
| Ukraine (1989) | 44 | **Industrial processes; use of high-**ash Donets coal |
| Hungary (1988) | 40 | Industrial sector, use of low-quality coal<br>Industry 50%<br>Powerplants 20%<br>Residential 20%. |
| U.S. (1989) | **24*** | **Industrial processes 45%**<br>**Highway vehicles 22%**<br>**Residential 18'%.** |

**Other countries with reported** emissions: Romania **(1990) 30, Moldova (1989) 18,** Belarus **(1989) 17,** Latvia **(1989) 14,** Lithuania **(1989) 11**

***For** comparative purposes, **this** figure **does not include** emissions **from** incineration, **waste dumps, or forest fires**

**SOURCES R C Cooper, "Environmental Problems and Pollution Abatement** in **Central and Eastern Europe, " contractor report prepared for the** Office **of Technology Assessment, Aug 6, 1993, pp 42, 127, and U S Environmental Protect Ion Agency,** *National Air Pollutant Emission Estimates 1940-1989* **(Research** Triangle **Park, NC March 1991)**

fur content of the lignite deposits in the western regions of the United States is very low, sulfur removal has not been a major goal of U.S. technologies.

U.S. firms also have a great deal of experience in post-combustion particulate removal. While ESPs have been the main focus of particulate abatement, the exploitation of Western, low-sulfur coals in recent years has increased baghouse filter usage.

## Sulfur Dioxide

Sulfur dioxide is formed when sulfur contained in the fuel combines with oxygen during the combustion process to form $SO_2$. It is released in the

combustion gases. Certain industrial processes, such as the smelting of sulfur-containing ores, also result in $S0_2$ emissions. When $S0_2$ is carried into the upper respiratory system and the lung, it can increase airway resistance. While this may be merely troublesome for a healthy person, it can be fatal to someone already afflicted with chronic bronchitis or emphysema.

In recent years, concerns about $S0_2$ emissions have focused on acid rain. Acid rain is the result of an additional chemical change in the atmosphere, when some $S0_2$ is oxidized to form sulfuric acid ($H_2S0_4$). $NO_x$ can also be oxidized to form the pollutant nitric acid ($HN0_3$). Aerosols containing these acids have a short residence time in the atmosphere (from two days to a week), and are then deposited on the ground through rain or snow. Acid rain can lower the pH of lakes, with consequent damage to fish and other aquatic life, and it is suspected that acid rain harms crops and forests.

Coal is generally considered the main contributor to fuel-based $S0_2$ emissions. However, because of the lack of desulfurization equipment in the refinery system, $S0_2$ emissions from residual fuel oil are greater than emissions from coal use in some regions, even on an energy-equivalent basis. Without desulfurization equipment, the sulfur contained in crude oil is concentrated in the heavier components. Because much refinery technology in the region is based on primary distillation, high shares of high-sulfur components, such as residual fuel oil, are produced, exacerbating the problems of sulfur emissions. Although low-sulfur residual fuel oil is produced in the region, most is high- or medium-sulfur grade.[40]

## Regional Problems

There have been very few controls to reduce $S0_2$ emissions in the region. Instead, taller stacks have been used at large polluting sources to disperse sulfur emissions away from residential areas. As shown in table 5-2, the Czech Republic had the highest density of $S0_2$ emissions (measured per capita) in the region, due to high-sulfur lignite use. Since the energy content of this lignite is very low, large volumes must be consumed.

Although not evident from table 5-2, emissions of $S0_2$ fell in many countries of the region during the 1980s because of changes in the fuel balance. During the 1980s, large amounts of natural gas from the Urengoi fields started to move westward through large-diameter pipelines. Increased gas availability, coupled with a stagnation in oil production, resulted in a gas-for-oil substitution program at powerplants in the former Soviet Union. Between 1980 and 1985, natural gas consumption at powerplants in the former Soviet Union almost doubled.[41] The initial increase in gas use came from powerplants located nearest the production region of Western Siberia (the Urals and Volga regions) or along the newly constructed export line (Ukraine). By the early 1990s, powerplants in Moldova, Belarus, and Latvia had switched to gas use. Natural gas not only replaced high-sulfur residual fuel oil, but also coal and peat.[42]

According to Soviet statistics, $S0_2$ emissions dropped dramatically in the 1980s, from a peak of 20.2 million tons in 1983 to 16.8 million tons in 1989, a 17-percent decline.[43] However, this was due almost exclusively to a reduction in residual

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[40] PlanEcon, Inc., *Petroleum Product Marketing: Eastern Europe and Former Soviet Republics* (Washington, DC: PlanEcon, Inc. and DRI/McGraw-Hill, March 1993), p. 7.

[41] A. A. Troitskii (@, *Energetika SSSR v 1986-1990 godakh* (Power Engineering in the USSR, 1986-] 990) (Moscow: Energoatomizdat, 1987), p. 90.

[42] R. Caron Cooper, "Petroleum Displacement in the Soviet Economy: The Case Of Electric Power Plants," *Soviet Geography,* vol. 27, No. 6, June 1986.

[43] By comparison, during the same period, $SO_2$ emissions in the United States fell by only 8 percent. R. Caron Cooper, "Sulfur Dioxide Emissions in the Republics of the USSR," joint meeting of the Association for Comparative Economic Studies and the Association for Environmental and Resource Economics, Allied Social Science meetings, New Orleans (January 1992).

TABLE 5–2: Emissions of Sulfur Dioxide

| Country | Kg/per capita | Main sources |
|---|---|---|
| Czech Republic (1988) | 200 | High-sulfur lignite consumption:<br>Powerplants 66%<br>Industrial sector 13% |
| Bulgaria (1985) | 193 | High sulfur lignite consumption |
| Estonia (1989) | 124 | Use of locally produced shale:<br>Shale-fired powerplants 70%<br>Other sources 30% |
| Hungary (1988) | 115 | Use of locally produced coal and residual fuel oil, industrial activities:<br>Powerplants **40%**<br>**Industry 33%**<br>Home heating 22% |
| Slovak Republic (1988) | **112** | Not available |
| Kazakhstan (1989) | **95** | Industrial processes |
| Poland (1990) | 90 | Coal consumption:<br>Powerplants 50%<br>Home heating 25% |
| **Russia (1989)** | **71** | Industrial processes, high-sulfur residual fuel oil consumption:<br>Metallurgy 50%<br>Powerplants 35% |
| Romania (1989) | 67 | Industrial activities, coal, and residual fuel oil |
| U.S. (1989) | 85 | Coal consumption (powerplants), industry |

**Other** countries with **reported** emissions: **Ukraine (1989) 60;** Belarus **(1989) 58; Moldova (1989) 55,** Lithuania **(1989) 51,** Latvia **22**

**SOURCES R C Cooper, "Environmental Problems and Pollution Abatement in Central and Eastern Europe, '<contractor report prepared for the Office of Technology Assessment, Aug. 6, 1993, p. 39, 125; and U S. Environmental Protection Agency,** *National Air Pollutant Emission Estimates 7940-7989* **(Research Triangle Park, NC: March 1991)**

fuel oil and high-sulfur coal use, rather than the installation of post-combustion abatement equipment.

In Central Europe, gas consumption increased slightly in the 1980s, based on imports from the Soviet Union. However, in recent years, new import pricing and the industrial downturn reduced gas use in the region. Gas was used primarily in the industrial sector, with the residential sector only recently increasing in importance. Gas has not been used extensively in powerplants, except for Hungary (35 percent of fossil-fired generation) and Romania (45 percent of fossil-fired generation).

### Environmental technology options

Besides switching to low-sulfur fuels, there are many ways to reduce $SO_2$ emissions. Only the most common commercial practices are explored

here. Sulfur can be removed from the fuel before combustion through coal cleaning and desulfurization of fuel oil. Modifications can be made in combustion, or exhaust gases can be treated after combustion.

Little has been done in the region to reduce $SO_2$ emissions. Only a small amount of coal is cleaned or processed, and there is little abatement equipment in place. In Poland, only 58 of the almost 1,600 $SO_2$-emitting sources regulated had $SO_2$ abatement equipment, and only six of these had sulfur removal efficiencies greater than 90 percent. Almost half the $SO_2$ abatement equipment had efficiencies of less than 50 percent.[44] Only three powerplants in the FSU had scrubbers, and these were experimental units.

Coal cleaning can reduce the amount of sulfur in fuel before combustion. It is also the only method, besides fuel switching, to address emissions from small boilers and individual consumers in the residential sector. Although coal cleaning technologies are advancing rapidly, commercial coal cleaning can presently remove only the pyritic sulfur components found in coal, not the organic sulfur. In Polish coal, the share of organic sulfur is high (60 percent) .45 Since conventional coal cleaning can remove 30 to 70 percent of the pyritic sulfur,[46] cleaning of Polish coal would offer only a 10 to 30 percent reduction in $SO_2$ emissions. While cleaning Polish coal provides a number of benefits (e.g., reducing particulate, lowering transport needs), it does not provide a significant reduction in sulfur emissions. In Ukraine, on the other hand, coal cleaning offers a larger reduction in sulfur emissions, because a large share of the sulfur is in pyritic components. Donets Basin coal has from 60 to 75 percent of sulfur in pyrites.[47] Therefore, high-efficiency conventional coal cleaning could reduce sulfur emissions by up to 50 percent. However, since the sulfur content of Donets coal is high (from 2.5 to 3.5 percent sulfur), $SO_2$ emissions even with coal cleaning would still be much higher than EU standards would allow.

Desulfurization of fuel oil at refineries (hydrotreating) is particularly important in this region because much of the refining capacity, especially in the FSU, is based on primary distillation, which results in high shares of heavier components, such as residual fuel oil. Residual fuel oil accounted for the largest share of fuel-based $SO_2$ emissions in Russia, Belarus, Moldova, and Lithuania, and a significant share of $SO_2$ emissions in Romania. Sulfur scrubbers can be used to reduce $SO_2$ emissions, but fuel oil-consuming plants are usually dual-fired, using natural gas when it is available in the summer, which reduces the economic effectiveness of installing abatement equipment.[48]

Several technologies reduce $SO_2$ in the combustion process. Fluidized-bed combustion (FBC) employs a circulating bed design to capture almost 95 percent of the sulfur (compared with 85 percent capture in deep-bed designs, and 60 percent in shallow-bed designs) .49 The circulating bed also has the best performance in reducing $NO_x$ emissions. In the FSU, some FBC boilers have been installed in industry, and a 135-megawatt (MW) bubbling-bed utility version has been under development, using coal from the Kansk-Achinsk region of Siberia.[50] This project, however, does

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[44] *Ochrona Srodowiska 1992*, p. 152.

[45] Robert A. Meyers, *Coal Desulfurization* (New York, NY: Marcel Dekker, 1977), p. 4.

[46] DOE, *Energy Technologies and the Environment*, p. 13.

[47] *Energeticheskoe Toplivo SSSR*, 2d ed. (Moscow: Energoatornizdat, 1991 ), pp. 16-17.

[48] M. A. Styrakovich and A. K. Vnukov, "Sopostavlenie ekologo-ekonomicheskoi tselesoobraznosti udleniia sery na neftepererabaty - vaiushchikh zavodakh i TETs," (Determining the Ecologic-Economic Goals for Sulfur Abatement, Refineries and Cogeneration Plants), *Teploenergetika*, *No. 12, 1989*, p. 39.

[49] International Energy Agency, Emission *Controls* i, *Electricity Generation and Industry* (Paris: OECD/IEA, 1988), p. 72.

[50] Jon Cohen, "The Soviet Power Industry Opens Its Doors," *EPRI Journal*, vol. 15, No. 2, March 1990, p. 34.

not have much potential for reducing sulfur emissions, because Kansk-Achinsk coal is a low-sulfur lignite. Another combustion modification currently being explored is furnace sorbent injection. This technology injects a dry sorbent (usually lime) into the furnace, where it reacts with sulfur and forms solid particles, which can be collected by the particulate control device. While $SO_2$ removal can be up to 65 percent, this still might not be sufficient to meet regulations.[51]

Flue-gas desulfurization (FGD), a post-combustion $SO_2$ removal technology, is the most widespread method in the West. FGD systems use a sorbent to react with and scrub sulfur directly from flue gas. A 90-percent reduction or more of $SO_2$ is common with wet scrubbers. The disadvantages of wet scrubbers include space and energy requirements and relatively high retrofit costs. An additional problem is the high-volume of byproduct.[52] The choice of FGD technologies often depends on waste-disposal regulations. The spray dryer FGD is the second-most-common system in use and has been popular in Europe. This FGD process injects lime into an absorber vessel, which reacts with the sulfur, leaving dry particles of the sulfur for collection in the particulate filter system. The advantages of the spray dryer system include lower energy losses, ease of handling the byproduct, and lower capital and operating costs.[53]

Combined $SO_2$ and $NO_x$ control systems are presently being developed. A combined approach to post-combustion cleaning would offer lower total capital and operating costs than the installation of separate equipment for control of each pollutant. The limestone-injection, multi-stage burners (LIMB) is a promising type of combustion technology designed to reduce both $SO_2$ and $NO_x$ emissions. It also reduces particulate emission levels. It is a relatively simple system and attractive for retrofit applications. LIMB should achieve reductions of 50 to 60 percent in $SO_2$ and 50 percent in $NO_x$ emissions. However, these levels of reduction might not be enough to meet standards.[54] Advanced FGD systems, which potentially reduce both $SO_2$ and $NO_x$ to compliance levels are under long-term development.[55]

FGD systems could play a role in reducing SOL emissions in some former East Bloc countries. If regulatory priorities mirror those of the West, standards will be strictest and the need for FGD greatest at large fuel-consuming units such as powerplants. The facilities best suited to the use of FGDs or similar sulfur-abatement equipment are the coal-fired powerplants in Poland, the Czech Republic, Ukraine, and Russia, and possibly the shale-fired plants in Estonia. Post-combustion removal of sulfur would probably not make sense in Slovakia or Bulgaria (powerplants are small), Hungary (coal consumption has been displaced by gas and nuclear power), and Belarus or Moldova (large powerplants have been converted to gas, and $SO_2$ emissions are from residual fuel oil at smaller facilities). In Ukraine, a new coal-fired powerplant (a 300-MW unit at Dobrotvor, on the border with Poland) received a $50-million investment grant from the German Environmental Ministry for the installation of FGD and particulate control technologies.[56] In Poland, a Dutch firm will build two smokestack scrubbers for the

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51 Jason Makansi, "Controlling $SO_2$ Emissions," *Power, vol. 137, No. 3,* May *1993,* p. 50.

52 Ibid.

53 Ibid.

54 1 bid., pp. *67-68.*

55 1 bid., p. 68.

56 "Germany to Help Provide Financing to Clean Coal-Powered Plant in Ukraine," *International Environment Reporter, vol. 15, No. 19,* Sept. *23, 1992.*

Belchatow Powerplant, and provide engineering for two others.[57] The Czech government has called for the installation of FGD equipment at the country's largest and most modem powerplant, Prunerov II, and funding has been received for this project from the World Bank, the EU, and the German government.[58]

### U.S. opportunities to transfer technology

Technologies for sulfur abatement extensively used and manufactured by U.S. firms have some advantages in the region. FGD systems in the United States can handle coals with much higher sulfur contents than their overseas counterparts.[59] This could be a significant advantage in countries with high-sulfur coal such as the Czech Republic and Ukraine. The United States also holds an edge in FBC, having the largest share of installed capacity (among International Energy Agency members) of circulating-bed plants.[60] However, Europe has greater experience in spray dryers.[61]

## | Nitrogen Oxides

$NO_x$ is a mixture of nitric oxide (NO) and $N0_2$. When combustion occurs at high temperatures—regardless of the fuel used—some nitrogen contained in the air is oxidized to NO and $N0_2$ (thermal $NO_x$). Nitrogen contained in some fuels, such as coal, is also oxidized during the combustion process (fuel $NO_x$). At stationary sources, the quantity of $NO_x$ emissions is determined by the temperature of combustion and the amount of excess air in the furnace unit. For large, pulverized-coal boilers, the highest rate of $NO_x$ emissions occurs at cyclone furnaces, followed by wall-freed units and tangential-fired boilers.[62] Cyclone furnaces are common throughout the former East Bloc. For example, Ukraine alone has 85 of these units.[63] The health effects of long-term $NO_x$ exposure are still unknown, but emissions of $NO_x$ are linked to acid precipitation and ozone formation.

The major sources of $NO_x$ emissions include cars and trucks, powerplants, and the industrial sector (from fuel use rather than industrial processes). With the advent of catalytic converters on cars, $NO_x$ emissions have decreased in many countries, even where vehicular ownership increased. For example, in the United States, $NO_x$ emissions from the transport sector as a whole fell from 9.8 million metric tons in 1980 to 7.9 million tons in 1989.64 In the former East Bloc, most $NO_x$ emissions come from industry, although most large cities experience high $NO_x$ levels due to the use of cars without catalytic converters. Moreover, the future of $NO_x$ emissions in the region is presently unclear. In many countries, the low level of private car transport has kept $NO_x$ emissions at artificially low levels. Increases in car ownership may significantly increase $NO_x$ emissions.

### *Regional Problems*

One of the difficulties in assessing $NO_x$ emissions in former East Bloc countries is that the emission statistics for thermal $NO_x$ are almost impossible

[57] "Dutch Firm to Build Scrubbers for a Polish Power Plant," *International Environment Reporter, vol. 15, NO. 8,* Apr. 22, 1992, p. z@.

[58] Stanley J. Kabala, "EC Helps Czechoslovakia Pay Debt to the Environment," RFE/RL Research Report, vol. 1, No. 20, May 15, 1992, P. 55; "Czech Government Accepts German Grant to Install ScrubberSat Coal Plants in North," *International Environment Reporter, vol. 15, No. 24, Dec. 2, 1992;* "World Bank Approves Loan to Cut Power Plant Pollution," *International Environment Reporter, vol. 15, No. 12,* June 17, 1992, p. 425.

[59] Makansi, "Controlling $S0_2$ Emissions," p. 28.

[60] IEA, *Emission Controls in Electricity Generation and Industry,* p. 73.

[61] Makansi, "Controlling S02," p. 46.

[62] IEA, *Emission Controls* in *Electricity Generation and Industry, p. 65.*

[63] "US, Ukraine, and *Russia* to Produce New 'Reburn' Technology," *Environmental Watch, East Europe, Russia & Eurasia,* vol. 1, No. *4,* November 1992, pp. 6-7.

[64] EPA, *National Air Pollutant Emission Estimates 1940-1989, p.* 21.

TABLE 5–3: Emissions of Nitrogen Oxides ($NO_x$)

| Country | Kg/per capita | Main sources |
|---|---|---|
| Czech Republic (1988) | 83 | Stationary sources 75%<br>Mobile sources 25% |
| Romania (1990) | 39 | Not available |
| Poland (1990) | 36 | Stationary sources 67% (half from powerplants)<br>Mobile sources 33% |
| Slovak Republic (1988) | 37 | Stationary sources 80%<br>Mobile sources 2570 |
| Bulgaria (1985) | 34 | Not available |
| Estonia (1989) | 31 | Stationary sources 55%<br>Mobile sources 45%. |
| Hungary (1988) | 24 | Stationary sources 55%<br>Mobile sources 45% |
| U.S (1989) | 80 | Stationary sources 60%<br>Mobile sources 401%0 |

Other countries with reported emm.ions. Kazakhstan (1989) 22;[a] Ukraine (1 989) 21, Lithuania (1 989) 21, Russia (1989) 19;[a] Moldova (1989) 19; Belarus (1989) 10;[a] Latvia (1989) 5

[a]Mobile-source data not included.

SOURCES R C Cooper, "Environmental Problems and Pollution Abatement in Central and Eastern Europe," contractor report prepared for the Office of Technology Assessment, Aug 6, 1993, p. 39, 125, and U S Environmental Protect Ion Agency, *National Air Pollutant Emission Estimates 1940-1989* (Research Triangle Park, NC: March 1991)

to verify. Furthermore, for many former Soviet republics, no data on mobile-source emissions by specific pollutant have been reported.

To calculate mobile-source $NO_x$ emissions, a large data base containing information on gasoline consumption, engine efficiency, operating conditions, miles driven, emissions, and other factors for many categories of transport modes is needed. However, most of this data have not been tracked, recorded, or reported.

Therefore, the emission figures in table 5-3 must be approached with some caution. Although the Czech Republic again tops the list of polluters, the density of $NO_x$ emissions in the Czech Republic was very similar to that of the United States. However, stationary sources play a much more important role in $NO_x$ emission in the Czech Republic than they do in the United States.

### Environmental technology options

**Combustion** modifications were the first methods employed to reduce $NO_x$ emissions in the West. Originally used to reduce mobile-source emissions, they are now used almost exclusively on stationary sources. The success of combustion modification methods depends on the type of furnace and burner. In general, wall- and tangentially fired units are easier to retrofit for low-$NO_x$ burners than are cyclone furnaces. In the cyclone units common to the FSU, fuel reburning is thought to be the only option to reducing $NO_x$ emissions during combustion.[65]

[65]Ibid.

For post-combustion $NO_x$ removal, selective catalytic reduction (SCR) has been the primary commercialized technology. While SCR technology is much more efficient than combustion modification in removing $NO_x$ (as high as 90 percent removal, compared with approximately 50 percent for combustion modification), SCR systems have high operating and capital costs compared with combustion modification.

A second, recently commercialized technique for removing $NO_x$ from flue gases is selective, noncatalytic reduction (SNCR). This system has lower costs and lower $NO_x$ removal efficiencies (about 50 percent) than SCR.[66] Also, SCNR is extremely sensitive, and additional $NO_x$ can form if temperatures are too high. Another problem preventing widespread use of SNCR is that some NO is converted to $N_20$, a greenhouse gas.

Advanced generation technologies, such as high-efficiency gas turbines, also emit $NO_x$. Injection of steam from the exhaust boiler into the gas turbine burner can be used to control $NO_x$ emissions from the basic gas turbine. Conventional $NO_x$ control techniques, such as combustion control, SCR, or SNCR can also be employed.

### U.S. opportunities to transfer technology

The primary advantage of U.S. firms in reducing $NO_x$ emissions at stationary sources is reburn technology, which can reduce $NO_x$ emissions by up to 50 percent. Reburning is an in-furnace technique for reducing $NO_x$ by creating a reducing zone downstream from the primary combustor. The injection of natural gas into the reducing zone with insufficient oxygen bums the fuel completely. A demonstration project to retrofit a powerplant boiler at the Ladyzhin PowerPlant (located in Ukraine, 150 kilometers southeast of Kiev) with U.S. reburn technology was sponsored by the U.S. Environmental Protection Agency, working with ABB Combustion Engineering (Windsor, Connecticut). While retrofitting was very labor-intensive, this factor was not a deterrent in Ukraine, where wages for skilled workers are very low. Reburn technology was also the cheapest method for retrofitting cyclone boilers.[67]

In post-combustion $NO_x$ removal, however, the United States is at a disadvantage. While SCR has been commonly used in gas-turbine cogeneration and combined-cycle systems in the United States, the first full-scale utility applications (one coal-fired, one oil/gas-fired powerplant) are just starting up. Meanwhile, tens of thousands of megawatts of fossil-fired boilers are operating with SCR in Japan and Europe.[68]

## | Other Pollution Problems

Hundreds of other pollution problems are noted during fuel combustion. Principal among them are hydrocarbon, carbon monoxide, and lead emissions and photochemical smog formation. Motor vehicle traffic is a major source of these problems.

There are relatively few trucks in the FSU compared with the United States,[69] but the potential for expanding truck transport in the former East Bloc is substantial. Under almost any scenario of economic development, trucks will play a much greater role in freight transport, particularly if regions, industries, and consumers have more autonomy in the production and purchase of goods.

The pattern of passenger transport in the region varies from other industrial countries, as well. Passenger transport has been dominated by collective carriers (buses and trains), although private vehicles have started to make inroads. By

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[66] IEA, *Emission Controls in Electricity Generation and Industry*, p. 67.

[67] Ibid.

[68] Makansi, "Controlling $SO_2$ Emissions," p. 22.

[69] While Statistics are unclear, it appears that in the late 1980s there were 5.4 million trucks in the Soviet Union, compared with 40 million in the United States. See Vavilov, "Vce krugi chada," *Energetika, ekonomika, tekhnika, ekologiia, No. 10, 1989.*

Western standards, there are very few private cars in the FSU.[70] In Central Europe, car ownership levels are higher, but vary significantly.[71] There is tremendous potential for motor vehicle usage to increase rapidly if market conditions permit.

As noted earlier, data on emissions from mobile sources are insufficient to perform a detailed analysis at this point. Even given the scant data, it appears that emissions are quite high, despite the low level of truck transport and private car ownership. For example, in 1987 for the Soviet Union as a whole, hydrocarbon emissions from mobile sources were at 90 percent of U.S. levels for mobile sources. Carbon monoxide was at 65 percent, and $NO_x$ was at 25 percent,[72] even though the U.S. had almost eight times the number of cars and three times the amount of freight haulage (measured as ton-kilometers) by trucks.

Emissions control equipment on cars manufactured in the region has been minimal. Very few vehicles manufactured in the FSU were equipped with catalytic converters, owing in part to shortages of platinum and palladium and the low production levels of unleaded gasoline.

### Environmental technology options

Most domestic auto industries, in joint ventures with Western firms, are shifting to production of cars with catalytic converters. But due to financial constraints and the lack of unleaded gasoline, it is not clear how rapidly these new vehicles will penetrate the market. The problem of the highly polluting existing car fleet will remain for many years because cars are typically held and operated for much longer periods of time in former East Bloc countries than in the West. Therefore, an important engine emission control system under development for retrofit to four-stroke engines is the lean combustion system. This system uses a microprocessor with a lean-mixture sensor, and works to ensure the leanest fuel mixture under varying engine loads. This system not only reduces emissions, but it also increases overall fuel efficiency. Recentl y, a Maryland firm won a patent for its lean-bum design, which can be retrofitted to pre-1980 cars and trucks.[73] While emission reductions with lean-bum technology are not as large as with catalytic converters, lean bum technology could play an important role in reducing automotive emissions in the region.

### U.S. opportunities to transfer technology

Opportunities to transfer U.S. mobile source emissions abatement technologies are limited in former East Bloc countries. U.S. firms face stiff competition from European and Japanese firms that have significant manufacturing capacity and technical expertise. Also, vehicle emissions are not likely to be a pressing concern in former East Bloc countries because of the present low level of car ownership. Moreover, it is likely that emissions control technologies, such as catalytic converters, will be tied in with the automobile manufacturing process.

## OUTLOOK FOR U.S. TECHNOLOGY TRANSFER

U.S. abatement equipment manufacturers are well positioned to meet some regional needs (see table 5-4). Specifically, U.S. suppliers could supply the

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[70] In 1990, for the Soviet Union as a whole, there were only 50cars per 1,000 people, compared with over 250 in Japan, 440 in the FRG, and nearly 600 (including personal light trucks) in the United States. See Goskomstat, *Transport i sviaz'* (Moscow: Informatsionno-izdatel 'skii Tsentr Goskomstata, 1991 ).

[71] Car ownership levels have been highest in the former Czechoslovakia(219 cars per 1,000 people), followed by Hungary (202), and Poland ( 155),

[72] E. Iu Bezuglaia, G.P. Rastorgueveva, I.V. Smironova, *Chem dysit promyshlennyi gorod* (How Do Industrial Cities Breathe) (Leningrad: Girdrometeoizdat, 1991), p. 219.

[73] Warren Brown, *. Carburetor Device May He]p Mexico Clean Up Its Air," *Washington Post*, Washington Business Section, June 28, 1993, p. 9.

TABLE 5-4: Summary of Potential U.S. Equipment and Expertise Needs, by Energy Complex

| Country | Environmental equipment or expertise needed |
|---|---|
| All countries | Monitoring equipment, air and water purification systems for refineries, low-sulfur residual fuel oil production, unleaded gasoline production, low $NO_x$ combustion modifications, lean-burn, mobile-source reductions. |
| Russia | Offshore drilling expertise, arctic operations and equipment reclamation of mined areas, ESPs or baghouse filters. |
| Ukraine | Coal reclamation, acid mine drainage abatement, coal cleaning, FGD for powerplants (when operated on coal year-round), ESPs or baghouse filters for particulate removal. |
| Kazakhstan | Coal reclamation, ESPs or baghouse filters for particulate removal. |
| The Baltics | Reclamation of shale areas (Estonia), abatement equipment to reduce particulate and sulfur dioxide emissions from shale combustion. |
| Poland | Control of saline discharge from mines, reclamation of tailing piles, coal cleaning, FGD at large power plants, ESPs or baghouse filters for particulate removal. |
| Czech Republic | Reclamation of surface mined areas, coal cleaning, FGD at large powerplants, ESPs or baghouse filters for particulate removal. |
| Slovak Republic | Coal cleaning. |
| Hungary | Coal cleaning. |

**SOURCE: R.C Cooper, "Environmental Problems and Pollution Abatement in Central and Eastern Europe," contractor report prepared for the Office of Technology Assessment, Nov. 9, 1993.**

needs for FGD units, electrostatic precipitators, baghouse filters, reburn technology for low-$NO_x$ combustion, lean-bum technology for mobile sources, desulfurization equipment for refineries, and coal cleaning and improved mining techniques. U.S. firms have had a significant amount of experience in a range of activities that are needed to produce fuels with less environmental damage and to mitigate the damage that has already occurred. For instance, the sensitive tundra ecosystem in Russia could benefit from some of the lessons learned in Alaska. U.S. mining firms also have more experience dealing with acid mine drainage than does any other country in the world, as well as extensive experience in land reclamation.

However, unlike energy supply investments, most environmental improvements are diffilcult to finance because they produce no direct revenue stream. FGD systems might be of interest to avoid future fines, but much of the electricity in the former East Bloc is still sold at low rates, leaving the power company without means to invest. Thus government export financing may be necessary. However, the transboundary effects of some pollutants ($S0_2$ and $NO_x$, in particular) mean that Western European countries are more impacted by pollution coming from the region than the United States is. Western Europe thus has additional incentive to offer financial and technical support to address these issues.

In addition, U.S. regulatory standards and the phase-in periods for the Clean Air Act have put U.S. firms that supply pollution abatement equipment at a competitive disadvantage in the region. The EU standards to which many countries in the region aspire are, in general, stricter than U.S. standards, giving European (and Japanese)

manufacturers of abatement equipment a market advantage. Because of differences in regulatory framework, European and Japanese firms have much more experience in retrofit designs and equipment for powerplant abatement equipment than do U.S. firms. For example, while U.S. low-$NO_x$ combustion modifications provide a low-cost means of reducing $NO_x$ emissions, the reductions are not enough to meet upcoming EU standards. Differences in regulatory regimes have resulted in higher prices for some U.S. domestic equipment as compared with other countries. For example, the allowance for some operational downtime of control systems due to failure, as in Germany and Japan, lowers FGD system costs in comparison with the United States, where no period of nonattainment is allowed, and systems must be built with additional redundancies.[74]

Environmental technology transfer is also plagued by a number of problems in former East Bloc countries. These include the lack of experience in regulatory enforcement, the uncertain results of economic reform, the costs of environmental technologies, and the number of other pressing environmental problems not directly related to energy.

Lack of regulatory enforcement will delay environmental reform. Enforcement is being postponed in part by the need first to develop new environmental laws and regulations.[75] But the enforcement problem also stems from overlapping and uncertain authorities among ministries, as well as competition between republic-level and local authorities.[76]

The uncertain path of regulatory reforms reduces the incentives to install abatement equipment. Even in the Czech Republic, where regulatory reform has been greatest, there is little incentive. For example, under the new environmental law in the Czech Republic, annual pollution fees for a 1,000-MW powerplant will rise steadily from 80 million to 200 million korunas ($2.4 million to $6 million), but the installation of abatement equipment would cost 12 billion korunas ($360 million) .77 In this case, the fee for pollution is smaller than interest on a loan to install a scrubber and particulate removal device.

Abatement will be very expensive throughout the region. Although labor and material costs might be lower, the capital requirements for abatement control emission, particularly for air purification, are high. For example, the costs of FGD alone for a 1,000-MW coal-fired powerplant (in the United States) would be $170 million. Adding particulate removal equipment would bring this figure to over $300 million.[78] Assistance would be needed not only for capital investments, but also for operations and maintenance ($60 million for the annual operation and maintenance of the above-noted FGD system), because electricity rates are presently too low to generate sufficient revenue to support abatement programs.

Another issue is how to plan environmental protection for an economy in transition. In addition to the immediate difficulties of financing and currency convertibility, these countries must design environmental regulation for a mix of economic activities that have no historic basis in the region. While $NO_x$ and hydrocarbon emissions are not a significant concern at this point, ownership levels of private cars can increase quite rapidly, which could present new abatement requirements for both mobile and stationary sources. Further, a large share of the technology transfer needs identified in chapter 3 to stimulate fuel production have environmental impacts of their own. New types of drilling muds might re-

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[74] IEA, *Emission Controls in Electricity Generation and Industry*, p. 125.

[75] Bowman and *Hunter*, "Environmental Reforms in Post-Communist Central Europe," p. 972.

[76] Ibid., pp. *972-73.*

*77.* Genera]* Environmental Law Adopted *by* Federal Parliament, *International Environment Reporter*, Jan. 15, 1992, p. 8.

[78] IEA, *Emission Con fro/s in Electricity Generation and Industry*, p. 111.

quire different containment linings; increased remote sensing and exploration could damage pristine regions; increased drilling and production from offshore sites could result in increased spills; and coal cleaning wastes need reclamation and proper disposal systems.

The pace of economic reform is also an important aspect of pollution planning. For example, coal production from the Donets basin has long been subsidized by the Soviet, and now Ukrainian, government. The Donets basin produces a high energy value coal (although it is also high in sulfur and ash) and is located near the sources of demand. However, mines must now penetrate deeper, to less economical portions of the basin. Production costs and incremental capital requirements are very high, and production has been falling. The Ukrainian government will need to decide whether to invest billions of dollars in sulfur scrubbers for powerplants that currently use Donets coal, or to shut mines and purchase natural gas from Russia or Turkmenistan. Until subsidies are removed throughout the economy (resulting in large energy savings) and some sort of safety net is established to mitigate labor dislocations, the signals for environmental technology will be adverse.

Finally, it is unclear whether the pollution from fuel production, processing, transportation, and consumption is the most pressing environmental problem in some countries in the region. For example, Belarus and Ukraine still have to face the long-term consequences of the Chernobyl accident. Toxic and hazardous waste disposal has resulted in extremely dangerous environmental conditions. Many areas do not have safe drinking water. Also, in the FSU, since fuel production, particularly of oil and gas, usually occurs away from population centers, it is difficult to correlate the impact of fuel production on human health. Instead, it is the health of surrounding ecosystems that is at risk, but the economies of the region might not be able to afford such protection in the short term.

## CONCLUSIONS

At present, economic, scientific, and regulatory uncertainties make specific recommendations for U.S. involvement in the transfer of environmental technology and expertise to the energy sector difficult. Serious consideration should be given to projects that will play a significant role in protecting human health, which means thinking primarily about pollution at the ground level (low stacks and mobile sources). The Environmental Action Programme (EAP),[79] a product of the collaborative efforts of Western governments and multilateral organizations, has recommended that health and productivity costs be used as guiding priorities for environmental policy formulation and for investment in environmental cleanup.

Perhaps the best way to reduce the impacts of fuel production, processing, and transportation, is to plan environmental protection as part of the transition to a market economy. Environmental mitigation needs to be encompassed in all new Western activities in the region, from coal cleaning operations to offshore drilling activities.

Finally, it is important to remember that environmental problems cannot be addressed without considering the wider context of the economies in transition. Environmental problems are linked to a host of issues that must be addressed in the near future: investment and industrial policy, energy policy, subsidies, unemployment, and privatization. Examining environmental problems in isolation from economic and social policies will result in misguided and ineffective programs.

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[79] The Environmental Action Programme for Central and Eastern Europe is based on the principles and priorities outlined at the Ministerial Conference "Environment for Europe," which took place in Lucerne, Switzerland, in April 1993. The report outlines a broad strategy for environmental reform in the region and is based on studies funded jointly by the governments of the Netherlands, Switzerland, Denmark, the United States, Germany, Italy, the United Kingdom, the European Union Commission, OECD, and the World Bank.

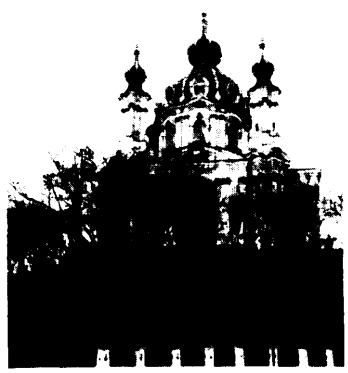
# The Political, Economic, and Social Context of Reform

6

Economic reform in the societies of the former East Bloc is a tremendously complex process. The post-Communist transition is not just a process of economic restructuring and modernization-the reforms under way involve fundamental changes in the political and social orders of the societies of the former East Bloc. The relationship between economic reform and energy technology transfer is an interactive one. Although the introduction of new energy technologies can facilitate reform, undue slowness in economic restructuring can undermine the effectiveness of energy technology transfer. Without the adoption of market structures and business practices, the modernization of facilities, technologies, and techniques in the production and consumption of energy will be extremely difficult.

To understand the prospects for economic and energy sector reform, especially in the former Soviet Union (FSU), we must consider the larger context in which the transition from Communist authoritarianism is taking place. This transition involves several distinct but closely interrelated processes: the conversion to capitalist economies, sectoral economic restructuring, the establishment of democratic political orders, the design of a new set of state institutions to regulate political and economic relations, the implementation of new methods of social protection, and the development of the broader "cultural" changes necessary for successful transition from Stalinist dictatorship to market democracy.

Of all these processes of transformation, the most important change is the establishment of a new political order that embodies a popular consensus about the need for economic reform. Without" a stable and popularly recognized political order it is difficult to achieve popular consensus and then to translate it into political



ALAN T. CRANE

*St. Andrew's Church, Kiev, Ukraine.*

action on questions of economic reform. Governments that attempt to move too quickly without substantial popular and political support for their programs run the risk of failure. As economist Stanley Fischer has observed, "[T]he pace of reform cannot get too far ahead of its political base."[1]

Democratization may not be an absolute prerequisite to the establishment of this popular consensus and the enactment of an effective economic reform program. However, it is not surprising that the Central European countries, which have moved most quickly to replace old Communist-era political structures with new constitutional orders and popularly elected governments, have also made the most progress in pursuing economic reform. Other former East Bloc countries, where there is less popular consensus about reform and which have yet to consolidate new political structures, have moved much more slowly and less successfully to stabilize their economies and lay the foundations for a new economic system. The result has been a multi-tiered portrait of reform in the region, with three groups of countries at different levels of transformation.

As chapter 8 will discuss, it is important for U.S. policymakers to consider a country's progress toward reform, because the degree of success in economic and political restructuring will affect the appropriateness of U.S. policy. In particular, assistance for those countries that have made the least progress toward reform will be most useful if it emphasizes policy changes, while the more advanced countries can benefit more from development assistance. Similarly, trade and development programs may be more effective and appropriate in promoting U.S. goals in those countries that have already made substantial progress in reform.

## THE VANGUARD: COUNTRIES IN THE FIRST TIER OF REFORM

Poland, the Czech Republic, and Hungary occupy the first tier of reform. They were the quickest to establish a political consensus on the need for democratic and market transformations and to translate this political will into effective mechanisms for the implementation of reform programs. They can assimilate the broadest range of U.S. programs in the region.

### | Historical and Political Background

The Poles, Czechs, and Hungarians moved so quickly and decisively for several reasons, among the most important of which is their historical legacy. Between World War I and World War II, these countries were politically independent, operated functioning (though problematic) representative constitutional orders, and had market-based economies. The memory of this period has been strong, providing a base of experience in the operation of participatory political institutions and market economies, as well as previously tested models for reform.

Another factor in the rapid pace of economic reform in Poland and Hungary is the fact that their economies were never fully "sovietized." Polish agriculture remained, for the most part, in private hands. Hungary developed a strong semiprivate service and small-scale manufacturing sector that has been an important factor in economic transition. Also, an underground economy thrived in both countries.

The close proximity of the Polish, Czech, and Hungarian lands to Western Europe also provided an impetus for reform.

[1] Stanley Fischer, "Socialist Economy Reform: Lessons of the First Three *Years,''AEA Papers and Proceedings, vol. 38, No. 2* (May 1993), p. 393.

Finally, the geographically small and ethnically homogeneous nature of these countries has bolstered efforts to break decisively with Communist-era institutions and policies (perceived as having been forced upon the area from outside), promoted social stability, and facilitated the construction of representative political institutions.[2]

## | Poland

Poland launched the earliest, most radical, and to date, the most successful reform program. Under "shock therapy," the state drastically cut subsidies to industry, placed strict controls on the budget, checked the inflationary growth of wages, and raised interest rates. Backed by an International Monetary Fund-sponsored currency stabilization fund, the government devalued the zloty and introduced currency convertibility. Simultaneously, Poland started the process of privatization. Finally, prices were freed and laws on foreign trade and investment were liberalized to encourage capital investment and export activity.

The initial costs of the Polish program were quite high: industrial output declined initially by 24 percent, and unemployment, almost nonexistent in Communist times, shot up to 15.7 percent by the end of 1993. However, inflation, which had reached 2,000 percent in late 1989, is currently running at about 35 percent.[3] After several years of economic contraction, Poland's gross domestic product (GDP) rose in 1992 by 1 percent, and industrial production expanded by 4.2 percent-the first economic growth in any post-Communist country. In 1993, Polish GDP grew by 4 percent.[4]

Even more important are the structural changes the Polish economy has experienced. The private sector is now the engine of Polish economic growth. Although privatization of large-scale industry is just beginning in earnest, almost all small-scale retail business and most medium-sized enterprises have been privatized. Employment in Poland's non-agricultural private sector, which accounted for only 13 percent of the work force in 1989, has expanded to 45 percent. And, in 1992, the expansion of private employment (500,000 jobs) completely compensated for the loss of state-sector jobs. Private employment now constitutes almost 60 percent of the total Polish work force.[5]

Nevertheless, the nature and speed of Poland's transition have produced political problems. Although the country appears to have turned the economic comer, and significant numbers of Polish citizens have prospered under the new program, large portions of the population, especially senior citizens and the hundreds of thousands of workers still employed in unreformed sectors of the state economy, have suffered and face uncertain futures.

During 1992 and 1993, dissatisfaction with the disproportionate benefits of economic reform, and nostalgia for the social protections provided by the previous state-sponsored economy, fueled resistance to the reform program in Poland's politically fractured parliament In May 1993, President Lech Walesa dissolved parliament after the reformist government of Hannah Suchocka lost a no-confidence vote to Solidarity-led forces demanding pay and pension increases. In elections in September 1993, a coalition of ex-Communist and peasant parties came into power.

Although these post-Communist parties campaigned on a populist, antireform platform, they

2 Czechoslovakia split apart because Of the ethnic division between Czechs and Slovaks and the more radical approach to economic reform advocated by the more economically advanced Czech lands of Bohemia and Moravia. Although the split entailed large economic and social costs, the Czech Republic is now freer, as a result of the breakup, to pursue a program of radical economic change.

3 Organization for Economic Cooperation and Development, *Regional Development Problems and Policies in Poland* (Paris: 1992), p. 19; FBIS, *Eastern Europe Report*, *FB1S-EEU-94-021* (Feb. 1, 1994), p. 9.

4 *RFE/RL Research Report, vol. 2, No. 32* (Aug. 13, 1993), p. 43; FBIS, *Eastern Europe Report,* FBIS-EEU-94-021-A (Feb. 1, 1994), p. 8.

5 "'Poland Stays the Course Despite Political Turmoil," *RFE/RL Research Bulletin, vol. 10, No. 17* (Sept. 7, 1993), p. 1.

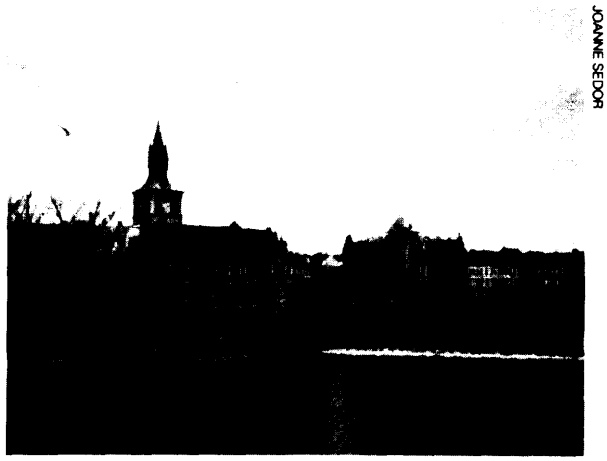
have been moderate in their legislative plans. The new ruling coalition has raised taxes on entrepreneurs and increased spending to mitigate social hardships. But a retreat on the core issues of economic reform is unlikely because all parties know that critical international financial support for Poland would dry up if the country pursued fiscally irresponsible policies. In fact, in late December 1993, Prime Minister Pawlak stated that despite campaign pledges to reverse the economic policies of the previous government, his government would continue the economic policies instituted by its predecessors.[6] In March 1994, the new coalition passed a fiscally conservative 1994 budget that limits the deficit to 4.1 percent of the GDP.

### *Prognosis for Reform*

Poland is well on the way to market reform. So much progress has already been made in restructuring and stabilizing the economy that many observers feel that the country has passed the point of no return. The biggest threat to continued success in economic transformation is political backsliding in the legislature. But even this potential reaction against reform would only delay economic progress, not reverse the course of reform.

## Czech Republic

The Czech economy, which once was one of the leading industrial powers of Europe, has been very responsive to change. The Czech Republic entered into a program of fiscal austerity and shock therapy and in some ways enjoys better economic conditions than Poland. In 1992 and 1993, it had the lowest regional inflation rate. Its per capita indebtedness is much lower than that of Poland or Hungary. The country ran a $268 million trade surplus in 1993. Unemployment stood at just 3.5 percent at the end of 1993. Monetary policy has been tight, the koruna has maintained its value against Western currencies, and the Czech banking system is the most highly developed in the region. Virtually all consumer service enterprises have been privatized, mostly through private sales and auctions.



JOANNE SEDOR

*Vltava River, Prague, Czechoslovakia*

Due to a more cautious approach toward economic transformation, however, the Czech economy has not experienced the expansion that Poland has. Moreover, several political and economic shocks have hindered progress. First, the economy suffered a severe shock from the division of Czechoslovakia into two countries.[7] Further, a national value-added tax, introduced in January 1993, had a greater-than-expected effect on the inflation rate, which ran at 20 percent in 1993, compared with 11 percent in 1992. GDP fell by 7 percent in 1992 but remained steady during 1993. Industrial production fell by over 5 percent during 1993.[8] And finally, despite levels of unemployment that are among the lowest in Europe, economists suspect that levels of real underemployment and unemployment are higher.

The Czechs are counting on privatization as the basis of economic transformation. Privatization is particularly important in the Czech Republic be-

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[6] *RFE/RL Daily Report* (Dec. 30, 1993).

[7] GDP dropped by 2.3 percent in the first quarter of 1993. *Financial Times*, Aug. 6, 1993, p. I I.

[8] *RFE/RL Research Report*, vol, *3,* No. 1, Jan. *7, 1994,* p. 73. *RFE/RL* Daily *Report*, Aug. 19, 1993; *The Economist,* Dec. 18, 1993, *p. 58.* FBIS, *Europe Economic Review*, Nov. 16, 1993.

**cause,** unlike its neighbors, the Czech private sector was virtually nonexistent during the Communist era. The Czechs have undertaken two ambitious and innovative waves of privatization, involving 1,500 state firms, based on the distribution of privatization vouchers to all Czech citizens. By distributing vouchers to all adults, the Czechs solved two problems. They created a capital market where there had been very little liquidity, and they gave each citizen a chance to participate in the privatization process. The Czechs' voucher scheme was the first of its kind and is serving as a model for privatization in Russia.

Although privatization has proceeded more slowly than planned, it has produced substantial results. Over 50 percent of the country's 10 million citizens have bought shares. By the end of 1993,60 percent of the country's large enterprises had been privatized. The Czech private sector accounted for almost half of 1993 GDP and 23 percent of total employment.[9]

Yet there are questions about the privatization process and the depth of change in the Czech economy. High-pitched speculation in vouchers and unrealistic promises about returns on investment funds may have created serious financial risks. If large investment funds are unable to fulfill their high-yield promises, the government may have to step in to restore liquidity to capital markets or bail out bankrupt funds. This would place severe stress on the state budget and slow economic recovery. Economists are also concerned about high levels of inter-enterprise debt and the fact that one-third of all privatized enterprises are in de facto bankruptcy.

### *Prognosis* for Reform

Despite the tremendous political and economic shocks of the past two years, the Czechs have made substantial progress in introducing structural and institutional change, as well as stabilizing the economy. Czech entrepreneurism has shown new vibrancy in an energetic private economy. Like Poland, the country has laid a firm basis for future growth.[10] Potential short-term setbacks in the areas of privatization and finance should not threaten the success of long-term transformations already well under way.

## Hungary

Although Hungary was at the forefront of Central European economic reform during the Communist era, the country currently lags behind Poland and the Czech Republic. Hungary's problems are due partly to the high levels of foreign debt (at $2,000 per person, the highest in the world) that it inherited from the Communist era. The country has also suffered from the influx of 100,000 refugees from the Yugoslav civil war and the disruption of trade ties caused by the trade embargo on Yugoslavia.

But Hungary's economic problems are also caused by the choices it has made with regard to reform. Instead of launching economic shock therapy, like the Poles and Czechs, Hungary pursued a deliberately more cautious strategy, hoping to minimize the social costs of change. Precisely because there has been no economic "big bang" in Hungary, the costs of reform have been strung out and even accentuated. Hungary is experiencing many of the negative effects of economic reform without many of its benefits.

Despite a sizable private sector (estimated at 40 percent of GDP) and the highest levels of foreign investment in the former East Bloc, the economy remains in recession. A privatization program has been launched, but it is proceeding slowly, in part because Hungary has depended on foreign capital to provide funds for the privatization process and has not developed the financial structures necessary to underwrite and support the process from

[9] *RFE/RL Research Report, vol.* 2, No. 32, Aug. 13,1993, p. 50; also, vol. 3, No. 1, Jan. 7, 1994, P. 72.

[10] The Vienna Institute for Comparative Economic Studies and Commerzbank predict 3-percent GDP growth in the Czech Republic during 1994. *The Economist, Dec. 18, 1993,* p. *58.*

within the country. As a result, less than 17 percent of the 1992 work force was employed in the private sector.11

There are signs, however, of stabilization and the beginnings of economic growth. Hungarian GDP, which fell by an estimated 5 percent in 1992, may have leveled off in 1993.[12] Industrial production increased by over 3 percent in 1993.[13] Hungary's annual inflation rate remained steady at 23 percent in 1992 and 1993. Throughout 1993, unemployment hovered at about 13 percent.[14] The government tried to remedy some of its problems in 1992 with the passage of a strict bankruptcy law. And in March 1994, the government announced the Small Shareholders Program, a new mass privatization program that will lend citizens about $1,000 each to buy shares in privatized state enterprises.

The political situation is a greater cause of concern than the economy. During 1993, the government coalition, led by the Hungarian Democratic Forum (HDF), came under increased pressure from both left and right. On the left, as in Poland, thousands of pensioners and workers hurt by the economic decline demanded that the government spend more money on social protection measures. This fueled renewed support for the Hungarian Socialist Party (HSP), the successor to the Communists, which, in alliance with trade unions, advocated a social-democratic type program,

On the political right, an increasingly nationalistic tone in Hungarian politics manifested itself in exchanges of criticism with Slovakia and Romania over the status of Hungarian minorities living in those countries. The emergence of Istvan Csurka, a right-wing politician pressing for policies more favorable to "native Hungarians," may further inflame tensions within the country and with Hungary's neighbors.

The country's economic ills and political troubles reduced support for radical reform in the parliament. Political maneuvering in preparation for 1994 general elections and government disputes with the independent media also impeded efforts to push ahead more aggressively with restructuring. One of the major issues of the 1994 Parliamentary election was the proper balance between the requirements of economic transformation and the need to provide social protections to the many people adversely affected by the reforms.

In the first round of elections in May 1994, the HSP led with one third of the vote. The HDF came in third with only 12 percent. The HSP is likely to form a governing coalition when the elections are complete.

### *Prognosis for Reform*

Despite Hungary's problems, the country's emerging market economy and high engagement with foreign investors place it firmly within the vanguard of regional economic reform. Like both Poland and the Czech Republic, Hungary is building a sound legal and institutional infrastructure for long-term economic growth.[15] The victory of ex-communists at the polls may further complicate reform, but is unlikely to undermine progress already made.

## SLOW REFORMERS: COUNTRIES IN THE SECOND TIER OF REFORM

Kazakhstan and Russia occupy the next tier of reform. Whereas the Central European states have

11 *RFE/RL Research Report,* Aug. 13, 1993, p. 52.

12 The size of Hungary's black market, estimated at about one-quarter of GDP, makes it difficult to measure GDP exactly. In January 1994, the country's finance minister announced that economic growth had finally begun. *Financial Times,* Jan. 19, 1994, p. 2.

13 FBIS, *Europe Economic Review,* Dec. 28, 1993, p. 50.

14 *RFE/RL Daily Report,* Dec. 28, 1993.

15 Commerzbank predicts 1 percent *GNP* growth for 1994. *The Economist,* Dec. 18, 1993, p. 58.

established new political orders and have embarked on programs of radical economic reform, the course of change has not yet been decisively resolved in Almaty or Moscow. This indecisiveness over reform will limit U.S. policy options, making it more difficult to promote reform and energy sector modernization simultaneously.

## | Historical and Political Background

Kazakhstan is a Central Asian country with no legacy of prior independence. The second largest republic of the FSU, Kazakhstan is an ethnically diverse country in which only 40 percent of the population is native Kazakh, while 38 percent of its citizens are ethnic Russians. The population is also differentiated geographically and occupationally, with Russians concentrated in the northern part of the country in industrial, scientific, and administrative positions. Ethnic Kazakhs are concentrated in the south and are more heavily represented in agriculture, health care, and other lower paying sectors of the economy.

Under Soviet rule, Kazakhstan was industrialized (though not to the extent of the Slavic republics), and its economy was closely integrated into the Soviet system. Both Kazakhstan's industry and agriculture are oriented toward and heavily dependent upon the other republics of the FSU, especially Russia, for markets and for supplies of raw materials and manufactured goods. However, Kazakhstan's huge reserves of oil and minerals make the country an attractive prospect for foreign investment and economic development.

Soviet Russia saw itself as the rightful inheritor of the empire built by the tsars and remained the center of the Soviet multinational state.

Russia was also the center of Soviet economic development. Although Moscow pursued economic policies that made the republics highly dependent upon one another for supplies of raw materials and manufactured goods, Soviet economic policies favored the European portion of the country, which was consistently better supplied with goods and which experienced higher and more integrated forms of economic development. Other regions-especially the non-Slavic areas and much of Siberia-were often over-exploited for one product such as oil and were turned into economic dependencies, supported by subsidies and material aid from the center.

When the Soviet Union broke up, this complex system of economic inter-relations was tom apart, leaving 15 separate countries with highly interdependent economies based on economically irrational systems of pricing, distribution, and manufacture. Although Moscow is no longer the center of the Soviet empire, it is still by far the most important economic and political entity in the FSU. While the Central European countries may already be too far advanced economically and too independent politically for events in Russia to seriously threaten their stability, the nature of Russian economic reform and the battles over Russia's future are of crucial importance to all the other countries in the region. A successful, comprehensive, and peaceful transition to a market economy and representative democracy in Russia could greatly facilitate similar processes in all the remaining countries of the FSU. Conversely, the failure of Russian economic reform or continued "muddling along" could promote economic and political instability, not only in Russia, but among all of its neighbors.

## I Kazakhstan

Independence has come hard to Kazakhstan. The country faces two major sets of problems: an economy still highly integrated into the FSU and suffering from the disintegration of inter-republic economic ties, and the conflicting political interests of newly emergent Kazakh national forces and the large contingent of ethnic Russian residents. The country's president, Nursultan Nazarbaev, has pursued a delicate economic and political balancing act, seeking to introduce economic reform and establish a multi-ethnic state while maintaining economic and political stability.

The breakup of the Soviet Union and the economic instability of Russia have had devastating effects on the Kazakhstani economy. Still highly dependent upon Russia for markets for agricultur-

al and manufactured products, the economy has contracted as markets and sources of supply have dried up. In 1993, Kazakhstan's GDP fell by 15 percent. [16] This decline, combined with rapidly escalating energy prices and ruble instability, has contributed to a soaring inflation rate—about 1,500 percent in 1992 and about 30 percent per month in 1993. '7

Progress toward reform has been slow. Most prices have been freed, but subsidies remain for some items, especially food and energy products. Substantial progress has been achieved in enacting a legal framework for privatization and market relations, as well as in the conversion of small service and retail establishments to private ownership. But the privatization of medium- and large-scale enterprises is only just beginning. And although Kazakhstan has been a leader within the FSU in opening its economy to foreign investment, sectoral development outside the oil and gas sector has been limited.

The slowness of Nazarbaev's reform strategy has been deliberate. He and his economic ministers have criticized the effects of rapid economic reform programs in Poland and Russia and have given greater priority to slowing the growth of wages and prices, increasing state industrial productivity, and directing a slow, "controlled" privatization process. [18]

The pace of democratization has also been slow. Although there is a multiplicity of parties of all political orientations—possibly more than 100-only three parties have been permitted to register officially. In early 1993 a constitution was enacted, guaranteeing basic rights, but political and press freedoms have been restricted. Morover, the parliamentary elections of March 1994 were criticized by West European and Russian observers for arbitrariness, media harassment, and favoritism toward ethnic Kazakh candidates.

Nazarbaev has maintained what has been called a "mild authoritarianism," partly in response to the political tensions plaguing the country. With the advent of independence, tensions developed between newly emergent Kazakh nationalists and ethnic Russians over political power and the socioethnic character of the Kazakhstani state. One of the biggest issues of contention has been language. Ethnic Kazakhs have demanded that their language be recognized as the only official language, while Russians have advocated giving both languages legal status. Nazarbaev has backed a compromise, making Kazakh the official tongue, but establishing Russian as the language of "inter-ethnic communication. " The conflict over language is symbolic of a larger tension within Kazakhstani society: the extent to which ethnic Russians will adapt to Kazakh ways, which includes not just language, but schooling for their children, new interpretations of history, and asserting Kazakhstan's interests against those of Russia.

Although the emergence of Kazakh nationalism has raised concern in Russia and the West about the possible rise of radical Islamic fundamentalism, Kazakhs are not like] y to take the fundamentalist path. Other ties, such as those of clan or region, are strong and compete with Islam as a means of cultural identification among ethnic Kazakhs. A more serious nationalist danger may come instead from Kazakhstan's ex-Communists, who may join with Kazakh nationalists and coopt the nationalist agenda. The "partocrats," intent on restoring the old relations of power, may try to undermine Nazarbaev and the Western-oriented reformers by accusing them of "selling out" to the

16 The *Economist*, Dec. 18, 1993, p. 58.

17 Ahmed Rashid, "The Next Frontier," Far *Eastern Economic Review*, Feb. 4, 1993, p. 49; *RFE/RL Daily Report*, July 21, 1993.

18 The minister of the economy has spoken of the need not to "lurch" from one extreme to another, from a Soviet-type economy to laissez-faire policies. FBIS, *Central Eurasia Bulletin*, FBIS-USR-93-086, July 13, 1993, p. 78.

Russians.[19] This kind of politics could stir large-scale emigration of ethnic Russian specialists and managers from Kazakhstan, with catastrophic effects on the economy.

One other issue threatens Kazakhstan's economic prospects in general and the full development of its oil export industry in particular. Kazakhstan's oil can be exported only through other countries. At present, the only practical route is through Russia. However, Russia has arbitrarily restricted exports through its Transneft pipeline system to one-third of Kazakhstan's present export capacity. The Russian oil industry (which considers itself the heir of the Soviet-era industry) has also recently demanded a 30-percent share in revenues from all oil-export ventures in former Soviet republics. Russian restrictions and demands contributed to a recent decision by Chevron to curtail its ambitious development program for the Tengiz field.

Alternative pipelines to the Black Sea via Iran and Turkey or Azerbaijan and Georgia have been proposed, but both are polically problematic and may be possible only in the long term. Moreover, Turkey will not permit the large increase in oil tanker traffic through the straits (two tankers per hour) that would be required to develop oil exports fully.

Thus, surmounting Russian opposition to increased Kazakhstani exports and controlling Russian economic demands will be vital to Kazakhstani economic development. This is likely to require sustained U.S. policy pressure.

### *Prognosis for Reform*

Political and economic uncertainties, together with Nazarbaev's cautious approach toward market reform, render it difficult to make firm predictions about Kazakhstan's prospects. Although the current energy bonanza provides grounds for optimism, oil development is extremely capital-intensive and will have only a limited effect in the short term. As a result, international institutions such as the World Bank do not expect the Kazakhstani economy to start growing substantially until the second half of the 1990s.

## | Russia

### *Politics of Reform*

Russia has not yet established either the popular consensus or the vast legal and regulatory structure that are vital to successful economic transformation. Instead, since the coup attempt of August 1991, Moscow has been in the throes of a complex battle about the country's future. Westerners have too often viewed Russian politics in simplistic and bipolar terms as a fight between democratic, capitalist modernizers and Communist, nationalist reactionaries. Instead, Russia is experiencing a multifaceted struggle over questions of a more fundamental nature: power, sovereignty, property, and the nature of the future socioeconomic order.

The central arena in this struggle is economic reform, where principled disagreements also exist between political and social constituencies over the nature and course of reform. These debates about the best course of reform are anchored firm-

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*Moscow, the "kiosk" economy*

[19] For a discussion of these issues, see Martha Brill Olcott, "Central Asia on its Own," *Journal of Democracy*, vol. 4, No.1, January 1993, pp. 92-103.

ly in Russia's uniqueness. Unlike the relatively small and ethnically homogeneous states of Central Europe, Russia is a gigantic country with a much larger, more complex, and more deeply troubled economy. As a result, Russia is less amenable to the types of Western-sponsored aid and trade programs that have been instrumental in the transformation of the economies of Central Europe. Whereas multinational lending has had a profound impact in Central Europe, Russia's size makes its capital requirements much larger. Moreover, success in Russia depends on the conversion of the immense defense sector to civilian production. Finally, Central European countries had a history of market economic relations before and during Communism, but the legacy of the market in Russia is much weaker.

The dilemmas raised by Russia's uniqueness are reflected in a struggle between several different and competing visions of economic reform, some more radical than others, but very few of which envision a return to the old system of centralized state ownership and planning. Among a multiplicity of approaches to economic reform, three main blocs have emerged.[20] The first bloc, centered around President Boris Yeltsin and officials of the 1992 and 1993 Russian government, includes the liberal democratic reformers, who advocate a rapid and radical program of economic transformation based on the Polish model.

The second group, the centrist opposition, includes a broad spectrum of Russians, some affiliated with enterprise managers, others representing disadvantaged social groups, a portion of whom identify themselves as Communists. These Russians favor the transition to a market economy but advocate a more gradual approach to economic change. They would prefer a transition in which the state maintains greater levels of support for large industrial enterprises and managers receive greater powers over the direction of industry. They also endorse a much more active program of state-sponsored social protection. Representatives of this group, led by Prime Minister Viktor Chemomyrdin, appear to have replaced reformers in the Russian government in the winter of 1994.

The third group, the "irreconcilable opposition," is a small but vocal collection of ultranationalists and some ex-Communists who oppose both market reform and democratization. Although Vladimir Zhirinovsky, the most well-known member of this group, enjoyed parliamentary electoral success in the December 1993 elections, neither he nor the other parties that share his view point have articulated a specific economic program.

In addition to divisions over economic reform, Russia is also riven by disagreements over the country's future internal and external political course. This struggle has expressed itself in several ways. The power struggle between Boris Yeltsin and Ruslan Khasbulatov, which culminated in the battle of October 4, 1993, was on one level a personal political rivalry. At the same time it was an institutional struggle for power and political legitimacy between the executive and legislative branches of the Russian government. The struggle also reflected at least two different visions of Russia's future geopolitical orientation. Advocates of one vision hope for a Russia more oriented toward the West, with Western-style political and economic institutions, cooperating as a partner with the United States and Europe in matters of foreign policy. Advocates of the other vision are Russian nationalists who suspect the motives of Western governments, want Russia to establish a powerful independent identity, see Russia's foreign policy interests separate from those of the West, and wish to find a distinctly "Russian" course of governmental and economic reform. These more fundamental issues have yet to be resolved. This struggle and its eventual resolution will have profound effects on Russia's openness to foreign assistance and investment in the energy sector.

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20 This group conceptualization is based in part on a framework in Stuart D. Goldman, *CRS Issue Brief: Russia* (Washington, DC: Library of Congress, May 3, 1993), pp. 4-5.

In fact, the victory of Vladimir Zhirinovsky's party in the December 1993 elections indicated the extent to which questions of both Russia's economic and political future remain unresolved. Zhirinovsky's strong electoral support was widely interpreted a sign of disenchantment with declining standards of living and with Russia's reduced world stature. It served as a warning to radical reformers, as well as to moderates, of the need to find compromise solutions to avert catastrophe.

Another component of the struggle over political and economic reform is the battle over sovereignty and property between Moscow and Russia's ethnically and geographically autonomous regions. The devolution of power from Moscow may be a healthy development if it resuscitates moribund local governments and opens the way for innovative reformers to take initiatives from below. But demands for local autonomy, sovereignty, and even independence, endanger the viability and integrity of the Russian state. Until the interests of the central government are balanced against those of the regions within a workable and commonly accepted constitutional framework, attempts to promote democratization and economic stabilization will stagnate.

### *Progress Toward Reform*

On January 1, 1992, under the direction of acting prime minister Yegor Gaidar, Russia entered into a rapid program of economic stabilization and reform similar to Poland's shock therapy. The first results of Russian reforms were quite promising. Despite huge price hikes for many staple items, a large assortment of previously unavailable goods appeared for sale in state retail outlets and in a rapidly expanding network of private establishments. The initial inflationary effects of the price rises were mitigated by tight state monetary policies.

The effects of the rest of the economic program were more negative. Instead of laying off underemployed workers, modernizing production, and changing their product mix to adapt to market conditions, Russian enterprises entered upon a massive spree of borrowing. Initially, without central bank credits, firms simply borrowed from one another, and the size of inter-enterprise debts skyrocketed. Later, enterprise managers asserted their political power and forced the Russian Central Bank to issue massive new credits and to forgive old debt.

The results of the liberalization of prices and the explosion of state and inter-enterprise credit were a hyperinflationary spiral and a huge devaluation of the ruble. By the end of 1992, inflation had reached 2,000 percent per year, and the ruble/dollar exchange rate had soared from 100 to near 1,000. Simultaneously, the steady contraction of Russian production accelerated. During **1992,** Russian economic output fell by about 20 percent.

The spring of 1993 brought some hopeful signs. After a year of bickering over monetary policy, the Russian government came to an agreement with the Central Bank to limit credits to state enterprises. Inflation was reduced to a lower, though still unacceptable, level. Despite a sudden rise in October 1993, inflation fell to 12 percent per month by the end of the year.[21] Although the ruble/dollar exchange rate continued to climb, the ruble moved closer to the dollar in purchasing power parity, and average salaries more than doubled their hard-currency value.

However, industrial production continued to decline during 1993 and GDP fell by 12 percent.[22] Industrial production in the first quarter of 1994 was 25% below the same period in 1993. Simultaneously, the payments arrears crisis worsened considerably. By the winter of 1994, arrears totaled 32 trillion rubles, one half of which was owed to enterprises in the energy sector. Moreover, a January 1994 International Labor Organization (ILO) study placed the level of real

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21 *RFE/RL Daily Report,* Jan. 4, 1994.

22 FBIS, *Central Eurasia Bulletin, USR-94-015,* Feb. 17, 1994, p. 24.

unemployment in Russia at over 10 percent, much higher than the official level of 1-2 percent.[23] Although inflation fell to 10 percent per month in the beginning of 1994, Russia's economic situation remains highly uncertain.[24]

Nevertheless, reformers can point to one area of real success: Russia's private sector. In mid-1992, the Russian government announced a two-year program to privatize state firms based on a Czech-type voucher system. That fall, vouchers were distributed to all Russian adults. Russians can use the vouchers to purchase shares in privatizing enterprises directly, to buy shares in investment funds, or to sell on the open market. Although the privatization process started slowly and the value of vouchers fell by as much as 60 percent, they now exceed their nominal value (unadjusted for inflation), and the pace of privatization has accelerated. By the end of 1993, over two- thirds of Russia's small service enterprises had been privatized through conversion to employee ownership or public sale. Of Russia's 14,500 large state enterprises, 11,000 had been converted into joint-stock companies, of which 7,000 were fully privatized.[25]

Russia's new private sector has also undergone a huge expansion in the past year. The development of new private enterprise is even more important than the privatization process because, as experience in Central Europe has shown, the new private sector is the true engine of economic growth. Although the size of the private sector is hard to measure, it is estimated that private enterprise constitutes about 20 percent of Russian gross national product (GNP) and employs over 15 percent of the Russian labor force.[26]

However, the character of private sector development has been extremely problematic. Although many small and large Russian enterprises have been formally "privatized," ownership of shares has remained concentrated in state hands. Moreover, the types of new private enterprises that have developed under the market reforms have been characterized as a type of "kiosk" economy—small businesses importing Western goods to be sold at a high markup. Relatively little has been done to reform the manufacture of domestic goods and stimulate market-oriented production at home.

Moreover, in the absence of strong governmental authority and freely functioning markets for capital and goods, criminal elements (commonly referred to as the Russian Mafia) have proliferated and corruption by government officials assigned to supervise market relations has been rampant. The proliferation of organized criminal power is dangerous not only for the type of market that is developing in Russia, but also for the negative public perceptions of capitalism that are being created in the process.

Finally, high levels of inflation, political uncertainty, and ruble instability have led to enormous levels of capital flight that dwarf the size of Western aid proposals.[27] Until Russian capitalists can be persuaded to invest their capital at home, little progress can be made in building a larger, more vigorous market.

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23 Only a small fraction of the unemployed actually register with government agencies because the process is difficult, benefits are small, and job-seekers are given little help finding new employment. *RFE/RL Daily Report*, Feb. 1, 1994.

24 Margaret Shapiro, "IMF Agrees to Release $1.5 Billion, Says Russia," *Washington Post*, Mar. *23, 1994,* p. A24.

25 *RFE/RL Daily Report, Dec.* 29, 1993.

26 Keith Bush, "Light at the End of the Tunnel?," *RFE/RL Research Report,* vol. *2, No.* 20, *May* 14, 1993, *p.* 61.

27 During 1993, capital outflow from Russia was estimated at $ I billion per month, far exceeding inflows of private capital and Western development assistance. "The Russian Investment Dilemma" *Harvard Business Review*, May-June 1994, p. 36.

### *Prognosis for Reform*

Despite the impressive strides that have been made in price reform and private-sector growth, the Russian economy is in a state of limbo. The central problem blocking progress in reform is Russia's crisis of state authority—that is, the lack of a political consensus on issues of political power, property, institutional and regional sovereignty, and the nature of the future socioeconomic order. Unless Russia resolves this crisis and its government pursues consistent and coordinated monetary and fiscal policies, it will not achieve the type of solid economic stabilization that is an absolute prerequisite to economic reform and growth. Until then, Russia will at best flounder or muddle through reform.

## FOOT-DRAGGERS: COUNTRIES IN THE THIRD TIER OF REFORM

Despite the profound economic and political changes occurring in the FSU, one group of countries has barely taken even the first steps down the road of economic reform. The reasons for this substantial lag are fundamentally political—none of these states has achieved a political and social consensus about the need for market reform.

### | Historical and Political Background

Ukraine, Turkmenistan, Uzbekistan, and Azerbaijan differ in profound ways. But they share some fundamental characteristics that promote irresolution about reform.

Ukraine is a Slavic country in the European portion of the FSU. Unlike its neighbors in Central Europe, Ukraine has not had significant experience in modern times as an independent, state. For the first time in their history, Ukrainian citizens can elect their own leaders, choose policies, and decide a host of political, economic, and social questions never before within their purview. Ukraine has also had to resist what it perceives as undue Russian influence in its affairs while maintaining (or restoring) economic stability based on existing ties to the FSU. Finally, Ukraine faces the difficulty of defining and asserting a national ethnic identity in a multinational state.

Unlike Ukraine, Turkmenistan and Uzbekistan are Central Asian, Muslim countries. Turkmenistan emerged from the Soviet era as one of the poorest countries in the FSU. An overwhelmingly agricultural country, Turkmenistan concentrated during Soviet times on the cultivation of cotton, which occupied over half of all arable land. Soviet planners also created a cotton monoculture in Uzbekistan (cotton still employs 40 percent of Uzbekistan's labor force), which is the third largest producer of cotton in the world. Low levels of industrial development in both countries, especially Turkmenistan, have left them extremely dependent upon economic and political ties to Moscow

Azerbaijan is a country at war. Since the mid-1980s, Azerbaijan has been locked in a struggle with neighboring Armenia over the status of the predominantly Armenian area of Nagorno-Karabakh. After the breakup of the Soviet Union, the conflict worsened considerably. Since May 1992, Armenians have achieved military control over the territory and have sought to consolidate their position by conquering Azeri areas bordering on Karabakh. Despite international efforts to mediate the conflict, cease-fires have not held, the parties have not yet been willing to agree to peace terms, and Azerbaijan's military losses have promoted domestic political disarray.

### | Ukraine

Since it attained statehood, Ukraine has been plagued by a debilitating competition for political power and by an escalating process of economic disintegration. The mixed nature of the Ukrainian economic and political record is symbolized by Leonid Kravchuk, the former head of the Ukrainian Communist Party, who outmaneuvered his nationalist rivals and won election to the Ukrainian presidency in December 1991.

Kravchuk's victory was not just a personal triumph. It also represented the victory of an entire cadre of state apparatchiks behind him: bureaucrats who had maneuvered to survive the transition from Communism to nationalism, more interested in protecting their state positions than reforming the economy. The result of this phe-


*Podol district, Kiev Ukraine*

nomenon, along with Ukraine's preoccupation with nationality issues and the attention to squabbles with Russia over the legacy of Soviet-era property and weapons, has been the neglect of economic reform. Despite the efforts of prime minister Leonid Kuchma, who was forced to resign in the summer of 1993, the Ukrainian parliament spent 1992 and 1993 debating competing reform proposals without implementing a systematic program.

Consequently, despite some monetary, fiscal, and regulatory reforms, major elements of the state economy remained in force (e.g., price controls and public ownership of most land and property), and the authority of Kiev to manage the process of economic change eroded substantially. Economic reform in the provinces was characterized not by conversion to private ownership, restructuring, or modernization, but by a process of "spontaneous" privatization whereby the majority of state enterprises were converted to the de facto ownership of managers and workers through the abuse of a very liberal law on leasing. Simultaneously, in both the capital and the provinces, corruption proliferated.

The increasing economic chaos caused a precipitous decline in production and stimulated hyperinflation. According to the World Bank, output (measured in net material product, NMP) has been falling continuously since 1990 by 16 percent in 1992 and at the same rate throughout 1993.[28] By December 1993, inflation was running at 200 percent per month and 9,000 percent for the year as a whole.[29]

The economic crisis has been felt acutely in the energy sector. The Ukrainian government has been unable to pay hard currency prices for imports of natural gas from Russia and Turkmenistan. In the winter of 1994, Turkmenistan cut off gas supplies to Ukraine for nonpayment of $700 million in gas debt. Ukraine's energy debt to Russia is even higher: $900 million. However, since 90 percent of Russia's gas exports to Western Europe travel through Ukraine, the Russians cannot simply shut off gas supplies to Ukraine. Instead, Russia's Gazprom has restricted gas supplies to Ukraine in an effort to pressure payment, either in cash or in the form of energy-related assets.

Complicating these issues is the fact that Ukraine is not ethnically homogeneous. Almost one-quarter of the Ukrainian population is Russian. The Russians are concentrated in coal-mining regions in the east and in the Crimea in the south, an area that became part of Ukraine only in 1956. Although ethnic Russians in the past have generally been supportive of Ukrainian independence, Russian miners struck in June 1993, demanding wage increases, greater local autonomy, and a referendum on Kravchuk's leadership and the performance of parliament. The strike contributed to a

28 World Bank, Ukraine: *Country Economic Memorandum* (June 2, 1993), p. 2. The Vienna Institute for Comparative Economic Studies measured the contraction of GDP at 18.5 percent in 1992 and 15 percent in 1993. *The Economist (Dec. 18, 1993),* p. *58.* The Ukrainian Ministry of Statistics reported a 14-percent drop in GDP for 1993. FBIS, *Central Eurasia Bulletin, FBIS-USR-94-024* (Mar. 14, 1994), p. 36.

29 The *Economist*, Dec. 18, ]993, p. 48. BISNIS, "Ukraine-Economic and Trade Overview" (Washington, DC: U.S. Department of Commerce, April 1994), pp. 4, and Simon Johnson and Oleg Ustenko, "Ukraine Slips Into Hyperinflation," *RFE/RL Research Report, vol. 2, No. 26,* June 25, 1993, p. 24. Inflation ran at 4,000 percent in 1992 (an average of 35 percent per month). FBIS, *Central Eurasia Bulletin*, FBIS-USR-94-018, Feb. 28, 1994, p. 21.

summer-long political crisis in Kiev, to Kuchma's resignation, and to new elections in March and April 1994. Thus, a resolution to Ukraine's crisis is not likely for quite some time.

### *Prognosis for Reform*

Ukraine is in the throes of a possibly catastrophic economic crisis. Unless a political consensus is reached in Kiev over questions of political and economic policy, the economy will continue to contract, and hyperinflation will spiral even further out of control. The political consequences of such economic disintegration could be extremely serious, including the assumption of power by an authoritarian leader and/or secession efforts by non-Ukrainians.

## Turkmenistan

Political and economic reform have not yet come to Turkmenistan. Instead, the country is dominated by its president, Saparmurad Niyazov, an authoritarian ruler who has created a Stalin-like cult of personality around himself and who has suppressed potential political opposition. Niyazov has imposed official censorship, restricted freedom of speech, and harshly repressed political opposition.

Although Niyazov has negotiated potentially very lucrative gas and oil extraction deals, the country has remained one of the poorest in the FSU. Its 1991 GNP was less than 1 percent of that of the FSU, and poverty is endemic.[30] Niyazov has pursued economic reform and the introduction of private property rights very slowly. There has been some attempt at reducing the country's dependence on cotton, but Niyazov does not envision a process of radical economic reform or diversification. Rather, he has advocated a very gradual process of change in which state-owned enterprises will co-exist with an emerging private economy for quite some time. For example, in his economic plan for the next 3 to 5 years, the oil, gas, mineral, and agricultural sectors—which constitute 80 percent of the economy—will remain under state ownership and control.

As in Kazakhstan, the potential for an Islamic fundamentalist movement is low. Turkmenistan is characterized by intense clan loyalties that inhibit not only the spread of Islamic fundamentalism, but also the formation of a strong common Turkmen national identity.

### *Prognosis for Reform*

In theory, its vast gas and oil wealth presents Turkmenistan with an excellent opportunity to overcome the economic distortions of the Soviet era, develop a diversified agricultural, industrial, and commercial economy, and build the physical and social infrastructure that the country so sorely lacks. Energy revenues, however, may be squandered through corruption and the operation of Niyazov's self-aggrandizing political machine. The result may very well be the development of a small, wealthy elite, loyal to the Niyazov political regime, in a country that retains high levels of poverty and underdevelopment.

## Uzbekistan

After Turkmenistan, Uzbekistan is the most politically repressive state in Central Asia. Uzbekistan is a good example of what can happen when the partocrats retain power in a post-Soviet country. The country is headed by president Islam Karimov, Uzbekistan's Soviet-era president, and the Popular Democratic Party (PDP), the successor to the Uzbekistani Communist Party. Karimov has suppressed almost all other parties, jailed opposition activists, enforced press censorship, and stifled the development of democratic politics. Citing the civil wars in Tajikistan and Afghanistan, he justifies his repressive political policies by saying that only he and the PDP can ensure stability in Uzbekistan. Karimov openly asserts that

[30] Congressional Research Service, *Turkmenistan: Basic Facts* (Washington, DC: Library of Congress, Mar. 16, 1993), p. 5.

law and order must take priority over the propagation of democratic values.

Since the breakup of the Soviet Union, economic conditions in Uzbekistan have deteriorated but have been moderated by state policies that maintain many of the characteristics of the Soviet-era economy. Although prices were liberalized in January 1992, the prices for most basic items are still regulated. Heavy subsidies for goods sold through the state retail sector and for staple foods keep these products cheaper than those sold on the open market, thereby creating supply problems. Large state subsidies have also contributed to a substantial budget deficit, which constituted about 5 percent of GNP in 1993.[31] Despite some diversification away from cotton, the country still depends on imports of grains, cooking oil, and other staple products from FSU countries.

Karimov has moved with deliberate slowness in the area of economic reform. His stated goal is to create "market socialism," a combination of the old and new orders. Accordingly, any type of shock therapy has been rejected. Privatization has barely started and is destined to proceed very slowly. Industry and almost the entire retail sector remain in state hands, and the private sector produces less than 10 percent of GNP.

### *Prognosis for Reform*

Like Turkmenistan, a rich energy endowment gives Uzbekistan excellent potential for economic recovery. But the entrenchment of partocrats in power and their determination to retain many of the fundamentals of the old system bode poorly for Uzbekistan's economic future. Energy revenues are much more likely to be squandered through corruption and wasted on old, state-centered economic structures, rather than used to modernize Uzbekistan and build a market economy. And continued political repression in the face of rising opposition from democratic, nationalist, and Islamic fundamentalist forces raises the possibility of violent conflict in the future.

## Azerbaijan

Systematic economic reform has also not yet begun in Azerbaijan. Instead, the country's attention has been diverted to the military conflict with Armenia. With tens of thousands of Azeri refugees demanding retribution and a foreign power occupying 10 percent of the country, it is difficult to focus on imperatives for domestic economic restructuring and political reform.

However, Azerbaijan's domestic political troubles are not rooted just in the conflict with Armenia. Strategically located at the crossroads between Russia, Turkey, and Iran, Azerbaijan has also been a target of the political, economic, and social ambitions of its neighbors. Although Azerbaijan has some economic ties with Iran, the Iranians have not been successful in their attempts to spread Islamic fundamentalism in the Caucasus. Turkey gained commercial and political influence in Azerbaijan during the short tenure of President Abulfaz Elchibey, who attempted to reorient the country's economy away from the FSU. But in June 1993, Elchibey was overthrown by the forces of Colonel Suret Huseinov, in concert with former Azerbaijan Communist Party leader Geidar Aliev. Elchibey lost power in large part due to his military failures in Karabakh and a drastically worsening economic situation. Huseinov and Aliev enjoyed the support of Moscow against Elchibey and have reoriented government policy toward Russia and the rest of the FSU.

In light of the tumultuous domestic military and political situation, economic reform has received relatively little attention. Despite the proliferation of small-scale capitalism and negotiations with foreign companies to develop the Caspian's energy resources, there has been no systematic program of economic reform. Instead,

[31] *BISNIS*, "Uzbekistan-Economic and Trade Overview" (Washington, DC: U.S. Department of Commerce, January 1993), p. 3.

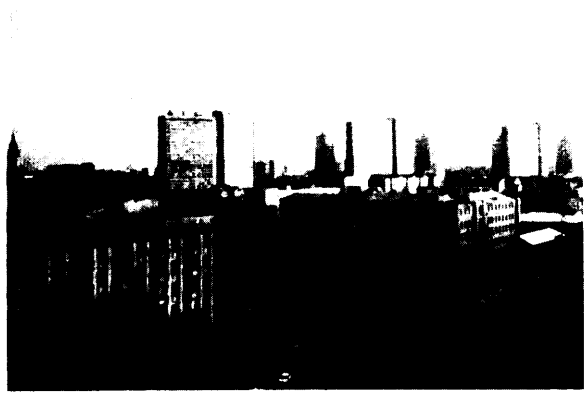
corruption and a highly lucrative illicit trade in oil and other valuable raw materials have proliferated. Despite a relatively low government budget deficit and modest foreign trade surpluses, inflation has hit rates of 1,500 percent, and the government has been criticized for incompetence, for rampant corruption, and for merely substituting its own people for the old *nomenklatura,* instead of building a new system.

### *Prognosis for Reform*

In the short to medium term, Azerbaijan may be able to maintain a semblance of economic stability, supported by ad hoc deals with Western oil companies and semilegal exports of raw materials. But until reform-minded leaders assume power in Baku, the country is unlikely to enact the sweeping legal and structural changes needed to convert to a market economy. U.S. oil companies could participate in the development and improvement of Azerbaijan's oil production with considerable mutual benefit. However, that cooperation is unlikely to be a major force for reform until the political situation stabilizes. Furthermore, Azerbaijan resents the U.S. prohibition on assistance imposed in response to the conflict over Nagomo-Karabakh.

## BUILDING NEW SOCIETIES-THE CULTURE OF REFORM

Despite their differences, the countries of the former East Bloc share a similar set of problems in the transition from Communist authoritarianism to market democracy. One such problem is providing social protection during the transition period. These countries will need to transfer traditional responsibilities for housing, medical care, and pensions from enterprises to the state, while devising systems to deal with new problems, such as unemployment and job retraining. This will be particularly difficult, because new expenditures must be justified in light of the pressures of fighting inflation and the need to adhere to the monetary and fiscal requirements of the International Monetary Fund, the World Bank, and other multilateral institutions.



JOANNE SEDOR

*Moscow skyline*

These states also face an even broader set of cultural problems in building societies based on new political and economic orders. To make the transition from state-directed economies to markets, they will have to overcome a broad lack of understanding of market principles. After decades of Communist rule, at least some of the principles of socialist economic relations have sunk strong roots in the popular psyche or resonate with already extant popular values of communalism and preferences for state-directed economic relations. For example, if market relations are to work effectively, people must learn the function of distributive prices and the harmful effect that subsidies and price controls can have on the rational distribution of goods.

If the goal is to promote a thoroughgoing capitalist system, the mentalities and characteristics of the old system must also be eliminated. After decades of state economic planning and direction, it will be difficult to adjust to the idea that the individual, not the state, is most responsible for his or her own fate. Instead of a system where personal contacts and access to resources are paramount, citizens must also build and become accustomed to a system where money, personal initiative, and merit determine success. Communist-era customs of lackadaisical work must be overcome, entrepreneurship must be nurtured, and firms-in retail and other sectors—must become much more customer oriented.

Unfortunately, this process is complicated by the character of newly emergent market relations,

which often creates a negative image of capitalism and highlights its worst aspects. The appearance of wide disparities in income and personal wealth in societies that previously were noted for economic homogeneity has created feelings of unease and perceptions of injustice. The conspicuous consumption of many of the area's new capitalists in the face of mass economic misery incites popular anger. Finally, the rapid growth of violent, organized crime has produced deep anxiety about personal security and may further poison popular attitudes toward capitalism.

Cultural adjustment is also an important subject on the political level. After the initial euphoria about the achievement of national independence, these new states must now deal with a fractious set of new political issues. Independence has brought new conflicts between various ethnic groups and the rise in some countries of new radical right-wing parties. In the countries understudy here, the most serious national conflicts have occurred in Azerbaijan. Nevertheless, although there have been fewer disputes over national boundaries than might have been expected, questions over border areas and disputes over land and ethnic minorities continue to smolder and threaten long-term regional stability.

Perhaps as serious is a more general mass disillusionment with politics and a growing political apathy. This is compounded by a lack of experience among the political leadership with democratic institutions.

Finally, the huge drop in living standards and the political chaos of the post-Communist era has led to a crisis of identity in many areas of the FSU, especially Russia. Before the decline of Communist economies and the breakup of the Soviet Union, Soviet people felt themselves to be citizens of an economic, political, and military superpower. With Russia and the other FSU countries now in an extremely weak position on the world stage, with economies in collapse, with crime on the rise, and with citizens wearing hand-me-down clothing and earning paltry incomes, nostalgia for the old system has grown. The perception is that no matter how repressive or stagnant the old system was, it still provided basic levels of sustenance, security, and national pride. Unless these countries start achieving economic and political progress soon, this nostalgia is bound to grow, and the popular support or social consensus needed for the transition to democratic politics and market economics will evaporate.

# Assistance, Trade, and Investment Programs

7

The countries of the former East Bloc are in the midst of a major energy and environmental transition and could benefit immensely from the knowledge, technologies, and services that the United States and other advanced industrial countries can provide. However, there are significant obstacles to the rapid rehabilitation and development of the energy supply sector. OTA's previous report reviewed the obstacles to improving energy efficiency in the region and U.S. programs to promote more efficient use of energy resources. [1]This chapter will address similar issues about technologies affecting energy supply?

The first section of this chapter reviews the barriers to energy sector modernization and market reform in the former East Bloc energy sector and briefly describes the U.S. and multilateral programs designed to address them. The next section offers an evaluation of U.S. bilateral programs and of multilateral programs addressing energy and the environment in the former East Bloc. The final section presents a survey of bilateral and multilateral programs.

## BARRIERS TO ENERGY SECTOR DEVELOPMENT

A broad range of institutional, economic, and technical barriers are impeding market reform and technology transfer to the former East Bloc energy sector. These barriers are listed in table 7-1.

JOANNE SEDOR

*Gum Department Store, Moscow.*

[1]U.S. Congress, Office of Technology Assessment, Energy Efficiency *Technologies for Central and Eastern Europe, OTA-E-562* (Washington, DC: U.S. Government Printing Office, May 1993).

[2]Please note that this chapter will address programs in all areas except nuclear power. That subject is analyzed inch. 4.

TABLE 7–1: Barriers to Diffusion of Energy and Environmental Technologies

| |
|---|
| **Institutional barriers** |
| Lack of comprehensive legal framework |
| Multipliclty of governmental authorities |
| Weak enforcement of regulatory standards |
| Lack of market information |
| Lack of market and r'management training |
| Ambivalence about foreign investment |
| Bilateral trade restrictions (in West and East) |
| **Economic barriers** |
| Lack of domestic capital |
| High levels of political and financial risk |
| inconsistent and punitive tax regimes |
| Government energy-price subsidies |
| Low emissions fines |
| Lack of feasibility financing for U.S. small business |
| **Technical barriers** |
| Inadequate physical infrastructure |
| Lack of trained personnel (in East and West) |
| Differences in technical standards |

SOURCE U S Congress, Off Ice of Technology Assessment, 1994

## | Institutional Barriers

The policy and institutional climate remains the major inhibitor to technology adoption and diffusion in many countries of the region. The most serious institutional barrier to market reform and modernization is the lack of a comprehensive legal and regulatory framework to govern energy sector development, to define the rights and responsibilities of joint ventures, and to prevent reconsideration of completed contracts. In addition to this basic framework, most countries in the region lack a well elaborated system of intellectual property rights. Since recipient countries often do not have adequate patent protection, U.S. industry has been reluctant to transfer proprietary technologies. An absence of a clear system of title and ownership over land also inhibits energy exploration and production. The multiplicity of governmental authorities, each of whom has a veto over the decision of other parties, has further complicated the development of joint ventures.

Environmental regulations have been a major factor in promoting energy facility modernization in the west, but that has not been true in the former East Bloc. Many countries, particularly in the former Soviet Union (FSU), lack regulations to ensure environmental quality (despite economic costs). But even in Central Europe, where there is a highly developed regulatory framework for the environment, enforcement is extremely weak.

Another important institutional impediment to energy-sector development is the lack of a systematic means of disseminating information to potential users about the benefits and costs of improved technologies, as well as how to obtain and use them. Inadequate information for U.S. producers about export markets and a lack of contacts in foreign markets also discourages more aggressive export activity. Even when market information is available, its high cost puts it out of reach.

Finally, unfamiliarity with basic Western business practices and concepts such as profit and depreciation greatly complicates business negotiations. A widespread lack of training in free market economics and a lack of knowledge about the rates of return needed to attract investment create unrealistic expectations among enterprise managers. Weak management skills and little experience in project evaluation or least-cost energy planning also impede technology transfer.

As noted in chapter *6*, the countries of Central Europe have made a great deal more progress addressing the above issues than have the FSU states. One of the reasons for institutional inertia in the FSU, especially in Russia, is a deep ambivalence toward foreign investment and ownership. Continuing barriers to trade in both donor and recipient countries also reduce the incentive for institutional reform in both Central Europe and the FSU.

## | Economic Barriers

The second set of barriers to diffusion of energy technology is economic in nature. A severe lack of domestic capital and foreign currency constrains the ability of former East Bloc states and enterprises to purchase improved energy and environ-

mental equipment. These constraints may be somewhat less severe for oil and gas because they are highly exportable commodities. However, capital constraints are 1ikely to be acute for renewable, coal, electricity y, and environmental technology. But even in the oil and gas sector, advanced Western technology is typically more expensive than domestic technology, even when the average life of equipment is taken into account.

Continuing high levels of political and economic instability in former East Bloc countries translate into high levels of economic and foreign currency risk, even in Central Europe. Commercial banks remain reluctant to loan on a conventional basis.

Government policy—in both East and at home—also contributes to economic impediments to technology transfer in the former East Bloc. In the East, uncoordinated, inconsistent, uncertain, and frequently punitive tax regimes increase the cost of doing business. Subsidized energy prices reduce incentives to invest in more efficient or environmentally improved equipment, or to increase supplies. Low fines for emissions violations provide little economic incentive for the purchase and installation of environmental equipment in many countries.

In the United States, inadequate access for smaller suppliers to risk capital, or to financing for feasibility studies and startup costs, greatly restricts the ability of U.S. small business to take advantage of newly opened markets in the former East Bloc. Other governments are believed to offer more generous export credits, thus putting U.S. companies at a competitive disadvantage in these markets.

## | Technical Barriers

The final set of barriers to trade and technology transfer is technical in nature. These barriers include an inadequate regional support infrastructure for high-quality technology. Trained manpower, spare parts, and supplier systems may also not be available locally. Differences in technical standards can block transfer of U.S. technology. Many countries of the region are adopting European Union (EU) emissions standards that are much stricter than the U.S. standards. U.S. technology, designed to meet U.S. conditions, may not correspond to the needs of the recipient country. And the costs of adaptation may be too high.

Integration of Western and local technologies may prove difficult. In some cases, improved technology may not be as flexible as existing technology. Difficulties arise when enterprises attempt to mix imported and local technologies. And the energy equipment supply industry in some countries is so large that Western technologies can only supplement rather than replace it.

Finally, former East Bloc governments lack adequate numbers of technical and business trained personnel. And in the United States, companies suffer from a lack of U.S. personnel who are knowledgeable about the countries and regions and proficient in local languages

## | Overview of U.S. and Multilateral Assistance Programs

The United States supports a large number of programs designed to overcome these barriers by promoting the mutual benefits of energy and environmental technology cooperation and encouraging the economic and institutional reforms necessary for the diffusion of improved technology. Western energy and environmental assistance began in 1989-90, with the extension of aid to Poland, Hungary, and Czechoslovakia. Energy and environmental assistance to the FSU began in 1992, and has grown rapidly (see box 7-1 ).

Current bilateral development assistance programs, operated primarily by the U.S. Agency for International Development (AID), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA), encompass a wide range of functions. These include technical assistance, training in market-related skills, provision of market information, government policy advice, research and development (R&D), and technical cooperation.

Other bilateral programs, managed primarily by the Export-Import Bank of the United States

## BOX 7–1: Legislation and Funding for U.S. Assistance to the Former East Bloc

U.S. assistance to the former East Bloc is mandated under two major pieces of legislation, the Support for East European Democracy (SEED) Act of 1989 (PL 101-1 79), and the Freedom for Russia and Emerging Eurasian Democracies and Open Markets (FREEDOM) Support Act of 1992 (PL 102-51 1). Funds for the assistance effort have also been appropriated under other foreign aid bills as well as reprogrammed by some agencies.

**Central Europe**

The SEED Act was passed by the Congress and approved by the Administration in November 1989. It authorized $930 million for fiscal years 1990-92. Foreign aid appropriations for fiscal year 1990 included $659 million for Poland and Hungary. Amid much debate over the appropriate scope of U.S. assistance, Congress provided about $370 million in assistance for fiscal year 1991, along with $70 million for the newly formed European Bank for Reconstruction and Development (EBRD) and $3 million for Romania. In September 1991, Congress reprogrammed $11 million in aid to start SEED programs in the Baltics. Funding for fiscal year 1992 was appropriated under a Continuing Resolution which made $370 million available for the entire region. The Foreign Appropriations Act of 1993 (PL 102-391) provided $400 million in assistance in fiscal year 1993 for Central Europe and the Baltics, plus $69 million for EBRD. Although fiscal year 1994 appropriations were signed into law in September 1993 (PL 103-87), portions of this appropriation were rescinded in February 1994 (PL 103-211 ) to offset the costs of earthquake relief for California. Under the revised 1994 appropriation, foreign assistance for Central Europe and the Baltics totaled $390 million and EBRD received no funds.

**Former Soviet Union**

U.S. assistance to the FSU has consisted of a number of commitments made bilaterally and to multilateral organizations. Assistance to the FSU, and in particular to Russia, began in 1990 with the extension of food credits ($5,1 billion) and assistance in the destruction of weapons ($800 million). In 1992, Congress passed the FREEDOM Support Act, which provided a comprehensive framework for U.S. foreign aid programs for the FSU and authorized $410 million for humanitarian and technical assistance for fiscal year 1993. On April 1993, at the U.S.-Russian Vancouver Summit, President Clinton announced a $1.6-billlon aid package for Russia, composed completely out of funds that had already been appropriated, including under the FREEDOM Support Act. Shortly thereafter, on April 15, 1993, at a meeting of G-7 ministers, the U S. announced an additional $1.8 billion in assistance. Congress funded $1.6 billion of this assistance through a supplemental appropriation for fiscal year 1993, attached to the foreign operations appropriation bill for fiscal year 1994 (PL 103-87). That bill provided an additional $904 million for fiscal year 1994, for a total of $2.5 billion in additional assistance.

**SOURCES Congressional Research Service, selected issue briefs and reports for Congress**

(Eximbank), the Overseas Private Investment Corporation (OPIC), and the U.S. Department of Commerce (DOC), provide backing to the U.S. private sector to encourage U.S. business to play a key role in the rehabilitation of the regional energy sector.

As the largest shareholder in the multilateral development banks (MDBs), the United States also actively exercises influence in their large project lending programs. Much of the past and anticipated lending has been to the oil and gas industry and the power sector. However, there are also active programs for coal and energy efficiency.

Bilateral and multilateral lending is designed to provide the capital to overcome economic barriers to technology transfer. Conditions attached to some lending programs, especially from the

TABLE 7-2: Comparative Levels of Multilateral and Bilateral Funding for Energy-Related Development Assistance Projects in Central Europe and the FSU*

| Source | Fiscal years 1990-94 funding ($ million) | |
|---|---|---|
| **World Bank** | | |
| Central Europe | 1,651 | |
| FSU (Russia) | 1,210 | |
| Total | | 2,860 |
| **European Union** | | |
| Central Europe (PHARE) | 550 | |
| FSU (TACIS) | 123 | |
| Total | | 673 |
| EBRD | | |
| Central Europe | 220 | |
| FSU (Russia) | 250 | |
| Total | | 470 |
| United States | | |
| Central Europe | 151 | |
| FSU | 93 | |
| Total | | 244 |

* Does not Include bilateral trade-promotion programs

SOURCE U S Congress, Office of Technology Assessment, 1994

MDBs, are intended to force countries to make the institutional changes that are crucial to reform.

As illustrated in table 7-2, the bulk of assistance for energy-sector development comes in the form of World Bank loans. Lending by the European Bank for Reconstruction and Development (EBRD), though smaller, also provides energy-related development financing. European Union energy-related development programs provide almost three times the level of resources as U.S. bilateral assistance programs.

U.S. government agencies have pursued different energy-related development assistance policies in Central Europe and the FSU. In Central Europe and the Baltics, U.S. assistance has focused on diversifying sources of energy supply, rehabilitating and modernizing the energy supply infrastructure, improving end-use energy efficiency, and controlling pollution. In the FSU, maintaining and increasing oil and gas production has had clear initial priority.

While much U.S. energy assistance has environmental components, particularly with regard to air pollution and greenhouse gas emissions, the overall assistance effort has not been nearly as environmentally oriented as was anticipated in its earliest phase. This is due, in part, to the recognition of other priorities, especially economic revitalization.[3]

## EVALUATION OF U.S. PROGRAMS

Since most programs addressing energy and the environment in the former East Bloc are quite recent in origin, it is not possible at this point to offer detailed critiques. Nevertheless, even on the basis of limited experience, it is possible to identify both particular strengths and incipient weaknesses in the collection of programs dealing with assistance to the energy sector. It is also possible to identify the external constraints that limit the effectiveness of U.S. and multilateral programs. Before considering the strengths and weaknesses of U.S. programs, it would be useful to review these constraints.

### | Constraints on U.S. and Multilateral Programs

U.S. programs have been developed and implemented under difficult circumstances and under a variety of political, institutional, and financial pressures. Considerable political pressure was put on agencies to disburse funds quickly to give visible evidence of Western support for the new regimes following the end of the Cold War. All agencies have experienced difficulties in recruit-

[3]For example, see Gordon Hughes, "Are the Costs of Cleaning Up Eastern Europe Exaggerated? Economic Reform and the Environment," *Oxford Review of Economic Policy, vol. 7, No. 4, 1991,* pp. 106-135.

ing permanent staff with the necessary area expertise. AID programs have been developed and carried out during its own reorganization, and with staff cuts affecting personnel in programs for the region. The ongoing reorganization at AID is designed to provide the agency with further flexibility and streamlined contract procedures, but in the meantime has hampered program development. Continuing pressure on all agency budgets has limited resources available to finance development and lending programs.

A further extenuating circumstance is that many programs are lodged in institutions that were designed for different types of operations. The World Bank and AID, for example, were designed for projects in developing countries whose experiences and needs differ considerably from those of the former East Bloc. In some cases, such as the World Bank negative pledge waiver, agencies have been asked to abandon policies that they consider crucial for carrying out their worldwide mission in order to provide assistance to the former East Bloc countries.

Eximbank is a striking example of an agency being obliged to combine differing functions in carrying out programs for former East Bloc countries. The primary mission of Eximbank is to support U.S. exports. The bank is not a development assistance agency; but the Oil and Gas Framework Agreement for Russia, which is a major support to U.S. exports, is also a cornerstone of U.S. financial assistance to the FSU countries. Eximbank therefore has had to balance the different political and economic pressures arising from the perception that it is an instrument of industrial, trade, and development policy.[4] In addition, the Eximbank Framework Agreement has encountered major organizational and procedural problems that delayed its final implementation for almost a year.

Conditions in the recipient countries have also not been conducive to rapid and efficient disbursement. In several countries, especially in the FSU, highly unstable political conditions have hampered or prohibited program development. It is difficult to plan specific energy improvements in the context of a drastic economic restructuring, falling living standards, and institutional disarray.

An important additional factor affecting the success of U.S. and multilateral programs is the difficulty of ensuring that countries adhere to the political and economic conditionality attached to assistance. To receive World Bank loans, for example, countries are typically expected to raise energy prices and encourage market reform throughout the energy sector. In practice, however, governments often resist the discipline of price reform and the privatization of energy enterprises, and thus make it difficult to advance assistance. This has been one of the principal factors holding up aid for Russian economic reform in general, and for Russian energy sector assistance in particular.

Reluctance to accede to conditionality can affect demand for assistance as well. Several U.S. agencies report a shortage of viable projects in the FSU countries, either because of lack of interest or unwillingness to accept conditions attached to financial assistance. In several countries, notably in the Russian oil and gas sectors, there is both a marked ambivalence toward the type of assistance the United States can offer, and a deep-seated suspicion of foreign investment.

## | Strengths of U.S. Programs

**The** U.S. government and Congress moved with exemplary speed to develop energy assistance programs in support of reform efforts. Agencies

[4] For a discussion of Eximbank's multiple roles, see Richard E. Feinberg and Stuart K. Tucker, "Export Credits in U.S. Trade, Development? and Industrial Policy," in Rita M. Rodriguez, *The Export-Import Bank at Fifty: The International Environment and the Institution's Role* (Lexington: Lexington Books, 1987). See also U.S. General Accounting Office, *Export Finance: The Role of the U.S. Export-Import Bank,* GAO/GGD-93-39 (Washington, DC: U.S. Government Printing Office, December *1992).*

have been quick to develop new programs or expand the scope of old ones as new needs have arisen. These programs appear to have been prosecuted with vigor and enthusiasm.

OTA's survey of the existing programs shows them to be comprehensive in coverage. Within overall budget constraints, they address the main barriers to reform previously discussed. Programs have been developed to help ease capital constraints for both energy supply and conservation projects, to promote energy sector and macroeconomic reform, and to provide a wide range of technology and technical assistance. Particularly strong efforts have been made to include the U.S. private sector in these efforts. All in all, there are no obvious major gaps in the coverage of U.S. programs, though their size, design, and implementation are open to debate (see below and ch. 8).

U.S. programs have shown considerable flexibility and responsiveness to changing conditions, even over their short period of operation. There was a clear shift in the early years of the assistance effort from promising to provide energy and environmental technologies directly, to a strategy of building the policy and institutional capacity to enable countries to absorb new technologies. Efforts have also been made to respond to early criticisms of the U.S. effort, some of which were cited in the previous OTA report. These included too many temporary consulting missions, lack of in-country expertise, slow procurement, and confusion over country needs due to a regional approach to aid disbursement. The energy projects in Central Europe are now developed on a country-by-country basis. In the FSU, contract delays at AID have apparently slowed project startups, but AID has established in-country missions at an early stage.

## Weaknesses of U.S. Programs

Despite the many achievements of the past years, major weaknesses to U.S. assistance have emerged. One major set of weaknesses is related to the scale of the assistance effort and to problems in program design and implementation. The proliferation of initiatives has caused problems. There are abundant reports from officials of former East Bloc countries of their being swamped by visiting missions and the resulting technical assessments. There is a further perception that the assistance available is going largely to foreign consultants rather than the recipient countries.[5] The large number of agencies offering broadly similar services raises major problems of coordination and duplication.

Coordination between the various donors, fairly low during the first years of assistance, has continued to be a problem.[6] There are several cases of lack of donor coordination that seriously weaken the entire effort. For example, while the World Bank supports an oil export tax as an efficient means of bridging the wide gap between domestic and export oil prices, other government agencies, more concerned with the promotion of foreign investment, strongly oppose it. There also continues to be lively competition among bilateral assistance programs to influence technology choices in former East Bloc countries. This can result in duplication of effort and a concentration on too narrow a group of technologies.

However, progress is being made in other areas. Currently, the World Bank, EBRD, AID, and the EU have several joint energy projects, including a major power sector restructuring project in Poland. Also, there is a more systematic data collection process under way to keep track of energy

[5] See for example, Barry Newman, "Disappearing: Act: West Pledged Billions Of Aid to Poland—Where Did It All Go'?," *The Wall Street Journal* (Feb. 23, 1994), pp. A 1, 8; John J. Fialka, "Helping Ourselves: U.S. Aid to Russia Is Quite a Windfal—lFor U.S. Consultants," *The Wall Street Journal*, Feb. 24, 1994, pp. A 1, 8.

[6] The lack of coordination is repined in U.N. Economic and Social Council, Economic Commission for Europe, Committee on Energy, "Multilateral Assistance to Economies in Transition in the Field of Energy: A Preliminary Overview and Evaluation," Geneva: Aug. 28, 1992, p. 9.

project requests in the FSU, managed by the International Energy Agency.

Underpinning these weaknesses in implementation lies a more serious and fundamental problem: a developing uncertainty over the best means to achieve U.S. policy aims in the region, if not the nature of those policy aims themselves. The original program emphasis in the FSU—widely shared by all agencies and most Western industrial countries—was on oil production projects, mainly through private sector investments. This emphasis was accompanied by MDB lending programs designed to supplement and leverage private investment. Oil and gas received the most attention because production in that sector could most quickly generate the extra foreign exchange needed to underwrite the reconstruction of the entire economy.

The assumptions behind this strategy are now in doubt. It is proving more difficult to achieve the anticipated production increases, partly because of the lack of enthusiasm in some host countries, notably Russia, for Western programs and the conditions that accompany them. There is also the belief in some international oil circles that government support of an active MDB oil policy and expansion of bilateral export credits undermines foreign investment by reducing the need for governments and enterprises to deal directly with private Western companies on an equity-stake basis.

The rationale that underlies the distribution of funds among the many countries of the region is also not clear. The allocation of assistance within the energy sector is open to question, particularly the emphasis on expanding supply, despite the immense potential for energy conservation. The reluctance of some host countries, especially Russia, to cooperate in key parts of the assistance program raises questions about the wisdom or feasibility of the present approach.

This is an opportune moment to use this experience in the assistance programs to re-examine the totality of U.S. efforts toward the former East Bloc in light of original U.S. policy objectives, and to suggest improvements in programs that support those our policies. These issues, especially the need to define U.S. goals and priorities, are elaborated in greater detail in the next chapter.

## SURVEY OF ENERGY AND ENVIRONMENTAL PROGRAMS

Energy and environmental programs fall into two broad categories: development assistance and private sector support. In principle, the primary objective of development assistance is direct assistance to the recipient country. Trade and investment support, on the other hand, is primarily designed to help domestic industry. In practice, the distinction between the two is becoming increasingly blurred, for a number of reasons. First, benefits to U.S. industry can create a strong constituency for development assistance, especially important in times of budget stringency and recession. Second, export and investment promotion efforts are a natural concomitant to the recent emphasis on privatization and the primacy of the private sector in technology transfer. Third, project finance is becoming increasingly complex, including both multilateral, bilateral, and private sector participants. Fourth, greater private sector participation can screen ill-designed projects.

On the other hand, critics complain that the merging of development assistance and export promotion can compromise developmental goals and skew existing development programs in the direction of export promotion.

### | U.S. Programs to Assist Former East Bloc Development

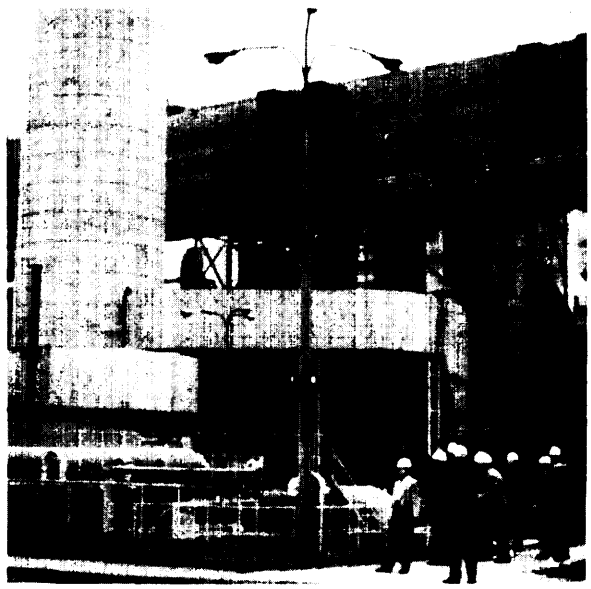
Assistance programs were designed first for Central European countries and then the FSU. The two regions will be discussed separately because of the differences between the programs. Additional information is included in chapters 3 and 4. Current budget data are listed in chapter 8.

### *Central Europe and the Baltics*[7]

U.S. energy and environmental assistance to Poland has centered around a group of projects demonstrating U.S. know-how in Krakow. The Skawina Retrofit project has installed advanced U.S. clean-coal technology at a 550-MW (megawatt) plant near Krakow chosen by a U.S.-Polish project steering committee. This technology choice reflects the growing priority given to the export of U.S. clean-coal technologies by DOE, building on its extensive Clean Coal Technology Program in the United States.[8] In July 1991, Airpol, a New Jersey-based firm, was awarded a $7.6-million contract to install emission Controls on two 50-MW boilers.[9] The powerplant subsequently bought another.

Polish power sector assistance has several elements. The Power Sector Restructuring, Privatization, and Management program provides support for a multidonor power sector restructuring initiative developed by the World Bank and the Polish Ministry of Industry. AID contractors are working on increasing the efficiency of powerplants and transmission and distribution systems, privatization, and corporate management. A demand-side management and demonstration program is under way, and a utility partnership between Commonwealth Edison Co. and the Polish Power Grid is examining management issues.

In Hungary, the power sector and energy efficiency are also the primary focus of U.S. assistance. The New England Electric Co. and the Hungarian Power Cos. Ltd partnership has focused on improving management, financial systems, and consumer relations. A complementary program will address key regulatory and privatization issues. Building on energy audits undertaken in 1991, AID is assisting in commercializing low-cost efficiency technologies, developing local private energy service companies and joint ventures, and establishing training programs for promoting private investment in oil, gas, and coal.



GEORGE REISER, LARRY MARKEL, ELECTROTEK CONCEPTS, INC.

*Combined Heat and Powerplant, Krakow, Poland*

Energy efficiency is also a major element of U.S. assistance in the Czech Republic and Slovakia. SEVEn, the energy efficiency center in Prague, conducts outreach to the private sector. Several towns in the Czech Republic, including Cesky Krujlov, Plzen, and Ostrava, have ongoing energy efficiency and pollution reduction demonstration projects.

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[7]This section summarizes and updates projects by country or at a regional level (where new information is available), focusing on clean coal, electric power, oil and gas, and environmental components. For additional information, see Office of Technology Assessment, *Energy Efficiency Technologies for Central and Eastern Europe.*

[8]See u ş Department of Energy, c/can *Coal Technology Export Programs,* National Energy **Strategy** Technical Annex 6, DOE/S-0095P ( 1991/2).

[9]While limited to U.S.-based firms, the specifications for the project had to be adjusted (restrictions on foreign ownership were relaxed and the $SO_2$ emissions reduction target reduced from 70 percent to 65 percent) to allow for a sufficient number of U.S. bidders. Further detail can be found in ch. 4. Background to the project and the bidding process can be found in U.S. General Accounting Office, *Fossil Fuels: DOE's Effort to Provide C/can Coal Technology to Poland,* GAO/RCED-91-*155* (Washington, DC: U.S. Government Printing Office, May 1991 ).

In the power sector, Houston Lighting and Power Co. and the Czech Power Co. (CEZ) have formed a partnership. AID contractors will provide additional technical assistance to CEZ and support for privatization efforts.

In Slovakia, a utility partnership has been formed by Southern Electric International (Georgia) and the Slovak Electric Power Company (SEP), focused on management, organization, and finance. Follow-on power sector restructuring measures are being defined by AID in cooperation with SEP and the Ministry of Economy. In the oil sector, a study of options for upgrading heavy oil processing has been undertaken at the Slovnaft refinery in Bratislava.

In the Baltic countries, AID is attempting to stimulate the development of a domestic energy service industry. The first phase had focused on a series of energy efficiency audits. In the power sector, AID is assisting in pricing and model contracts for international electricity contracts. A utility partnership has been formed between Central Vermont Public Service and Latvenergo (Latvia). A partner is being sought for the Lithuanian utility.

AID is also conducting regional efforts in Central Europe and the Baltics. A major initiative is a project to rationalize the refining and oil transport sector. This will include developing a database, identifying policy. legal, and institutional factors to improve competitiveness, and identifying a list of potential capital projects.

## The Former Soviet Union

As in Central Europe, U.S. energy and environmental assistance to the FSU is undertaken by AID, DOE, and EPA. AID has attempted to build in-country representation more rapidly than in Central Europe.

### NIS Task Force

In January 1992, AID formed the Washington-based New Independent States (NIS) Task Force, linked to AID field missions, which currently include Moscow (Russia), Kiev (Ukraine, Belarus, and Moldova), Almaty (Kazakhstan, Turkmenistan, Kyrgyzstan, Tajikistan, and Uzbekistan), and Yerevan (Armenia, Georgia and Azerbaijan). The task force's energy program has four stated strategic objectives: 1. energy pricing policy and institutional reform. 2. energy efficiency and performance improvements. 3. energy production and delivery system improvements. and 4. nuclear power safety. [10]

**Energy Pricing Policy and Institutional Reform.** This component aims to introduce energy pricing reforms and sector restructuring and privatization. Another key element is training and exchanges between energy companies in the United States and the Former Soviet Union.

In Russia, assistance included planning for privatizing state-owned energy producers, reforming the price and tariff structure, and introducing an appropriate regulatory framework in the energy sector. The Institute for International Education is providing technical assistance and training to develop a petroleum commodity exchange in Moscow. Technical assistance has been given to Ukraine, Kazakhstan, and Armenia in drafting national energy plans and formulating privatization strategies. DOE is heavily involved in drafting a new oil and gas law, and implementing legislation for Russia.

As in Central Europe, AID has begun a program of twinning and exchanges between U.S. energy companies and those in the FSU. This program is discussed in chapter 4.[11] The Energy Industry Partnership Program (EIPP) for the Newly Independent States includes companies and

[10] Nuclear power safety programs are reviewed in ch. 4.

[11] The EIPP's progress is reported quarterly in *USEA—Focus on the New Independent States* and in the *USEA Annual Report 1992.*

associations from the electric power, gas, and petroleum sectors. AID funding for the EIPP is $7.2 million over three and a half years, with additional funding from participating companies.

**Energy Efficiency and Performance Improvement.** This component has focused on improving efficiency in electric power, refineries, industries, and residential buildings. Some funding was also directed to support the Moscow Energy Efficiency Center. Three U.S. engineering and consulting firms assessed efficiency options in selected district heating systems in Armenia, Belarus, Kazakhstan, Kyrgystan, Russia, and Ukraine and identified appropriate instrumentation and equipment to improve efficiency.

**Energy Production and Delivery Systems Improvements.** This component will improve production from existing power facilities, develop additional power generation capacit y from safe sources, and promote demand-side efficiency in key parts of the energy sector. One of the long-term goals is to provide alternative energy sources needed to decommission unsafe nuclear reactors.

Partners in Economic Reform, a U.S. nongovernmental organization consisting of the National Coal Association and the AFL-CIO, is providing advice on the management and safety of coal mines in Russia, Ukraine, and Kazakhstan. In Armenia, AID contractors helped prepare a $57-million loan from the EBRD to complete the Hrazdan power generation facility. AID is also conducting feasibility studies in Russia on greater efficiency in gas transmission.

DOE is proposing Oil and Gas Centers for the major oil- and gas-producing areas of Russia, providing information about U.S. technology and services. Functions would include seminars and training, matching of U.S. companies with Russian production associations, and technical assistance for economic, financial, and field analysis.

### Gore-Chernomyrdin Commission

President Clinton and President Yeltsin agreed at the Vancouver summit meeting in May 1993 to establish a joint commission on energy and space cooperation. Vice President Gore and Russian Prime Minister Chemomyrdin were appointed to chair the commission, which met for the first time in September 1993. Agencies involved with the commission include DOS (overall policy and international coordination), AID (funding coordination), DOE and the Nuclear Regulatory Commission. Nuclear assistance is discussed in chapter 4.

Much of DOE's activity in the Russian energy sector is focused around the Gore-Chernomyrdin Commission. DOE has divided this program into three working groups. DOE's commercial and legislative working group sets up energy-infrastructure demonstration projects to educate Russians in business practices. Its largest effort so far has been a project to open 25 gas stations in the Moscow area. This group has also promoted the development of production-sharing agreements as an interim measure to facilitate U.S. involvement in oil and gas development. In the legislative area, DOE was heavily involved in drafting oil and gas law. Finally, the commercial and legislative working group sends U.S. academic advisors to the FSU to provide policy assistance.

An oil, gas, and coal development working group has developed seven projects to promote technology transfer and joint research. Its main project so far has been an oil and gas technology center located in the Russian city of Tiumen, the capital of the West Siberian oil and gas region. This technology center is designed to link Western companies and technologies with Russian enterprises.

DOE'S energy efficiency working group is currently working on 24 projects. The largest project, financed by a one-time transfer of $125 million from the AID commodity import program (fiscal year 1994 funds), facilitates purchases of U.S. energy-efficiency technologies. The working group is also conducting a study of energy use and alternative sources, with an emphasis on replacing the FSU's most dangerous nuclear reactors.

DOE's total budget for FSU activities is only $3 million (with a separate nuclear safety line of $73 million). Agency personnel note that the small size of the budget limits their activities.

They also note that the way in which funding is routed (all money must pass through AID before coming to DOE) adds a layer of bureaucracy to an already cumbersome system. Finally, DOE officials would like to have more direct authority to negotiate energy-related agreements. These officials note that the United States is the only Western country in which the State Department (or its equivalent), not the Department of Energy, takes the lead in negotiating energy-related agreements.

### Environmental Assistance

AID and EPA are jointly undertaking a number of environmental projects. EPA is focusing its programs on three areas of activity: strengthening the capacity of environmental institutions, focusing resources on environmental "hot spots" and regional environmental management, and demonstrating environmental and energy technologies. EPA participated in a joint mission with the World Bank to plan with the Russian government two major Bank energy and environmental loans: the Oil Rehabilitation Project and the forthcoming Environmental Project. A key objective of the joint mission was to leverage limited U.S. grant assistance with the larger World Bank projects.

### Bilateral Energy Agreements and Working Groups

Energy cooperation with Russia and other FSU countries has accelerated since 1992 but the immense potential for science and technology cooperation between the United States and Russia, as well as other FSU states, has only begun to be tapped. The United States and the Russian Federation Framework Agreement on Scientific and Technical Cooperation in the Field of Fuel and Energy provides for data exchanges, joint projects, and private sector contacts in a number of energy areas, including energy efficiency and renewable. A U.S.-Russian Joint Committee established under the agreement meets annually. DOE plans to pursue Fuel and Energy Agreements with other FSU states, with an initial focus on Kazakhstan, Ukraine, and Azerbaijan.

DOE also supports the U.S./Gazprom Working Group, which brings together U.S. and Russian gas industry officials to develop joint projects, and an Oil and Gas Equipment Working Group under the U.S.-Russia Business Development Committee. There have been delays, however, in organizing the International Science and Technology Center headquartered in Moscow. The founding parties, which included Canada and Sweden, pledged $70 million in fiscal year 1993, with a $25-million share from the United States. There is also an agreement (signed in June 1992) to establish a science and technology center in Kiev, Ukraine, with a $10-million donation from the United States, but friction over Ukraine's nuclear arsenal has delayed the program.

## Multilateral Programs to Assist Former East Bloc Development

Much of the energy and environmental assistance to the former East Bloc is channeled through multilateral initiatives, primarily the World Bank Group and the EBRD.[12] The Central Asian Republics of the FSU have applied for membership in the Asian Development Bank (ADB).[13] The Global Environmental Facility (GEF) also provides multilateral financing. Assistance on policy and research issues is provided by the International Energy Agency, the U.N. Economic Commission for Europe, and the European Energy Charter (see box 7-2).

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[12] Of the $28.4 billion G-7 Multilateral Assistance Package for the FSU announced at the Tokyo Ministerial Meeting in April 1%$ $17.9 billion was to be provided through the International Monetary Fund, the World Bank, and EBRD.

[13] On July 1, 1993, the ADB's Board of Directors proposed 10 approve the membership of Kazakhstan, Kyrgyzstan, and Uzbekistan tentatively for Nov. 30, 1993. Tajikistan, Turkmenistan, and Azerbaijan have also applied for membership. Like the other regional development banks, the ADB provides loans and equity investments for projects, technical assistance, and other advisory services in support of projects. The ADB annually lends over $6 billion, with energy/power and the environment being two major sectors. U.S. Department of Commerce, *BISNIS*, July/August 1993, p. 6.

## BOX 7–2: European Energy Charter

The European Energy Charter is a polltical declaration of principles, objectives, and actions that aims to create a new framework for cooperation, investment, and trade in energy across Europe and possibly across the world. The charter was Initiated by the European Community (now the European Union) with the major objective of integrating former East Bloc countries into world energy markets, Following several months of preparation, it was signed by **43 countries, including the United States,** in December 1991, and several others since then. A legally binding "basic agreement" to the Charter and additional protocols are currently under negotiation.[1]

The charter's objectives are organized around three functional areas energy trade, international cooperation in the energy field, and energy efficiency and environmental protection. The first two of these ininclude provisions to promote more sound legal frameworks for energy activities, access to energy resources, lower barriers to trade in energy goods and services, efficient management and use of energy resources, modernization of Infrastructure, information exchanges, research and development, and policy consultation.[2]

[1] **Richard Greenwood,** "The **European Energy Charter A New Framework for Pan-European Energy Cooperation,** *'Energy in Europe*, No *19,* July **1992, pp 69-72**

[2] **"Concluding Document of the Hague Conference on the European Energy Charter" (The Hague, Netherlands Dec 16-17, 1991)**

### *The World Bank Group*

The World Bank[14] is the most influential multilateral organization affecting energy and the environment in the former East Bloc, lending almost $3 billion for energy projects between 1989 and 1993. The policy framework for Bank energy lending in the region is laid out in the country economic memoranda that typically precede lending, and in energy sector conditionality attached to loans. Conditions include raising energy prices to world market levels, restructuring and privatization of energy sector enterprises, and encouraging foreign investment. The power sector and district heating have been the major focus of Bank energy lending in Central Europe, while oil and gas will dominate in the FSU.

#### Central Europe

The Bank has been assessing problems of common regional concern through the Central and Eastern Europe Network for Regional Energy (CEENERGY) program, in coordination with the European Union, United States, and the Internaational Energy Agency.[15] **CEENERGY seeks to facilitate technical assistance and pre-investment activities in high priority areas.** It has supported studies of petroleum refining and transport, electrical power interconnection and trade, natural gas trade, energy efficiency in the context of environmental impacts, and the impact of Soviet energy exports on Central Europe.

World Bank energy and environmental projects in Central Europe are heavily concentrated in Po-

[14] The World Bank Group consists of the International Bank for Reconstruction and Development, the International Development Association, the International Finance Cm-p., and the Multilateral Investment Guarantee Agency.

[15] The following project descriptions are drawn from Bernard G. Montfort and Harold E. Wackman, "The World Bank Support for Energy Sector Transformation in Central and Eastern Europe" (World Bank, July 1992); and The World Bank, "Central Europe Department Projects Related to Energy/Environment" (May 17, 1993).

land, with loans of almost $1 billion approved in 1990-1993 (most of which are for the energy sector), and several more in the preparation stages. The policy framework for the energy lending was negotiated with the Polish government in 1990 and 1991. Energy price increases, were supported in a structural adjustment loan in 1991 ($300 million) and also in the first energy loan the Energy Resource Development Project approved in 1990 (the World Bank loan is for $250, million with $60 million in cofinancing from the European Investment Bank, toward a total project cost of $648 million). The project also sought to encourage fuel switching from coal, and development of a regulatory framework to support privatization and joint venture arrangements.

The subsequent Heat Supply Restructuring and Conservation Project approved in 1991 (the World Bank loan is for $340 million, with $50 million in cofinancing from the EBRD, toward a total project cost of $619 million) continues sector-wide restructuring and introduces modern technologies into the district heating system. A Cogeneration Privatization Project (the tentative loan amount from the World Bank is $120 million toward a total project cost estimated at $320 million), will promote private investment and ownership of major powerplants in Krakow and throughout the country.

A Power Transmission Project will rehabilitate and reinforce the existing electric power transmission system, and develop the transmission system to meet essential reliability requirements and international standards.

There are two prospective World Bank energy projects in Poland. The Coal Sector Restructuring and Environment project, anticipated for Board approval in early 1995, will support coal sector restructuring,. The Power Privatization project aims to promote independent power production and joint ventures between Polish powerplants and foreign investors.

The power sector is the major focus of the World Bank in the Czech Republic and Slovakia. The Power and Environmental Improvement Project ($246 million toward a total of $557.5 million) aims to reduce the environmental impact of powerplants in Northern Bohemia, through increasing the efficiency of powerplants and the reliability of the CEZ transmission system. Flue gas desulphurization equipment and particulate control (dust and ash) will be installed.

The Second Czech Power Project (about $200 million;) will improve system security and operational reliability and also assist in completing the restructuring of CEZ.

There are two prospective projects in Slovakia. The Slovak Gas project ($150 million, with proposed cofinancing with EBRD) would support a new international gas pipeline to increase domestic consumption and security of supply. The Slovak Power project would assist the Slovak Electric Power company in improving thermal efficiency and reducing pollution at the Vojany power station through installation of circulating fluidized-bed boilers.

In Hungary, the Bank is undertaking an energy/ environment project ($1 00 million for a total cost of $213.2 million) to support diversification of energy supply, energy conservation, and environmental protection. The project would include:

- construction of a gas-fired combined cycle cogeneration unit of 230 MWe (megawatts electrical) and 240 MWt (megawatts thermal) at Dunamenti powerplant;
- upgrading of Hungary's existing Energy Management System;
- assistance for environmental planning and management and,
- training and institution building in the power sector.

### Former Soviet Union (FSU)

In Russia, priority elements of an initial energy policy package consist of energy price reform and the development of a regulatory framework to stimulate investment in the oil and gas sectors. [16]

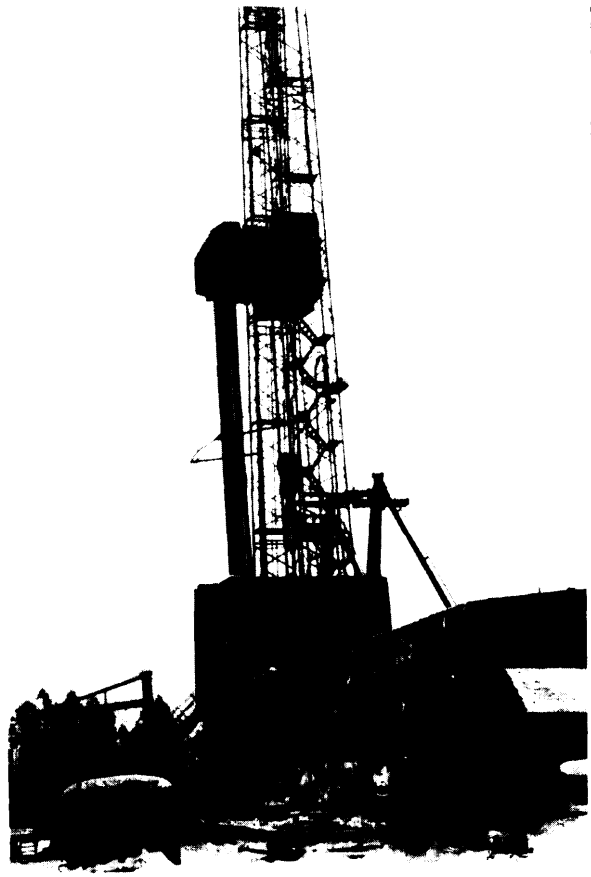
[16] The World Bank, *Russian Economic Reform: Crossing the Threshold of Structural Change* (Washington, DC: World Bank, September 1992), pp. I 80-81.

Bank energy and environmental lending to Russia includes several large projects under way or in preparation. A $610-million loan has been approved toward a $1-billion Oil Rehabilitation Project aimed at reviving oil production in Western Siberia. A natural gas project has also been identified $300 million) that would assist in reducing losses in gas distribution and enhance export potential. The petroleum sector could also be affected by a $300 million environmental project under preparation, to reduce gas flaring, repair pipelines, and increase recovery of liquids from natural gas. The Bank estimates that lending to the Russian energy sector could average between $500 million and $1 billion annually for the next several years.

The Oil Rehabilitation Project is intended to be the first in a series of large projects designed to help stabilize oil and gas production in the FSU, strengthen the managerial and technical capabilities and the financial viability of the participating oil producer associations, and mobilize cofinancing. Three oil producer associations in Western Siberia were chosen for the project: Kogalymneftegas, Pumeftegas, and Varyeganneftegas. A key element will be promotion of a policy framework that will increase foreign investment. The Bank aims to stimulate levels of investment of between $2 billion and $3 billion annually in Russia's oil and gas sector.

The project is intended to increase national oil output by 3 percent per year and bring in $1.5 billion in annual oil revenue. The loan will support repairs at 1,300 oil wells, drill 84 new wells in existing fields, and replace 1,000 kilometers of pipeline.

The Bank is also undertaking energy sector technical assistance and preparing project lending in Ukraine and Moldova (power sector) and the Central Asian Republics (primarily oil sector rehabilitation). In Kazakhstan, two projects are in preparation—a technical assistance loan of about $20 million for fiscal year 1994 and a rehabilitation loan of about $150 million for the Uzen oil field.



SPEARS AND ASSOCIATES INC

*Drilling Rig, West Siberia*

### *The International Finance Corp.*

The International Finance Corp. (IFC) is the private sector arm of the World Bank. The IFC typically makes loan and equity investments of no more than 25 percent of project cost and has an upper limit of $100 million.

In Russia, the IFC is currently supporting two oil and gas projects. A loan of $60 million has been made to the Polar Lights Co., a joint venture between Conoco and Arkhangelskgeologia in the Ardalin oil field in Northern Russia. About $11 million is being provided to a joint venture involving Canadian Fracmaster and two Russian entities

for increasing production at existing wells in Western Siberia.[17]

The IFC is also increasing its participation in private power projects.[18] A new infrastructure investment group was formed in 1992 to assist the IFC in increasing its portfolio of power projects, including a 400-kV (kilovolt) transmission line under consideration in Poland.

## *The European Bank for Reconstruction anti Development (EBRD)*

The European Bank for Reconstruction and Development (EBRD), through both its public sector and merchant banking activities, has approved almost $800 million for the energy sector.[19] Its larger energy loans have for the most part been cofinancing components of World Bank power sector and oil sector rehabilitation projects, although some smaller loans have been made for energy efficiency.

The Bank's short-term priorities are as follows: repairing and rehabilitating existing supply facilities (e.g., oil and gas pipelines); completing existing high-priority projects (e.g., transmission lines and power stations already under construction); assisting countries to diversify sources of energy supply; and private sector projects that promote diversification of supply and the injection of foreign capital (e.g., projects to bring existing oil and gas fields on stream). The Bank will also assist governments with emergency energy sector technical assistance in response to energy shortages and hardships resulting from economic restructuring.

### Central Europe and the Baltics

The EBRD began its energy lending in 1991, with a $50-million cofinancing of the World Bank's Heat Supply Restructuring and Conservation project in Poland. In 1992, energy loans totaling $200 million to public sector operations focused on supply rehabilitation, completion of projects under construction, and end-use efficiency improvement. The Bank has also increased technical cooperation activities.[20]

Latvia, Lithuania, and Estonia were all recipients of loans to support Energy Sector Emergency Investment for $37 million, $44 million, and $47 million, respectively. Each loan focused on rehabilitation of energy supply facilities and end-use efficiency. On the merchant bank side of its operations, the EBRD has made several loans to energy companies in Central Europe, including expansion of generator producing capacity.

### Former Soviet Union

As in Central Europe, EBRD lending for major energy projects in the FSU has typically been cofinanced with the World Bank and export credit agencies. The Bank is providing $250 million in cofinancing for the World Bank Oil Rehabilitation Project in Russia and has loaned the Armenian Ministry of Fuel and Energy $57 million to complete a powerplant. The Bank is also undertaking feasibility studies for rehabilitation of gas pipelines.

On the merchant banking side, the Board had approved five private projects on oil and gas for a total of$188 million to Russia. Four of these proj-

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[17] International Finance Corp., Oil and Gas Division, "IFC Investments in the Oil and Gas Sector," (June 1993).

[18] Jack D. Glen, *Private Sector Electricity in Developing Countries: Supply and Demand*, IFC Discussion Paper 15 (Washington, DC: The World Bank and the International Finance Corp., 1992).

[19] The EBRD's hesitancy t. lend too quickly or creatively has been widely noted. Most countries in the former East Bloc apparently regard the Bank's lending as too cautious, too little, skewed toward larger infrastructure projects, and not supportive enough of the private sector. Bank *officials concede* that it is not cost effective for the Bank to lend less than 5 million ecus. Also, they maintain that the EBRD's status as a merchant bank necessitates a cautious beginning to its lending, See Karol Okolicsanyi, "Eastern Views of the EBRD," *RFE/RL Research Report, vol. 2, No. 23,* Jun. 4, 1993, pp. 502.

[20] EBRD, *Annual Report, 1992.*

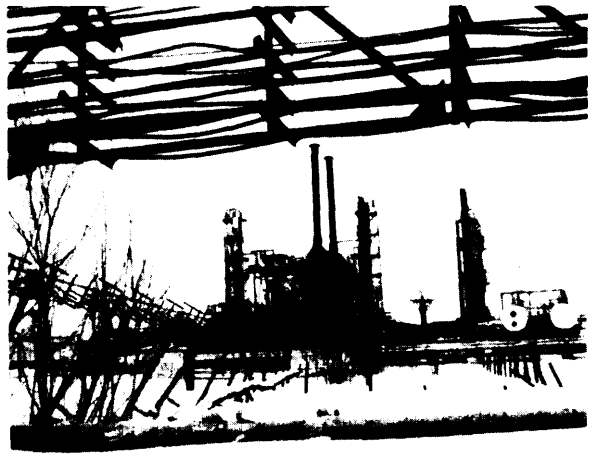
ects were joint ventures with U.S. and Canadian companies, and cofinancing partners include the IFC, OPIC, and Eximbank. These loans include: $33 million toward a loan of $90 million for a Canadian Fracmaster project; $40 million for a $300-million project by Chemogomeft in Tiumen Province; and $90 million for Conoco's Polyarnoye Siyanie project in Archangels province, with OPIC lending $50 million and Eximbank a possible $60 million.

### The Global *Environment Facility*

The Global Environment Facility[21] (GEF) currently has one energy project in Central Europe, a coal-to-gas conversion project in Poland cofinanced with the World Bank. The GEF/World Bank contribution is $26 million toward a $52 million project. The project has several objectives, including an investment component that will initially convert two coal-fired boilers in Krakow to gas-fired, and a technical component that will address institutional and energy efficiency issues. The project also has been allocated a portion of a $4.5-million cofinancing grant from Norway to simulate joint implementation arrangements between Norway and Poland. Other prospective GEF projects include providing lines of credit for energy efficiency demonstration zones.

## | European and Japanese Assistance Programs

The EU has a large and multifaceted program of energy and environmental assistance with former East Bloc countries. The "request driven" PHARE program engages in a diverse set of activities similar to the U.S. assistance program, including policy guidance, training, energy efficiency audits, and installing flue-gas desulphurization equipment. The EU's Technical Assistance Programme to the Commonwealth of Independent States (TACIS) was begun in December 1990. Energy had an allocation of $132 million in 1991 ($61 million for nuclear programs) and $167 million in 1992 ($115 million is for nuclear programs). Non-nuclear activities include oil, gas, and power sector projects, energy efficiency, and energy centers. The Directorate General for Energy's (DG XVII) Thermie program undertakes market assessments, trade promotion events, and energy efficiency audits.


SPEARS AND ASSOCIATES, INC.

*Pumping Station Samotlor Field, Nizhnevartovsk.*

Energy projects are also financed by the European Investment Bank (EIB), an autonomous organization within the EU structure that funds capital investment projects. Energy and the environment are a component of the "Europe Agreements," signed with Poland, Hungary, the Czech Republic, and the Slovak Republic that seek to provide the basis for the future integration of those countries into the EU.

A number of European countries and Japan have bilateral energy and environmental activities

[21] In 1992, the Global Environmental Facility (GEF) was designated as the interim financial mechanism for the Framework Convention on Climate Change. The GEF replenishment, estimated at between $2 billion and $3 billion, will be substantially devoted to projects that reduce greenhouse gases, including energy efficiency, renewable energy, and cleaner fossil energy.

in Central Europe and the FSU.[22] These programs vary widely in scope. Most offer small technical assistance programs on a grant basis and access to export credits. Priorities for the Western European countries include transboundary pollution control, power sector rehabilitation and transmission connections between East and West, oil and gas pipelines, and, increasingly, access to the oil and gas resources in the FSU.

Bilateral relations often reflect a mix of historical ties, geographical proximity, and national interest. For example, Scandinavian environmental assistance is concentrated in the countries that share the Baltic sea coastline and that also account for a large share of transboundary pollution.

Germany has focused its bilateral energy programs in Hungary and Russia. Austria's energy assistance programs are focused on pollution and power sector rehabilitation in the Czech Republic and Slovakia.

Japan's assistance activities have included industrial energy efficiency audits in Hungary and sending a survey team to Russia to establish the basis for more extensive future contacts. Japan has announced a $1 .2-billion package of bilateral aid for the FSU, a large part of which will be devoted to the construction of a facility for the disposal of nuclear waste.

Like the United States, other bilateral donors sometimes coordinate assistance with the World Bank and other multilateral lenders. The United Kingdom for example, is participating with the World Bank on power sector restructuring in Poland, and the Netherlands is providing cofinancing for technical assistance to the World Bank oil rehabilitation project in Russia.

## U.S. Trade and Investment Programs

Western assistance for the former East Bloc was complemented from the beginning by efforts to stimulate trade and investment.

A large number of U.S. government agencies are involved in energy and environmental export assistance to former East Bloc countries. DOC, AID, DOE, OPIC, and the Trade and Development Agency (TDA) provide export and investment promotion, such as market information, training, conferences, official visits, and in-country support for business. Eximbank, OPIC, TDA, and, to a lesser extent, AID and DOE provide financing for exports, projects, and investments.

The proliferation of activities led to some confusion. Establishment of the Trade Promotion Coordinating Committee (TPCC) should improve coordination. The TPCC was initiated by the Export Enhancement Act of 1992 (Public Law No. 102-429). Chaired by the Secretary of Commerce, it consists of all 19 federal agencies[23] involved in export promotion plus the National Security Council and the National Economic Council. The purpose of the TPCC is to provide an export promotion strategy, coordinate and prioritize the government's export promotion activities, and provide a central source of information.[24]

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[22] Reviews of these activities relating to energy efficiency can be found in International Energy Agency, "Energy Efficiency Update, No. 14, March 1992, and U. N., Economic Commission for Europe, *East- West Energy Efficiency: Policies, Programmes, Technologies, and Who's Who (New* York, N. Y.: United Nations, 1992). On European and Japanese environmental aid programs generally see U.S. Congress Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology Background Paper,* OTA-BP-ITA-107 (Washington, DC: U.S. Government Printing Office, August 1993), pp. 55-69.

[23] Departments of Commerce, Agriculture, Interior, Labor, State, Treasury, Defense, Energy, and Transportation; the Agency for International Development, Environmental Protection Agency, Export-import Bank, Council of Economic Advisers, United States Information Agency, United States Trade and Development Agency, United State Trade Representative, Office of Management and Budget, Overseas Private Investment Corporation, Small Business Administration.

[24] The committee is required to submit annual reports to Congress. The first report, entitled, *Towards a National Export Strategy,* was submitted in September 1993. This report emphasizes the need to combine functions, allocate resources strategically, involve the private sector, practice aggressive advocacy, evaluate export promotion efforts, and reduce export controls.

In Central Europe there has been modest but growing demand for U.S. technologies and services in the power sector, in air pollution control, and in energy efficiency. By far the greatest demand for U.S. investment could be in the oil and gas sector in the FSU. While the large oil companies have operated extensively across the world, many other U.S. energy companies and much of the environmental industry have not had a strong international orientation. Awareness of the large potential offered by a large and growing global market, a declining U.S. share of those markets, and, in some cases, the concomitant maturation of the U.S. market have increased industry interest in government involvement in supporting exports and overseas investment.[25]

### Information Programs

U.S. information about business opportunities in Central Europe and the FSU is channeled through a variety of sources. DOC's Eastern European Business Information Center (EEBIC) and the Business Information Service for the Newly Independent States (BISNIS) act as clearinghouses for trade and investment opportunities for U.S. businesses.[26] DOC's U.S. and Foreign commercial Service (US&FCS) undertakes export promotion activities in the region. Electric power technologies and oil and gas equipment are promoted as a "best prospect" for U.S. trade in several countries.

International conferences, trade missions, and reverse trade missions can also be cost-effective means of promoting business. TDA and DOE have funded, and cofunded, a number of energy and environmental conferences and visits of officials.[27]

In-country support of business development is provided by a growing network of business centers that provide visiting company representatives with services such as telephone and fax, temporary office space, market information, and assistance in making business contacts. The American Business Center is open in Warsaw, Poland, and the FSU American Business Center Program, funded by AID, plans twelve centers. The US&FCS also has offices throughout Central Europe and in the FSU and is planning a substantial increase in personnel.

The DOE-managed energy efficiency centers engage in business development, including U.S. liaison support with U.S. companies, and in developing the Automated Eastern Europe and Newly Independent States Information System. The Czech and Slovak center, SEVEn, supports a series of energy efficiency business weeks featuring energy management and efficiency programs and appliances.

Other types of trade promotion activities involve increasing U.S. commercial opportunities at the multilateral and regional development banks. There is also support for firms seeking procurement opportunities at the banks. The DOC Office of International Major Projects maintains a reference room of World Bank and EBRD (and other regional development banks) project documents, project pipelines, and provides procurement liaison officers.

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[25] U.S. Department of Energy, *National Energy Strategy: Analysis of Options to Increase Exports of U.S. Energy Technology*, Technical Annex 5 (Washington, DC: U.S. Government Printing Office, 1991/1992); Interagency Environmental Technologies Exports Working Group, U.S. Department of Commerce, *Environmental Technologies Exports: Strategic Framework for U.S. Leadership* (Washington, DC: U.S. Government Printing Office, November 1993).

[26] The EEBIC publishes the *Eastern Europe Business Bulletin*, on a monthly and sometimes bimonthly basis, which includes general information on trade and investment as well as specific business opportunities in the energy sector and in energy equipment. It also produces the occasional publication, *Eastern Europe Looks for Partners*, which provides information on joint ventures in specific sectors. BISNIS similarly publishes the *BISNIS Bulletin*.

[27] These include a U.S. Power Technologies Conference in Prague in July 1992, followed by BuckPest, September 1993, and visits by energy officials from Poland, Hungary, the Czech Republic, Latvia, and Lithuania.

### Pre-Export and Pre-investment Financing

Several different U.S. government agencies, including Eximbank, OPIC, TDA, and AID, provide pre-export financing for energy firms, which can lead to follow-on export or project opportunities. U.S. firms have lobbied in recent years for an increase in government funding for feasibility studies. The TPCC has recommended that all U.S. government funding for feasibility studies be centralized in the TDA.

TDA, the primary source of funding for feasibility studies, has steadily increased its energy and environment activities in the former East Bloc. These studies have been undertaken by U.S. firms, including Westinghouse, Bechtel, Enron, Fluor Daniel, Foster Wheeler, and Black & Veatch. Other project development funds include the Capital Development Initiatives for energy and the environment, managed by AID.

### Financing for Exports and Investment

Eximbank and OPIC financing for the region has grown significantly since 1989. Both agencies face persistent demands to increase financing in the region. Energy capital goods are a key strate-, gic sector.

#### Eximbank Programs

Eximbank programs are designed to support exports that would not otherwise attract private sector financing, by offering loans with longer term maturities, providing export credit insurance, and countering export credit subsidies of foreign governments. While not explicitly stated as such by the Bank, which is not a development lender, the credits to former East Bloc countries are integral to U.S. foreign policy objectives of stabilizing the region economically and demonstrating U.S. financial commitment to its development.

The Bank is directed to support "key industries" that, among other things, export high value--added products, develop new capital goods technologies, and support highly skilled jobs in the United States.** Energy capital goods exports, particularly electric power and oil and gas, have been a large component of Eximbank's lending in recent years. The Bank has also received congressional mandates to reach targets in certain other energy and environmental sectors. A target for renewable energy exports of 5 percent of total energy exports was set in 1990 and adhered to since then.[29] Under the Export Enhancement Act of 1992, Eximbank was required to support the export of goods and services that have "beneficial effects on the environment or mitigate potential adverse environmental effects."

Eximbank offers short-term and medium-term loans and guarantees in most of Central Europe and the Baltics. By fiscal year 1992, the Bank had a total exposure of about $647 million in Poland, $196 million in the Czech and Slovak Republics, and $1.7 million in Hungary. The Bank began lending to the then-Soviet Union in 1991. By fiscal year 1992, its exposure in Russia was $115.5 million .30

But the poor quality and unreliability of the nascent banking sector and the indebtedness of the state sector in Russia makes sovereign borrowing difficult. To promote capital goods exports, Eximbank has been seeking alternatives to sovereign lending by offering various types of "limited recourse" financing, including project financing and a large export credit line for oil and gas equipment.[31]

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[28] Export-Import Bank, *Annual Report 1992* (Washington, DC: 1993).

[29] See U.S. General Accounting Office, *Export Promotion: Federal Efforts to Increase Exports of Renewable Energy Technologies*, GAO/GGD-93-29 (Washington, DC: U.S. Government Printing Office, December 1992).

[30] The Bank's total exposure as of Sept. 30, 1992 was $41.8 billion.

[31] Limited recourse financing is lending that is secured on the cash flow and earnings of the project rather than the guarantees from (recourse to) the project owners/sponsors.

The Bank's project financing is available for transactions that involve over $50 million in U.S. content. It applies to new projects, not expansions, which can be structured as BOT (Build Operate Transfer), BOOT (Build Own Operate Transfer), BOO (Build Own Operate), or variations. Project finance loans are looked at more favorably if they involve cofinancing with other ECAs and/or commercial banks. The first project financing deal put together for the FSU was a $47-million joint venture between Anderman Smith and Chemogoneft, a private, Russian-owned oil and gas production company. Exporters benefiting will include Halliburton Company, National Oilwell, and National Engineering and Constructors.[32]

But the bulk of limited recourse financing will come under the U.S.-Russia Oil and Gas Framework Agreement signed in July 1993, estimated to provide financing for $1 billion of U.S. oil, gas, and petroleum equipment and services. The operation of the agreement was delayed pending negotiations over the World Bank's negative pledge clause. This clause requires World Bank borrowers to avoid further liens on any public assets already pledged for Bank loans and to allow the Bank to claim priority over others in repayment of debt. This clause has effectively precluded state oil enterprises in the FSU from pledging their assets as security for foreign credit.[33] The World Bank recently agreed to waive this pledge for lending to Russia's oil and gas sector.

This waiver clears the way for Eximbank financing, which will be secured from the hard-currency sales of the oil and gas produced under the project. To qualify for a loan under the limitations set out by the World Bank as conditions for the waiver, the oil and gas equipment must be shown to provide incremental oil, that is, oil not available without the equipment purchase. Applications for financing under the agreement thus require a great deal of technical and financial information from all parties to the deal, notably including a yield consultant report on the technical and economic feasibility of the transaction Another limitation of the agreement is that many oil and gas equipment transactions are on a smaller scale than the financing minimum of $25 million.

The offering of export credits can also introduce a distorting effect into the recipient country's development path. Since export credits typically support heavy capital goods on attractive terms, or make accessible capital goods that would otherwise be unavailable, borrowers may be biased toward capital-intensive imports. This question has also been raised with respect to the Russian need for imports of U.S. oil and gas equipment, given the existence of a huge Russian and Azerbaijani oil and gas equipment industry, which, while not as technologically sophisticated as that of the United States, nevertheless supported the extensive development of Soviet oil and gas. At this point (spring 1994) it is too early to assess the likely success of the Eximbank framework agreement (see ch. 8 for further discussion).

### OPIC Programs

OPIC's financing for U.S. investors in former East Bloc countries, which includes political risk insurance, loans, and guarantees, is oversubscribed. Political risk coverage, in particular, is a major requirement for many companies wanting to do business in the region. Table 7-3 reviews OPIC energy and environmental financing for the region.

OPIC is increasingly active in the FSU oil and gas sector, with financing for projects by Anderman Smith, Conoco, and Texaco. Assistance in oil and gas projects includes both political risk insurance and loan guarantees. However, OPIC has limitations on the type of financing and size of the

[32] "Caspian Progress Tops C.I.S. Deals", *Oil and Gas Journal*, vol. 91, No. 24, 1993, p. 20.

[33] Jeffrey A. Burt, "Positive Movement on the Negative Pledge," *Russian Petroleum Investor*, March 1993, p. 52.

TABLE 7-3: OPIC Loans and Insurance for Energy and the Environment to Former East Bloc Countries 1990-1993

| Country | Recipient | Amount (U.S.$) | Type of assistance |
|---|---|---|---|
| Poland | Air products and Chemicals (industrial gas) | 12,029,000 | Insurance |
| Hungary | General Electric (lighting) | 150,000,000 | Insurance |
| Czech Republic and Slovakia | Environmental Systems Corp. (monitoring) | 250,000 | Insurance |
| Russian Federation | Anderman-Smith Overseas (oil and gas) | **7,000,000** | Insurance |
| Russian Federation | Conoco (oil and gas) | **50,000,000** | Loan guarantee |
| Russian Federation | Texaco (oil rehabilitation) | 28,000,000 | Loan guarantee |

**SOURCE OPIC, 1994.**

projects it supports. The ceiling on loan guarantees will probably be raised to $200 million (from the previous $50 million) in line with Trade Promotion Coordinating Committee recommendations.

OPIC has also supported a "Russia Country Fund," which is expected to generate several hundred million dollars of investment in the Russian economy.[34] The fund will provide equity to a wide range of new businesses, expansions, and privatizations, with particular emphasis on energy and environmental projects.

### Enterprise Funds

Energy and environmental companies doing business in Central Europe and the FSU may also be eligible for enterprise funds established by the U.S. government to foster overseas investment and private sector development. The funds are converted to small and medium size funds Such funds have been established in Poland (1990), Hungary (1990), the Czech and Slovak republics (1991 ), and Russia ( 1993). The funds emphasize the financing of firms in the recipient countries and the joint ventures with U.S. firms, but will also finance U.S. companies doing business in the recipient countries.

## European and Japanese Trade and Investment Programs

Most European countries and Japan have export credit agencies (ECAs) and investment promotion and financing programs against which U.S. programs are often negatively compared.[35] Indeed, export financing supports a much higher percentage of many of these countries' exports than do U.S. programs. European and Japanese governments are reported to be more aggressive in supporting deals by their companies than is the United States. But the exposure of the European and Japanese programs in the former East Bloc generally, and in the energy and environmental sectors specifically, is difficult to monitor.

The Japan Export-Import Bank is preparing a $1.5-billion line of credit for the FSU that would include financing for a refinery in Uzbekistan be-

[34] Managed by Paine Webber, Inc. in cooperation with International Economic Cooperation.

[35] For surveys of other countries programs, see U.S. General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Countries*," AO/GGD-92-97 (Washington, DC: U.S. Government Printing Office, June 1992); William E. Nothdurft, Going *Global: How Europe Helps Small Firms Export* (Washington, DC: The Brookings Institution, 1992); and Therese J. Belot and Dale R. Weigel, *Programs in Industrial Countries to Promote Foreign Direct Investment in Developing Countries,* Foreign Investment Advisory Service, Occasional Paper 3 (Washington, DC: The World Bank, 1992).

ing constructed by Marubeni Corpo and Chiyoda Corp. An EU political risk insurance fund for energy investors in the FSU has reportedly been started by Energy Private Investment Support, a private bank consortium with between $6 billion and $12 billion in resources.[36] Also, the investment activities in the former East Bloc of European state-owned energy enterprises, such as Elf-Aquitaine (France) or Statoil (Norway), could be considered a form of export assistance, given these companies' access to public finance. U.S. companies benefit from European and Japanese export financing, but are required to reduce sharply the level of U.S.-made components. For example, a U.S. supplier to a petrochemical project in the FSU reported having to reduce U.S. components to less than 5 percent when financing was sought at Italian and Japanese export credit agencies.[37]

[36]Cited in U.S. International Trade Commission, "Trade and Investment Patterns in the Crude Petroleum and Natural Gas Sectors of the Energy-Producing States of the Former Soviet Union," Publication 2656 (Washington, DC: U.S. International Trade Commission, June 1993) pp. 5-3 and 5-4.

[37]U.S. Department of Commerce, "Obstacles to Trade and Investment in the New Republics of the Former Soviet Union" (Washington, DC: U.S. Government Printing Office, March 1992), p. 21.

# U.S. Goals and Policy Options

8

The U.S. national interest would be served well if all countries in the former East Bloc become prosperous, democratic trading partners. Some are very likely to do so; others hold less promise. The reform transition is proving extremely difficult, and in Russia and several other former East Bloc countries there is no consensus that it is worthwhile. Failure in reform could have very undesirable implications for the United States, including a possible resumption of the Cold War and dangerous international instability.

U.S. policy must be based on a realistic understanding of the situation and of the United States' ability to influence decisions. The transfer of energy technology can be a major vehicle for supporting reform and, if done wisely, can greatly benefit both the United States and the recipient countries. However, poorly thought-out programs may actually impede reform while providing only a marginal increase in U.S. exports. This chapter reviews the main goals guiding U.S. policy toward the region and suggests specific policy options relating to energy that support U.S. goals. Since national goals can conflict, it also considers how the options can be coordinated in overall strategies.

PAULA A. WHITE

*National Theater, Sofia.*

## U.S. NATIONAL GOALS

The chief U.S. goal, over which there is no disagreement, is to promote the transition of formerly hostile East Bloc countries to democratic, market-oriented trading partners. The primary justification for U.S. assistance has been the "historic opportunity" to ensure world peace and the security and prosperity of American citizens that has arisen from the collapse of Communism and the end of the Cold War. Promoting political stability and economic

prosperity in the former East Bloc should lessen the risk of future conflict and dampen geopolitical competition.

## Energy-specific Goals

Reform and modernization of the energy sector is a critical factor in the transition because of its great economic importance. As a component of overall American strategy in the former East Bloc, U.S. goals with energy-specific implications include the following:

- to promote market reform in the energy sector,
- to modernize energy sector facilities and technologies,
- to advance U.S. energy-related business interests,
- to reduce energy-related pollution and threats to the environment, and
- to augment world fuel supplies.

### *Promoting Market Reform*

Energy sector reform is a crucial component in the transformation of the countries of the former East Bloc to market-oriented societies. It is unlikely that energy production can be increased significantly, and energy use rationalized, unless broad-based policy changes are made. Successful marketization of the economies of the region depends most fundamentally on introducing comprehensive programs of privatization, enacting basic changes in legal structures, eliminating state subsidies, freeing domestic prices, achieving currency convertibility, and establishing a favorable climate for foreign investment. In particular, energy price reform is essential to economic transition and has been a key condition of loans from the multilateral development banks (MDBs) to Russia and other former Soviet Union (FSU) republics.

### *Modernizing Facilities and Technologies*

Energy sector modernization is of special importance for several reasons. The enormous fossil fuel reserves of several former East Bloc countries represent the largest and most immediately exploitable source of exports that can generate the hard currency so desperately needed to finance general political-economic reforms. Since inefficient and antiquated supply and consumption patterns severely restrict the quantity of oil and gas available for export, modernization of energy technologies and facilities is imperative.

Countries lacking large oil and gas reserves must import supplies. Imported energy is very costly, especially as Russia moves to world prices in its exports to other FSU republics. The bulk of Ukraine's huge debt to Russia stems from oil and gas imports. Many countries must resort to burning high-pollution domestic coal, and several rely on unsafe nuclear powerplants. The introduction of cleaner and more efficient energy technologies will enable these countries to spend less on imported fuels and to reduce pollution.

### *Advancing US. Energy-Related Business Interests*

U.S. companies are competitive in many energy areas. Assisting them in former East Bloc markets will lead to increased U.S. exports and jobs. In particular, American oil and gas companies are world leaders in exploration and production technologies. The former East Bloc represents an excellent opportunity for U.S. firms to find new reserves, increase business, and employ their excess capacity. Increased activity in the FSU could boost U.S. employment in the oil and gas industry, which has shrunk by 400,000 jobs over the past 10 years.

### *Reducing Energy-Related Pollution and Threats to the Environment*

Pollution in the former East Bloc has caused great devastation in some regions, adversely affecting public health and the economy. Some pollutants have global implications. Carbon dioxide emissions from the former East Bloc account for a disproportionate share of worldwide greenhouse gas emissions. Addressing energy-related environmental problems in the former East Bloc also offers business opportunities and jobs to the United States.

### *Augmenting World Fuel Supplies*

World-wide availability of fuels will benefit significantly from energy sector modernization and Western investment. Oil and gas are plentiful now, but supplies are likely to tighten over the next decade, especially if Russia has to start importing oil. Western technology can at least slow the decline of Russian oil production. Kazakhstan and Azerbaijan have the potential for increased exports.

Even greater potential can be gained from improved efficiency of energy use, especially in the near-term.[1] Reducing energy waste is equivalent to increased production, and will make more energy available for export from the region. Increased world energy availability, whether obtained from increased production or reduced consumption, will mitigate future world market oil price increases and diversify sources for energy imports.

## The Political Context of Energy Sector Reform

As described in chapter 6, political reform and economic reform are closely intertwined. Success of market-oriented economic reform depends on the creation of political systems that embody some type of popular consensus about the nature and pace of reform and in which leaders have the political will to carry out the painful process of restructuring and reform. U.S. goals and priorities must take account of this relationship.

It is important to recognize, however, that Western priorities will not always coincide with local preferences. What may seem to Westerners the most economically rational course of action might not be acceptable to local reformers. For them, successful reform often means maintaining employment, renewing human and physical capital, and creating future opportunities as well as maximizing economic activity. This is not just a question of political-cultural preferences, but a recognition that the maintenance of social peace requires a transition that balances economic needs with social costs.

In Russia, this orientation--coupled with Russian 1eaders' fear of appearing subservient to the West—has profound implications for the energy sector. Instead of importing Western equipment and advisers, Russians have so far preferred to develop their own oil and gas "majors." They want to use the energy sector as an engine to modernize decrepit and outdated enterprises and to convert the former military-industrial economy to civilian uses. In this context, it may make economic and political sense for Russians to buy domestically manufactured but inferior parts rather than import Western equipment. Not only are first costs lower, but buying domestic parts maintains domestic employment and provides some basis for a slow upgrade of manufacturing capacity.[2]

In effect, some former East Bloc governments may find it a wise policy to "buy" social peace by maintaining state support for old and inefficient industries with only gradual conversion to a market economy. The cost—greater but more predictable inflation and higher budget deficits-may be justified for local reformers if it results ultimately in a peaceful transition to a more efficient market-based economic system. The energy sector will not be immune from this calculus. U.S. goals and priorities should therefore be flexible enough to take adequate account of local priorities in economic reform, particularly in the energy sector.

## POLICY OPTIONS

Policymakers have a variety of instruments to support the goals discussed above. These tools can be categorized under bilateral development assistance, export promotion, multilateral development institutions, and investment promotion. In addition, improved coordination of all these programs is desirable and may permit new, effective initiatives. Most of the specific programs

[1] For an overview of energy use and policy options to improve efficiency, see chapter 4 of OTA'S earlier assessment, *Energy Efficiency Technologies for Central and Eastern Europe, OTA-E-562* (Washington, DC: U.S. Government Printing Office, May 1993).

[2] It is worth noting that our own "buy American" legislation also aims to support domestic employment.

mentioned in this chapter were discussed in more detail in chapter seven

## | Bilateral Development Assistance

Congress recognized the great need for help in the former East Bloc and created a substantial development assistance program with major energy and environmental components. The assistance program is having some success, particularly with energy efficiency, but experience is limited. Most of the elements have been well selected, and fundamental changes in direction appear unnecessary. However, Congress could consider ways to improve the effectiveness of the overall assistance program and its components.

The major purposes of the U.S. energy assistance program are to promote economic reform and to modernize energy systems. Assistance can play a significant role in promoting reform within the energy sector, if properly directed. U.S. government aid programs must be coordinated with advisory activities to promote internal price, regulatory, and other reforms.

U.S. resources are very limited compared with the immense need for development projects to improve energy supply and consumption. However, projects focused on specific areas (e.g., training, technical assistance, institution building) can maximize the impact of U.S. government resources and fill precise needs that large multilateral institutions such as the World Bank find difficult to address.

Most programs are funded by the U.S. Agency for International Development (AID), sometimes with the involvement of other agencies such as the U.S. Department of Energy (DOE). AID's program budgets for Central Europe and the FSU are shown in tables 8-1 and 8-2. These tables include AID programs that are either specifically targeted at the energy sector or that address general areas of economic and systemic reform that are important for energy-sector development and that are highlighted in this report.

Areas and programs that OTA's analysis indicates are exceptionally effective for meeting urgent needs and satisfying U.S. goals in the former East Bloc energy sector are listed in table 8-3 and discussed below. This section also describes how these programs can be improved through redirection and/or increased funding.

### *Policy Assistance*

Policy assistance guides governments in establishing democratic processes and in adapting to a market economy. Helping establish a new set of economic ground rules that provide proper financial and regulatory incentives for producers and consumers will provide a framework within which other problems (including investment in oil and gas production) may be resolved, either through the operation of the market or with the aid of U.S. development assistance programs.

The primary goal for the energy sector is price reform. The advantages of price reform are compelling. Higher energy prices would provide producers with the necessary capital to develop new energy supplies and would encourage efficient energy use in all sectors of the economy. Reducing energy use would also have important environmental benefits since much pollution is energy-related. Reduced subsidies to the energy sector would help reduce budget deficits, a key requirement for improved fiscal management. Foreign exchange earnings would be augmented by increased exports of oil and gas now consumed locally.

Exportable forms of energy, including oil, gas, and coal, should be priced at world levels for economically rational decision making. The target for electricity is to increase prices to a level that covers the full costs of production and distribution and provides a surplus for future system expansion. Current prices in the FSU are far below either of these levels. For example, oil and gas prices in Russia are still less than half world prices because rapid inflation has diluted much of the impact of the frequent price increases of the past three years.

However, rapid energy price increases cause considerable hardship, especially to residential consumers, because long-established patterns of consumption are based on low energy prices. That

TABLE 8–1: USAID Central Europe Budget Allocations
(Italics indicate energy sector–specific items)[a]

| Program type | FY 1993 (millions) | FY 1994: preliminary (millions) |
|---|---|---|
| **Regional energy efficiency** | 7.0 | 9.0 |
| Energy-sector *restructuring and privatization* | *7.0* | *8.0* |
| *Krakow Power Project* | *7.0* | *4.5* |
| *Nuclear safety (DOE and NRC)* | *5.0* | *5.0* |
| Rule of law | 2.1 | 2.8 |
| Democratic governance and public administration | 13.5 | 23.0 |
| Privatization | 42.0 | 44.3 |
| Small business development | 32.0 | 30.0 |
| Commercial law reform | 9.3 | 11.3 |
| Financial sector reform | 18.5 | 18,1 |
| American business initiative | 5.1 | 3.0[b] |
| Trade enhancement | 1.5 | O.ob |
| Enterprise funds | 110.0 | 55.8 |

[a]This table IS *not* a comprehensive listing of USAID Central Europe-related programs Instead, it includes only those programs that are either specifically targeted at the energy sector or that address general areas of economic and systemic reform that are Important for energy-sector development, areas that are highlighted in this report

All figures represent original appropriations and do not reflect carryover

[b]ABI Terminated after fiscal year 1994.

Trade Enhancement merged with Small Business Development program in fiscal year 1994

SOURCE U S Congress, Off Ice of Technology Assessment, 1994

is why the Russian government has resisted strict programs of price reforms as a condition of receiving MDB loans. High political dissatisfaction and accelerating inflation will make further progress more difficult.

Though correct energy pricing is a necessary condition for energy sector reform, it is frequently not sufficient, because institutional and market imperfections can weaken the signals provided by higher prices. In the FSU, for example, many consumers, particularly large, energy-intensive, industrial enterprises, along with some FSU importing countries, do not pay their oil and gas bills. In this case, the specified price is an administrative fiction that has no restraining impact on consumption patterns. Effective energy pricing will require major policy changes and reforms throughout all sectors.

Privatization is a close companion to price reform. In all countries of the region, conversion of behemoth state energy industries into a system of more rationally structured, profitable, private enterprises can serve as a model for economic transition in nonenergy sectors of the economy. Rationalization of enterprise management and elimination of government subsidies and price controls in the energy sector can also reduce the incentives driving the widespread corruption that is undermining public confidence in economic reform.

Centrally planned economies rarely incorporated regulation as it is practiced in the West, but several forms will be needed as privatization proceeds. Most obvious is environmental regulation to meet modem standards. Most former East Bloc countries have stringent regulations on the books,

TABLE 8-2: Selected USAID FSU Program Budget Allocations (Italics indicate energy sector-specific items)[a]

| Program type | FY 1992-3 funding (millions) | FY 1994 funding (millions) |
|---|---|---|
| **Policy and market reform assistance** | | |
| *Pricing policy and institutional reform* | 5.7 | *22.0* |
| Rule of law | 9.5 | *25.5* |
| Local governance | 9.7 | *9.5* |
| Privatization | 125.3 | 115.0 |
| Business development | 14.2 | 75.0 |
| Banking sector reform and bankers training | N A[b] | 12.6 |
| Fiscal sector reform | 13,2 | 15.5 |
| Financial and monetary sector reform | 13.4 | 10.7 |
| Training and macroeconomic advice (Dept. of Treasury) | NA | 2.1 |
| Market environment | 2.2 | 14.4 |
| Business **and organizational training** | | |
| Short- and Long-term training | 2.7 | 91.5 |
| US/NIS partnerships | NA | 5.0 |
| Exchanges (USIA) | 56.3 | 128.0 |
| SABIT program (DOC) | 2.0 | 2.0 |
| CAST program (NAS) | 2.0 | 2.0 |
| Eurasia Foundation | 8.0 | 12.0 |
| **Energy efficiency** | | |
| *Efficiency & performance improvement* | 22.4 | *35.0* |
| *Production and delivery systems* | 15.7 | *39.0* |
| *Special earmarks (Lab-to-lab, etc.)* | *NA* | *33.0* |
| **Nuclear power** | | |
| *Nuclear power plant safety and regulation* | 45.2 | 85.0 |
| **Technical assistance** | | |
| *Russia Energy & Environment Commodity Import Program* | *NA* | *125.0* |
| **Environment** | | |
| Policy and institution building | 3.4 | 21.9 |
| Technology cooperation | 5.7 | 36.5 |
| Local NGO support | 2.3 | 14.6 |
| **Trade and investment promotion** | | |
| Transfer payments to DOC and TDA | 23.2 | 8.5 |
| Enterprise funds | | |
| Russian-American Enterprise Fund | **20.0** | 120.0 |
| Western NIS Enterprise Fund | NA | 45.0 |
| Central Asian Enterprise Fund | NA | 30.0 |
| Fund for large enterprises in Russia | NA | 100,0 |
| EBRD Small Business Fund | NA | 15.0 |
| Multi-Lateral Equity Fund | NA | 21.0 |

[a]This table is *not* a comprehensive listing of USAID FSU-related programs. Instead, it includes only those programs that are either specifically targeted at the energy sector or that address general areas of economic and systemic reform that are Important for energy-sector development, areas that are highlighted in this report.

All figures represent original appropriations:

- They do not reflect recisions under way in February 1994.
- They do not reflect considerable carryover of funds appropriated in fiscal year 1992-93.

The higher levels of funding in fiscal year 1994 representaone-time infusion Fiscal year 1995 appropriations will revert to fiscal year 1992 -93 levels or lower

[b]NA=Not applicable.

SOURCE U S Congress, Off Ice of Technology Assessment, 1994

TABLE 8–3: Exceptionally Effective Development Assistance Programs

- Policy assistance
  - Price reform
  - Privatization
  - Regulation
- Training in market activities and skills
- Energy efficiency
  - Demonstrations and assistance
  - Efficiency centers and information
- Nuclear safety and proliferation control
- Environmental information and assistance
- Specific technology transfer programs
  - Utility Partnership Program
  - Powerplant renovations
  - Clean-coal demonstrations and assistance
  - Coal mine safety
- Energy research and development

SOURCE U S Congress, Office of Technology Assessment, 1994

but they are not enforced. Assistance is needed to achieve a workable regulatory code and to train regulators to administer and enforce the environmental laws, as discussed in chapter 5.

In addition, electric power must be regulated appropriately. At present, rates in some countries are held well below costs, but the opposite could occur once the utilities are privatized. Yet few former East Bloc governments have any experience with cost-based regulation, a role that is handled in the United States by the Federal Energy Regulatory Commission and by state regulatory agencies. U.S. expertise should become very important as central planning is reduced.

Policy assistance is not expensive. It generally involves reciprocal visits and training. Government, industry, and academic personnel should be involved. The main agencies coordinating the work involving energy sector policy should be DOE, AID, the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), and the Department of State (DOS). An additional appropriation of about $1 million per agency should allow for many visits in both directions and extensive training in skills needed for operating a modem, market-oriented government.

### *Training in Market Activities and Skills*

As privatization has progressed, officials of former East Bloc countries and Western observers have realized that new skills are needed. These include specific technological expertise and market economy skills that Westerners take for granted, such as accounting, planning, and financial management. Developing these general market economy skills is essential for putting the energy and environmental industries and their customers on a rational and more efficient footing.

Training programs to transfer technical and business-related skills will also help create an environment more conducive to reform and U.S. investment. Without the skills necessary to manage financing, operations, and personnel within the structures of a market economy, former East Bloc firms will not be able to purchase and efficiently make use of advanced technologies from the West. The importance and effectiveness of this type of training has been demonstrated in China by the success of the American-sponsored Dalian Management School. The Department of Commerce (DOC) assisted the founding of that school.

Business, technical, and cultural training is possibly the most effective form of assistance at the moment. With highly educated work forces, the societies of the former East Bloc have excellent prospects for successfully absorbing training in Western-style management techniques and market-related skills. Education and training programs in these countries have produced high rates of success. For example, the U.S. director of a major Russian-American oil production joint venture in Western Siberia reports that the company plans to turn its operations over completely to Russian managers within just five years. In almost all other countries where he has worked, it has taken at least one generation to train local personnel to manage production themselves.[3]

[3]Robert E. Tornstrom, president and general manager, Occidental Petroleum of the CIS, personal communication, November 1993.

Furthermore, such programs are traditional activities for U.S. government agencies, especially AID and the Peace Corps, and can directly support all five goals discussed in the previous section. Throughout the former East Bloc, these activities fill avoid that the private sector cannot adequately address. Finally, educational and training programs are inexpensive and have demonstrated high cost-effectiveness.

It is important to ensure that these programs are well defined, tightly focused, and closely supervised. They can have substantial long-term impact if they are result-oriented (teaching appropriate and measurable skills) and targeted toward countries or firms making significant progress in reform. Training can occur in the United States for intensive sessions at universities and industrial facilities. But for maximum effectiveness, the bulk of the programs should involve sending U.S. trainers to the region to teach large groups and to train local residents to teach the skills themselves. Not only do such programs develop desperately needed expertise, they spread the use of Engl ish as the international language, a major advantage for Americans involved in international activities, and will create personal and institutional ties.

The costs involved would depend on the extent of the program. The need is almost unlimited. However, a series of short courses for enterprise managers could have significant near-term impact for several million dollars additional. AID or DOC could fund these programs.

### Energy Efficiency

Energy efficiency has been discussed previously, but it is so central to economic revitalization that it is worth revisiting. Minimizing costs by reducing labor, materials, energy, and capital needs is basic to a free market. Since energy is a major cost in these energy-intensive economies, a focus on efficiency provides a compelling demonstration of free market advantages as well as substantial, immediate economic benefits. Since improvements can be implemented quickly, efficiency programs can also provide very rapid returns, improving the energy balance and enhancing Western credibility at a time of great skepticism about reform.

Increased efficiency is also vital to maintaining and expanding export earnings. In Russia, oil and gas exports currently account for more than 80 percent of convertible currency earnings-money that is critical to Russia's economic transition. However, production continues to fall and, given the normal time lag in bringing major projects on line, is not expected to revive significantly for several years. In the short- to medium-term, the amount of oil and gas available for export will therefore depend on the amount freed up by reducing waste. The World Bank has estimated that reforms in domestic pricing and taxation in Russia could produce additional oil exports worth $11 billion in the first year alone,[4] much more than is likely to result from increased production.

As discussed in the OTA energy efficiency report, options for helping achieve efficiency include: policy assistance, technical assistance (including demonstrations), and other programs designed to provide information about opportunities and incentives to save energy; and material assistance to support the purchase of equipment. In addition, improved U.S. government agency coordination and increased attention by the MDBs are important.

AID has hired contractors to perform energy audits and recommend improvements. It also supports (through DOE) energy efficiency centers in Poland, the Czech Republic, Russia, and Bulgaria. In some cases, it has helped retrofit facilities with energy-saving equipment. Retrofits that pro-

[4] The World Bank, *Russian Economic Reform* (Washington, DC: September, 1992), p. 183. Given the fall in world oil prices since the World Bank made this estimate in 1992, the present value of these incremental exports would be somewhat less than the original $11 - billion estimate. However, the amount would surely be quite large in any case—dwarfing the amount of money available from bilateral and multilateral funding sources.

vide tangible demonstrations of the feasibility and benefits of energy efficiency measures are particularly effective. All these activities could be increased. Expanding current energy efficiency activities might require several million dollars. Greater assistance with the implementation of improvements would cost much more, maybe up to several tens of millions of dollars, but would yield more tangible gains.

An approach to coordinate the efforts of several agencies to implement energy efficiency improvements is discussed below under Program Management and Coordination.

### Nuclear Safety and Proliferation Control

As discussed in chapter 4, the risk of a major nuclear disaster is significant. As the world's leading manufacturer and operator of nuclear powerplants, the United States has significant experience in helping reduce safety risks. In addition, U.S. safety analyses and procedures developed after the accident at Three Mile Island are partially relevant to Soviet nuclear technology.

Considerable assistance is already being extended in the nuclear safety area. For example, NRC and DOE review and exchange information on plant designs, operation, and regulation of FSU powerplants. The United States is also providing two training centers (in Russia and Ukraine) equipped with reactor simulators.

Nuclear safety cooperation has been valuable even at its present modest cost. An increase in funding could substantially enhance the program's efforts to improve practical impact by expanding efforts to improve safety equipment at nuclear stations. Much higher levels of funding would be justified if U.S. concern over nuclear safety is very high. In this case, consideration should be given to supporting the construction of replacement power, since none of these countries can easily afford to build alternative plants or supply fuel for them.

Assistance that focuses on physical improvements rather than information would be expensive. Billions of dollars are likely to be required to upgrade safety to near Western levels or to replace the riskiest plants. Western European countries and Japan would share much of this burden.

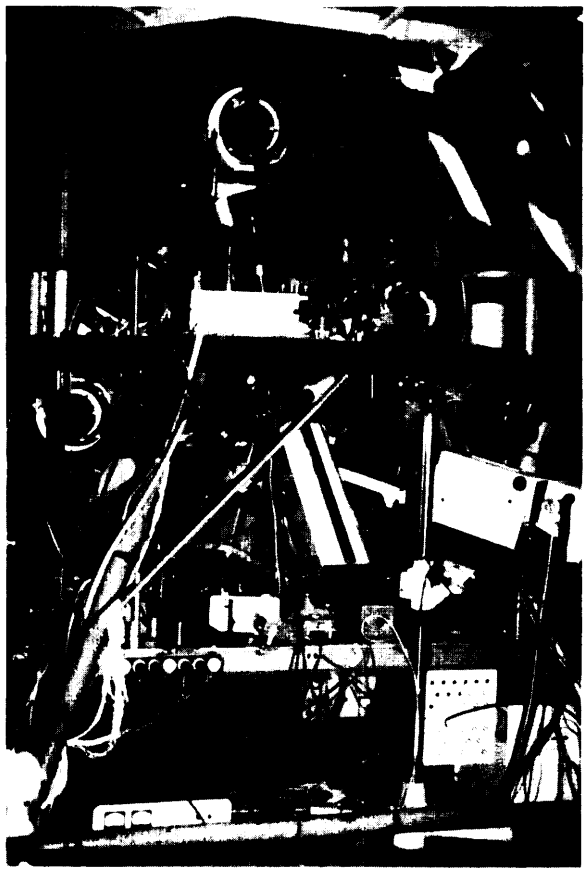
Proliferation control will involve two major areas: safeguarding the nuclear materials from dismantled weapons and reducing the chance that expertise in weapons design and manufacture will become available to other countries or terrorist groups. The former is the subject of an earlier OTA report[5] and is beyond the scope of this report. The latter is relevant to civilian nuclear power because a constructive way to employ nuclear weapons experts is in analyzing and improving nuclear reactor safety, or in nuclear power R&D. For example, U.S.-Russian collaboration on gas cooled reactors could greatly speed progress and reduce design and testing costs.

Assistance to Russia and Ukraine to establish institutions for R&D has been offered. The Russian center was initiated in December 1993 by presidential promulgation, but the Ukrainian Parliament has not yet ratified the agreement. Pending full operation, DOE could be encouraged to seek joint R&D projects and other stabilizing activities.

### Environmental Information and Assistance

Major improvements will be required simply to reduce current pollution that is contributing to the heavy contamination of the last several decades, as discussed in chapter 5. Environmental degradation has damaged human health and economic productivity in former East Bloc countries. The United States has pioneered pollution control measures and regulation, and has the world's best technology in many areas. U.S. equipment and expertise are particularly important for: preventing environmental damage by oil and gas production in the Arctic and offshore; coal mine runoff and

[5] U.S. Congress, Office of Technology Assessment, *Dismantling the Bomb and Managing the Nuclear Materials, OTA-O-572* (Washington, DC: U.S. Government Printing Office, September 1993).


DAN FENSTERMACHER

*Russian fusion test equipment. Fusion R&D has benefited from U.S. -Russian cooperation,*

reclamation; coal cleaning; and control of particulate, sulfur dioxide, and nitrogen oxides.

A variety of U.S. programs provide environmental information, technical assistance, and financial assistance. The latter addresses the major problem—lack of investment funds—which is especially critical since few environmental projects are directly self-supporting. Several initiatives funded by AID, EPA, and DOE contribute to environmental projects, but generally on a relatively small scale. Since some activities lead to sales of U.S. equipment, it is likely that increased financial assistance would benefit U.S. enterprises.

It is important to assure that environmental expertise and enforcement are in place before major new energy facilities are constructed. Training, information, and policy programs could be usefully augmented for this purpose.

Increasing the flow of information would not be expensive. Another million dollars per year would pay for significant activities. Assistance in actual improvements in pollution control would be much more costly because help is needed almost everywhere. If such help is profferred on a wider scale, it will be important to select appropriate projects (e.g., control of air pollution sources that affect human health and for which American expertise is particularly appropriate.)

### *Specific Technology Transfer Programs*

The following programs involve transfer of American technology and expertise to specific areas of the energy and environment sector. Each of the programs relies heavily on technical training, which is intrinsic to technology transfer. The skills of engineers and workers must be upgraded to manage modern equipment and systems. Although the highly educated residents of former East Bloc countries have shown great aptitude in learning new skills, technical training (other than that accompanying sales) is not likely to occur rapidly without assistance.

**The Utility Partnership Program (UPP)** enables U.S. utilities to transfer their expertise directly to their counterparts in the former East Bloc. It pays expenses for travel and seminars. The program also allows U.S. utilities to learn of new techniques and approaches. This program has been instrumental in helping Central European utilities make the transition to market economies (as discussed inch. 4). Expansion of the program to the FSU is too recent to have seen such results. So far, the contacts have led to at least one contract for the U.S. partner to implement some of its recommendations.

However, some U.S. partners are finding that the demands on their time, which are not covered by the program, are getting too great to be justified before their public utility commissions. Additional funding of several million dollars would permit an increased level of activity, such as more extensive training. To some extent, AID has opened the door to greater funding of this program, but participants must bid competitively on specific proj-

ects, a cumbersome and uncertain process. Expanding the scope of the UPP would increase the transfer of some very useful technology, at relatively nominal cost.

**Powerplant renovations** are necessary because a large fraction of the generating capacity is old and dilapidated. Major retrofits involving new combustion technology with modem operational and emissions controls should result in greater efficiency and less pollution, as discussed in chapter 4. As with clean-coal technology, discussed below, none of these countries can afford on their own to do the work as rapidly as needed. Unlike investments for pollution control, powerplant renovation can be self-supporting, but few projects are likely to occur over the next several years without assistance.

**Clean coal technologies** (discussed in chs. 3 and 4) will be essential because many of these countries have no choice but to continue heavy reliance on coal. The current demonstration project in Poland is now undergoing tests. This project has installed flue-gas desulfurization (FGD) and other modernizations on two small coal-fired boilers. The total cost is about $12 million, about two-thirds of which is funded by DOE.

Although the project is a small one, the potential for American business is huge. Assuming the tests prove out and such equipment is installed on all boilers, the market in Poland alone could amount to $3.6 billion.[6] However, neither Poland nor any of the other coal-dependent countries can afford such an investment for cleaner air, no matter how great the indirect benefits (e.g., improved public health) may be. Foreign aid (including cost sharing) will greatly speed the adoption of such equipment, much of which can be supplied by U.S. companies.

Continued demonstrations of other new technologies will also open the door for major U.S. exports and combat some very serious environmental problems. FGD will require further demonstrations in other countries, especially if different types of coal are to be used. Technologies such as fluidized-bed combustion will also need demonstration to achieve significant market penetration. Total costs of an expanded program would depend on the level of expansion. Tens of millions of dollars could easily be used between demonstrations and export financing.

**Coal mine safety** has been sadly neglected in the entire region, and miners have paid a heavy price, as noted in chapter 3. AID has supported assistance through the United Mine Workers and the National Coal Association to improve conditions. Partners are sharing their expertise in reducing accidents. Equipment such as methane detectors (to prevent explosions) has also been delivered.

This program is primarily a humanitarian gesture to a sector that has been badly exploited. And although it has less potential to produce additional business for U.S. companies than other programs discussed here, the program will help a key sector operate more efficiently. Even an expanded program would entail only modest costs. Nevertheless, policy makers should closely scrutinize coal mine safety programs to ensure that they fulfill these humanitarian and efficiency related goals and not unwittingly prolong the operation of mines that should more properly be closed.

### *Energy Research and Development*

R&D, discussed in chapters 3 and 4, can bring mutual benefits. Russia has considerable R&D expertise that can be constructively employed in projects that produce results useful for the United States. The Russian focus on pure science dovetails with the U.S. strength in applied engineering and commercialization. For example, Russia can contribute significantly to R&D programs on flywheels, turbines, high voltage transmission and cogeneration.

[6] The $12 million is for two 50 MW boilers. Poland has 30,000 MW of coal-fired capacity. Some of this capacity will be replaced, not modified, but new units will also need pollution control equipment.

R&D programs could provide forums for the exchange of R&D information and fruitful interchange of personnel. This area could attract support from a range of donors—bilateral and multilateral, foundations, nongovernmental organizations (NGOs), and some industries hoping to stimulate future sales through the contacts developed as well as with new products.

Some R&D institutions are already planned or in existence; for example, a U.S.-Russian Joint committee established under the U.S.-Russian Federation Framework Agreement on Scientific and Technical cooperation in the Field of Fuel and Energy, and an International Science and Technical Center headquartered in Moscow. Ways of augmenting their programs, activities, and participants could be investigated. Ultimately, cooperative R&D should be profitable, but startup costs could be significant.

### *Problems in Program Execution*

AID created its assistance programs for the former East Bloc in just a very few years, yet it selected quite appropriate energy and environmental topics. For this, AID deserves commendation. However, the execution of the program leaves more to be desired.[7] As noted in the OTA energy efficiency report, procurement is very lengthy and costly and discourages small businesses. Current employees and contractors have been used despite a lack of knowledge of the region or of the ways in which it differs from developing countries. Some of this was inevitable because of the speed with which the program was created, but AID could be encouraged to employ regional experts whenever possible and to recognize that its mission in the former East Bloc differs fundamentally from its activities in less developed countries. Congress could require AID to document the qualifications of the people involved in the programs, especially those in decisionmaking positions. Congress also could consider lifting the hiring ceiling at AID if necessary.

Another complaint (and not just about AID) has been about the number of consultants proffering inappropriate advice while offering no tangible help, thus damaging American credibility. These visits can interfere with work without offering compensating advantages. Focusing assistance on projects that will provide visible benefits to the recipients will improve impressions of U.S. involvement.

More attention can be paid to widening the benefits to U.S. business of development assistance programs. AID's missions are often in touch with potential customers, and the contacts can produce information that leads to additional business for U.S. companies. Thus, the net cost to this country of the assistance program is less than the appropriated funds. However, U.S. firms sometimes find AID unresponsive and bureaucratic. Congressional initiatives may be necessary to make business promotion an official function. Perhaps AID could work more closely with the Foreign and Commercial Service (FCS, part of DOC).

## | Export Promotion

From the beginning, the private sector has been recognized as the major player in rejuvenating former East Bloc energy systems, and the promotion of energy-related products and services exports has been a fundamental goal of U.S. policy. Modernization of the energy sector is essential for economic health and good business for U.S companies and workers.

The United States is highly competitive in a wide range of energy and environmental technologies. Table 8-4 lists some of the areas where U.S. technology is especially competitive. These products and services should find markets if the conditions are right. Often, however, support by the

[7] Various proposals have been made t. revamp the entire foreign aid program. Congress is now considering the Administration's recommendations.

TABLE 8–4: Competitive U.S. Technologies

- Oil and gas
  - Exploration—seismic analysis, deep drilling, deep water & Arctic
  - Production—reservoir engineering, workovers, stimulation
  - Gas pipeline compressors and control equipment
  - Environmental protection
  - Refining
  - Spill cleanup
- Coal
  - Coal cleaning
  - Fluidized-bed combustion
  - Gasification/combined cycle
- Nuclear
  - Control systems
  - Safety equipment
- Electric power
  - Advanced generation
  - Integrated resource planning
- Energy efficiency
  - Control systems
- Environment
  - Monitoring equipment
  - Pollution control ($SO_x$ and particulate at powerplants, refineries etc.)
  - Reclamation and acid mine drainage

SOURCE U S Congress, Off Ice of Technology Assessment, 1994

U.S. government is required. The main elements of export promotion are well known: financing, information procurement and dissemination to industry, and active trade promotion policy. In the former East Bloc, U.S. companies have been at a disadvantage because Japan and most countries of Western Europe do more to support their exporters. U.S. export promotion programs are discussed in chapter 7.

### *Financing*

Few customers have the money to pay for the Western goods and services they need, particularly in the FSU. Hence financing is critical for maximizing exports. In many cases, private financing is inadequate because of the risk or if foreign governments provide subsidies. U.S. government financing is usually provided in the form of loan guarantees. The major policy issues concern the level of funding for export credits and the extent to which export financing can be used to leverage reform.

Congress has approved $2.5 billion in foreign aid for the FSU, much of which will be channeled through Eximbank and OPIC to involve American companies directly. These funds serve several purposes: to provide FSU countries with the capital needed for crucial energy-related imports, to provide financing for American exports, and, to some extent, to provide incentives for firms and governments to engage in economic reform. Eximbank's Framework Agreement (see ch. 7) is one of two main financing instruments in the overall program and is the major vehicle for financing exports of American oil and gas equipment to the FSU.

However, financing increased exports to the FSU has been difficult (even for bilateral and multilateral credit agencies) because of the high levels of political and economic instability. In addition, Russia has ambiguous feelings about foreign involvement, especially in the oil and gas industry, and even more particularly if conditions are attached. Although U.S. export-credit agencies and the multilateral banks have tried to make loans contingent on progress toward economic reform, it has been extremely difficult in practice to achieve conditionality.

These programs have forced U.S. export-credit agencies to fulfill missions for which they were not designed. Increased exports to Russia are a U.S. policy goal even though the Russian financial situation does not warrant the loans necessary to support them. As a result, Eximbank is accepting loans for Russia under conditions that it would reject for other countries.

Eximbank's traditional mission has been to finance exports, especially those that are threatened by subsidized financing from other countries or are too risky for commercial lenders. It is not a foreign aid agency, yet it has been asked to expedite loans to Russia beyond its customary practices. This has put a strain on the bank's staff and forced it to work in areas in which it has little experience. Moreover, the financial costs of lending to high-risk countries may deprive Eximbank of opportunities to lend in other countries to enterprises that are less risky and promise greater immediate economic benefit to the United States. Even other countries of the FSU, such as Kazakhstan, may present fewer risks than Russia, but they are being neglected.

U.S. economic and political priorities will almost certainly dictate continued support for large-scale export credit programs because they provide great potential for growth and reform. However, Congress should be aware of the explicit financial costs of export-credit programs for the former East Bloc. If too many risky loans fail, increased subsidies will be required.

It is possible that the volume and impact of the transactions resulting from the Eximbank Framework Agreement will be considerably smaller than anticipated, at least over the next year or so. To begin with, the mechanism for accessing these loans is complex, highly information-intensive, and time-consuming. For projects based on revenues from increased production of oil, a duly authorized expert must visit the site of the proposed project, confirm the technical feasibility of the project, and make an estimate of the additional oil that could be produced through the use of the new imported equipment. Proceeds from the sale of this oil support the escrow account from which the Eximbank loan is repaid. The near certainty of serious disagreements among all parties over baseline production estimates is liable to slow the process further.

In addition, interest on the part of the Russian production associations is reported to be less than anticipated, largely because they are obliged to go through the Ministry of Fuel and Energy to apply for loans. That complication may deter some associations from participating in the Eximbank framework agreement. In addition, the minimum loan for consideration is $25 million, a large sum in relation to the cost of some of the items of equipment such as special drills that are most likely to be in demand. Eximbank has suggested that this minimum requirement could be met by combining several companies in one loan application, but this adds an additional layer of complexity to the already cumbersome system.

Additional production generated by the deals may well be smaller than analysts had previously anticipated, for two reasons. First, although the framework agreement applies to all "incremental" production—including green fields and rehabilitation projects—the program is predicated on the idea that a speedy infusion of capital can produce a significant short-term increase in production through rehabilitation of many of the 30,000 wells that currently stand idle. However, recent experience suggests that relatively few of these wells (between 5,000 and 8,000) are realistic candidates for rehabilitation at present world oil prices.

Second, the focus of the agreement—reflecting opinion current at the time the agreement was being conceptualized—is the provision of technology. Observers of the Russian oil scene now see the

institutional and policy environment, rather than technology, as the major factor behind the failure of the Russian oil sector. However, the Eximbank agreement does not impose any conditions with regard to policy reform.[8] Eximbank's mission, after all, is to promote U.S. exports rather than Russian reform.

Nevertheless, the framework agreement is an enterprising and imaginative endeavor to provide better loan security and a much larger potential market than any of the alternatives. The first transaction under the Oil and Gas Agreement was announced in early 1994. It provides $245 million in loan guarantees for Permneft, a Russian oil production association, to assist in rehabilitating oil fields.

In addition to direct financing, U.S. programs include feasibility studies. These studies have been valuable in promoting U.S. exports. The U.S. Trade and Development Agency (TDA) has won many plaudits from industry for its projects, which frequently lead to contracts much larger than the cost of the study. AID has also sponsored feasibility studies that have proved fruitful. This is an area that could usefully be expanded, benefiting both development and American exports. Small companies have reported difficulty in competing for TDA studies because larger companies often bid below costs to position themselves for contracts later. Special programs or procedures in qualifying might allow small companies to expand their foreign work. Alternatively, the Small Business Administration (SBA), which now is essentially not involved in the region, could be directed to start such a program. The Overseas Private Investment Corp. (OPIC) also offers limited financial support for feasibility studies, but if the company secures any contracts as a result, it must repay OPIC's contribution. These conditions greatly limit OPIC's activities.

Analysts in the oil equipment and supply industry and at DOC advocate a significant expansion of U.S. credit promotions through Eximbank, OPIC, and TDA. They argue that U.S. programs, such as Eximbank, are too conservative in their activities—that the low levels of default on Eximbank loans and OPIC investment insurance prove that these agencies are not promoting American exports aggressively enough. According to this view, American firms will have a unique opportunity over the next few years to establish strong positions in markets just being opened to them if the U.S. government provides credits for the first, inherently risky projects.

Finally, trade promotion programs have a strategic dimension, especially in the former East Bloc. Even if economic returns are less than optimal, U.S. programs demonstrate a commitment to the region in its time of crisis. U.S. projects also support and encourage those forces seeking to open long-closed societies to the outside world. Further, increased Western contact provides a positive and accessible example of a functioning capitalist-democratic society.

### *Conditionality*

Virtually all bilateral and multilateral aid embodies elements of conditionality, which refers to conditions a recipient is required to meet, over and above normal agreements on repayment schedules. For the recipient country, conditionality is

[8] The World Bank granted Russia a Waiver of its standard "negative pledge" provision in order to allow implementation of the Eximbank Framework Agreement. The negative pledge requires that borrowing countries give the Bank a first and undiluted lien on all public assets and promise not to use those assets against credits received from other sources. In addition, they must have in place a program of structural reform, including a comprehensive set of policy reforms to promote privatization and a macroeconomic program that is satisfactory to the World Bank. According to the Bank, the negative pledge is a major reason why its borrowing costs are so low, enabling it to provide otherwise unsecured loans to the world's neediest countries. Thus the waiver could reduce incentive for reform if it encourages Eximbank rather than World Bank loans. The waiver also could elicit hostility from developing countries that have made great sacrifices in austerity programs mandated by the World Bank and the International Monetary Fund (IMF). Some countries could seize on this example to resist further austerity measures, thus undermining World Bank and IMF efforts in the developing world.

part of the price that must be paid to gain access to funds that otherwise might not be available. Conditionality gives the donor agency or government influence over policy in the recipient country. In general terms, the larger the financial transaction, the greater the potential for conditionality.

In the former East Bloc energy sector, conditionality has applied to MDB loans and bilateral development assistance programs. Such conditionality has usually required the recipient country to institute a program of energy price increases, market-oriented reforms, and sectoral restructuring. Though conditionality has always been a prominent feature of MDB lending activities in developing countries, it has received new focus in MDB programs for the former East Bloc as a way to overcome major obstacles to energy sector reform and development.

Expanding conditionality to bilateral export credit programs could also be beneficial. At present, the United States supports conditionality in MDB and U.S. Agency for International Development (AID) lending programs, but not in programs for export or investment promotion. There are good reasons for this difference, since the purpose of OPIC and Eximbank is to support the U.S. private sector, not to reform the Russian energy sector.

However, Eximbank programs represent a major part of U.S. financial assistance to Russia, and conditioned credit mechanisms could be the most effective means of forcing adoption of necessary price and structural reforms. To make the conditions effective and to articulate U.S. policy in the clearest light, Congress could direct the Eximbank to enforce conditionality more strongly and to deny export credits and development assistance to those former East Bloc countries that refuse to accept conditions.

Central European countries are already open to foreign investment or committed to reform, but the situation is different in most of the FSU. There, Congress may be able to help U.S. firms get a "foot in the door" and promote political-economic reform by directing U.S. export credit agencies to assist only those enterprises that are truly privatized (e.g., with a majority of shares owned by private investors, not by the state). By rewarding companies that have converted to private ownership and made politically difficult decisions to welcome foreign investors, the U.S. government can encourage the type of fundamental reforms that are so sorely needed while also promoting the needs of American business.

There are also solid arguments in favor of a substantial export-credit program for the FSU energy sector even without imposing conditions to promote reform. U.S. exports of equipment and services help increase oil and gas production, which is necessary for economic survival, especially in the near-term. In addition, most observers agree that American credit programs should be large and versatile enough to allow U.S. firms to compete against their foreign rivals. Western European countries and Japan actively assist their companies through financing programs designed to support their ability to sell goods and services abroad.

Insisting on conditionality will slow the pace of financing. Much of the impetus for rapidly expanding assistance and export-credit programs has come from a sense of the need for providing help rapidly. There is a clear tradeoff here between speed and effectiveness, and the relative merits are difficult to predict.

### Business Information

Government agencies can play a key role in promoting U.S. business by notifying American companies of business opportunities and organizing trade shows and conferences to introduce American products to potential customers. Several DOC activities have received favorable reactions from business, including the FCS and the American Business Centers (funded by AID).[9]

[9] **Olga Bilyk,** Continuum International Inc., "U.S. Government Export Promotional Efforts," OTA contractor report, January 1994.

Both programs could be expanded significantly, especially in the FSU. The Business Information Service for the Newly Independent States (BISNIS) and the Eastern Europe Business Information Center (EEBIC), located in Washington, are very useful in helping U.S. companies enter the market and in keeping them informed about business conditions in the region.

Neither DOE nor EPA appears yet to have had great impact on promoting U.S. business, especially in the FSU, despite activities such as trade shows and the Coal and Technology Export program.[10] Low program funding and lack of financing capability may be the reasons. Combining the activities of these two agencies and giving them funding at least for feasibility studies could strengthen them. The Federal International Energy Trade and Development Opportunities Program may be a prototype.

Small businesses are particularly in need of information. Many are not even aware of the government help that is available. Those that have marketed in the region have often become interested because of ethnic heritage connections, The SBA apparently has not been involved in the region. Initiating a program in the SBA could be a significant asset.

### *U.S. Policy Involvement*

U.S. diplomatic representatives also can have a significant impact on the level of exports. U.S. embassies support U.S. firms, but not to the same degree as other countries. Congress could direct DOS to make such support a major part of U.S. policy, possibly combined with an upgrading of status for the FCS. A related step could be to enlarge the office of the U.S. Trade Representative.

U.S. policies not aimed at exports still can effect them. In particular, Congress might also reconsider the ban on assistance to Azerbaijan.[11] This ban was imposed because of Azerbaijan's blockade of Armenia, arising from the war over Nagorno-Karabakh, the Armenian enclave in Azerbaijan. Armenian armies from Nagorno-Karabakh, apparently with backing from Armenia, have conquered large areas of Azerbaijan outside the enclave. Armenian-Azeri relations have been difficult and often violent in the past, and this study has not attempted to assign blame for the current situation. However, the ban has, in effect, given U.S. backing to one of the antagonists. The ban is greatly resented in Azerbaijan because the Azeris see themselves as victims of Armenian aggression. It has significantly hurt American business in Azerbaijan, a major producer of oil. Other countries have not joined in the ban, and their oil companies are enjoying the lack of competition from the United States.

## | Multilateral Development Banks

The MDBs are by far the largest contributors of public finance to the energy sectors of the former East Bloc. The World Bank has made loans of $1.7 billion to countries of Central Europe, mainly Poland. The European Bank for Reconstruction and Development (EBRD) has loaned an additional $225 million. Russia has received $600 million from the World Bank with an additional $600 million under review and $250 million from the EBRD. MDB lending is important because of its size and also because of the leveraging effect of its lending activities, which give rise to as much as five or six times the value of the original contribution.

The World Bank has traditionally (in its developing country programs) concentrated on large-scale conventional energy supply projects, notably centralized power generation and hydroelectric projects. Few energy projects have been devoted to efficiency or the development of smaller scale renewable energy resources even where such projects might be more economical and appropriate. This criticism, made originally in the context of the Bank's developing country lending

[10] Ibid., p. 35.

[11] Public Law 102-511, Section 907.

*Control center in the Dukovany Nuclear Power Plant, Czech Republic. This site has 4 WER 440-213 reactors.*

program, has again surfaced with regard to its new lending activities in the former East Bloc, where the loans are still heavily oriented toward the power sector and district heating in Central Europe, and oil in Russia. Though these loans may result in improved efficiency in the supply system, there are few MDB activities directed at end-use efficiency, where the greatest gains are available.

There are several reasons for this neglect. Energy efficiency projects are complex and harder to put into a project format for lending. The benefits are harder to estimate and incorporate into energy planning. Past emphasis in favor of traditional supply-side projects is difficult to change. Moreover, there is no clear organized center of expertise in the World Bank to support implementation of energy efficiency projects.

In recognition of the MDBs' role in energy lending, Congress has taken an active interest in their activities throughout the world, with particular reference to the World Bank developing country program. Congress has instructed the U.S. Executive Directors to the MDBs to take into account end-use energy efficiency, renewable energy, and environmental impacts in making decisions about new energy projects. Congress has also addressed the issue of bundling, or combining small energy projects into large projects, on the financial scale usually handled by the large development banks. In addition, Congress has promoted increased assistance and support for NGOs in MDB activities.

Although programs for the former East Bloc differ considerably from those for the developing countries—the World Bank has made no large-scale oil loans for developing countries—these same congressional directives could be applied to the Bank's new activities in the former East Bloc. The deteriorating energy situation in Russia particularly, but also in the other countries of the region, gives a new urgency to energy conservation, and Congress could reiterate its insistence on MDB attention to energy efficiency in this new context.

The United States has considerable leverage over the MDBs, and could be more explicit and consistent in its advocacy of MDB priorities. In particular, if Congress decides that promoting economic reform supersedes the goal of raising short-term energy production (see section on conditionality, above), one of the most important things it could do would be to instruct the U.S. MDB representatives to insist on stronger enforcement of conditionality on existing and future loans. Although the MDBs have been successful in achieving conditionality in Poland and other areas of Central Europe, they have had less success in Russia. For example, in its $600-million oil sector rehabilitation loan to Russia, the World Bank failed to secure a timetable for raising domestic Russian energy prices to world market levels. Instead, it received a promise that domestic prices for oil and oil products would rise only slightly faster than inflation through May 1994. After that date, the Russians have agreed only to a subsequent gradual approach to the level of average European prices.

Congress could bolster other American reform goals by instructing MDB representatives to ensure that small projects and business are accommodated in the lending program and that priority is placed on energy efficiency projects.

## | Investment Promotion

The rationales for supporting exports and foreign investment are different. Investment helps build the industrial infrastructure of the receiving country, and it also can be good for the United States,

even though it does not result in additional jobs here. It helps U.S. companies grow and become low-cost producers. It makes available new resources and products. And it helps accomplish what the U.S. foreign aid program is trying to do-assist in development.

Central Europe, especially Hungary, has been successful in attracting investment. Relatively little investment has yet occurred in the FSU, largely because of the unstable political situation and the ambiguous feeling (or even xenophobia) of many Russians toward foreign investment. Various levels of government have erected a formidable array of hurdles, including high and uncertain taxes, that confront the would-be investor. The Russian oil industry, in particular, opposes foreign participation in major oil production projects because of a strong sense that the domestic industry needs only loans and some occasional technology. Nevertheless, only the international oil companies have the financial resources necessary to increase Russian oil production.

Countering this opposition will be difficult. Patient diplomacy and gradual demonstration of the benefits will be required to overcome longstanding suspicions of the West and reluctance to accept foreign investment. Even where investment is welcome, as in Kazakhstan, opposition from Russia may cause serious problems because transport of oil exports across Russia is a geographic necessit y.

Russia has a strong penchant for using domestic equipment in the oil industry, even though it is generally inferior to that of the West. It may be useful to encourage joint ventures between equipment manufacturers in both countries as a way of promoting modernization. DOE and DOC could be instructed to play an introductory and facilitative role.

OPIC has been a major force for foreign investment through its insurance against political risk. However, OPIC is limited to $50 million for oil and gas projects, which is inadequate for large projects. Raising the limit and adding to OPIC's resources would provide a significant asset to U.S. activities.

Foreign investment in independent powerplants is also of interest to U.S. companies, but only if the revenue streams are adequate. Since controlled prices of electricity in the FSU frequently do not cover costs, no one wants to invest. Encouragement of market reforms is essential for this type of investment to grow.

## | Program Management and Coordination

The task of reform and modernization in the former East Bloc dwarfs even the Marshall Plan. Although mostly free of war damage, industrial facilities and infrastructure are crumbling. Worse problems are the lack of market economy expertise among managers and decisionmakers, and the mindset of much of the population, which is unaccustomed to personal initiative. Funding will not be as generous as it was for the Marshall Plan, so great care must be taken to assure that policies are implemented with the maximum possible effectiveness.

Improvements are possible, in particular in the coordination of the various agencies involved. It is not always clear that the agencies communicate well and support one another's activities as effectively as possible. Congress could require more active coordination through DOS or DOE in some cases (possibly including nuclear safety) to ensure, for example, that assistance projects and export promotion support the highest national priority objectives.

Extensive collaboration between agencies could reveal new approaches, which may be needed for intractable issues. In particular, the promotion of price reform in Russia must be based on a realistic appreciation of the problems involved and the tools that are available. One approach would be to combine higher prices with increased efficiency in energy use so that total bills do not rise, or at least increase less than the rise in prices.

To implement this approach the Russian government could announce that oil and perhaps gas prices will be brought to world levels over a specified period, perhaps five years. Industrial facilities, central heating plants, power stations, and

other large energy consumers would be promised their full energy quota at prices starting at the current level and rising over the five years. All fuel not used would be bought back by the supplier at a high fraction (perhaps 90 percent) of the world price in hard currency and could then be exported. As efficiency measures are implemented, a substantial revenue stream would be generated for the user, who could use them for further efficiency gains. Initial improvements could be financed by the World Bank or EBRD, based on the future revenue. This approach would require new Russian institutions such as energy service companies that finance themselves through their share of the savings they secure for energy users, and an energy efficiency equipment supply industry.

The U.S. role would entail close coordination between:

- DOS to negotiate the program with Moscow and the MDBs;
- DOE to supply energy-efficiency expertise;
- AID to assist in institution building in Russia;
- DOC to coordinate U.S. businesses and export activities; and
- Eximbank to finance large-scale efficiency exports.

This plan would address the major barriers to greater efficiency: lack of incentive, lack of capital to pay for improvements, and lack of information on how to do it. However, several factors could interfere. It is complex and would require unusually close coordination in the United States and in Russia. Corruption would also be a real concern when money is flowing.

## POLICY STRATEGY

This report has emphasized the importance of focusing policy to ensure that U.S. programs support the fundamental U.S. goals that were listed at the start of this chapter. The options discussed above fall into three groups of activities: maximizing the effectiveness of current U.S. programs; additional funding for effective programs; and selecting priorities on near-term trade vs. long-term reform. This section suggests how the options discussed above can be combined as elements of a comprehensive strategy.

### Maximize the Effectiveness of U.S. Aid and Trade Programs

Administration of U.S. programs is discussed in the previous section and in chapter 7. Improving program effectiveness is a low cost option that should be considered whether or not any further options are pursued. Thus it is the first element in an overall strategy.

The following changes could greatly improve the effectiveness of all U.S. activities and programs in all countries of the former East Bloc:

*AID*

- Streamline and accelerate the grants and procurement process.
- Lift the hiring ceiling and require the agency to hire more personnel with regional expertise.
- Coordinate AID programs more closely with DOC to ensure maximum benefit to U.S. business.

*Eximbank, OPIC, TDA*

- Increase operating budgets to:
  a. Permit the hiring of personnel with regional expertise.
  b. Speed processing and improve monitoring of credit, insurance, and other applications.

*Commerce and State Departments*

- Upgrade status of the FCS to ensure maximum coordination between trade-promotion and diplomatic efforts.

*DOE*

- Provide more funding for international programs.

### Expand Effective Assistance Programs

Bilateral and multilateral development aid supports all U.S. goals simultaneously. Government assistance is small compared to overall needs, but it can play an important role in showing the way to reform and modernization. The level of funding allocated depends, of course, on the priority accorded rejuvenation of the former East Bloc vis-a-vis other U.S. budgetary priorities. The contro-

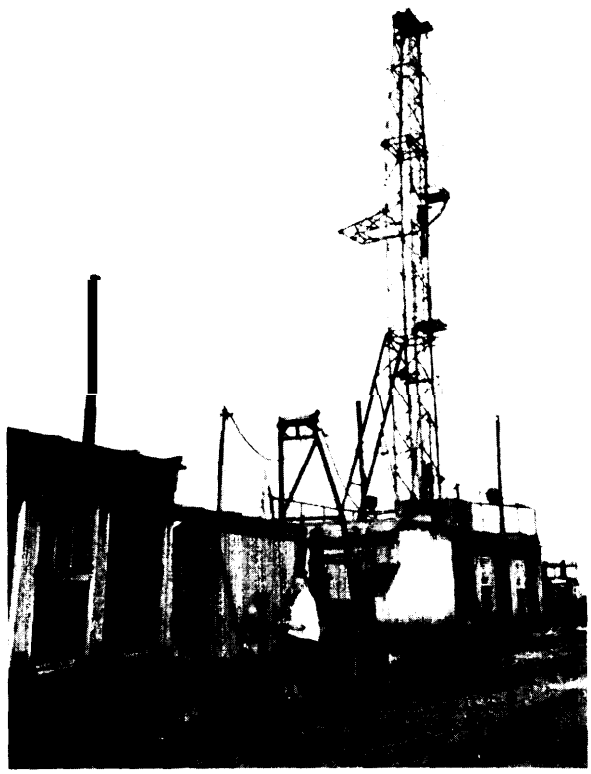
versial aspects of assistance have to do with the level of funding that is appropriate. This section reviews areas that have been effective and could usefully be expanded if more funds are made available, As noted in the detailed programmatic discussion above, almost any level of funding could be well-spent because the needs are so great. Selecting the level of assistance is the second element in an overall strategy.

### Emphasize Government-to-Government Policy *Assistance*

Under any scheme of priorities, it is important that the U.S. government continue to engage intensively in a dialogue with former East Bloc countries about the nature and philosophy of economic reform. The more Congress wants to promote economic transition, the more actively should U.S officials try to persuade local policy makers to take the painful steps involved in economic transformation and help them design realistic reform programs that meet the need to maintain domestic political and social stability. As a first order of priority, Congress can direct the U.S. government to continue to exert influence on these countries through policy advice provided through diplomatic channels and through contact between American officials and representatives of former East Bloc countries. In the energy sector, DOE, NRC and other agencies can expand visits in both directions, host extended training sessions, and provide analysis of specific issues.

### *Expand Business anti Organizational Training*

Regardless of whether a country has embarked on a course of radical reform or has yet to take steps toward economic transformation, American-sponsored training programs in business skills are essential to promoting the idea of reform, supporting reform processes already under way, and making it easier for American energy-related firms to conduct business. The more active Congress wishes to be in promoting stability, modernization, reform, and U.S. business interests, the more it should expand programs in this area.



ADVANCED RESOURCES INTERNATIONAL

*Coal coring exploration rig, Kuznetz Basin, Kazakhstan*

### *Expand Energy-Efficiency Programs*

Energy efficiency remains one of the most important priorities in the energy-intensive economies of the former East Bloc. Even in countries that have not undertaken programs of systemic reform, energy-efficiency projects can promote reform by demonstrating that it is possible to cushion the effects of raising energy prices and introducing market-based economic relations.

Given this potential, U.S. policy makers might redirect policy priorities away from investing public sector funds in energy production projects and toward improving the energy consuming sectors. Although capital needs for FSU exploration and development will be great under any set of priorities, concentration by Western governments and companies on projects to enhance efficiency promise to be much more effective than projects to increase production.

### *Expand Technical Assistance Programs*

Technical assistance programs—through demonstration projects and other activities—prov ide access to technologies essential to short-term stabilization and long-term modernization and economic growth. Since U.S. firms are leaders in several areas, an expansion of technical assistance programs-consistent with an activist program of U.S. policy—would provide benefits for U.S. business. Priority projects as discussed in the previous section include:

- *Coal and Electric Power Generation*
  a. Utility partnerships
  b. Powerplant renovation and advanced generation
  c. Clean coal demonstrations
  d. Coal mine safety

  *Nuclear Energy*
  a. Safety information and assistance
  b. Funds for safety upgrades or replacement power
- *Collaborative Energy Research and Development*
  a. Nuclear safety and R&D

## | Select Priorities for Trade and Development

In Central Europe, U.S.-funded export-credit and training programs provide privatized and new enterprises with the finances and education needed to establish themselves and build toward future profitability. There, ample financing both encourages U.S. exports and reinforces reform.

However, in Russia and other countries of the FSU (with the partial exception of Kazakhstan), some U.S. and multilateral export-credit programs may, under some conditions, be counterproductive to domestic economic and political reform by strengthening old, statist economic mindsets and government structures.[12] Ready availability of Western public sector credits and guarantees helps Russia avoid resorting to much larger but more burdensome private sources of Western capital. In particular, this weakens the incentive for Russia to allow foreign oil exploration and production companies greater freedom of operation, including direct investments. Western public sector credits, if not made conditional on aspects of reform, also weaken U.S. efforts to promote a long-term change in mindset from Communist, centrally planned economies toward private enterprise. Even the staunchest proponents of reform in the FSU seem to prefer Western public sector credits or loan guarantees to building the types of legal structures and nurturing the economic climate needed to attract large-scale Western investment projects based on investment in Russia itself.

This reluctance to seek large-scale Western private investment is also fueled by a deep suspicion of foreigners—particularly by Russia, which exhibits a pervasive reluctance to give up control of even a portion of its patrimony to Westerners. American oil exploration and production companies say that the availability of World Bank loans and the potential for credits under the Export-Import Bank (Eximbank) Framework Agreement have helped create the perception among managers of Russian state-owned enterprises and private firms that there is a pool of “easy money” available to finance new exploration and workover projects, thus obviating the need to grant equity stakes to potential Western investors.

The final element in an overall policy strategy involves a relative] y controversial selection of priorities on U.S. exports, modernization, and reform. As has been noted, some goals conflict, especially in countries that have not yet embarked on a solid course of economic reform. Policies must be tailored to each country or region to ensure their appropriateness and consistency.

The key question for Congress is the priority accorded to promoting market reform and long-term sectoral modernization versus near-term economic stability and maximization of immediate

[12] As illustrated above, the scope of U.S. exports may ultimately be limited by local preferences and reform priorities which may dictate ‘he purchase of domestic over imported goods, even in cases where the economic advantages of purchasing American products are clear.

U.S. economic interests. It should be noted that this is not a clear choice; promoting market reform will lead to increased U.S. business, and near-term stability is necessary for long-term reform. Rather, it is a matter of degree and emphasis. The most important vehicle for expressing this policy preference is the conditionality provision of export credits and insurance. The question rises most visibly when a potential recipient refuses (or ignores) conditions attached to the financing of an otherwise viable project. That poses a dilemma for the U.S government or MDB since the goals of reform and modernization conflict.

The differing conditions among the former East Bloc countries suggest two alternative approaches for U.S. policy:

1. *Support near-term economic stabilization through expansion of energy production.* This option seeks to support East Bloc countries by maximizing their energy output to provide foreign exchange, regardless of their progress on economic reform. It also aggressively emphasizes U.S. exports.

**Policies:** Expand export-credit and MDB programs to ensure that financing is not a major constraint; make only minimal provisions for conditionality and restrictions on loans. Higher subsidies might be necessary for OPIC and Eximbank to cover increased losses on bad debt.

2. *Support long-term energy sector modernization and systemic market reform. This* approach may entail further short-term declines in oil and gas production in order to achieve long-term gains.

**Policies:** Expand export-credit programs only insofar as exports support reforms and can be effectively used. Impose maximal conditionality on credits: export-credit and investment assistance would go only to firms actively engaged in a real transition to market functions.

Congress can capitalize on the importance of export-credit programs for opening up markets previously closed to American products. But Congress may wish to balance this policy against the possible disincentives that such programs can create for internal reforms and for opportunities for U.S. investment in the FSU.

A balanced approach is appropriate for Poland, the Czech Republic, and Hungary because their progress toward economic reform makes it possible to promote both trade and reform simultaneously. This option may also be appropriate in Kazakhstan. Although market reform has been limited there, Kazakhstan is open to foreign investment and trade.

In other countries of the former East Bloc, the choices are not so easy. Declining oil production is a serious threat to Russia's weak economy. Bolstering that economy may be essential for preventing social and political instability. The United States has the technology and the resources to provide significant help. However, an overemphasis on providing help is likely to interfere with the reforms that are essential for long-term economic health.

## CONCLUSION

Improved energy technology will be a critical factor in modernizing the economies of the former East Bloc, and the transfer of energy technology will be an important asset in achieving U.S. national goals. However, internal constraints and the lack of capital in these countries will limit Western investment and purchases of equipment and services. A strong and active U.S. government role is necessary to expedite the transition to market economies and democracy, and to assure that the U.S. economy shares in the growth. The policy options discussed above, if implemented skillfully and with adequate funding, can contribute very significantly to the process. Congress will face the issue of whether increased efforts are warranted in light of other national priorities and uncertainties over progress toward reform in Russia and other countries of the former East Bloc.

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