Overview of Energy Supply and Demand

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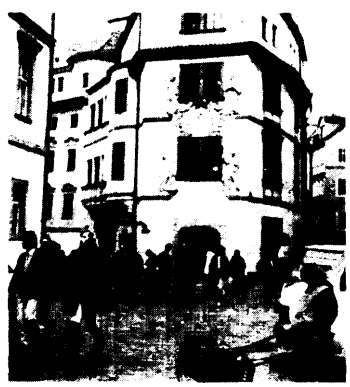
Energy resources differ significantly among countries of the former East Bloc. Russia and the Central Asian countries have substantial energy resources, Central Europe has limited resources, and the Baltics are resource poor. Patterns of energy use differ as well. For example, Russia and Romania use 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).