CHAPTER 9

East European Energy Options

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Eastern Europe is now struggling to adjust to an energy-expensive world. During the present decade, the six Council for Mutual Economic Assistance (CMEA or CMEA-6) countries examined here–Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania–will attempt to resolve their energy problems while simultaneously increasing living standards at a politically acceptable pace, and without falling more deeply into debt with Western banks. All this must be done without the degree of reliance on Soviet subsidies in the form of cheap energy which has played such an important role in East European energy supplies in years past. The outcome will have important implications not only for political stability and economic development in Eastern Europe, but also for Soviet-East European relations.

The most important international dimension of Eastern Europe's energy problem lies in its relations with the U.S.S.R. Soviet oil subsidies to Eastern Europe at present are enormous, their value in 1980 amounting to half of all Eastern Europe's exports to the West or to half the value of all Soviet imports from developed countries. As the U.S.S.R. has faced the prospect of increasing constraints on its own energy supplies, its willingness to supply Eastern Europe with cheap energy has diminished. But it is by no means clear that the Soviets could quickly reduce these subsidies without precipitating a degree of economic crisis and political unrest in some East European countries.

The Soviet Union's strategy with regard to East European energy combines plans to stabilize the level of its energy exports (i. e., by cutting the increments of energy, especially oil, to be supplied) with assistance to the CMEA countries in their efforts to develop their *own* energy resources and to use energy more efficiently. At the basis of this policy seems to be the assumption that tight energy supplies in the U.S.S.R. preclude increments to shipments comparable to those of the 1960's and 1970's.

The purpose of this chapter is to illuminate the degree to which this Soviet strategy is feasible, given the problems and opportunities in domestic energy production and consumption which will confront the nations of Eastern Europe in the next decade. The chapter briefly reviews energy trends in Eastern Europe over the last 20 years. It then analyzes the energy problem from both the supply and demand sides, identifying constraints and opportunities and evaluating the political and economic implications for East European energy imports-particularly imports from the Soviet Union. The discussion addresses the important issue of whether Eastern Europe will be able to cover its energy needs with Soviet imports supplementing domestic production, or whether large energy deficits which must be met with other imports may occur. The latter situation could augur heightened domestic political and economic difficulties in Eastern Europe and might necessitate alterations in Soviet policy.

The East European countries make up a fairly well-defined energy system, characterized by relatively few options for expanded domestic energy production and well-established historical trends of energy usage. Therefore, it is possible to make reasonable guesses about future trends, In the analysis that follows, East European plan targets for energy production are evaluated and contrasted to best and worst case projections for energy production, demand, economic growth, net energy imports,

Figures for exports, imports and debt are based on 1979 data in CIA, *Handbook of Economic Statistics* ER 80-10452, October 1980; and on 1980 estimates provided to OTA by Edward Hewett and hard currency debt. These cases, constructed by OTA, are judgments of what appear to be most and least optimistic alternative futures, and are included in order to delineate a range of possible alternatives. They are not predictions, but informed guesses about likely possibilities.

INTRODUCTION

The key goals of the Soviet energy strategy for CMEA are outlined in the "Long-Term Target Program for Cooperation in the Areas of Energy, Fuels, and Raw Materials." They are: 1) the development of natural resources to their fullest in every member country through expanded exploration and quick development of newly discovered deposits; 2) strong promotion of nuclear power, particularly through intra-CMEA cooperation; 3) promotion of the development of energy-saving technologies and the application of energy-saving processes; and 4) changes in the structure of output designed to reduce the share of energy-intensive products in gross national product (GNP).[2]

The emphasis in this program, one evidently supported by East European planners, has been on supply-side remedies to the energy problem. But while there has been little discussion of conservation, and few concrete measures have been designed to promote it, at least one Soviet expert has recently raised serious doubts concerning the viability of a supply-side approach in view of recent difficulties in expanding East European production of coal and other energy sources. He suggests that conservation measures deserve serious consideration since the only other alternative—energy imports from third countries—is simply too expensive.[3]

The energy-saving approach recognizes that it is cheaper to conserve than to increase production, but the problem of how genuine conservation can be achieved remains.[4] One way is to change the structure of GNP to reduce the share of energy-intensive industries and product. This approach has adherents, but it gives rise to other difficulties, since energy-intensive sectors (chemicals, fuels, metallurgy, and construction materials) are so important in CMEA economies. The development of energy-saving technology is a promising long-term solution, but the quickest short-term option—reform of the economic system—is understandably downplayed. An enhanced role for meaningful prices, and for profits, combined with a workable set of bankruptcy and enterprise reorganization laws, would probably help to reduce energy wastage by industries. The political costs of such a strategy could be quite high, however, and such reforms have not received widespread support.

Understanding East European domestic political and economic considerations, as well as those that govern relations with U. S. S. R., is important for comprehending the policy choices which East European leaders have made, and those which they are likely to make in the years ahead. The approaches they take to the energy problem will combine three elements: 1) increased domestic energy supplies; 2) reduced energy demand; and 3) increased imports. Each country calculates the costs and benefits of these strategies differently, depending on its energy situation and on perceptions of the political consequences of one or another path.

[2] P. Bagudin, "The Long-Term Tar-get Program for Cooperat ion in the Area of Energy, Fuels, and Materials, and its Realization," *Vneshnyaya torgovlya*, October 1980, pp. 13-18.

[3] Vladimir M. Gzovskiy, "The Economics of Energy Resources in the CMEA Countries, *Voprosy ekonomiki*, December 1980, pp. 96-103.

[4] Miklos Szocs, " Program for the Next Five Years,"' *Figyelo*, Dec. 24, 1980, pp. 1, 4.

ENERGY SUPPLY AND DEMAND IN EASTERN EUROPE, 1960-79: MAJOR THEMES

This section reviews major trends in the development of East European energy production and consumption over the past 20 years. These themes will form the context for the choices facing planners, and will become the basis for OTA own projections for Eastern Europe's energy future in the coming decade,

RESERVES

East European energy reserves are small and dwindling. The size of Eastern Europe's oil reserves is only about 3 percent of that of the estimated proved oil reserves of the U.S.S.R. Gas reserves are even smaller. Most of this petroleum is concentrated in Romania, which has about 89 percent of all Eastern Europe's proven oil reserves. In 1976, however, Romanian oil production peaked and now appears to be in long-term decline. If reserves are exploited at late 1970's production rates, they will be exhausted in a little more than 10 years. Romania also holds Eastern Europe's largest gas reserves, about 40 percent of the total. Here too declining production trends are clear.

Forty percent of Eastern Europe's coal reserves, and almost all of its hard coal, are located in Poland. These reserves have been the sole source of net energy exports from Eastern Europe, but recent events in Poland put continued exports in considerable doubt. The other major deposits, located in Czechoslovakia and East Germany, are coals with low calorific value that have served as the backbone of those countries' primary energy and electricity production.

ENERGY IMPORTS

East European net energy imports have been rising rapidly. In every year since 1961, Eastern Europe as a whole has been a net energy importer, with imports rising to 23 percent of consumption in 1978. The rate of increase, too, has been growing. One indicator of this has been the recent rise in the marginal import to consumption ratio, which records the proportion of the increment to consumption that is covered by net imports. In recent years, two-thirds of the increase in energy consumption has been covered by increases in energy imports. The increasing import/consumption ratio represents a significant policy problem in that it creates an added strain in export requirements necessary to pay for the additional energy. Almost all of these imports are of oil and gas and the percentage of the latter is rising.

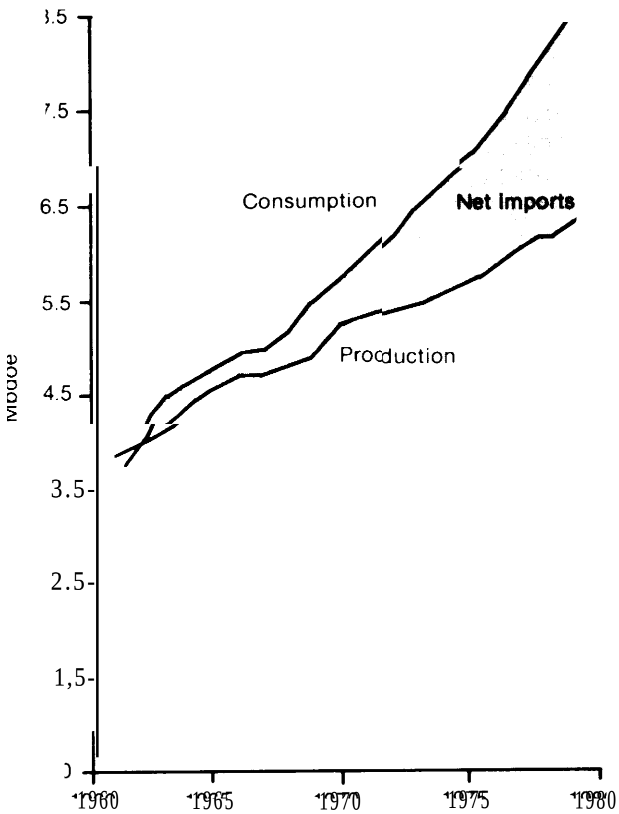
Figure 24 shows the growing importance of net energy imports in Eastern Europe. Some perspective may be gained by comparing the East European energy situation with that of Western Europe.[5] In 1978 the countries of the European Economic Community (EEC) produced 81 million barrels per day of oil equivalent (mbdoe) or 438.7 million tons of oil equivalent (mtoe), importing 54 percent of all their energy. During the same year, consumption in Eastern Europe was about 9.5 mbdoe (473.1 mtoe) and production 6.24 mbdoe (3 10.7 mtoe). Thus, it was necessary to import only 23 percent of energy consumed. But the EEC's far higher import dependence is declining over time, and between 1974 and 1978 net imports to the EEC actually fell as North Sea oil production began. The opposite is true in Eastern Europe where import dependence is growing and where there is no prospect of a North Sea.

THE ENERGY BALANCE

Figure 25 illustrates the strikingly dominant position of coal in East European energy consumption. In 1979, 78 percent of the energy produced in the area was coal;

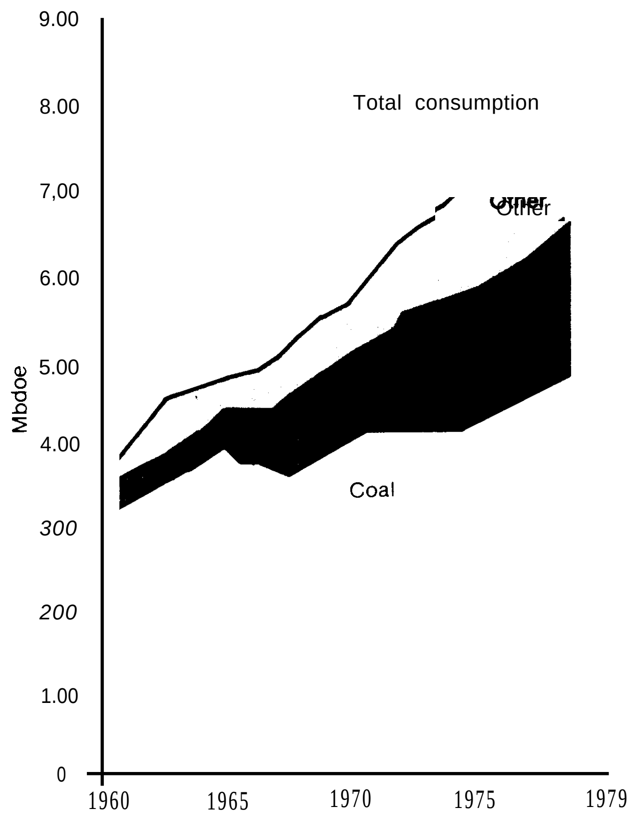
[5] International Energy Agency Organization for Economic Cooperation and Development (OECD), *Energy Balances of OECD Countries 1974-1978* (Paris: OECD, 1980),

Figure 24.—Consumption, Production, and Net Imports of Energy for All of Eastern Europe, 1960-79



SOURCE Data are from CIA Energy Supplies in Eastern Europe A Statistical Compilation, " ER 7610624, December 1979, and CIA, *Handbook of Ecorrorrrlc .Sfatlsflcs* ER 80.10452 October 1980

Figure 25.—East European Energy Consumption by Energy Source, 1960-78



SOURCE Data are from CIA "Energy Supplies ın Eastern Europe A Statlstlcal Compilation ER 76-10624 December 1979, and CIA Handbook of Economic Statlstlcs ER 80-10452. October 1980

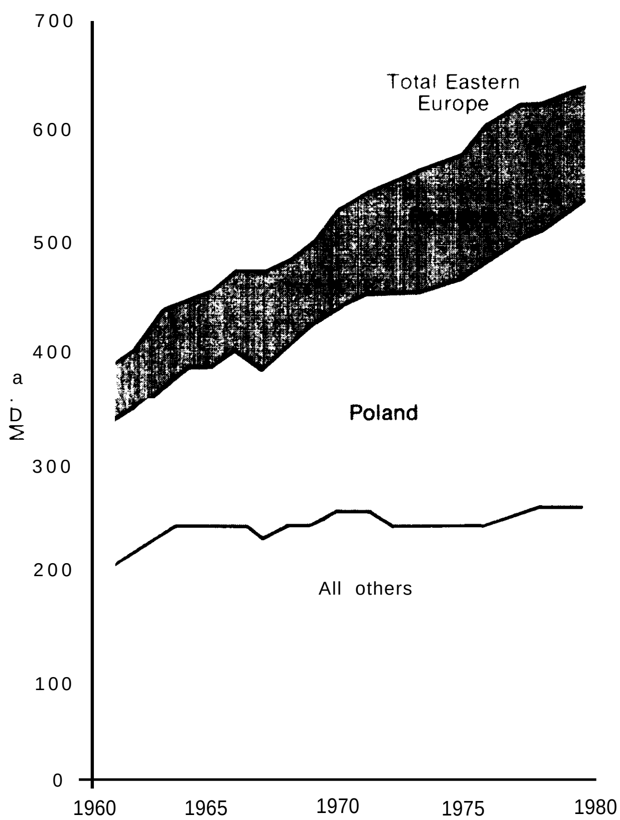
natural gas constituted 14 percent. and nuclear and hydropower together 3 percent. Poland, the mainstay of this production, provided 2.7 mbdoe (134.4 mtoe) in 1979—42 percent of all energy output for the region. The second largest energy producer, Romania, contributed 17 percent in the same year, but Romanian energy production has been falling since 1976. Figure 26 illustrates the crucial importance of Polish coal. Poland was primarily responsible for increases in energy production during the 1970's. Without those increases the small output gains made by other countries would have been completely canceled by Romania's decline.

Coal also plays a dominant role in East European energy consumption. Among EEC nations in 1978, coal accounted for 22 percent of total energy consumption; in Eastern Europe in 1979, 57 percent of energy was consumed in the form of coal. In contrast, oil and gas--which made up 74 percent of EEC energy consumption-provided 40 percent of the total in Eastern Europe. Consumption of petroleum has increased over the last two decades in Eastern Europe, but world price rises have slowed that process. This gives CMEA one advantage relative to the rest of the world. As many nations attempt to switch back to coal, Eastern Europe can merely slow its transition to oil.

THE ROLE OF THE U.S.S.R.

The Soviet Union is overwhelmingly important as an energy supplier to Eastern Europe. Table 62 shows estimated Soviet

Figure 26.— Energy Production in Eastern Europe, Total, and by Country, 1960”79



SOURCE Data are from C 1A Energy Supplies in Eastern Europe A Statitical Compilation ER 76 10624 December 1979 and CI A Handbook of Economic Statistics ER 80-10452 October 1980

crude oil and product exports to CMEA during the 1970’s. The Soviet Union’s oil exports to all nine CMEA countries have generally been about 55 percent of its exports to the world. In 1979, for example, the Soviet Union shipped to CMEA 87.1 million tons (1.74 mbd) of crude oil and oil products, more than half of all its exports (158.1 million tons or 3.16 mbd). This percentage has remained relatively constant, although the rate of growth of Soviet oil exports to CMEA has slowed. This reflects a reduction in total Soviet oil exports over the past 5 years.

Even more important than the huge quantities of Soviet oil shipped to Eastern Europe is its relatively low price. This has constituted a substantial subsidy. The average price per ton chargedl by the Soviet Union for crude oil shipped to Eastern Europe in 1980 was about half of the world price.[6] This price is calculated according to a method, adopted in 1975, called the “Five Year Moving Average." This system uses world oil market price averages over the previous 5 years as a basis for annual price negotiations in intra-CMEA oil trade. The result is a considerable lag in CMEA prices for oil. The advantage to Eastern Europe has been enormous. While world oil market prices rose almost thirteen-fold between 1972 and 1980, prices paid by East European countries for Soviet oil rose only about 4.5 times. In 1980, Soviet exports to Western nations brought an estimated average price of $230/ton, while export prices to CMEA countries were $105/ton. Assuming a subsidy amounting to the difference between the two prices, the 1980 subsidy was 81.1 million tons x $125 = $10.1 billion. This was one-half the value of all Eastern Europe’s exports to the West. If East European nations were forced to pay the full world market value for this oil, they would have had to increase their dollar exports by 50 percent, or double their annual hard currency borrowing. Such loans would be very difficult, if not impossible, to Obtain.[7] Conversely, by selling this oil on the world market. the U.S.S.R. could increase its hard currency, imports 50 percent. Obviously, however, the subsidy is so large that if the Soviets tried to eliminate it quickly, the result would be chaos for Eastern Europe.

I t must be noted, however, that Eastern Europe actually imports slightly more energy from the Soviet Union than yhe total of its net energy imports. The reason is that while Eastern Europe has been a net importer of energy from the Soviet Union, it has also exported energy, mostly coal, to

[6] Jan Vanous, "Eastern European and Soviet Fuel Trade, 1970-75," in *Eastern Europe Assessment*, U.S. Congress, Joint Economic Committee (Washington, D.C.: U.S. Government Printing Office, 1981).

[7] Ibid. In fact, the oil subsidy to Eastern Europe is probably even higher if one allows for the fact that the dollar ruble exchange rate is overvalued. The total subsidy to CMEA is, moreover, higher than the oil subsidy alone since other primary products are subject to similar kinds of subsidies.

Table 62.–Soviet Exports to CMEA of Crude Oil and Oil Products, 1979-80

Exports to														
Bulgarla	48	7.1	99	11.6	10.0	11.9	108	12.9	11,3	13.4	13,0	14.1	13.0	14.0
Czechosolvakia	9.4	105	155	16.0	163	17.2	17.0	17.0	17.7	17.7	183	18.3	19,2	19.2
East Germany	9.2	93	15.1	15.0	16.0	168	17.0	17.0	17.8	17.8	185	18.5	19.0	19.0
Hungary	4.0	4.8	6.9	7.5	7.7	84	7,7	9.1	85	10,2	8.6	11.0	9.5	12,0
Poland	7,0	86	10.9	133	11.7	14.1	12.8	14.7	13.4	15.5	12.9	14.0	13.1	15.9
Romania	—	—	—	—	—.	—	—	—	—	—	0.4	0.4	1.0	1,0
CMEA-6	344	403	58.2	63.4	61.7	68.4	65.3	70,7	68.6	74.6	71.7	76.3	73,8	81.1
Cuba	43	6.0	58	8.1	6.0	8.8	6.2	9.2	6.4	9.6	6.7	9.6	7.0	10.0
Vietnam	—	0.4	–	0.4	–-	0.4	—	0.5	—	0.5	—	0.6	–	0.6
Mongolia	—	0.3	–	0.4	–-	0.4	—	0.5	—	0.5	—	0.6	–	0.6
CMEA-9	387	47.0	640	72.3	67.7	780	71.5	80.9	750	85.2	78.4	87.1	80.8	92.3
Entire world	668	95.8	93.1	130.4	110.8	1485	NA	152,5	NA	165,6	NA	1581	NA	NA

C Crude T Crude plus products
NA = not available
[a] These are estimates necessitated by the fact that the Sovtet Unlon stopped reporting quantlty data on its energy exports in 1977, but they are probably fairly reliable indlcators of actual shipments
[b] These are estimates but somewhat less reliable than the 1977-78 figures They should be taken only as indicators of general magnitudes in some cases the actual number could be easily 1 ton larger or smaller

SOURCES The data through 1976 are from Soviet foreign trade yearbooks (*Vneshnyaya torgovlya SSSR*) Figures concerning the proportion of crude and products for Cuba, Vietnam, and Mongolia are estimated Data beginning in 1977 are estimates based on CMEA, *Vneshayaya torgovlya* (Statistical Yearbook of the Member-Countries of the Council for Mutual Economic Assistance) (Moscow "Statlstlka," 1979 and 1980), and The *Journal of Commerce*

nonsocialist countries. In effect, Eastern Europe as a whole is reexporting in the form of coal some of the energy it imports from the Soviet Union in the form of oil.

Table 63 shows estimated Soviet natural gas shipments to CMEA in the last decade. The Soviet Union only began to develop its natural gas export capabilities in the 1970's, with the completion of the Orenburg (or Soyuz) gas pipeline, the result of a 3 billion transferable ruble joint development project involving the U.S.S.R. and the CMEA-6. Each of the East European countries provided some combination of equipment, labor, and hard currency to buy Western equipment for construction of the 2,750-km pipeline, 22 compressor stations, gas treatment plant, and gas condensation unit at Orenburg. The pipeline began operating at full capacity (transporting 15.5 billion cubic meters or bcm of gas per year to Eastern Europe) during 1980.

It is likely that most future increments in Soviet energy shipments to Eastern Europe will be in the form of natural gas. The implications of this trend are important because, in contrast to oil, the Soviet Union has not been subsidizing natural gas prices paid by Eastern Europe. In fact, it appears that while the Soviet Union has sold Eastern Europe oil at one-half the world market prices, it has sold gas at about the world price level,

Table 64 provides a rough comparison of average 1976 prices of Soviet oil and gas exports to both Eastern and Western Europe. This table shows that Soviet gas prices to Western Europe on a per calorie basis were about one-half oil prices, 35 rubles/ton of oil equivalent of gas compared to 68.6 rubles/ton of oil. This is consistent with world practice: gas prices generally are lower on a calorific basis than are oil prices, reflecting the higher transport costs and the fact that gas is an imperfect substitute for oil. In contrast, Soviet gas and oil exports to Eastern Europe in that year cost about the same per calorie—39.5 rubles/ton of gas v. 38.1 rubles/ton of oil. Moreover, the gas price was actually higher than the average price to West European countries.

Table 63.–Soviet Natural Gas Exports, 1970-80

	1970	1975	1976	1977[a]	1978[a]	1979[b]	1980[b]
Bulgaria.	—	1.19	2.23	2.90	3.00	340	5.80
Czechoslovakia.	130	3.69	4,29	5.20	5.30	7.30	8.10
East Germany	—	3.30	3,37	355	3.62	4.33	570
Hungary	—	—		1,00	1,03	2.50	383
Poland	1 00	2,51	2,55	2.77	2.76	3.99	5.56
Romania	—	—	—	—	—	0.75	1,49
Total, CMEA-6	230	10.69	1244	1542	1571	22.22	30.48
Total, all countries	330	19.33	25.78	3123	NA	NA	55.00

NA = not available

[a] These are estimates necessitated b, the fact that the Soviet Umon stopped reporting quantity data on its energy exports in 1977: but they are probably fairly reliable indicators of actual shipments

[b] These are estimates also but somewhat less reliable than the 1977-78 figures They should be taken only as indicators of general magnitudes the actual figures could differ from these

Table 64.—Comparison of Unit Values for Soviet Gas and Oil Exports, 1976

	1976			1979		
	Gas		Oil	Gas		Oil
	Rubles per					
	Bcm	Toe[a]	Ton	Bcm	Toe	Ton
Exports to:						
West Germany	227	27.8	65.5	NA	NA	NA
Finland	473	57.8	80.9	NA	NA	NA
France	256	31.3	66.4	NA	NA	NA
Italy	140	17.1	650	NA	NA	NA
Austria . . . ., ...	335	40,9	654	NA	NA	NA
Average, West . . . ., ., ...	28.6	350	686	NA	NA	NA
Bulgaria.	334	408	37.5	45 9a	561	64.4
Czechoslovakia.	34.5	422	34.1	45.9	561	561
East Germany	277	33.9	32.0	50.5	61.7	55,3
Hungary	33.9	41 1	44.7	50.6	619	76.0
Poland	320	39.1	42.0	49.5	60.5	716
Romania				51 1	630	—
Average, CMEA	323	39.5	38.1	489	599	64.7

NA = not available

Bcm Billions of cubic meters

Toe Tons of oil equivalent of 1000 cubic meters of gas 0818 toe)

[a] Assumed equal to the Czech unit value

SOURCE *Vneshnyaya* torgovlya SSSR

If, as it appears, Soviet gas sold in Eastern Europe is not being subsidized,[8] one possible explanation lies in the fact that large gas shipments only began after the 1974 world oil increases, and the Soviets must have been able to force through a full market price for gas. This would have been possible because even at that price, Soviet gas remains attractive for Eastern Europe. In any case, CMEA countries can buy additional increments of energy only at the world market price, and the world price of gas is still much lower than that of oil on a calorific basis. Transport costs also make the closest supplier the cheapest.

[8] 'Set' eral additional factors temper these gas prices, however. First, the official exchange rate understates the rate of subsidy. Even at roughly equivalent gas prices at official exchange rates, Eastern Europe is receiving some implicit subsidy in being able to pay for the gas with manufactured goods sold to the Soviets at what are, in effect, inflated prices. Secondly, gas prices are complicated because of compensation deals. For example, the Orenburg pipeline agreement involved machinery and equipment, labor, and money capital in exchange for gas. I t is possible that those East European investments of labor, money, and goods were overvalued relative to the final prices of gas.

Photo *credit* Oil *and* Gas *Journal*

Orenburg gas pipeline

Imports of Soviet gas have, therefore, grown rapidly. In 1977 these amounted to about 15.42 bcm or 18 percent of the 70.7 million tons of the Soviet crude oil and products imported. By 1980 the Soviets were shipping 30.48 bcm of gas to Eastern Europe. This equals 24.93 mtoe, or 31 percent of the 81.1 million tons of crude and products shipped to Eastern Europe that year. Assuming that oil shipments from the U.S.S.R. will not increase above 1980 levels, the critical issues for Eastern Europe are how rapidly the oil subsidy will be reduced, and how quickly imports of natural gas will increase.

These major themes—dwindling East European energy reserves, rising imports, the continuing importance of coal, and the overwhelming importance of the Soviet Union as an energy supplier—delineate the policy context of future East European energy planning. The next two sections, on supply and demand prospects for the 1980's, investigate critical opportunities for and constraints on future East European energy strategies.

EAST EUROPEAN ENERGY SUPPLIES IN THE 1980'S

A centerpiece of the East European energy strategy is the commitment to increased coal and nuclear development to cover increases in demand over the next decade. Almost all of the additional coal output will be used in conventional powerplants, condensing stations, and cogeneration units. Coal and expanded nuclear power together will thus cover incremental electricity demands. At the same time, petroleum will be freed for use as chemical industry feedstocks, for automobile fuel, and other uses where solid fuels are inappropriate. In Romania, where state policies already prohibit the commissioning of any new heat or power stations operating on oil and gas, the proportion of electricity generated from these fuels is projected to drop from the current level of 65 to 40 percent by 1990.[9] Other East European nations, lacking Romania's domestic petroleum reserves, have been attempting to cover all of their incremental energy needs with coal and nuclear power. For example, Czechoslovakia employed this strategy during its 1976-80 plan period, but did not succeed by the amount originally targeted.[10]

Coal is likely to remain the predominant source of domestically produced energy in Eastern Europe, at least in the near future, and official plans for the next 10 years feature expanded output of coal, particularly lignite. Eastern Europe's success in domestic energy output over the next decade will rest mainly on its ability to increase coal output.

A second major source of energy will be nuclear power. Despite the currently tiny fraction of East European domestic energy production (1.25 percent) accounted for by

[9] "WPC Host Country Romania Swaps Tools and Technology for Crude, *Oil and Gas Journal* vol. 77, No. 35, Dec. 27, 1979, p. 76ff.

[10] "The National Economy . .," 1980, p. 11. See also Radio Free Europe (RFE), Czechoslovak SR No. 4, Jan. 31, 1979, pp. 1-2.

nuclear power, future prospects for the industry are promising. It is the focus of one of the major, and apparently rather successful, cooperative efforts within CMEA. (See below and ch. 4.) Finally, prospects for the Romanian petroleum industry are poor. The sections that follow explore the constraints and options for each of these energy sectors, as a foundation for the projection of future net energy import needs.

THE COAL INDUSTRY

Table 65 summarizes the plans of various East European countries for coal output in the 1980's. Since the quality of information varies considerably for different countries, these data should be viewed only as general approximations. All six countries are planning a major expansion of coal output, mostly lignites. Taken together, the plans suggest a growth rate of lignite and brown coal production of 5.4 percent per annum during 1980-85, and a growth rate of 3.8 percent for hard coal production during the same period. Lower growth rates are projected for the second half of the decade, but these are less certain, as a number of the countries have not yet announced formal plans.

The projected growth rates for coal are ambitious. During the last 5 years (1975-80) lignite and brown coal output grew 2.9 percent and hard coal grew 1.9 percent per year. 1980 production was slightly below that of 1979, reflecting a drop in Polish coal production, and continued stagnation in Hungarian, Czech, and East German output. The plans for the 1980's thus call for a doubling of the growth rates of the past 10 years, and a substantial improvement over 1979-80 performance. While this is not impossible, there is normally a considerable lag between the time that the decision is made to increase output, and the actual completion of the mine capacity necessary to implement this decision. Investment processes to increase lignite production have, to some extent, been set in motion in all six East European countries. When these investments will begin to bear fruit, and what type of coal will be produced, remain to be seen.

There are at least three potentially serious obstacles to the fulfillment of coal output targets. The first applies mainly to open-pit mining of lignite and is a technology constraint: East European machinery in this area is apparently of low quality, but planners are reluctant, or unable, to approve large imports of Western equipment because of severe foreign currency constraints. Second, there may be labor problems in underground mining of both brown and hard coals. Finally, there may be an environmental constraint, again associated primarily with lignites. The following sections briefly discuss each of these problems, describe intra-

Table 65.— East European Plans for Coal Output in 1985 and 1990

	(1980 estimate)				1985 (plan)				1990 (plan)			
			Total				Total				Total	
	HC	BC + LIG	Mtnat	Mbdoe	HC	BC + LIG	Mtnat	Mbdoe	HC	BC + LIG	Mtnat	Mbdoe
Bulgaria	0	31	31	0.12	0	37	37	0.15	0	45	45	0.18
Czechoslovakia	28	95	123	0.91	28	104	132	0.96	28	109	138	0.99
East Germany	0	250	250	1.05	0	275	275	1.16	0	300	300	1.26
Hungary	3	23	26	0.14	3	32	35	0.18	3	34	37	0.19
Poland	193	37	230	2.30	235	85	320	3.20	260	115	375	3.75
Romania	8	32	40	0.20	13	74	87	0.44	15	82	97	0.49
Total	232	467	700	4.72	279	607	887	6.09	306	685	992	6.86

HC = hard coal BC = brown coal LIG = lignites. Mtnat = million tons in natural units: mbdoe = million barrels per day of 011 equivalent Hard coal contains at least 57 million kilocalories per ton.
All tonnages rounded off to the nearest ton. Thus some "0"s simply indlcate a figure of less than 0.5 tons, and some totals will not equal the sum of the components of the columns due to rounding

SOURCE Off Ice of Technology Assessment

CMEA cooperation in coal, and evaluate the feasibility of plans to increase coal output.

Technology

The Polish and Czech cases, about which there is a good deal of information, illustrate the types of measures which East European nations are taking to increase lignite production. Hoping to set aside as much hard coal as possible for export, Polish planners are pushing lignite for domestic consumption.

Much of Poland's planned expansion of low-calorie coal and electric power centers on the Belchatow Power Plant and the Szczezercow lignite mine. The Belchatow station is designed to have twelve 360-MW generators by 1985 (completion of which may be delayed by such problems as water incursion). The entire station will run on lignites with calorific contents ranging from 1.600 to 1.900 kilocalories/kg.[11] At full capacity, the station should produce 26.5 billion kWh of electricity per year, the equivalent of 23 percent of all the electricity produced in Poland in 1979. A second station (Belchatow II), with a total generating capacity of 2,880 MW, is to come online in the period 1985-90. This complex is the major source of Polish incremental demand for lignites in the 1980's. Between 1980 and 1985, the complex will use 33 million tons of lignite, or 87 percent of the total increase in Poland's planned lignite production.[12]

While it is difficult to judge the progress of the Polish project, there are indications of problems similar to those which have developed in Czechoslovakia in attempts there to expand lignite production. First, open-pit mining equipment of East European design is evidently inferior in quality to comparable Western equipment; it breaks down frequently, causing delays in removing overburden, mining the coal, and moving it by conveyor belt. The Czechs, who have reported repeated problems with excavators and conveyors, were finally forced to import conveyors from the West. A second problem is that East European suppliers of mining equipment are not meeting their orders on time. It may well be that the sudden increase in demand for mining equipment is pushing the suppliers beyond their capabilities. At the same time, severe hard currency shortages preclude imports of high-quality Western mining equipment. These common and recurring problems suggest that East European plans to expand lignite production may be overly ambitious.[13]

Labor

A second potentially important impediment to the fulfillment of East European plans for expanded coal output lies in the unwillingness of the labor force to work long hours in underground mines. The labor constraint is a key to Polish coal production, but it is also significant in Hungary, where new brown coal mines run 24 hours a day, 6 days a week; and in Romania, where miners in the Jiu Valley have shown reluctance to work for low wages.

Indeed, Poland's plans for hard coal—about 42 million tons, constituting almost all

[11] Bagudin, op. ci t., p. 15, reports these calorific values for the coal and calls it "lignite."' Bartosevich calls it "brown" coal of approxima tely 2,000 kilocalories kg. See Abignev Bartosevich, "The Sign] ficance of Cooperation in the Long-Term Development of Energy in Peoples' Republic of Poland, " *Ekonomicheskoye sotrudnichestvo stran-chlenov SEV,* February 1980, pp. 37-42. The calculations assume that the lower figure is correct.

[12] These calculations assume a 70-percent load factor in the stat ion and 40-percent efficiency. Each 1,000 kWh equals 0.0875 toe, and at 40-percent efficiency!', it will require 0.219 toe to produce that 1,000 kWh. The lignites feeding Belchatow run from 1,600 to 1,900 calories. Assuming the average is 1,750, they convert at O. 175 toe. Thus 1,000 kWh, which require 0.219 toe, will require 0,2190.175 = 1.25, or 0,00125 tons of lignite per kWh. 26.5 billion kWh multiplied by 0.00125 yield 33.125 million tons of lignite to produce the 26.5 billion kWh.

[13] Hungary may be the one CMEA country that has tried to directly deal with the technology problem by buying the proper equipment in the West, and then using it effectively. In the early 1970's it completed construction of the Visonta Thorez Open-Pit mine which was then responsible for a 20-percent increase in the output of surface-mined coal. It was equipped with what was called "world level technology." Judging from the pictures accompanying the story, this consisted of Western equipment. *Nepszabadsag, Dec. 7,* 1980, p. 1. The Hungarians are now finishing construction of two highly mechanized brown coal mines, Markushegy and Nagyegyhaz, which will increase brown coal production by 9.6 million tons by the mid- 1980's, an increase of 40 percent. Again, it would appear that they are relying heavily on Western equipment.

of Eastern Europe's planned increment to 1985—seem unattainable. Goals for lignite production increases in all the countries of Eastern Europe amount to 140 million tons, but in calorific value this equals only 30 mtoe. If Polish targets for hard coal are not met, two-fifths of Eastern Europe's projected coal increment will be eliminated.

Nevertheless, it is difficult to imagine how such growth in Polish coal output can be attained. Increased production in the 1970's was made possible by the implementation of a four brigade system of working the mines, supplemented with overtime and, more recently, Sunday work. This effort was part of a frantic search for hard currency exportable brought on by Poland's severe debt problems. One source of Polish labor unrest in the summer of 1980 was the rapid pace of mining activity, and one concession won was reversion to a 5-day workweek. Polish hard coal output for 1980 fell to 193 million tons, 14 million tons below plan. The original 1981 plan of 188 million tons was abandoned in midyear after output during the period January-June amounted to only 81.3 million tons. Now planners feel that they can achieve approximately 170 tons for all of 1981 only if workers will again agree to work 6 days a week; otherwise, an output of 160 million tons—41 million tons below the 1979 peak of 201 million tons—appears likely. [14]

As of this writing, no one can say how the Polish situation might be resolved, and in particular, how the resolution will affect coal production. Certainly the old targets of 235 million tons in 1985 and 260 million tons in 1990 seem unattainable, having been constructed on the now impossible assumption that Polish coal mines could be worked 7 days a week. On the other hand, the low coal outputs in 1980-81 are surely below what is possible with given capital stock and a normal 5-day workweek.

[14] See RFE. Polish SR No. 10, May 9, 1979, pp. 1 -4; and RFE, Polish SR No. 1, Jan. 26, 1981, p. 13; RFE, Polish SR No. 12, July 3, 1981, p. 14; and *Petroleum Econo mist,"* August 1981, p. 359.

Environmental Costs

Environmental costs form another potentially important political and economic constraint on lignite production. Two major problems are the loss of land to other uses as open-pit mines are developed, and the effects on air and water of mining and coal burning.

The land costs have not been quantified, but they are potentially important. In both East Germany and Czechoslovakia, countries which are heavily engaged in open-pit mining, cities and rivers have been moved to obtain access to coal deposits.[15] Aside from the enormous costs in capital and labor, the dislocation of people and the disruption of the countryside may create popular dissatisfaction which cannot be discounted.

Even more serious, however, are the air and water pollution which result from heavy reliance on coal. Environmental damage caused by coal mining dates back to the 1950's in Eastern Europe. At that time heavy fallout of particulate matter and emissions from chemical plants in some areas in Czechoslovakia reduced morning light by 50 percent, killed 37,000 spruce trees, and cut 90 percent of the ultraviolet rays.[16] These impacts evidently presented enough of a political problem that the Dubcek government responded by halting work in the North Bohemian brown coal basin in 1968. Today official statements recognize the environmental problems associated with open-pit mining. " While there is insufficient evidence of how deep feelings run, it seems possible that major attempts to increase coal output will do enough damage and displace enough people to turn this into a political issue.

[15] Leslie Dienes, "Energy Prospects for Eastern Europe, " *Energy Policy,* June 1976, p. 126; V. Belianov, "Working Successes of the Miners, *Ekonomicheskaya gazeta,* Feb. 9, 1978, p. 21.

[16] J. G. Polach, "The Development of Energy in East Europe, "' in Joint Economic Committee, Subcommittee on Foreign Economic Policy, U.S. Congress, *Economic Developments in Countries of Eastern Europe* (Washington, 1), (‘.: (J. S. Government Printing office, 1970), p. 360,

'R FE , Czechoslovak SR No. 4, Jan. 31, 1979, p.2.

CMEA Cooperation in Coal

There are currently no joint CMEA coal mining efforts, but some cooperative activity is aimed at developing coal-fired plants using low-calorific coals, and at cogeneration from conventional plants. For example, Bulgaria and the U.S.S.R. are reconstructing power stations to burn low-calorie coals without prior preparation. East Germany, the U. S. S. R., Poland, and Hungary are working on a joint project in East Germany involving the construction of mines and power stations for low-calorie coal. At various research institutes, cooperative work is being conducted in cogeneration, high-productivity steam boilers, and centralized steam production. However, none of the cooperative CMEA projects hold real promise of increasing coal supplies in the next decade. Such efforts may have some effect in efficient utilization of coal, but even in that area the joint R&D effort is modest. Prospects for East European coal in the next decade will depend to a great extent on the initiatives taken by individual countries.

The Feasibility of Meeting Coal Output Targets

The success of aggregate East European plans for the coal industry rests on developments in Poland and Romania. These two countries account for all of the planned increment to hard coal production in the 1980's, and 65 percent of the planned 140-million-ton increase in brown coal and lignites. This equals approximately 80 percent of planned increases when these figures are converted to tons of oil equivalent. The key problem in evaluating these targets is the uncertainty associated with the Polish crisis. At the very least, it seems impossible for Poland to reintroduce 7-day workweeks for miners.

Mindful of these uncertainties, OTA has constructed "best" and "worst" case estimates for coal output. Table 66 summarizes these best and worst case projections, and compares them to plan targets.

Table 66.—Projected and Planned East European Coal Production (million barrels per day of oil equivalent)

	1980	1985	1990
Actual	4.72		
Plan		6.09	6.86
Best case projection		5.46	5.98
Worst case projection		4,99	5.44

SOURCE Office of Technology Assessment

For Poland, the best case assumes that output levels in 1985 will reach 210 million and in 1990 220 million tons (as opposed to the planned targets of 235 million and 260 million tons). These best case figures are still above what the Minister of Mining has implied are possible; they assume a settlement of labor troubles, some new investment, and productivity improvements. OTA's worst and increasingly probable case assumes that although output will fall below long-term trends in the early 1980's, it will recover in the latter half of the decade, reaching 190 million tons in 1985 and 200 in 1990. Current events in Poland are a reminder that things could be worse in 1985 than even this worst case. But the year 1985 here is merely representative of the mid-1980's, and it is unlikely that the current level of chaos in the Polish economy can or will be sustained for that long. This is, therefore, not the worst imaginable case (which is no coal output), but rather the worst case within the range of likely coal outputs.

Romanian plan targets appear to be no more realistic. Indeed, since 1977 these have been consistently underfulfilled. In 1980, for example, Romania planned to produce 54 million tons of of coal, but probably attained an output of no more than 40 million tons. The situation has been serious enough that the army has been called in to assist the miners.[18] While it is difficult to estimate

[18] RFE, Romanian SR No. 18, Dec. 10, 1980, p. 15. It seems certain that they will not meet the 1979 plan, but the figure of 40 is a guess which assumes that they underfulfill in 1980 by the same amount they underfulfilled in 1975.

future output, OTA projection of a reasonable best case is 60 million tons in 1985, 20 million tons above actual performance in 1980. Since there are no Romanian plan figures now available for 1990, projections are necessarily speculative. But it would appear unlikely that total output could rise above 80 million tons for that year. A worst case projection would put 1985 output at 40 million tons, and 1990 output at 60 million tons.

The other countries of Eastern Europe are less important in coal production, but if their planned targets are taken as a best case, and somewhat lower levels as a more realistic case, it appears unlikely that Eastern Europe will be able to attain regional production goals. Even under the best case conditions, therefore, the combined coal output for Eastern Europe as a region is likely to grow only half as much between 1980 and 1985 as planned (0.74 mbdoe or 36.8 mtoe v. 1.37 mbdoe or 68.2 mtoe).

THE NUCLEAR POWER INDUSTRY

Nuclear power is the only other feasible source of substantial increases in domestic energy production in Eastern Europe, although at the moment it contributes only a small portion of the electric power produced in the region, Eastern Europe's nuclear power program has been behind schedule for some time. As late as 1976, forecasts of 10,000 MW of installed nuclear capacity by 1980 were common.[19] But in 1979 installed nuclear capacity in the six countries was 3,100 MW, or about 3.4 percent of total generating capacity. This amounted to about 4.7 percent of all electricity generated in Eastern Europe during that year.[20] In 1980 installed capacity was increased to 4,440 MW by the addition of new reactors in Bulgaria, Czechoslovakia, and Hungary.

Current plans for nuclear power production contrast sharply with past performance. The six individual East European country plans, added together, call for a fourfold capacity increase between 1979 and 1985, and a tripling of that between 1985 and 1990 (see table 65). These plans depend heavily on an extremely complex cooperative CMEA effort involving specialization and cooperation in the production of, and trade in, equipment for nuclear powerplants. This program aims at raising nuclear capacity to 37,000 MW by 1990. With the exception of Romania, which is developing its own industry using Canadian "Candu" reactors, East European nuclear power is being built with Soviet technology -Soviet-designed VVER-440 reactors, produced in Czechoslovakia and the U.S.S.R. These 440-MW pressurized water reactors are apparently both reliable and economical. Another series of Soviet reactors, the 1,000-MW VVER-1000, is now under development and in the mid-1980's East European countries plan to commission stations using the new design. (see ch. 4 for a detailed description of the Soviet nuclear power industry). Plans call primarily for VVER-440 reactors to be introduced through 1985, and for VVER-1000s to be added thereafter. One exception is Bulgaria, which hopes to have a VVER-1000 in operation by 1985. Romania hopes to produce its own 660-MW "Candu" reactors and to have six of these operating by 1990.[21]

Two joint enterprises have been established to assist in this effort. One, *Interatomistrument,* oversees the manufacture of high-technology equipment for nuclear powerplants; another, *Interatomenergo,* handles shipment of equipment, parts, materials, and apparatus for nuclear powerplants. It has already been decided that two 4,000-MW nuclear power stations will be constructed in the Ukraine with Polish, Hungarian, Czech, and Romanian participation. Repayment to

[19] For 1976 forecasts, see Figyelo, Sept. 11, 1976, p. 9; M. Virius and J. Balek, "Cooperation Between CMEA Countries in Securing Supplies of Fuels and Energy" *Czechoslovak Economic Digest,* No. 3, May 1976, p. 39.

[20] These calculations simply assume a 0.7 load factor for nuclear powerplants, and then divide the electricity generated at that load factor by all electricity generated that year.

[21] RFE, Romanian SR No. 2, February 1981, pp. 12-13.

Eastern Europe will be in the form of electricity, shipped via 750-kV powerlines. The first of these powerlines, between Albertirsa near Budapest in Hungary and the Ukraine, was completed in 1978.

The first Ukrainian 4,000-MW station is scheduled to be completed in 1984-85. Czechoslovakia, Poland, and Hungary will pay half of the estimated total cost of 1.5 billion transferable rubles (TR). Poland's contribution of 400 million TR will be made in goods and services; the Czechs will cover 240 million TR through supplying equipment and machine tools; and the Hungarians will supply 110 million TR. Half of the capacity of the new station will be dedicated to shipments to each of the East European nations in proportion to their contributions to its construction. A second 4,000-MW station, Konstantinovka, is projected for the latter part of the decade, but the details remain unclear. In addition, draft agreements on cooperative development of atomic cogeneration units and atomic boilers for producing steam for industry are in preparation. CMEA agreements on specialization and cooperation in manufacturing generally lack substance, but it appears that those relating to the nuclear power industry may be exceptions. The most plausible explanation for the exceptional efforts being made in the area of cooperative nuclear programs is that Soviet leaders recognize the importance of East European development and are determined to retain control of the technology.

One great attraction of nuclear power is that it relieves pressure on the coal industry, which otherwise would be called on to provide the fuel necessary to generate equivalent amounts of electricity. But while the amount of coal "displaced" by an extensive nuclear power program could be significant, nuclear development will not much diminish the importance of Eastern Europe's coal industry.

Assuming that it replaces a conventional thermal powerplant working at 40-percent efficiency, a new 440-MW reactor operating at 70-percent capacity can displace 2.94 million tons of lignite per year.[22] Nuclear powerplants are now usually built with at least four VVER-440s (i.e., with installed capacities of 1,760 MW). Commissioning such a plant would thus obviate the mining of nearly 12 million tons of lignite per year. This amount of lignite equals 2.3 mtoe or 0.047 mbdoe. The best case increase in coal output between now and 1985 was 0.74 mbdoe. Thus, it would take almost sixteen 1,760-MW nuclear powerplants (each with four 440-MW reactors) to match that increment. This is clearly impossible. Even in the best case, therefore, nuclear power's contribution to increased supplies of domestic energy in Eastern Europe in the 1980's will be much smaller than that of coal.

The potential obstacles to fulfillment of nuclear targets differ sharply from those likely to be encountered with coal production. As in the U. S. S. R., there are no East European counterparts to the Western antinuclear groups. Nuclear power is officially considered much cleaner than coal, and therefore a very attractive energy source. Press reports include little discussion of safety issues, and individuals who may worry about the safety of nuclear power have no easy way to express their concern. Barring an accident near a major population center (a prospect not to be dismissed since current plans call for cogeneration using nuclear reactors situated in heavily populated areas), it is unlikely that safety and environmental concerns will impede the development of nuclear power. Labor problems are also unlikely to be a major factor, since the nuclear industry is not as labor-intensive as the coal industry.

[22] A new 440-MW reactor operating 70 percent of the time can produce 2.6981 billion kWh of electricity per year (24 hours per day x 365 days x .70 x 440 MW = 2.6981 billion kWh). Modern fossil-fired plants can produce 1,000 kW of electricity using approximately 0.218 toe of energy equivalent inputs. 1,000 kW equals approximately 0.0875 toe of energy, and therefore energy out divided by energy in is 0.0875/0.218 = 0.4 efficiency of energy conversion. A 440-MW lignite-fired plant working at that efficiency level will require 2.6981 billion kWh x 0.000218 mtoe = 0.588 mtoe of energy inputs per year. Assuming the lignite inputs average 0.2 mtoe per ton, that requires 0.58/0.2 = 2.941 tons of lignite.

The two potentially significant constraints on the development of nuclear power in Eastern Europe are technology and capital costs. While there appear to be few problems with the VVER-440 reactors, the introduction of new VVER-1000s and their attending support equipment is tantamount to an experimental program and delays are not unlikely. The capital costs of nuclear power may also impede the realization of plans for nuclear power development in the 1980's. Nuclear powerplants are huge, highly visible investment projects. If, as seems likely, East European GNP growth rates are low during this decade, the need to maintain living standards might result in a slowdown in nuclear power development, and possibly a heightened interest in conservation.

The Feasibility of Meeting Installed Nuclear Capacity Targets

East European plans for 1985 nuclear power capacity appear to be fairly realistic (see table 67). These foresee a capacity of 12,000 MW in 1985, 2,000 MW above mid-1970's forecasts for 1980. This installed capacity would support electricity production amounting to 0.320 mbdoe (15.9 mtoe). Most of the planned increment for the 1980-85 period is associated with the introduction of additional VVER-440 reactors, with which the East European and Soviet power industries now have considerable experience. Therefore, 12,000-MW installed capacity in 1985 can be viewed as a reasonable best case. A worst case could assume that Bulgaria's VVER-1000 is not operational until after 1985, that the Czechs only manage to achieve the low end of their plan (2,200 MW of capacity operating in 1985), that the Poles can get none of the capacity at Zarnowiec operational in 1985,[23] and that Romania's first reactor does not make its scheduled commissioning in 1985. It is entirely possible that all of these delays could coincide. Under these worst case conditions, 9,250-MW capacity might be in place by that year, which would produce 56.66 billion kWh or 0.247 mbdoe (12.3 mtoe) of electricity.

It is difficult to determine best and worst cases for nuclear power for 1990 since in-

[23] 'See RFE, background report No. 11 -Eastern Europe, Jan. 20, 1981.

Table 67.— Nuclear Power Capacity, and Production of Electricity From Nuclear Powerplants,
1979 (actual), and Planned for 1985 and 1990

	Actual			Planned					
	1979			1985			1990		
	Capacity (mkW)	Production[a] (bkWh)	(mbdoe)	Capacity (mkW)	Production[a] (bkWh)	(mbdoe)	Capacity (mkW)	Production (bkWh)	(mbdoe)
Bulgaria	0.88	54	0.024	2.76	16,9	0.074	3.76	231	0101
Czechoslovakia	0.44	2.7	0.012	2.42	14,9	0.065	10.52	67.5	0,295
East Germany	1 76	10,8	0.047	(3.52)[b]	(21 .6)[b]	(0.094)[b]	(3.52+)[d]	(21 .6+)[d]	(0.094+)[d]
Hungary	0	0	0	1 76	10.8	0.047	(2.76)[e]	(16.9)[e]	(0.074)[e]
Poland	0	0	0	0.88	5.4	0.024	4.90	30.1	0.132
Romania	0	0	0	0.66	4.1	0.018	3.96	23.9	0.104
Eastern Europe, total	3.08	18,9	0.083	12.0	73.7	0.320	37.00'	226.9'	0.991[c]

[a] These are estimates assuming a O 7 load factor
[b] This is the German Democratic Republic's 1980 plan quote OTA had no information for 1985 or 1990, and assumed that the GDR plans to fulfill this early VerSlon Of the 1980 plan by ?985, and that more plants are planned in 1990
[c] This is an independent estimate of total nuclear capacity by 1990 The elements in the COlumn add up to 2942 mkWh Some of the remaining unexplained portion must be in the East German plans, and whatever is left apparently represents upward plan revision(s) that have not been published
[d] A~sumes that the German Democratic Republic plans more capacity by 1990 than the plan (guessed) for 1985

SOURCE Office of Technology Assessment

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formation on the plans themselves is incomplete. Several sources indicate that all CMEA countries except the U.S.S.R. plan to have a total nuclear capacity by 1990 of 37,000 MW[24] (see table 57). The available fragmentary 1990 official plan data shows that over the 1986-90 period Czechoslovakia apparently expects to bring on line eight VVER-1000 reactors; Poland, **at a** much earlier **stage** in its nuclear program and therefore less experienced, is planning to add four; and Bulgaria's target calls for the construction of an additional **two.** By 1990 Romania plans to have six Candu reactors in operation, at least three of which will be produced by the Romanians themselves under Canadian license. Romanian expectations for solving both the problems of construction and manufacturing of nuclear reactors in the next decade are especially ambitious. The country first 660-MW reactor is not scheduled for commission until 1985.

Based on past experience, OTA believes that goals for nuclear power development which rest on the timely installation of all of the planned reactors are too optimistic to serve as a best case projection. A realistic best case would assume that some, but not all, of the VVER-1000 reactors are in operation by the end of the decade, and that total capacity reaches about 30,000 MW. This assumes that Poland and Romania each fall 2,000 MW short of their 1980 targets, and that Czechoslovakia falls 3,000 MW below its plans. The scenario is still optimistic in that it assumes no slippage in Bulgarian and Hungarian plans. This best case projection for 1990 is 7,000 MW below the estimates referred to above by East European sources. If there are considerable investment constraints, or if there are significant difficulties in introducing the large VVER-1000 reactors, a worst case for 1990 would be total nuclear capacity of 20,000 M W (see table 68).

Even under best case conditions, nuclear power generation is likely to supply only a small increment to the growth in domestic energy production through the end of the decade. In the best case, production will reach 184 billion kWh in 1990 (0.804 mbdoe or 40 mtoe), accounting for a little over 1 percent of the yearly growth rate in energy production to 1990. If, instead, the worst case obtains, then the 20,000-MW capacity (0.536 mbdoe or 26.7 mtoe) would add 0.6 percent per annum to the growth in energy production over the same period.

It is interesting to compare feasible nuclear and coal production increments to get a sense of the contributions each is likely to make to Eastern Europe's energy supply in the next decade. Total energy production in Eastern Europe in 1979 was 6.737 mbdoe (336 mtoe). Production in 1980 was certainly no higher, due to leveling coal output. Under the best case conditions, nuclear power will add 0.201 mbdoe (10 mtoe), 3 percent of 1979 production, by the year 1985. In the best case coal could contribute more than four times that amount of energy over the same period, 0.86 mbdoe (43 mtoe). The worst case for coal is nearly equivalent to the best case increment to energy supplies from nuclear. Under the best of circumstances, by 1990 nuclear could provide a 0.684-mbdoe (34.1 -

Table 68.—Planned and Projected Nuclear Capacity to 1990 (million barrels per day of oil equivalent)

	1979	1985	1990	1990 (Coal)
Actual	0.119 (out of 6.37 total energy production)			
Plan		0.320	0.991[a]	(6.86)
Best case projection		0.320	0.803	(5.98)
Worst case projection		0.247	0.536	(5.44)

Best case Increment provided by nuclear (1979-90) = 0.684
Worst case increment provided by nuclear (1 979-90) = 0.417
Best case increment provided by coal (1979-90) = 1.36
Worst case Increment provided by coal (1979-90) = ,62

[a] Estimate Using 37000 MW and a load factor of O 7
SOURCE Off Ice of Technology Assessment

[24] Iu. Savenko and M. Samkov, "Cooperation of the Member-Countries of CMEA in the Development of Electric Energy," *Ekonomicheskoye sotrudnichestvo stran-chlenov SEV*, February 1980, p. 52.

mtoe) increment to 1980 total energy production; under the worst case nuclear power in 1990 would provide a 0.417-mbdoe (20.8 - mtoe) increment. Coal, on the other hand, would provide under best conditions 1.36 mbdoe (67.7 mtoe), and under worst conditions an increment of 0.62 mbdoe (30.9 mtoe), by 1990. In sum, even in the best of circumstances, throughout the 1980's nuclear power will provide no more of an increment to domestically produced energy in Eastern Europe than coal.

SOVIET ELECTRICITY EXPORTS TO EASTERN EUROPE

Soviet electricity exports to Eastern Europe have never been large. In 1979 these amounted to 12.6 billion kWh, about 3 percent of Eastern Europe's own electricity production that year. One important constraint on exports of electricity has been the lack of high-voltage transmission lines to link up with the East European system. The previously mentioned 750-kV line running from the Soviet Ukraine to the Hungarian electric power grid near Budapest was the first step in breaking this bottleneck. The Soviets built the portion of the line within their borders, while the Hungarians built the rest with Polish and Czech assistance. At full capacity of 6.4 billion kWh the line will increase Soviet electricity export capacity about 50 percent above 1978 levels.[25] This line accounts for all of the increment to Soviet electric energy export capacity to Eastern Europe in 1978 and 1979.

The transmission network will grow further. When the two jointly built Ukrainian nuclear power stations are operating at full capacity in the latter half of the decade, 20 billion to 22 billion kWh of electricity will be shipped to Eastern Europe through the completed Hungarian line, and two similar lines to Poland and Romania. This will triple present levels of Soviet exports of electricity to Eastern Europe.

In the absence of projections for total electricity production in Eastern Europe in the 1980's, it is difficult to say how large the contribution of imported Soviet electricity will be. An additional 20 billion to 22 billion kWh of electricity would amount to 0.096 mbdoe (4.8 mtoe), or less than 25 percent of the worst case increment to domestic energy supplies coming from nuclear power in the next 10 years. Clearly, the exports of electricity from the Soviet Union will not make a contribution as large as is likely to come from coal and nuclear power development.

OTHER DOMESTIC SOURCES OF ENERGY

Romania is the only significant East European producer of petroleum, supplying most of Eastern Europe's oil and two-thirds of its gas in 1979. However, Romanian output of both oil and gas has been declining since 1977 and it is generally agreed that this trend will continue. Romanian plans call for maintenance of oil production at the 1979 level (0.25 mbd or 12.4 mtoe) and a reduction in natural gas production to 0.51 mbdoe or 25.4 mtoe (down from 0.61 mbdoe or 30.4 mtoe in 1979). Hungary, which produces 0.04 mbd (1.99 mmt) of oil and 0.11 mbdoe (5.48 mtoe) of gas expects to maintain, but not increase, those levels. Poland's natural gas production plans are unknown, but it seems unlikely that output will increase significantly. Therefore, it is realistic to assume that East European hydrocarbon production, which totaled 1.22 mbdoe (60.8 mtoe) in 1979, will probably fall to about 1.10 mbdoe (54.8 mtoe) for the 1980's.

The only remaining East European domestic energy source is hydroelectric power, the contribution of which is small in comparison to coal, nuclear, or even oil and gas. Since plans for hydropower either have not been developed or are not available, it is very difficult to make meaningful predictions. A few hydropower development projects can

[25] Leslie Dienes and Theodore Shabad, The Soviet Energy *System Resource Use and Policies* (Washington, D.C.: V. H. Winston& Sons, 1 979), pp. 239-40.

be identified, however. Two of these–in Bulgaria and Hungary–are aimed at the development of pumped storage capacity to handle peakloads and have evidently received preliminary approval in CMEA.[26] A number of East European nations are also discussing the development of minihydro stations (less than 100 MW) to supply small rural areas. Finally, there are traditional hydroelectric stations under construction in several countries. Overall, however, it does not appear that hydroelectric power can make a major contribution to added domestically produced energy supplies.

CONCLUSIONS

OTA's best and worst case projections of East European energy supply in the 1980's are summarized in table 69, which also shows actual and official energy production in 1979, and present plans where these were available.

Between 1970 and 1979 total East European energy production grew at an annual rate of 2.4 percent.[27] Projections of total energy production in Eastern Europe for 1985 are at best 7.07 mbdoe (352.1 mtoe) and at worst 6.43 mbdoe (320.2 mtoe). The best case figure represents annual growth in energy production of 1.8 percent, while the worst case represents virtual stagnation in production over the 1980-85 period. The 1990 projections range from a best case of 7.88 mbdoe (392.4 mtoe) production, which implies a 2-percent annual growth rate over the decade, to a worst case of 6.89 (343.1 mtoe) mbdoe which implies a growth rate of 0.7 percent.

[26] Bagudin, op. cit., pp. 39-40.

[27] This is a simple compound growth rate, computed from 1980 CIA data.

Table 69.—East European Energy: 1979-90, Plans and Projected Actual Supplies (million barrels per day of oil equivalent)

		1979					1985					1990				
		Coal	Oil	Gas	Electric	Total	Coal	Oil	Gas	Electric[a]	Total	Coal	Oil	Gas	Electric[d]	Total
Bulgaria	Plan[b]	0.11	0.01	0	0.04	0.16	0.15	NA	NA	0,09	NA	0.18	NA	NA	0.12	NA
	Projected (b)[c]	—		—		—	0.15	0.01	0	0.09	0.25	0.18	0.01	0	0.12	031
	Projected (w)[c]	—		—		—	0.12	0.01	0	0.06	0.19	0.15	0.01	0	0.09	0.25
Czechoslovakia	Plan[b]	0.93	0	0.01	0.03	0.97	0.96	NA	NA	0.08	NA	0.99	bd	bd	0.33	NA
	Projected (b)	–		—		—	0.96	0	0.01	0.08	1.05	0.99	0	0.01	0.23	1.23
	Projected (w)	—		—		—	0.93	0	0.01	0.08	1.02	0.96	0	0.01	0.12	1.09
East Germany	Plan[b]	1.06	0	0.05	0.05	1.17	1.16	NA	NA	NA	NA	1.26	NA	NA	NA	NA
	Projected (b)	—		—	—	—	1.15	0	0.05	0.09	1.29	1.26	0	0.05	0.09	1.40
	Projected (w)	—	—	—	—	—	1.06	0	0.05	0.09	1.20	1.15	0	0.05	0.09	1.29
Hungary	Plan[b]	0.14	0.04	0.11	0	0.29	0.18	0.04	0.10	0.05	NA	0.19	0.04	0.10	0.07	0.40
	Projected (b)	—		—		—	0.18	0.04	0.10	0.05	0.37	0.19	0.04	0.10	0.07	0.30
	Projected (w)	—		—		—	0.16	0.04	0.10	0.05	0.35	0.18	0.04	0.10	0.05	0.37
Poland	Plan[b]	2.56	0.01	0.12	0.01	2.70	320	NA	NA	0.03	NA	3.75	NA	NA	0.14	NA
	Projected (b)	—		—	—	—	2.82	0.01	0.12	0.03	2.98	3.06	0.01	0.12	0.09	3.28
	Projected (w)	—		—		—	2.42	0.01	0.12	0.01	2.56	2.60	0.01	0.12	0.03	2.76
Romania	Plan[b]	0.16	0.26	0.61	0.05	2.08	0.44	0.25'	0.51	0.07	1.27	0.49	NA	NA	0.15	NA
	Projected (b)	—		—		—	0.30	0.25	0.51	0.07	1.13	0.40	0.25	0.51	0.10	1.26
	Projected (w)	—	—	—	—	—	0.20	0.25	0.51	0.05	1.01	0.30	0.25	0.51	0.09	1.15
Total	Plan[b]	4.96	0.32	0.90	0.19	6.37	6.09	NA	NA	NA	NA	6.86	NA	NA	NA	NA
	Projected (b)	—		—		—	5.56	0.31	0.79	0.41	7.07	6.08	0.31	0.79	0.70	7.88
	Projected (w)	—		—		—	4.89	0.31	0.79	0.34	6.43	5.34	0.31	0.79	0.45	6.89

NA = not available
[a] This includes electricity produced in 1979, plus the planned Increment from nuclear PowerPlants
[b] The 1979 figures are actual production
[c] Projected (b) IS best projected case, Projected (w) IS worst projected case
[d] This includes electticity produced in 1979 and the Increment planned from nuclear power through 1990

SOURCE Off Ice of Technology Assessment

The results of this analysis suggest that Eastern Europe's plans for domestic energy supplies in the 1980's are overly optimistic. The plans assume that growth in energy production can be maintained at levels attained in the last decade—an assumption which seems unjustified. While there are no data available on total planned energy output in Eastern Europe in 1985, it is reasonable to assume that planners' expectations for energy production resemble OTA best case projections for all fuel sources except coal, where their plans show much higher production levels. The implied plan for 1985 is 7.6 mbdoe (378.4 mtoe) total energy production, an annual growth of 3 percent over 1979; for 1990 the plan is 8.66 mbdoe (431.2 mtoe) or 2.8 percent per annum growth rate over the 1979-90 period. These growth rates are higher than those actually achieved in the last decade, and probably unattainable. It would be more reasonable to assume that, at best, East European energy production will grow at 1.8 percent, and at worst at less than 1 percent yearly.

EAST EUROPEAN ENERGY DEMAND IN THE 1980'S

In the last 15 years, energy consumption in Eastern Europe has grown at approximately 4 percent per year, while production has been growing at about 2.5 percent per year. The difference has been met with Soviet oil. This situation cannot continue. As previously noted, the U.S.S.R. has announced that henceforth it intends to maintain its oil exports to Eastern Europe at 1980 levels. Thus, even maintaining the status quo would involve East European countries' increasing imports of OPEC oil at world market prices. As the analysis in the previous section has shown, even under the best of circumstances the growth rate of East European energy production in the 1980's will be no more than 2 percent, and under worst case conditions the growth rate might fall below 1 percent. These statistics underline the importance of efforts to moderate growth in energy consumption in the years ahead.

A critical determinant of the growth of energy demand in any country is the production of goods and services, as measured by GNP. One indicator of the relationship between GNP and energy is energy/GNP elasticity, i.e., the percentage change in the consumption of energy divided by the percentage change in GNP. Table 70 summarizes estimates of historical trends in energy/GNP elasticity for Eastern Europe. A coefficient (an indicator of energy/GNP elasticity) of "1" for a given period means that when GNP has grown by 1 percent, average energy consumption has grown by a like amount.

Table 70.— Energy GNP Elasticities in Eastern Europe: Past Trends and Future Projections

	1965-78	1974-78	1981-90 (projection)
Bulgaria	1.79	1.50	1.65
Czechoslovakia	1.06	2.34	1.00
East Germany	,76	.79	.75
Hungary	1.20	1.34	100
Poland	1.01	1,29	1,00
Romania	1,34	1,10	1.21
Total - Eastern Europe[b]	109	1.28	1,00

[a]None of these elasticities is significantly different from the elasticity for the entire 1965-78 period

[b]Weighted average from a regression for all of Eastern Europe

SOURCE All the elasticities are from the equation

$$\log(C_1 e) - a_1 + b_1 \log(DUM) + c_i \log(GNP) + d_i \log(DUM) - \log(GNP)$$

where C_i^e - consumption of energy in the ith country

GNP_i GNP of the ith country

DUM a dummy variable -1 through 1973 and e for 1974-78

For a discussion of the econometric technique used here see Edward A Hewett, "Alternative Econometric Approaches for Studying the Link Between Economic Systems and Economic Outcomes *Journal of Comparative Economics. 4 (1980)* pp 274-290

Several important conclusions can be drawn from table 70. First and most important, the energy/GNP relationship has been above "1" for each covered period for every Eastern European nation except East Germany. For the six countries together, between 1965 and 1978 a l-percent increase in GNP was associated with a 1.12-percent increase in energy consumption.

Secondly, the figures for the brief 1974-78 interval show no statistically significant differences from the elasticity for the entire period, although clearly the trend was for elasticities to *increase* during this period. There is no evidence that frequent public statements on energy conservation in Eastern Europe have had any tangible effect. On the other hand, one should not place a great deal of weight on the 1974-78 elasticities. The sample period is quite short, and the fact that there is no statistically significant difference between these estimates and those for 1965-78 indicates high variability in energy/GNP elasticities. Hence these 1974-78 coefficients are averages of a broad range of numbers,

Third, there is evidence that levels of economic development influence the energy/GNP elasticity. In countries such as Bulgaria and Romania where industrialization is occurring at a fairly rapid pace, energy/GNP elasticity is high. East Germany and Czechoslovakia, on the other hand, have lower energy/GNP coefficients. This suggests that the elasticities may fall over time as development proceeds.

East European leaders have become increasingly concerned with energy/GNP elasticity, and their concern has been enhanced both by recognition of the costs involved in expanding domestic energy production and awareness of the U.S.S.R.'s intentions not to increase its energy exports. Not surprisingly, therefore, discussions of conservation as the least expensive policy for avoiding a full-fledged energy crisis are becoming increasingly frequent,[28] and a variety of energy conservation measures are now being contemplated or employed. The most important of these include the following:

1. reducing the proportion of energy-intensive products in total output;
2. development and installation of energy-saving machinery in energy-intensive sectors, including efforts to recapture heat lost in power stations;
3. introduction of various administrative regulations designed to control household and industrial energy demand; and
4. increasing prices to cut energy use throughout the economy, including in the household sector.

These efforts appear to have had little effect so far on the energy/GNP ratio. Slowdowns in the growth of energy consumption in Eastern Europe in the late 1970's were due to slowdowns in production, not to conservation. Now, as concern about energy supply increases, energy conservation is being taken more seriously. Soviet leaders have also apparently urged their East European counterparts to adopt conservation measures, particularly those aimed at restructuring GNP and modernizing capital stock in energy-intensive industries.

These policies may have some effect, but it is doubtful whether they will seriously reduce energy/GNP elasticity. Excess use of energy in Eastern Europe is a manifestation of a general pattern of excess use of all industrial materials. The situation is similar to that in the U. S. S. R.: traditionally, economic institutions have emphasized high output growth rates over economizing on inputs to the production process. In most cases, East European leaders are attempting to deal with the energy crisis by using the same administrative techniques they have relied on in the past. In 1979 and 1980, for example, East European countries introduced special plan targets designed to reduce energy use by industry, with penalties for noncompliance. However, this consumption target is only one of a variety of targets which enterprise managers must consider. Often managers give preference to the fulfillment of production tasks rather than to rationalization measures. For example, a survey in East Germany, a country which has been fairly successful in controlling energy demand, showed that one-third of all enter-

[28] Gzovskiy, op. cit.

prises simply ignored their energy -economizing targets.[29]

Enterprises will probably avoid energy conservation until they are forced to do otherwise. Administrative measures have limited impacts since enterprise managers know a number of ways to get around them. The only effective method of introducing conservation may be to weave energy conservation into a package of comprehensive economic reform. This is presently being attempted in Hungary. If the Hungarian experiment proves successful, it may suggest a promising approach for other countries.[30]

Overall, it appears unlikely that the energy/GNP coefficient will fall sharply in the absence of economic reforms. As the industrialization drives in Romania and Bulgaria slow, coefficients for those countries could fall slightly, but Hungary is the only country in which the energy/GNP elasticity may fall significantly, Assuming no other major economic reforms, it is reasonable to expect that during the next decade the energy/GNP coefficient for all of Eastern Europe will fall from 1.09 to 1.00, if Hungary is able to achieve relatively higher levels of conservation (see table 70).

In order to make energy demand projections based on energy/GNP elasticity, it is necessary to consider likely developments in economic growth. Analyzing the prospects for East European GNP is complicated by two problems. First there are no reliable GNP projections for Eastern Europe. Second, it is possible that tight energy supplies may constrain GNP in the 1980's, reversing the situation of the last decade. This would occur if the supply projections developed in the last section result in import and balance of payments problems which force East

Table 71 .—Energy Demand Projections for Eastern Europe, 1985 and 1990 (million barrels per day of oil equivalent)

	1979 energy consumpton	1985 energy consumption		1990 energy consumptlon	
		High	Low	High	Low
Bulgaria	0.65	0.80	072	093	079
Czechoslovakia	1.59	1,77	1 68	2.08	1 75
East Germany.	1.74	1.97	185	2.18	196
Hungary	060	071	065	0.81	070
Poland	238	2,86	262	333	2.83
Romania.	139	2.00	1.68	268	1.96
Eastern Europe, Total	8.35	10.10	920	1201	9.99

SOURCE The 1979 figures are an estimate based on 1978 figures the energy/GNP elasticities in table 70, and 1979 GNP growth rates reported by CIA for each East European country The 1985 and 1990 projections are derived by applying the high and low GNP growth rates assumed for 1981.90, and the assumed energy demand elasticities to estimated energy consumption in 1979 For example the figure for the high case for Bulgaria in 1985 is derived as 21 percent x 165 = 3465, which is the estimated per annum growth rate of energy con sumption 1.03456' x 0.65 = 0.80 mbdoe

European countries to curtail imports and GNP. With these caveats in mind, OTA has attempted projections of likely rates of economic growth in the next 10 years without considering a feedback from energy constraints.

During the *1970's,* GNP growth rates in Eastern Europe declined from about 5 percent to less than half that figure. Although the reasons for this are multifarious and complex, the energy crisis exacerbated already existing problems by putting tremendous pressure on Eastern Europe's balance of payments. OTA here assumes as a best case that Eastern Europe will be able somehow to maintain the levels of growth achieved for the latter half of the 1970's (2.9 percent per year) in the next decade. A worst case would involve growth at half of this rate—i.e., rates of GNP for 1981-90 of 1.5 percent. These GNP projections, combined with the energy/GNP elasticity projections above, yield the energy demand projections in table 71. The final section of this analysis combines these demand projections with the supply projections developed above. The result is a projection of Eastern Europe's energy import needs in the next decade.

[29] Szocs, op. cit.

[30] Edward A. Hewett, "The Hungarian Economy: Lessons of the 1970's and Prospects for the 1980's," in Joint Economic Committee, U.S. Congress, *East European Economic Assessment* (Washington, D.C.: U.S. Government Printing Office, 1981).

EAST EUROPEAN ENERGY IMPORTS IN THE 1980'S: IMPLICATIONS FOR TRADE WITH THE SOVIET UNION AND THE REST OF THE WORLD

IMPORT NEEDS: BEST, WORST, AND MIDDLE CASES

Combining projections of domestic production and energy demand can yield a reasonable estimate of energy import needs for the next decade. Table 72 summarizes these estimates, and outlines best, worst, and middle cases for net imports in the 1980's. The worst cases for both 1985 and 1990 assume that energy consumption continues to grow at a high rate, while simultaneously domestic energy production follows the worst case in table 69. The best case is based on the lowest projections for growth in energy consumption and the highest for production. One middle case is also identified. This assumes that while energy consumption grows at a high rate, the six East European nations are successful in attaining the best case energy production projections.

Table 72 posits a best case in which Eastern Europe maintains a stable net import/energy consumption ratio throughout the 1980's. This outcome is not impossible, although it is based on the assumption that everything goes well for Eastern Europe; i.e., demand grows slowly and production increases at best case rates. Under these conditions, which are certainly less optimistic on the production side than those outlined in the official plans, net imports for the six Eastern European countries together will actually fall from about 24 percent of all energy consumed in 1979 to about 21 percent in 1990.

The worst case is dramatically different. Under worst case conditions even Poland becomes an importer of energy and by 1990 Eastern Europe as a whole will import 43 percent of all the energy it uses. For all countries except Poland, the net import/consumption ratio is even higher by 1990—52 percent. Like the best case, this is a possible outcome. It is conceivable that energy production will grow slowly while energy conservation programs fail to have significant impacts.

The middle case, which is probably the most likely, assumes favorable develop-

Table 72.—Projected Energy Consumption and Production in Eastern Europe, 1985 and 1990 (million barrels per day of oil equivalent)

	1979 actual			1985 projected							1990 Projected						
	Con-sump-tion	Pro-duc-tion	Net Imp.	Consump-tion High	Consump-tion Low	Produc-tion Worst	Produc-tion Best	Net Imp.[a] Worst	Net Imp.[a] Mid	Net Imp.[a] Best	Consump-tion High	Consump-tion Low	Produc-tion Worst	Produc-tion Best	Net Imp.[a] Worst	Net Imp.[a] Mid	Net Imp.[a] Best
Bulgaria	0.65	0.16	0.49	0.79	0.72	0.19	0.25	0,60	0.54	0.47	0.93	0.79	0.25	0.31	0.68	0.62	0.48
Czechoslovakia	1.59	0.97	0.62	1,77	1,68	1.02	1.05	0,75	0.72	0.63	2,08	1.75	1.09	1,23	0.99	0.85	0,52
East Germany	1.74	1,17	0.57	1,97	1,85	1,20	1.29	0,77	0.68	0.56	2,18	1.96	1.29	1.40	0.89	0.78	0.56
Hungary	0.60	0.29	0.31	0.71	0.65	0,35	0.37	0.36	0.34	0.28	0,81	0.70	0.37	0.40	0.44	0.41	0.30
Poland	2.38	2,70	-0320	2.86	2.62	2.56	2,98	0.30	-0.12	-0.36b	3.33	2.83	2.76	3.28	0.57	0.05	-0,45
Romania	1.39	1,08	0.31	2.00	1.68	1.01	1.13	0.99	0,87	0,58	2.68	1.96	1.15	1.26	1.53	1.42	0.70
East Europe, Total	8.35	6.37	1.98	10.10	9.20	6.43	7.07	3,77	3.03	2.16	12,01	9.99	6.89	7.88	5.12	4.13	2.11

[a] The worst case is when consumption is 'high and production is worst Thus for Bulgaria in 1975, the worst case ISO 79-019 = O 60 mbdoe The mid (middle) case is when consumption is high and production is 'best The best case is when consumption is low and production is best

[b] Indicates net energy exports

SOURCE Office of Technology Assessment Actual 1979 consumption data are estimated by multiplying the 1978 Consumption data by actual 1979 GNP growth rates, and those by the elasticities in table 70 ments in energy production, combined with high-GNP growth rates. This case assumes that for political reasons East European planners will place high priority on attempting to maintain relatively high economic growth rates, hence acceptable growth rates for personal consumption.

SOVIET ENERGY EXPORTS TO EASTERN EUROPE

Thus far, this chapter has approached the question of East European energy in the 1980's from the perspective of the East European planners themselves. But Eastern Europe's energy future rests heavily on the actions of the Soviet Union. The amount of energy that the Soviet Union is willing to export to Eastern Europe for transferable rubles will to a large extent determine the amounts which Eastern Europe will be forced to buy on world markets–at world prices, for hard currency.

In order to make precise projections here, one would have to know the intentions and capabilities of the Soviet Union regarding energy exports to Eastern Europe. All that is known about Soviet intentions is embodied in several statements by the late Premier Kosygin, indicating that energy exports to all CMEA countries will be about 20 percent more in the 1981-85 period than they were in the 1976-80 period, and that crude oil exports to CMEA during the first half of the decade will total 400 million tons.[31] If these statements are accurate, the Soviet Union will export about 117.98 mtoe (about 2.36 mbdoe) of energy annually between 1981-85 to Eastern Europe. This is a substantial *cut in increments* to energy exports as compared to the situation in the last decade. Table 73 summarizes plans for Soviet energy exports to CMEA.

Table 74 combines estimates and projections of Eastern Europe's net energy imports in 1979, 1985, and 1990, with estimates and projections of Soviet energy exports to Eastern Europe in those years. The table shows that in 1979 Eastern Europe as **a** whole was a slight net exporter of energy to the world outside the Soviet Union. This was due to Poland's imports of energy from the Soviet Union and simultaneous exports of coal to the rest of the world. The other East European countries were able to cover most of their needs with Soviet energy, except for Romania, which had significant imports from outside CMEA.

If the *best case* obtains, Eastern Europe will be able overall, and in each individual case, to cover virtually all of its net energy needs with imports from the Soviet Union. Overall, Eastern Europe would remain a slight net exporter of energy to the rest of the world. If the *worst case* should occur, by 1985 Eastern Europe will switch from being a small net energy exporter to a net importer of 1.41 mbdoe (70.2 mtoe); by 1990 imports would reach 2.74 mbdoe (137 mtoe). Even in

Table 73.—Soviet Energy Exports to CMEA, Actual in 1976-80, and Planned for 1981.85

	1976-80 (estImates)[c]		1981-85 plan	
	Natural[a]	Mtoe	Natural[a]	Mtoe
Natural gas.	97.8	80.1	152.4[d]	124.8[d]
Crude Oil, ...	370.4	370.4	400.0[e]	400.0[e]
Oil products.	55.0	55.8	64.4[i]	65.3[i]
Electricity	55.6	19.5	80.0[h]	28.0[g]
Coal and coke[b].	41.0	28.1	41.0[g]	28.1[g]
Total	—	553.9	–	646.2[f]
Eastern Europe . . .	—	501.2	[j] —	589.9[k]

[a]Natural unlts of measure bcm for natural gas metric tons for crude oil. Oil products coal and coke and bkWh for electricity
[b]These figures are net of East Europe s coal exports to the Soviet Unlon
[c]Each of these figures cnclude estimates for 1980 as well as earner years in some cases The hydrocarbon exports are from tables 1 and 2 Electricity exports are given in table 11 For coal and coke the assumption is that 1976-80 exports remained at the 1976 level since value data suggest that this trade is quite stable
[d]Assumes 1980 levels of Soviet **gas** exports through 1985 since Orenburg was at full capacity in 1980
[e]Statement by Premier Kosygln, 1979
[f]Kosygin in 1980 stated that energy exports to Eastern Europe from the Soviet Union will rise 20 percent in 1981.85 over 1976-80, and he gives the figures for 1976-80 Those figures which equal 538.5 mtoe, multiplied by 0.12 yield the 6462 mtoe for 1981-85 Note that Kosygin's preliminary figures were apparently low
[g]Assumes 1976-80 delivery levels will be maintained
[h]Assumes 1979-80 levels is of electricity exports and **that Khmel nitska nuclear** powerplant begins full shipments in 1984 (Optimisic)
I This is a residu al obtained by subtracting al l other elements from the total derived from Kosygin statement
j T his subtracts the 52 7 mtoe of 011 and products shipped to Cuba V ietnam and Mongolia
k Assumes that 563 mtoe of 011 and products will be shipped to Vietnam Cuba and Mongolia during 1981-85 which is 5 x the 1980 level

SOURCE Off Ice of Technology Assessment

[31] A.N. Kosygin, "Speech of the Head of the Delegation of the Union of Soviet Socialist Republics, Comrade A. N. Kosygin," *Ekonomicheskoye sotrudnichestvo stran-chlenol SEV,* April 1980, p. 30.

Table 74.—East European Projected Net Energy Imports, 1985 and 1990: Total, From the Soviet Union, and From the Rest of the World (million barrels per day of oil equivalent)

	1979 actual			1985 projected							1990 projected						
				Total				Net from ROW[a]			Total				Net from ROW[a]		
	Total	From U.S.S.R.	Net from ROW[a]	Worst	Mid	Best	From U.S.S.R.	Worst	Mid	Best	Worst	Mid	Best	From U.S.S.R.[b]	Worst	Mid	Best
Bulgaria.	0.49	0.45	0.05	0.60	0.54	0.47	0.49	0.13	0,05	-002	0.68	0,62	0.48	0.49	0.19	0.13	-0.01
Czechoslovakia. . .	0.62	0.53	0.09	0.75	0.72	0.63	0.57	0.18	0,15	0.06	0.99	0.85	0.52	0,57	0.42	0,28	-0.05
East Germany	0.57	0.51	0.06	0.77	0.68	0.56	0.55	0.22	0.13	0.01	0.89	0.78	0.56	0,55	0.34	0,23	0.01
Hungary	0.31	0.30	0,01	0.36	0.34	0.28	0,36	0	-0.02	-008	0.44	0.41	0.30	0.36	0.08	0.05	-006
Poland	-032	0.22	-054	0.30	-012	-0.36	0.30	0	-042	-066	0,57	0,05	-0.45	0,30	0.27	-0,25	-075
Romania	0.31	0.05	0.26	0.99	0.87	0.58	0,09	0.90	0.78	0,49	1.53	1.42	0.70	0.09	1.44	1.33	0.61
Eastern Europe, total	1.98	2.06	-008	3,77	3.03	2.16	2,36	1,41	0.67	0.20	5,10	4.13	2.11	2.36	2.74	1.77	0,25

[a]Net Imports from the rest of the world, derived by subtracting the imports from the U S S R from 1979 actual in the case of 1979, and for the projections, by subtracting Imports from the U S S R from the worst medium and best cases Thus the worst case for East German net Imports from the rest of the world in 1985 equals their worst case net imports from all sources (0.77) minus net imports from the U.S.S.R. (0.55) - 022
b There are no public Commitments for Soviet energy shipments to Eastern Europe after 1985 This assumes the same commitments made for the 1981-85 period

SOURCE Off Ice of Technology Assessment

the worst case, Hungary and Poland would be able to cover their energy needs with Soviet imports. However, Bulgaria, Czechoslovakia, East Germany, and Romania would be forced onto world markets to purchase substantial amounts of energy. Energy imports would surely be in the form of oil or gas, the most easily transported fuels. The *middle* ***case*** projects net energy imports to Eastern Europe from the rest of the world at 0.67 mbdoe (33.4 mtoe) in 1985, and 1.77 mbdoe (88.1 mtoe) in 1990. In the middle case, Poland remains a net energy exporter, and Hungary exports a small amount (0.02 mbdoe or 1.0 mtoe) to the rest of the world. Romania accounts for two-thirds of all net imports in the middle case.[32]

It is possible, although unlikely, that Polish energy production will fall below OTA's worst case projections. Should that occur, it will probably be accompanied by a general economic slowdown which will also cause a reduction in Polish energy demand below the low case. Because of this connection between energy supplies and energy demands, OTA's forecasts of energy balances in Poland (and Eastern Europe) are less sensitive to unforeseen events than are either the production or demand forecasts by themselves. Therefore, even in light of recent events in Poland, OTA regards these balances as a realistic view of the range of possible outcomes in 1985 and 1990.

HARD CURRENCY REQUIREMENTS

In order to evaluate the feasibility of any of these outcomes, it is important to ascertain whether the foreign exchange burden implied by a projection can actually be handled by the East European nations, given their export capacities and their abilities to absorb new debt.

Table 75 shows Eastern Europe's hard currency debt in 1979, and projections of the hard currency requirements for 1985 and 1990 based on the energy import levels

[32]The only other comparable estimates have been done by Jan Various with results strikingly similar to OTA's projections. Various estimates that in 1985 Eastern Europe will be buying from the Middle Eastern suppliers at worst 1.23 mbdoe (OTA's projection is 1.41), and as a medium projection 0.88 mbdoe (0.67 in the OTA projection). See Various, op. cit.

Table 75.—Projected Hard Currency Burden on Eastern Europe of Various Projected Net Imports of Energy, 1985 and 1990 (millions of dollars)

	Net Hard currency debt 1979	Hard currency exports (dev. countries)	Net oil Imports at $30/barrel 1985 Best	1985 Medium	1985 Worst	1990 Best	1990 Medium	1990 Worst
Bulgaria	3.73	1.29	-0.22	0.55	1.42	-0.11	1.42	2.08
Czechoslovakia	3.07	2.85	0.66	1.64	1.97	-0.55	3.07	4.60
East Germany	844	4.10	0.11	1.42	2.41	011	2.52	3.72
Hungary	7.32	2.64	-0.88	-0.22	0	-066	0.55	0.87
Poland	20.00	5.04	-7.28	-4.60	0	-8.21	-2.74	2.96
Romania	6.70	3.45	5.37	8.54	9,86	6.68	14.56	15.77
Eastern Europe, total	49.23	19.37	-2.24	7.34	15.66	-2.74	19.38	30.00

SOURCE Office of Technology Assessment

outlined above at 1980 oil prices ($30/barrel). These data provide a very conservative estimate of the hard currency burden implied in each of the three cases, since the world market price of oil may rise faster than the value of Eastern Europe's exports in the next 10 years.

The best *case* is a possible scenario for Eastern Europe as a whole and for each country. It is, however, rather implausible, since it assumes that per capita consumption growth rates will stagnate. The *worst case* would impose extreme difficulties, both for Eastern Europe overall, and for each individual country with the possible exception of Hungary. If the worst case actually occurred, Romania would be spending three times its 1979 dollar exports for energy imports. Bulgaria, Czechoslovakia, and East Germany would all be forced to significantly increase their debts. For all of these countries, the 1990 worst case is even more unattractive. Hungary appears to be the only country which might be able to surmount the worst case with no critical difficulty.

The worst case should therefore not be viewed as a feasible outcome. The nations of Eastern Europe have neither the export reserves nor the borrowing capacity to handle such hard currency problems. If the conditions underlying this case actually begin to develop, a number of factors are likely to intervene and prevent its fulfillment. In the short run, growth rates would fall sharply if hard currency constraints hold back imports of energy and other inputs. Stagnating production, which would accompany such a situation, would create political tensions over declining living standards, and perhaps even rekindle discussion of significant economic reforms. Under such conditions, the Soviet Union would surely participate in all decisions, and might choose to alleviate part of the crisis by increasing energy exports (particularly natural gas). Soviet preoccupation with a politically stable Eastern Europe would probably stimulate the U.S.S.R.'s assistance if worst case conditions developed. The other eventuality which might redirect a worst case scenario would be the introduction of significant economic reforms aimed at reducing energy demand, and increasing production of manufactured goods which could be exported for hard currency. This would not be an easy road, nor one that the East European nations are likely to freely choose. In a worst case situation, however, there might be no alternative.

The *middle,* and probably most likely, case is closer to the worst outcome than to the best. It suggests that in 1985 an amount equal to 38 percent of Eastern Europe's 1979 hard currency export proceeds will be required for the purchase of oil, and that all of the amount of 1979 export sales will be necessary to cover oil imports in the year

1990. In this case, Hungary would be under no apparent pressure and Poland would be much better off than it is likely to be in the worst case. The pressure would be greatest on Romania, which would spend more than double its hard currency export proceeds on oil imports, and on Czechoslovakia, which would be spending more than half. The pressure would be comparatively strong on Bulgaria and East Germany as well, but neither of these nations would face such strong hard currency constraints as Romania and Czechoslovakia.

If, as is likely, hard currency burdens in the middle case are actually greater than is indicated by table 74 because of rapidly rising oil prices, then Bulgaria, Czechoslovakia and East Germany would all face added pressure. If these countries are forced to spend more than half their hard currency exports on oil, they will be less able to import the machinery and industrial materials necessary to expand output. If the medium case actually transpires, there will be pressure on the Soviet Union to increase energy exports. In the absence of such assistance from the Soviet Union, pressure for economic reform within Eastern Europe, as well as growing difficulties in the East European-Soviet energy relationship, will likely result.

This analysis suggests that most East European nations can make it through the 1980's without major crisis, if their domestic energy production develops according to the best case, and if the Soviet Union will continue to provide them heavily subsidized energy shipments at the quantities promised in the early 1980 's. Should an energy crisis in the Soviet Union cause a cutback in Soviet energy exports, or should Eastern Europe's energy production stagnate along worst case lines, there will be serious difficulties.

SUMMARY AND CONCLUSIONS

A review of Eastern Europe's energy options in the 1980's suggests the following conclusions: First, there is a wide disparity in the energy situations of various East European nations. Eastern Europe's natural resources are concentrated largely in Poland and Romania. Some nations such as Romania appear quite likely to encounter difficulties associated with requirements for additional imports of energy in the decade ahead, as domestic supplies are depleted; others such as Hungary may be capable of withstanding even worst case developments, Thus, while this chapter has treated Eastern Europe as a region, there are good reasons to watch the developments in individual nations. For example, a continuing and severe Polish crisis might strain domestic energy production for the region as a whole.

Second, and even more important, is the crucial position of the Soviet Union as an energy supplier to Eastern Europe. East European economic development has been significantly assisted by the subsidization of its oil imports from the Soviet Union. If this subsidy were abruptly removed, the negative impacts would be serious. While it is unlikely that the Soviet Union will opt to quickly end the subsidy, the transition from oil to gas exports in itself embodies a decisive change, since the U.S.S.R. is selling its gas to CMEA at world market prices.

An energy crisis in the Soviet Union would seriously impact the nations of Eastern Europe. If, for some reason, the U.S.S.R. decisively reduced its energy exports to the CMEA-6, these nations would be faced with a difficult set of choices. Hard currency constraints would preclude massive purchases of oil on the international market, but demand-reduction measures might be politically problematic.

While it is true that Eastern Europe as a region is much less dependent on imported energy than is Western Europe, there are a variety of additional constraints which bound the energy options available to

CMEA planners. With limited prospects for increased energy production, and with relatively energy-intensive economies, Soviet energy exports occupy a critical position in the energy situations of these countries. Regardless of whether best, worst, or middle cases actually transpire, East European energy plans and strategies will be significantly affected by those of the U.S.S.R.