ANALYSIS OF ENERGY RESOURCES AND PROGRAMS OF THE SOVIET UNION AND EASTERN EUROPE. APPENDIX A: FRAMEWORK OF ENERGY SUPPLY AND DEMAND

George D. Hopkins, et al

Stanford Research Institute

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Appendix A: Framework of Energy Supply and Demand

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ANALYSIS OF ENERGY RESOURCES AND PROGRAMS OF THE SOVIET UNION AND EASTERN EUROPE

Appendix A: Framework of Energy Supply and Demand

George D. Hopkins
Nick Korens
Dr. Richard A. Schmidt
Carl A. Trexel, Jr.

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Principal Investigator: George Hopkins
Phone: 415 326-6200, X-2685

Project Engineer: John M. Trossbach, Jr., Capt
Phone: 315 330-2344

Contract Engineer: Francis L. Karlin, Capt
Phone: 315 330-2719

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The objective of this study was to conduct an analysis of the energy resources and programs of the Soviet Union and Eastern Europe and their relationship to the rest of the world. A survey was made of energy development technology which included exploration, development, production, distribution, storage and utilization of energy and new forms of energy. Also, an appraisal was made of recent resource recovery and research and development of energy conversion technology, distribution, and utilization (Over)

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efficiency. The economic aspects of energy developments and use were discussed as related to patterns of consumption, trade, and the Gross National Product of the Soviet Union and Eastern European countries. The overall energy supply and demands of these countries were projected to the 1980 and 1990 time frames. Finally an analysis was made of the Soviet political/military/energy strategy policies relative to the economic impact on Eastern and Western Europe.

This appendix presents detailed information on the economic base, relation of economic growth and energy demand, and energy demand by type of energy of the Soviet Union and Eastern Europe.

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ILLUSTRATIONS

TABLES

I INTRODUCTION

This appendix presents detailed information for the USSR and each of the six other CMEA countries in Eastern Europe on:

- The economic base
- Relation of economic growth and energy demand
- Energy demand by type of energy.

For the USSR, energy demand is also presented on an end use basis. The use sectors considered include:

- Residential
- Commercial
- Industrial
- Electric power
- Transportation
- Agriculture
- Military

The 1960-71 period was generally used as the historical data base for the overall analysis. Projections are made to 1990, with estimates also given for 1975, 1980, and 1985.

Energy supply and demand balances have been developed for the USSR and each of the six CMEA countries by type of energy. Some of the topics presented are: short term and long term implications of trade in energy materials; the basic information sources and estimating procedures used to develop the historical data; a general description of the methodology used in making the projections; and further significant changes that have occurred and those that are expected to occur in energy use.

The projections given in this appendix are based on the assumption that consumption patterns of energy--in terms of total use as well as by type of fuel--will continue to follow historical trends, and that

adequate supplies of each fuel will be available. To the extent that any one energy resource--such as natural gas, for example--may be in short supply for some interim period, this will be noted, and possible substitution by other fuels will be discussed.

II ECONOMIC FRAMEWORK

A. Historical Period 1960-1970

The USSR and the CMEA countries--Bulgaria, Czechoslovakia, German Democratic Republic (East Germany), Hungary, Poland, Romania--have been undergoing a rapid growth in their economies. This is reflected by a rising

- Gross national product (GNP)
- Primary energy consumption
- Electric power production

During the period 1960-1970 the population of the countries grew at significantly lower rates and in one case, East Germany, the population actually decreased. Table A-1 shows GNP, primary energy consumption, and population for 1970 by country. As shown, the USSR produced $314,209 million dollars of GNP in 1970, which is approximately 2.3 times the combined GNP of the other East European CMEA countries. The population of USSR in 1970 was 242,768,000, which was also approximately 2.3 times the combined population of the Eastern Bloc, giving per capita GNP of approximately $1,300 for both the USSR and Eastern Bloc countries. Of the latter, Czechoslovakia and East Germany had the highest per capita GNP at $1,826 and $1,726 respectively, and Romania had the lowest at $932.

On a growth rate basis, the GNP of USSR has been growing at a substantial 6.7 percent/year and at the same time, the GNP of the Eastern Bloc countries has been growing at 5.6 percent/year. Within the Eastern Bloc, Czechoslovakia and Eastern Germany, with more highly developed economic bases, have been growing at approximately 4.5 percent/year, and Romania, with a lower base, at 8.0 percent/year.

The population of the USSR has been growing approximately 1.3 percent/year and that of the Eastern Bloc at a stable 0.6 percent/year. The importance of the industrial sector of the USSR is emphasized in

Table A-1

COMPARISON OF THE USSR AND EASTERN BLOC--GNP, PRIMARY ENERGY, POPULATION, AND PER CAPITA VALUES
(1970)

Region	GNP			Primary Energy			Population	
	Million 1970 Dollars*	Growth %/Year (1970/1960)	Per Capita (1970 dollars)	Thousand TCE†	Growth (%/year 1970/1960)	Tons per Capita	Thousands*	Growth %/Year (1970/1960)
USSR	311,209	6.7	1,294	994,078	5.7	4.09	242,768	1.3
Bulgaria	9,508	7.3	1,120	29,831	12.3	3.51	8,190	0.5
Czechoslovakia	27,214	4.5	1,881	77,176	3.5	5.33	14,467	0.5
German Democratic Republic	29,120	4.4	1,725	120,115	2.3	7.01	17,050	-0.1
Hungary	12,486	5.2	1,209	27,895	1.8	2.70	10,331	0.3
Poland	39,539	8.1	1,218	118,301	4.7	3.64	32,470	0.9
Romania	18,867	8.0	932	17,398	5.7	2.34	20,253	1.0
Eastern Bloc	137,034	5.6	1,330	420,716	4.5	3.91	103,061	0.6

* Source: UN Year Book of Statistical Accounts, 1971.

† Source: Stanford Research Institute.

Table A-2, which shows the 1970 output of the various reported components of GNP in the USSR. We note that the industrial sector of USSR produced $160,875 million dollars in 1970 which is larger than the entire GNP output of Eastern Bloc countries. Furthermore, this sector is growing at a very healthy 9 percent/year. As we will see later, the size and growth rates of this sector dominate the energy picture in the communist countries.

Table A-2

IMPORTANCE OF INDUSTRIAL SECTOR IN THE USSR
(1970)

Economic Sectors*	Million U.S. Dollars	Percent of GNP	Growth Rate (%/year 1970/1960)
Agriculture, hunting, forestry, and fishing	$68,497	21.8%	1.6%
Industrial activity†	160,875	51.2	9.5
Wholesale and retail trade, and restaurants and other eating places	20,109	6.4	4.6
Construction	32,363	10.3	5.7
Transportation, storage, and communication	16,967	5.4	7.7
Other activities in the material sphere	15,396	4.9	-
	$314,207	100.0%	6.7

* Source: Stanford Research Institute.

† Source: UN Statistical Year Book.

To put numbers in perspective, the percent GNP output of Eastern Bloc countries and the USSR are as follows:

	Percent	Millions of U.S. Dollars
Eastern Bloc	30.4%	$137,034
USSR Industrial	35.6	160,875
USSR Non-industrial	34.0	153,334
Total	100.0%	$451.243

The primary energy consumption which is the sum of coal equivalent consumption of oil, gas, solid fuels including coal, hydroelectric energy, and nuclear power, shows a remarkedly similar pattern to GNP. The USSR consumed 994,049 thousand tons of coal equivalent (TTCE) in 1970, which is 2.3 times the consumption of energy in the entire Eastern Bloc. The per capita values for the Eastern Bloc and the USSR are essentially the same at 4.09 and 3.90 tons/capita, respectively. The USSR growth rate in primary energy consumption was 5.7 percent/year, against the Eastern Bloc countries' growth in consumption rate of 4.5 percent/year. A comparison of the energy consumption in the industrial sector of USSR shows that industry in the USSR consumes 412,800 TTCE, which again is larger than the consumption of the entire Eastern Bloc.

The data source on population is the "U.N. Demographic Yearbook;" the GNP is "U.N. Year Book of Statistical Accounts, 1971." GNP values are given on the basis of constant 1970 dollars and are converted at market prices--a conversion that is different than official conversion rate on Communist currencies. For this and other reasons, the GNP values should be viewed as approximate and reflecting trends and order of magnitude rather than exact values. The primary energy consumption was derived from U.N. statistics.

During the period 1960 to 1970, the Eastern Bloc countries experienced considerable political unrest as was exemplified by the Czechoslovakian revolt of 1967 and significant changes in government in the USSR, Hungary, and Poland. Because of this and other reasons, trend analysis of GNP and primary energy consumption should be viewed from a five and ten-year period, rather than on a year-to-year basis. Data on primary energy consumption have some scatter, but the long term trends are easily recognized.

B. Five-Year Plans

In the early periods (1930-1960) of developing and implementing five-year plans, the USSR and Eastern Bloc countries were consistently over-optimistic in their plans. This lack of achievement of five-year

goals was partly a result of over-enthusiasm, hardships of World War II, lack of planning techniques, and poor management control. In more recent years and particularly in the time period 1960 to 1970, the USSR and the more economically advanced Eastern Bloc countries appear either to have become better planners and implementers, or have employed more conservative estimates. This is illustrated in Table A-3 (taken from USSR's five-year plans) which compares the income goals and achievements of the USSR for the period 1961-1970. Viewed at face value, the comparison shows that the USSR has been achieving its goals, particularly in the industrial sector, a prime user of energy. This pattern appears to be true in the more economically advanced Eastern Bloc countries--but Bulgaria and Romania seem to be consistently overstating their achievable goals. However, further study is needed to account for the relatively small difference between goals and the actual case.

Table A-3

COMPARISON OF PLANS AND ACHIEVEMENTS IN THE USSR

	1961-1965	1966-1970	
	Actual	Plan	Actual
National income	132	138-141	141
Industrial income	151	147-150	150

The planned growth in national income, as reported in Plánovane Hospodarstvi in April 1973, for the various countries is as follows:

Source: USSR Five-Year Plan, p. 65.

Country	1971-1975 Growth Rate (%)
Bulgaria	8.0 - 8.5%
Czechoslovakia	5.1
East Germany	4.9
Hungary	5.5 - 8.5
Poland	6.6 - 6.8
Romania	11.0 - 12.0
USSR	7.1

The five-year planned growth rate for USSR, as presented in the USSR five-year plan 1970, was 6.8 percent per year.

C. Population Forecast

The UN has forecast the population of the various countries to 1985 on the basis of various demographic factors. We have extended their population forecasts to 1990, using essentially the same growth rate in the period 1980-1985 for the period 1986-1990. Summary values of these forecasts are shown below.

POPULATION FORECAST 1970-1990
(Thousands)

	1970	%	1980	%	1990	%
USSR	242,768	70.1%	270,808	70.8%	301,706	71.8%
Eastern Bloc	103,061	29.9	111,154	29.2	118,658	28.2
Total	345,829	100.0%	381,962	100.0%	420,364	100.0%

The population of the USSR will have increased by approximately 59 million to 302 million, and the Eastern Bloc by only 15 million to 118 million. The USSR forecast of 301.7 million compares favorably with discussed values in Soviet literature of 300 million in 1990.

Details showing historical and forecast values on a five-year basis for population, GNP, and primary energy for the period 1960 to 1990 are shown in Table A-4. This table will be repeatedly referred to in this report as it summarizes the above significant variables.

D. GNP Forecast

From five-year planned goals, historical trends, economic base, energy resources, and other data, we have estimated the GNP of the USSR and the Eastern Bloc countries. These countries will continue to expand at a significant but decreasing rate during the period 1970 to 1990. The assumed annual growth rates for GNP are tabulated as follows:

Table A-1

POPULATION, GNP, AND PRIMARY ENERGY--HISTORICAL PERIOD 1960-1970
AND FORECAST PERIOD 1970-1990

	1960	Growth Rate (%/year)	1965	Growth Rate (%/year)	1970	Growth Rate (%/year)	1975	Growth Rate (%/year)	1980	Growth Rate (%/year)	1985	Growth Rate (%/year)	1990
Population (Thousands)													
USSR	214,238	1.5	230,556	1.0	242,768	1.0	255,718	1.1	270,808	1.2	287,066	1.0	301,706
Bulgaria	7,867	0.1	8,201	0.7	8,490	0.8	8,831	0.7	9,143	0.6	9,396	0.5	9,575
Czechoslovakia	13,654	0.7	14,159	0.1	14,167	0.7	15,023	0.7	15,542	0.5	15,937	0.1	16,256
German Democratic Republic	17,241	-0.2	17,029	<0.1	17,050	0.2	17,245	0.3	17,506	0.3	17,770	0.3	18,036
Hungary	9,984	0.3	10,148	0.4	10,331	0.1	10,563	0.5	10,829	0.4	11,046	0.3	11,211
Poland	29,561	1.0	31,145	0.8	32,170	0.9	34,042	1.0	35,779	1.0	37,601	1.0	39,521
Romania	18,403	0.7	19,027	1.3	20,253	1.1	21,359	0.9	22,355	0.8	23,246	0.7	24,059
Eastern Bloc	96,710	0.6	99,709	0.7	103,061	0.8	107,063	0.8	111,151	0.7	114,999	0.6	118,658
Gross National Product (Million 1970 U.S. Dollars)													
USSR	164,282	6.4	224,027	7.0	314,209	6.8	436,751	6.4	595,728	6.0	797,084	5.0	1,017,079
Bulgaria	4,681	6.2	6,323	8.5	9,508	7.1	13,396	6.5	18,351	6.0	24,562	5.5	32,103
Czechoslovakia	17,457	3.1	20,336	6.0	27,214	5.1	34,888	4.9	41,308	4.7	55,739	4.5	69,451
German Democratic Republic	19,222	3.7	23,051	5.0	29,120	5.5	38,152	5.0	49,065	4.5	61,135	4.5	76,171
Hungary	7,521	4.9	9,553	5.5	12,186	5.5	16,319	5.5	21,329	5.5	27,877	5.0	35,571
Poland	21,974	6.0	29,407	6.1	39,539	6.6	54,425	6.0	72,832	5.5	95,191	5.0	121,161
Romania	8,780	7.7	12,722	8.2	18,867	7.5	27,039	7.0	38,000	6.0	50,852	5.5	66,464
Eastern Bloc	79,635	4.9	101,392	6.2	137,034	6.1	184,519	5.8	243,888	5.3	315,356	4.9	401,227
Primary Energy Consumption (Thousand Tons of Coal Equivalent)													
USSR	567,138	6.58	779,978	4.97	994,049	5.7	1,308,440	5.4	1,705,915	5.3	1,214,366	4.7	2,769,192
Bulgaria	9,362	16.95	20,478	9.81	29,830	7.0	41,839	6.5	57,323	6.0	76,711	5.5	100,259
Czechoslovakia	54,735	3.97	66,494	3.02	77,176	3.6	92,105	3.5	109,391	3.4	129,297	3.3	152,085
German Democratic Republic	81,576	2.93	94,254	1.71	102,612	3.2	120,115	3.1	139,923	3.0	162,209	2.9	187,134
Hungary	17,462	6.38	23,796	3.23	27,895		34,431	3.7	42,295	3.6	51,706	3.5	61,409
Poland	75,036	4.24	92,351	5.08	118,301	4.3	149,553	4.5	186,371	4.3	230,038	3.8	277,196
Romania	20,632	9.06	31,828	8.29	47,397	7.0	66,477	6.1	89,382	5.1	114,621	4.1	140,126
Eastern Bloc	258,803	4.93	329,201	4.14	403,211	4.58	504,520	4.37	624,685	4.12	764,582	3.73	918,209

	GNP Forecast Growth Rates (%)			
	1975/1970	1980/1975	1985/1980	1990/1985
USSR	6.8%	6.4%	6.0%	5.0%
Bulgaria	7.1	6.5	6.0	5.5
Czechoslovakia	5.1	4.9	4.7	4.5
East Germany	5.5	5.0	4.5	4.5
Hungary	5.5	5.5	5.5	5.0
Poland	6.6	6.0	5.5	5.0
Romania	7.5	7.0	6.0	5.5
Eastern Bloc Average	6.2	5.8	5.3	5.0

For the entire period, the USSR will grow at an average rate of 6.1 percent/year and Eastern Bloc at a rate of 5.5 percent/year. The lower growth rate in the Eastern Bloc can be expected because the USSR has a larger economic base, controls essentially most of the national resources, and exerts a strong political influence in these countries. On an absolute basis, the growth in GNP of these countries is shown pictorially in Figure A-1. From this we note that the USSR is, and will continue to be, the largest economic factor. Detailed values of the GNP for each country are given alongside the population forecasts in Table A-4. Summary values for the GNP of the USSR and the Eastern Bloc are shown below.

	(Millions of U.S. Dollars)		
	1970	1980	1990
USSR	314,209	595,728	1,017,079
Eastern Bloc	137,034	243,888	401,227

GNP, as reported in the USSR differs in several ways from GNP as reported in the United States. Yet, despite these differences, the 20-year lag between the two GNPs appears reasonable, judging by all that is known of Soviet economic conditions.

Comparing USSR with the Eastern Bloc countries on a per capita basis, we are forecasting over the period 1970 to 1990 a 5.0 percent growth rate in GNP for USSR and 4.8 percent growth rate in GNP for the Eastern Bloc. A semilog plot showing historical and forecast values for per capita GNP is presented in Figure A-2. Czechoslovakia and East

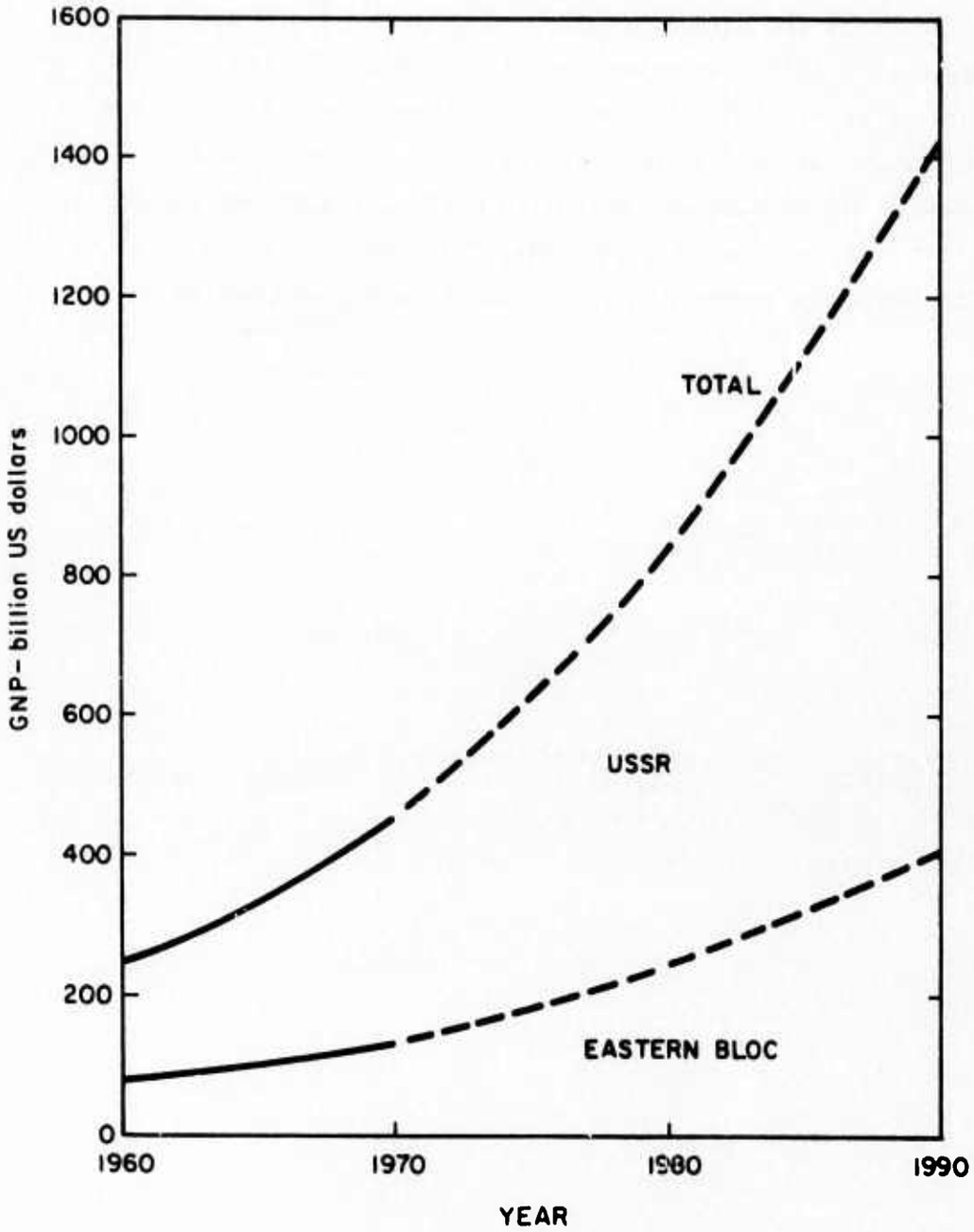

Figure A-1

GROSS NATIONAL PRODUCT--USSR AND EASTERN BLOC

Germany will maintain their rank, and the USSR, Bulgaria, Hungary, Poland, and Romania will follow in that decreasing order. The range will be as high as $4,300 for East Germany and as low as $2,800 for Romania.

Our forecasts are based on a trend extrapolation, together with interpretation of five-year plans and other economic factors. Thus, there could be considerable variability in these forecasts, and they should be viewed only as our best estimate. Probable error in the growth rates could be ±.5% for period 1970-1975, ± 1.0% for period 1975-1980, ± 1.5% for period 1980-1990. This variability could be caused by unforeseen events such as droughts, wars, and political changes.

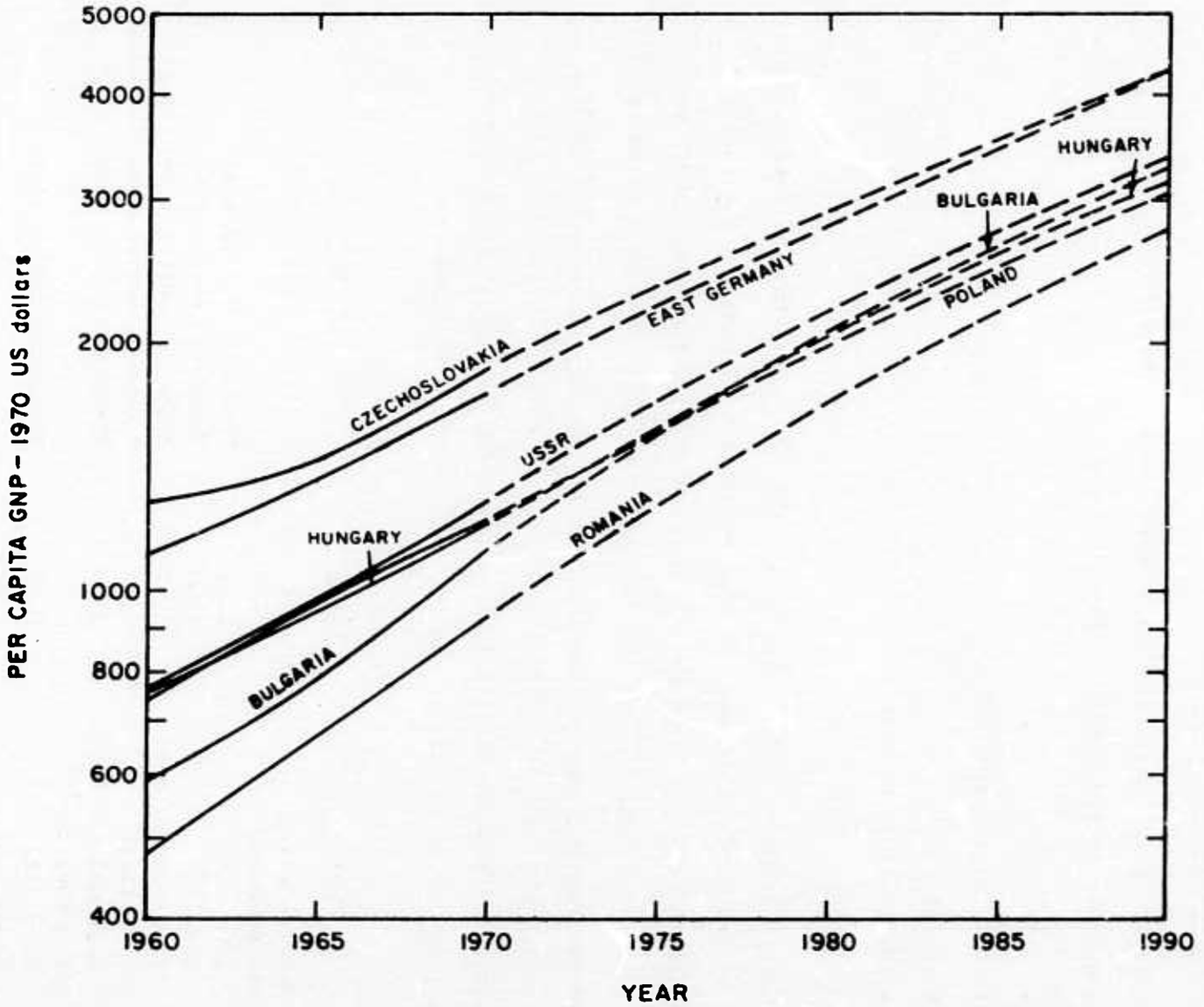

Figure A-2
GROSS NATIONAL PRODUCT PER CAPITA -- 1960 - 1990

III ECONOMIC GROWTH AND ENERGY DEMAND

A. Primary Energy Definition

Primary energy as used in this report is fuel or energy sources obtained directly from nature. This includes:

- Natural gas
- Oil and its products
- Solid fuels
- Hydroelectric power
- Nuclear power.

In order to compare these various fuels the concept of tons of coal equivalent is developed. The tons of coal equivalent is based on the substitution heat content of each fuel in generating electric power. Data on fuel usage are usually given in a naturally measured unit such as cubic meters and metric tons. Conversion factors are developed to convert to the replacement heat equivalent of 1 ton of hard coal in electric power generation. These conversion factors vary from country to country, year to year, and fuel to fuel. Some typical constants for USSR are:

Fuel	Conversion Factor	Natural Units
Natural gas	1.2	Million cubic meters
Oil products		
LPG	1.67	Thousand metric tons
Gasoline	1.50	Thousand metric tons
Kerosene/jet fuel	1.47	Thousand metric tons
Distillate	1.45	Thousand metric tons
Residual	1.39	Thousand metric tons
Solid fuel		
Hard coal	0.88	Thousand metric tons
Brown coal	0.365	
Hydroelectric	0.340	Million kilowatt hours
Nuclear power	0.340	Million kilowatt hours

These conversion factors when multiplied by natural units give the thousands of tons of coal equivalent. For example, 1.39 thousand tons of residual fuel oil must be burned to replace 0.88 thousand tons of Soviet hard coal, which in turn could replace 0.340 million kilowatt hours of hydroelectric power. On a strict energy equivalent, 0.88 thousand tons of Soviet hard coal would replace 0.125 millions of kilowatt hours of hydroelectric power. For every unit of energy input from hard coal to the electric power plant, only about 0.36 units of energy are produced in electric power. The rest is either lost as waste heat or rejected as low pressure steam. Because of this low efficiency, the coal equivalent is not 0.125 but 0.125/0.36 or 0.340.

All consumption data are given on the basis of net internal consumption which is production plus imports minus exports minus losses. That is, net internal consumption is the apparent consumption less losses.

B. Relationship Between Primary Energy Consumption and GNP

A plot of primary energy consumed per capita versus GNP per capita is shown in Figure A-3 for the USSR and for an average of the Eastern Bloc countries during the period 1960 to 1970. From this figure, we see that for this historical period, there is a good correlation between primary energy and GNP. This is not surprising; to increase the output of an economy requires additional energy consumptions by industry, commerce, government, and other sectors. Further, to produce the same level of GNP, the Eastern Bloc countries consume less energy. This can be accounted for partly by the fact that these countries have limited energy reserves and therefore must conserve their energy. Furthermore, they are more compact geographically and therefore have lower energy consumption for transportation.

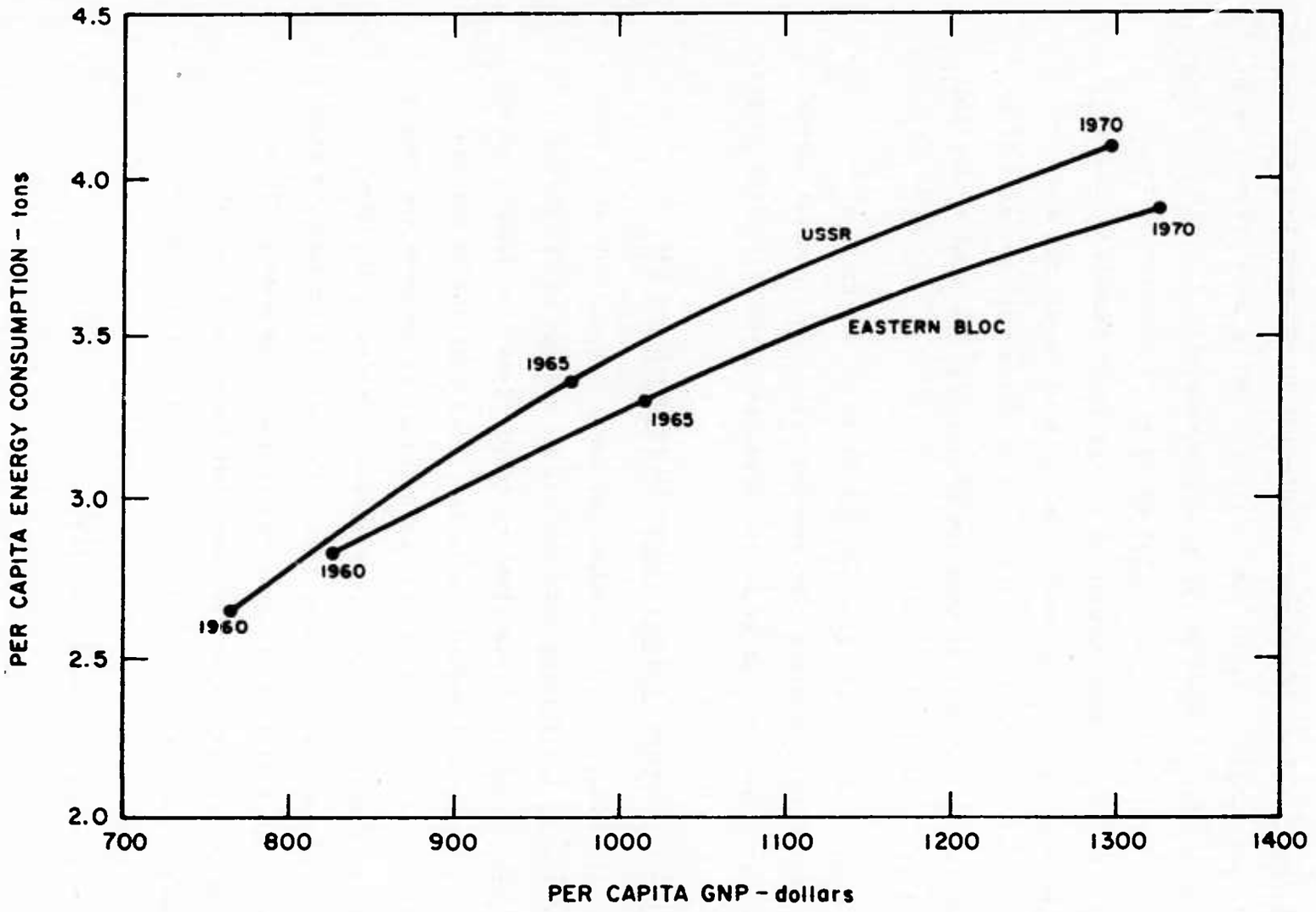

Figure A-3

PRIMARY ENERGY CONSUMPTION PER CAPITA VERSUS GNP PER CAPITA
--USSR AND EASTERN BLOC

Shown in Table A-5 are the per capita values of GNP and energy for these countries for 1960, 1965, and 1970.

Table A-5

PER CAPITA VALUES OF GNP AND ENERGY
(U.S. 1970 Dollars; Thousand TCE)

	1960		1965		1970	
	GNP	Energy	GNP	Energy	GNP	Energy
USSR	$ 766	2.65	$ 971	3.36	$1,294	4.09
Bulgaria	595	1.19	771	2.49	1,120	3.51
Czechoslovakia	1,279	4.00	1,436	4.69	1,881	6.13
East Germany	1,115	4.73	1,354	5.53	1,726	6.96
Hungary	753	1.75	941	2.34	1,209	2.70
Poland	743	2.53	944	2.96	1,218	3.64
Romania	477	1.12	669	1.67	932	2.34
Eastern Bloc	$ 827	2.55	$1,019	3.28	$1,348	4.21

Source: Stanford Research Institute

This table shows that two countries with the highest GNP per capita also have the highest energy consumption per capita.

Economists have attempted to correlate energy with GNP by an equation of the form

$$E = K\,(GNP)^{\epsilon}$$

where E = the energy consumption

K = a constant

ϵ = an exponent representing the efficiency of producing energy from GNP.[1,2,3] This exponent ϵ can be shown to be equal to the ratio of the growth rate in energy to the growth rate in GNP. All growth rates are in percent per year.

$$\epsilon = \frac{\text{growth rate in energy}}{\text{growth rate in GNP}}$$

For the periods 1960 to 1965, 1967 to 1970, and 1960 to 1970 we calculated the ratio of growth rates for the USSR and the Eastern Bloc, as shown below:

Ratio of Growth Rates
(Primary Energy/GNP)

	1965/1960	1970/1965	1970/1960
USSR	1.02	0.71	0.87
Eastern Bloc	1.00	0.66	0.83

Stated another way, in the period 1960-1970, to achieve a 1 percent increase in GNP in the USSR required a 0.87 percent increase in energy consumption in USSR. As a commentary on the United States during the same period, the ratio was 1.05 indicating higher energy consumption for the same growth in GNP.

C. Forecast of Primary Energy

From the data and discussions in the preceeding sections, we have forecast the total primary energy consumption in the USSR and the Eastern Bloc countries. The forecast values are shown in Table A-6.

Table A-6

FORECAST GROWTH RATES OF PRIMARY ENERGY
(Percent)

	1975/1970	1980/1975	1985/1980	1990/1980
USSR	5.7 %	5.4 %	5.3 %	4.7%
Bulgaria	7.0	6.5	6.0	5.5
Czechoslovakia	3.6	3.5	3.4	3.3
East Germany	3.2	3.1	3.0	2.9
Hungary	4.3	4.2	4.1	3.5
Poland	4.8	4.5	4.3	3.8
Romania	7.0	6.1	5.1	4.1
Eastern Bloc (avg)	4.98	4.15	4.32	3.85

The value for USSR is a calculated value, based on consumption of energy by end use. (See later section on Energy End Use in the USSR.)

The planners in the Eastern Bloc have also made forecasts for per capita primary energy consumption[4] in their countries. Their values are shown in Table A-7 on a per capita basis.

Table A-7

PER CAPITA PRIMARY ENERGY CONSUMPTION[4]

	1960	1970	1975	1980	1990
Bulgaria	1.25	3.3		6.0	8.0-8.5
Czechoslovakia	4.6	5.5		7.2	9.2
East Germany	4.6	5.8		7.0	7.8-8.0*
Hungary	1.95	2.9	3.5		
Poland	3.2	3.6†	4.3		
Romania	1.4	2.4		4.3-4.4	

*2000

†1968

The values shown in the above tabulation can be recast as growth rates per year.

A comparison of the SRI forecast with those calculated from the central planners of[4] the Eastern Bloc countries is shown below:

	Growth Rates from Eastern Bloc	1980/1970 from SRI
Bulgaria	6.9	6.7
Czechoslovakia	3.4	3.5
East Germany	2.3	3.1
Hungary	4.3*	4.3
Poland	4.7*	4.8
Romania	7.0	6.5

*1975/1970.

The forecasts are very similar, with the exception of East Germany. Our estimates on East Germany reflect recent discoveries (1972 and 1973) of natural gas in East Germany, and hence, higher consumption.

Using the foregoing assumption on growth rates, we have calculated the primary energy consumption in USSR and Eastern Bloc countries. The values are shown in Table A-4, and Figure A-4 illustrates this consumption.

As shown in the table and graph, the primary energy consumption in the USSR is far larger than combined consumption by Eastern Bloc countries. According to these forecasts, the primary energy consumption in the USSR will increase from 994,049 thousand tons to 2,769,192 thousand tons (an increase of 179 percent), whereas as the Eastern Bloc will increase from 403,214 thousand tons to 918,213 thousand tons (an increase of 127 percent). As shown later, the primary energy consumption in the industrial sector of the USSR will have grown from 412,800 thousand tons to 948,000 thousand tons. Again, the consumption of primary energy in the USSR industrial sector is larger than the combined consumption of the Eastern Bloc.

On a per capita basis, the values as derived from total energy and population forecasts are presented in Table A-8. A summary graph showing per capita values for the USSR and Eastern Bloc is given in Figure A-5. As seen from these, on the average the Eastern Bloc countries will consume slightly less energy per capita than the USSR. Bulgaria will lead the consumption at 10.5 tons/capita in 1990, followed closely by East Germany with 10.4 and Czechoslovakia 9.35. Romania will be the least at 5.8, but also, Romania is starting with the lowest per capita base.

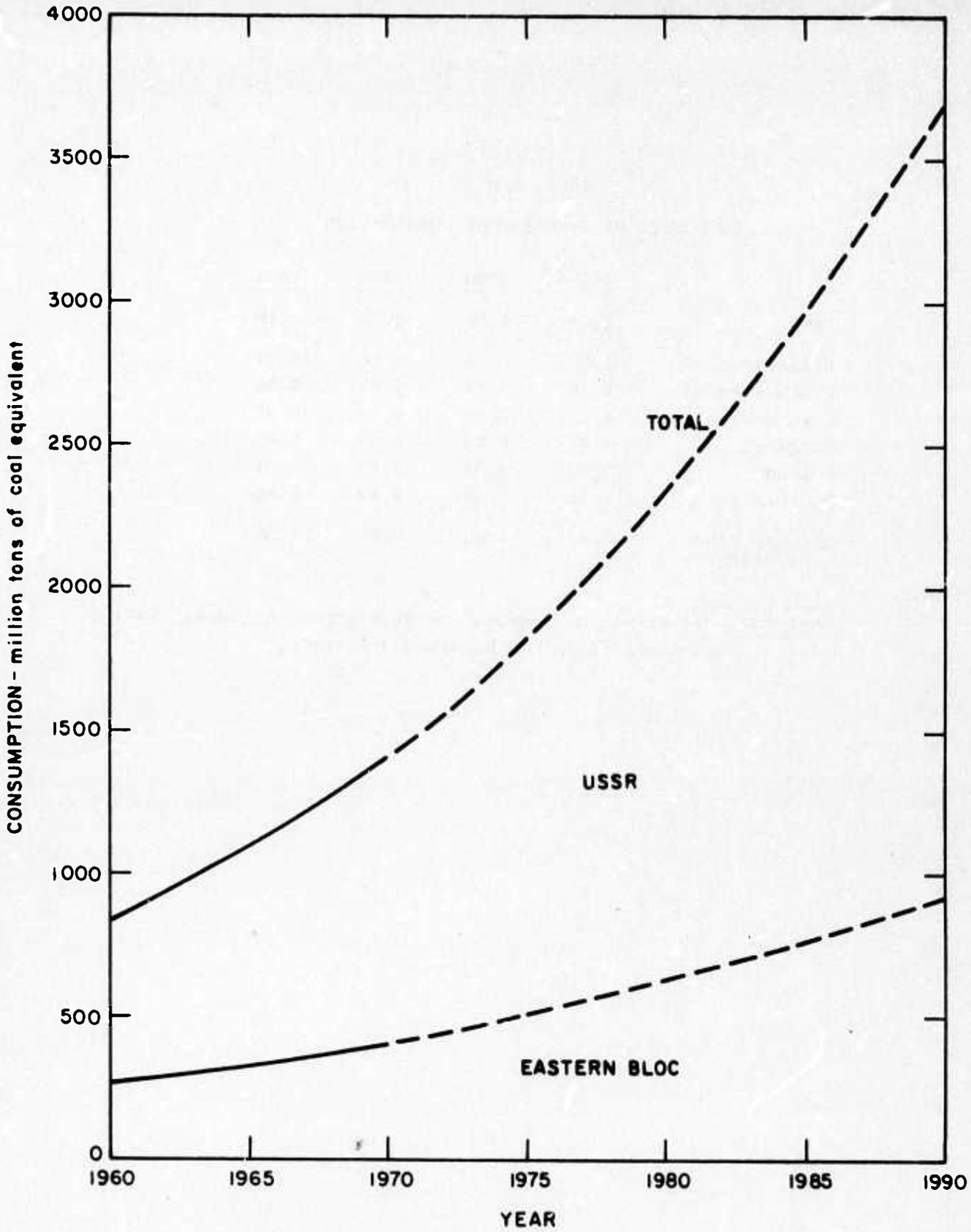

Figure A-4

PRIMARY ENERGY CONSUMPTION OF THE USSR AND THE EASTERN BLOC--1960-1990

Table A-8

PER CAPITA PRIMARY ENERGY CONSUMPTION

	1960	1970	1980	1990
USSR	2.64	4.09	6.30	9.18
Bulgaria	1.12	3.44	6.26	10.47
Czechoslovakia	3.93	5.26	7.03	9.35
East Germany	4.72	5.99	8.20	10.37
Hungary	1.74	2.69	3.90	5.47
Poland	2.53	3.62	5.20	7.01
Romania	1.11	2.30	3.99	5.82
Eastern Bloc Average	2.53	3.88	5.76	8.08

Sources: History--U.N. Yearbook of Statistical Accounts, 1971.
Forecast--Stanford Research Institute.

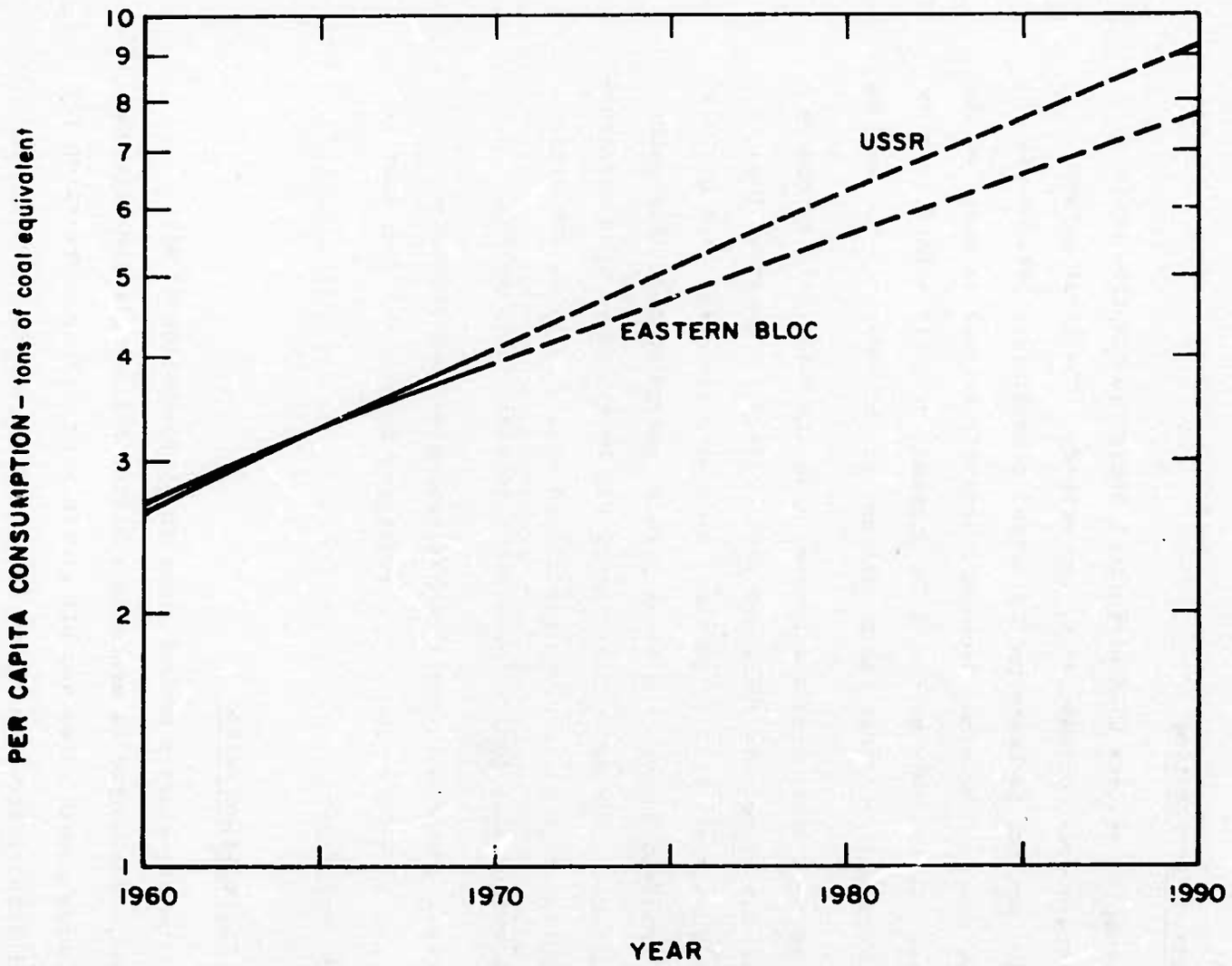

Figure A-5

PRIMARY ENERGY CONSUMPTION PER CAPITA--USSR AND EASTERN BLOC

IV USSR ENERGY CONSUMPTION

A. Methods of Forecasting

This chapter reviews USSR historical energy consumption patterns and forecasts energy consumption by two methods. The first method (correlation method) is based on historical correlations between oil and primary energy; the other (economic activity method) is based on end use of energy by economic sector. The economic activity method is more accurate because it reflects the actual use of the energy in the economy.

Both methods start with the premise that the total primary energy may be forecast by methods described previously. The question then is how much natural gas, oil, solid fuel, hydroelectric power, and nuclear power are required to meet the total primary energy demand. For both methods, hydroelectric and nuclear power can be estimated from construction schedules for nuclear power plants and available sites for hydroelectric plants. This limits the choices to coal, oil, and gas.

The total solid fuel (coal) can be estimated from production schedules and five-year plans. The remaining incremental fuel must be either oil or gas.

1. Correlation Method

The correlation method gives an approximation of oil consumption. The method is based on a historical correlation between primary energy growth rates and oil growth rates. This correlation for historical data is shown in Figure A-6 where oil growth rates are plotted against primary energy growth rates.

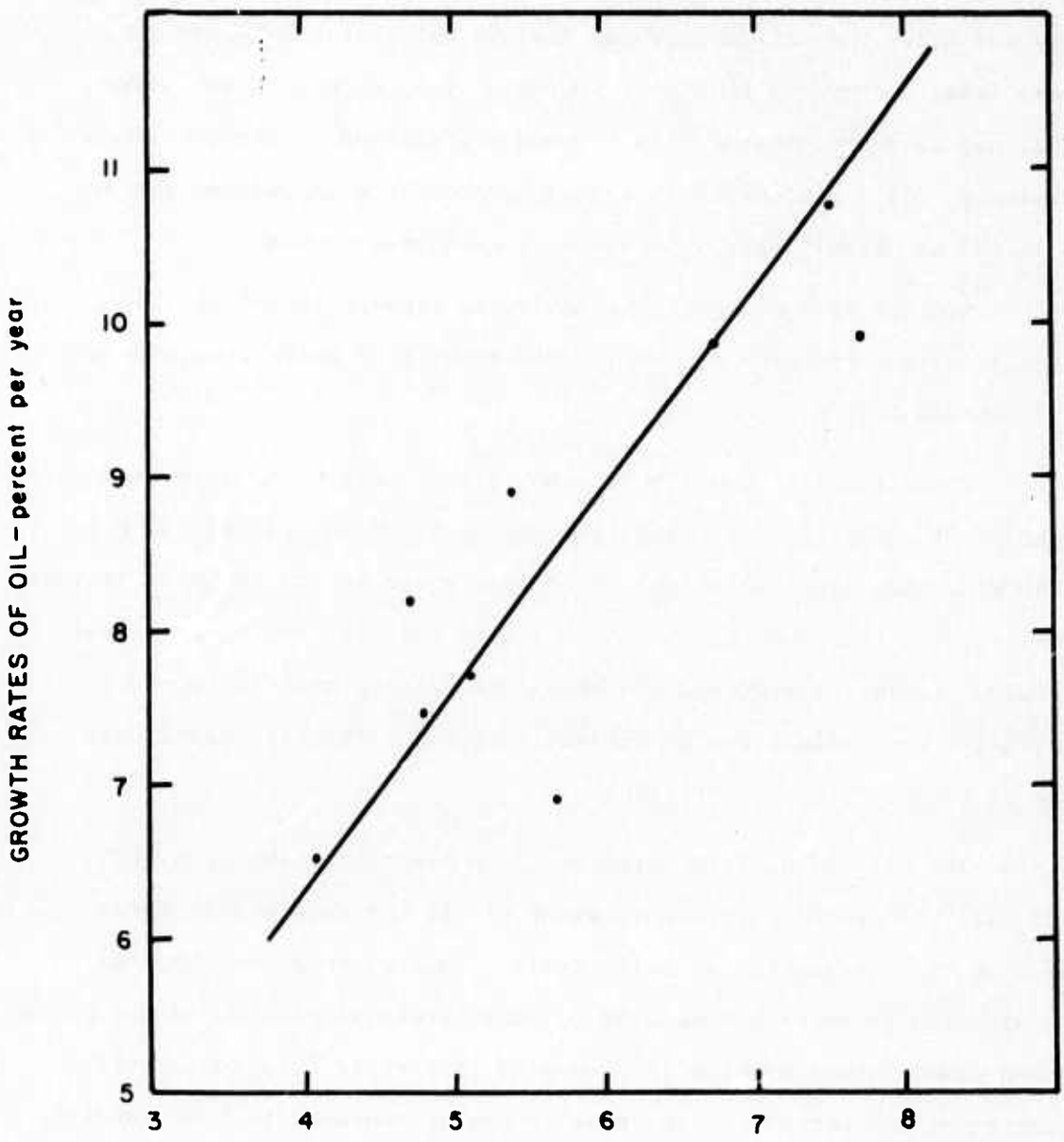

Figure A-6

GROWTH RATES OF OIL COMPARED WITH PRIMARY ENERGY GROWTH RATES FOR THE USSR, 1960-1970

The total primary energy is forecast on the basis of GNP-energy considerations. Hydro, nuclear, and solid fuels are based on production schedules, five-year plans, and available sites. The oil is forecast on the basis of the correlation (Figure A-6) between growth rates for primary energy and oil. The natural gas may then be calculated by difference between total energy and the other sources. The calculated value for natural gas is then compared with five-year plans and trends to assure consistency. If a discontinuity arises, appropriate adjustment can be made in oil or primary energy to assume a consistent trend.

Because of the repetitive nature of these calculations, we developed certain computer programs. The results of these programs are shown in Table A-9.

These results should be viewed as preliminary and were used only as a basis of comparison with the economic activity method, in which we have considerably more confidence. The heat units are in thousand of tons of coal equivalent. The years shown are 1960 through 1990 at five-year intervals. Primary energy sources shown are natural gas, oil products, solid fuels, and nuclear and hydroelectric power. The historical data source is primarily U.N. Statistics.

The results of these preliminary calculations show the USSR substantially increasing its consumption of oil and gas, and modestly increasing its consumption of solid fuels. This consumption compares favorably with production schedules of USSR five-year plans. In the period 1985 and 1990 nuclear power will grow at a very rapid rate and should produce about 8.7 percent of the primary energy consumed in that country. These calculations were performed mainly for use as a basis of comparison with the economic activity method.

2. Economic Activity Method

This method is based on dividing the USSR economy into basic end users of energy. The basic economic users and the percentage of

Table A-9

USSR NET INTERNAL CONSUMPTION OF HEAT UNITS

(Thousand Metric Tons of Coal Equivalent)

Energy Type	1960	1965	1970	1975	1980	1985	1990
Gas Products							
Natural Gas	52,087	136,655	217,104	356,013	514,551	735,260	759,496
Subtotal	52,087	136,655	217,104	356,013	514,551	735,260	759,496
Oil Products							
LPG	1,019	4,661	8,004	11,434	16,576	22,710	29,681
Gasoline	28,425	41,952	55,717	83,556	122,784	168,224	219,862
Kerosene/Jet Fuel	28,533	30,729	45,688	63,766	89,018	121,963	159,400
Distillate Fuel Oil	36,395	60,175	81,490	127,092	164,530	217,009	272,629
Residual Fuel Oil	39,059	76,043	118,289	153,918	221,010	311,215	417,738
Subtotal	133,430	213,560	309,188	439,766	613,918	841,121	1,099,311
Solid Fuel							
Hard Coal	262,835	291,996	319,337	354,150	373,600	391,300	410,200
Brown Coal	41,042	46,085	48,590	64,550	98,900	130,500	152,400
Peat	20,422	17,000	17,679	21,700	20,700	19,900	19,600
Firewood	28,700	33,495	26,600	19,000	8,000	2,600	1,500
Shale Oil	4,794	7,391	8,408	10,200	10,700	11,000	11,300
Subtotal	357,793	395,968	420,614	469,600	511,900	555,300	595,000
Other							
Hydro	23,827	33,795	45,646	56,100	73,814	24,112	119,136
Nuclear			1,284	8,500	32,300	94,520	244,800
Subtotal	23,827	33,795	46,931	64,600	106,114	118,632	363,936
Total	567,138	779,978	993,837	1,329,979	1,746,483	2,250,313	2,817,743

Source: History from U.N. Statistics. Forecast by SRI.

total energy consumed by each sector are shown in Table A-10. Included

Table A-10

USSR CONSUMPTION OF TOTAL ENERGY

Sector	Thousands of TCE	Percent of Total
Industry	616,114	48.1%
Electric power	364,316	28.5
Transportation	78,430	6.1
Commercial	66,846	5.2
Residential	60,943	4.7
Agriculture	58,131	44.5
Military	29,160	2.9
Total	1,273,940	100.0%

Source: "Narodnoil khogeastoo USSR v 1970 g" Moscow 1971 and other Russian sources--modified by SRI.

in total energy is all primary energy plus all secondary energy such as electricity, coke, manufactured gas, and others.

As seen from this table, industry alone consumes 48.1 percent of the total energy; industry plus electric power consumes 76.6 percent of total or more than three-fourths of total energy.

On a primary energy basis, industry consumed 412.8 million TCE of primary energy in 1970. On a percentage basis industry consumed 41.5 percent, electric power 35.6 percent, and combined they consumed 77.2 percent of the total primary energy. Industry and electric power clearly dominate the energy consumption picture in the USSR. By comparison, U.S. industry consumes 22.4 percent of primary energy, electric power 24.0 percent, or combined 46.4 percent.

The economic activity method considers all the energy consumed in a particular sector, both primary and secondary. This energy consumption is then correlated with economic activity in that sector, and economic forecasts are made on the economic activity in the sector. These economic forecasts are based on five-year plans together with

a comparison with the overall GNP forecast. The energy consumption required to achieve that level of activity is then forecast on the basis of correlations between economic activity and energy consumption. After the total energy is forecast for the sector, forecasts are made for individual fuels in that sector. To achieve a balanced forecast, totals of all the energy consumed in the country are next compared with forecasts of primary energy requirements in the various sectors and energy sources to the sectors. The calculation is basically trial and error, and various computer programs were developed to alleviate some of these hand calculations.

The trial and error method is essentially as follows. Economic and detail forecasts on energy requirements are made for each sector. A total primary energy requirement is then computed as a sum of the energy requirements for each consuming sector. This computed primary energy forecast was then compared with the forecast for primary energy which had previously been developed based on correlations with GNP (see Economic Framework Tables A-6). Appropriate adjustments were then made in economic activity, and energy consumption within a sector to assure a consistent trend with the GNP correlation.

These calculations are repeated until a consistent pattern develops for both economic activity and energy consumption. This pattern thus represents our forecast.

3. Energy Consumption Patterns Forecast by Economic Activity Method

Shown in Figure A-7 and A-8 are graphs showing primary energy consumption by energy type for the historical period 1960 and 1970 and the forecast period 1970 to 1990. From these figures, we see that total

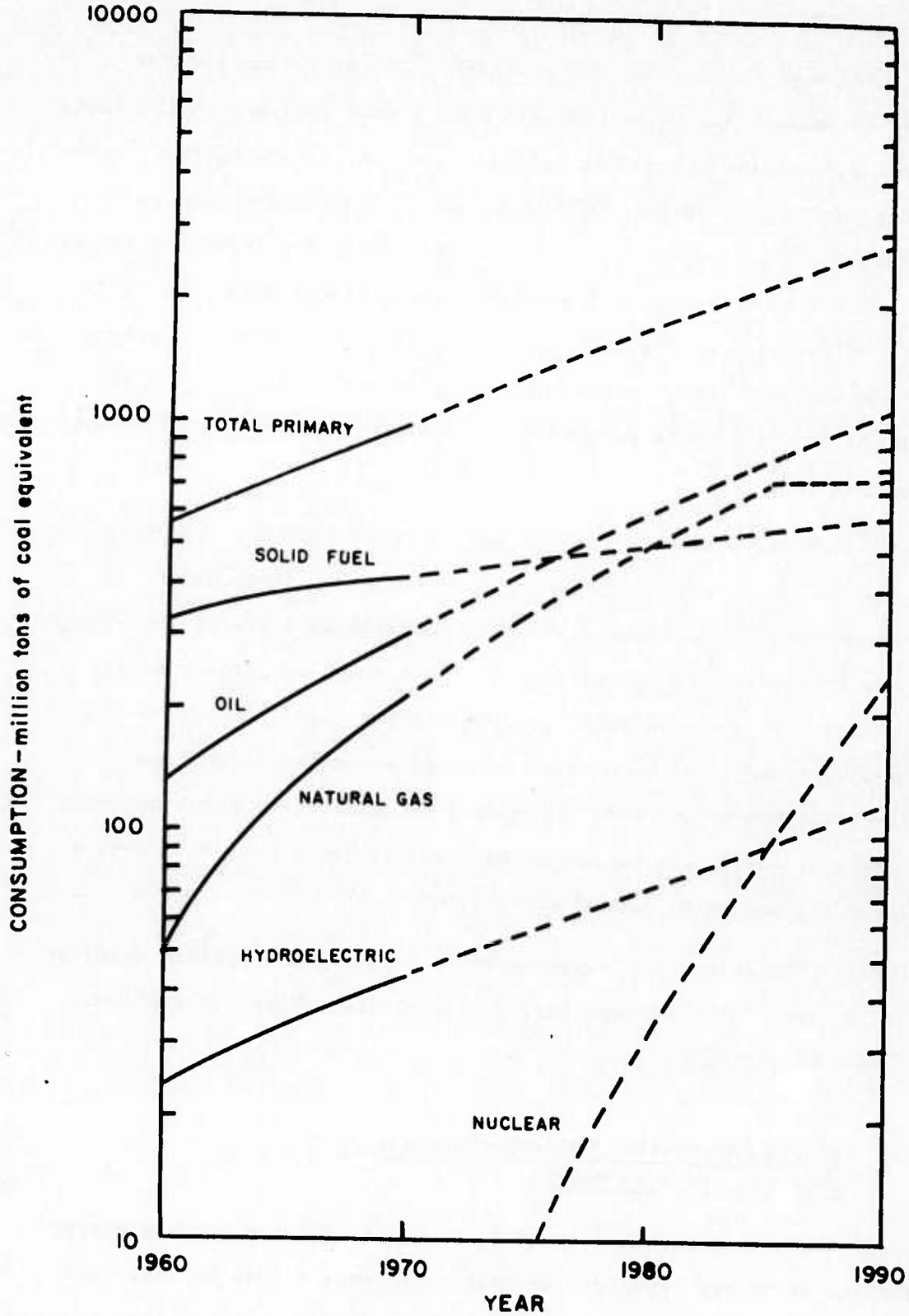

Figure A-7

PRIMARY ENERGY CONSUMPTION IN THE USSR

BY ENERGY TYPE

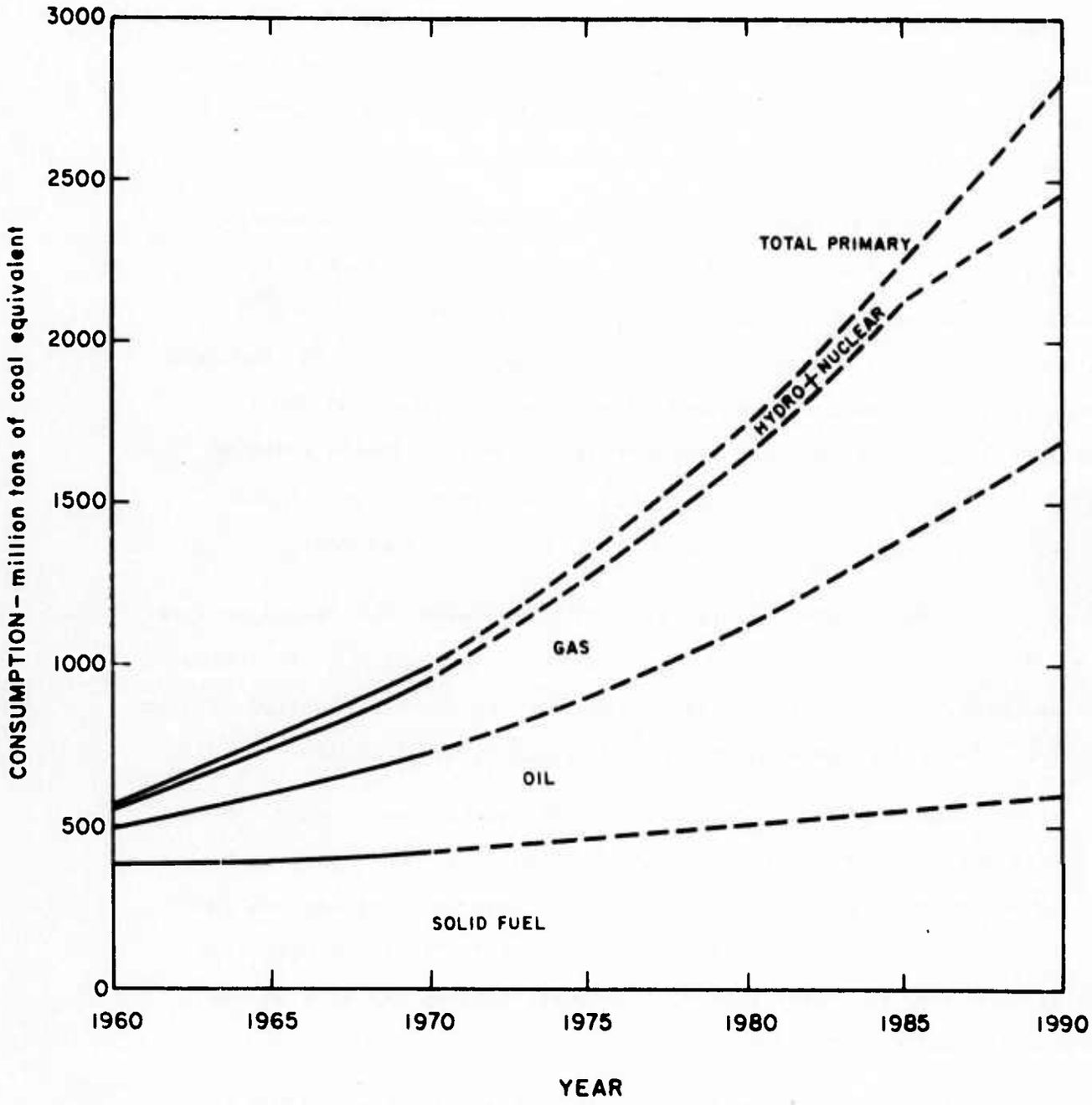

Figure A-8

PRIMARY ENERGY CONSUMPTION IN THE USSR

primary energy, gas, and oil consumption are growing at a substantial rate, 5-7 percent per year. Solid fuels are growing but at a slower rate, 1-2 percent/year. Furthermore, we note that nuclear power will become an important part of the primary energy supply beginning about 1985. Coal will continue to be the largest supplier of primary energy up until approximately 1976; thereafter, oil will be the largest. In approximately 1980, gas consumption will surpass coal.

Table A-11 shows history and forecasts based on economic activity for total energy consumption in the USSR by energy type. Table A-12 shows five-year growth rates for each fuel. Table A-13 shows each fuel type's percentage of total energy. It is seen that gas consumption increases from a 1970 value of 217,069 thousand TCE to 806,837 thousand TCE in 1990 at decreasing five-year growth rates of 9.7, 7.1, 6.6 and 4.3 percent per year. The percent of gas in the total energy consumption increases from 17.0 to 23.15 percent.

Based on our calculation, oil at the same time increases from 309,188 thousand to 1,003,419 thousand TCE at decreasing growth rates of 7.18, 6.98, 5.93, and 4.19 percent/year for the five-year period 1970 to 1990. Oil's percentage increases from 24.27 to 28.97 percent.

Solid fuels increase from 420,861 to 595,000 thousand TCE at growth rates of 2.22, 1.74, 1.64 and 1.39 percent. Soft coal is increasing at a faster rate than hard coal, and this corresponds to forecast reserve and production schedules. Solid fuels nevertheless will be a very important part of the energy pattern and will be the dominant fuel to 1977.

Hydroelectric power increases from 45,646 thousand TCE to 119,136 thousand TCE and growth rates of about 5 percent/year. Nuclear power has the highest growth rate and increases from 1,284 thousand TCE

Table A-11

USSR TOTAL ENERGY CONSUMPTION IN HEAT UNITS
(Thousand Metric Tons of Coal Equivalent)

Energy Type	1960	1965	1970	1975	1980	1985	1990
Primary Energy							
Gas Products							
Natural Gas	52,087	136,655	217,069	336,925	475,215	653,261	806,837
Subtotal	52,087	136,655	217,069	336,925	475,215	653,261	806,837
Oil Products							
LPG	1,019	4,661	8,001	10,672	13,773	18,637	25,665
Gasoline	28,425	41,952	55,717	74,839	98,415	128,104	166,229
Kerosene/Jet Fuel	28,533	30,729	45,688	65,449	84,534	103,811	127,907
Distillate	36,395	60,175	81,490	117,382	150,816	203,816	266,036
Residual Fuel Oil	39,059	76,043	118,289	168,972	265,148	362,806	417,582
Subtotal	133,430	213,560	309,188	437,315	612,686	817,173	1,003,419
Solid Fuels							
Hard Coal	262,835	291,996	319,479	354,150	373,600	391,300	410,200
Soft Coal	41,042	46,085	48,590	64,550	98,900	130,500	152,400
Peat	20,422	17,000	17,679	21,700	20,700	19,900	19,600
Firewood	28,700	33,495	26,705	19,000	8,000	2,600	1,500
Shale Oil	1,791	7,391	8,408	10,200	10,700	11,000	11,300
Subtotal	357,793	395,968	420,861	469,600	511,900	555,300	595,000
Total	543,310	746,182	947,118	1,243,840	1,599,801	2,025,734	2,405,256
Other							
Hydro	23,827	33,795	45,646	56,100	73,814	94,112	119,136
Nuclear	0	0	1,284	8,500	32,300	94,520	224,800
Subtotal	23,827	33,795	46,931	64,600	106,114	188,632	363,936
Electric Power							
Electricity	31,971	54,406	78,368	112,776	160,877	222,000	290,376
Subtotal	31,971	54,406	78,368	112,776	160,877	222,000	290,376
Secondary Energy							
Manufactured Gas	23,626	26,844	35,632	45,500	56,000	67,250	76,500
Steam from Electric Power	30,286	66,428	99,857	138,791	182,875	230,443	273,942
Subtotal	53,912	93,272	135,489	184,291	238,875	297,693	350,442
Secondary Solid Fuel							
Solid Coke	50,610	62,168	66,035	69,500	71,500	73,500	75,500
Subtotal	50,610	62,168	66,035	69,500	71,500	73,500	75,500
Grand Total	723,631	989,824	1,273,941	1,675,007	2,177,167	2,807,560	3,485,510

Table A-12

USSR GROWTH RATES IN VARIOUS ENERGY SOURCES
(Percent)

Energy Type	1965	1970	1975	1980	1985	1990
Primary Energy						
Gas Products						
Natural Gas	21.28	9.70	9.19	7.12	6.57	4.31
Subtotal	21.28	9.70	9.19	7.12	6.57	4.31
Oil Products						
LPG	35.55	11.42	5.92	5.23	6.23	6.61
Gasoline	8.10	5.84	6.08	5.63	5.41	5.35
Kerosene/Jet Fuel	1.49	8.26	7.45	5.25	4.19	4.26
Distillate	10.58	6.25	7.57	5.14	6.21	5.47
Residual Fuel Oil	14.25	9.24	7.39	9.43	6.47	2.85
Subtotal	9.86	7.68	7.18	6.98	5.93	4.19
Solid Fuels						
Hard Coal	2.13	1.82	2.08	1.08		.95
Soft Coal	2.34	1.06	5.84	8.91	5.70	3.15
Peat	-3.60	.79	4.18	-.94	-.79	-.30
Firewood	3.14	-4.43	-6.58	-15.89	-20.13	-10.42
Shale Oil	9.04	2.61	3.94	.96	.55	.54
Subtotal	2.05	1.23	2.22	1.74	1.64	1.39
Other						
Hydro	7.24	6.20	4.21	5.64	4.98	4.83
Nuclear			45.93	30.60	23.96	20.96
Subtotal	7.24	6.79	6.60	10.44	12.19	14.05
Total	6.58	4.97	5.7	5.4	5.3	4.7
Secondary Energy						
Electric Power						
Electricity	11.22	7.57	7.55	7.36	6.65	5.52
Subtotal	11.22	7.57	7.55	7.36	6.65	5.52
Manufactured Gas	2.59	5.83	5.01	4.24	3.73	2.61
Steam from Electric Power	17.01	8.49	6.81	5.67	4.73	3.52
Subtotal	11.59	7.75	6.35	5.33	4.50	3.32
Secondary Solid Fuel						
Solid Coke	4.20	1.21	1.03	.57	.55	.54
Subtotal	4.20	1.21	1.03	.57	.55	.54
Grand Total	7.06	5.18	5.63	5.38	5.22	4.42

Table A-13

USSR PERCENTAGES OF ENERGY

Energy Type	1960	1965	1970	1975	1980	1985	1990
Primary Energy							
Gas Products							
Natural Gas	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Subtotal	7.40	13.81	17.04	20.11	21.83	23.27	23.15
Oil Products							
LPG	.76	2.18	2.59	2.44	2.25	2.28	2.56
Gasoline	21.30	19.64	18.02	17.11	16.06	15.68	16.57
Kerosene/Jet Fuel	21.38	14.39	14.78	14.97	13.80	12.70	12.75
Distillate	27.28	28.18	26.36	26.84	24.62	24.94	26.51
Residual Fuel Oil	29.27	35.61	38.26	38.64	43.28	44.40	41.62
Subtotal	18.96	21.58	24.27	26.11	28.14	29.11	28.72
Solid Fuels							
Hard Coal	73.46	73.74	75.91	75.42	72.98	70.17	68.94
Soft Coal	11.47	11.64	11.55	13.75	19.32	23.30	25.61
Peat	5.71	4.29	4.20	4.62	4.04	3.58	3.29
Firewood	8.02	8.46	6.35	4.05	1.56	.47	.25
Shale Oil	1.34	1.87	2.00	2.17	2.09	1.98	1.90
Subtotal	50.85	40.00	33.04	28.04	23.51	19.78	17.07
Other							
Hydro	100.00	100.00	97.26	86.84	69.56	49.89	32.74
Nuclear	0.00	0.00	2.74	13.16	30.44	50.11	67.26
Subtotal	3.39	3.41	3.68	3.86	4.87	6.72	10.44
Secondary Energy							
Electric Power							
Electricity	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Subtotal	4.54	5.50	6.15	6.73	7.39	7.91	8.33
Manufactured Gas	43.82	28.78	26.30	24.69	23.44	22.59	21.83
Steam from Electric Power	56.18	71.22	73.70	75.31	76.56	77.41	78.17
Subtotal	7.66	9.42	10.64	11.00	10.97	10.60	10.05
Secondary Solid Fuel							
Solid Coke	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Subtotal	7.19	6.28	5.18	4.15	3.28	2.62	2.17
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

in 1970 to 224,800 thousand TCE in 1990. By 1990, nuclear power will represent 8.8 percent of total primary energy input to the Soviet economy.

Secondary fuels including electricity, manufactured gas, steam from electric power, and solid coke will be increasing at substantial rates. Electricity consumption will grow from 78,368 thousand TCE in 1970 to 290,376 thousand TCE in 1990, representing healthy growth rates of 7.5, 7.4, 6.7 and 5.5 percent per year over succeeding five-year periods.

Manufactured gas and steam produced from electric power will grow at slightly lower rates than electricity consumption. Nevertheless, this secondary source of energy will continue to be a major energy source in the Soviet economy. Because of this efficient use of steam, the Soviets' primary energy requirements are less than those of countries that discharge steam as waste--for example, the USA. In fact, the consumption of energy by these two sources will continue to exceed the total electricity consumption in the country. The numerical values of the tons of coal equivalent for steam from electric power represent production values and might be slightly high, since no losses are assumed. Solid coke and products primarily of steel production will also grow.

4. Comparison of Methods

Table A-14 shows a comparison of the correlation and economic activity methods.

The methods compare exactly for nuclear, hydro, and solid fuels; the total in the correlation method is about 2 percent higher than economic activity method. The oil and gas values differ on the average by about $\pm$ 5 percent with a maximum spread of 10 percent.

Table A-14

COMPARISON OF FORECASTING METHODS--THE USSR

	1980			1990		
	Correlation Method	Economic Activity	Percent Difference	Correlation Method	Economic Activity	Percent Difference
Gas	514,551	475,215	+8.2%	759,496	806,837	-5.9%
Oil	613,918	612,686	+ .2	1,099,311	1,003,419	+9.5
Total Primary	1,746,483	1,705,915	+2.3%	2,817,743	2,769,192	+1.7%

B. Sector Analysis

For each energy use sector of the USSR economy, economic indicators were selected. The USSR five-year plan was used as a source of most of these indicators because a consistent history and forecast were presented in this plan. The historical indices were then compared with the U.N. Statistical Yearbook. In general, there was good agreement.

The indices used were as follows:

Economic Sector	Index	Basic Source
Total country	Gross national product	UN Statistics
Industry	Industrial output	USSR five-year plan
Transport	Freight turnover	USSR five-year plan
Commercial	Retail turnover	USSR five-year plan
Residential	Personal consumption	UN Statistics
Agriculture	Gross output agriculture	USSR five-year plan
Population		UN Statistics

The indices are the percentage ratio between the value at any year and the value in 1960.

Table A-15 tabulates these indices for the historical period 1960-1970 and shows forecast values for the period 1970 to 1990. The forecasts were made to 1975 by USSR five-year plans and 1975 to 1990 by trend extrapolation. The trends forecasts were made with reference to the GNP forecast and were adjusted to meet energy consumption requirements. A summary of these forecasts is shown in Figure A-9.

Industry has the highest growth rate; agriculture has the least. This trend in growth rates is similar to the energy consumption pattern. The historical energy consumed in a sector was then correlated versus the index for the sector. Good correlation resulted; see Figure A-10 which shows energy consumption in industry versus the index for industrial consumption. On the basis of these correlations, total energy consumption in each sector was then estimated for the years 1970 to 1990.

Table A-15

INDEX OF ECONOMIC ACTIVITY IN THE USSR

	History			Forecast			
	1960	1965	1970	1975	1980	1985	1990
Gross national product	100	136	191	265	362	485	619
Industry	100	151	226	332	445	590	760
Transport	100	146	205	278	380	510	640
Commercial	100	134	196	277	380	510	640
Residential	100	133	192	270	380	510	640
Agriculture	100	112	137	167	203	242	290
Population	100	107	113	119	126	133	140

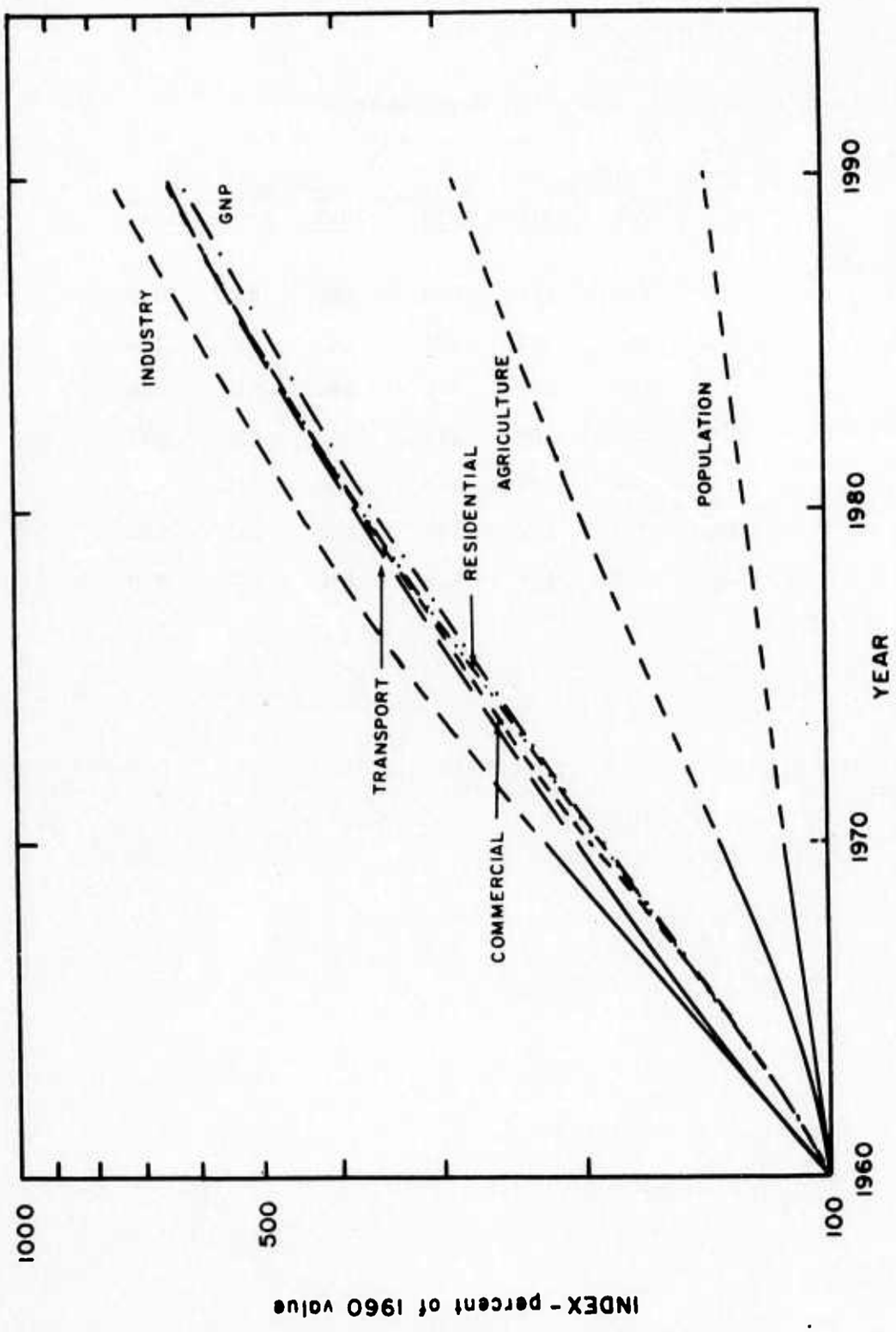

Figure A-9

INDEX OF ECONOMIC ACTIVITY IN THE USSR

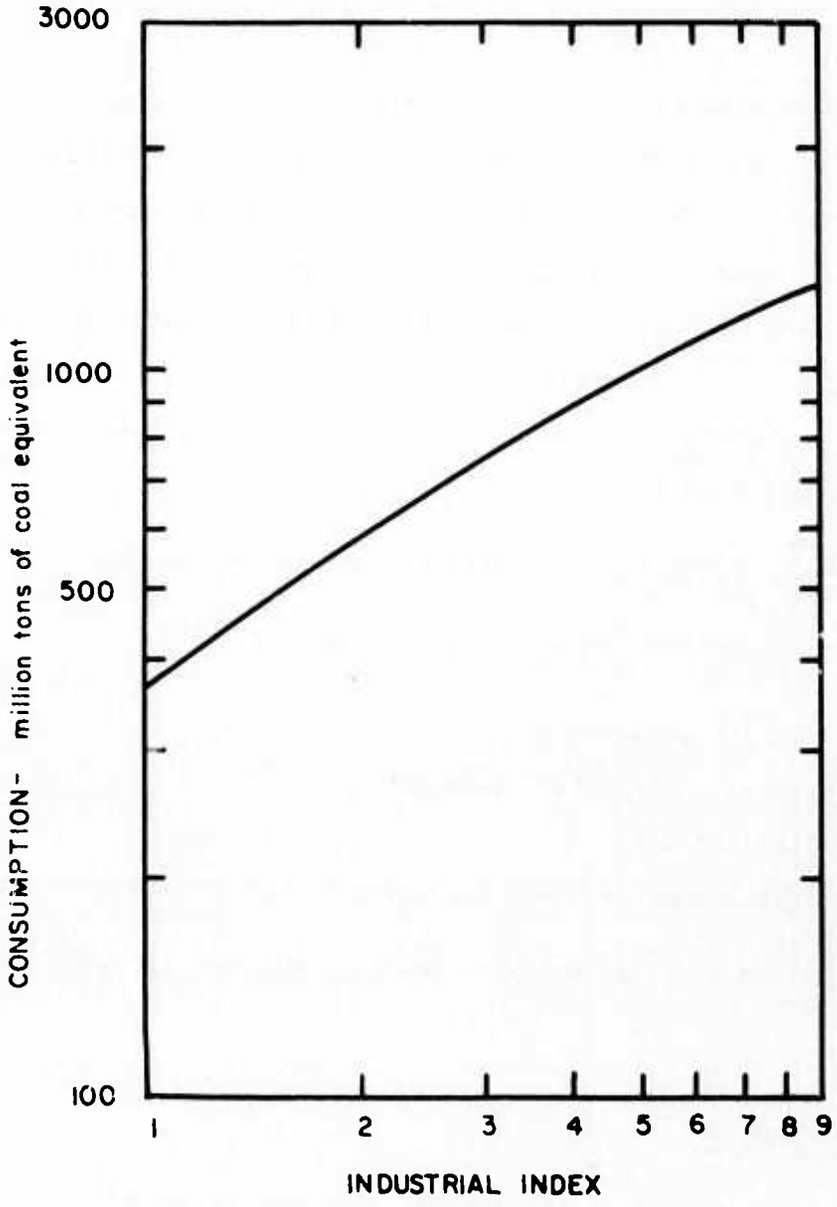

Figure A-10

TOTAL ENERGY CONSUMPTION IN INDUSTRY VERSUS INDUSTRIAL INDEX

The methodology for electric power consumption is similar and is detailed in the electric power section. The index used in the electric power is GNP.

A summary graph showing the relative importance of each sector is shown in Figure A-11. In this figure, the total energy consumed by each sector is plotted versus years of both historical and forecast period. In Figure A-12 primary energy by end use sector is shown. For both total and primary energy consumption, industry and electric power are the dominant consumers. Transportation, commercial, residential, and agriculture are approximately the same size, each consuming between 5-7 percent of the total energy.

In the industrial sector, the significant users of energy are:

- Primary metal industries such as steel, aluminum and copper
- Chemical and allied industries
- Petroleum refining and related products
- Paper and allied products
- Stone, clay, glass, and concrete products.

Further study is required to show the exact energy requirements for each industry.

1. Industry Forecast

The industrial sector is the largest consumer of primary energy in the USSR. As recently as 1960, this sector used just over 45 percent of total energy, and by 1970, it still accounted for about 42 percent of energy use. Between 1960 and 1970, industrial energy use increased about 50 percent--from 258 million TCE to 413 million TCE. Table A-16 shows industrial energy use by type of fuel, including both primary fuels and secondary energy.

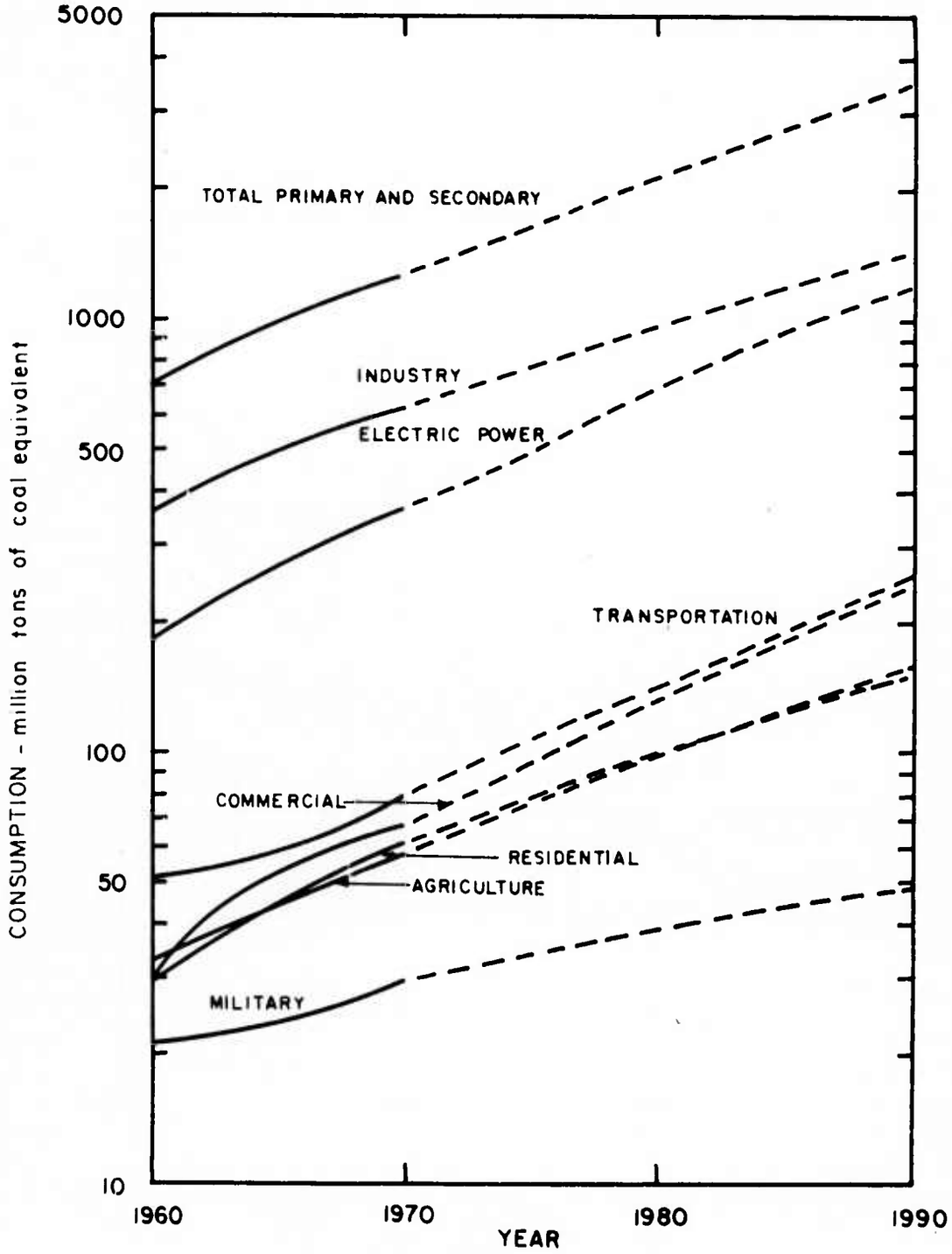

Figure A-11
TOTAL ENERGY CONSUMPTION BY ECONOMIC SECTOR IN THE USSR

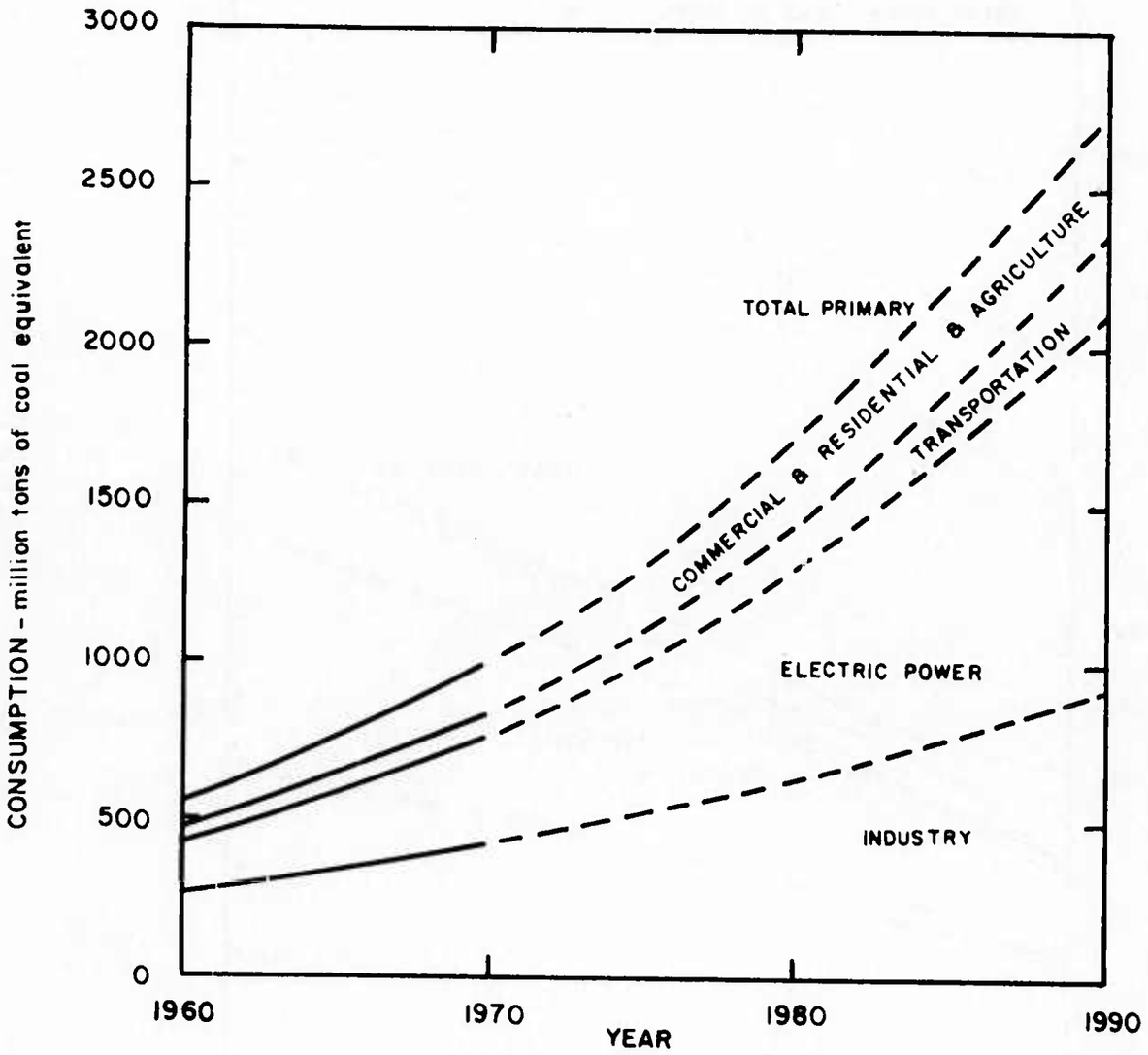

Figure A-12

CONSUMPTION OF PRIMARY ENERGY IN THE USSR
BY END USE SECTORS

Table A-16

ENERGY USE BY USSR INDUSTRIAL SECTOR IN HEAT UNITS
(Thousand Metric Tons of Coal Equivalent)

Energy Type	1960	1965	1970	1975	1980	1985	1990
Primary Energy							
Gas Products							
Natural Gas	30,329	76,883	123,141	190,000	270,000	370,000	480,000
Subtotal	30,329	76,883	123,141	190,000	270,000	370,000	480,000
Oil Products							
LPG	102	466	800	1,183	1,650	2,550	3,610
Gasoline							
Kerosene/Jet Fuel							
Distillate	16,434	23,271	31,736	50,050	61,600	85,500	110,200
Residual Fuel Oil	23,554	36,239	31,660	39,767	46,750	61,950	76,190
Subtotal	40,090	59,976	64,196	91,000	110,000	150,000	190,000
Solid Fuels							
Hard Coal	147,095	162,221	180,967	196,700	213,500	227,300	242,200
Soft Coal	18,254	21,157	24,450	25,500	26,500	27,500	28,500
Peat	3,467	2,046	2,649	3,300	3,500	3,700	3,900
Firewood	15,750	18,305	14,630	12,000	3,300		
Shale Oil	3,230	3,609	2,768	3,000	3,200	3,300	3,400
Subtotal	187,796	207,338	225,463	240,500	250,000	261,800	278,000
Other							
Hydroelectric							
Nuclear							
Subtotal	0	0	0	0	0	0	0
Total	258,215	344,197	412,800	521,500	630,000	781,800	948,000
Secondary Energy							
Electric Power							
Electricity	24,718	40,704	56,618	78,375	108,588	145,400	184,375
Subtotal	24,718	40,704	56,618	78,375	108,588	145,400	184,375
Manufactured Gas	14,695	17,299	25,529	34,500	44,000	54,250	62,500
Steam from Electric Power	26,286	54,571	77,143	103,500	132,000	162,750	187,500
Subtotal	40,981	71,870	102,672	138,000	176,000	217,000	250,000
Secondary Solid Fuel							
Solid Coke	33,740	40,252	44,023	46,000	47,000	48,000	49,000
Subtotal	33,740	40,252	44,023	46,000	47,000	48,000	49,000
Grand Total	357,654	497,022	616,114	783,875	961,588	1,192,200	1,431,375

Historically, the industrial sector in the USSR has relied very heavily on coal and other solid fuels for its energy needs. In 1960, for example, solid fuels supplied over 70 percent of the total energy consumed, and oil, about 15 percent. By 1970, however, solid fuels supplied only about 55 percent of the total while oil's share stayed roughly the same at 15 percent. About one-half of the oil consumed was supplied by residual fuel oil. The use of natural gas made up much of the difference, increasing rapidly during the 1960-1970 period--from 12 percent of primary energy use to nearly 30 percent by 1970.

Secondary energy--electricity, manufactured gas, steam (from the electric power industry), and coke--all contribute significantly to industry's total fuel requirements, but the primary energy sources from which they have been produced are already accounted for in the total primary energy needs of the USSR. Electricity and steam are produced by both the industrial sector and the electric power generation sector. The figures shown in Table A-16 for use of these two energy sources are only the quantities supplied by electric power plants; no attempt was made to estimate the amount self-produced and used. Industry produces manufactured gas and coke in quantities surplus to its own needs; the figures shown in the table are only those used by industry. Most of the remainder of these two secondary fuels are consumed in the residential and commercial sectors, although small quantities do move to other consuming sectors.

Total future energy requirements by industry were estimated on the basis of a correlation of energy consumption with the industrial index (see Figure A-10). Solid fuels, coke, and manufactured gas were forecast on the basis of the five-year plan production schedules and a trend analysis. For example, since coke is used primarily in steel production, the five-year plan for steel was considered in making the forecast.

For estimating gas and oil, the following approach was used. On a total energy input basis, these two fuels represent approximately 40 percent of the energy input. Industry usually has the choice of using either gas or oil for heating. The forecast of gas and oil was based on an extrapolation of the historical relationship between the percentage of oil and gas to industry, but the estimates could be significantly different, depending on Soviet policy with regard to the use of these two fuels. For example, if the Russians decide to increase exports of oil, they will use more gas in industry.

Industrial sector energy requirements are expected to more than double between 1970 and 1990, although this sector's share of total energy use will continue to decline and will be roughly 35 percent in 1990.

While coal will continue to be an important fuel in the industrial sector, nevertheless it will show little growth for the forecast period (Table A-17). As a result, its share of the total will drop to about 40 percent in 1980 and to 29 percent by 1990. The use of oil is expected to increase at an annual rate of between four and seven percent per year--slightly faster than industrial energy use--with the result that oil's share of the total for the sector will increase modestly. It is anticipated that natural gas will be the predominant industrial fuel of the future in the USSR economy. By 1980, its share will be about 43 percent of the total, and by 1990, over 50 percent. In the 1970-75 period, and perhaps even during the following five-year period to 1980, it is doubtful that supplies of natural gas will be sufficient to meet the estimated demands (see section on natural gas). In this event, oil and coal will make up the difference.

Table A-17

GROWTH RATES OF INDUSTRIAL SECTOR
(Percent)

Energy Type	1965	1970	1975	1980	1985	1990
Primary Energy						
Gas Products						
Natural Gas	20.45%	9.88	9.06	7.28	6.50	5.34%
Subtotal	20.45	9.88	9.06	7.28	6.50	5.34
Oil Products						
LPG	35.54	11.42	8.14	6.88	9.10	7.20
Gasoline						
Kerosene/Jet Fuel						
Distillate	7.20	6.40	9.54	4.24	6.78	5.21
Residual Fuel Oil	9.00	-2.67	4.67	3.29	5.79	4.22
Subtotal	8.39	1.37	7.23	3.87	6.40	4.84
Solid Fuels						
Hard Coal	1.98	2.21	1.68	1.65	1.26	1.28
Soft Coal	3.00	2.94	.84	.77	.74	.72
Peat	-10.01	5.30	4.49	1.18	1.12	1.06
Firewood	3.05	-4.38	-3.89	-22.76		
Shale Oil	2.24	-5.17	1.62	1.30	.62	.60
Subtotal	2.00	1.69	1.30	.78	.93	1.21
Other						
Hydroelectric						
Nuclear						
Subtotal						
Secondary Energy						
Electric Power						
Electricity	10.49	6.82	6.72	6.74	6.01	4.86
Subtotal	10.49	6.82	6.72	6.74	6.01	4.86
Manufactured Gas	3.32	8.09	6.21	4.98	4.28	2.87
Steam for Electric Power	15.73	7.17	6.05	4.98	4.28	2.87
Subtotal	11.89	7.39	6.09	4.98	4.28	2.87
Secondary Solid Fuel						
Solid Coke	3.59	1.81	.88	.43	.42	.41
Subtotal	3.59	1.81	.88	.43	.42	.41
Total	6.80	4.39	4.93	4.17	4.39	3.72

2. Electric Power Forecasts

The electric power sector is a large fuel user in the Soviet national economy. In 1970, this sector consumed about 33.5 percent of all primary fuel consumed in the country.

Historically, thermal power stations have relied on coal--mainly hard coal--as their main fuel (Table A-18). In 1960, coal covered 70 percent of their fuel needs (Figure A-13). Yet, because coal consumption growth rates were considerably lower than the growth rates of thermal power generation, coal's share has continuously been dropping, to 48 percent in 1970. This trend is expected to continue but at a slower pace, to 39 percent in 1980 and 35 percent in 1990. While hard coal was the main solid fuel in electric power generation, its future growth is expected to slow down considerably because of the demands of the industrial sector, particularly for coking coal. On the other hand, brown coal, and to some extent peat, will experience a rapid expansion between 1970 and 1980, with a gradual slowdown in the 1990s. Several large stations planned for the western part of the USSR are intended to burn peat while future plans for the eastern part call for use of large quantities of brown coal.*

Starting at a very low level in 1960, oil has increased its share to 24 percent in 1970. In the future, it will have to provide the bulk of the incremental fuel demand, along with natural gas. Between 1970 and 1990, oil consumption for electric power generation will quadruple from 75 to 303 million metric tons of coal equivalent. Oil will increase its market share to 33 percent in 1980 and 37 percent in 1990. During the same period, natural gas will triple its quantity from 61 to

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* See Electric Power Technology Section VI.

Table A-18

ENERGY USE BY USSR ELECTRIC POWER SECTOR IN HEAT UNITS
(Thousand Metric Tons of Coal Equivalent)

Energy Type	1960	1965	1970	1975	1980	1985	1990
Primary Energy							
Gas Products							
Natural Gas	11,675	41,650	61,139	96,700	132,000	182,000	190,000
Subtotal	11,675	41,650	61,139	96,700	132,000	182,000	190,000
Oil Products							
LPG							
Gasoline							
Kerosene/Jet Fuel							
Distillate							
Residual Fuel Oil	11,600	32,201	71,800	112,900	196,600	271,000	303,300
Subtotal	11,600	32,201	71,800	112,900	196,600	271,000	303,300
Solid Fuels							
Hard Coal	94,860	118,587	133,056	155,000	159,600	164,000	168,000
Soft Coal	14,899	18,620	20,411	36,700	71,900	103,000	123,900
Peat	10,782	11,309	10,287	15,700	15,700	15,700	15,700
Firewood	1,995	2,185	1,995	1,800	1,700	1,600	1,500
Shale Oil	1,564	3,782	5,640	7,200	7,500	7,700	7,900
Subtotal	124,100	154,784	171,389	216,400	256,400	292,000	317,000
Other							
Hydroelectric	23,827	33,795	45,646	56,100	73,814	94,112	119,136
Nuclear			1,284	8,500	32,300	94,520	244,800
Subtotal	23,827	33,795	46,931	64,600	106,114	188,632	363,936
Total	174,202	262,429	354,258	490,600	691,114	933,632	1,174,236
Secondary Energy							
Electric Power							
Electricity							
Subtotal	0	0	0	0	0	0	0
Manufactured Gas	8,040	9,238	10,058	11,000	12,000	13,000	14,000
Steam from Electric Power							
Subtotal	8,040	9,238	10,058	11,000	12,000	13,000	14,000
Secondary Solid Fuel							
Solid Coke							
Subtotal	0	0	0	0	0	0	0
Grand Total	182,242	271,667	364,316	501,600	703,114	946,632	1,188,236

Source: Compiled by SRI. Forecasts by SRI.

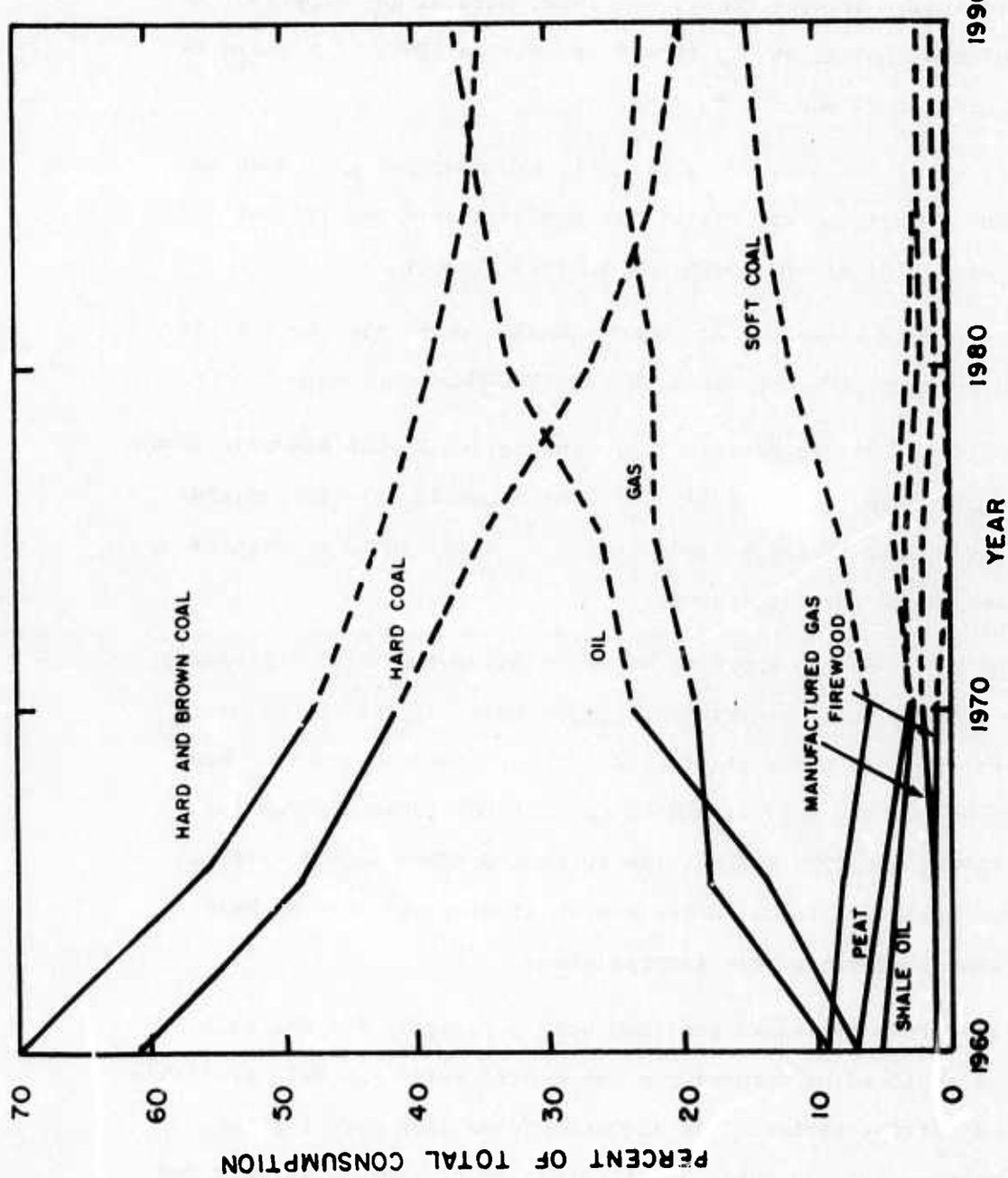

Figure A-13
FUEL CONSUMPTION OF USSR ELECTRIC POWER SECTOR BY TYPE OF FUEL

190 million metric tons of coal equivalent. In forecasting gas consumption in the electric power section, we have assumed that no sizable increases will occur after 1985. This is because the natural gas will become too valuable a fuel for electric station use--similar to what is happening in the United States already today. In 1970, natural gas supplied 19 percent of the fuel input, up from 9 percent in 1960. Its share is expected to peak at 24 percent in 1985.

The other fuels (wood, shale oil, manufactured gas) used in electric power generation are relatively insignificant and they are expected to remain of minor importance in future years.

Table A-19 shows the compound annual growth rates by fuel for all the five-year periods between 1960 and 1990 (based on Table A-18).

Soviet-published data on fuel consumption by the electric power sector are incomplete. Up to 1961, the USSR reported this information for the public sector to the United Nations.[5] After that, no regular or consistent series has been released.

SRI has used the approach of calculating the total fuel energy input into electric power generation, including steam and hot water production in electric power stations for the historical years. These totals could be checked and calibrated against published figures for 1960, 1965, 1970, and 1975 (Plan). An estimated percentage breakdown into types of fuels was found in the Soviet literature[6] for the same years. Intermediate years were interpolated.

Since this breakdown provided only a category for gas as a whole, it was replaced by natural gas and manufactured gas data available in the United Nations series.[7] An adjustment was then made for the difference between the two total gas figures, which appears largely due

Table A-19

ENERGY GROWTH RATES IN USSR ELECTRIC POWER SECTOR BY TYPE OF FUEL
(Percent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS		23.20	7.98	9.60	6.42	6.63	.86
SUB TOTAL		23.20	7.98	9.60	6.42	6.63	.86
OIL PRODUCTS							
LPG							
GASOLINE							
KEROSENE/JET FUEL							
DISTILLATE							
RESIDUAL F/O		22.65	18.36	8.58	11.73	6.63	2.28
SUB TOTAL		22.65	18.36	8.58	11.73	6.63	2.28
SOLID FUELS							
HARD COAL		4.57	2.33	3.10	.59	.55	.48
SOFT COAL		4.56	1.85	12.45	14.40	7.45	3.76
PEAT		.96	-1.88	0.82	0.00	0.00	0.00
FIRE WOOD		4.49	-4.30	-2.04	-1.14	-1.21	-1.28
SHALE OIL		19.32	8.32	5.01	.82	.53	.51
SUB TOTAL		4.52	2.06	4.77	3.45	2.63	1.66
OTHER							
HYDRO		7.24	6.20	4.21	5.64	4.98	4.83
NUCLEAR				45.93	30.60	23.96	20.96
SUB TOTAL		7.24	6.79	6.60	10.44	12.19	14.05
ELECTRIC POWER							
ELECTRICITY							
SUB TOTAL							
SECONDARY ENERGY							
MANUFACTURED GAS		2.82	1.72	1.81	1.76	1.61	1.49
STEAM FROM ELEC POW							
SUB TOTAL		2.82	1.72	1.81	1.76	1.61	1.49
SECONDARY SOLID FUEL							
SOLID -COKE							
SUB TOTAL							
TOTAL		8.31	6.04	6.60	6.99	6.13	4.65

to the use of different calorific values for natural gas.* This difference amounted to 3.6 percent in 1971, which is well within the margin of error of the estimates.†

The data employed in calculating fuel input into the electric power sector is shown in Table A-20. It consists, in principle, of determining the net thermal electricity generation in public and large industrial power stations as well as their net heat (steam and how water) production. These were then multiplied with the appropriate specific fuel consumption.

The future total fuel requirements of the electric power sector were determined with the same method.

3. Transportation Forecast

Forecasts on energy requirements for the transportation, commercial, residential, agriculture and military sectors are difficult to establish. In order to establish highly reliable forecasts for each of these sectors one would need to know details on political and economic activity in each sector, for example projected new housing starts, mix of automobile, number of new airplanes, etc. Because reliable forecasts on all these factors are not available we correlated total energy consumption in a sector to economic activity in the sector; for historical data there appeared to be a good correlation with these indices. Based on five year plans a forecast was made for the index and in turn energy requirements were projected for each sector. The components of energy

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* Gross versus net calorific value. SRI has used net heat values, which are around 8,300 kcal per cubic meter for natural gas.

† SRI's calculated adjusted total fuel input for 1960 and 1965 are 1 percent lower than figures quoted in Energetika SSSR, and for 1970 are 3.5 percent lower.

Table A-20

FUEL USE IN ELECTRIC POWER GENERATION AND STEAM GENERATION IN ELECTRIC POWER PLANTS

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Gross production of electricity and heat																
Total production of electricity ($KWh \times 10^9$)	292.3	327.6	369.3	412.4	458.9	506.7	544.6	587.7	638.7	689.1	740.9	800.4	1065	1526	2101	2745
Centralized	257.5	289.1	327.3	376.6	424.6	470.3	508.9	551.7	606.3	658.3	711.5	772.0	1037	1498	2073	2717
Hydro	50.9	59.1	71.9	75.9	77.4	81.4	91.8	88.6	104.0	115.2	124.4	126.1	165*	217	277	350
Nuclear	--	--	--	--	--	--	1.6	1.8	2.5	2.9	3.5	4.5	25*	95	278	720
Gross production--centralized thermal (public & large industrial)	206.6	230.0	255.4	300.7	347.2	388.9	415.5	464.3	199.8	540.2	583.6	641.4	847	1186	1518	1647
Total thermal production of electricity	241.4	268.5	297.3	336.6	381.5	425.2	451.1	497.3	532.1	571.0	613.0	669.8	875*	1214	1546	1675
Public stations	175.4	192.8	215.4	257.4	323.2	363.2	390.0	438.7	472.5	511.9	555.0	610.8	817*	1156	1488	1617
Large industrial stations	31.2	37.2	40.0	43.3	24.0	25.7	25.5	25.6	27.3	28.3	28.6	30.6	30	30	30	30
Small industrial stations	34.8	38.5	41.9	35.9	34.3	36.3	35.6	33.0	32.3	30.8	29.4	28.4	28	28	28	28
Total heat production (steam-hot water/ Gcal x 10^6)	212	242*	290*	340*	400*	465	503*	549*	593*	643	699	748*	970	1290	1590	1700
Public stations	145	171	191	223*	263*	308	344*	380*	424*	470	507	550*	760	1080	1380	1490
Large industrial	67	71	99	117	137	157	159	169	169	173	192	198	210	210	210	210
Net production of electricity																
Public stations - gross ($KWh \times 10^9$)	175.4	192.8	215.4	257.4	323.2	363.2	390.0	438.7	472.5	511.9	555.0	610.8	817*	1156	1488	1617
Self-use in electric power	10.7	11.6	12.5	15.2	19.4	21.8	23.0	25.4	26.9	28.2	29.4	31.6	41	58	74	81
Percent of gross	6.1	6.0	5.8	5.9	8.0	6.0	5.9	5.8	5.7	5.5	5.3	5.2	5.0	5.6	5.0	5.0
Self-use in heat ($KWh \times 10^9$)	3.7	4.4	4.9	5.8	7.0	8.3	9.4	10.5	12.1	13.3	14.3	15.6	22	31	41	45
KWh/Gcal	25.7	25.8	25.8	26.2	26.5	27.0	27.2	27.6	28.5	28.2	28.2	28.4	28.8	28.9	30.0	30.0
Net electricity produced	161.0	176.8	198.0	236.4	296.8	333.1	357.6	402.8	433.5	470.4	511.3	563.4	754	1067	1373	1491
Large industrial - gross ($KWh \times 10^9$)	31.2	37.2	40.0	43.3	24.0	25.7	25.5	25.6	27.3	28.3	28.6	30.6	30	30	30	30
Self-use in electric production	2.0	2.4	2.6	2.8	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	2	2	2	2
Percent of gross	6.59*	6.5	6.4	6.4	6.3	6.2	6.2	6.1	6.1	6.0	5.9	5.9	5.6	5.6	5.6	5.6
Self-use in heat* ($KWh \times 10^9$)	1.7	1.8	2.6	3.1	3.6	4.2	4.3	4.7	4.8	4.9	5.4	5.6	6	6	6	6
KWh/Gcal	25.7	25.8	25.8	26.2	26.5	27.0	27.2	27.6	28.5	28.2	28.2	28.4	28.8	28.9	30.0	30.0
Net electricity produced	27.5	33.0	34.8	37.4	18.9	19.9	19.6	19.3	20.8	21.7	21.5	23.2	22	22	22	22

Table A-20 (concluded)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Net electricity produced (continued)																
Small industrial - gross	34.8	38.5	41.9	35.9	34.3	36.3	35.6	33.0	32.3	30.8	29.4	28.4	28	28	28	28
Self-use	2.6	2.9	3.1	2.7	2.5	2.6	2.6	2.3	2.3	2.2	2.0	1.9	2	2	2	2
Percent of gross	7.5	7.5	7.4	7.4	7.3	7.2	7.2	7.1	7.1	7.0	6.9	6.8	6.5			
Net electricity produced	32.2	35.6	38.8	33.2	31.8	33.7	33.0	30.7	30.0	28.6	27.4	26.3	26	26	26	26
Fuel Consumption																
Public stations																
Electricity: spec. cons. (kg C.E. per net KWh)	0.468	0.459	0.448	0.438	0.428	0.415	0.405	0.394	0.385	0.377	0.367	0.359	.344	.340	.340	.340
x C x 10^6 KWh	161.0	176.8	198.0	236.4	296.8	333.1	357.6	402.8	433.5	470.4	511.3	563.1	754	1067	1272	1191
= fuel consumption (TCE x 10^6)	75.3	81.2	88.7	103.5	127.0	138.2	141.8	158.7	166.9	177.3	187.6	202.3	259	362	467	307
Heat: spec.cons. (TCE per Gcal)	0.1812	0.1802	0.1794	0.1791	0.1792	0.1781	0.1777	0.1770	0.1766	0.1765	0.1757	0.1751	0.176	.175	.175	.175
x A x Gcal x 10^6	145.0	171.0	191.0	223.0	263.0	308.0	344.0	380.0	424.0	470.0	507.0	550.0	760	1080	1380	1490
= fuel consumption (TCE x 10^6)	26.3	30.8	34.3	40.0	47.1	54.9	61.1	67.3	74.9	83.0	89.1	96.3	134	189	242	261
Total public stat. (TCE x 10^6)	101.6	112.0	123.0	143.5	174.1	193.1	205.9	226.0	241.8	260.3	276.7	298.6	393	552	709	768
Large industrial stations																
Electricity: spec. cons. (kg C.E. per net KWh)*	0.650*	0.620	0.585	0.555	0.525	0.500*	0.475	0.455	0.435	0.420	0.400*	0.380	.365	.360	.360	.360
x D x 10^6 KWh	27.5	33.0	34.8	37.4	18.9	19.9	19.6	19.3	20.8	21.7	21.5	23.2	22	22	22	22
= fuel consumption (TCE x 10^6)	17.9	20.5	20.1	20.8	9.9	10.0	9.3	8.8	9.0	9.1	8.6	8.8	8	8	8	8
Heat: spec. cons. (kg C.E. per net KWh)*	0.1812	0.1802	0.1794	0.1791	0.1792	0.1781	0.1777	0.1770	0.1766	0.1765	0.1757	0.1751	0.176	.175	.175	.175
x B x Gcal x 10^6	67.0	71.0	99.0	117.0	137.0	157.0	159.0	169.0	169.0	173.0	192.0	198.0	210	210	210	210
= fuel consumption (TCE x 10^6)	12.1	12.8	17.8	21.0	24.6	28.0	28.3	29.9	29.8	30.5	33.7	34.7	37	37	37	37
Total large industrial stat. (TCE x 10^6)	30.0	33.3	48.2	41.8	34.5	38.	37.6	38.7	38.8	39.6	42.3	43.5	45	45	45	45
Small industrial stations																
Electricity: spec. cons. (kg C.E. per net KWh)*	0.725*	0.695	0.670	0.645	0.625	0.600*	0.575	0.555	0.535	0.520	0.500*	0.485	.465	.460	.460	.460
x E x 10^6 KWh	32.2	35.6	38.8	33.2	31.8	33.7	33.0	30.7	30.0	28.6	27.4	26.5	26	26	26	26
= fuel consumption (TCE x 10^6)	23.3	24.7	26.0	21.4	19.9	20.2	19.0	17.0	16.1	14.9	13.7	12.9	12	12	12	12
Grand total fuel consumption (TCE x 10^6)	154.9	170.0	187.2	206.7	228.5	251.3	262.5	281.7	296.7	314.8	332.7	355.0	450	609	766	825
SRI with natural gas adjusted	158.5	172.2	185.1	203.6	220.9	237.9	252.9	270.1	283.7	300.1	317.4	342.1	437	597	758	825

* Estimated. Years in between interpolated based on average annual decreasing rate.

Sources: USSR Statistical Yearbooks; Energetika SSSR v 1971-1975; Elektrifikatsia SSSR (Electrification of the USSR), "Energiia, Moscow, 1970; Industry of the USSR. 1964 Statistical Annual.

within the sector were then assumed to follow the historical percentage relationships. Following are certain details on the forecasts for the transportation, commercial, residential, agriculture and military sectors.

The total energy for transportation was estimated on the basis of a transportation index, which was the freight turnover. Oil is the largest component (87 percent), and it was calculated by difference after estimating natural gas. The composition of oil was estimated by trend analysis of percentage distribution of oil concerned. Table A-21 presents historical and forecast consumption of energy in the USSR for the transportation sector.

4. Commercial Forecast

The total commercial consumption of energy was estimated from correlations with the commercial index. Solid fuels, steam from electric power, and solid coke were estimated by trend analysis. Solid fuels were assumed not to be used after 1980. Gas was calculated by extrapolating growth rates; oil was then calculated by difference. Table A-22 presents energy consumption for the commercial sector.

5. Residential Forecast

The total residential use was again forecast by correlation to residential index. Gas, steam, and solid coke were forecast by trend analysis. It was assumed that the use of coal in residences would decrease. Oil was calculated by difference and oil products were forecast by analysis of trends. Table A-23 presents energy consumption for the residential sector.

6. Agriculture Forecast

Oil is the major input to this sector. Electricity, gas, and solid fuels were forecast on the basis of trend analysis. The total was

Table A-21

ENERGY CONSUMPTION OF USSR TRANSPORTATION SECTOR IN HEAT UNITS
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	254.	447.	888.	1500.	2300.	2800.	3700.
SUB TOTAL	254.	447.	888.	1500.	2300.	2800.	3700.
OIL PRODUCTS							
LPG							
GASOLINE	17055.	25171.	33430.	46067.	62637.	84122.	112877.
KEROSENE/JET FUEL	11128.	13828.	20559.	29144.	37071.	44636.	55287.
DISTILLATE	1035.	4341.	8074.	11282.	17896.	27468.	41465.
RESIDUAL F/O	1953.	3802.	5914.	7521.	10226.	15451.	20733.
SUB TOTAL	31171.	47143.	67978.	94013.	127830.	171678.	230362.
SOLID FUELS							
HARD COAL	11880.	2416.	1232.	900.			
SOFT COAL	4519.	1368.	802.	400.			
PEAT							
FIRE WOOD	805.	945.	735.	200.	0.	0.	0.
SHALE OIL							
SUB TOTAL	17204.	4729.	2769.	1500.	0.	0.	0.
OTHER							
HYDRO							
NUCLEAR							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
ELECTRIC POWER							
ELECTRICITY	2205.	4634.	6795.	9438.	13675.	18875.	24688.
SUB TOTAL	2205.	4634.	6795.	9438.	13675.	18875.	24688.
SECONDARY ENERGY							
MANUFACTURED GAS							
STEAM FROM ELEC POW							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
SECONDARY SOLID FUEL							
SOLID -COKE							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
TOTAL	50835.	56953.	78430.	106451.	143805.	193353.	258750.

Table A-22

ENERGY CONSUMPTION OF USSR COMMERCIAL SECTOR IN HEAT UNITS
(Thousand tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS		12136.	22059.	34725.	52215.	74961.	105137.
SUB TOTAL	0.	12136.	22059.	34725.	52215.	74961.	105137.
OIL PRODUCTS							
LPG							
GASOLINE							
KEROSENE/JET FUEL	1783.	1921.	2856.	9434.	14723.	20519.	26696.
DISTILLATE	489.	1520.	2024.	6226.	9717.	13543.	17619.
RESIDUAL F/O	391.	760.	1183.	3207.	5006.	6976.	9077.
SUB TOTAL	2662.	4201.	6063.	18867.	29446.	41038.	53392.
SOLID FUELS							
HARD COAL	4140.	4922.	2464.	1000.	500.		
SOFT COAL	1570.	2736.	1684.	1000.	500.		
PEAT	1295.	781.	996.	500.	0.	0.	0.
FIRE WOOD	6685.	7735.	6160.	2000.	1000.		
SHALE OIL							
SUB TOTAL	13691.	16175.	11294.	4500.	2000.	0.	0.
OTHER							
HYDRO							
NUCLEAR							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
ELECTRIC POWER							
ELECTRICITY	2091.	3353.	5068.	7638.	10813.	15650.	21375.
SUB TOTAL	2091.	3353.	5068.	7638.	10813.	15650.	21375.
SECONDARY ENERGY							
MANUFACTURED GAS	571.	196.					
STEAM FROM ELEC POW	2000.	5929.	11357.	18291.	26875.	37693.	50442.
SUB TOTAL	2571.	6125.	11357.	18291.	26875.	37693.	50442.
SECONDARY SOLID FUEL							
SOLID -COKE	8435.	10958.	11000.	11500.	12000.	12500.	13000.
SUB TOTAL	8435.	10958.	11000.	11500.	12000.	12500.	13000.
TOTAL	29450.	52949.	66846.	95521.	133348.	181843.	243347.

Table A-23

ENERGY CONSUMPTION OF USSR RESIDENTIAL SECTOR IN HEAT UNITS
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	6829.	5271.	9002.	13000.	17500.	22000.	26000.
SUB TOTAL	6829.	5271.	9002.	13000.	17500.	22000.	26000.
OIL PRODUCTS							
LPG	917.	4195.	7204.	9489.	12123.	16087.	22055.
GASOLINE							
KEROSENE/JET FUEL	1783.	3841.	5711.	7299.	9325.	12374.	16966.
DISTILLATE	896.	2522.	6519.	7542.	9636.	12787.	17531.
RESIDUAL F/O							
SUB TOTAL	3596.	10558.	19435.	24330.	31085.	41248.	56552.
SOLID FUELS							
HARD COAL	2070.	2416.	792.	300.	0.	0.	0.
SOFT COAL	766.	1368.	561.	200.			
PEAT	648.	372.	493.				
FIRE WOOD	3465.	4025.	3185.	3000.	2000.	1000.	
SHALE OIL							
SUB TOTAL	6949.	8181.	5031.	3500.	2000.	1000.	0.
OTHER							
HYDRO							
NUCLEAR							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
ELECTRIC POWER							
ELECTRICITY	1711.	3078.	5068.	7950.	11713.	17650.	25088.
SUB TOTAL	1711.	3078.	5068.	7950.	11713.	17650.	25088.
SECONDARY ENERGY							
MANUFACTURED GAS	319.	111.	45.				
STEAM FROM ELEC POW	2000.	5928.	11357.	17000.	24000.	30000.	36000.
SUB TOTAL	2319.	6039.	11402.	17000.	24000.	30000.	36000.
SECONDARY SOLID FUEL							
SOLID -COKE	8435.	10958.	11006.	12000.	12500.	13000.	13500.
SUB TOTAL	8435.	10958.	11006.	12000.	12500.	13000.	13500.
TOTAL	29839.	44086.	60943.	77780.	98798.	124898.	157140.

estimated on the basis of an index, and oil was then calculated by difference. Table A-24 presents energy consumption for the agriculture sector.

7. Military Forecast

Oil is the major input to this sector and is used primarily for transportation. Oil and solid fuels were forecast on the basis of trend analysis. Table A-25 presents energy consumption for the military sector.

Table A-21

ENERGY CONSUMPTION OF USSR AGRICULTURE SECTOR IN HEAT UNITS
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	199
GAS PRODUCTS							
NATURAL GAS		268.	841.	1000.	1200.	1500.	2000.
SUB TOTAL	0.	268.	841.	1000.	1200.	1500.	2000.
OIL PRODUCTS							
LPG							
GASOLINE	8527.	12585.	16716.	21556.	26895.	33494.	41172.
KEROSENE/JET FUEL	6419.	1920.	2855.	3170.	3718.	4433.	5086.
DISTILLATE	11977.	23806.	29635.	38674.	48491.	60585.	74835.
RESIDUAL F/O							
SUB TOTAL	26924.	38311.	49206.	63399.	79104.	98513.	121093.
SOLID FUELS							
HARD COAL							
SOFT COAL							
PEAT	4229.	2492.	3265.	2200.	1500.	500.	0.
FIRE WOOD							
SHALE OIL							
SUB TOTAL	4229.	2492.	3265.	2200.	1500.	500.	0.
OTHER							
HYDRO							
NUCLEAR							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
ELECTRIC POWER							
ELECTRICITY	1246.	2637.	4819.	9375.	16088.	24425.	34850.
SUB TOTAL	1246.	2637.	4819.	9375.	16088.	24425.	34850.
SECONDARY ENERGY							
MANUFACTURED GAS							
STEAM FROM ELEC POW							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
SECONDARY SOLID FUEL							
SOLID -COKE							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
TOTAL	32399.	43709.	58131.	75974.	97892.	124938.	157943.

Table A-[illegible]

ENERGY CONSUMPTION OF USSR MILITARY SECTOR IN HEAT UNITS
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
OIL PRODUCTS							
LPG							
GASOLINE	2842.	4195.	5571.	7217.	8883.	10487.	12180.
KEROSENE/JET FUEL	7419.	9218.	13706.	16402.	19697.	21848.	23873.
DISTILLATE	5564.	4715.	3502.	3609.	3476.	3933.	4385.
RESIDUAL F/O	1562.	3041.	4732.	5577.	6566.	7428.	8282.
SUB TOTAL	17388.	21171.	27511.	32805.	38622.	43697.	48720.
SOLID FUELS							
HARD COAL	2790.	1432.	968.	250.			
SOFT COAL	1034.	836.	682.	750.	0.	0.	0.
PEAT							
FIRE WOOD							
SHALE OIL							
SUB-TOTAL	3824.	2268.	1650.	1000.	0.	0.	0.
OTHER							
HYDRO							
NUCLEAR							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0.
ELECTRIC POWER							
ELECTRICITY							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0
SECONDARY ENERGY							
MANUFACTURED GAS							
STEAM FROM ELEC POW							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0
SECONDARY SOLID FUEL							
SOLID -COKE							
SUB TOTAL	0.	0.	0.	0.	0.	0.	0
TOTAL	21212.	23439.	29160.	33805.	38622.	43697.	48720

V ENERGY CONSUMPTION OF CMEA COUNTRIES

A. Summary

The primary energy consumption of the combined Eastern Bloc or CMEA* countries is approximately 40 percent of the total consumption in the USSR. Figure A-14† shows the historical and forecast energy consumption for the various Eastern Bloc countries. From this figure, we see that Poland consumes the most energy, followed by East Germany (German Democratic Republic), Czechoslovakia, Romania, Bulgaria, and Hungary. The total consumption of energy in the Eastern Bloc is less than the consumption of energy by the USSR's industrial sector. The energy consumption of Poland or East Germany or Czechoslovakia is approximately the same size as the consumption of energy in the USSR's transportation sector. The energy consumption of Romania, Bulgaria, and Hungary is less than that of most economic sectors in the USSR. Because of the relative size of each country in the total energy picture, we will forecast only the primary energy in those countries.

Figure A-15 shows the relative importance of the various fuels in the economy of the CMEA countries, where coal is and will continue to be the largest source of primary energy. In 1970 coal represented 71.6 percent of the total primary energy; in 1990 the value will still be a healthy 43.4 percent.

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* CMEA--Council for Mutual Economic Assistance. Other synonyms for Eastern Bloc or CMEA countries are: Soviet Bloc; COMECON countries. In this part of the report, CMEA is used to refer to Eastern European countries other than the USSR.

† Figures in this section were derived from the tabular data for each country developed by SRI.

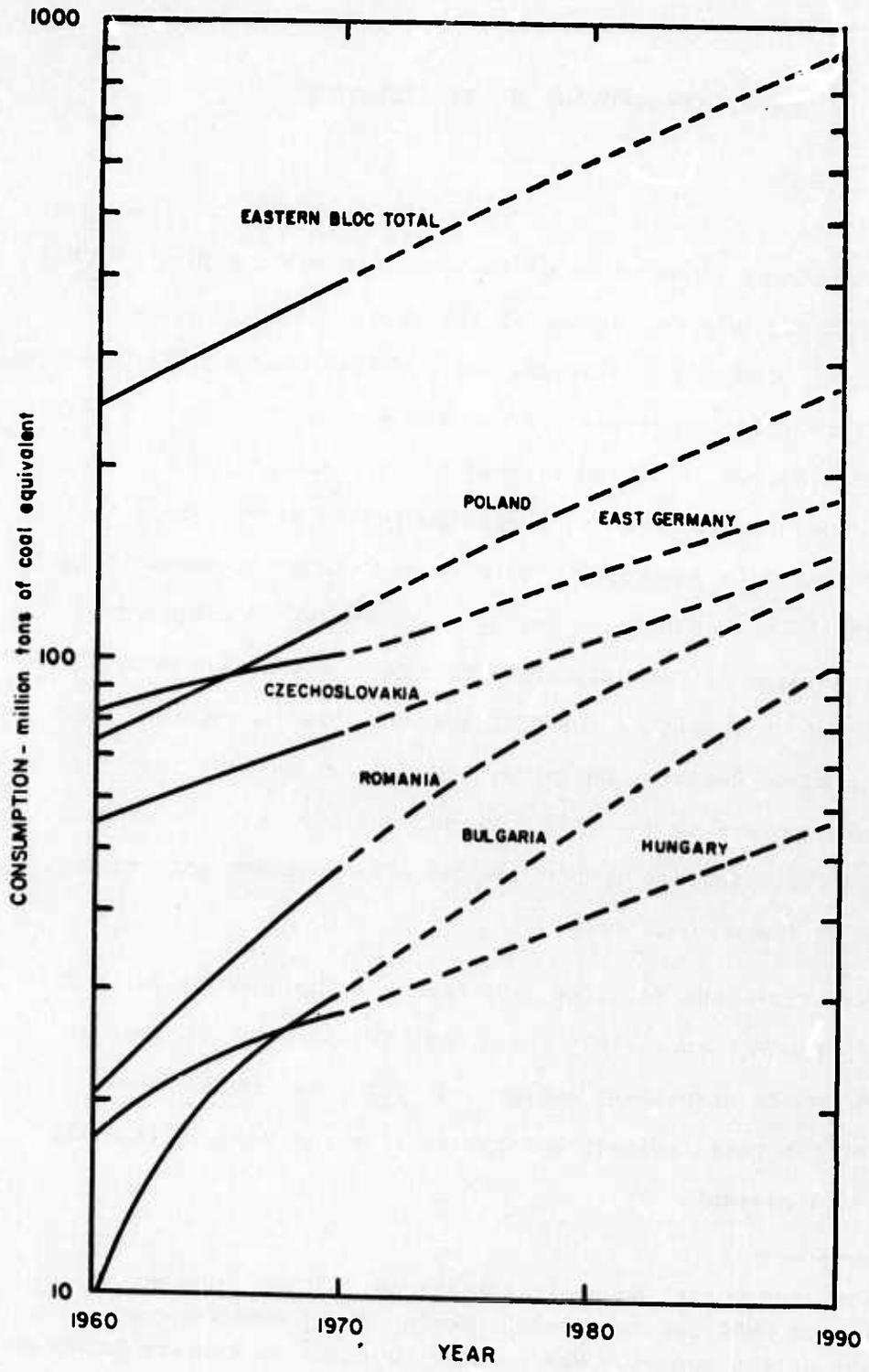

Figure A-14
NET INTERNAL CONSUMPTION OF PRIMARY ENERGY
IN CMEA COUNTRIES

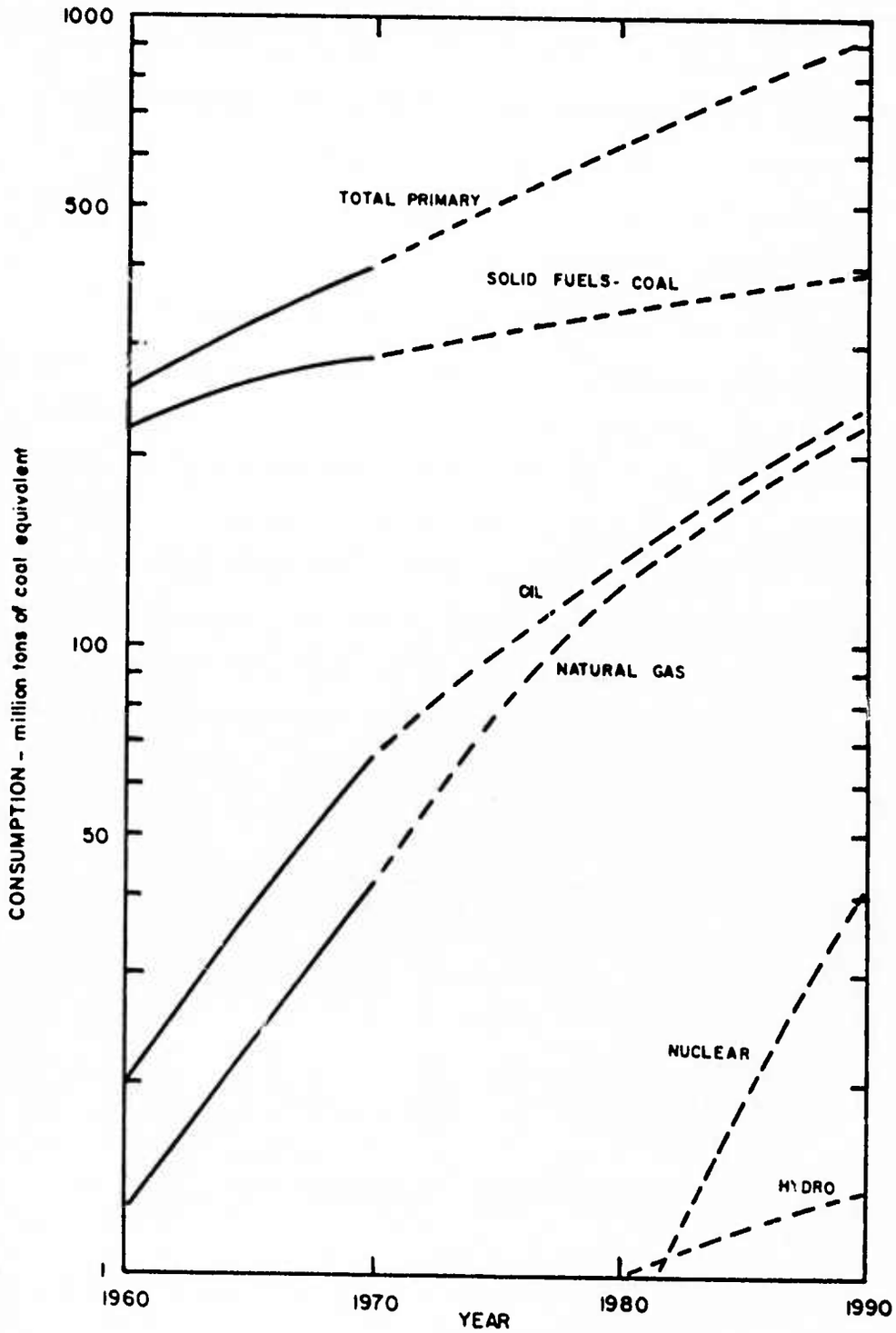

Figure A-15
PRIMARY ENERGY CONSUMPTION IN CMEA COUNTRIES

Shown on the following pages are three summary tables on energy consumption of the CMEA countries. Table A-26 gives heat values in thousand tons of coal equivalent, Table A-27 gives percentages, and Table A-28 gives growth rates of the various fuels.

B. Country by Country Forecast

The basic forecast consists of two parts, a forecast of total primary energy, followed by an allocation of energy components of oil, coal, gas, hydro and nuclear. The forecast for total primary energy was based on the relationship between gross national product and energy consumption. Nuclear and hydroelectric power forecasts are based primarily upon current production and proposed construction plans. The basic allocation of oil and gas was based upon a trend extrapolation. As mentioned previously, the Central Planners have made estimates of their oil and gas requirements for their countries (see Table A-29). These trend extrapolations were

Table A-29

FORECAST BY CENTRAL PLANNERS
(Percent of Primary Fuel)

	1975		1980	
	Gas	Oil	Gas	Oil
Bulgaria	2.5%	43.3	16.4	49.0%
Czechoslovakia	5	27	7	30
East Germany		23*		29*
Hungary			21.3	39.6
Poland	8.4	13.7	8.5	19
Romania		71.8*		65*

* Total of oil and gas.

Table A-26

ENERGY CONSUMPTION OF CMEA COUNTRIES IN HEAT UNITS
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	12903.	22815.	41813.	80778.	124093.	171803.	227459.
SUB TOTAL	12903.	22815.	41813.	80778.	124093.	171803.	227459.
OIL PRODUCTS							
LPG	197.	519.	1132.	1731.	2592.	3673.	5056.
GASOLINE	4672.	8059.	15369.	23161.	33919.	47940.	64092.
KEROSENE/JET FUEL	1690.	2334.	3343.	4986.	7187.	9438.	11844.
DISTILLATE F/O	6278.	11475.	20571.	29814.	42371.	57841.	75148.
RESIDUAL F/O	7758.	15081.	27455.	39164.	52964.	68610.	83821.
SUB TOTAL	20596.	37470.	67870.	98859.	139032.	187502.	239960.
SOLID FUEL							
HARD COAL	107171.	124253.	137646.	157224.	177106.	194631.	210701.
BROWN COAL	114436.	139644.	149569.	156819.	165327.	178063.	182474.
PEAT,ETC.	1350.	1354.	1470.	1727.	1820.	1940.	1979.
SUB TOTAL	222958.	265251.	288685.	315771.	344253.	374634.	395154.
OTHER							
HYDRO	2348.	3668.	4659.	7960.	9958.	11950.	13740.
NUCLEAR	0.	0.	186.	1154.	7352.	18695.	41900.
SUB TOTAL	2348.	3668.	4845.	9114.	17310.	30645.	55640.
TOTAL	258805.	329205.	403214.	504522.	624687.	764584.	918213.

Table A-27

ENERGY CONSUMPTION OF CMEA COUNTRIES IN PERCENTAGES

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	100.00	100.00	100.00	100.00	100.00	100.00	100.00
SUB TOTAL	4.99	6.93	10.37	16.01	19.86	22.47	24.77
OIL PRODUCTS							
LPG	.96	1.39	1.67	1.75	1.86	1.96	2.11
GASOLINE	22.69	21.51	22.64	23.43	24.40	25.57	26.71
KEROSENE/JET FUEL	8.21	6.23	4.93	5.04	5.17	5.03	4.94
DISTILLATE F/O	30.48	30.63	30.31	30.16	30.48	30.85	31.32
RESIDUAL F/O	37.67	40.25	40.45	39.62	38.09	36.59	34.93
SUB TOTAL	7.96	11.38	14.83	19.59	22.26	24.52	26.13
SOLID FUEL							
HARD COAL	48.07	46.84	47.68	49.79	51.45	51.95	53.32
BROWN COAL	51.33	52.65	51.81	49.66	48.02	47.53	46.18
PEAT,ETC.	.61	.51	.51	.55	.53	.52	.50
SUB TOTAL	86.15	80.57	71.60	62.59	55.11	49.00	43.04
OTHER							
HYDRO	100.00	100.00	96.17	87.34	57.53	38.99	24.69
NUCLEAR	0.00	0.00	3.83	12.66	42.47	61.01	75.31
SUB TOTAL	.91	1.11	1.20	1.81	2.77	4.01	6.06
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table A-28

GROWTH RATES OF VARIOUS FUELS IN CMEA COUNTRIES
(Percent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS		12.07	12.88	14.08	8.97	6.72	5.77
SUB TOTAL		12.07	12.88	14.08	8.97	6.72	5.77
OIL PRODUCTS							
LPG		21.39	14.87	8.86	8.41	7.22	6.60
GASOLINE		11.52	13.78	8.55	7.93	7.16	5.98
KEROSENE/JET FUEL		6.67	7.45	8.33	7.59	5.60	4.65
DISTILLATE F/O		12.82	12.38	7.71	7.28	6.42	5.37
RESIDUAL F/O		14.22	12.73	7.36	6.22	5.31	4.09
SUB TOTAL		12.71	12.62	7.81	7.06	6.16	5.06
SOLID FUEL							
HARD COAL		3.00	2.07	2.70	2.41	1.91	1.66
BROWN COAL		4.06	1.38	.95	1.06	1.50	.49
PEAT,ETC.		.05	1.67	3.27	1.06	1.29	.39
SUB TOTAL		3.53	1.71	1.81	1.74	1.71	1.07
OTHER							
HYDRO		9.34	4.95	11.31	4.58	3.71	2.83
NUCLEAR				44.12	44.82	20.52	17.52
SUB TOTAL		9.34	5.72	13.47	13.69	12.10	12.67
TOTAL		4.93	4.14	4.58	4.37	4.12	3.73

then compared with the estimates given by the central planners. If the trend and central planners' values were essentially the same, then the trend values were used; elsewhere a compromise between these two values was accepted. The majority of the forecasts agreed closely with the central planners' estimates.

In most Eastern Bloc countries, coal is the dominant fuel and can be used as a substitute or swing fuel. To maintain accuracy in forecasting, the fuels with the lowest consumption were subtracted from the total to obtain the swing fuel. The swing fuel as computed was then compared with a trend extrapolation to assure continuity. Following are certain details on the forecast for each country.

1. Bulgaria

Bulgaria has ambitious plans for hydroelectric and nuclear power, as presented in electric power Section VI. Gas was forecast on the basis of trend extrapolation and recent 1973 reports of consumption.[8] The oil was forecast by similar methods. Coal was computed by difference. The calculated value for coal was then plotted to assure a consistent trend and compared against the forecast by central planners. Table A-30 presents the forecast for energy consumption of Bulgaria by fuel type.

2. Czechoslovakia

Czechoslovakia is a relatively developed economic country. Because of its larger base, its growth rate in primary energy will be less than those of less developed ones. Nuclear power will begin to be a significant energy supplier in 1970. Coal, the major supplier of energy, will maintain its dominance through 1990.

In forecasting, gas and oil were forecast by trend extrapolation and compared to central forecasts. Solid fuels, the largest component, were calculated by difference. The growth rates in coal and forecasts

Table A-30

NET INTERNAL CONSUMPTION IN HEAT UNITS-BULGARIA
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS		86.1	559.3	3550.3	9171.7	13808.0	20051.7
SUB TOTAL	0.0	86.1	559.3	3550.3	9171.7	13808.0	20051.7
OIL PRODUCTS							
LPG	1.7	1.7	10.0	51.0	141.0	310.0	570.0
GASOLINE	495.0	780.0	2086.5	3230.0	4600.0	6510.0	8350.0
KEROSENE/JET FUEL	29.4	124.9	197.0	340.0	690.0	930.0	1140.0
DISTILLATE F/O	65.2	906.3	2511.4	3740.0	5520.0	8060.0	10640.0
RESIDUAL F/O	771.4	3030.2	6858.3	9639.0	12029.0	15190.0	17290.0
SUB TOTAL	1362.8	4843.1	11663.2	17000.0	23000.0	31000.0	38000.0
SOLID FUEL							
HARD COAL	311.6	2515.1	4356.9	6835.1	8085.1	10116.9	12092.7
BROWN COAL	6933.0	12234.0	12390.5	12693.7	13766.4	16506.5	18914.2
PEAT,ETC.				0.0	0.0	0.0	0.0
SUB TOTAL	7244.6	14749.1	16747.4	19528.8	21851.5	26623.3	31007.0
OTHER							
HYDRO	754.4	800.0	860.8	1600.0	2300.0	2800.0	3200.0
NUCLEAR				154.0	1000.0	2480.0	8000.0
SUB TOTAL	754.4	800.0	860.8	1754.0	3300.0	5280.0	11200.0
TOTAL	9361.8	20478.3	29830.7	41839.1	57323.2	76711.4	100258.7

for coal were then compared with national plans to arrive at a firm foundation for forecasting. The energy consumption forecast for Czechoslovakia is shown in Table A-31.

3. East Germany

East Germany, a developed economic nation, is highly dependent on coal. Recent internal production of gas[8] will shift this trend but coal will still maintain its dominance through 1990. Nuclear power again will become significant starting in 1980.

Gas was forecast using recent 1973 values and comparing them with planned gas consumption and known reserve. Oil was forecast by trend extrapolation and comparison to planned values. Coal was computed by difference and again compared with the central planners' forecast to assure consistency. The energy consumption forecast for East Germany is presented in Table A-32.

4. Hungary

Hungary is a relatively small country, and like most Eastern Bloc countries, depends on coal as its principal energy source. Because of its relatively low reserves of all fuels and ease of transport of oil and gas, the energy consumption pattern will change over the next 20 years. Oil and gas will grow much more rapidly than coal.

In our analysis, oil and gas were forecast using trend analysis and forecasts by central planners. The swing fuel, coal, was computed by difference and compared with the central planners' forecast. The energy consumption forecast for Hungary is shown in Table A-33.

5. Poland

Poland is the largest consumer of energy in the Eastern Bloc and has significant coal reserves. In 1970 coal consumption represented

Table A-31

NET INTERNAL CONSUMPTION IN HEAT UNITS--CZECHOSLOVAKIA
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	1515.1	1065.5	2773.0	4605.2	7657.4	11634.7	15208.6
SUB TOTAL	1515.1	1065.5	2773.0	4605.2	7657.4	11634.7	15208.6
OIL PRODUCTS							
LPG	21.7	83.5	83.5	160.0	275.0	409.0	559.0
GASOLINE	525.0	780.0	2086.5	3200.0	5250.0	7680.0	10320.0
KEROSENE/JET FUEL	367.5	558.6	939.3	1440.0	2250.0	3060.0	3870.0
DISTILLATE F/O	994.7	1854.6	2418.6	3520.0	5500.0	7680.0	9460.0
RESIDUAL F/O	903.5	2621.5	5051.3	7680.0	11725.0	15572.0	18791.0
SUB TOTAL	2812.4	5898.2	10579.2	16000.0	25000.0	34000.0	43000.0
SOLID FUEL							
HARD COAL	23035.0	24880.3	25335.1	27721.0	28480.1	29047.5	29666.2
BROWN COAL	25673.8	32068.3	36122.0	41406.0	44384.6	47250.6	50392.0
PEAT,ETC.	800.1	800.1	899.1	1054.7	1109.6	1161.9	1219.2
SUB TOTAL	49508.9	57748.8	62356.2	70179.7	73974.4	77460.0	81277.3
OTHER							
HYDRO	898.8	1782.4	1468.0	1160.0	1160.0	1160.0	1400.0
NUCLEAR				160.0	1600.0	5040.0	11200.0
SUB TOTAL	898.8	1782.4	1468.0	1320.0	2760.0	6200.0	12600.0
TOTAL	54735.3	66494.9	77176.3	92106.9	109391.8	129296.7	152085.9

Table A-32

NET INTERNAL CONSUMPTION IN HEAT UNITS-EAST GERMANY
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	17.7	97.9	1370.0	16816.1	27984.7	38930.3	52397.7
SUB TOTAL	17.7	97.9	1370.0	16816.1	27984.7	38930.3	52397.7
OIL PRODUCTS							
LPG	16.7	167.0	347.4	528.0	725.0	936.0	1242.0
GASOLINE	600.0	1489.5	2484.0	4180.0	5800.0	7560.0	10120.0
KEROSENE/JET FUEL	147.0	323.4	441.0	660.0	841.0	972.0	1196.0
DISTILLATE F/O	1859.1	3274.1	5247.5	7260.0	9280.0	11160.0	13800.0
RESIDUAL F/O	661.6	2395.0	6399.6	9372.0	12354.0	15372.0	19642.0
SUB TOTAL	3294.4	7649.0	14919.5	22000.0	29000.0	36000.0	46000.0
SOLID FUEL							
HARD COAL	8840.0	9428.2	7462.1	4797.5	4682.3	3879.0	3571.8
BROWN COAL	69176.4	76765.8	78174.4	75161.4	73356.5	73700.4	67865.0
HEAT,ETC.				0.0	0.0	0.0	0.0
SUB TOTAL	78016.4	86194.0	85636.7	79959.0	78038.8	77579.4	71436.8
OTHER							
HYDRO	249.0	314.0	500.4	500.0	500.0	500.0	500.0
NUCLEAR			185.4	840.0	4400.0	9200.0	16800.0
SUB TOTAL	249.0	314.0	686.0	1340.0	4900.0	9700.0	17300.0
TOTAL	81576.5	94254.9	102612.2	120115.1	139923.5	162209.7	187134.5

Table A-33

NET INTERNAL CONSUMPTION IN HEAT UNITS--HUNGARY
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	350.5	1210.7	4198.4	6411.3	8902.4	11590.3	15486.3
SUB TOTAL	350.5	1210.7	4198.4	6411.3	8902.4	11590.3	15486.3
OIL PRODUCTS							
LPG	25.0	59.4	213.9	253.0	360.0	456.0	552.0
GASOLINE	412.5	533.5	1321.5	1870.0	2700.0	3610.0	4600.0
KEROSENE/JET FUEL	73.5	195.5	224.4	330.0	450.0	570.0	690.0
DISTILLATE F/O	1058.5	1516.2	2826.6	3960.0	5400.0	6840.0	8280.0
RESIDUAL F/O	1181.5	2325.5	3442.5	4587.0	6090.0	7524.0	9878.0
SUB TOTAL	2751.0	4678.2	8068.7	11000.0	15000.0	19000.0	23000.0
SOLID FUELS							
HARD COAL	3079.6	5192.7	4495.6	4561.7	4409.4	4386.2	4007.6
BROWN COAL	10695.2	12131.2	10546.1	11078.3	11264.4	11803.7	11381.5
OTHER	550.1	553.4	571.2	651.7	653.2	674.5	641.2
SUB TOTAL	14324.8	17877.3	15612.8	14291.7	16331.0	16862.5	16030.3
OTHER							
HYDRO	36.4	30.0	35.2	40.5	40.0	40.0	40.0
NUCLEAR				0.0	192.0	800.0	2800.0
SUB TOTAL	36.4	30.0	35.2	40.5	232.0	840.0	2840.0
TOTAL	17462.7	23796.2	27895.2	33743.4	40465.3	49292.7	57356.6

84 percent of total primary energy consumption. Coal will maintain its dominance in the energy consumption pattern through 1990. Our forecasts were thus based on the plans of the central planners and a trend extrapolation of other fuels.

The same calculation procedure was used in Poland as in other Eastern Bloc countries. The coal value was compared with plans to assure consistency. The energy consumption forecast for Poland is shown in Table A-34.

6. Romania

Romania is unique in the Eastern Bloc in being a large producer of gas. Gas represents 55 percent of total energy consumption in Romania. In forecasting energy demand, demand for gas was correlated against primary energy consumption. Oil was correlated against gas, and coal was calculated by difference. The forecasts were then compared with the forecasts by central planners to assure consistency. The energy consumption forecast for Romania is shown in Table A-35.

Table A-34

NET INTERNAL CONSUMPTION IN HEAT UNITS--POLAND
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	754.0	2036.3	6934.9	11964.3	18637.1	27604.6	38807.4
SUB TOTAL	754.0	2036.3	6934.9	11964.3	18637.1	27604.6	38807.4
OIL PRODUCTS							
LPG	6.7	28.4	153.6	329.0	547.9	911.0	1338.9
GASOLINE	1725.0	2388.0	3885.0	6251.3	9914.9	15734.6	22120.2
KEROSENE/JET FUEL	174.4	124.9	248.4	411.3	652.3	1035.2	1455.3
DISTILLATE F/O	362.5	1328.2	3285.9	5593.3	9132.2	14906.5	21538.1
RESIDUAL F/O	973.0	1979.4	2613.2	3966.0	5844.6	8819.7	11758.7
SUB TOTAL	3243.6	5848.9	10186.2	16450.9	26092.0	41406.9	58211.2
SOLID FUEL							
HARD COAL	69727.2	79179.2	91954.0	109328.0	126021.7	140643.9	154860.1
BROWN COAL	1050.0	4924.2	8551.8	10812.5	14002.4	17383.0	21117.3
PEAT,ETC.				0.0	0.0	0.0	0.0
SUB TOTAL	70777.2	84103.4	100505.8	120138.5	140024.1	158026.8	175977.4
OTHER							
HYDRO	261.2	365.2	754.8	1000.0	1458.0	2200.0	2600.0
NUCLEAR				0.0	160.0	800.0	1600.0
SUB TOTAL	261.2	365.2	754.8	1000.0	1618.0	3000.0	4200.0
TOTAL	75036.0	92351.8	118381.6	149553.7	186371.1	230038.3	277196.0

Table A-35

NET INTERNAL CONSUMPTION IN HEAT UNITS--ROMANIA
(Thousand Tons of Coal Equivalent)

ENERGY TYPE	1960	1965	1970	1975	1980	1985	1990
GAS PRODUCTS							
NATURAL GAS	10266.0	18320.7	25977.7	37294.3	51336.8	67413.8	84412.6
SUB TOTAL	10266.0	18320.7	25977.7	37294.3	51336.8	67413.8	84412.6
OIL PRODUCTS							
LPG	125.2	189.4	324.0	410.2	523.5	659.4	793.7
GASOLINE	915.0	2038.5	3505.5	4429.9	5653.9	7045.7	8572.2
KEROSENE/JET FUEL	896.7	1006.9	1290.7	1804.8	2303.4	2870.5	3492.4
DISTILLATE F/O	1928.5	2596.9	4363.0	5742.5	7538.5	9394.3	11429.4
RESIDUAL F/O	3266.5	2730.0	3070.5	4019.8	4920.9	6132.4	7461.0
SUB TOTAL	7131.9	8552.7	12553.7	16407.2	20940.2	26095.3	31748.9
SOLID FUEL							
HARD COAL	2178.0	3057.5	4042.4	3828.8	5042.3	5885.3	5762.8
BROWN COAL	908.0	1520.9	3784.0	5287.4	7563.4	9602.4	10702.4
PEAT,ETC.				0.0	0.0	0.0	0.0
SUB TOTAL	3086.0	4578.4	7826.5	9116.3	12605.7	15487.8	16465.2
OTHER							
HYDRO	148.9	376.9	1039.9	3660.0	4500.0	5250.0	6000.0
NUCLEAR				0.0	0.0	375.0	1500.0
SUB TOTAL	148.9	376.9	1039.9	3660.0	4500.0	5625.0	7500.0
TOTAL	20632.8	31828.7	47397.8	66477.8	89382.7	114621.8	140126.7

VI ENERGY SUPPLY-DEMAND BALANCE

A. Coal and Other Solid Fuels

1. Role

Hard coals, including anthracite and bituminous, and brown coals have played a major role in the development in nearly all sections of the USSR. In particular, continued Soviet industrial expansion depends on coal both as a primary source of power and as a source of raw material for chemical and metallurgical industries. Hard coals have characteristically been used for coking in metallurgical processes and other industrial applications where a high heat-content fuel is essential. Brown coals, on the other hand, have much lower heat content, and characteristically have been used for space heating as well as for fuel in electrical power stations.

A knowledge of the USSR's coal resources and production outlook is essential for an understanding of USSR industrial potential. Unfortunately, however, although there is literature available on the Soviet coal industry, it is not described in terms consistent with Western nomenclature, and no single reference source provides an authoritative study of how the coal industry functions or how well it performs. Further, the several reference sources do not indicate consistent information on either production or use. As a result, historical data on solid fuels production and sector end-use demand are not continuous over a time period sufficient to establish appropriate trends (i.e., ten years). In order to establish appropriate trends, Stanford Research Institute has made estimates where necessary to translate USSR data into information usable by Western standards, and where necessary to make up

for obviously lacking or inconsistent information. Where estimates were made, they were based on production or demand rates that would yield consistent trends over the time period under consideration.

One primary difference between USSR and Western coal production reporting is the point of reporting; USSR reports production of raw coal as mined (before cleaning) whereas in the West, production of marketable coal is reported.* Further, in the USSR about one-fourth of the total coal cleaned is treated after delivery to plants associated with the coking industry (ferrous metallurgy).[11] These factors can lead to overstatement of USSR coal use compared to Western use.

2. Losses

Loss for both hard and brown coals have been excessive in the USSR.[12] However, Soviet efforts are attempting to reduce these losses. For hard coals, most losses occur in handling and transport, where fines are lost in transit or by wind action. For brown coals, additional loss occurs because in some instances, partial decomposition occurs over a period of time. Losses of this nature approximated 20 percent of raw production for soft coal and 15 percent for hard coals in 1960. Trends in loss have been downward, reaching 10 to 15 percent in 1970.[13] With increased emphasis, future losses are expected to be even less.

Loss in cleaning will vary, of course, with the type of coal as well as with the degree of cleaning. Cleaning losses are illustrated in Table A-36 which indicates USSR historical average production of raw and cleaned coal by type for 1960 through 1967. In general, the total amount of cleaned coal is about 61 percent of the amount of raw coal--

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* UN Coal Statistics.

Table A-36

CLEANING OF COAL IN THE USSR
(Million Metric Tons)

	1960	1962	1963	1964	1965	1966	1967
Total raw coal cleaned	152.1	169.8	181.7	198.0	215.0	221.2	236.1
Total cleaned coal produced	95.1	105.6	113.1	119.6	129.4	135.?	143.0
Percent	62.5%	62.2	62.2	60.4	60.2	61.2	60.6%
Avg. percent (61.3)							
Raw coal at mine plants	116.8	132.2	141.9	158.0	171.9	181.0	195.7
Cleaned coal at mine plants	67.8	77.0	83.1	89.2	98.7	104.5	112.0
Percent	58.0%	58.2	58.6	56.5	56.4	57.7	57.2%
Avg. percent (57.5)							
Raw coal at coke-chemical plants	35.3	37.6	39.8	40.0	40.1	40.2	40.4
Cleaned coal at coke-chemical plants	27.3	28.6	30.0	30.4	30.7	30.8	31.0
Percent	77.3%	76.1	75.4	76.0	76.6	76.6	76.7%
Avg. percent (76.4)							
Raw coking coal at mine plants	63.2	73.4	79.0	85.0	89.8	90.8	90.6
Cleaned coking coal at mine plants	42.8	49.8	53.1	58.1	60.8	61.7	63.5
Percent	67.7%	67.8	67.2	68.4	67.7	68.0	70.1%
Avg. percent (68.1)							
Total raw coking coal	98.5	111.0	118.8	125.0	129.9	131.0	131.0
Cleaned coking coal	70.0	78.5	83.1	88.5	91.5	92.5	94.5
Percent	71.1%	70.7	69.9	70.8	70.4	70.6	72.1%
Avg. percent (70.8)							

Sources: National Technical Information Service, U.S. Department of Commerce, No. 26. Sec. 62F (Rev.).

or a loss of 39 percent in cleaning. A breakdown of this total is: coal cleaned at mine plants--about 58 percent of raw coal (a loss of 42 percent in cleaning); coking coal cleaned at mine plants--about 68 percent of raw coal (a loss of 32 percent in cleaning); and total cleaned coking coal--about 71 percent of raw coking coal (a loss of 29 percent in cleaning).*

3. Trends

Historically, coal has been the predominant primary energy source for electric power generation, industrial heat and power, and rail transportation. This situation is currently undergoing a change, with some coal energy uses being supplanted to various degrees by oil or gas. However, because coal is essential in some uses (i.e., metallurgy), because delivered energy cost may not always favor oil or gas, and because sufficient oil or gas may not be available where needed, coal demand is not expected to suffer a decline. Instead, in spite of the decreasing part played by coal in the energy fuel balance, the absolute amount of coal extracted will continue to increase and will reach very large figures. Coal will be mainly used as energy fuel for electric power generation plants, as technological fuel (coking coal) for metallurgical processes and machine construction, as feed for the chemical industry, and as fuel for domestic and communal demands.[14] Although projected total energy trends indicate a greater emphasis on oil and gas as energy sources, coal will remain an important energy source and continue to grow slowly.[15] This importance of coal is demonstrated by

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* SRI estimates from unclassified data, included in NIS 26 SEC 62F (Rev).

approximate relationships of coal to oil and gas and other energy projected by one source for 1980 compared with 1970. These relationships are shown below.[15] Although this projection shows coal demand trend slightly above that indicated by the Ninth Five-Year Plan, the overall future position of coal as fuel energy is well demonstrated.

Fuel Energy Production*	1970 Percent	1970 10^6TCE†	1980 Percent	1980 10^6TCE
Coal	36.1	456	27.6	524
Oil and natural gas	59.3	750	72.4	1,376
All other	4.6	58		
Total	100.0%	1,264	100.0%	1,900‡

* Fossil fuels, fuelwood, hydroelectric, nuclear.

† 10^6TCE = Million metric tons of coal equivalent fuel.

‡ Consumption of energy in 1980 projected as 1,650 × 10^6TCE. Difference is net of import and export.

Similar estimates of the projected USSR coal and coke production at specific points in time are shown in Table A-37 and Figure A-16 (reference 15). However, to project demand for coal by sector, it is necessary to develop historical end-use demand by type of coal. For the USSR, continuous published records of cleaned coal produced (by type of coal extracted) have not been available; instead, continuous recorded production of coal by type is available only as raw coal produced. In order to maintain consistency of information, the latter raw coal production by type as reported by the Minerals Yearbooks and UN statistics is adjusted for known ash content (ranging from 19-20 percent for hard coal to 45 percent for lignite) to yield an approximation of commercial quality of each type of coal produced. The latter quantities plus

Table A-37

SOVIET COAL AND COKE STATISTICS
(Million Metric Tons)

	Actual			Estimated		
	1960	1965	1970	1971	1975	1980
Coal						
Domestic output						
Run-of-mine coal*	509.6	577.7	624.1	641.0	670.0	720.0
Clean coal†	306.0	331.0	357.0	366.0	383.0	412.0
Imports						
From Communist countries‡	4.7	6.7	7.1	7.0	7.0	8.0
Exports						
Communist countries	8.2	15.2	14.8	16.4	18.0	20.0
Non-Communist countries	4.1	7.2	9.7	8.5	9.5	11.0
Total	12.3	22.4	24.5	24.9	27.5	31.0
Apparent consumption						
Run-of-mine coal*	502.0	562.0	606.7	623.1	649.5	697.0
Clean coal†	298.4	315.3	339.6	348.1	362.5	389.0
Coke						
Domestic output	56.2	67.5§	76.0	78.0	86.0	96.0
Imports						
From Communist countries‡	0.7	0.7	0.7	0.7	1.0	1.0
Exports						
Communist countries	2.2	2.8	3.2	3.4	4.0	5.0
Non-Communist countries	0.4	1.0	0.9	0.9	1.0	1.0
Total	2.6	3.8	4.1	4.3	5.0	6.0
Apparent consumption	54.3	64.4§	72.6	74.4	82.0	91.0

* Run-of-mine coal as reported in Soviet sources.
† Clean coal, estimated in accordance with Western practice and experience.
‡ Nooe from noo-Communist countries.
§ Estimated.

Source: Reference 15.

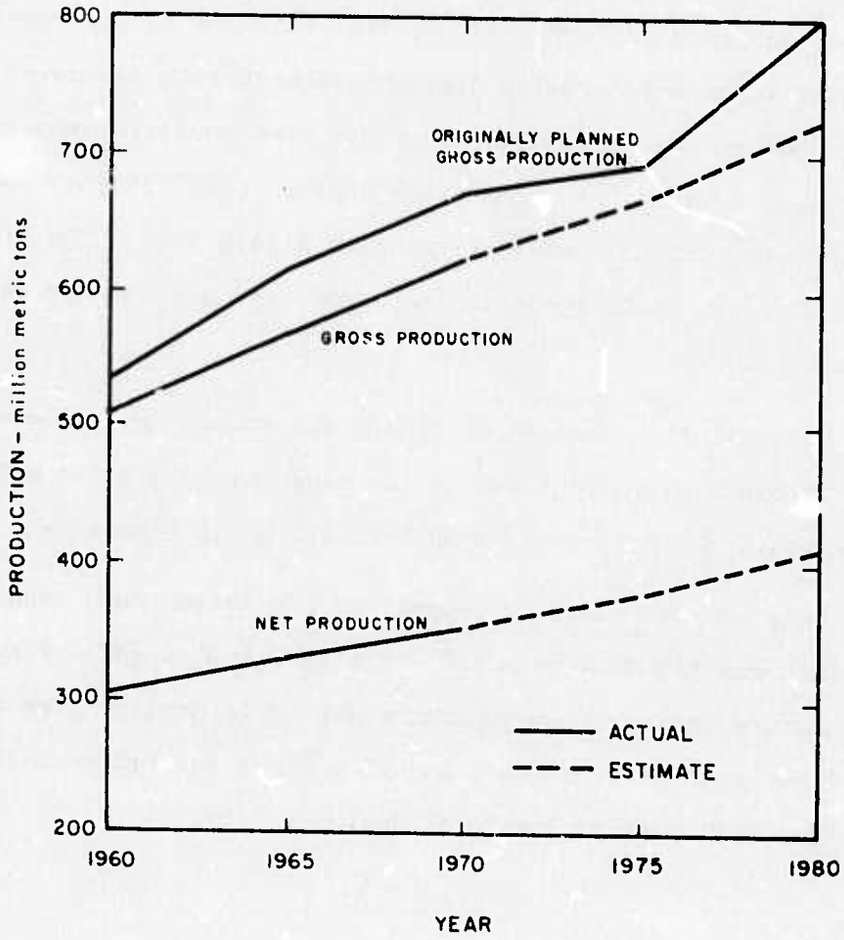

Figure A-16

SOVIET COAL PRODUCTION, ACTUAL AND ESTIMATED, 1960-1980

imports less exports, loss, and own use (used in process) yields the net internal or inland consumption. The resultant net internal consumption is the quantity distributed to the individual end use sectors.

Historic supply trends* and projected supply† for both hard and brown coals are detailed in Table A-38. Categories shown include raw production, ash adjustment, commercial quality, import, export, apparent consumption, and loss and own use. Natural units or metric tons are given because these are normally used when considering supply or production: the percentage of raw production is also shown for convenience in establishing trends. Raw production history, net internal consumption history, and projections are illustrated in Figure A-17. The projected rapid rise of brown coals reflects increased emphasis and use in electric power generation.

Historically, the net of import and exports has fluctuated somewhat, but is expected to continue in the range of 18 million metric tons export per year. This trend is also illustrated in Figure D-1.

Loss and own use as a percent of production have seen a steady slow decline over the last decade.* This is illustrated in Figure A-18. Projected future loss and own use are expected to decline even more, reaching 7 percent for hard coals and 11 percent for brown coals, or approximating 9-10 percent for total coals by 1990.

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* UN Statistics and Minerals Yearbook.

† SRI estimates using USSR 9th Five-Year Plan as a guide (together with various published projections).

Table A-36

USSR COAL SUPPLY
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1975	1980	1985	1990
	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	%	10⁶ MT	10⁶ MT	10⁶ MT	10⁶ MT
Hard Coal																												
Production	374.925	100*	377.019	100*	386.132	100*	395.132	100*	408.870	100	427.881	100*	439.195	100*	451.422	100*	455.881	100*	467.316	100*	476.406	100	487.539	100*				
Less Ash Content Correction	18.925	5	21.113*	5	23.196*	6	25.830	7	27.803*	7	30.240*	7	32.628	7	37.355	8	39.657	9	41.521	9	43.091	9	45.539	9				
Commercial Quality	356.000	95	355.906*	95	363.216*	94	369.302	93	381.067*	93	397.501*	93	406.567	93	414.067	92	416.224	91	425.795	91	432.715	91	442.000	91				
Plus Imports	4.600	1	4.732	1	4.887	1	5.100	1	5.100	1	6.800	1	7.300	1	7.900	2	8.928	2	7.226	2	7.072	1	8.388	1				
Less Exports	12.315	3	13.117	4	20.350	5	21.362	5	23.628	5	22.423	5	21.828	5	22.227	5	21.250	5	23.299	5	24.099	5	24.843	5				
Apparent Gross Availability	348.285	93	345.522*	92	347.783*	90	353.040	89	362.539*	89	381.878*	89	392.039	89	399.640	89	403.902	88	409.722	88	415.288	87	425.545	87				
Less Losses and Own Use	50.246	13	56.552	15	54.100	14	55.314	14	57.241	14	55.625	13	57.065	13	58.683	13	59.705	12	58.078	12	62.405	11	63.029	11				
Net Internal Consumption	292.039	78	288.970	77	293.683	76	297.722	75	305.298	75	326.253	76	334.944	76	340.955	76	347.197	76	351.644	76	352.883	76	371.910	76	402.964	424.545	444.[illegible]	466.136
Brown Coal																												
Production	134.698	100	129.345	100	130.976	100	136.590	100	145.127	100	149.950	100	146.424	100	143.815	100	146.299	100	140.486	100	147.708	100	153.342	100				
Less Ash Content Correction	0.898	1	0.740*	1	0.780*	1	0.843	1	1.200*	1	1.600*	1	2.230	2	2.371	2	2.413	2	2.818	2	2.963	2	3.212	2				
Commercial Quality	134.000	99	128.605*	99	130.196*	99	135.747	99	143.927*	99	148.250*	99	144.204	98	141.444	98	143.886	98	137.668	98	144.745	98	150.130	98				
Plus Imports	0.100		0.100		0.100		0.100		-		-		-		-		-		0.065	-	0.080		0.070					
Less Exports	-		-		-		-		-		-		-		-		-		-	-	-		-					
Apparent Gross Availability	134.100*	99	128.705*	99	130.296*	99	135.847	99	143.927*	99	148.250*	99	144.204	98	141.444	98	143.886	98	137.733	98	144.825	98	150.200	98				
Less Loss and Own Use	26.940	20	24.575	19	24.885	19	25.952	19	27.574	19	26.973	18	27.965	19	25.886	18	23.511	17	23.882	17	23.033	16	24.535	16				
Net Internal Consumption	107.160*	80	104.130*	80	105.401*	80	109.895	80	116.353*	80	121.277*	81	122.239	83	115.550	80	112.375	83	113.851	83	121.172	82	125.665	82	176.049	270.950	357.534	417.534
Total Internal Consumption	399.199		393.100		399.084		407.617		421.651		447.530		457.183		456.513		459.572		465.495		474.055		497.561		578.362	695.504	802.103	883.670

Note: MT - Metric Tons

* CIA estimate.

Source: UN Coal Statistics.

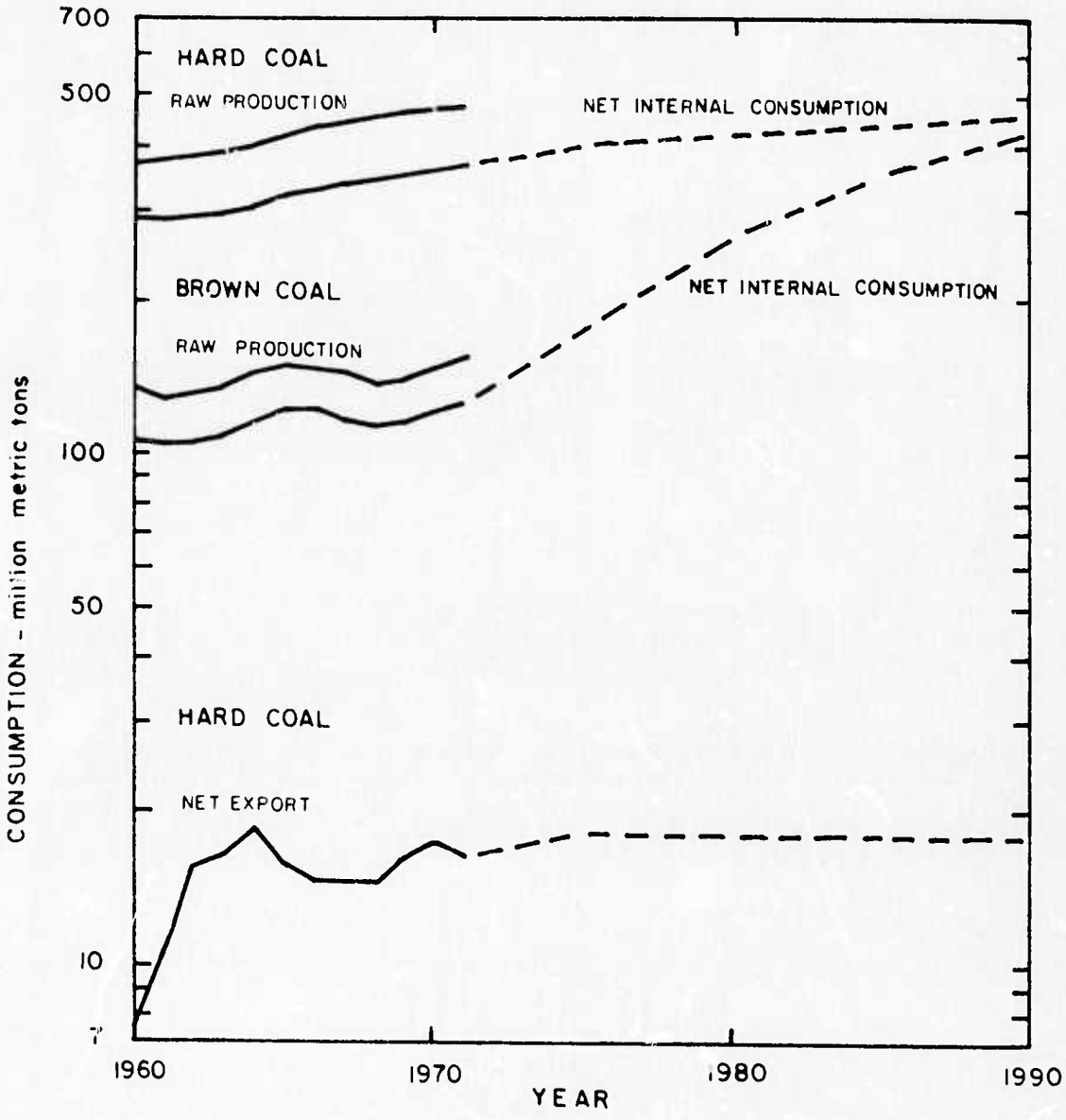

Figure A-17

TOTALS OF NET INTERNAL CONSUMPTION OF HARD AND BROWN COALS AND NET IMPORT AND EXPORT OF HARD COAL IN THE USSR

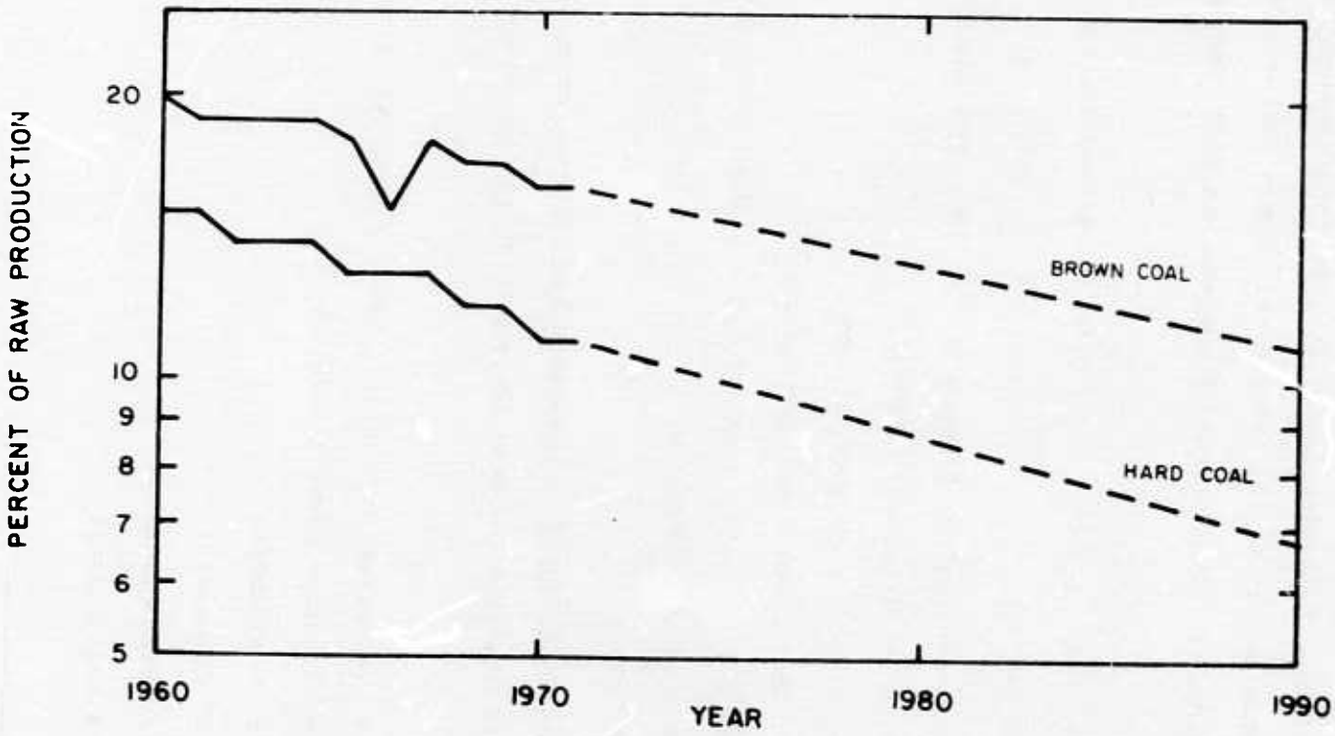

Figure A-18

LOSS AND OWN USE AS PERCENT OF PRODUCTION -- USSR
HARD COALS AND BROWN COALS

4. Sector Use

The bulk of the solid fuels distributed to end-use sectors in 1971 was hard coal, making up about 70 percent of fuels supply before import or export. Well over four-fifths of this hard coal was bituminous, and about one-fifth was anthracite. Brown coal constituted 22 percent of supply; the balance of 8 percent was peat, fuelwood, and shale.

Published information of USSR energy end use typically lists the distribution to:

- Reprocessing of raw material into other kinds of fuel
- Electric energy production
- Thermal energy production
- Mechanical energy production
- Industrial furnace and other technological installations
- Public consumption
- Other

To be useful in comparisons with Western or non-USSR information, this distribution must be converted to the following sector end uses*:

- Industrial ex-electric power generation
- Electric power generation
- Residential
- Commercial
- Transportation
- Agriculture

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* It is recognized that the USSR has published some sector end-use data such as natural gas data and electricity data. However, coal data are insufficient to establish trends.

Conversion to these end-use sectors reflects several approximations and assumptions. In this the Institute has followed the approach of first using published data for the largest coal end-use sectors (electric power, coking, transportation) at the points in time that they are given. For these largest uses, trends were established, and where necessary, use in intermediate years was estimated. This included making assumptions of heat content (tons of coal equivalent per ton) for hard and brown coals to correspond to published information of energy and tonnage use.* Then from various published sources, relative end use by the remaining sectors of the small balance of coal use was approximated, and each sector end use was estimated.

As a result, the indicated historical end use of coal by type in the electric power and industrial sectors may be considered as relatively exact--the bulk of coal use. The distribution of coal among the other sectors is less exact, but because of the relatively small magnitude of this balance, small differences are believed to be of minor significance.

The shift of rail transportation from coal to electric and diesel drive (during the past ten years) has had a significant impact on coal demand. In 1970 the relative share of coal-steam drive locomotives had been reduced to only 4 percent of the total.[16]

However, projected increases in coal demand by other sectors is expected to force continued growth in the coal supply.

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* Published information showing heat values indicate that the heat conversion factors for both hard and soft coals are decreasing with time. Plotting conversion factors at given years permitted interpolation for values at intermediate years.

5. Ninth Five-Year Plan

In the Ninth Five-Year Plan (1971-1975), production of coal is planned to expand to 685-695 million tons.[16] The five-year plan reflects the intention of significantly expanding open pit extraction of coal. By 1975 the relative share of open pit mining is expected to be raised to not less than 30 percent, compared with 26.7 percent in 1970. The driving force behind this is the desired reduction of fuel cost. By 1975 increased open pit mining, together with exploitation of more economic production of crude oils and gas, is expected to result in a 16 percent reduction of cost of fuel extraction (expressed in terms of standard fuels) compared with 1970.[16]

Sources of coal supply for the USSR are unevenly distributed. More than 90 percent have been concentrated east and southeast of the Urals, including 60 percent in Siberia. In the European regions and in the Urals, there are less than 10 percent. A full discussion of coal distribution is given in this study's resource section.

At the same time, the demand for fuel energy is concentrated in the European region and in the Urals. This means that coal must be brought in long distances from basins such as the Ekibastuz, Kansk-Achinsk, and Kuznetsk basins. The result is a twofold thrust:

- Reduction of extraction cost by placing greater emphasis on open pit mining.
- Reduction of transportation cost by use of more economic fuel (switch of railroads from coal-steam to diesel-electric drive during the past decade). This is more fully discussed in this study's section on transportation of coal.

Growth in coal delivery is connected basically with the growing demand for Ekibastuz coals at the Urals electric power plants, and

for Kuznetsk coals in the European part of the USSR. It appears expedient to expand the open pit mining in these areas. In some areas such as Siberia and Kazakhstan, competition of coal with furnace mazut (crude oil mid-barrel product) as a boiler fuel is forcing development of open pit coal mining to reduce extraction costs.[17]

The current five-year plan treats different areas differently. Extraction of coal from the PodMoscow basin and in the Urals is expected to be reduced (probably because of lesser heat content than other coals). Coal from the Donets and Pechora basins will be increased, largely for coking; in the Donbass areas, primarily the anthracites (cheapest)[17] will be expanded to a limited degree to meet electric power station needs; but open pit extraction at eastern USSR basins will be greatly enlarged to meet electric power plant requirements.

6. Delivered Cost

Because the location of fuel-energy supply is in many instances a great distance from the point of demand, the delivered energy cost must be recognized, and selection of a partieular type of energy made accordingly. A simplified comparison is illustrated in Table A-39. For For example, open pit Kuznetsk coal delivered 1,000 kilometers is slightly more economic than Ekibastuz coal delivered 2,000 kilometers. As another example, Kansk-Achinsk coal by USSR eost indieators is the least costly of fuels to extract. However, delivered eost at 3,000 kilometers exceeds the cost of open pit Kuznetsk coal at 3,000 kilometer delivery. Similar comparisons of other fuels will give some insight into fuel energy developments selected by the USSR.

7. Other Solid Fuels

Other solid fuels normally used by USSR include peat and fuelwood. An additional minor fuel is shale, primarily used for power generation, and from which a hydroearbon liquid can be extraeted.

Table A-39

APPROXIMATE EXPENDITURES IN EXTRACTION AND TRANSPORTATION OF VARIOUS TYPES OF FUEL
(Rubles per Ton of Standard Fuel)

	Tyumen Gas	Central Asian Gas	Mangyshlak Crude Oil	Open-pit Kuznets Coal	Ekibastuz Coal	Kansk Achinsk Coal	Tyumen Crude Oil
Expenditures in extraction	2.2	5.4	8.3	6.6	2.7	1.8	6.2
Transport over a distance of 1,000 kilometers							
Costs of transport*	2.2-1.4	2.2	0.6	3.2	4.2	5.4	0.4
Total, transport and production costs	4.4-3.6	7.6	8.9	9.8	6.9	7.2	6.6
Transport costs as percent of total	50 - 39	29	7	33	61	75	6
Transport over a distance of 2,000 kilometers							
Costs of transport*	4.3-2.8	4.3	1.1	6.2	8.2	10.4	0.88
Total, transport and production costs	6.5-5.0	9.7	9.4	12.8	10.9	12.2	7.08
Transport costs as percent of total	66 - 56	44	12	48	75	85	12
Transport over a distance of 3,000 kilometers							
Costs of transport*	6.5-4.2	6.5	1.6	9.2	12.1	15.4	1.3
Total, transport and production costs	8.7-6.4	11.9	9.9	15.8	14.8	17.2	7.5
Transport costs as percent of total	75 - 66	55	16	58	82	90	17

* The first number refers to expenditures incurred in the movement of gas through a 1,420-millimeter gas pipeline; the second number refers to the movement of gas through a 2,520-millimeter line.

Source: Sotsialisticheskaya Industriya, p. 2, August 22, 1971.

Historic use of peat, fuelwood, and shale,* together with 1975 projected use according to the Soviet Ninth Five-Year Plan and demand projected to 1990,† are detailed in Table A-40 and Figure A-19. Because use is primarily local and storage time is minimal, losses are not taken into account. Tonnage of peat has fluctuated somewhat over the last decade, in the range of about 35 to 65 million metric tons per year. Net internal consumption is projected to increase to approximately 71 million metric tons by 1975. Tonnage of fuelwood has remained relatively stable but since 1965 there has been a downward trend. Net internal consumption for 1975 is projected at about 54 million tons.

The supply of shale has been small relative to coal but the current five-year plan indicates that by 1975, production will reach nearly 30 million metric tons of shale per year. Of this, about 10 million tons are expected to enter processing for furnace oil, gasoline, fuel gas, phenols, and aromatic hydrocarbons. The balance, which is the bulk of the production or about 20 million tons per year of shale, is expected to be burned at thermal electric power plants, in spite of its characteristically high ash content, and residues that are destructive to boilers.[18]

8. Projections

The Institute bases the projected USSR solid fuels consumption by sector, particularly the coal consumption, on the Ninth Five-Year Plan in conjunction with historical trends for the major end uses of electric power generation, technological uses (coking coal), and other industry use. The balance of coal use in the remaining sectors is relatively small, and projections are made on the basis of established trends.

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* USSR Statistical Yearbook.

† SRI estimate.

Table A-40

NET INTERNAL CONSUMPTION OF
OTHER SOLID FUELS IN THE USSR

	Peat			Fuelwood			Shale		
	10^6MT	TFE/MT*	10^6TFE	10^6MT	TFE/MT	10^6TFE	10^6MT	TFE/MT	10^6TFE
1960	53.6	.381	20.4	82.0	.35	28.7	14.1	.340	4.8
1961	51.6	.378	19.5	84.6	.35	29.6	15.2	.342	5.2
1962	34.7	.372	12.9	83.1	.35	29.1	16.4	.341	5.6
1963	58.5	.371	21.7	87.7	.35	30.7	18.3	.355	6.5
1964	59.5	.373	22.2	93.7	.35	32.8	20.2	.351	7.1
1965	45.7	.372	17.0	95.7	.35	33.5	21.3	.347	7.4
1966	65.4	.373	24.4	91.1	.35	31.9	21.4	.350	7.5
1967	60.2	.372	22.4	87.4	.35	30.6	21.6	.347	7.5
1968	49.1	.373	18.3	82.0	.35	28.7	21.9	.347	7.6
1969	44.8	.373	16.7	80.0	.35	28.0	23.0	.348	8.0
1970	57.4	.308	17.7	76.0	.35	26.6	24.3	.346	8.4
1971	54.3	.308	16.7	76.0	.35	26.6	26.3	.346	9.1
1975†	70.5	.308	21.7	54.3	.35	19.0	29.5	.346	10.2
1980‡	67.2	.308	20.7	22.9	.35	8.0	30.9	.346	10.7
1985‡	64.6	.308	19.9	7.4	.35	2.6	31.8	.346	11.0
1990‡	63.6	.308	19.6	4.3	.35	1.5	32.7	.346	11.3

* TFE/MT - tons of fuel equivalent/metric ton = MTCE/MT.

† 1975 data are based on Ninth Five-Year Plan.

‡ SRI estimates.

Sources: For peat and fuelwood, N. V. Melnikov, Mineralnoe toplivo (Mineral Fuel), Pub. "Nedra," Moscow 1971; Statistical Annual, USSR 1972; M. S. Lvov, Resursy Prirodnogo Gaza SSSR (Natural Gas Resources of USSR), Pub. "Nedra," Moscow 1969.
For sale, N. V. Melnikov, The Role of Coal in the Energy Fuel Resources in the USSR, CIM Bulletin, June 1972; Gazovoye delo, No. 4, pp. 30-37, 1970; Lvov, op. cit.

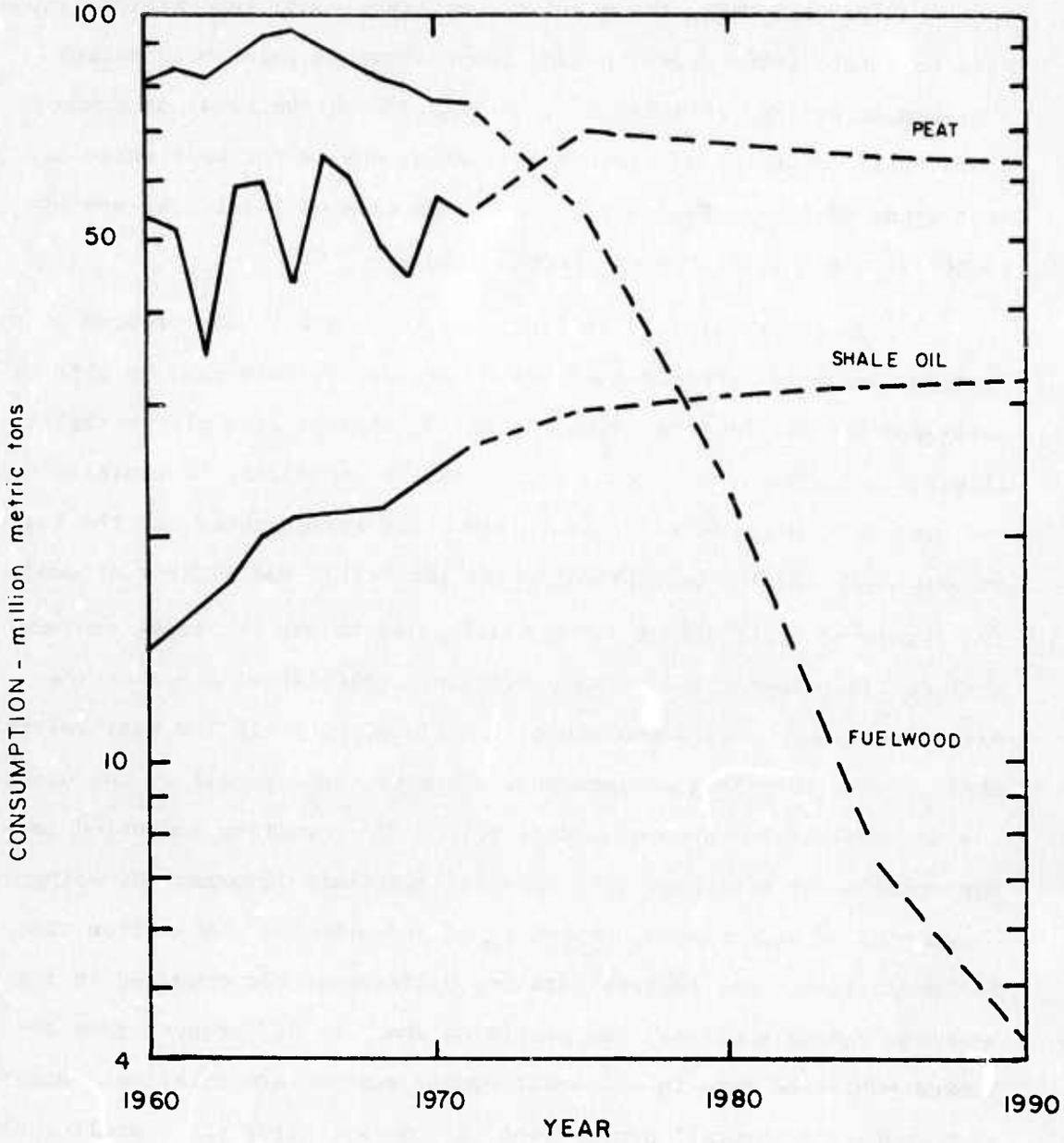

Figure A-19

NET INTERNAL CONSUMPTION OF OTHER FUELS
(PEAT, FUELWOOD, SHALE OIL) IN THE USSR

Because fuel consumption is normally considered in terms of heat, demands by sector are indicated in heat units--million tons of coal equivalent.

For the USSR, the available published coal information requisite to establishing sector demand projections is relatively meager. A breakdown of type of solid fuel (anthracite, bituminous, or grade of brown coal) by sector use is not available, nor is the heat value of each grade of fuel. Further, parts of the data of total coal use by sector that are available are inconsistent.

As noted earlier, the Institute approach to the problem of projections was to estimate sector demand trends--in this case by type of coal--for all sectors over time, using information from all available literature sources, and making adjustments as necessary to minimize apparent discrepancies. Sector demands are first approximated for the largest or principal sectors (electrical power generation and industrial use). The remaining small demand is then allocated to the remaining sectors (residential, commercial, transportation, agriculture) based on the estimated trends. This procedure is believed to yield the most reliable base for use in making projections. However, as a result of not using any one published source as a data point, the resulting indicated sector demands may not agree with selected available information, being overstated or understated, depending on the selected publication used for comparison. The largest relative differences are expected in the smallest demand sectors. The resulting apparent differences from selected published data in the small demand sectors are relatively minor with respect to overall projections, and do not alter the overall conclusions of projected coal demands.

a. Electric Power Generation

Published information indicates that coal will continue to be a primary source of energy in the generation of electric power.

Further, there appears to be greater emphasis on brown coal for the future; according to the current five-year plan, brown coal is expected to have a significant use increase, beginning about 1975. Table A-11 and Figure A-20 show historical and projected supply of energy to the electrical power generation sector by energy type in terms of millions of tons of coal equivalent.

b. Industry and Other Sectors

Another large demand for coal is the industrial sector, in which coking coal will continue to play an important part. Historically, the annual growth rate of coal demand here has decreased from 4.6 percent growth in the 1960-1965 period to 2.8 percent growth in the 1965-1971 period. These trends indicate that a growth will continue but at a reduced rate, resulting in projected growth rate of demand for coking coal in industry as follows:

Estimated Annual Growth
Rate of Coking Coal Demand

	Percent
1971-1975	2.5%
1975-1980	2.0
1980-1990	1.5

Historically, small amounts of hard coal have gone for end uses that correspond to the residential, commercial, transportation, and agriculture sectors. With the increased emphasis on oil and gas, the use of hard coal here is expected to decline, becoming negligible after 1980.

The balance of demand for hard coal is in industry. Although industry in total is projected to grow, the demand for energy to meet that growth is projected to be principally oil and gas fuels. The resulting projected demand together with 1970-1971 demands for energy

Table A-41

COAL DEMAND IN ELECTRIC POWER GENERATION IN THE USSR
(Million Tons of Coal Equivalent)

Year	Hard Coal	Brown Coal	Total Coal
1960	94.9	14.9	109.8
1961			114.4
1962			119.8
1963			126.1
1964			132.1
1965	118.6	18.6	137.2
1966			138.3
1967			143.7
1968			146.6
1969	131.3	19.2	150.5
1970	133.1	20.4	153.5
1971	141.7	19.8	161.5
1975	155.0	36.7	191.7
1980	159.6	71.9	231.5
1985	164.0	103.0	267.0
1990	168.0	123.9	291.9

Source: Compiled by SRI.
Forecast by SRI.

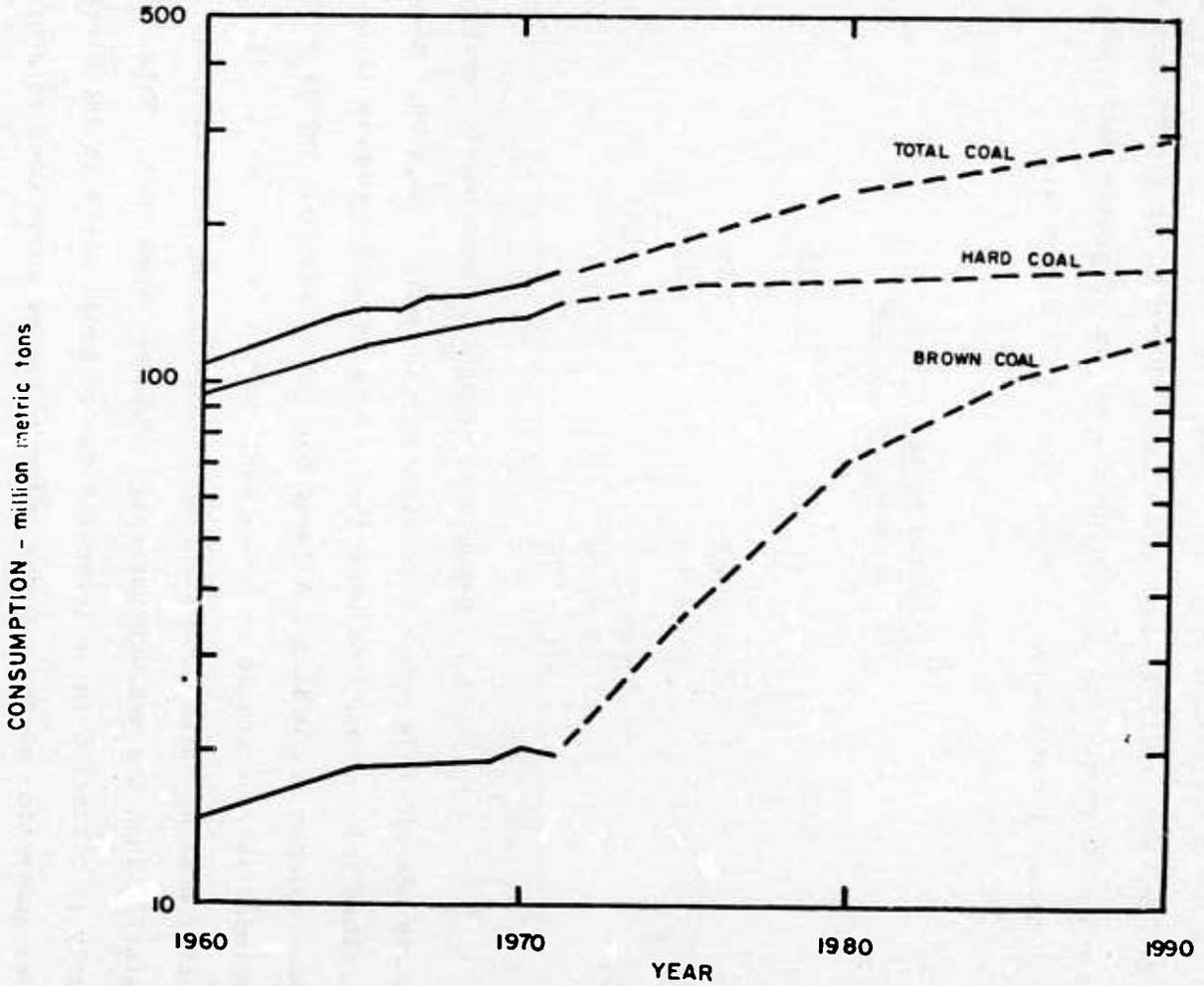

Figure A-20
COAL DEMAND IN ELECTRIC POWER GENERATION IN THE USSR

from hard coal is illustrated in Table A-12 and Figure A-21, in terms of millions of tons of coal equivalent.

A similar slow-down of growth of brown coal demand in industry has been experienced, and additional slow-down is projected for 1975 in the Soviet Ninth Five-Year Plan. This trend indicates that in the future, there will be some additional slow-down of growth here but to a lesser degree. With a continued slowdown of growth SRI's projected annual growth rates of brown coals in industry are:

Estimated Annual Growth
Rate of Brown Coal Demand

	Percent
Historical	
1960-1965	3.1%
1965-1971	1.8
Projected	
1971-1980	1.0
1980-1990	0.5

The bulk of brown coal demand has been about evenly split between the electric power generation and industrial sectors. However, published information indicates that a much greater emphasis is to be placed on open pit mining. A large portion of new coal supply to be developed is expected to be brown coal, but of better quality (i.e., greater heating value from Kuznetsk, Kansk-Achinsk, and Ekibastuz basins)[19] than the average currently produced brown coal. This new supply is reflected in an increased use of brown coals in the electric power generation sector. Other industry use of brown coal is projected to remain relatively steady. Brown coal in other uses corresponding to the residential, commercial, transportation, and agriculture sectors has been relatively small, and is expected to be negligible after 1980

Table A-42

CURRENT AND PROJECTED ENERGY DEMAND FOR HARD COAL IN THE USSR
(Million Metric Tons of Coal Equivalent)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Industry																
Coking coal	99.2	104.4	108.9	114.3	119.3	124.4	129.6	134.6	139.5	145.1	145.1	146.5	161.7	178.5	192.3	207.2
Other	47.9	41.3	39.4	34.8	33.0	37.9	40.8	37.4	36.4	35.4	35.8	35.3	35.0	35.0	35.0	35.0
Total industry	147.1	145.7	148.3	149.1	152.3	162.3	170.4	172.0	175.9	180.5	180.9	181.8	196.7	213.5	227.3	242.2
Electric Power	94.9	99.1	102.5	107.7	112.1	118.6	119.0	124.8	127.9	131.3	133.1	141.7	155.0	159.6	164.0	168.0
Residential	2.1	2.1	2.2	2.1	2.2	2.4	2.4	1.9	1.5	1.1	0.8	0.6	0.3	-	-	-
Commercial	4.1	4.0	4.2	4.1	4.2	4.9	5.0	4.2	3.5	3.0	2.5	2.0	1.0	0.5	-	-
Transportation	11.9	7.2	5.2	3.4	2.6	2.4	2.2	1.7	1.4	1.3	1.2	1.1	0.8	-	-	-
Agriculture	2.8	2.1	1.9	1.5	1.4	1.4	1.4	1.3	1.2	1.1	1.0	0.9	0.4	-	-	-
Total	262.9	260.2	264.3	267.9	274.8	292.0	300.4	305.9	311.4	318.3	319.5	328.1	354.2	373.6	391.3	410.2
Heat content TFE/MT	.900	.900	.900	.900	.900	.895	.897	.897	.897	.900	.880	.880	.880	.880	.880	.880
Tonnage 10^6 MT	292.0	289.0	293.7	297.7	305.3	326.3	334.9	341.0	347.2	353.6	363.1	372.9	402.5	424.6	444.7	446.2

Sources: For historical period, U.N. Coal Statistics; USSR Statistical Yearbook, 1972; N. V. Melnikov, The Problem of Fuel Losses in the USSR.
For 1975, USSR Ninth Five-Year Plan.
For other projections, Stanford Research Institute.

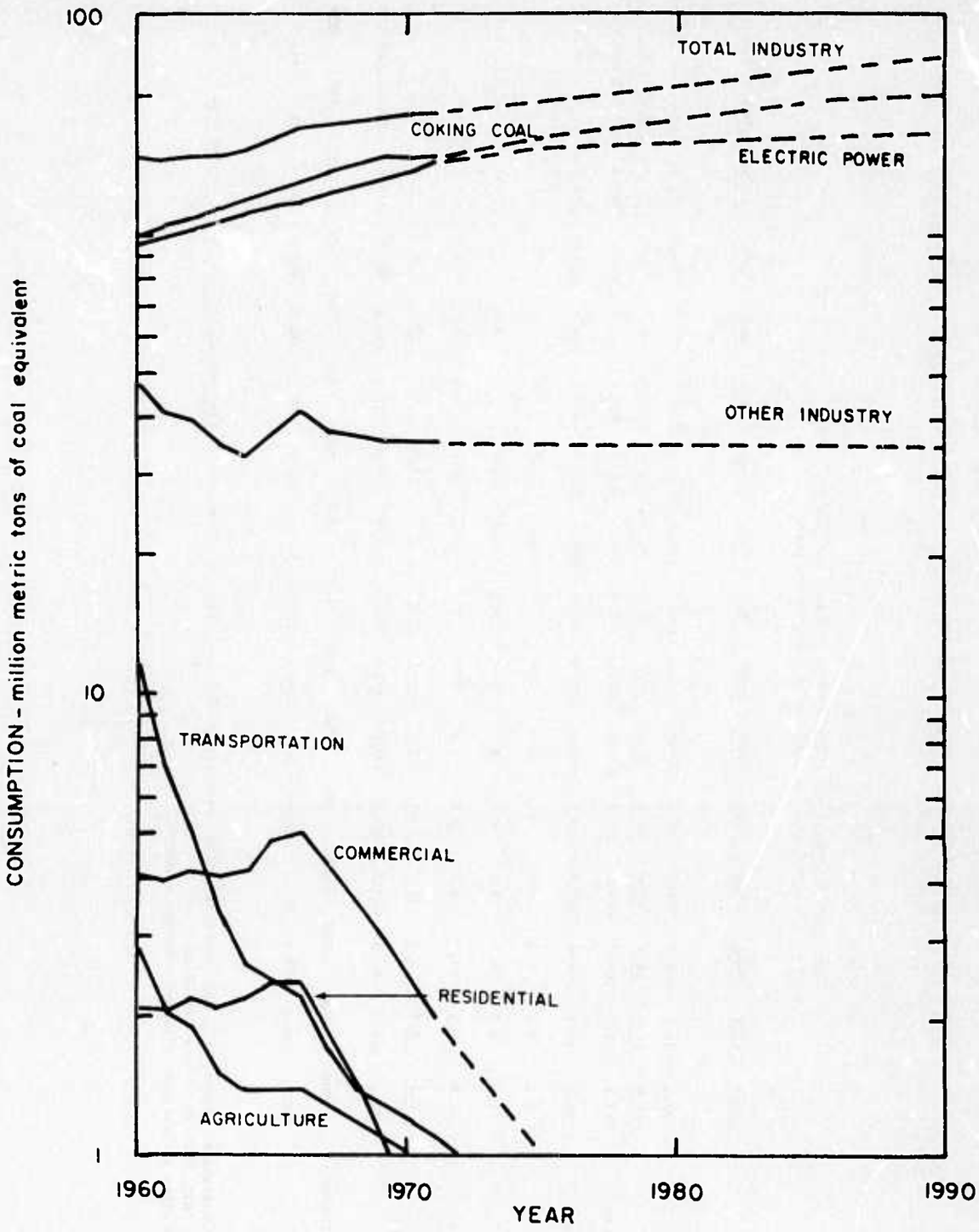

Figure A-21

CURRENT AND PROJECTED DEMAND FOR HARD COALS
FROM PRINCIPAL SECTOR USES IN THE USSR

(essentially replaced by oil and gas). The total current and projected demands for brown coals are illustrated in Table A-43 and Figure A-22.

These projections compare closely with information contained in the Soviet Ninth Five-Year Plan, which indicates 1975 total production of raw coal at 694.9 million metric tons. Reconciliation is approximated as follows:

	1975	
	10^6 Metric Tons	10^6 TCE
Total raw coal production projected by Soviet Ninth Five-Year Plan	694.9	500.3*
Net exports†	18.0	15.8
Available for consumption		484.5
Losses‡		69.9
Distributed to sectors		414.6
SRI projection of coal distributed to sectors		
Hard coal		354.2
Brown coal		64.3
Total coal		418.5
Difference§		3.9

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* Assumes 0.72 coal equivalents per metric ton for overall average coal.

† Assumes net of import/export (hard coal) remains about 18.0 million metric ton; average hard coal heat content approximates 0.88 coal equivalent per metric ton.

‡ Historically, loss approximates 14 percent of raw production.

§ Difference of 3.9 in 500.3 approximates 0.8 percent.

Table A-43

CURRENT AND PROJECTED DEMAND FOR BROWN COALS IN THE USSR
(Million Metric Tons of Coal Equivalent)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Industry	18.2	18.2	19.7	20.5	22.1	21.2	22.9	22.2	22.0	23.0	24.5	22.7	25.5	26.5	27.5	28.5
Electric power generation	14.9	15.3	17.2	18.4	20.0	18.6	19.2	18.9	18.7	19.2	20.4	19.8	36.7	71.9	103.0	123.9
Residential	.8	.9	1.1	1.3	1.4	1.4	1.4	1.1	.9	.7	0.6	0.4	0.2	-	-	-
Commercial	1.6	1.7	2.1	2.4	2.8	2.7	2.9	2.5	2.1	1.9	1.7	1.3	1.0	0.5	-	-
Transportation	4.5	3.2	2.6	2.0	1.7	1.4	1.2	1.0	.8	.8	0.8	0.7	0.4	-	-	-
Agriculture	1.0	.9	.9	.9	.9	.8	.8	.8	.7	.7	0.6	0.6	0.5	0.3	-	-
Total	41.0	40.2	43.6	45.5	48.9	46.1	48.4	46.5	45.2	46.3	48.6	45.5	64.3	99.2	130.5	152.4
Heat content TFE/MT	.383	.386	.414	.414	.421	.380	.396	.403	.402	.407	.401	.365	.365	.365	.365	.365
Tonnage 10^6MT	107.2	104.1	105.4	109.9	116.4	121.3	122.2	115.6	112.4	113.9	121.2	124.7	176	272	358	418

Source: For historical period, U.N. Coal Statistics; USSR Statistical Yearbook, 1972; N. V. Melnikov. The Problem of Fuel Losses in the USSR.
For 1975, USSR Ninth Five-Year Plan.
For other projections, Stanford Research Institute.

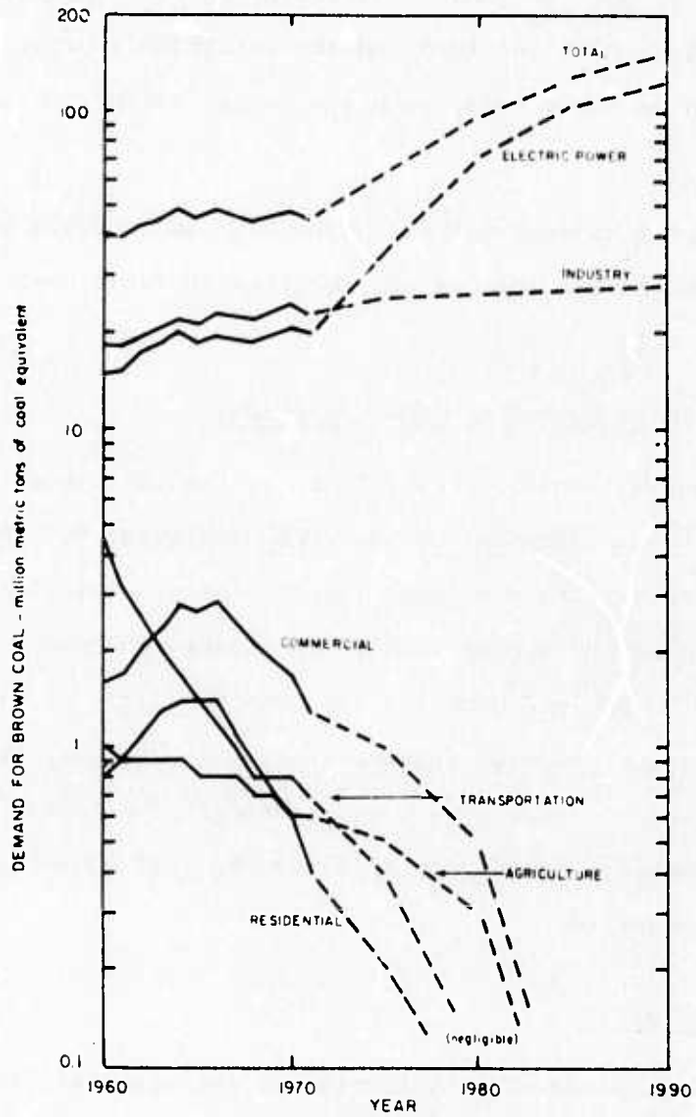

Figure A-22
CURRENT AND PROJECTED DEMAND FOR BROWN COALS IN THE USSR

Small amounts of other solid fuels (peat, shale, and fuelwood) will also be distributed to the end-use seetors. These, however, contribute only a minor amount of energy and are relatively insignifieant with respeet to eoal. Current produetion together with the USSR Ninth Five-Year Plan for 1975 and the Institute's projeetions to 1990 are detailed in Table A-44, with the larger seetor uses illustrated in Figure A-23.

Total current and projeeted USSR solid fuels energy distributions to the end-use sectors are detailed in Table A-45 and illustrated in Figure A-24.

9. Solid Fuels Demand in CMEA Countries

In the CMEA countries as well as in the USSR, eoal has been a large faetor in the development of the CMEA eountries, but there are difficulties in converting published information on historieal or projected use to end use by seetor (aceording to Western nomenelature). In addition, the solid fuels demand for the CMEA eountries is of minor magnitude eompared to the USSR demand. For these reasons, sector demands for solid fuels are not projeeted here.* Instead, the sector demands are briefly discussed, and only total demand in eaeh eountry by fuel energy type is projected.

a. Bulgaria

Coal produeed in Bulgaria has charaeteristieally been predominantly brown coal, and thus of relatively low quality. Historic produetion and projeeted production of hard and brown eoals are detailed in Table A-46 and Figure A-25. Production in 1971 ineluded nearly 24 million metrie tons of brown eoal but less than 1 million metric tons of

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* Total demand is not separated by industrial, commercial; industrial transportation or agrieulture end uses.

Table V-11

ENERGY DEMAND FOR PEAT, SHALE, FUELWOOD IN THE USSR
(Million Tons of Coal Equivalent)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Peat																
Industry	3.5	3.1	0.7	3.7	3.8	2.1	4.6	3.9	2.5	1.8	2.6	1.9	3.3	3.5	3.7	3.9
Electric power	10.8	11.0	11.2	11.6	11.1	11.3	11.6	11.5	11.6	11.7	10.3	11.1	15.7	15.7	15.7	15.7
Residential	0.6	0.6	0.1	0.7	0.7	0.3	0.9	0.7	0.4	0.3	0.5	0.4	0	0	0	0
Commercial	1.3	1.1	0.2	1.3	1.5	0.8	1.7	1.5	0.9	0.7	1.0	0.7	.5	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	4.2	3.7	0.7	4.1	4.8	2.5	5.6	4.8	2.9	2.2	3.3	2.3	2.2	1.5	0.5	0
Total	20.4	19.5	12.9	21.7	22.2	17.0	24.4	22.4	18.3	16.7	17.7	16.7	21.7	20.7	19.9	19.6
Heat TFE MT	.381	.378	.372	.371	.373	.372	.373	.372	.373	.373	.308	.308	.308	.308	.308	.308
Tonnage 10^6MT	53.6	51.6	34.7	58.5	59.5	45.7	65.4	60.2	49.1	44.8	57.4	54.3	70.5	67.2	64.6	63.6
Shale																
Industry	3.2	3.3	3.3	3.8	3.9	3.6	3.6	3.3	2.9	3.0	2.7	3.1	3.0	3.2	3.3	3.4
Electric power	1.6	1.9	2.3	2.7	3.2	3.8	3.9	4.2	4.7	5.0	5.7	6.0	7.2	7.5	7.7	7.9
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1.8	5.2	5.6	6.5	7.1	7.4	7.5	7.5	7.6	8.0	8.4	9.1	10.2	10.7	11.0	11.3
Heat TFE MT	.340	.342	.341	355	.351	.347	.350	.347	.347	.348	.346	.346	.346	.346	.346	.346
Tonnage 10^6MT	14.1	15.2	16.4	18.3	20.2	21.3	21.4	21.6	21.9	23.0	24.3	26.3	29.5	30.9	31.8	32.7
Fuelwood																
Industry	15.7	16.3	15.9	16.9	18.0	18.3	17.3	16.6	15.5	15.2	14.5	14.6	12.0	3.3	0	0
Electric power	2.0	2.0	2.1	2.1	2.3	2.5	2.6	2.5	2.1	2.2	2.0	1.8	1.8	1.7	1.6	1.5
Residential	3.5	3.6	3.5	3.7	4.0	4.0	3.8	3.7	3.1	3.4	3.2	3.2	3.0	2.0	1.0	0
Commercial	6.7	6.9	6.8	7.1	7.6	7.8	7.3	7.0	6.6	6.4	6.2	6.2	2.0	1.0	0	0
Transportation	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.8	0.2	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	28.7	29.6	29.1	30.7	32.8	33.5	31.9	30.6	28.7	28.0	26.6	26.6	19.0	8.0	2.6	1.5
Heat TFE MT	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350	.350
Tonnage 10^6MT	82.0	84.6	83.1	87.7	93.7	95.7	91.1	87.4	82.0	80.0	76.0	76.0	54.3	22.9	7.4	4.3

Sources: Historical--N. V. Melnikov, Mineral Fuel, Pub. "Nedra," Moscow 1971; Melnikov, The Role of Coal in Energy Fuel Resources in the USSR, 1972; Gazovoye delo, No. 1, 1972; Natural Gas Resources, USSR 1969; Statistical Abstracts USSR, 1972; U.N. Statistics, 1972; Pravda, April 28, 1972.
1975 estimate--Ninth Five-Year Plan, USSR.
Other projections--Stanford Research Institute.

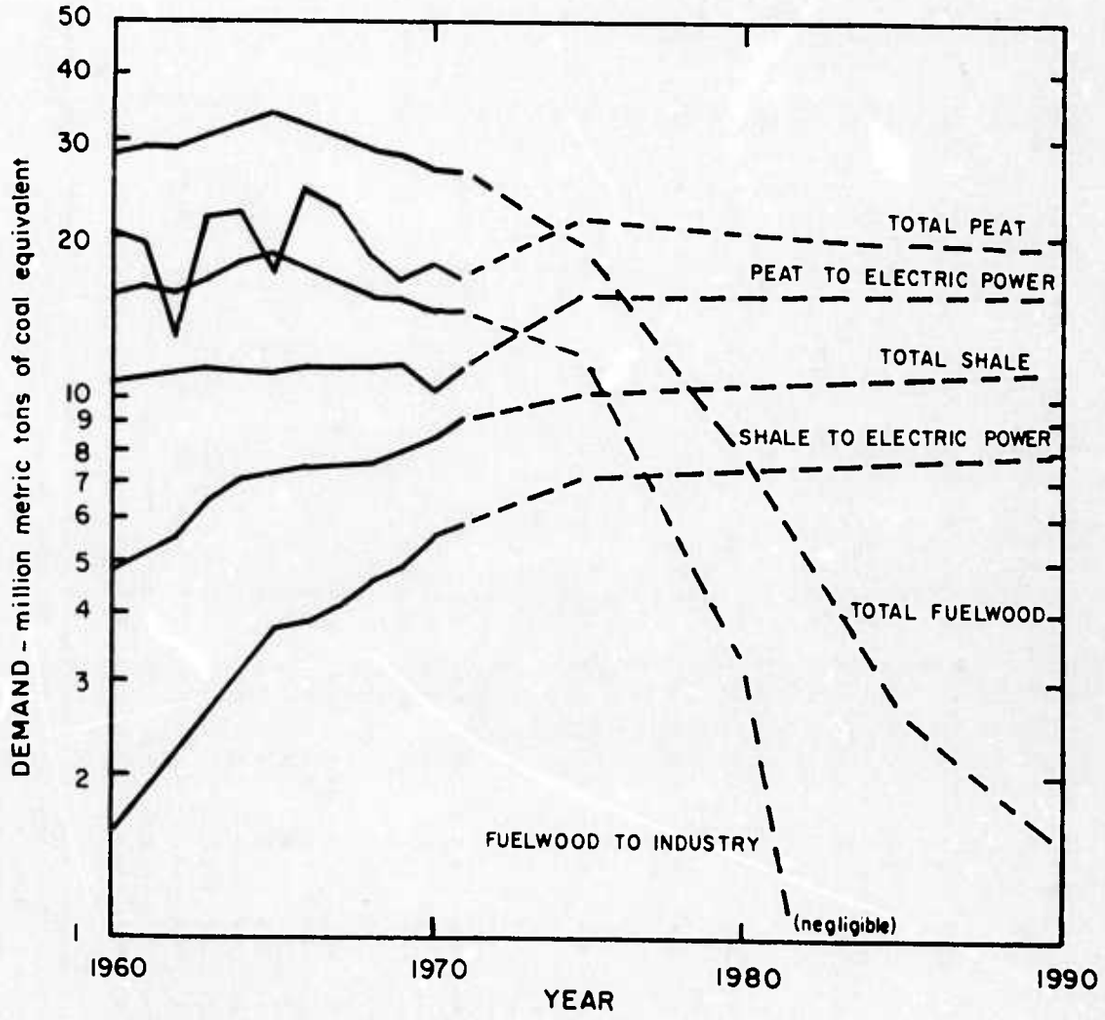

Figure A-23

ENERGY DEMAND FOR PEAT, SHALE, AND FUELWOOD FROM PRINCIPAL USE SECTORS IN THE USSR

Table A-45

TOTAL SOLID FUELS ENERGY DEMAND IN THE USSR
(Million Metric Tons of Coal Equivalent)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Industry	187.7	186.6	187.9	194.0	200.1	207.5	218.8	218.0	218.8	223.5	225.2	224.1	240.5	250.0	261.8	278.0
Electric power	124.2	129.3	135.3	142.5	149.0	154.8	156.3	161.9	165.3	169.4	171.5	180.7	216.4	256.4	292.0	317.0
Residential	7.0	7.2	6.9	7.8	8.3	8.1	8.5	7.4	6.2	5.5	5.1	4.6	3.5	2.0	1.0	-
Commercial	13.7	13.7	13.3	14.9	16.1	16.2	16.9	15.2	13.1	12.0	11.4	10.2	4.5	2.0	-	-
Transportation	17.2	11.2	8.3	6.3	5.2	4.7	4.3	3.5	3.0	2.9	2.7	2.6	1.5	-	-	-
Agriculture	8.0	6.7	3.5	6.8	7.1	4.7	7.8	6.9	4.8	4.0	4.9	3.8	3.1	1.8	0.5	-
Total	357.8	354.7	335.5	372.3	385.8	396.0	412.6	412.9	411.2	417.3	420.8	426.0	469.5	512.2	555.3	595.0

Sources: Historical--N. V. Melnikov, Mineral Fuel, Pub. "Nedra," Moscow 1971; Melnikov, The Role of Coal in Energy Fuel Resources in the USSR, 1972; Gazovoye delo, No. 4, 1972; Natural Gas Resources, USSR 1969; Statistical Abstracts USSR, 1972; U.N. Statistics, 1972; Pravda, April 28, 1972.
1975 estimate--Ninth Five-Year Plan, USSR.
Other projections--Stanford Research Institute.

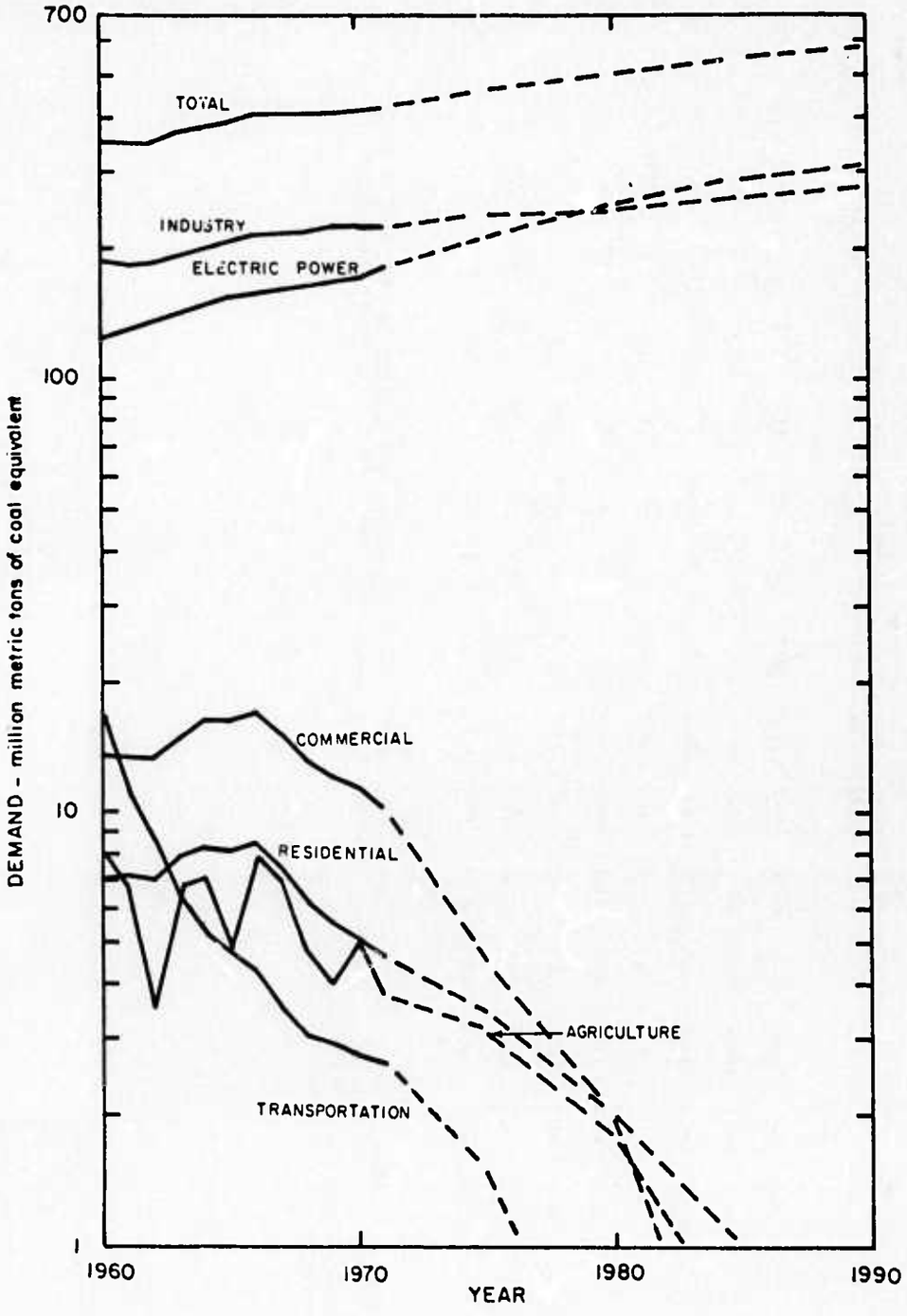

Figure A-24

TOTAL SOLID FUELS ENERGY DEMAND BY SECTOR IN THE USSR

Table A-48

COAL SUPPLY IN BULGARIA
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1975	1980	1985	1990
	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	10^6 MT	10^6 MT	10^6 MT
Hard Coal																												
Production	0.503	100	0.591	100	0.636	100	0.575	100	0.588	100	0.652	100	0.890	100	0.887	100	0.839	100	0.970	100	0.947	100	0.3as	100				
Plus imports	0.500	99	0.505	85	0.932	146	1.263	220	1.961	333	2.504	451	2,913	327	3.231	692	3.320	756	4.063	1098	4.690	1232	5.910	1523				
Less exports	0.060	12	0.056	9	0.052	8	0.036	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Apparent gross production	0.943	187	1.040	176	1.516	238	1.802	317	2.549	433	3.056	551	3.802	681	3.888	782	3.759	856	5.033	1198	5.287	1332	6.29a	1623				
Less losses and own use	0.543	108	0.540	91	1.016	160	-0.036	6	-	-	-	-	-	-	-	-	-0.905	89	.264	77	094	24	.361	93				
Net internal consumption	0.400*	79	0.500*	85	0.500*	78	1,858	323	2.592*	433	3.056*	554	3.803	6.84	3,888	782	4.064	925	1.148	1121	5.193	1308	5.937	1530	8.127*	9.614*	12.030*	14.379*
Brown Coal																												
Production	13.866	100	16.966	100	19.104	100	20.234	100	23.721	100	24.488	100	24.926	100	26.739	100	28.262	100	26.832	100	28 654	100	28,620	100				
Plus imports																												
Less exports																												
Apparent gross production	13.866*	100	16.966*	100	19.104*	100	20.234*	100	23.721*	100	24.488*	100	24.926*	100	26.739*	100	28,262	100	26.832	100	28,654	100	28,620	100				
Less losses and own use							-4.00	-20									-.190	2	2.695*	9	4.073*	14	2.670*	10				
Net internal consumption	13.866*	100	16.966*	100	19.104*	100	24.234	120	23.721*	100	24.488*	100	24.926*	100	26.739*	100	28.772	102	25,937	91	24.781	86	33,950	90	35.387*	37.533*	39.018*	37.888*
Total internal consumption	14.266		17,166		19.604		26,092		26,313		27,524		28.029		30.437		32.836		30.086		29,974		39.887		33.514*	37.147*	48.043*	52.308*

Note. Negative numbers reflect stock and inventory adjustments

* UN estimate.
* SRI estimate.

Source. UN Coal Statistics.

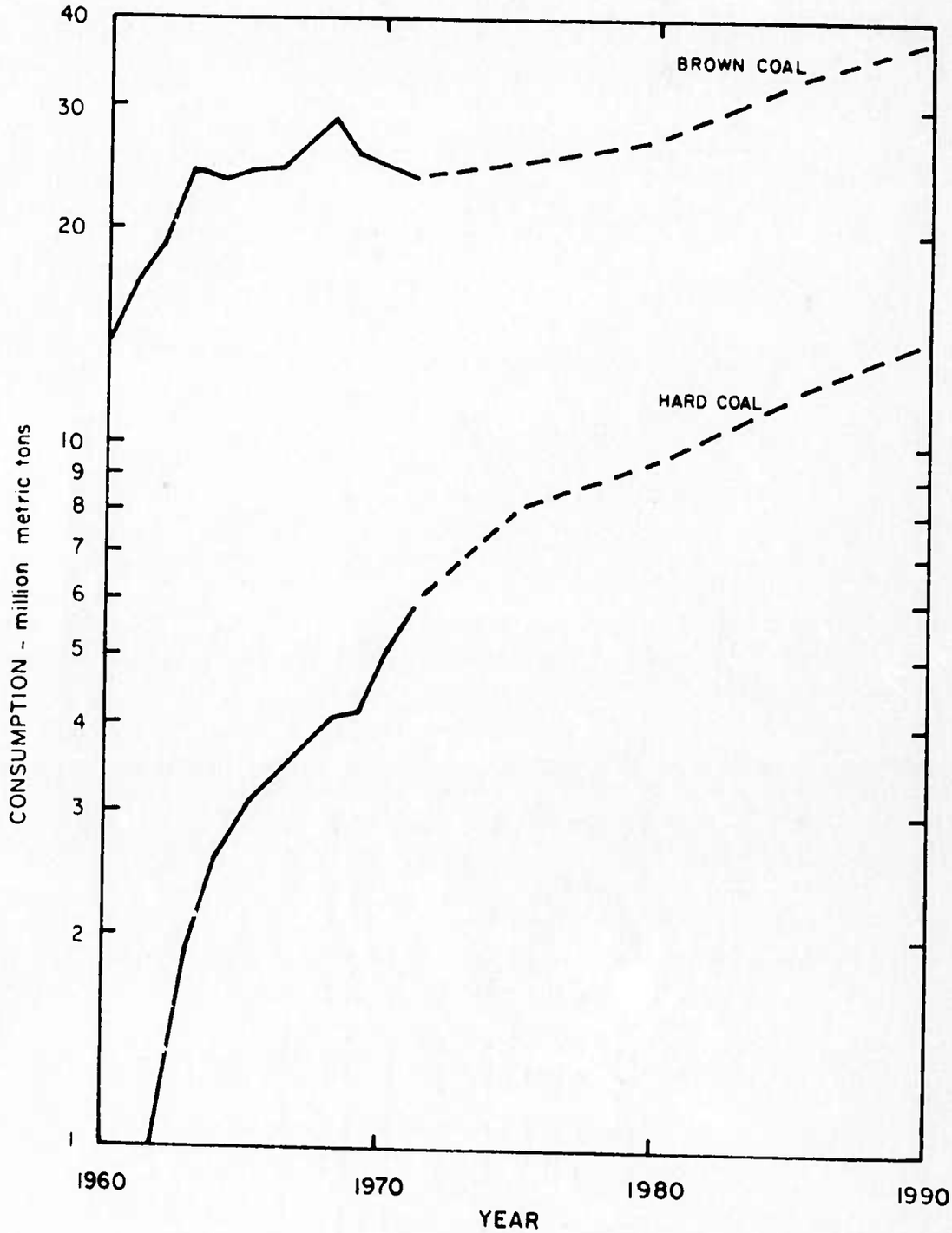

Figure A-25

NET INTERNAL CONSUMPTION OF COALS IN BULGARIA

hard coal. As a result, Bulgaria's energy demands by sector are geared to brown coal use. .Electric power generation, for example, has been primarily from brown coal; in 1971 this included about 16 million metric tons or nearly two-thirds of Bulgaria's brown coal production. Nearly all of the balance, or 6 million metric tons of brown coal, was used in industry, with small amounts going to transportation, commercial, and residential sectors (less than 0.4 million metric tons to transportation and less than 2 million metric tons to residential and commercial sectors combined).*

A relatively small amount of hard coal (slightly less than 6 million metric tons) was imported from the USSR in 1971. About half of the imported coal (2.9 million tons) was used by industry, a slightly lesser amount (2.6 million tons) was used in electric power generation, and the remainder (less than 0.5 million metric tons) was distributed to the transportation, commercial, and residential sectors.

The current five-year plan for Bulgaria indicates that the electric power generation sector will see fairly rapid growth. The plan reflects a production of 35 million metric tons of coal (total) production, with 78 percent or 27.3 million tons being used for electricity in 1975. Continued growth is expected with 74 to 85 percent of coal being used for electric power in 1980.[20/21/]

b. Czechoslovakia

Czechoslovakia energy end-use sectors are similarly geared to use of brown coals. In 1971 brown coals produced locally approximated 84 million metric tons which netted, after import, export, loss, and own use, about 82 million metric tons. By comparison, local hard coal production was about 29 million metric tons, which after net of imports and exports approximated 31 million tons. Details of historic

* U.N. Annual Bulletin of Coal Statistics for Europe.

and projected supply are shown in Table A-47 and illustrated in Figure A-26.

Of the brown coal, 31 million metric tons (38 percent) went to the electric power sector, 35 million (43 percent) to other industry, about 2 million (2 percent) to transportation, and the rest of about 14 million metric tons (17 percent) went to combined commercial and residential end-use sectors.‡

Of the 31 million metric tons of hard coal in 1971, about 6 million (20 percent) went to electric power generation, about 22 million (70 percent) went to other industry, 1 million (4 percent) went to transportation, and slightly less than 2 million metric tons (6 percent) went to the combined commercial and residential sectors.‡

c. East Germany

If established trends continue into the future, total consumption of energy is expected to continue to rise in East Germany. However, coal demand is expected to drop both in share of the energy market and in quantity. Expected trends, according to one published source, are as follows[22]:

	1965	1970	1975	1980	2000
Energy demand (10^6TCE)	93	104	113	120	140-150
Coal share (percent)	88.5	81.2*	73.5	57.6	n.a.
Coal use (10^6TCE)	82	84	83	69	n.a.

Like the preceding CMEA countries, East Germany energy consumption is geared to use of brown coals. Local brown coal production after loss and own use was nearly 263 million metric tons in 1971.†

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n.a. - not available.

* SRI estimate.

† U.N. Coal Statistics.

‡ U.N. Annual Bulletin of Coal Statistics for Europe.

Table 4-47
COAL SUPPLY IN CZECHOSLOVAKIA
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1975	1980	1985	1990
	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	%	10^6 MT	10^6 MT	10^6 MT	10^6 MT
Hard Coal																												
Production	26.214	100%	26.233	100%	27.119	100%	29.180	100%	28.314	100%	27.731	100%	26.964	100%	26.085	100%	26.065	100%	27.223	100%	28.194	100%	28.818	100%				
Plus Imports	2.402	9	3.355	13	4.023	15	4.072	14	4.349	15	4.538	16	4.039	15	4.174	16	4.823	17	4.595	17	4.497	16	5.396	19				
Less Exports	2.200	8	2.400	9	2.400	9	2.215	8	3.583	13	2.334	9	2.079	8	2.328	9	2.818	9	2.655	10	2.473	11	3.444	12				
Apparent Gross Production	26.416	101	27.188	104	28.772	106	30.037	106	30.080	106	29.891	107	28.921	107	27.931	107	28.270	108	29.163	107	29.718	105	30.770	107				
Less Losses and Own Use	-.884	3	-.312	-1	-.228	-1	.865	2	.630	2	.620*	2	.600	2	.467	2	-.226	-1	0.631	2	-.088	-1	-.016	-				
Net Internal Consumption	27.100	104	27.500*	105	29.000*	107	29.392	104	29.450	104	29.271*	105	28.224	105	27.464	105	28.496	106	28.542	105	29.806	106	30.818	107	32.813*	33.508*	34.174*	34.901*
Brown Coal																												
Production	58.402	100	65.303	100	69.185	100	72.847	100	73.605	100	73.214	100	73.156	100	70.760	100	74.307	100	78.659	100	81.298	100	84.181	100				
Plus Imports	0.800	1	-	-	-	-	0.070	-	-	-	-	-	-	-	-	-	-	-	0.406	1	0.044	-	-					
Less Exports	1.400	2	1.500	2	1.200	2	1.368	2	1.410	2	1.083	1	1.113	2	1.179	2	1.191	2	1.150	2	1.094	1	1.201	1				
Apparent Gross Production	57.803	99	63.803	98	68.265	98	71.114	99	74.195	98	72.213	99	72.343	98	69.621	98	73.146	98	77.915	99	80.248	99	82.980	99				
Less Losses and Own Use	0.750*	1	0.840*	1	.965*	1	1.155	2	0.940*	1	0.950	1	0.969	1	.812	1	0.812	-	1.975	2	1.722	2	1.246	2				
Net Internal Consumption	57.053*	98	62.963*	97	67.345*	97	69.963	96	74.215*	97	71.263*	98	71.374	97	68.809	97	73.134	98	76.940	97	78.526	97	81.711	97	90.813*	96.688*	103.719*	109.248*
Total Internal Consumption	84.153		90.863		96.365		99.365		102.865		100.534		100.018		96.873		101.630		105.182		108.332		112.532		122.626*	129.996*	138.093*	144.149*

Note: Negative numbers reflect stock and inventory adjustments

* SRI estimate.
* UN estimate

Sources: UN Coal Statistics, Minerals Yearbook

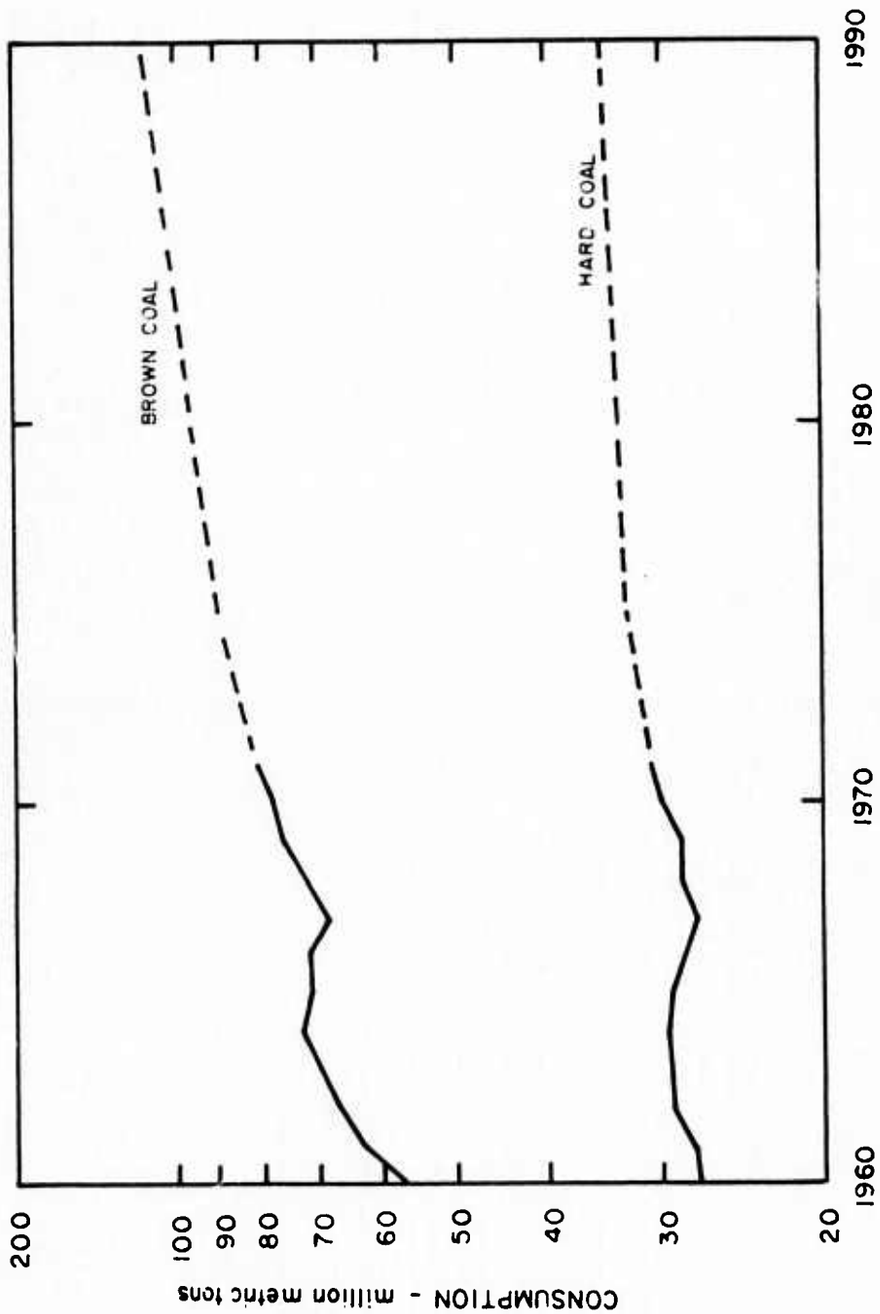

Figure A-26

NET INTERNAL CONSUMPTION OF COALS IN CZECHOSLOVAKIA

Compared to this, local hard coal production approximates only about 1 million tons per year in 1970, and even after imports, total hard coal is only 8-9 million metric tons. Details of net internal consumption are shown in Table A-48 and illustrated in Figure A-27.

No reliable breakdown is available on the sector end-use distribution of coals. However, end-use distribution should be similar to that of other CMEA countries--i.e., predominant use of the maximum quantity possible of brown coal in the electric power generation sector, with an additional small amount of hard coal only as needed. Essentially the remainder of brown coals and hard coals is used in the industrial sector, with small amounts of hard and brown coals distributed to transportation, commercial, and residential sectors.

d. Hungary

According to one published source,[23] recent plans for fuel-energy balance in Hungary reflect a total fuel demand of about 45 million metric tons of standard fuel (coal equivalent) for 1980. By comparison, 1970 demand was about 30 million, and 1960 demand was about 20 million tons.

This change of fuel demand results in a substantial change in the share of solid fuel energy source. Historically, Hungary has not produced enough fuel to meet its energy requirements. It has had to import both anthracite and bituminous coal as well as other energy sources (coke, petroleum, and electric power) to meet demand. Although imports of the various energy forms have been large (hard coal equal to about half of production in 1960, and slightly less than half of production in 1970), imports to meet projected demand must be even larger. The trend of imports indicates that in 1980, imports are expected to reach about half of demand. In the structure of imported energy, crude

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Table 4.48

COAL SUPPLY IN EAST GERMANY
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965	
	10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT	
Hard Coal												
Production	2.721	100	2.671	100	2.629	100	2.[illegible]	100	2.340	100	2.212	100
Plus Imports	8.300	305	7.936	297	8.881	337	8.819	356	10.411	115	9.161	[illegible]
Less Exports	0.300	11	0.300	11	0.300	11	0.300	12	-		-	-
Apparent Gross Production	10.721	391	10.307	386	11.210	426	11.033	454	12.751	515	11.676	528
Less Losses and Own Use	0.321	12	0.093*	3	0.610	23	0.333	13	0.572*	25	0.581*	26
Net Internal Consumption	10.400	382	10.400*	389	10.600*	403	10.700*	431	12.176*	520	11.092*	502
Brown Coal												
Production	225.465	100	237.000	100	244.900	100	251.219	100	258.426	100	250.839	100
Plus Imports	5.500	2	5.727	2	5.952	2	5.787	2	5.119	2	5.218	2
Less Exports	0.200*	-	0.200	-	0.600	-	0.288	-	0.270	-	0.255	-
Apparent Gross Production	230.765	102	242.527	102	250.252	102	256.718	102	262.105	102	255.802	102
Less Losses and Own Use	0.117*		0.170*	-	0.188*	-	0.070*	-	-0.087	-	0.067	-
Net Internal Consumption	230.648	102	242.357	102	250.061	102	256.648	102	262.192	102	255.715	102
Total Internal Consumption	241.048		252.757		260.664		270.318		274.368		266.807	

	1966		1967		1968		1969		1970		1971	
	10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT	
Hard Coal												
Production	1.992	100	1.[illegible]	100	1.579	100	1.332	100	1.094	100	n.a.	
Plus Imports	9.168	460	8.[illegible]	462	8.261	390	6.750	507	8.[illegible]	781	7.973	
Less Exports	-		-	-	-		-		-			
Apparent Gross Production	11.160	560	10.067	562	7.863	498	8.082	607	9.211	841	n.a.	
Less Losses and Own Use	0.558*	28	0.503*	28	0.393*	25	0.401*	30	0.462*	41	n.a.	
Net Internal Consumption	10.602*	532	9.560*	534	7.470*	473	7.678*	577	8.749*	837	n.a.	
Brown Coal												
Production	[illegible]	100	242.027	100	247.113	100	254.553	100	260.582	100	262.814	100
Plus Imports	5.066	2	3.732	2	4.002	2	4.040	2	-		-	
Less Exports	0.210	-	n.a.	-	n.a.	-	n.a.	-	n.a.		n.a.	
Apparent Gross Production	254.156	102	245.759	102	251.115	102	258.593	102	260.582	100	262.814	100
Less Losses and Own Use	0.125*	-	0.070*	-	0.131*	-	0.111*	-	-		-	
Net Internal Consumption	254.331	102	245.689	102	250.984	102	258.482	102	260.582	100	262.814	100
Total Internal Consumption	264.933		255.219		258.454		266.160		269.361		n.a.	

	1975	1980	1985	1990
	10^6 MT	10^6 MT	10^6 MT	10^6 MT
Hard Coal				
Net Internal Consumption	2.614*	5.509*	1.564*	4.302*
Brown Coal				
Net Internal Consumption	250.538*	244.522*	245.668*	236.217*
Total Internal Consumption	256.182*	250.031*	250.232*	240.519*

Note: Negative numbers reflect stock and inventory adjustments
n.a. - not available

* SRI estimate.
† UN estimate.

Sources. UN Coal Statistics: Jahrbuch 1965 der Deutschen Demokratischen Republik, Berlin 1972

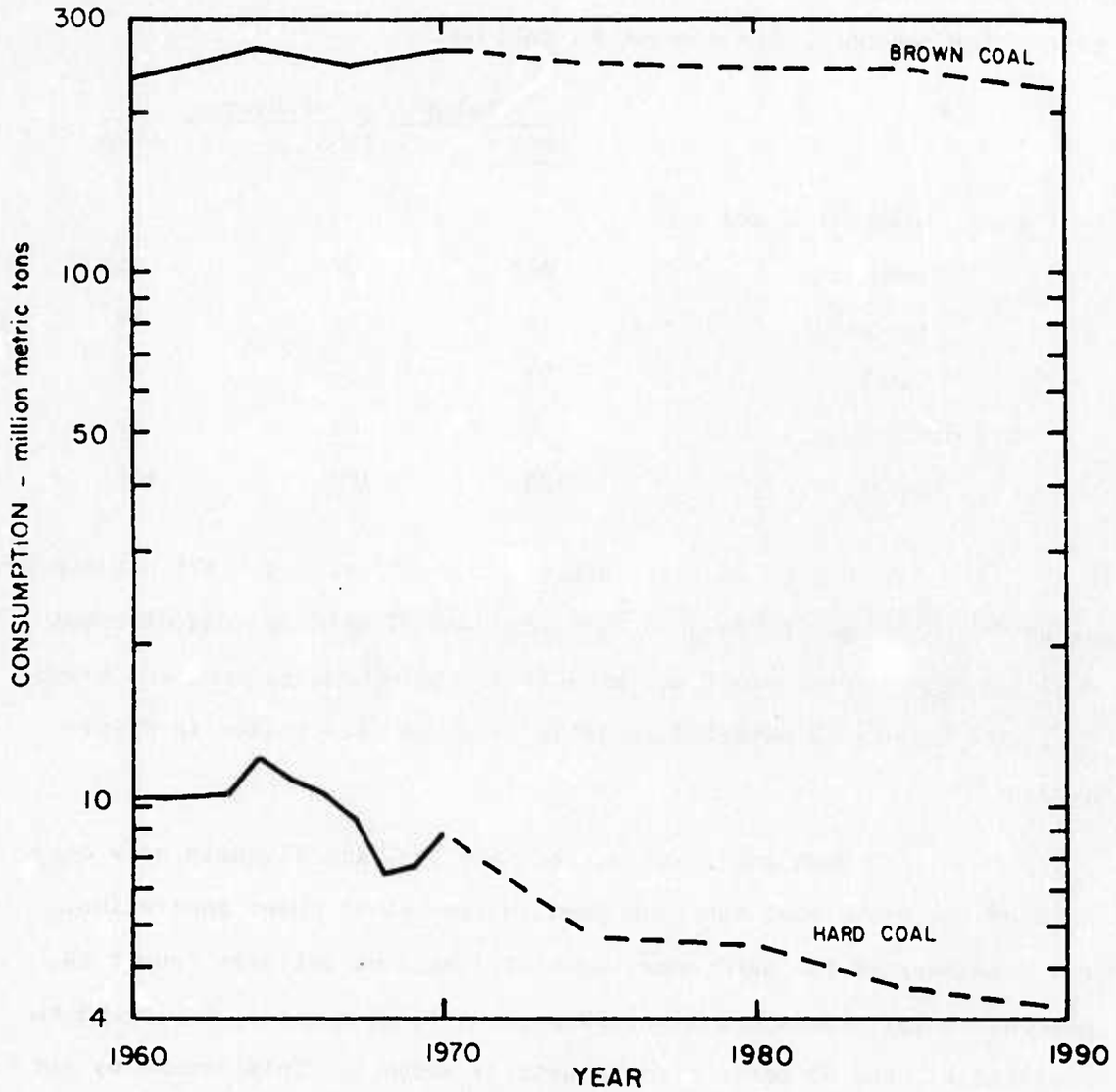

Figure A-27

NET INTERNAL CONSUMPTION OF COALS IN EAST GERMANY

oil and natural gas will be the dominant forms, replacing coal demand to a large degree.

Domestic coal has been characteristically of low quality, principally lignite. Because of the low quality and high mining costs[12], the trend of coal share of energy is downward, being supplanted by oil and gas as energy sources. Coal's share of energy production (including briquettes and coke) has dropped as follows:

	Percentage of Energy		
	1960	1965	1970
Coal, briquettes and coke			
Domestic	60%	52	41%
Imported	12	14	10
Total	72	66	51
All other energy	28	34	49
Total energy	100	100	100

In this context, Hungary's coal demand in 1971 had approximated 6 million metric tons of hard coal and 23 million tons of brown coal per year. Historical and projected supply of hard coal and brown coal for Hungary is detailed in Table A-19 and illustrated in Figure A-28.

About one-third of the hard coal and slightly over one-half of the brown coal had been used in electrical power generation. The remainder of the hard coal was distributed as follows: about 20 percent to rail transportation, 10 percent to commercial, 5 percent to residential, and 65 percent to industrial sectors. This demand by sectors is expected to be only slightly changed in the future.*

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* U.N. Annual Bulletin of Coal Statistics for Europe.

Table A-49

COAL SUPPLY IN HUNGARY
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1972	1973	1974	1975
	10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT		10^6 MT	10^6 MT	10^6 MT	10^6 MT
Hard Coal																												
Production	2,647	100	2,100	100	2,300	100	3,710	100	4,175	100	4,382	100	4,366	100	4,616	100	4,212	100	4,123	100	4,134	100	4,411	100				
Plus Imports	1,130	50	1,674	53	1,700	52	2,964	69	3,212	76	3,982	91	3,910	84	3,910	83	4,661	89	4,700	91	4,998	96	4,911	89				
Less Exports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,110	3				
Apparent Gross Production	3,777	150	3,774	157	3,900	152	6,674	160	7,387	176	7,921	191	8,870	184	8,966	177	8,963	189	8,836	191	8,132	196	9,212	186				
Less Losses and Own Use	0,041	1	0,251*	8	0,300*	9	0,025	1	0,050	1	0,128	3	0,072	1	-		-		-,342	-13	+,137	+1	+,051	+1				
Net Internal Consumption	3,736	149	3,500*	135	3,700*	143	6,229	159	7,287	177	6,806	168	6,811	157	8,966	177	8,983	189	9,178	154	8,713	152	9,196	187	6,393*	6,497*	6,855*	6,153*
Brown Coal																												
Production	23,700	100	25,105	100	25,311	100	26,789	100	27,423	100	27,025	100	25,988	100	22,968	100	22,972	100	22,453	100	23,679	109	23,183	100				
Plus Imports	0,800	2	0,600	2	0,800	2	0,101	1	-	-	0,003	-	-	-	-	-	-	-	-	-	-	-	0,030	-				
Less Exports	0,100	1	0,100	-	0,100	1	0,149	1	0,323*	2	0,067	-	0,072	-	0,091	-	0,081	-	0,155	1	0,092	-	0,105	1				
Apparent Gross Production	24,000	101	25,605	102	25,611	101	26,741	100	26,850*	98	26,996	100	25,916	100	22,877	100	22,911	100	22,710	99	23,587	109	23,108	99				
Less Losses and Own Use	0,180	1	0,736*	3	0,256*	1	0,273	1	0,300*	1	0,331	1	0,216	1	-	-	-	-	-,133	-2	0,255	1	0,807	3				
Net Internal Consumption	23,820	100	25,130*	101	25,355*	100	26,468	99	26,550	97	26,662	99	25,688	99	22,877	100	22,911	100	22,835	101	23,332	99	22,621	98	24,679*	26,351*	29,290*	28,995*
Total Internal Consumption	28,056		29,630		30,055		32,715		33,837		33,668		32,511		28,843		28,811		29,013		29,646		28,817		31,032*	29,848*	36,145*	35,028*

Note: Negative numbers reflect stock and inventory adjustments

* SRI estimate.

Sources: UN Annual Bulletin of Coal Statistics for Europe; Hungarian Statistical Yearbook 1971.

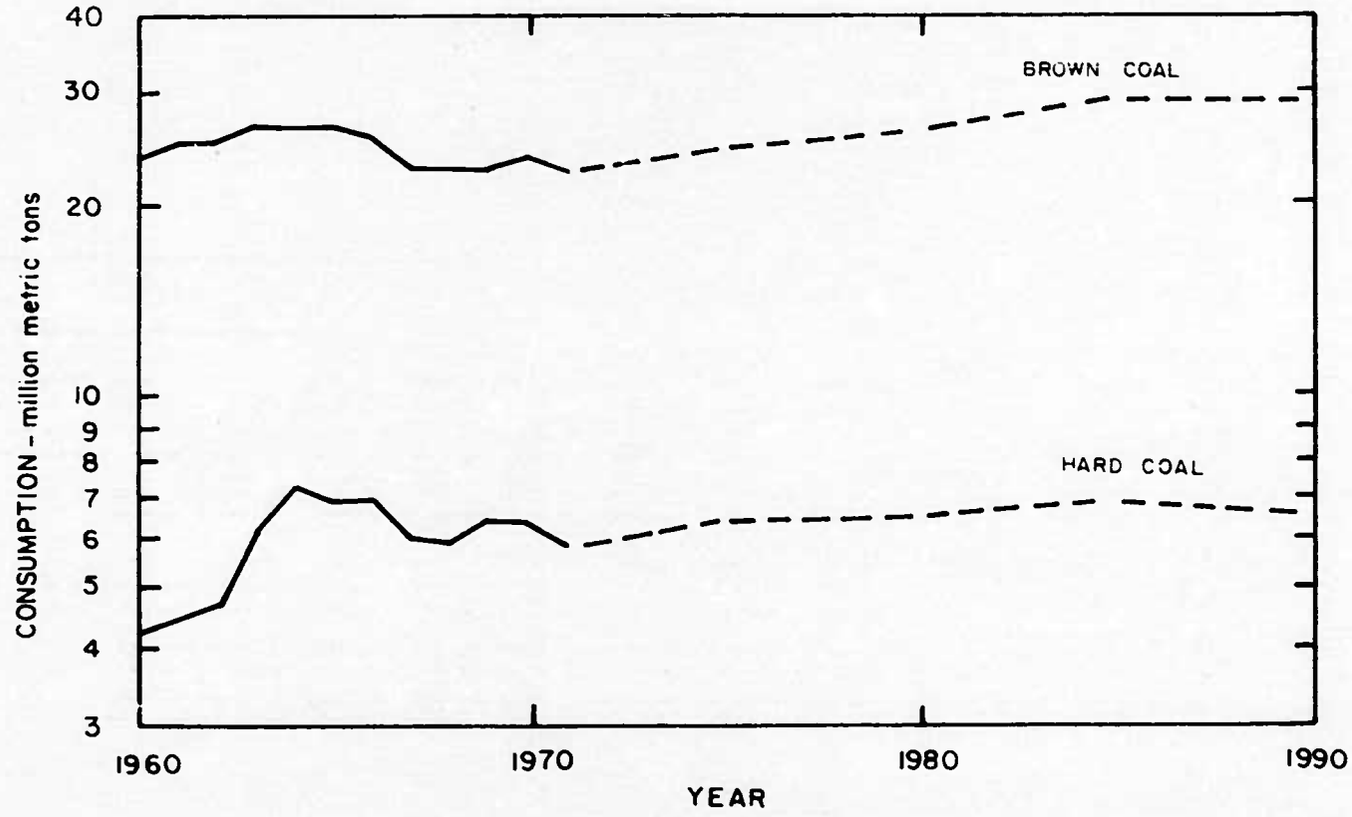

Figure A-28

NET INTERNAL CONSUMPTION OF COALS IN HUNGARY

e. Poland

Poland contrasts somewhat with the other CMEA countries in that local coal production is chiefly hard coal. In 1971 local production of hard coal reached over 145 million metric tons, which, after imports, exports, and losses, netted 112 million tons. By contrast, net brown coal production approximated 31 million metric tons. Details of historic and projected supply are given in Table A-50 and illustrated in Figure A-29.

Here too, the largest portion of hard coal is distributed to industry, which in 1971 used about 51 percent; the electrical sector used about 22 percent, the combined commercial and residential sectors used 21 percent, and the transportation sector used only 6 percent.*

Poland's soft coal is used mainly in the electrical power generation plants, which used nearly 93 percent of the net internal consumption. About 4 percent went to the industrial sector, and the remainder of about 3 percent went to the combined commercial and residential sectors.*

f. Romania

The remaining CMEA country, Romania, is a small coal producer. Historic and projected net internal consumption is detailed in Table A-51 and illustrated in Figure A-30.

As in the other CMEA countries, the industrial and the electric power generation sectors receive the bulk of the coal. In 1970 hard coal distribution approximated 42 percent to industry, 35 percent to electrical power generation, 19 percent to rail transportation, and only 4 percent to the combined commercial and residential sectors.*

Of the brown coal in 1970, most was used by the electrical power industry; 79 percent went to the electrical power generation

* U.N. Annual Bulletin of Coal Statistics for Europe.

Table A-50

COAL SUPPLY IN POLAND
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1975	1980	1985	1990
	a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT		a 10 MT	a 10 MT	a 10 MT	a 10 MT
Hard Coal																												
Production	104.000	100	106.600	100	109.864	100	111.150	100	117.300	100	119.300	100	121.979	100	123.881	100	129.631	100	135.010	100	140.101	100	145.691	100				
Plus Imports	0.776	1	0.929	1	1.062	1	1.233	1	1.201	1	1.210	1	1.111	1	1.213	1	1.256	1	1.088	1	1.097	1	1.264	1				
Less Exports	17.198	17	17.654	16	17.836	16	16.570	15	19.149	16	21.192	18	22.366	18	21.029	17	26.002	20	26.417	20	28.643	21	30.301	21				
Apparent Gross Production	87.578	84	89.875	85	93.090	85	97.813	88	99.352	85	99.317	83	100.624	83	103.065	83	102.888	81	109.681	81	117.555	84	116.654	80				
Less Losses and Own Use	5.546	5	6.231*	6	6.290*	6	4.961*	4	6.152*	5	6.265*	5	1.877	1	2.130	2	2.100	2	3.556	3	2.898	2	1.393	3				
Net Internal Consumption	82.032*	79	84.144*	79	87.072*	79	93.352	84	93.200*	80	93.152*	78	95.777	79	98.625	80	101.788	79	106.125	78	109.689	78	112.061	77	130.150*	150.020*	167.630*	194.357*
Brown Coal																												
Production	9.200	100	10.339	100	11.093	100	15.344	100	20.280	100	22.600	100	21.508	100	23.922	100	26.878	100	30.865	100	32.766	100	34.517	100				
Plus Imports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Less Exports	5.500	59	5.872	57	5.660	51	5.726	37	5.381	27	5.199	23	5.060	21	3.706	15	4.002	15	4.381	14	3.972	12	3.561	10				
Apparent Gross Production	3.800*	41	4.467	43	5.433	49	9.618	63	14.899	73	17.401	77	19.448	79	20.216	85	22.876	85	26.484	86	28.794	88	30.956	90				
Less Losses and Own Use	0.300*	3	0.350*	3	0.400*	3	0.461	3	1.128	6	0.987	4	0.380	2	0.335	2	0.383	1	0.375	1	0.288	1	0.399	1				
Net Internal Consumption	3.500*	38	4.117*	40	5.033*	45	9.111	60	13.771	67	16.414	73	19.068	77	19.881	83	22.493	84	26.109	85	28.506	87	30.557	89	38.042*	68.675*	57.043*	70.391*
Total Internal Consumption	85.532		88.261		92.105		102.496		106.971		109.566		114.845		118.466		124.281		132.234		137.975		142.618		168.192*	186.701*	220.376*	264.748*

* SRI estimate.

Sources: UN Coal Statistics; Poland Yearbook 1972.

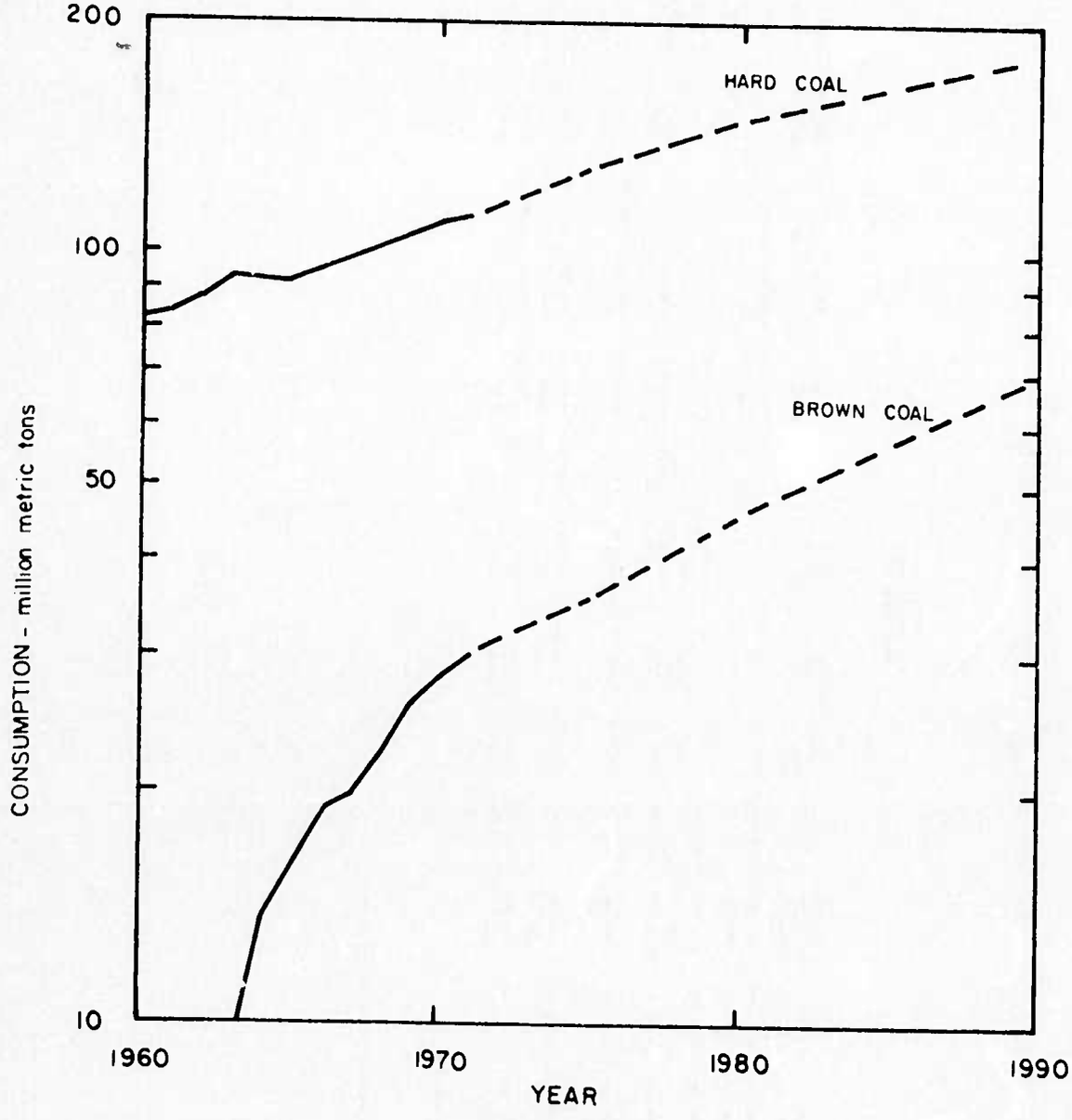

Figure A-29
NET INTERNAL CONSUMPTION OF COALS IN POLAND

Table A-31

COAL SUPPLY IN ROMANIA
(Million Metric Tons)

	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1975	1980	1985	1990
	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	%	Mill MT	Mill MT	Mill MT	Mill MT
Hard Coal																												
Production	3.405	100	3.763	100	4.084	100	4.336	100	4.917	100	4.658	100	4.822	100	5.112	100	5.450	100	5.863	100	6.402	100	6.793	100				
Plus Imports	0.416	12	0.441	12	0.750	18	0.695	16	0.716	14	0.706	15	0.699	14	0.762	15	0.711	13	0.588	10	0.880	11						
Less Exports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Apparent Gross Production	3.821	112	4.204	112	4.834	118	5.051	116	5.635	110	5.364	115	5.511	114	5.874	115	6.160	113	6.451	110	7.082	111						
Less Losses and Own Use	-	-	-	-	-	-	0.008	-	-	-	-	-	0.008	-	0.005	-	-	-	-	-	-	-						
Net Internal Consumption	3.821	112	4.204	112	4.834	118	5.043	116	5.635	110	5.364	115	5.503	114	5.869	115	6.160	113	6.451	110	7.082	111			8.717*	8.868*	10.325*	10.110*
Brown Coal																												
Production	3.363	100	3.801	100	4.270	100	4.288	100	4.865	100	5.673	100	6.699	100	7.853	100	9.345	100	11.113	100	14.179	100	13.782	100				
Plus Imports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Less Exports	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Apparent Gross Production	3.363	100	3.801	100	4.270	100	4.288	100	4.865	100	5.673	100	6.699	100	7.853	100	9.345	100	11.113	100	14.179	100	13.782	100				
Less Losses and Own Use	n.a.		n.a.		n.a.		-0.007	-	n.a.	-	-	-	0.000	-	0.005	-	0.061	1	0.188	2	0.114*	1	n.a.	-				
Net Internal Consumption	3.363*	100	3.801*	100	4.270*	100	4.295	100	4.865	100	5.637*	100	6.646	100	7.848	100	9.284	99	10.925	98	14.065	99	13.782	100	10.583*	28.013*	38.868*	39.826*
Total Internal Consumption	7.184		8.005		9.109		9.340		10.100		10.902		12.149		13.717		15.453		17.376		21.107				36.300*	36.880*	45.880*	49.749*

Note: Negative number reflects stock and inventory adjustments
n.a. - not available

* SRI estimate.

Sources: UN Burlm Energy Supplies, Series J. Comecon Statistics. UN Coal statistics for Europe.

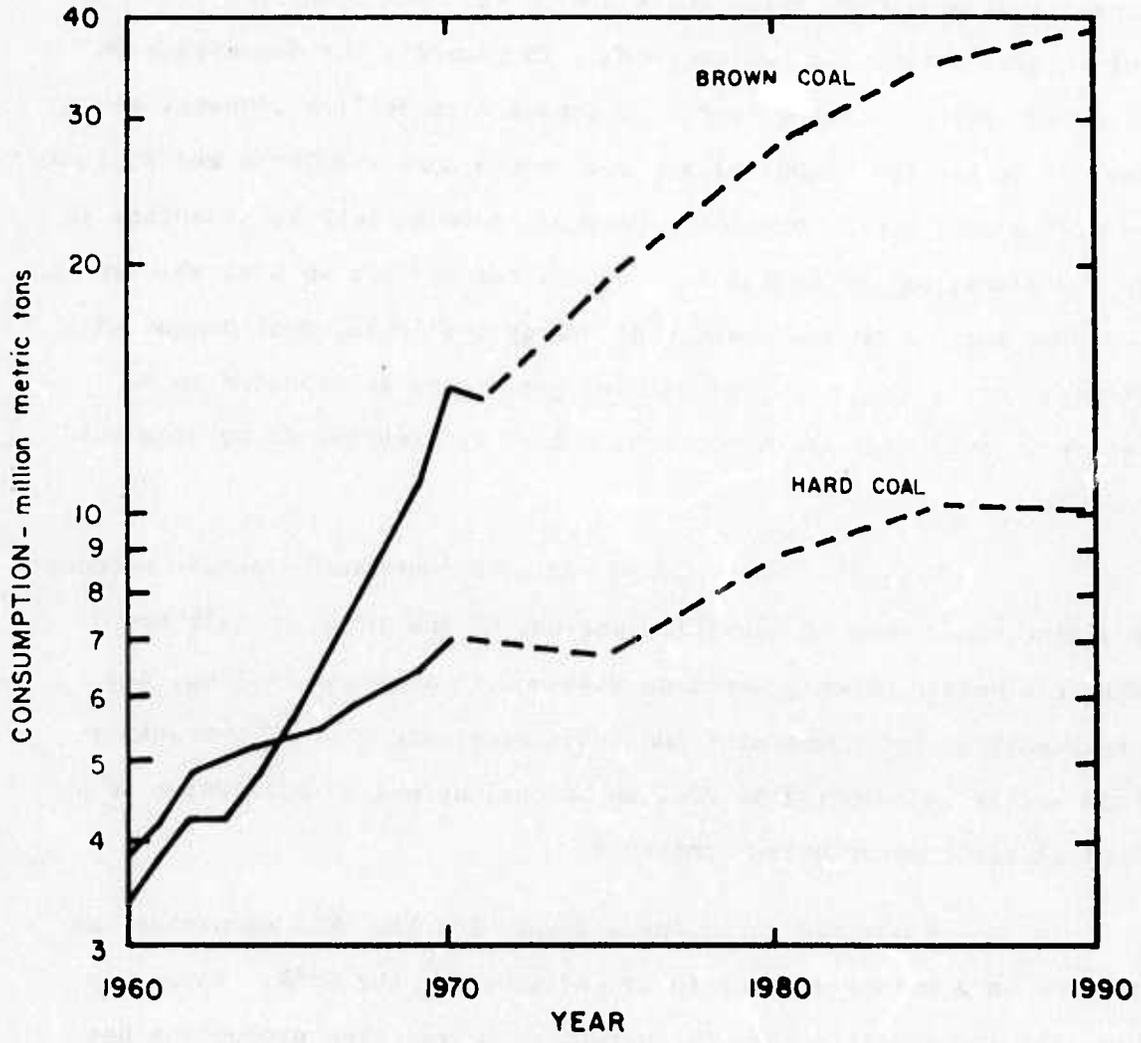

Figure A-30

NET INTERNAL CONSUMPTION OF COALS IN ROMANIA

sector, 5 percent went to the industrial sector, 5 percent was used in transportation, and the remaining 11 percent was used in the combined commercial and residential sectors.

g. All CMEA Countries

Available five-year plans together with other publications indicate that projected solid fuels use in the CMEA countries will parallel to some extent that of the USSR. In general, the dependency on coal as the primary energy source is expected to decline somewhat as crude oil (petroleum products) and gas become more available and supplant some of the coal energy demands. However, because coal is essential in many instances, and because oil or gas either may not be available where needed, or may not be the least-cost energy available, coal demand will continue. While the growth of oil and gas demand is expected to be relatively large, the growth of coal demand is expected to be slow but steady.

Projected coal demand reflects continued emphasis on open pit mining where this is feasible, and use of the lower quality brown coals in electric power generation stations, industrial heating, and where feasible, the commercial and residential sectors. The transportation sector is expected to decline in coal demand as conversion to diesel-electric power units continues.

Projected solid fuels supply for the CMEA countries has been done in a manner similar to projections for the USSR. Where possible, the individual country's current five-year plan projection has been used to determine the 1975 net internal consumption. Trends were developed for production, import, export, and losses on the basis of available historical data. Where necessary, estimates were made to make up for missing information or to adjust data that differed with different

published sources. The data that most closely followed an even trend were used.

In this context, the total solid fuels demand for the CMEA countries has been converted to million tons of fuel equivalent and projected, as detailed in Table A-52 and illustrated in Figure A-31.

B. Electricity

1. Summary and Conclusions

The electric power sector plays an increasingly important role in the economies of the countries of Eastern Europe. One indicator is the ratio of net internal consumption of electricity compared to total primary fuels (natural gas, oil, solid fuels). This ratio is shown below:

	Electricity as a Percent of Total Primary Fuels					
	1960	1970	1975	1980	1985	1990
USSR	6%	8%	9%	10%	10%	12%
Eastern bloc	5	7	7	8	9	11

The electric power industry is usually the largest single user of fuels in a country. In 1970 the fuel input into the USSR electric power sector amounted to about 33 percent of all the available primary fuel.

The countries of Eastern Europe are expected to consume the following amounts of electric power:

	Billions of Kilowatt Hours				
	1970	1975	1980	1985	1990
USSR	626.9	902.2	1,287.0	1,776.0	2,323.0
CMEA countries					
Bulgaria	15.8	24.4	35.9	51.6	71.9
Czechoslovakia	41.4	54.5	71.3	92.3	118.4
East Germany	55.4	71.6	90.5	114.5	141.4
Hungary	15.0	20.8	29.3	41.5	56.5
Poland	54.4	78.4	109.2	147.8	194.7
Romania	25.8	42.9	69.4	105.0	154.1
Total	207.8	292.6	405.6	552.7	737.0

The above values correspond to the average period growth rates tabulated below:

	Growth Rates in Percent				
	1960-1970	1970-1975	1975-1980	1980-1985	1985-1990
USSR	9.4%	7.6	7.4	6.7	5.5%
CMEA countries					
Bulgaria	14.6	9.1	8.1	7.5	6.9
Czechoslovakia	7.3	5.6	5.5	5.3	5.1
East Germany	4.7	5.2	4.8	4.8	4.3
Hungary	8.4	6.7	7.1	7.2	6.4
Poland	8.4	7.6	6.8	6.2	5.7
Romania	15.2	10.7	10.1	8.6	8.0
Weighted Avg.	7.9	7.1	6.7	6.4	5.9

Table A-52

HISTORICAL AND PROJECTED NET INTERNAL CONSUMPTION
OF SOLID FUELS IN CMEA COUNTRIES
(Million Metric Tons of Coal Equivalent)

	1960	1965	1970	1975	1980	1985	1990
Bulgaria							
Hard coal	0.3	2.5	4.3	6.8	8.1	10.1	12.1
Brown coal	6.9	12.2	12.4	12.7	13.8	16.5	18.9
Peat, other	0	0	0	0	0	0	0
Total	7.2	14.7	16.7	19.5	21.9	26.6	31.0
Czechoslovakia							
Hard coal	23.0	24.9	25.3	27.7	28.5	29.0	29.7
Brown coal	25.7	32.0	36.1	41.4	44.4	47.3	50.4
Peat, other	0.8	0.8	0.9	1.0	1.1	1.2	1.2
Total	49.5	57.7	62.3	70.1	74.0	77.5	81.3
East Germany							
Hard coal	8.8	9.4	7.4	4.8	4.7	3.9	3.6
Brown coal	69.2	76.8	78.2	75.2	73.3	73.7	67.8
Peat, other	0	0	0	0	0	0	0
Total	78.0	86.2	85.6	80.0	78.0	77.6	71.4
Hungary							
Hard coal	3.1	5.2	4.5	4.6	4.4	4.4	4.0
Brown coal	10.7	12.1	10.5	11.1	11.3	11.8	11.4
Peat, other	0.5	0.5	0.6	0.6	0.6	0.7	0.6
Total	14.3	17.8	15.6	16.3	16.3	16.9	16.0
Poland							
Hard coal	69.7	79.2	92.0	109.3	126.0	140.6	154.9
Brown coal	1.1	4.9	8.5	10.8	14.0	17.4	21.1
Peat, other	0	0	0	0	0	0	0
Total	70.8	84.1	100.5	120.1	140.0	158.0	176.0
Romania							
Hard coal	2.2	3.1	4.0	3.8	5.0	5.9	5.8
Brown coal 1	0.9	1.5	3.8	5.3	7.6	9.6	10.7
Peat, other	0	0	0	0	0	0	0
Total	3.1	4.6	7.8	9.1	12.6	15.5	16.5
Total Six CMEA Countries							
Hard coal	107.2	124.3	137.6	157.1	176.7	194.0	210.0
Brown coal	114.4	139.6	149.6	156.4	164.3	176.2	180.4
Peat, other	1.4	1.4	1.5	1.7	1.8	1.8	1.9
Total CMEA	223.0	265.3	288.7	315.2	342.8	372.0	392.2

NOTE: Columns may not total because of number rounding.

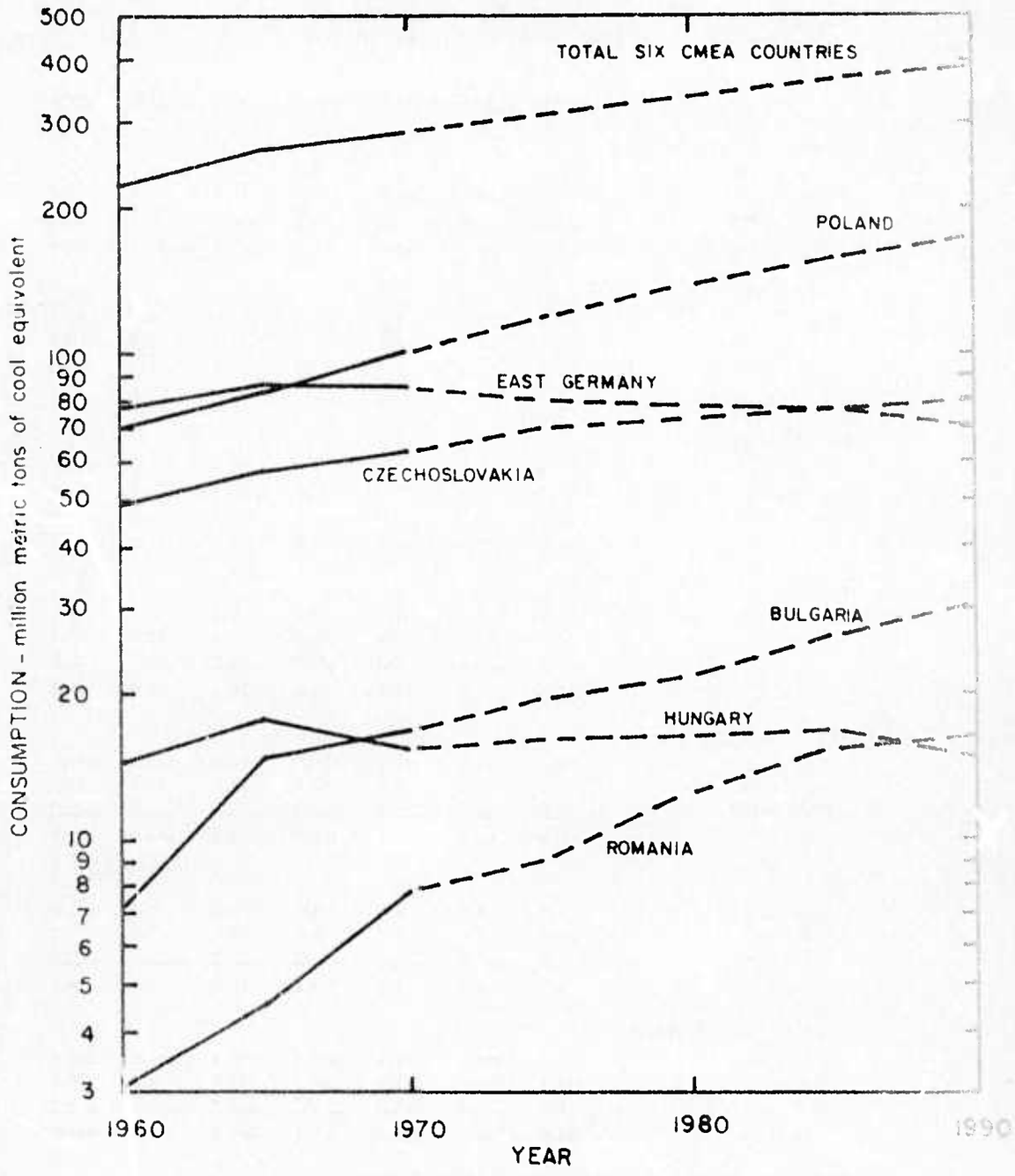

Figure A-31

HISTORICAL AND PROJECTED NET INTERNAL CONSUMPTION OF SOLID FUELS IN SIX CMEA COUNTRIES

It is evident that the USSR will consume much more electric energy than any other country included in this study. In 1970 all these countries combined used only one-third of the electricity consumed by the USSR, whereas their population amounted to 42 percent of the Russian population. By 1990, these percentages are expected to be 32 percent for electricity and 39 percent for population. By comparison, in 1970, the USSR consumed less than half the electricity used in the United States although the USSR had an 18 percent larger population. The per capita consumption was 2,600 kWh, or 38 percent of the U.S. level of 6,800 kWh. The USSR and the CMEA countries combined used 60 percent of the amount of electricity consumed in the United States. The per capita figure is 2,400 kWh, which is one-third the U.S. level.

In the decade 1960-1970, the USSR experienced a higher electricity demand growth rate than the Eastern Bloc as a group. Only Romania and Bulgaria were higher, but their combined electric power consumption amounted to less than 7 percent of that of the USSR. The USSR is projected to maintain its lead until some time after 1985 when the weighted average growth rate of the Eastern Bloc will catch up.

Figure A-32 shows the per capita net internal consumption of the USSR and the combined Eastern Bloc countries. After losing ground in the sixties, the CMEA countries as a group will slightly improve their relative position in the future. While no dramatic changes are evident for the group, noticeable shifts are foreseen within the bloc. These will be discussed in a later section.

2. Forecasting Method

The total demand for electric power generally relates closely to the growth in population and economic development of a country. Thus,

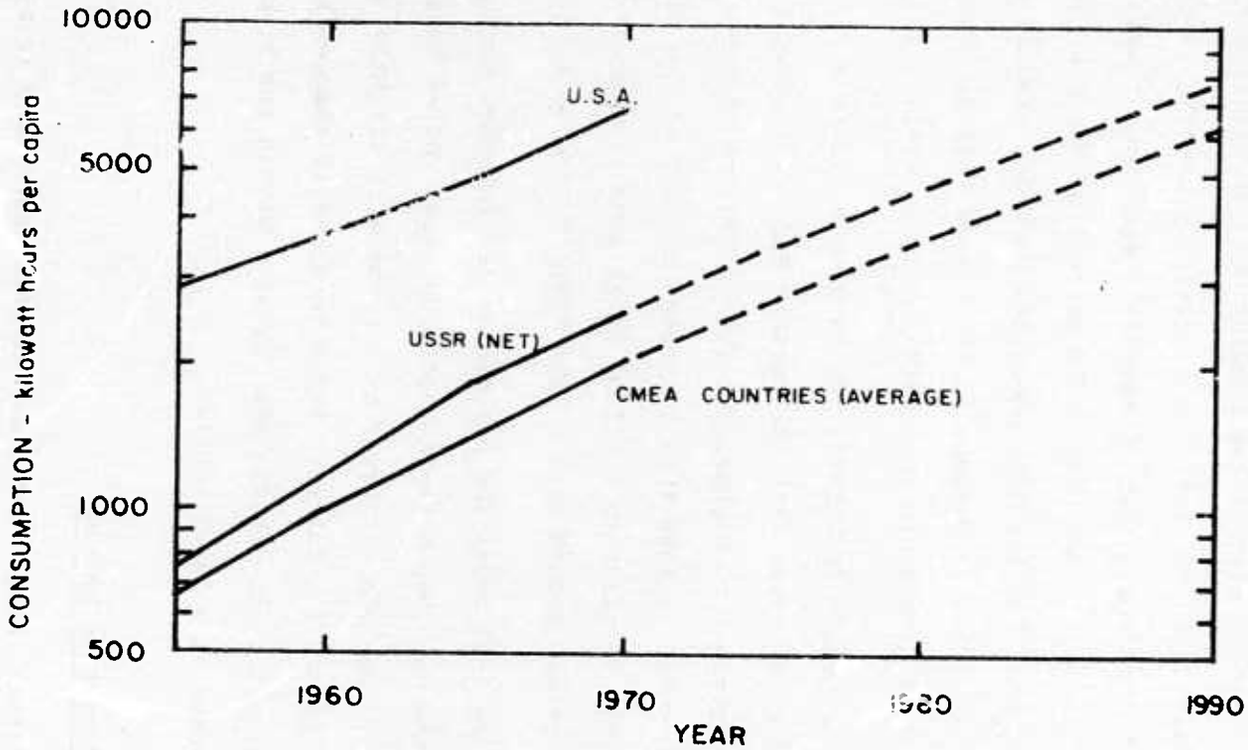

Figure A-32

INTERNAL CONSUMPTION OF ELECTRIC ENERGY PER CAPITA
FOR THE USSR AND CMEA COUNTRIES

demand for electric power can be extrapolated using functional relationships with macro-economic variables such as population and GNP. In this study it was found that in most of the countries examined, a very good correlation exists between kWh of electricity consumed per capita and GNP per capita when using the exponential function

$$Y = A(X)^B$$

where Y = kWh per capita

X = GNP per capita

A = Factor

B = Exponent

On a logarithmic scale, this function plots as a straight line, with the exponent determining the slope, and the factor, the position relative to the Y-axis.

While this method automatically accommodates changes in the explanatory variables (GNP and population), adjustments were made in a few instances to allow for expected shifts in the role of electric power in the total energy picture. One of the problems of some Eastern Bloc countries has been the periodic power supply shortages that lead to temporary demand restrictions. While power shortages in short term crisis situations cannot be ruled out in the future, SRI has assumed that in the long term, demand for electric power will be met. This assumption seems reasonable in light of the traditionally high priority given to the electric power industry in the economic planning of the USSR and increasing interconnection of the power systems among the CMEA countries.

3. Electricity in the USSR

a. Demand

During the fifteen years 1955-1970, electric power consumption has consistently shown high growth which is expected to continue during the current five-year planning period. The compound annual growth rates for net internal consumption of electric power and GNP growth are shown below:

	1955-60	1960-65	1965-70	1970-75
Electricity	11.4%	11.2	7.6	7.5%
GNP	7.9	6.4	7.0	6.8

It is evident that after a very strong expansion period from 1955 to 1965, increases in electricity demand have slowed down to a growth rate more in line with the GNP growth.

The same trend is illustrated in Figure A-33, which shows the correlation between per capita kWh consumed and GNP per capita, according to the previously described methods for estimating. The slope of the curve shows an obvious shift around 1964. As the growth rates since then are more representative of a mature economy which the USSR is approaching, we have used the period 1964-1971 as the basis for projection. A regression for this period for the two variables shown on Figure A-33 supplies the following exponential expression:

$$Y = 0.7945\ (X)^{1.13} \qquad r^2 = 0.997^{*}$$

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* r^2 (coefficient of determination) indicates what proportion of the variation in the dependent variable Y can be explained by the variation of the independent variable X, which here is GNP per capita.

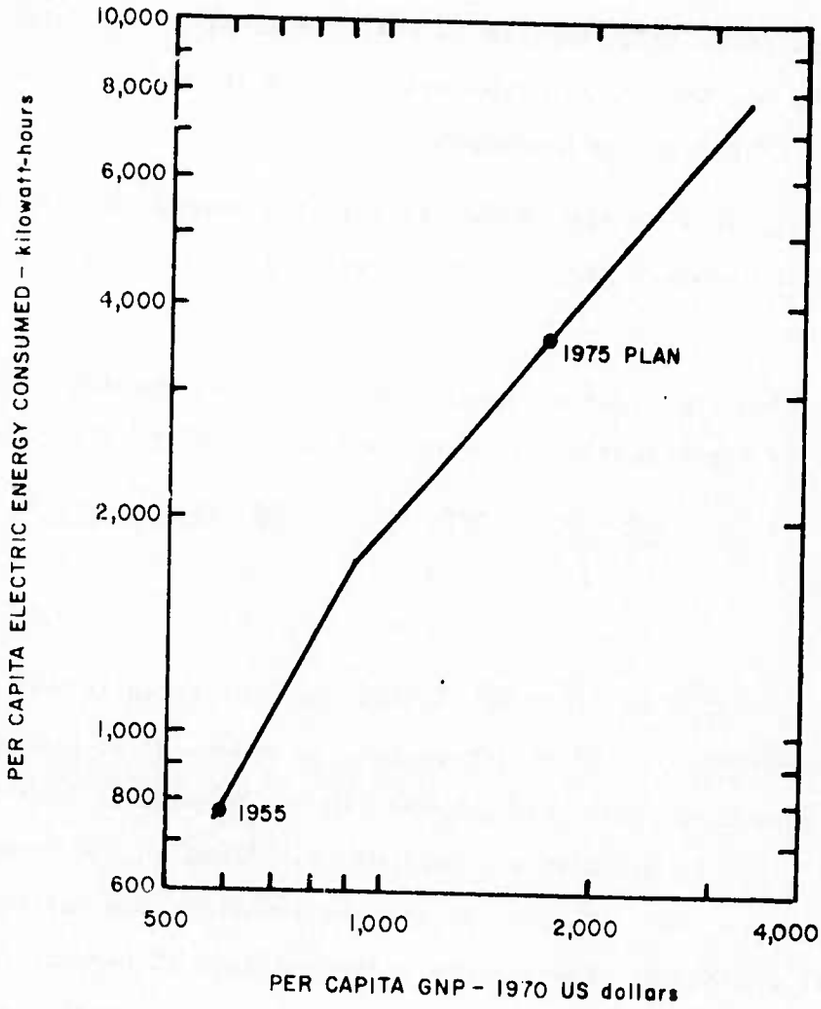

Figure A-33

USSR ELECTRIC ENERGY CONSUMED VERSUS GNP PER CAPITA

Using the GNP and population forecasts discussed earlier, the expected electricity consumption can be calculated.* Figure A-34 shows the electric power consumption of the USSR in total kWh and on a per capita basis for the period 1960-1990. The USSR per capita electricity consumption in 1971 compares to the 1954 level in the United States. By 1985 the Soviets are expected to reach the United States 1968/1969 level of per capita consumption.

Figure A-34 also shows the weighted average kWh per capita consumption of the Eastern Bloc countries, which is about 20 percent below the USSR level.

The USSR electric power consumption and the GNP are expected to grow at the following compound average annual growth rates:

	1970-75	1975-80	1980-85	1985-90
Electricity	7.5%	7.4	6.7	5.5%
GNP	6.8	6.4	6.0	5.0

The USSR net internal demand has traditionally been virtually monopolized by the industrial sector, as evidenced by Figure A-35. However, its percentage share has dropped from 77 percent in 1960 to 71 percent in 1971 and is expected to continue this trend in the future to reach 64 percent in 1990. The second largest end users are residential and commercial customers. Their share increased from 12 percent in 1960 to over 13 percent in 1971. This sector is expected to experience a

---

* The 1975 plan figure of 3,528 kWh per capita net consumption has also been used as a base input. It is slightly lower than the 3,639 kWh per capita forecast based on the 1964-71 historical base, and hence, indicates that the electric power planning of the current five-year plan is realistic and can be achieved. If the 1975 plan figure were not used in the forecast, the 1990 per capita consumption would be 4.7 percent higher (8,065 versus 7,700 kWh/capita).

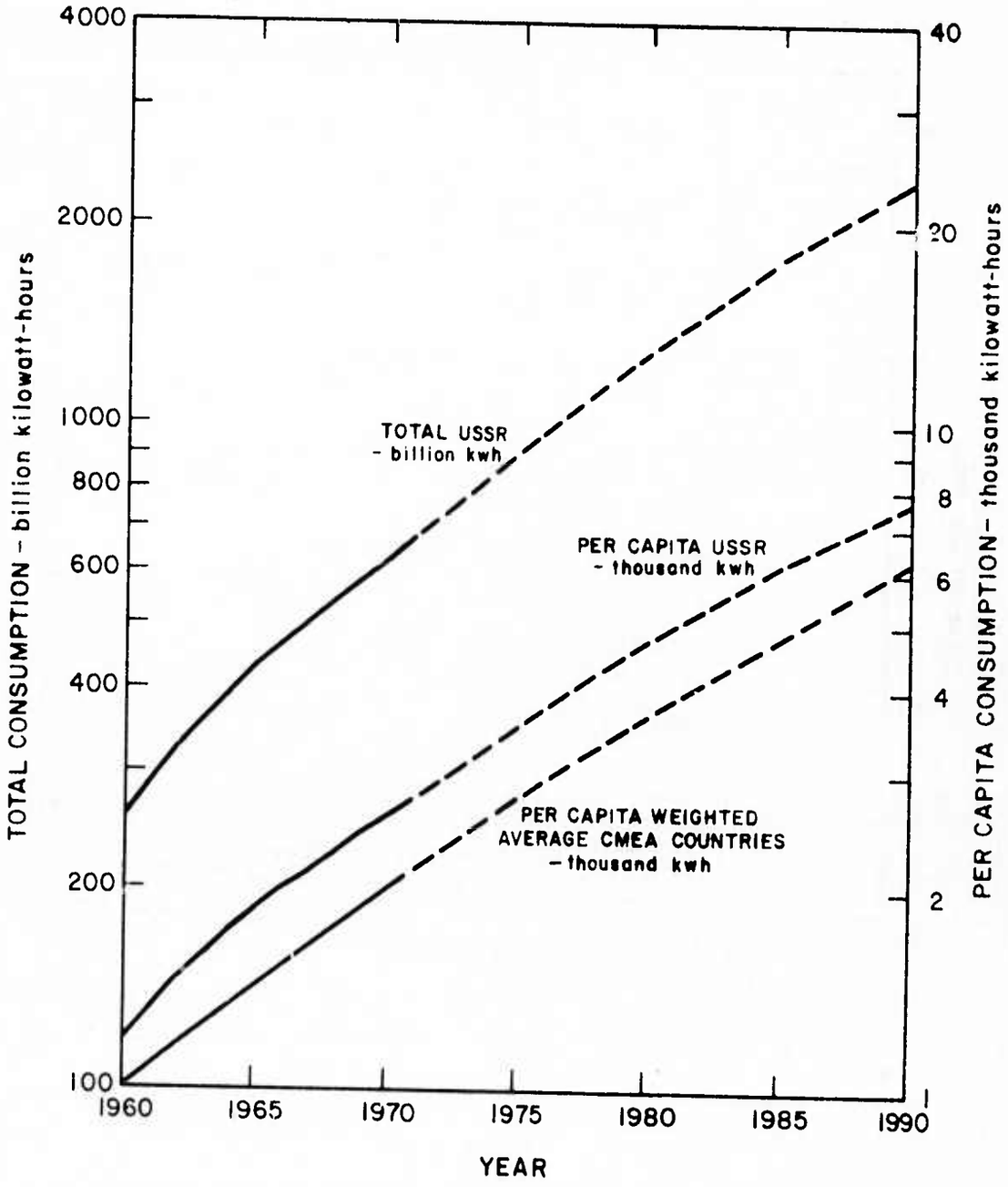

Figure A-34

NET INTERNAL CONSUMPTION OF ELECTRICAL ENERGY

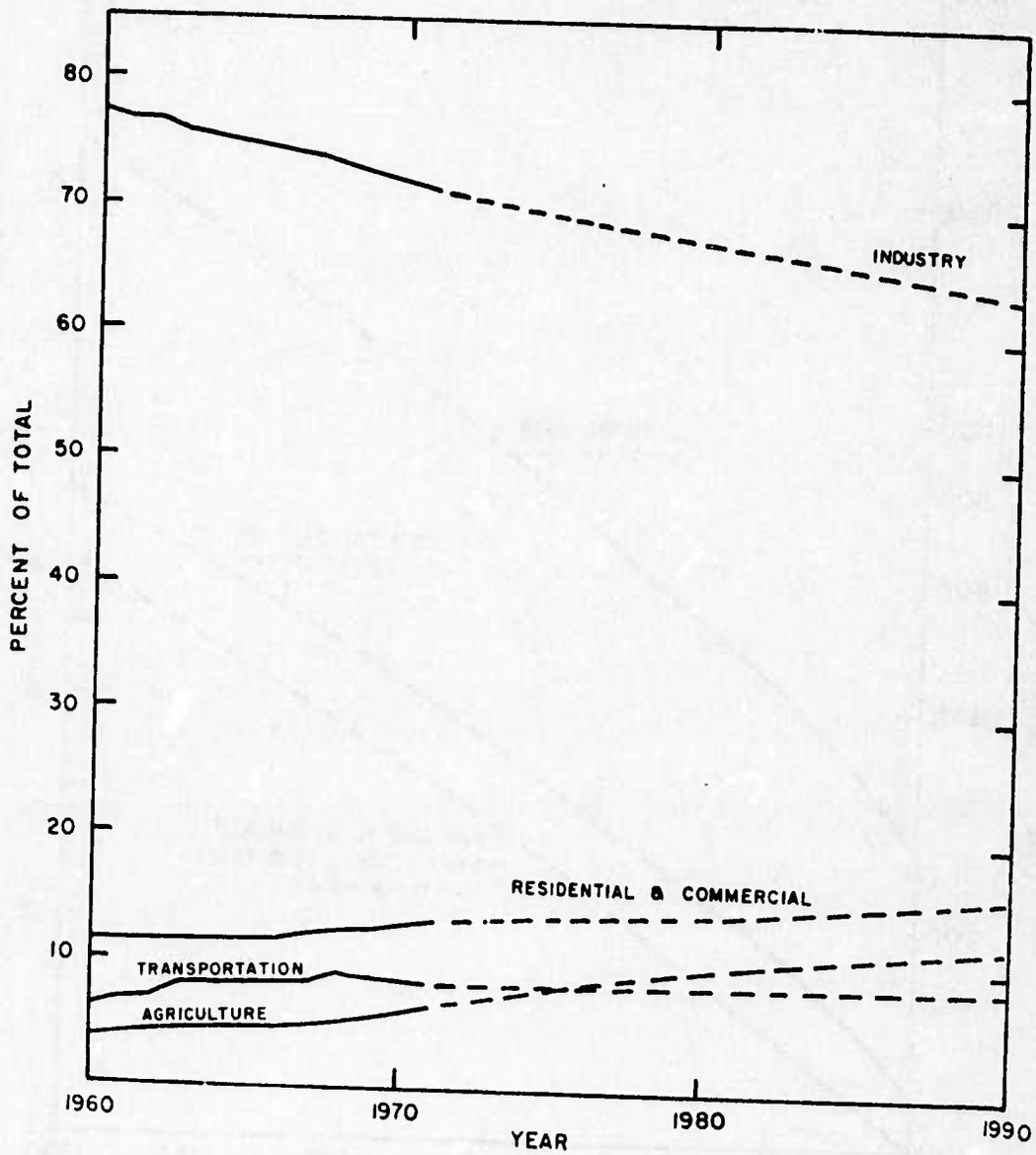

Figure A-35

END USE OF ELECTRIC POWER IN THE USSR

a continuous steady increase to 16 percent in 1990. This projection assumes that as in the past, Russian consumers will not be allowed the major consumer role that its U.S. counterpart plays, but that internal political pressures will guarantee a slow but steady improvement.

The transportation sector has experienced a gradually increasing importance from 7 percent in 1960 to 9 percent in 1968, which was due to increased freight turnover and electrification of the railroads.* However, this increase has leveled off since 1968. It is expected that the transportation sector will have an 8.4 percent market share in 1975 and will maintain this level through 1990. Finally, agriculture has steadily increased its share from a small 4 percent in 1960 to almost 7 percent in 1970. Under the current five-year plan, agriculture's consumption of electric power will almost double and reach 75 billion kilowatt-hours in 1975, which will amount to an 8.3 percent market share. SRI expects that the electrification of the agricultural sector will continue to receive a similar priority in light of the USSR and world food situation.

b. Supply

Figure A-36 shows the historical and projected net internal consumption of electric power in kWh by end use. Table A-53 shows the relationship between net internal consumption, which is the energy actually consumed by the end users, and gross production, which is the electricity generated at the power stations.

System losses and the stations' own use make up the largest item in reconciling production with consumption--amounting to 14.7 percent of gross production or 17.4 percent of net internal consumption

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* By 1970, about 50 percent of the Soviet railroads were electrified.

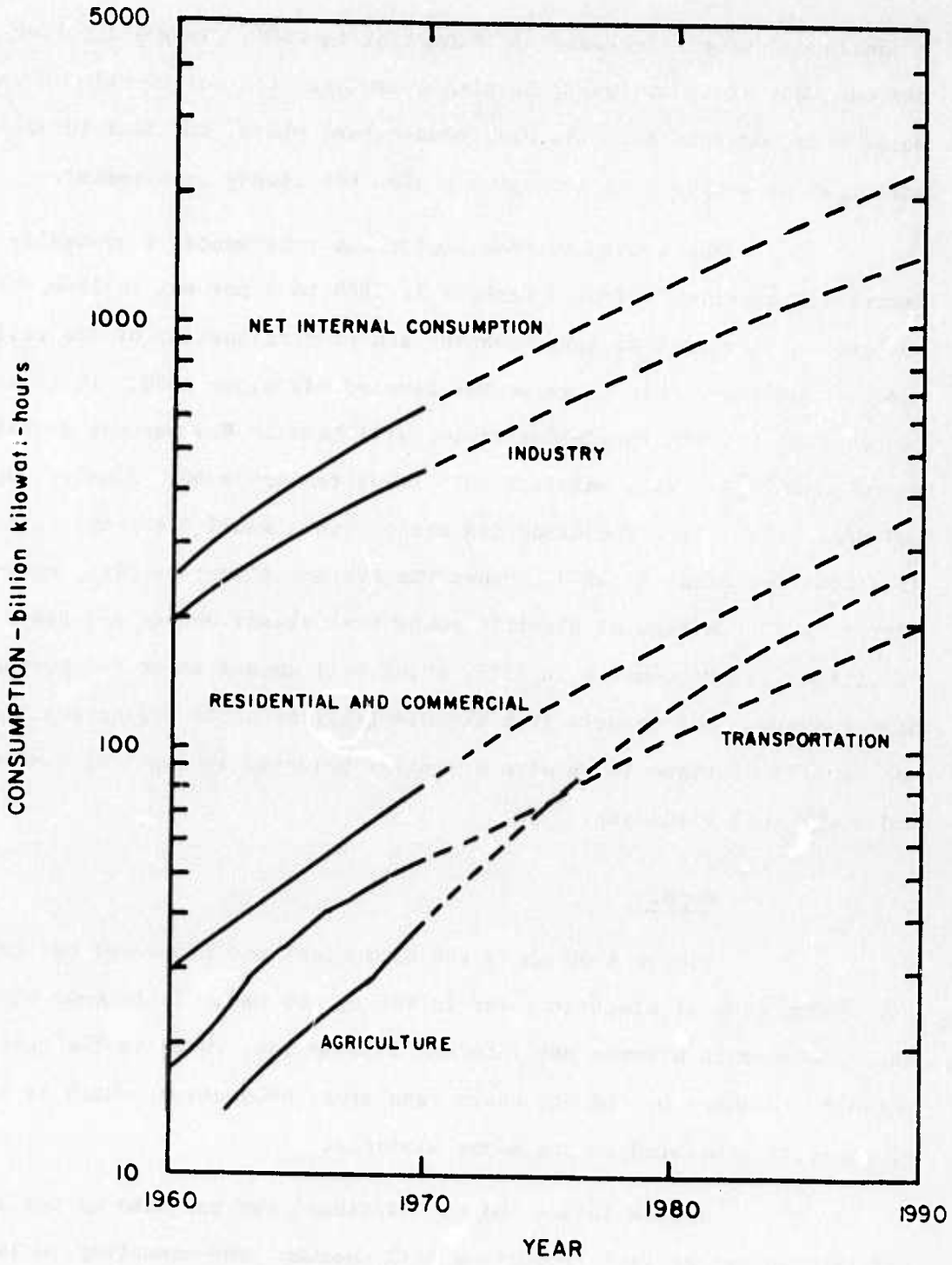

Figure A-36
NET INTERNAL CONSUMPTION OF USSR ELECTRIC POWER
BY END USE SECTORS

Table A-53

SUPPLY AND DEMAND OF ELECTRIC POWER IN THE USSR
(Billion kWh)

	Historical												Projected			
USSR Electric Power	1960*	1961*	1962*	1963*	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Supply																
Production	292.275	327.611	369.275	412.118	458.902	506.672	544.566	587.699	638.661	689.050	740.926	800.360	1,070.000	1,526.000	2,101.000	2,715.000
Plus imports	-	-	-	0.057	0.025	0.015	0.018	0.007	-	-	-	6.700	-	-	-	-
Less exports	0.030	0.074	0.232	0.804	1.329	1.516	1.601	1.804	2.470	3.939	5.197		11.300	16.000	18.000	20.000
Apparent gross production	292.245	327.537	369.043	411.671	457.598	505.171	542.983	585.902	636.191	685.111	735.729	793.660	1,058.700	1,510.000	2,083.000	2,725.000
Less power plant losses†	18.674	20.733	22.972	26.600‡	32.100‡	35.172	37.500	41.200‡	44.100‡	47.300‡	50.459	54.660	156.500	223.000	307.000	402.000
Less losses in transmission and distribution	17.800	20.000	23.000	27.118	31.252	35.109	38.506	43.200	48.400	53.650	58.326	63.200				
Net internal consumption	255.771	286.804	323.071	357.953	394.246	434.890	466.983	501.502	543.691	584.161	626.944	675.800	902.200	1,287.000	1,776.000	2,323.000
Demand																
Industry including construction	197.744	220.300	247.620	271.050	296.500	325.629	347.500	371.250	399.300	425.100	452.918	481.640	627.000	868.700	1,163.200	1,475.000
Transportation	17.643	20.500	23.900	29.200	32.900	37.072	40.600	43.800	48.700	51.600	54.362	58.200	75.500	109.400	151.000	197.300
Agriculture	9.970	12.304	14.078	16.130	18.410	21.099	23.209	25.754	28.500	33.256	38.552	45.870	75.000	128.700	195.400	278.800
Residential and commercial§	30.414	33.700	37.473	41.573	46.436	51.090	55.674	60.698	67.191	74.205	81.082	90.090	124.700	180.200	266.400	371.700

* Includes nuclear production.

† Public stations only.

‡ SRI estimate.

§ Includes public.

Sources: Historical - UN Electric Energy Statistics for Europe; UN Series J; USSR Statistical Yearbooks.
Projections - Stanford Research Institute.

in 1971. They break down into losses and own use in power stations, and rransmission and distribution losses. The combined losses showed an increasing trend relative to production or internal consumption in the historical period observed but are to level off by 1975, according to plan projections. The forecast assumes that these losses will stabilize at their 1975 level of 17.3 percent of net internal consumption.

Until recently, imports and exports of electric power were insignificant. Even in 1971, the USSR was an exporter of only 6.7 billion* kWh, which amounted to only 0.8 percent of gross production. Exports are planned to increase to a level of 11 to 12 billion[23] kWh in 1975 with the bulk going to the CMEA countries. While further increases in net exports have been assumed for the future, it is not expected that the Soviet Union will provide large quantities of electric power needed by the satellite countries. Rather, each COMECON member country will expand its generation facilities to provide the bulk of its power requirements while at the same time the interconnected power grid will be used to interchange larger and larger quantities of peaking power.

Production of electric power (gross) which increased by a factor of 2.5 between 1960 and 1970, is expected to double between 1970 and 1980 (see Tables A-53 and A-54). In 1990, the production is forecast at 1.8 times the 1980 level. Table A-54 shows the breakdown of the production by prime mover. It shows that conventional thermal power stations have been the backbone of the electric power industry and will remain in that position throughout the forecast period, although nuclear power generation will make noticeable inroads in the 1980s.

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* Exports are to Eastern Bloc countries and Finland.

Table A-54

USSR ELECTRIC GENERATING PLANTS

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Capacity (megawatts)																
Conventional thermal	51,835	57,627	63,731	72,115	81,118	91,871	99,015	105,791	111,319	122,715	133,352	139,947	181,600	248,700	322,400	373,200
Hydroelectric	14,781	16,366	18,622	20,830	21,251	22,241	23,077	24,813	27,035	29,615	31,368	33,418	42,770	59,000	77,100	100,000
Nuclear	105	105	105	105	915	915	915	1,150	1,150	1,430	1,430	1,970*	7,100	21,000	53,000	118,000
Total capacity	66,721	74,098	82,161	93,050	103,581	115,033	123,007	131,727	142,504	153,790	166,150	175,365	231,470	328,700	452,500	591,200
Production (million kWh)																
Conventional thermal	241,362	268,489	297,331	336,559	381,541	425,238	451,096	497,328	532,121	570,969	613,019	669,761	880,000	1,213,900	1,546,100	1,674,800
Hydroelectric	50,913	59,122	71,944	75,859	77,361	81,434	91,823	88,571	104,040	115,181	124,377	126,099	165,000	217,100	276,900	330,400
Nuclear	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1,647	1,800	2,500	2,900	3,500	4,500*	25,000	95,000	278,000	720,000
Total production	292,275	327,611	369,275	412,418	458,902	506,672	544,566	587,699	638,661	689,050	740,926	800,360	1,070,000	1,526,000	2,101,000	2,745,000
Capacity Factor																
Total system	50.0	52.7	51.1	50.6	50.6	50.3	50.5	50.9	51.2	51.1	50.9	52.1	52.8	53.0	53.0	53.0
Conventional thermal	53.2	53.2	53.3	53.3	53.5	52.8	52.0	53.7	53.1	53.1	52.5	54.6	55.3	55.7	54.7	51.2
Hydroelectric	39.3	41.2	44.1	41.6	41.6	41.8	45.1	40.7	43.9	44.1	45.3	43.0	44.0	42.0	41.0	40.0
Nuclear	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	20.5	17.9	24.8	23.2	27.9	27.5*	40.0	52.0	39.0	70.0

n.a. - not available.

* SRI estimate.

† Production kWh / Capacity kW x 8,760

Sources: Historical - UN Electric Energy Statistics for Europe; UN Series J: USSR Statistical Yearbook 1970, 1972.
Projections - Stanford Research Institute.

The breakdown of total power generation by source is as follows:

Power Source	Percent of Total Power Generation 1960	1970	1980	1990
Conventional thermal	82.0%	82.7	79.6	61.0%
Hydroelectric	18.0	16.8	14.2	12.8
Nuclear	n.a.	.5	6.2	26.2

The utilization of the Soviet electric power system changed little in the 1960s, hovering around a 50 percent system capacity factor (4,380 hours/year). Between 1970 and 1975, an increase to almost a 53 percent capacity factor is expected (4,640 hours/year). This utilization percentage was also used for the future years. In general, a system load factor of 65 percent is reasonable, which corresponds to a 54 percent capacity factor with a 20 percent capacity reserve.

In calculating the capacity additions required in conventional thermal power stations, hydro capacity, nuclear capacity, and production forecasts from other parts of this study were used. It was also assumed that the hydro capacity factor would drop slightly from the expected 44 percent in 1975 to 40 percent in 1990 to reflect increased use of hydro generating capacity for power needed at peak-load periods.

The difference will necessarily have to be covered by conventional thermal stations. Their capacity factor will decrease from 55 percent in 1975 to 51 percent in 1990, which reflects some shift from base load to intermediate operation and installation of gas turbines for peak-load operations. Between 1970 and 1975, about 48,000 megawatts (MW) of additional thermal capacity will be needed comparedtto 41,000 in the previous five years. The requirements for 1975-1980 will be

67,000 MW, increasing to 74,000 MW in the period 1980-1985. Finally, between 1985 and 1990, 51,000 MW of additional conventional thermal capacity must be built.

c. Steam

An important segment of the public thermal electric power stations and most industrial generating stations not only produces electric power but also steam and hot water (heat), which are used both for industrial purposes and for residential and commercial space heating. Data on steam production and consumption are sketchy. Figure A-37 which shows steam consumption by end use, is primarily based on some data for 1960 and flow diagrams developed for 1965, 1970, and 1975 from Russian sources.[24,25*] The intermediate years were interpolated. Lacking any other data, for purposes of this study it has been assumed that heat output and net internal consumption are the same.

The industrial sector is the predominant user of steam and hot water from thermal power stations, both public and industrial. The percentage end-use shares show the following trend:

	1965	1970	1975
Industrial	82%	77%	74%
Residential and commercial	18	23	26

* The reported heat production is higher than is theoretically possible from heat and power plants. It may include some steam from condensing type plants.

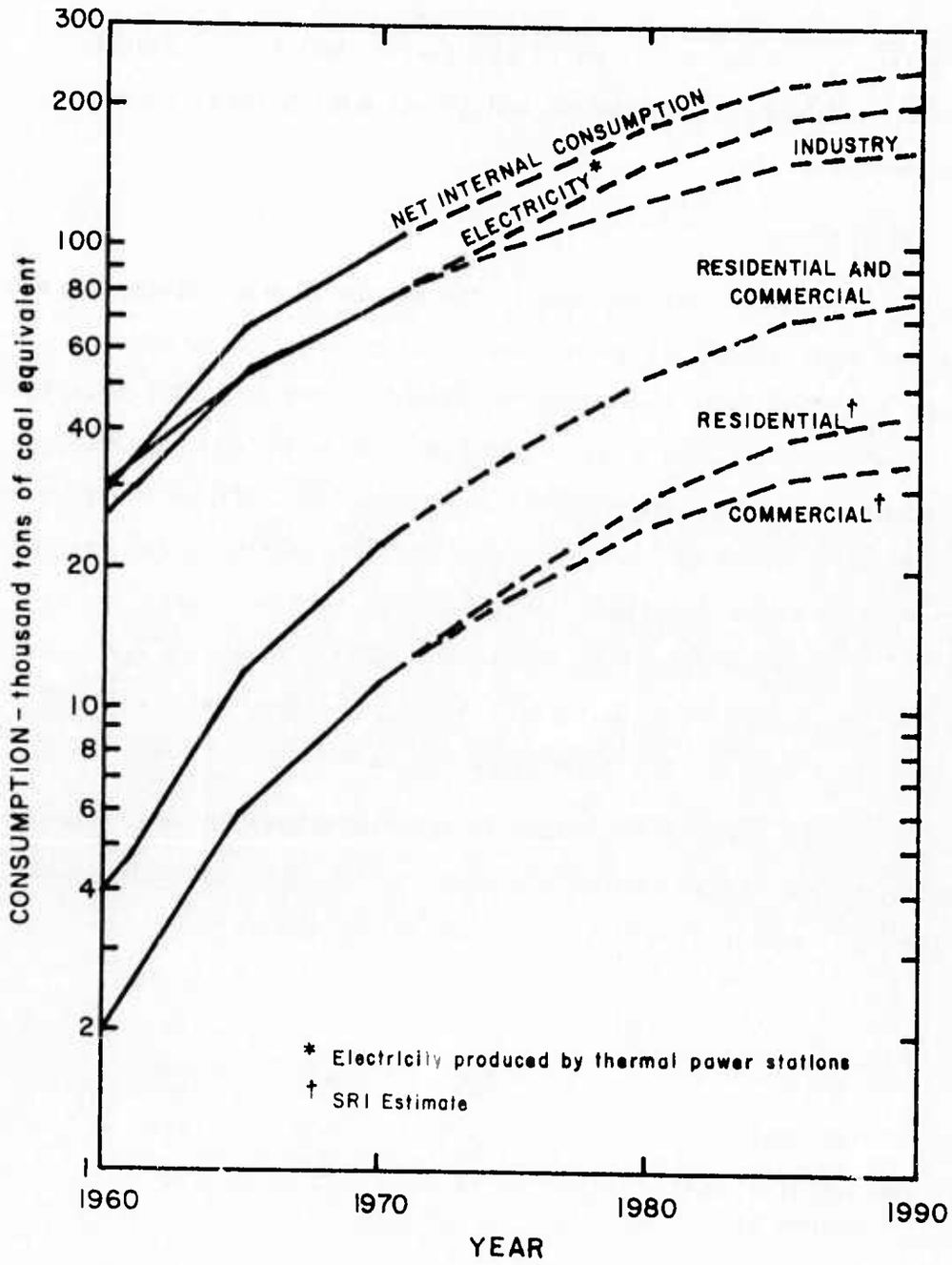

Figure A-37

CONSUMPTION OF STEAM/HOT WATER FROM THERMAL POWER STATIONS BY END USE SECTORS

Following the general trend, this breakdown was estimated for the other years:

	1960	1980	1985	1990
Industrial	87%	70	68	67%
Residential and Commercial	13	30	32	33

Figure A-37 also shows that the standard heat equivalent of the output of steam and hot water exceeds that of the electric power generated in thermal power stations throughout most of the period observed.

The projection of heat consumption from thermal power stations is based on its relationship to electric power produced by the same stations. As Figure A-38 demonstrates, a definite correlation exists between the two outputs. After a very steep slope in the early 1960s, the curve slowly bends over toward 1971 and 1975 and is expected to continue the same trend. This curve means that after a period of higher growth than electric power in the past, steam and hot water are now experiencing lower growth rates, as shown in the tabulation below:

Thermal Power Stations

	Steam/Hot Water	Electric Power Generated
1960-65	19.0%	12.0%
1965-70	8.5	7.6
1970-75	6.8	7.5
1975-80	5.9	6.6
1980-85	4.3	4.9
1985-90	1.3	1.6

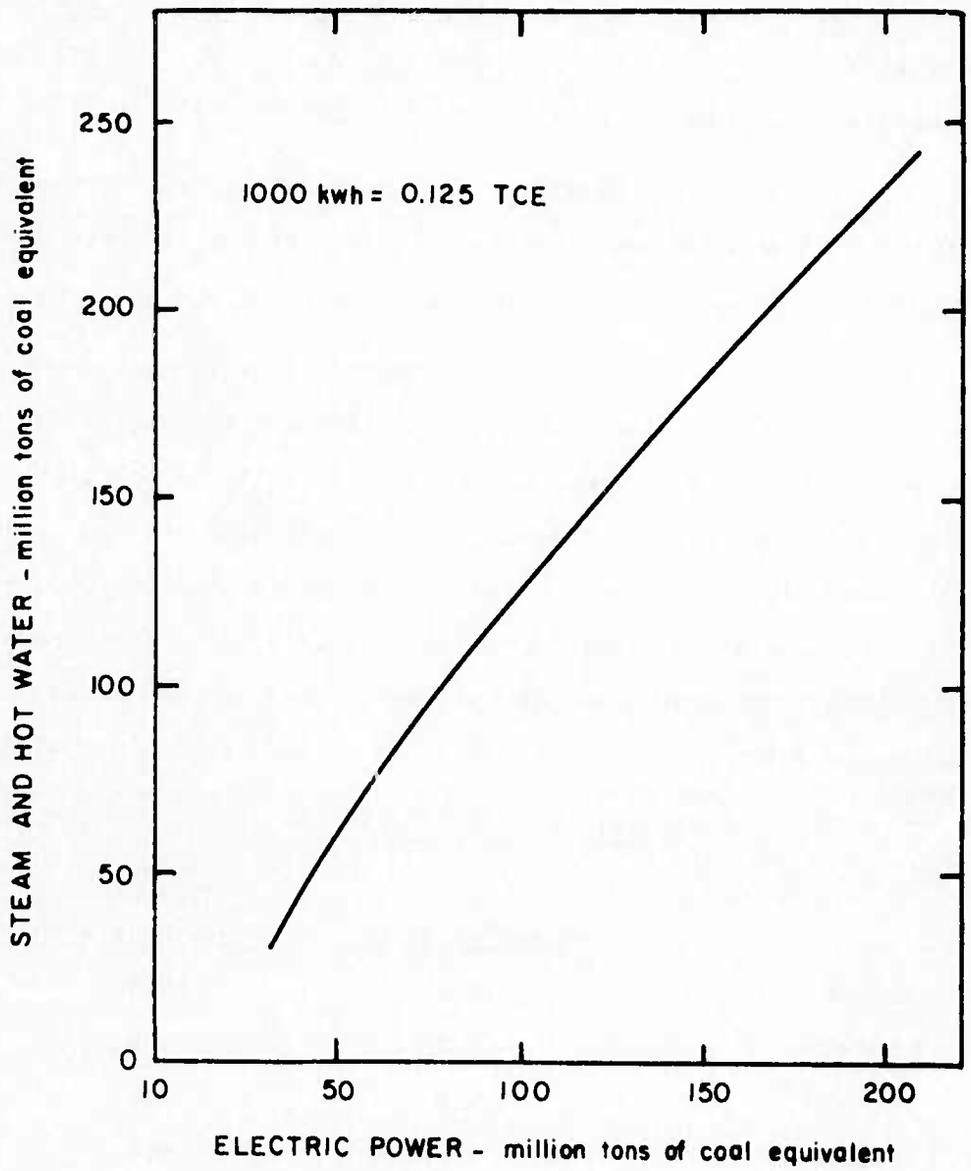

Figure A-38

STEAM AND HOT WATER VERSUS ELECTRIC POWER
IN USSR THERMAL POWER STATIONS

4. Electricity in CMEA Countries

Using the same method as described in the USSR demand section, we projected the total internal electricity consumption for each of the CMEA countries. Figure A-39 shows the historical and projected net internal consumption of the individual countries as well as their combined demand. Measured in 1971, Poland, with 58 billion kWh, is the largest electricity consumer among the East bloc satellites. It is followed closely by East Germany (57 billion kWh). Czechoslovakia is third, consuming 44 billion kWh, Romania fourth with 28 billion kWh. Bulgaria and Hungary trail with 17 and 16 billion kWh, respectively. The relative spread between smallest and largest consumer of electric power will be about the same throughout the projection years, except that Romania moves up to the number two rank. This is the result of a projected dramatic increase in the electricity consumed per person and an above-average population growth.

Figure A-40 shows the trend of electric power consumption per person in the six Eastern Bloc countries, and their weighted average as a bloc. The most striking phenomenon is that the spread between high and low per capita consumer has dramatically narrowed in the last 15 years. This trend is expected to continue, although to a lesser degree. For example, in 1955 the people of East Germany consumed almost seven times as much electricity per capita as the people of Romania. In 1970 this factor dropped to 2.5 and by 1990 is expected to be 1.6. Below is a comparison of the SRI projections with projections found in the literature.

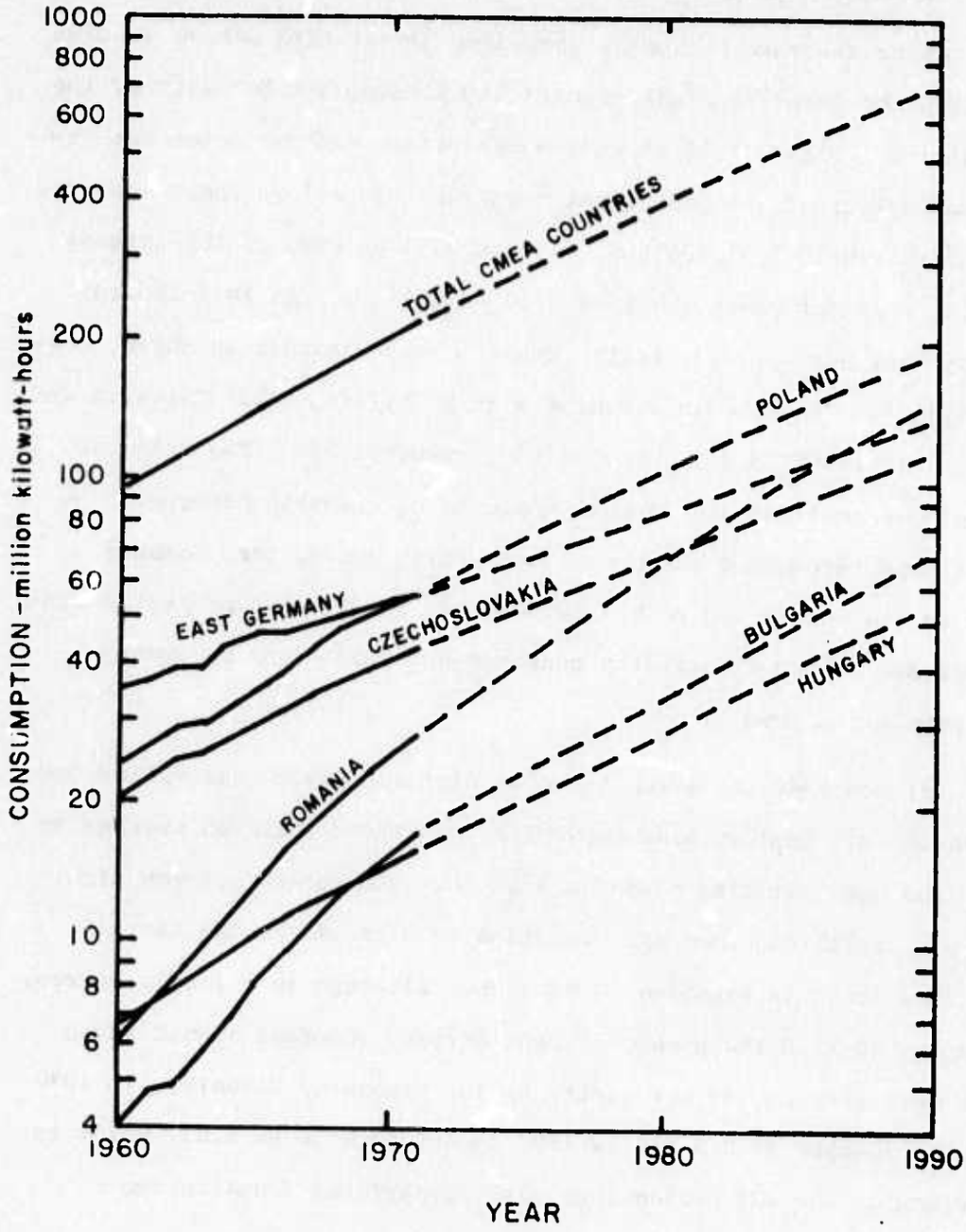

Figure A-39

NET INTERNAL CONSUMPTION OF ELECTRIC ENERGY BY COUNTRY

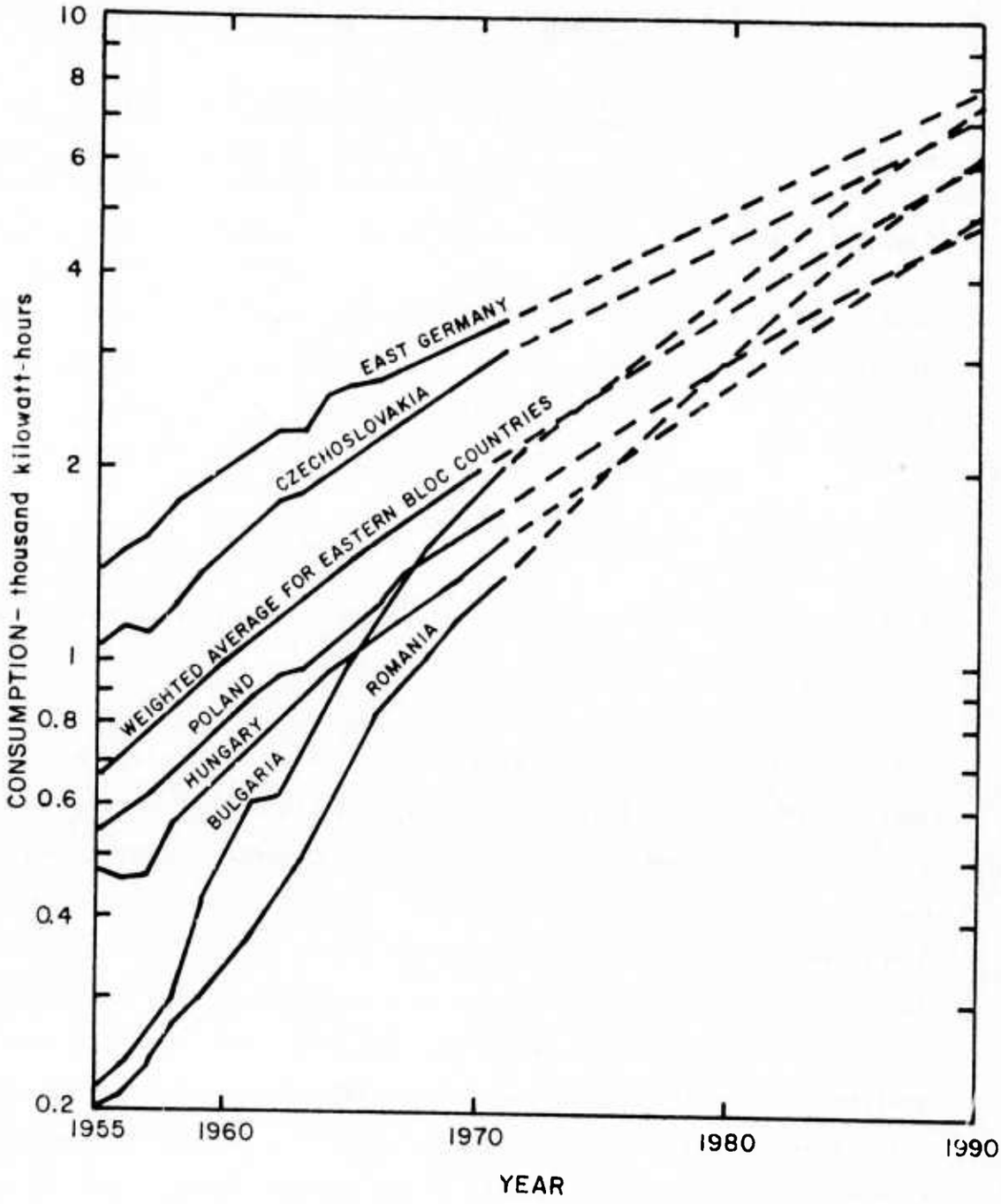

Figure A-40

NET INTERNAL CONSUMPTION OF ELECTRIC ENERGY PER CAPITA BY COUNTRY

	Kilowatt-Hours per Capita					
	1975		1980		1990	
	SRI	Literature	SRI	Lit.	SRI	Lit.
Bulgaria	2,767	. . .	3,936	5,000*-5,400	7,508	9,400-10,200*
Czechoslovakia	3,631	. . .	4,590	5,000†-5,300*	7,283	8,800†-9,700*
East Germany	4,149	4,300*	5,170	5,350*	7,839	8,150*
Hungary	1,974	2,050*	2,708	. . .	5,037	. . .
Poland	2,305	2,350*	3,053	. . .	4,927	. . .
Romania	2,008	. . .	3,105	3,000*-3,400	6,406	. . .

* From reference 4. Gross consumptions reported were reduced to net based on 1970 ratios.

† From reference 26.

Bulgaria has experienced the highest growth rates of electric power consumption per capita between 1955 and 1970 (Table A-55). Moving up from a very underdeveloped state in 1955, Bulgaria consumed slightly more electricity in 1970 than Hungary, which has a 22 percent larger population. While we anticipate above-average growth rates to continue into the future, the increase will occur at a slower pace. The SRI projection is in line with the trend of the last four years for which data are available (1968-1971). Compared to the 1960-1968 period, these four years show a marked slowdown in the growth of the per capita electricity consumption relative to the growth of the GNP per capita. The projection found in the literature appears overoptimistic in light of this slowdown already experienced and the GNP projections assumed in this report.

Table A-55

NET INTERNAL CONSUMPTION OF ELECTRIC ENERGY IN THE USSR AND CMEA COUNTRIES

	1955		1960		1965		1970		1975		1980		1985		1990	
	10^6 kWh	Increase*	10^6 kWh	Increase* '55-'60	10^6 kWh	Increase* '60-'65	10^6 kWh	Increase* '65-'70	10^6 kWh	Increase* '70-'75	10^6 kWh	Increase* '75-'80	10^6 kWh	Increase* '80-'85	10^6 kWh	Increase* '85-'90
USSR	149,096		255,771	11.4	434,890	11.2	626,944	7.6	902,250	7.6	1,287,000	7.4	1,776,000	6.7	2,323,000	5.5
Bulgaria	1,644*		4,035	19.7	8,409	15.8	15,826	13.5	24,435	9.1	35,087	8.1	51,565	7.8	71,889	6.9
Czechoslovakia	13,823		20,427	8.1	29,858	7.9	41,456	6.8	54,549	5.6	71,338	5.5	92,355	5.3	118,392	5.1
East Germany	24,719		35,138	7.3	46,289	5.7	55,424	3.7	71,550	5.2	90,506	4.8	111,492	4.8	141,384	4.3
Hungary	4,690		6,686	7.3	10,411	9.3	15,012	7.6	20,851	6.7	29,325	7.1	41,511	7.2	56,170	6.4
Poland	14,843		24,353	10.4	35,254	7.7	54,418	9.1	78,467	7.6	109,233	6.8	147,859	6.2	194,720	5.7
Romania	3,534		6,265	12.1	13,501	16.6	25,756	13.8	42,889	10.7	69,412	10.1	105,002	8.6	154,122	8.0
Total CMEA	63,253		96,886	8.9	141,702	8.2	207,092	7.7	292,731	7.1	405,801	6.7	552,784	6.4	736,977	5.9

PER CAPITA NET INTERNAL CONSUMPTION OF ELECTRIC ENERGY

USSR	760		1,191	9.5	1,886	9.6	2,583	7.6	3,528	6.4	4,751	6.2	6,185	5.4	7,700	4.5
Bulgaria	219		513	16.8	1,025	14.9	1,861	12.7	2,767	8.2	3,936	7.3	5,188	6.9	7,308	6.5
Czechoslovakia	1,056		1,496	7.2	2,107	7.1	2,866	6.3	3,631	4.8	4,590	4.8	5,795	4.8	7,283	4.7
East Germany	1,378		2,038	8.1	2,718	5.9	3,251	3.6	4,119	5.0	5,170	4.5	6,443	4.5	7,839	4.0
Hungary	477		670	7.0	1,026	8.9	1,456	7.3	1,971	6.3	2,708	6.5	3,758	6.8	5,037	6.0
Poland	544		823	8.6	1,132	6.6	1,676	8.2	2,305	6.6	3,053	5.8	3,932	5.2	4,927	4.6
Romania	204		340	10.8	710	15.8	1,272	12.4	2,008	9.6	3,105	9.1	4,517	7.8	6,406	7.2
Average CMEA (weighted)	663		1,002	8.6	1,441	7.5	2,018	7.0	2,734	6.3	3,651	5.9	4,807	5.7	6,211	5.3

* Average annual compound growth rate.

* SRI estimate.

Sources: Historical - U.N. Statistics
Forecasts - SRI.

Czechoslovakia has shown a remarkably regular growth in its historical per capita electricity consumption. The country is expected to continue that trend but subject to a slowdown. This expectation is in line with the projected GNP growth. The SRI projections are lower than those published in the literature by about 17 percent in 1990.

East Germany's kWh per capita consumption growth rate between 1965 and 1970 was only 3.6 percent, down from 5.9 percent during the previous five years. This decrease was, in spite of the increase in the GNP growth rate and this contradiction indicates unsatisfied demand. Today East Germany's electric power industry relies almost entirely on coal, for which production has virtually stagnated since 1965. Helped by the predicted rapid expansion of nuclear power generation, East Germany should be able to overcome the 1965-1971 slowdown in per capita consumption growth. According to the SRI projection, in 1990 East Germany will still have the highest kWh per capita figure of all the countries examined.

For Hungary, Poland, and Romania, only partial projections can be found in the literature. The figures available are well in line with those of the Institute.

C. Crude Oil and Petroleum Products

1. USSR

While the USSR continues to have difficulties in meeting schedules with regard to the production of crude oil, it appears that the country may be close to solving some of its most critical long term problems--that is, getting new fields in Siberia into production and completing pipeline facilities for moving oil to consuming centers. At the beginning of 1973, the Chairman of the USSR Planning Committee announced that industrial progress in general would probably be slower this year than

originally foreseen, largely because of delays in expanding capacity in certain industries; it is understood that this broad statement applies to the oil and gas industries also.

Crude oil production under the current five-year plan was scheduled to increase from 353 million metric tons in 1970 to 496 million metric tons in 1975, or by some 7.1 percent per year (see Table A-56).

Table A-56

USSR CRUDE OIL PRODUCTION
(Million Metric Tons per Year)

Year	Western Siberia	Other Areas	Total USSR
1960	--	148	148
1965	--	243	243
1970	31	321	353
1971	44	333	377
1972	56	338	394*
1973	84	340	424†
1975	120 - 125	371 - 376	496‡

* Provisional.

† Latest estimates.

‡ Five-year plan target.

This is a slightly lower annual growth rate than for the 1965-70 period. Production in 1972 is understood to have reached about 394 million metric tons, indicating average annual increases of only about 5.6 percent in 1971 and 1972. It is reported that there were actual declines in production over this period in a number of areas; namely, in Bashkivia, Brozny, the Ukraine, the Caspian Sea, Azerbaijan, Sakhalin, and Dagestan.

According to the latest information from the USSR, it now appears that the oil industry will post its largest monthly crude oil production gains in history. Furthermore, there is evidence from the journals and other official documents that some of the additional oil produced in 1973 is destined for the rest of the world. Barring major transportation breakdowns, there should be no recurrence of the oil shortages experienced during the past two winters in the USSR. Soviet crude oil and products available for export are at all-time highs and are expected to reach new peaks during the next two years.

Some of the developments that have brought about the present optimistic situation are:

- Western Siberia's 1973 crude output reached 59 million tons (365 million barrels) in mid-August, and it now appears certain that the area will exceed this year's production target of 86 million tons (1.73 million barrels per day).

- Total Western Siberian output passed 1.8 million barrels per day in August. The mammoth Samothorskoye field alone boosted production from 585,000 barrels per day at the beginning of 1973 to nearly 1 million barrels per day in September.

- Two more large middle-Ob oil fields, Fedorovskoye and Azanskoye, have just recently gone on-stream, and another, Ubinskoye, is being readied for exploitation.

- It is reported that about 350 development wells were completed in Western Siberian oil fields during the first eight months of 1973. This is more than 75 above plan.

- Impressive gains in Western Siberian production are being made possible by fast expansion in the capacity of two 48-inch crude pipelines tapping the huge oil fields along the middle course of the Ob River.

As can be seen in Table A-56, the country's overall production growth during the 1970-75 period will be chiefly sustained from the important new oil in Western Siberia. While the Soviets have been successful in maintaining high oil output in the Volga-Ural region (discovered in the 1930s and still the country's principal producing area), nevertheless industry officials already admit that many of the fields there are in the final stages of production. This could suggest that production from the region--amounting to an estimated 3.6 million barrels per day--will start a slow decline within the next two to three years, or some time after 1975.

For the Soviets to increase crude oil production to the levels planned to 1975 and 1980 will take a continuing substantial effort by all segments of the oil industry. Target production for 1980 is 625 million metric tons (Table A-57), or a five to six percent per year annual growth rate between 1975 and 1980. There is some question whether an expansion of this order of magnitude will be enough to sustain the oil needs of the country, to supply the necessary quantities to the Eastern Bloc countries, and still to export as much as 67 million tons to the rest of the world (see Table A-57).

Certainly the ultimate reserves to be found beneath the huge territory of the USSR will eventually allow much higher annual production figures, but only after further large-scale exploration and development work. And this will take time. Industry representatives in the USSR have estimated that it is entirely possible that Western Siberian production may reach a level of 500 million metric tons in the

Table A-57

USSR CRUDE OIL SUPPLY-DEMAND BALANCE
(Million Metric Tons)

	1970	1975	1980	1990
Production	353	480*	625	980
Demand†	289	368	470	768
Potential Surplus	64‡	112	155	212
Eastern Europen requirements	39§	61	88	161
Potential export to rest of world	28§	51	67	51

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* Five-year plan goal is 496 million metric tons.

† Includes losses and refinery charge for product exports.

‡ Difference between production and demand; with imports of 2 million metric tons, potential surplus is 66 million metric tons.

§ Actual deliveries.

Source: Stanford Research Institute.

future. But this could not be accomplished much before the mid- to late 1980s. There are, of course, two other regions of great ultimate promise--the largely unexplored area of Eastern Siberia between the Yenessei and Lena rivers, and the lowlands surrounding the northern part of the Caspian Sea.

The Institute's estimate of future production and apparent supply of crude oil for the USSR are shown in Figure A-41 and Table A-58. The estimates for 1975 are based on an annual increase of 28 million metric tons.* Beyond 1980, it has been assumed that continued development of Western Siberian reserves will be sufficient to permit crude production at the levels shown.

With these production forecasts, it is possible to cover future internal requirements--which include production and transmission losses and charge to the refineries--and exports both to Eastern Bloc countries and to the rest of the world. If the estimated maximum production figures shown on Table A-58 are assumed, exports would be enough to cover all of the Eastern Bloc crude import requirements and still leave considerable quantities of crude for shipment to the rest of the world. The following tabulation shows the results of this analysis:

	Million Metric Tons		
Year	Bloc Requirements	Balance for Rest of World	Potential Export
1975	61	51	112
1980	88	67	155
1985	123	59	182
1990	161	51	212

* In the two previous five-year periods, the annual increases were 19 and 22 million metric tons.

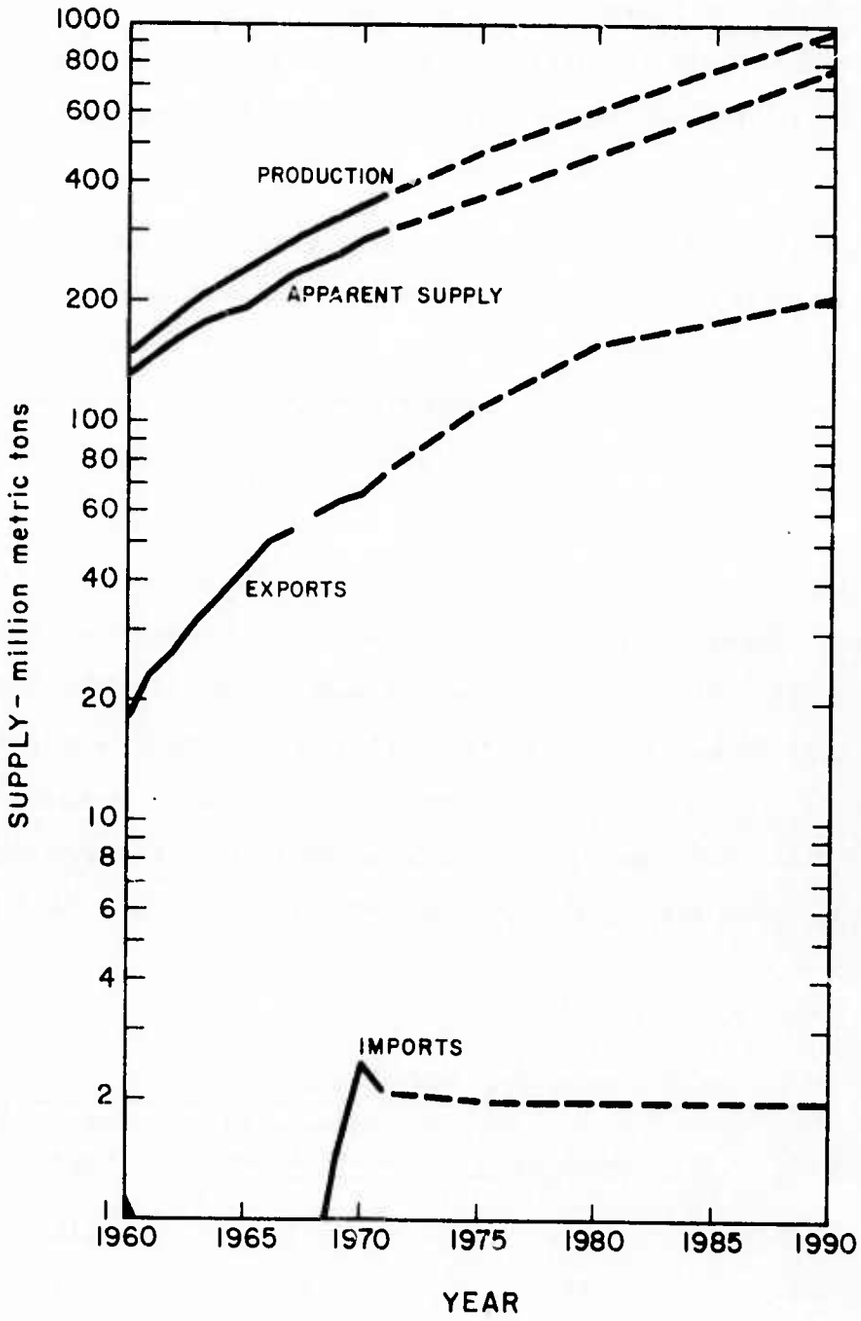

Figure A-41

CRUDE OIL SUPPLY IN THE USSR

Table A-58

CRUDE OIL SUPPLY IN THE USSR 1960-1990
(Million Metric Tons)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Production (including condensate)	147.86	166.07	186.24	206.07	223.60	242.89	265.12	288.07	309.15	328.37	353.01	377.08	470-480*	600-625	750-790	930-980
Imports	1.17	0.89	0.50	0.54	-	-	-	0.06	0.12	1.46	2.52	2.09	2	2	2	2
Exports+	17.82	23.39	26.28	30.24	36.69	43.43	50.31	54.12	59.22	63.89	66.81	74.80	112	157	182	212
Apparent supply±	131.20	143.57	160.46	176.37	186.91	199.46	214.81	231.01	250.06	265.87	288.76	304.36	370	470	610	770

* 1971-75 Plan figure: 496.

\+ For forecast period, estimated maximum exports based on high crude production figure.

± Estimated internal requirements, including losses.

Sources: Historical, United Nations; forecast, Stanford Research Institute.

There are several possible alternatives to the above schedule:

- If crude oil production is not as high as estimated then exports would be lowered accordingly.
- If Eastern Bloc requirements are partly satisfied by imports from outside countries--and this appears to be the position taken by several of the Bloc countries--then additional quantities would be available for export to the rest of the world.
- If internal USSR needs were to increase more rapidly than estimated--for example, if natural gas were in short supply for some interim period--then crude exports would have to be cut back; some of the reduction would presumably be at the expense of Free World countries, the balance at the expense of the Bloc countries.

According to the Ninth-Five-Year Plan, the refining industry in the USSR is expected to increase its capacity by 1.4 times. Thus by 1975, capacity would be at the 420 million metric tons level if the target were achieved. To accomplish this objective, total refining capacity would have to be increased by 24 million metric tons per year--additions that are probably within the capability of the construction industry. The plan also calls for increasing the unit capacity of the installations,* and building nine new petroleum refineries. Major emphasis will be placed on the construction of refineries scheduled to be located in the eastern regions--Achinsk, Pavlodar, Chardzhou, and Chimkent.

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* The average refinery to be placed into operation during the 1971-75 period is estimated at 5.2 million metric tons (approximately 100,000 barrels per day), contrasted with an average 3.2 million metric ton facility installed (approximately 65,000 barrels per day) during the 1966-70 period).

The Institute's forecast of new refining capacity in the USSR is shown in Figure A-42. It can be seen that capacity additions totalled 155 million metric tons between 1960 and 1970, for an average annual increase of 15.5 million tons. For the period to 1980, average annual additions are expected to be about 20 million tons. Capacity for 1975 is estimated to be 390 million metric tons, as opposed to the 1971-75 plan figure of 420 million tons.

Other forecasts relative to refining show crude runs (Figure A-43), refining product output by product (Figure A-44), refined product internal consumption (Table A-59), and refinery production and product exports (Table A-60).

Table A-60

USSR REFINERY PRODUCTION AND PRODUCT EXPORTS
(Million Metric Tons)

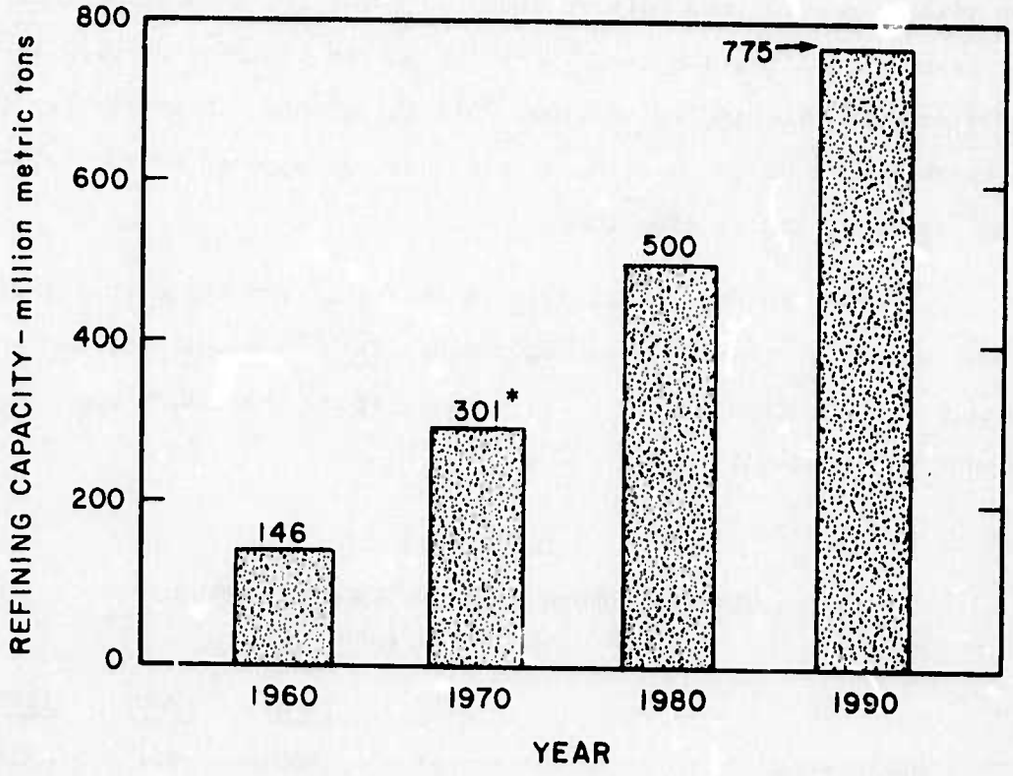
	1970	1975	1980	1990
Production	257	332	427	712
Less: Own requirements (includes losses)	230	305	422	690
Potential exports	27*	27	5	22

* Imports, 1 million metric ton; exports, 28 million metric tons.

Source: Stanford Research Institute.

2. Eastern Europe

Crude oil production in the Eastern European countries has expanded very slowly over the 1960-71 period. In 1960, total production only amounted to 13.6 million metric tons, of which 11.8 million tons (87 percent of the total) was accounted for by Romania alone. By 1961, production for the six countries had increased to only 17.2 million metric



1960 - 70	155	(310 thousand bbl/day/annum)
1970 - 80	199	(400 thousand bbl/day/annum)
1980 - 90	275	(550 thousand bbl/day/annum)

* Equivalent to approximately 6.0 million bbl/day

Source: Stanford Research Institute

Figure A-42

USSR REFINING CAPACITY BUILDUP

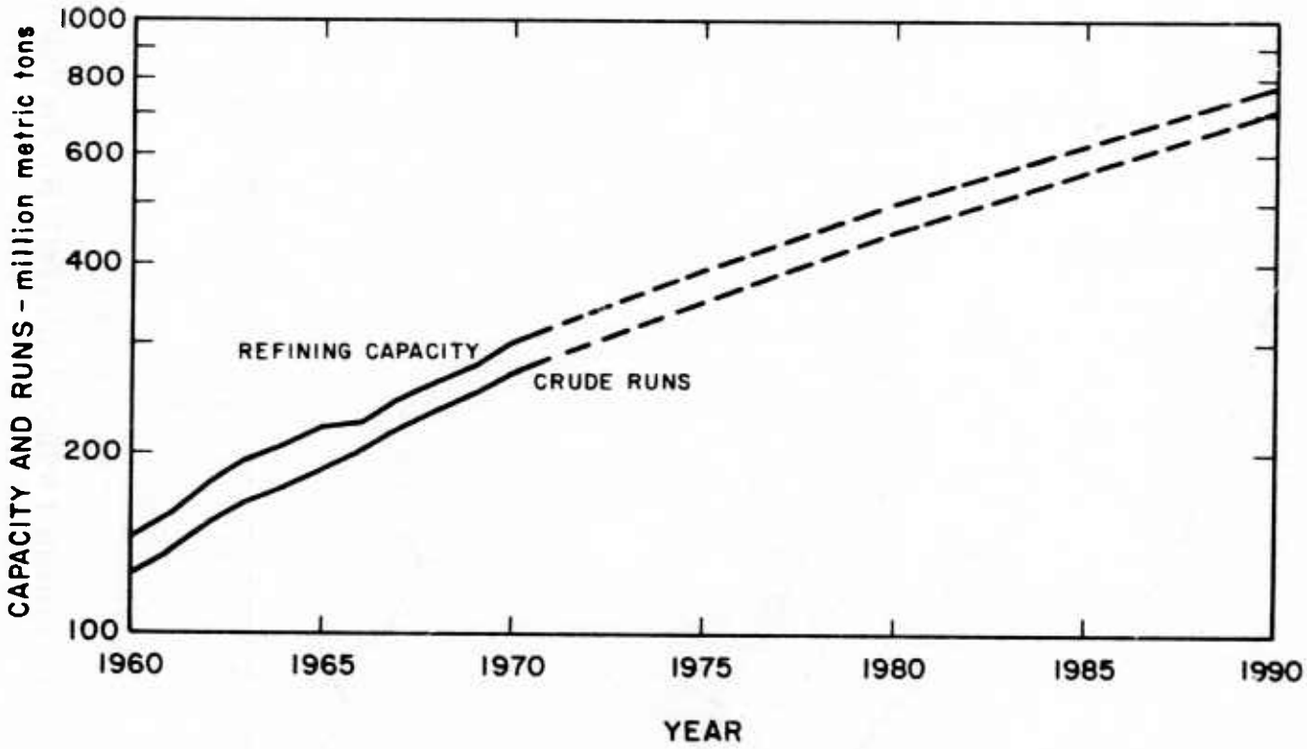


Figure A-43
USSR REFINING CAPACITY AND CRUDE RUNS

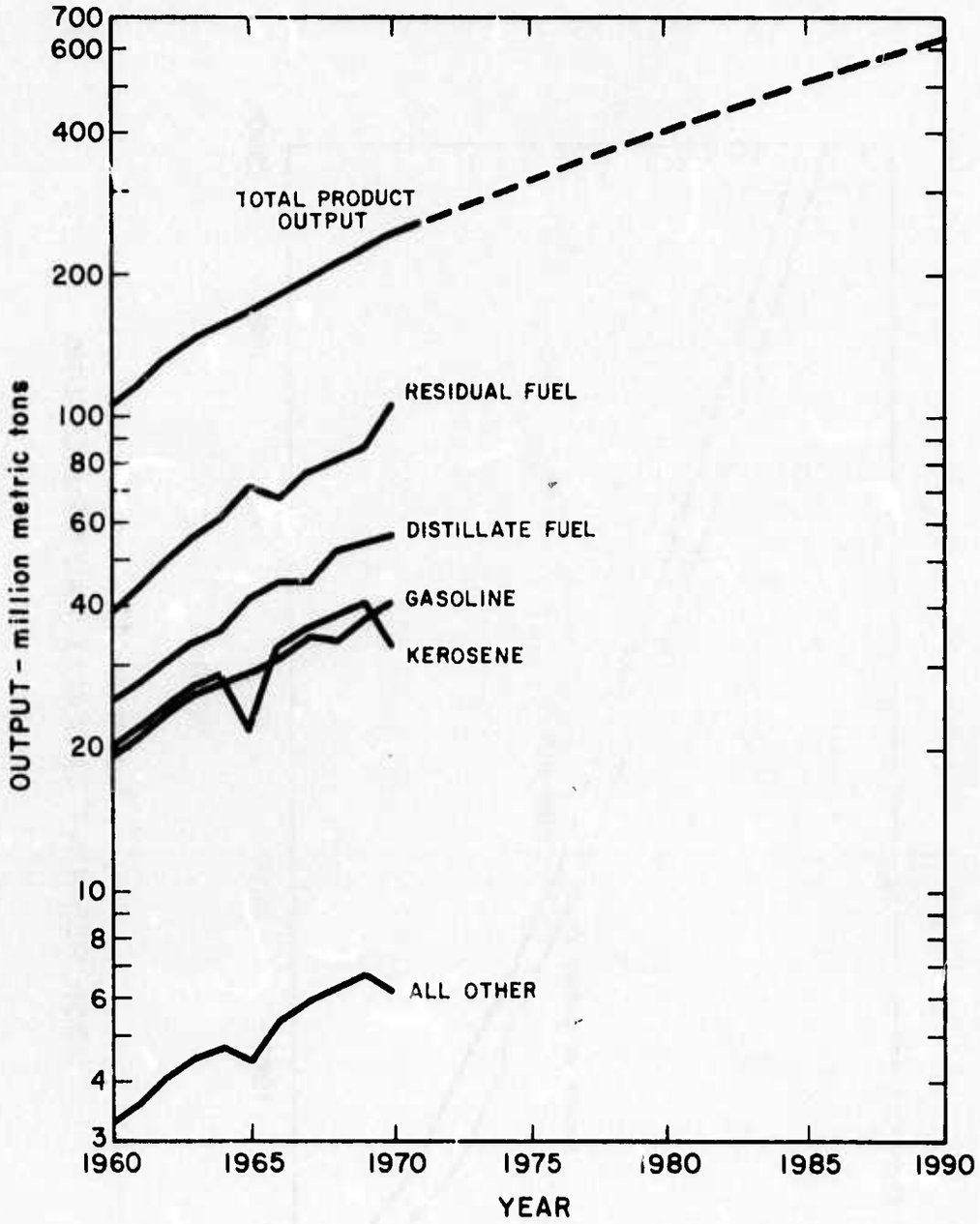


Figure A-44
USSR REFINING PRODUCT OUTPUT BY PRODUCT

Table A-59

USSR REFINED PRODUCT INTERNAL CONSUMPTION 1960-1990
(Million Metric Tons)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1975	1980	1985	1990
Production	116.41	126.85	142.19	156.66	166.40	177.79	191.84	208.84	223.41	237.48	257.42	315.0*	405.0*	530*	655*
Imports		2.37	2.10	2.03	1.82	1.67	1.46	1.17	0.92	0.95	0.86	1.0	1.0	1.0	1.0
Exports	12.03	17.22	18.27	20.68	19.54	20.59	22.88	24.52	26.51	26.43	28.52	11.0-28.0	+	+	+
Apparent internal consumption	104.38	112.00	125.71	138.02	148.67	158.87	170.42	185.49	197.82	211.99	229.77	305.0	422	565	690

* Based on a 90 percent operating rate and 90-10 ratio of product output to refinery fuel and losses. By operating the refineries at a 95 percent rate, product output could be increased by 15 million tons in 1975 to 46 million tons in 1990.

† Virtually in balance; possibly of some exports.

Source: Historical, United Nations; forecast, Stanford Research Institute.

tons, and Romania's output was 13.9 million tons (still about 81 percent of the total). Table A-61 shows the crude oil production by country.

There appears to be little opportunity for further development of oil reserves in any of these countries, although exploration activity is increasing (see Appendix C). Table A-62 shows a comparison of estimated reserves for the Eastern Bloc countries and the projected cumulative production. It is fairly clear that the six countries expect little increase in their reserve positions during the forecast period.

The Eastern European countries will need to rely on imported crude oil to a very significant extent to satisfy their internal requirements for petroleum, since domestic production is not expected to increase at all. Figure A-45 shows the anticipated rapid increase in crude oil imports for the forecast period. While most of this crude will continue to come from the USSR, it is expected that an increasing share will be supplied from Middle East and North African countries.

Until a few years ago, the Eastern Bloc's crude oil imports from countries other than the USSR were negligible. Recently, however, the have increased significantly, from 17,000 barrels per day in 1967 to 243,00 barrels per day in 1972.* As shown in Table A-63, last year's large overall increase was due primarily to a sudden use of imports from Iraq. Perhaps the reasons for this were the economic and political changes in Iraq--first, the takeover by the State of the Iraq Petroleum group's northern oil fields; and second, the start of regular production from the Soviet-developed North Rumaila area. Iran, which has been the top crude oil supplier to the Eastern Bloc, is now in second place. Other major suppliers are Egypt, Libya, and Syria. Table A-64 shows crude oil imports from these countries to the Eastern Bloc countries and the USSR.

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* 17,000 barrels per day equivalent to about 850,000 metric tons; 243,000 barrels per day equivalent to about 12.2 million metric tons.

Table A-61

CRUDE PRODUCTION IN EASTERN BLOC COUNTRIES 1960-1990
(Million Metric Tons)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971*	1975	1980	1985	1990
Bulgaria	0.20	0.20	0.20	0.17	0.60	0.23	0.40	0.50	0.48	0.32	0.33	0.35	0.3	0.3	0.3	0.2
Czechoslovakia	0.14	0.15	0.18	0.18	0.20	0.19	0.19	0.20	0.20	0.21	0.20	0.20	0.2	0.2	0.2	0.2
East Germany	-	0.03	0.04	0.06	0.08	0.21	0.24	0.27	0.29	0.30	0.30	0.30	0.3	0.3	0.3	0.2
Hungary	1.22	1.48	1.67	1.78	1.82	1.82	1.77	1.75	1.87	1.81	1.99	2.00	2.3	2.5	2.5	2.0
Poland	0.21	0.22	0.22	0.23	0.30	0.36	0.43	0.47	0.50	0.46	0.45	0.45	0.6	0.8	1.0	1.2
Romania	11.79	11.89	12.18	12.58	12.75	12.95	13.22	13.62	13.68	13.64	13.76	13.90	14.0	14.0	13.5	13.0
Total	13.56	13.97	14.49	15.00	15.75	15.76	16.25	16.81	17.02	16.74	17.03	17.20	17.7	18.1	17.8	16.8

* Estimate.

Sources: Historical, United Nations; forecast, Stanford Research Institute.

Table A-62

COMPARISON OF RESERVES AND PRODUCTION DATA FOR CRUDE OIL
(Million Metric Tons)

	Estimated Crude Reserves*	Projected Cumulative Production Required 1975 to 1990	Surplus of (Deficit)	Remarks Regarding Differences
Bulgaria	2.2	4.5	(2.3)	New fields not fully evaluated; could increase reserves.
Czechoslovakia	1.6	3.0	(1.4)	Depletion of oil fields; no significant new discoveries.
GDR	1.5	4.5	(3.0)	No significant discoveries.
Hungary	138.0	36.5	101.5	New discoveries have increased resources.
Poland	8.3	12.0	(3.7)	Depletion of old fields; no significant discoveries.
Romania	330.0	207.5	122.5	New discoveries have increased reserves.
Total	481.6	268.0	213.6	

* International Petroleum Encyclopedia, 1973.

Source: Stanford Research Institute.

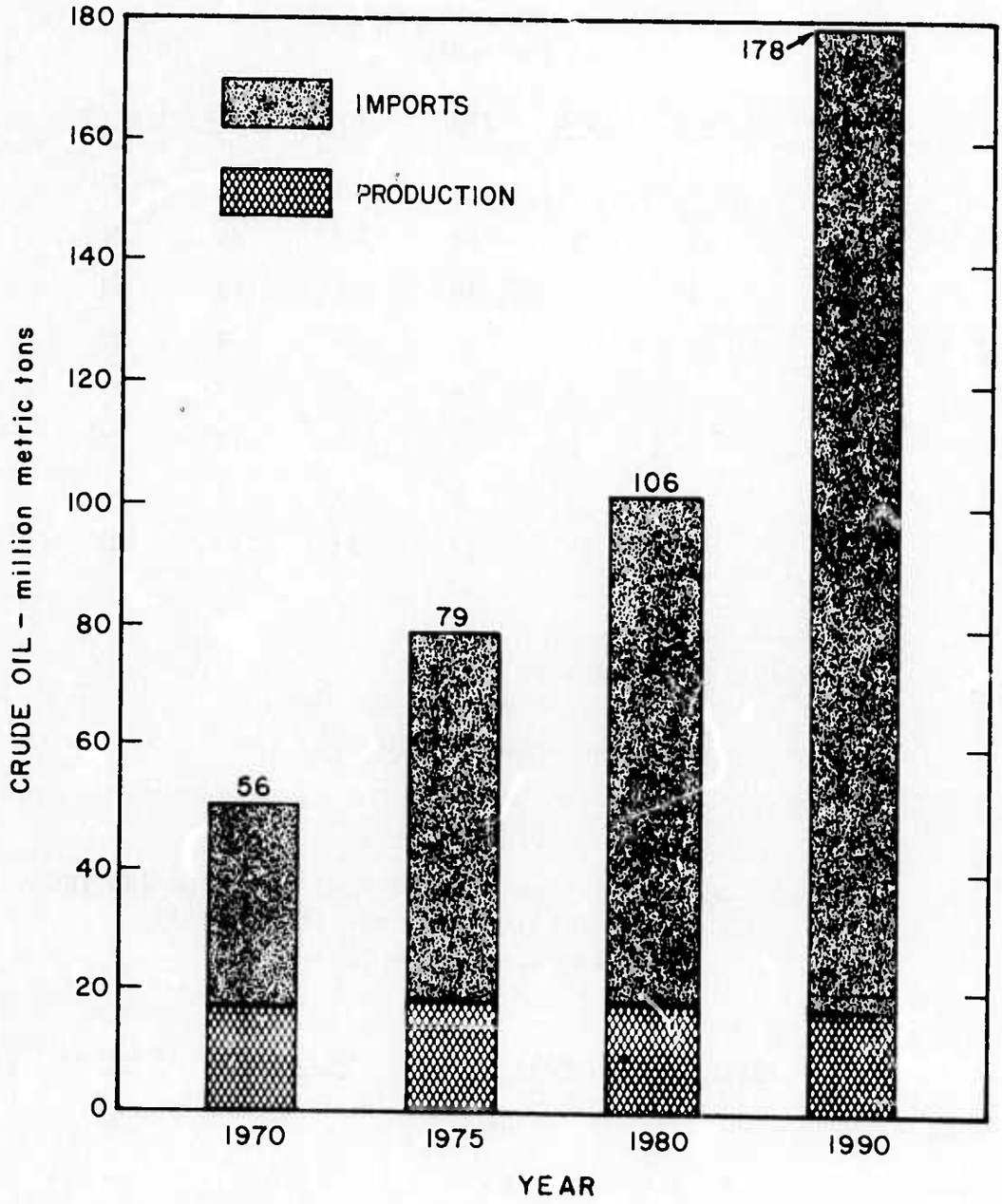

Figure A-45

ESTIMATED PRODUCTION, IMPORTS, AND DEMAND OF CRUDE OIL IN EASTERN EUROPE

Table A-63

CRUDE OIL IMPORTS OF EASTERN BLOC BY COUNTRY
(Thousand Barrels per Day)
1967-1972

	1967	1968	1969	1970	1971	1972
Iraq	--	--	1	8	13	100
Iran	14	5	31	66	72	76
Egypt	2	1	16	28	29	24
Syria	--	1	--	9	3	18
Libya	--	3	9	2	14	17
Algeria	1	1	6	10	18	8
Other	--	5*	2†	1	1	--
Total	17	16	65	124	150	243

* All from Saudi Arabia.
† May include 1,000 barrels/day from Syria.

Source: USSR Foreign Trade Statistics.

Table A-64

CRUDE OIL IMPORTS OF THREE EASTERN BLOC COUNTRIES AND THE USSR BY COUNTRY OF SOURCE AND DESTINATION
(Thousand Barrels per Day)
1972

	To Bulgaria	To East Germany	To Romania	To USSR	Total
Iraq	57	25	2	6	100*
Iran	2	34	40	--	76
Egypt	11	6	--	7	24
Syria	15	1	--	2	18
Libya	7	--	1	9	17
Algeria	1	3	4	--	8
Total	93	69	47	24	243*

* Includes 10,000 barrels per day to Hungary.

Source: USSR Foreign Trade Statistics.

a. Bulgaria

The expansion of the refining industry in Bulgaria is geared to a substatiial increase in the use of oil in the economy (Figure A-46). According to the 1971-75 plan, the relative share of oil and gas together is to reach 60 percent of total energy requirements, by 1975, and 65 to 70 percent by 1980. Much of this increase will be accounted for by oil. The basic portion of the oil requirements is expected to come from the USSR.

The capacity of facilities for refining crude oil in the country has increased from virtually nothing in 1960 (approximately 100,000 metric tons) to 2.7 million metric tons in 1965 and 6.0 million tons in 1970. Various sources indicate a 1975 refining capacity target of about 9 to 10 million metric tons. Scheduled shipments of crude oil from the USSR by 1975 are anticipated at about 10 million tons; hence, the refining estimate appears reasonable.

To meet expected demand for refined products in Bulgaria, it is estimated that refinery capacity will need to expand by over four times during the forecast period. The following tabulation shows anticipated additions to capacity, as well as crude import requirements to 1990:

	Million Metric Tons		
Year	Refinery Capacity	Crude Charge	Import Requirements*
1970	6.0	5.9	5.7
1975	9.5	8.6	8.8
1980	14.0	12.6	13.0
1985	20.0	18.0	18.6
1990	27.0	24.3	25.3

* Takes into account indigenous supply as well as losses (pipeline, storage, etc.).

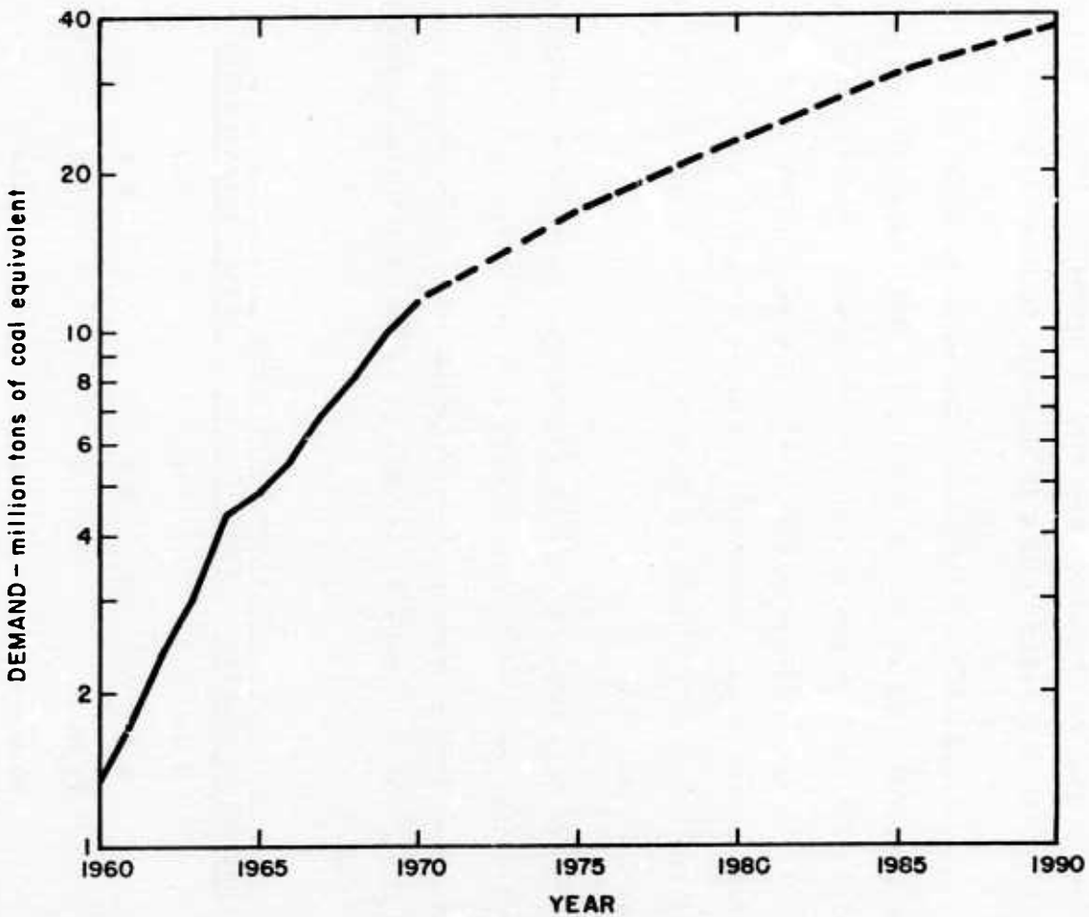

Figure A-46

DEMAND FOR OIL PRODUCTS -- BULGARIA

b. Czechoslovakia

The country's oil product demand during the 1971-75 period is expected to rise by about 50 percent to about 16 million tons per year (Figure A-47). Plans by the country call for a corresponding increase in refinery throughput from about 10 million tons in 1970 to 17-18 million tons in 1975. Czechoslovakia has long taken sizable quantities of Soviet oil--primarily crude rather than product--and under the current bilateral agreement, the USSR will deliver a total of about 65 million tons during the 1971-75 period. This quantity is expected to cover about 95 percent of the total import requirements over the period. By 1975, Soviet deliveries are scheduled to be about 15.5 million tons.

These figures are based on the assumption that refinery capacity will be increased to a level that would require the additional deliveries.* Czechoslovakia's own crude oil production of about 20,000 tons per year is insignificant in terms of the country's total needs. It has been assumed that demestic crude production will not increase during the forecast period.

To meet anticipated requirements for petroleum products within the country, it is expected that refinery capacity will have to increase over three times between 1970 and 1990. The following tabulation shows expected additions to capacity, as well as crude import requirements to 1990:

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* The Institute's estimate is that refinery capacity will be only about 15.0 million tons by 1975, and that imports of approximately 14.0 million tons will be needed.

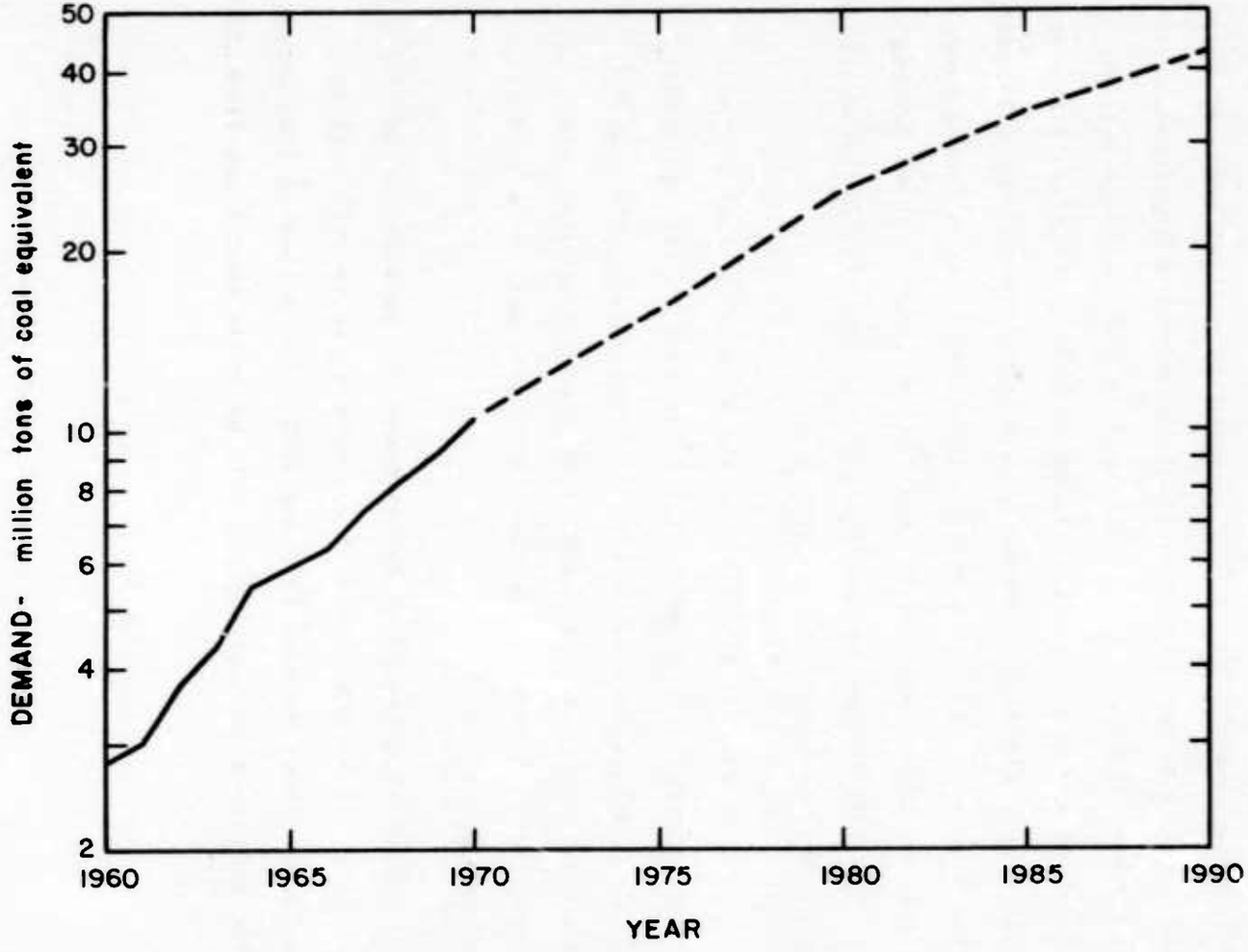

Figure A-47
DEMAND FOR OIL PRODUCTS--CZECHOSLOVAKIA

Year	Million Metric Tons		
	Refinery Capacity	Crude Charge	Import Requirements*
1970	11.0	10.0	9.8
1975	15.0	13.5	14.0
1980	19.0	17.1	17.8
1985	25.0	22.5	23.5
1990	32.0	28.8	30.0

* Takes into account domestic supply as well as losses (pipeline, storage, etc.).

c. East Germany

East Germany's current 1971-75 five-year plan devotes nearly one-third of all industrial investment to the energy sector as a means of modernizing facilities and improving efficiency. Another objective of the plan is to place greater emphasis on liquid and gaseous fuels rather than on solid fuels. This shift is reflected by the expected decline of the store of solid fuels (predominantly lignite) from about 80 percent in 1971 to 65 percent in 1975, while liquid and gaseous fuels are expected to increase from 20 percent to nearly 30 percent.

There was already a marked expansion in the supply and use of petroleum products during the 1960s (Figure A-18). The current plan provides for a further increase in crude oil throughput in local refineries, from 10 million tons in 1970 to about 18 million tons five years later.* Imports of products were significant in the early 1960s; now they have virtually ceased.

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* In addition, hydrogenation of lignite yields about 1 million tons of petroleum products each year, but it is understood that this process is now regarded as uneconomic and therefore may be abandoned within the next year or two.

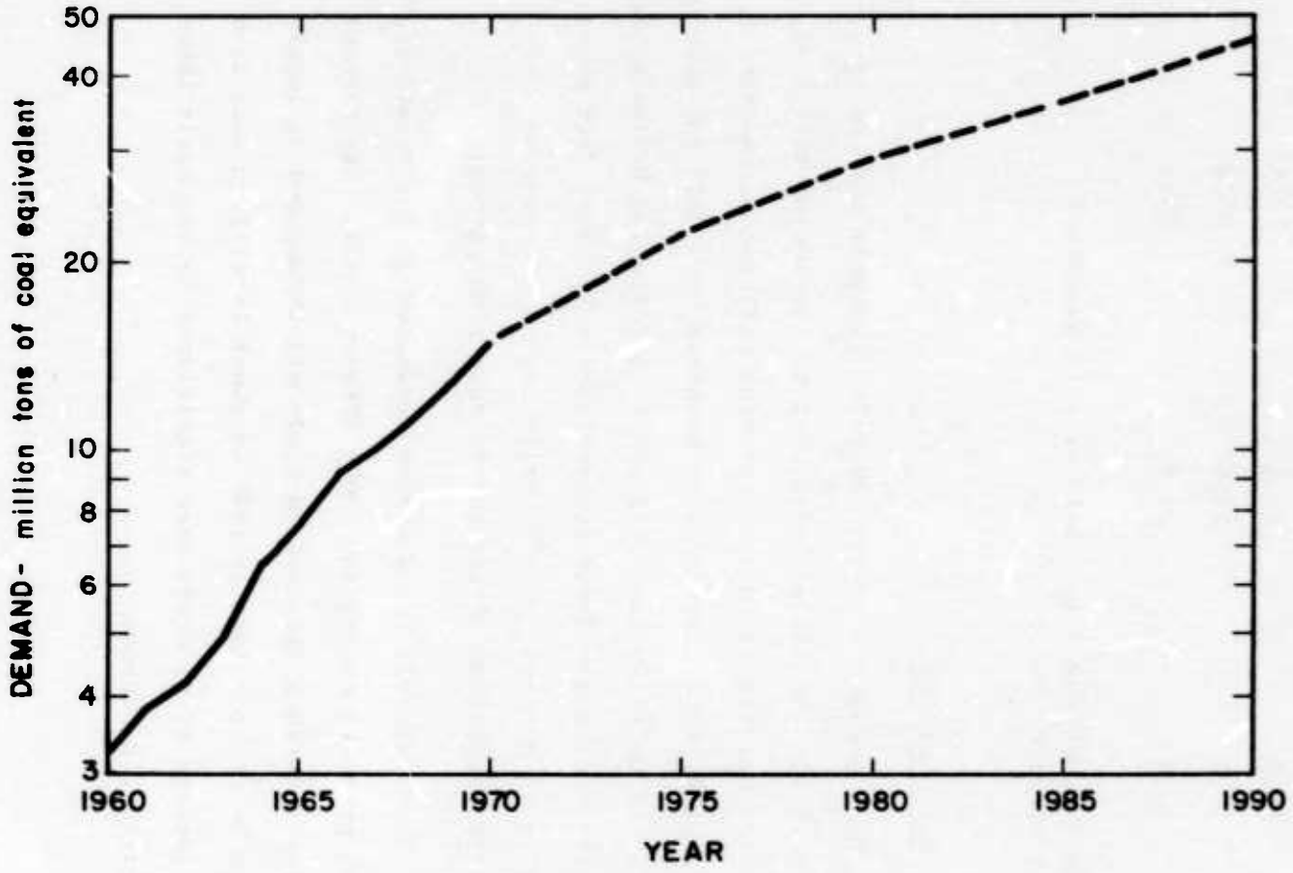

Figure A-48

DEMAND FOR OIL PRODUCTS -- EAST GERMANY

There are two principal refining centers in the country--the refining and petrochemical complex at Schwedt-on-Odes, close to the Polish border, which came into operation in 1964; and further south, the old established refining, hydrogenation, and chemical facilities in the Halle-Leipzig area. Throughput is to expand at Schwedt from 6.5 million tons in 1970 to 9.3 million tons in 1975. The increase in the Halle-Leipzig area will be even more rapid, from 3.9 million to about 8.7 million tons.

Virtually all of the crude oil must be obtained from outside the country.* The USSR has agreed to deliver a total of approximately 65 million tons to East Germany during the plan period. This quantity is expected to cover about 90 percent of the needs. These imports will reach about 13 million tons in 1973, 14 million in 1974, and perhaps 16 tons in 1975. Schwedt is conveniently located as one of the western terminals of the recently completed parallel section of the Druzhba pipeline system for the transport of Russian crude; an extension has also been laid from Schwedt to the Halle-Leipzig area.

The balance of East Germany's crude oil requirements under the present plan are supplied from the rest of the world. Part of the crude is provided under arrangements with government agencies (primarily Egypt, more recently Iraq), and part is provided through an agreement with British Petroleum. The seaport of Rostock is linked by pipeline with Schwedt, and indirectly with the other refineries. However, Rostock cannot, at present, handle tankers larger than 20,000 deadweight tons; thus, some of the crude supply is transshipped from Rotterdam.

The output of the East German refineries primarily serves the rapidly growing inland requirements. Exports of products have been a

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* The Remkenhagen field near the Baltic Coast does make a minor contribution to the nation's supply.

factor in the past, but they represent a declining portion of the total refinery output. It is understood that a scheme is now being discussed for construction of a 3.0 million ton refinery at Schwedt; the output would be almost entirely dedicated for export to West Berlin.

To meet anticipated requirements for products in East Germany, it is expected that refinery capacity will have to increase nearly four times between 1970 and 1990. The following tabulation shows expected additions to capacity, as well as crude import requirements to 1990:

	Million Metric Tons		
Year	Refinery Capacity	Crude Charge	Import Requirements*
1970	10.7	10.6	10.1
1975	17.9	16.1	16.7
1980	24.5	22.0	22.9
1985	30.5	27.5	29.0
1990	36.0	32.5	34.2

* Takes into account domestic supply as well as losses (transmission, storage, etc.).

d. Hungary

Plans for the expansion of the oil refining industry in Hungary are based on the growth in demand for petroleum products (Figure A-19). The capacity of facilities for refining crude oil in the country has increased from just under 1.0 million metric tons in 1950 to 2.7 million tons in 1960 and 6.7 million tons in 1970. The 1971-75 plan calls for an increase in refining capacity to 9.5 million metric tons by 1975.* In the city of Leninvaros, a new refinery is expected to be built that alone will

* Other sources place the 1975 target at 11.0 million tons.

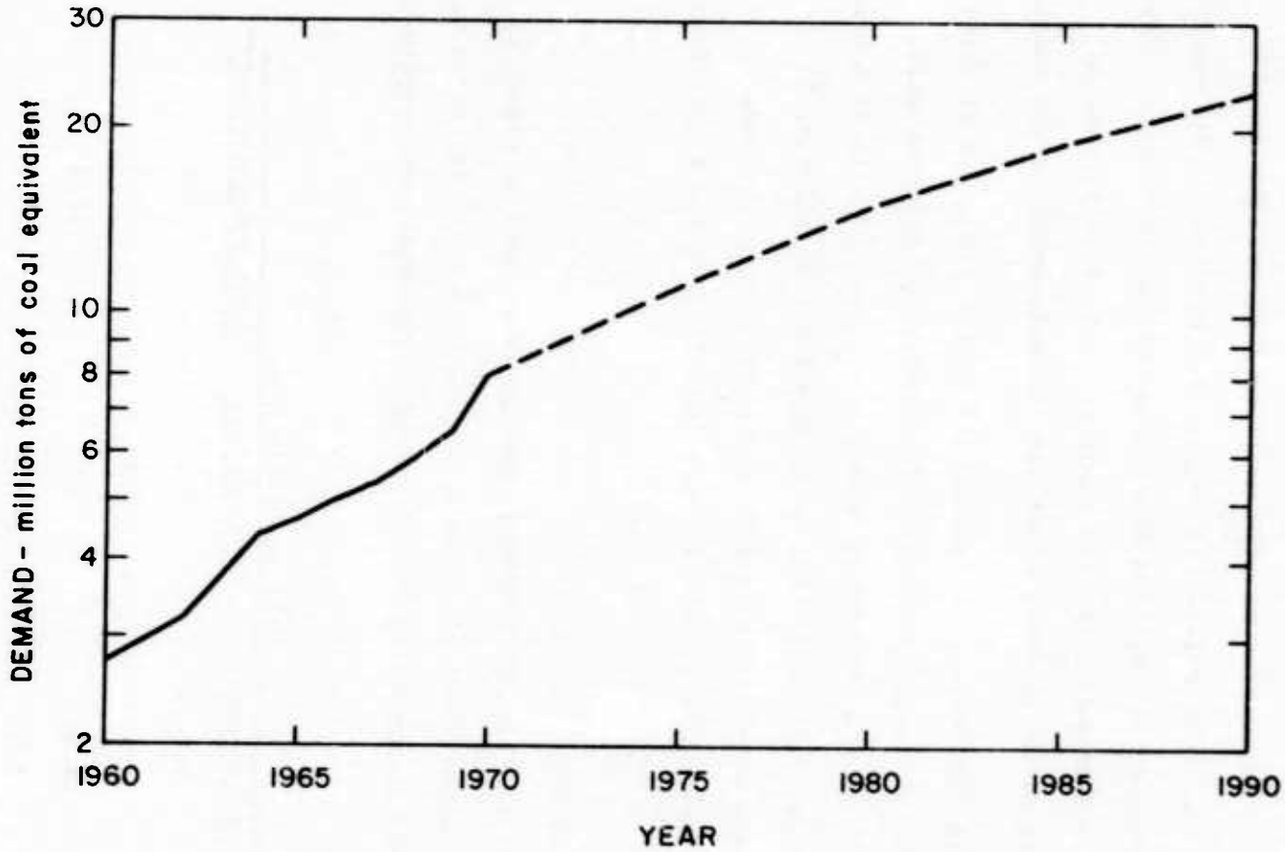

Figure A - 49

DEMAND FOR OIL PRODUCTS--HUNGARY

process some 6.0 million tons of crude oil. This facility is expected to be operative some time during the 1976-80 period; completion is actually scheduled for either 1976 or 1977.

The second Druzhba (Friendship) pipeline was completed in 1972, permitting deliveries of USSR crude to Hungary. During 1973, the line is expected to be delivering roughly 5.3 million metric tons of crude out of a total of 7.7 million tons being refined in Hungary. Major investments are continuing in the oil industry, and it is planned to extend the line in order to serve other and new refineries in the country.

In the future, it is expected that a crude oil pipeline will be built from the port of Bakar in Yugoslavia to Czechoslovakia. This pipeline will have a throughput capacity of about 17 million metric tons per year; 10 million tons would be destined for Yugoslavia, 5 million tons for Czechoslovakia, and 2 to 3 million tons for Hungary. This line will carry crude oil purchased primarily from the Middle East and North Africa.

To meet anticipated demand for refined products in Hungary, it is estimated that refinery capacity will need to expand by three times during the forecast period. The following tabulation shows expected additions to capacity, as well as crude imports requirements to 1990:

	Million Metric Tons		
Year	Refinery Capacity	Crude Charge	Import Requirements*
1970	6.7	6.0	4.3
1975	9.5	8.6	6.7
1980	13.5	12.2	10.4
1985	18.0	16.2	14.5
1990	22.5	20.2	19.2

* Takes into account domestic supply as well as losses (pipeline, storage, etc.).

c. Poland

In 1970, Poland refined about 7.5 million metric tons of crude oil in its six refineries, but this was still not enough to satisfy the refined product requirements of the country (Figure A-50). It was necessary that year to import about 2.5 million tons of various refined products, with fuel oil being the principal one imported. It is expected that the refining capacity will be expanded to supply virtually all of the requirements, but this self-sufficiency (in terms of products) probably will not come about until at least 1980, or perhaps even later.

During the 1971-75 period, it is planned to start construction of two more refineries in the country, as well as to expand the capacity of existing facilities. Refining capacity at Plock in central Poland currently stands at 7 million tons; it is due to be increased to about 10 million tons by the middle to late 1970s. The other two refineries, each with an eventual capacity of 6 million tons, are due to be built at Blachownia in Upper Silesia and at Danzig on the Baltic Coast. When these refinery projects materialize, the country should be nearly self-sufficient in refined products by about 1980.

The Plock refinery is located on one of the branches of the Druzhba pipeline which moves crude oil from the Ural-Volga region of the USSR to Poland and East Germany. A second parallel line is being completed in 1973. The Blachownia refinery will almost certainly be one of the terminals of the projected major pipeline system from the Yugoslav seaport of Bakar to refineries in several of the Eastern European countries. The Danzig refinery, when constructed, can be conveniently served by tankers either from Soviet seaports in the Baltic or alternatively, from any overseas sources.

Crude oil deliveries from the USSR through the Druzhba system have been fixed at 47 million metric tons for 1971-75. Deliveries

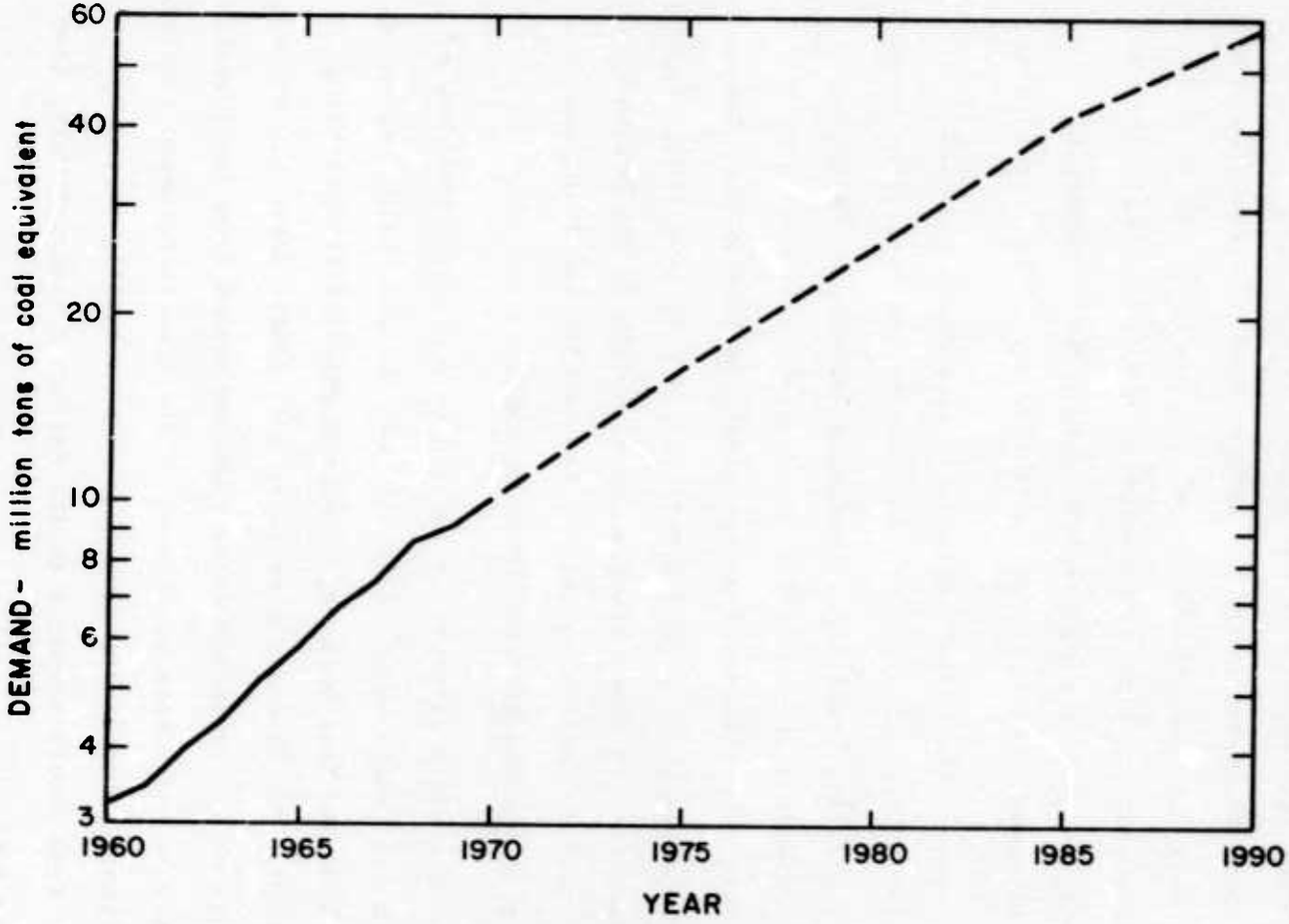

Figure A-50
DEMAND FOR OIL PRODUCTS--POLAND

will probably rise from about 8 million tons in the first year to perhaps 11 million tons in the last year of the period. Poland, in common with the other Eastern European countries, is now being encouraged by the USSR to make arrangements for supplemental crude oil purchases from non-Communist supplies. Poland presumably would want such deliveries to start in two or three years, after completion of the Bakar-Blachownia pipeline. By 1975, Poland's requirements of overseas crude might be as high as 2 million metric tons per year; they could be as high as 6 million tons per year by 1980, assuming that refining capacity is added as planned.

To meet the expected demand for refined products in Poland, it is estimated that refinery capacity will need to expand by over 8 times during the forecast period. The following tabulation shows anticipated additions to capacity, as well as crude import requirements to 1990:

	Million Metric Tons		
Year	Refinery Capacity	Crude Charge	Import Requirements*
1970	7.5	7.5	7.0
1975	13.1	11.8	11.8
1980	20.5	18.5	18.7
1985	31.0	27.8	28.3
1990	42.0	37.8	38.5

* Takes into account domestic supply, as well as losses (pipeline, storage, etc.).

f. Romania

Romania--one of the world's oldest crude oil producing countries--has been in a relatively favorable position for its crude supplies, compared with the other Eastern European countries. The country actually has had more than enough domestic crude oil to satisfy internal

demand for products (Figure A-51), but has traditionally been a fairly large exporter of products. As a consequence, through most of the 1960s, all of the crude produced--between 11 million and 13 million metric tons--was run to refineries, and products surplus to internal requirements were exported. Exported products amounted to about 50 percent of refinery production.

Thus, between 1960 and 1970, there was only a modest increase in refinery capacity--from 12 million metric tons in 1960 to 16 million tons in 1970. At the same time, however, facilities were greatly modernized and continuous additions were made to secondary refining processes. These improvements permitted considerably more flexibility in refining, and allowed Romania to supply a full slate of good quality products both for the internal market and for the export market.

For the long term, it has been assumed that Romania will continue to export products to both the USSR and other Eastern Bloc countries, as well as to the Free World--primarily to the Western European countries. The exact level of exports is difficult to estimate, but a reasonable expectation is 5 million to 6 million metric tons per year, about the same as exports during the 1960s. As internal demand for products increases, it is entirely possible that by the latter part of the 1970s, product exports will actually decline. Certainly, exports will be a smaller and smaller share of total refinery output.

To meet expected demand for petroleum products in Romania, it is estimated that refining capacity will need to nearly double during the forecast period. The following tabulation shows anticipated additions to capacity, as well as crude import requirements to 1990:

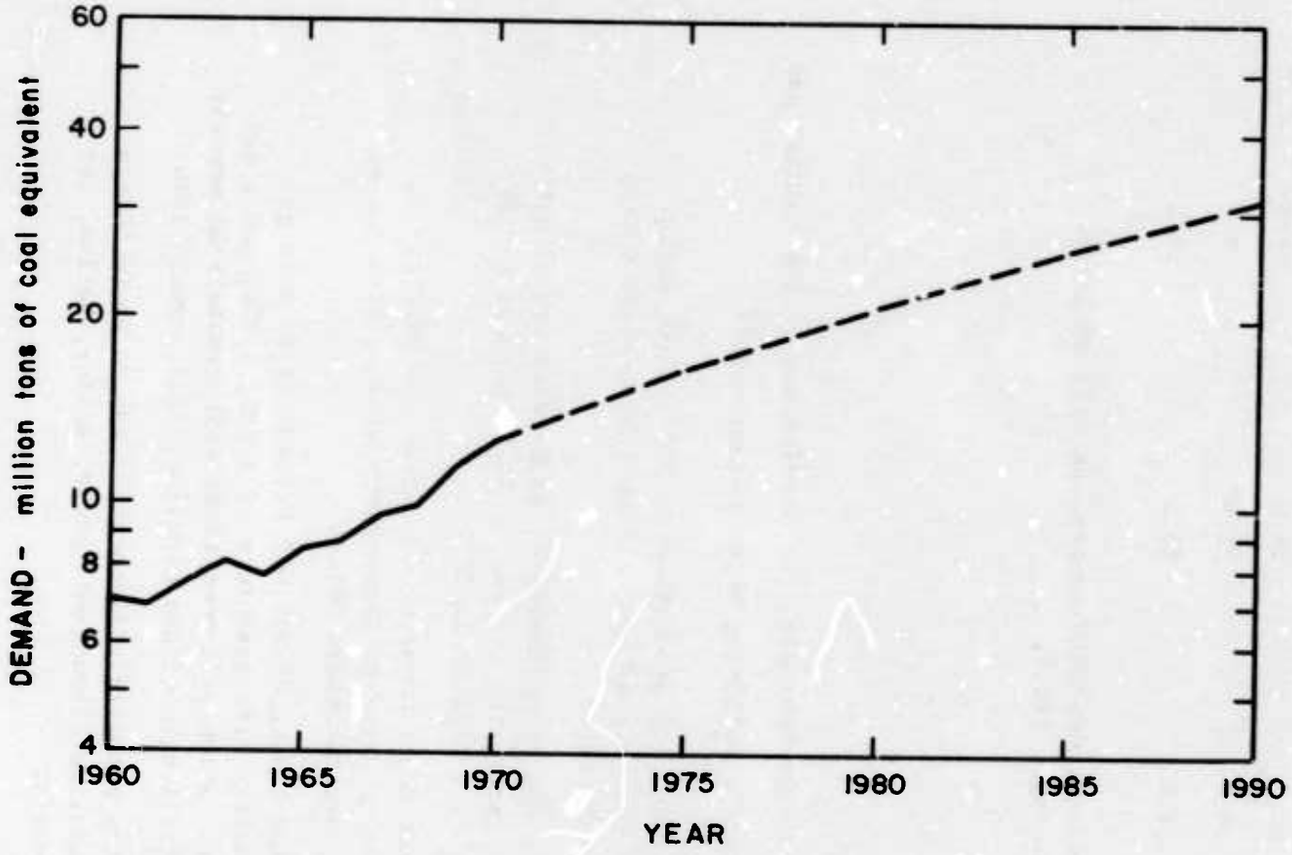

Figure A-51

DEMAND FOR OIL PRODUCTS--ROMANIA

Year	Million Metric Tons		
	Refinery Capacity	Crude Charge	Import Requirements*
1970	16.0	16.1	2.3
1975	18.0	16.2	3.1
1980	20.0	18.0	5.0
1985	24.0	21.5	9.2
1990	28.0	25.2	13.5

* Takes into account domestic supply, as well as losses (pipeline, storage, etc.).

D. Natural Gas

1. USSR

The Ninth Five-Year Plan for development of the natural gas industry sets forth the following major objectives:[27]

- Raising natural gas production to 320 billion cubic meters, an increase of 122 billion cubic meters during the five-year period.
- Eliminating the large losses of associated gas at oil fields and increasing its use to 85-87 percent in 1975, as against 61.1 percent in 1970.
- Ensuring the development of the large gas deposits in the northern regions of Tyumenskaya Oblast, Turkamenia, Komi ASSR, Orenburgskaya Oblast.
- Ensuring the laying of 300,000 kilometers of main gas pipeline mostly with diameters of 1,020, 1,200, and 1,420 millimeters, which will constitute approximately 50 percent of the total length of gas pipelines laid through 1970.
- Ensuring the complete refinement of gas so as to obtain from it gasoline, liquefied gases, sulfur, helium, and other products.

The basis for establishing a development plan along the lines just indicated was the discovery of very substantial commercial reserves of natural gas between 1966 and 1971. During this relatively short period,

gas reserves increased from 3.6 billion cubic meters to 15.7 billion cubic meters--more than a fourfold rise. As of 1972, reserves stood at about 20 billion cubic feet. It turns out, however, that there will be serious shortcomings of natural gas production not only for this year (1973) but for the next several years ahead. It is a matter of considerable concern to the Soviet authorities. Some of the reasons given include:

- Construction of better transmission and distribution pipeline networks is behind schedule.
- Location and development of underground gas storage reservoirs are not moving forward fast enough.
- Installation of necessary gas processing facilities is far short of requirements.

From Table A-65, it can be seen that production increases for 1972 and 1973 have been disappointing. Planned gas production for 1975, although unofficially abandoned, appears to be out of reach by the industry. For 1973, from figures so far reported by the Soviet authorities, an increase of approximately 15 billion cubic meters is foreseen, or 6.7 percent.* From this preliminary 1973 information, and from the industry record of recent years, it is doubtful that a production of much more than 275 billion to 280 billion cubic meters can actually be achieved by 1975.

For the long term, it would appear that the USSR will be able to achieve about a fourfold increase in natural gas production between 1971 and 1990. As noted previously, the 1975 production target of 320 billion

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* It has now also been indicated that production this year is to increase up to 12 billion cubic meters in Soviet Central Asia, 7 billion cubic meters in Tyumen (West Siberia), and 2 billion cubic meters in the Komi area of the far north, but these increases will be partly offset by a continued decline in some established and geographically more convenient regions, such as the Northern Caucasus and the Ukraine. Production in the important Orenburg region, within the Ural-Volga area, is due to start late this year.

Table A-65

USSR NATURAL GAS PRODUCTION
(Billion Cubic Meters)

Year	Production	Percentage Increase over Previous Year
1970	198	9.3
1971	212	7.1
1972	221	4.2
1973	236*	6.7
1975	320†	16.5‡

* Annual target according to latest estimate.

† Five-year plan target.

‡ Average annual growth rate required to achieve the target shown.

cubic meters is probably beyond reach, as possibly is the estimated 1980 production of 400-450 billion cubic meters. During this interim period--i.e., to 1980--any short fall in gas production will have to be made up by increased use of oil and/or coal. To the extent this is not possible, then overall use of energy will decline. It will be noted in Table A-66 that the potential shortage (internal consumption) in 1975 will be about 48 billion cubic meters if production does reach 270 billion cubicmmeters. These figures assume that export commitments of some 34 billion cubic meters will still be honored. By 1980, if production reaches, say 425 billion cubic meters, and imports are about 17 billion cubic meters, then the potential shortage in satisfying internal demand would be about 29 billion cubic meters. In this case, export commitments are estimated at 51 billion cubic meters, whereas only 22 billion cubic meters are actually available. Now if production were to be about 5 percent higher than forecast--and this certainly is possible, given the country's estimated gas reserve

Table A-66

USSR SUPPLY OF NATURAL GAS 1960-1990
(Billion Cubic Meters)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Production	45.3	59.0	73.5	89.8	108.6	127.7	143.0	157.4	169.1	181.1	197.9	212.4	270*	400-450	560-640	800-900
Imports	-	-	-	-	-	-	-	0.2	1.5	2.0	3.6	8.1	12-13.5	16-18	20-25	20-25
Exports	0.24	0.27	0.3	0.3	0.3	0.4	0.8	1.3	1.7	2.7	3.3	4.6	34†	22‡	45§	155
Apparent internal consumption	45.1	58.7	73.2	89.5	108.3	127.3	142.1	156.3	168.9	180.4	198.2	215.9	300**	420	580	720
Losses and own use	1.7	2.2	3.1	3.5	8.1	10.5	11.0	9.2	10.0	11.5	14.2	15.9	15	21	30	36
Net internal consumption	43.4	56.5	70.1	86.0	100.2	116.8	131.2	147.1	158.9	168.9	184.0	200.0	285	399	550	684

Note: Figures may not agree exactly because of rounding.

* 1971-75 target--320.

† Exports committed to Eastern Bloc (17) and to Western Europe (17).

‡ Available, but exports committed to Eastern Bloc and West Europe total 61 bcm ; if commitment is met, the cutback in domestic use would be recognized.

§ Available, but exports committed to Eastern Bloc and West Europe total 85 bcm.

** If commitments are met to Eastern Bloc and to Western Europe, this figure could be no higher than 249, and net internal consumption could be 237 (249 less 5 percent).

Sources: Historical, United Nations; forecast, Stanford Research Institute.

position--then both forecast exports and internal consumption could be met. By 1985, it is believed that all necessary facilities for producing and transporting gas to the various markets in the country will be installed and operating satisfactorily, with the result that estimated exports (some 85 billion cubic meters) and internal consumption will be supplied.

The use of natural gas in the USSR increased dramatically during the 1960-71 period;* most of the increase was accounted for by the industrial and electric power sectors. For example, in 1960, these two sectors alone accounted for over 85 percent of total gas use. By 1971, these two sectors still accounted for about the same share. In terms of total primary energy use, natural gas increased its share from about 9 percent in 1960 to about 22 percent by 1970. Trends in the use of gas in the country are illustrated in Table A-67.

Between 1970 and 1990, the use of natural gas in the USSR is expected to increase nearly four times, from 184 billion cubic meters in 1970† to about 684 billion cubic meters in 1990. The industrial and electric power sectors will continue to be the major users of natural gas, although the residential and commercial sectors each will increase their use significantly--the residential sector by three times, the commercial sector by nearly five times. By the end of the forecast period, gas use in the USSR economy will account for nearly 30 percent of total primary energy consumption.

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* Over 20 percent per year between 1960 and 1965, and nearly 10 percent per year between 1965 and 1970.

† Use in 1971 was 200 billion cubic meters.

Table A-67

USSR DEMAND FOR NATURAL GAS 1960-1990
(Billion Cubic Meters)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1975	1980	1985	1990
Energy Conversion	12.6	16.7	20.1	26.5	30.5	35.6	40.6	43.5	45.0	47.8	51.8	59.1	82	112	154	161
Petrochemical Feedstocks	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Other Industry and Construction	21.9	33.3	41.9	49.0	57.2	65.7	73.8	81.3	93.1	98.3	104.4	112.2	161	229	313	407
Transportation	0.21	0.094	0.12	0.06	0.08	0.38	0.11	0.63	0.59	0.61	0.75	0.8	1	2	2	3
Residential	5.7	2.3	2.7	3.5	3.7	1.51	1.55	5.6	6.3	7.0	7.6	7.9	11	15	19	22
Agriculture	-	-	-	-	-	0.23	0.26	0.25	0.12	0.51	0.7	0.9	1	1	1	2
Commercial and Other	n.a.	1.2	5.3	7.0	8.6	10.1	11.1	13.0	13.1	14.7	18.7	18.8	29	44	63	89
Net Internal Consumption	43.1*	56.6	70.1	86.0	100.1	116.8	131.0	147.3	158.8	169.0	184.0	200.0	285	403	552	684

* Totals may not add because of rounding.

Sources: Historical, United Nations; forecast, Stanford Research Institute.

To the extent that gas supplies may not be available in the next several years to 1980, it is expected that reductions in the use of natural gas by the industrial and electric power sectors would probably take place first. They are both large users, and either sector could substitute additional quantities of fuel oil or coal for natural gas over some interim period. This would mean, however, that some manufacturing and electric generating facilities would have to be designed for dual fuel systems so that they could be converted back to natural gas whenever it was again available in adequate amounts.

Table A-68 shows the estimated supply-demand balance for natural gas in the USSR. It was noted earlier that in 1975, there is likely to be a shortage of about 48 billion cubic meters in meeting internal consumption. This estimate assumes that the export commitments to both Eastern Europe and Western Europe will be met. Shipments to Western Europe include Austria, West Germany, and Italy. By 1980, France will also be receiving gas from the USSR. In 1980, the situation will still be one of tight supply--in fact, there will still be a small deficit--if production is no higher than 425 billion cubic meters.

The USSR imports natural gas from Afghanistan and Iran. Deliveries from Afghanistan began in September 1967--a year before the start of Soviet gas exports to Austria. The amount reached 2.0 billion cubic meters in 1969 and 2.6 billion cubic meters in 1970. Another 2.5 billion cubic meters were received in 1971. By 1973, the plan was to increase the quantity received to between 3.5 billion and 4.5 billion cubic meters and to remain at that annual level thereafter.* The Afghanistan gas comes from the Khwaja Gogirdak fields in Shibarghan, not far from the Russian border. These fields were developed with assistance from the USSR.

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* The increase to the maximum level depends upon completion of an aerial pipeline crossing of the Amu Darya river (at the border); this project has been underway since the fall of 1971.

Table A-68

USSR NATURAL GAS SUPPLY/DEMAND BALANCE
(Billion Cubic Meters)

	1970	1975	1980	1990
Production	198	270*	400-500	800-900
Demand	198	300	420	720
Potential surplus	3.3†	(30)§	5**	130††
Eastern Europe requirements	2.5††	17	36	109
Potential export‡‡	-	17	25	21

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* Five-year plan goal--320.

† Including losses.

‡ Available for export based on imports from Iran and Afghanistan.

§ Deficit.

** Assumed production of 425.

†† Assumed production of 850.

‡‡ Actual deliveries.

§§ Contract commitments to Western Europe, including options.

Source: Historical, United Nations; forecast, Stanford Research Institute.

The Iran-USSR pipeline (40-inch diameter) began moving natural gas to Russia in October 1970. Total throughput during the first two years of operation--that is, to the end of 1972--was about 12.5 billion cubic meters. Gains in Soviet imports of Iranian gas will be smaller in 1973 than they were in 1971 or 1972. While the Soviet section of the Iran-USSR pipeline was supposed to be operating at capacity long before now, it is unlikely that capacity operation will be achieved until additional compressor stations are installed in the system. Activation of these four additional stations probably will not take place until some time in 1974. When these stations go into service, throughput will rise to 10 billion cubic meters per year.

All together, imports of gas into the USSR from its two southern neighbors are expected to reach about 13.5 billion cubic meters in 1975 and 23.5 billion cubic meters per year at a later, unspecified date. Because of difficulties the Soviets are having in developing various domestic gas fields such as Tyumen, it is probably to their economic advantage to obtain foreign gas rather than raise their own production by a comparable amount. There are obvious political advantages. The quantities involved are actually only a small percentage of USSR natural gas production, and therefore, the risk of relying on these imports is not particularly great.

2. Eastern Europe

Natural gas production in the Eastern European countries has increased roughly three times between 1960 and 1971. In 1960, total production amounted to just over 11 billion cubic meters for the six countries; Romania alone accounted for nearly 9 billion cubic meters, or 80 percent of the total. By 1971, production for these countries had risen to slightly more than 35 billion cubic meters. Romania still accounted for a significant 65 percent of the total (22.5 billion cubic

meters), with Poland, Hungary, and East Germany each contributing between 10 and 20 percent of total Eastern Bloc natural gas production. Table A-69 shows natural gas production for the 1960-71 period by country, with projections to 1990.

The Institute sees gas production increasing roughly three times for the forecast period. This estimate is based on the following:

- Romania. Production will nearly double in the next 20 years, from 22 billion cubic meters to some 40 billion cubic meters. It is believed that this estimate is reasonable, for there appears to be substantial potential for adding to existing reserves as added exploration is undertaken, both onshore and offshore.
- Poland. Production will increase nearly six times in the next 20 years, from 5 billion cubic meters to about 30 billion cubic meters. This estimate may be somewhat optimistic, but the resource base would seem to be enough to support this production forecast. New discoveries have increased reserves significantly, but whether further discoveries will be made is a question that cannot be answered with any confidence.
- East Germany. Production will increase about 15 times in the next 20 years, from 2 billion cubic meters to about 30 billion cubic meters. This estimate could well be understated if one could believe industry representatives in the GDR. Certainly, major new discoveries have been made, and if further extensions to these reserves are forthcoming, then the production forecast is entirely reasonable.
- Bulgaria, Czechoslovakia, Hungary. The possibility of expanding natural gas reserves in these three countries does not appear promising.

Table A-70 shows a comparison of natural gas reserves for the Eastern Bloc countries, and the projected cumulative production for the forecast period. It can be seen that Bulgaria, Czechoslovakia, GDR, and Hungary each have a gas resource base that is large enough to support the forecast levels of production, even without any additions to these reserves

Table A-69

NATURAL GAS PRODUCTION OF CMEA COUNTRIES 1960-1990
(Billion Cubic Meters)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971*	1975	1980	1985	1990
Bulgaria	-	-	-	-	-	0.07	0.11	0.33	0.51	0.53	0.47	0.38	1.0	1.5	2.0	2.5
Czechoslovakia	1.3	1.1	1.2	1.1	1.0	0.97	1.1	1.0	1.1	1.2	1.2	1.2	1.2	1.3	1.4	1.5
East Germany	0.02	0.01	0.53	1.1	1.1	1.3	1.2	1.1	1.4	3.7	1.2	2.0	10.5	17.5	22.5	30.0
Hungary	0.34	0.32	0.34	0.6	0.78	1.1	1.6	2.0	2.7	3.2	3.5	3.7	4.3	5.3	5.5	5.0
Poland	0.55	0.73	0.82	0.98	1.2	1.4	1.4	1.6	2.6	3.9	5.2	5.1	9.0	15.0	22.0	30.0
Romania	8.9	9.7	11.1	12.7	14.1	15.7	16.9	18.7	19.8	21.7	22.6	22.5	28.0	33.0	37.0	40.0
Total Eastern Bloc	11.1†	11.9	13.8	15.5	17.2	19.4	21.2	23.7	26.8	31.0	34.1	35.3	53.7	73.6	90.4	109.0

* Estimate.

† Totals may not add because of rounding.

Sources: Historical, United Nations forecast, Stanford Research Institute.

Table A-70

COMPARISON OF RESERVES AND PRODUCTION DATA FOR NATURAL GAS
(Billion Cubic Meters)

	Estimated Gas Reserves*	Projected Cumulative Production Required 1975 to 1990	Surplus or (Deficit)	Remarks Regarding Differences
Bulgaria	29	26.2	2.8	New discoveries could further expand reserves
Czechoslovakia	15	20.2	(5.2)	Old fields being depleted; no significant discoveries
GDR	100◆	301.1	98.9	Newly discovered major reserves; estimate quite unknown
Hungary		64.1	20.8	New discoveries could expand reserves to about 112 billion cubic meters
Poland	112‡	285.0	(113)	New discoveries have increased resources; amount uncertain
Romania	285	517.5	(232.5)	Deep drilling may expand reserves by unknown amount
Total	956	1,214.1	(258.1)	

* International Petroleum Encyclopedia, 1973, except as noted.

◆ Encyclopedia table p. 261 gives 15 billion cubic meters, equivalent to one year's production for 1975 (p. 178). Value used here was calculated by SRI, assuming average production of 20 billion cubic meters per year and reserves production ratio of 20:1. Probably includes low heating value gas.

‡ Figure does not include low-heating value gas. Reference: "Prospects for the Development of the Oil and Gas Industry in Poland," Neftyrnaya i gazovaya promyshlennost, No. 4, pp. 52-53, July-August 1971.

§ Calculated from data in Encyclopedia p. 178, which disagrees with table on p. 261.

Source: Stanford Research Institute.

during the next 20 years. In the case of Poland and Romania, however, fairly substantial additions to existing reserves in each country will be required in the next several years to justify the production forecast indicated.

Although Eastern European gas production is expected to increase significantly during the forecast period, it will still be necessary to import increasingly large quantities to satisfy demand. In 1970, domestic production in the six countries met about 90 percent of total demand. By 1980, however, domestic production is expected to satisfy only about two-thirds of demand; imports will account for the balance. And by 1990, domestic production will be supplying roughly 55 percent of estimated demand; imports will account for 45 percent of the total. Figure A-52 shows how this situation is expected to develop.

a. Bulgaria

Sometime early in 1974, the gas line from the USSR through Bulgaria is expected to be completed. This first stage will go through the northern part of the country to Sofia. By 1975, Bulgaria will be receiving nearly 3 billion cubic meters of natural gas per year. Some 15 branches from the main line will provide gas service to the principal industrial complexes in the northern part of the country,* and in addition, gas will be supplied to Sofia for further distribution to the residential and commercial sections in the Sofia area. These imported supplies will meet virtually all of Bulgaria's demand for natural gas in 1975 (Figure A-53).†

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* Industrial service and thermal electric power stations.

† To convert millions of tons of coal equivalent to billions of cubic meters, divide by 1.18.

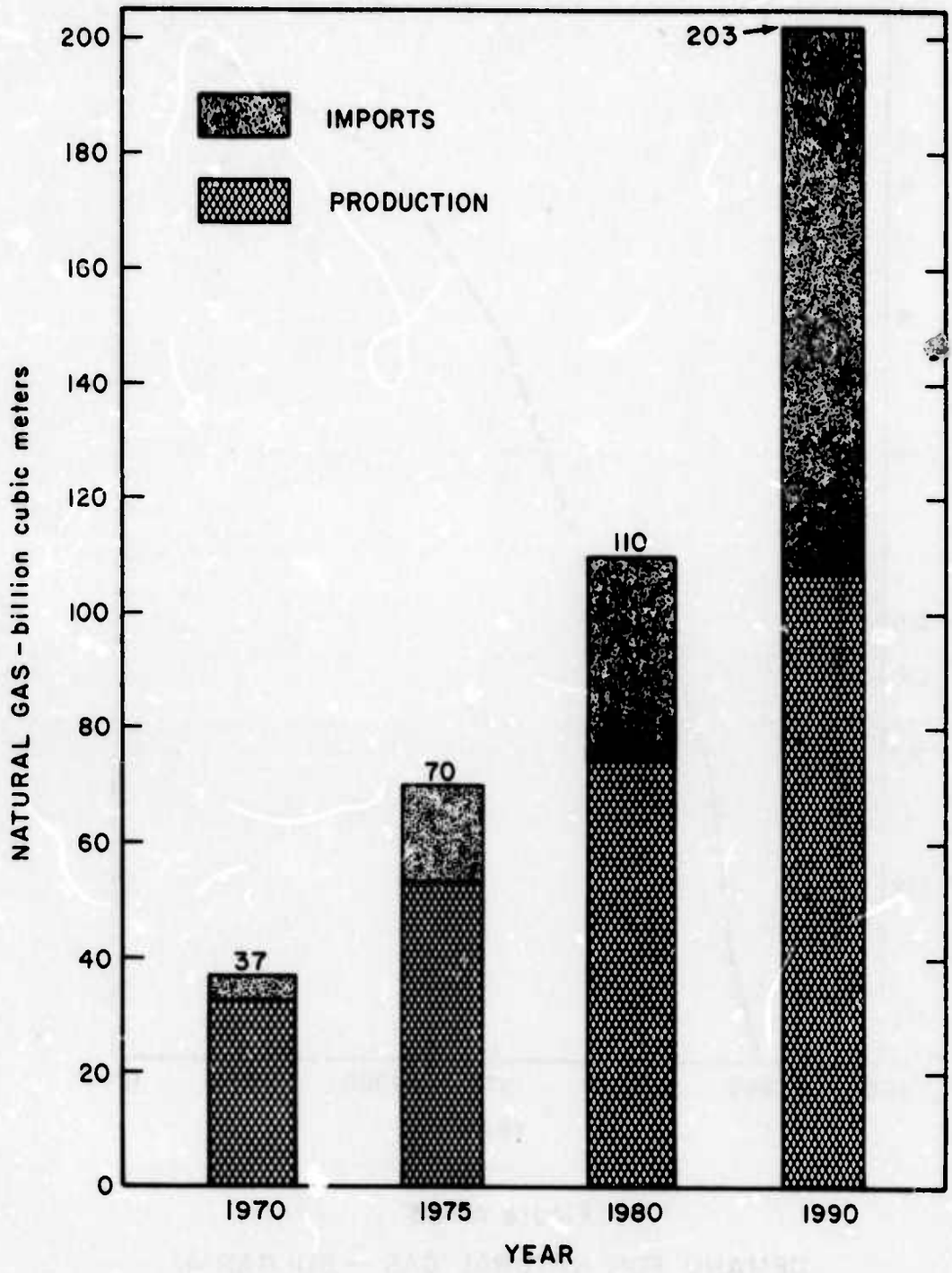

Figure A-52
ESTIMATED PRODUCTION, IMPORTS, AND DEMAND OF NATURAL GAS IN EASTERN EUROPE

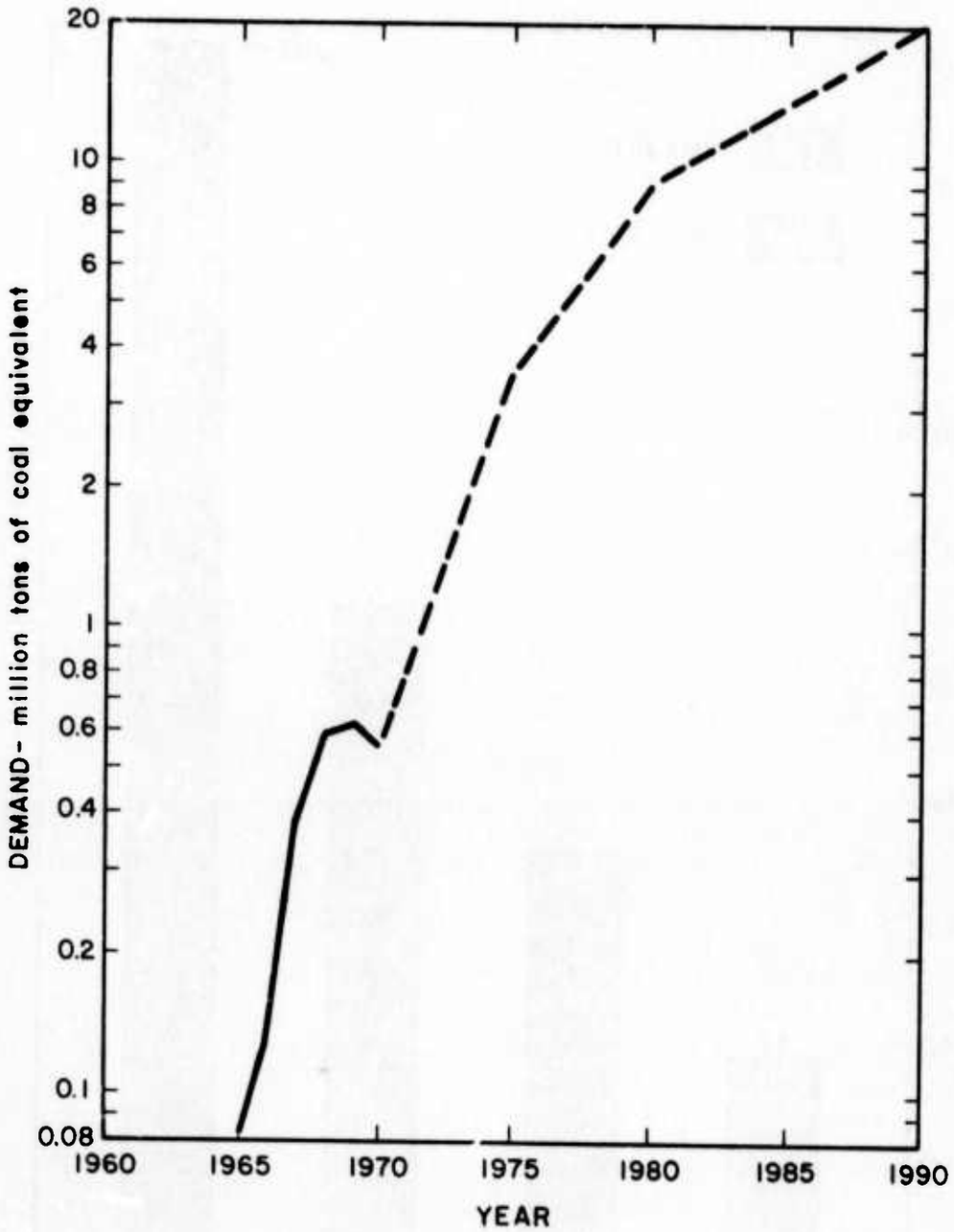

Figure A-53

DEMAND FOR NATURAL GAS -- BULGARIA

Imported natural gas supplies for the southern part of the country will be available sometime during the 1975-80 period. Construction of the Southern line is expected to start within the next one to two years. Upon completion of this line, Bulgaria will be able to receive up to 10 billion cubic meters of USSR gas annually.

b. Czechoslovakia

The 1971-75 plan calls for structural improvements in the whole energy economy. Supplies of primary fuels are scheduled to expand by about 20 percent over the five-year period; the combined share of liquid fuels and natural gas in the total will double from about 15 percent in 1970 to about 30 percent in 1975. Beyond that, it is hoped that oil and gas will reach a combined share of about 40 percent by 1980 and perhaps 50 percent by 1990.

With the completion of the Bratsvo or "Brotherhood" gas line from the Ukranian frontier westward across the whole length of the country, there will be a sharp increase in deliveries of Soviet gas to Czechoslovakia. This line, for the main part completed, plays an important role in the export arrangements of Soviet natural gas.* Czechoslovakia received about 900 million cubic meters of Soviet gas in 1970. With this new line, deliveries by 1975 will amount to about 3.5 billion cubic meters. When the line is in full-scale use, roughly 900 million cubic meters in 1975 and 1.6 billion cubic meters will be made in lieu of transit fees to pay for the line's construction and maintenance.

Czechoslovakia's own gas production--which amounted to 842 million cubic meters in 1970 and 1.2 billion cubic meters in 1971--will not be substantially increased. But the country's overall supply will

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* Deliveries through the line to Czechoslovakia, Austria, and East Germany started last spring or summer; deliveries to West Germany just recently started, and deliveries to Italy and France will start some time later.

nevertheless expand by some two to three times under the plan, and will stand at about 4.0 billion cubic meters in 1975.

Construction of new large storage facilities is currently underway. With the increased supply of natural gas, it is planned to phase out manufactured gas, but this could still take a number of years.

Czechoslovakia's production, together with the Bratsvo line imports, will satisfy the country's demand for natural gas in 1975 (Figure A-54).

c. East Germany

The emergence of natural gas as a major fuel in East Germany has been sudden. During the 1960s, supplies of natural gas came from a few small fields in the Erfurt, Cottbus, and Rostock area, but they never amounted to more than about 100 million cubic meters per year. The change is primarily due to the discovery and development of the Salzwedel reservoir in the district of Magdelburg near the West German borders. By 1975, this field alone is expected to yield between 11.5 billion and 14.0 billion cubic meters. Table A-71 shows East Germany's natural gas supplies for the 1970-75 period, and Figure A-55 shows the country's demand to 1990. From a comparison of these data, East Germany's supply will be more than enough to take care of the demand in 1975.

Table A-71

NATURAL GAS SUPPLY OF EAST GERMANY
(Billion Cubic Meters)

Year	Production	Imports	Supply
1970	600	-	600
1971	2,800	-	2,800
1972	5,400	-	5,400
1973	7,000	1,000	8,000
1975	11,500 - 14,000	4,200	15,700 - 18,200

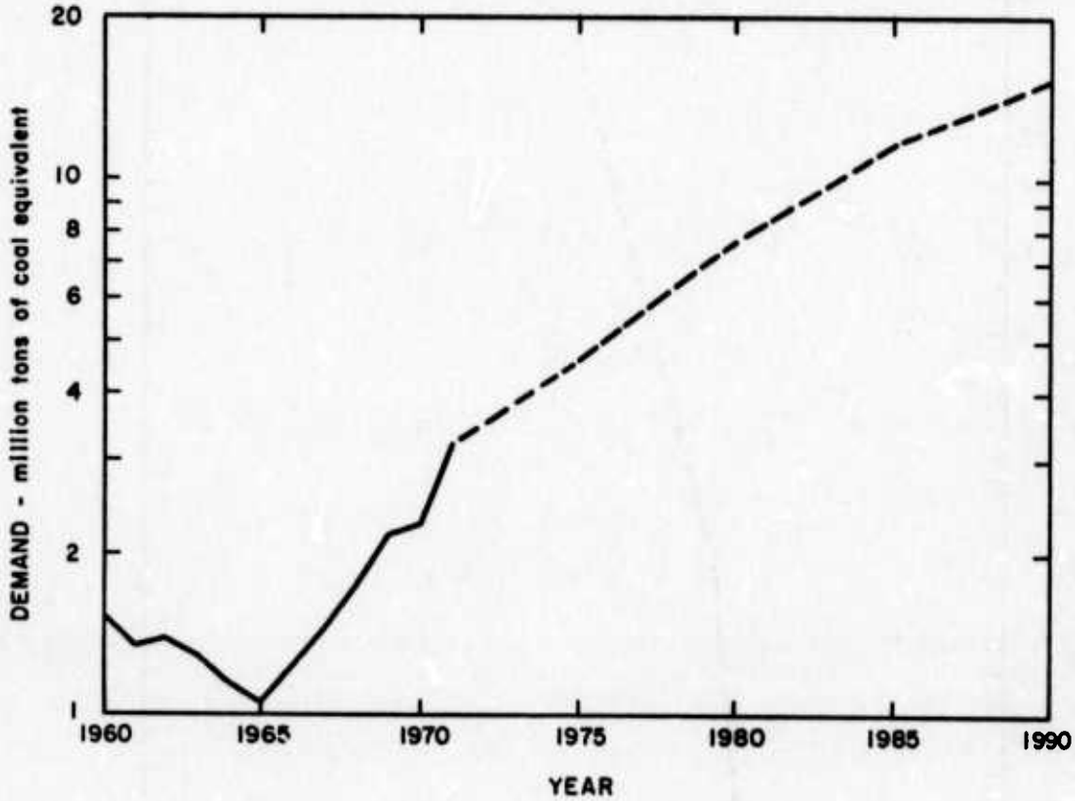

Figure A-54

DEMAND FOR NATURAL GAS--CZECHOSLOVAKIA

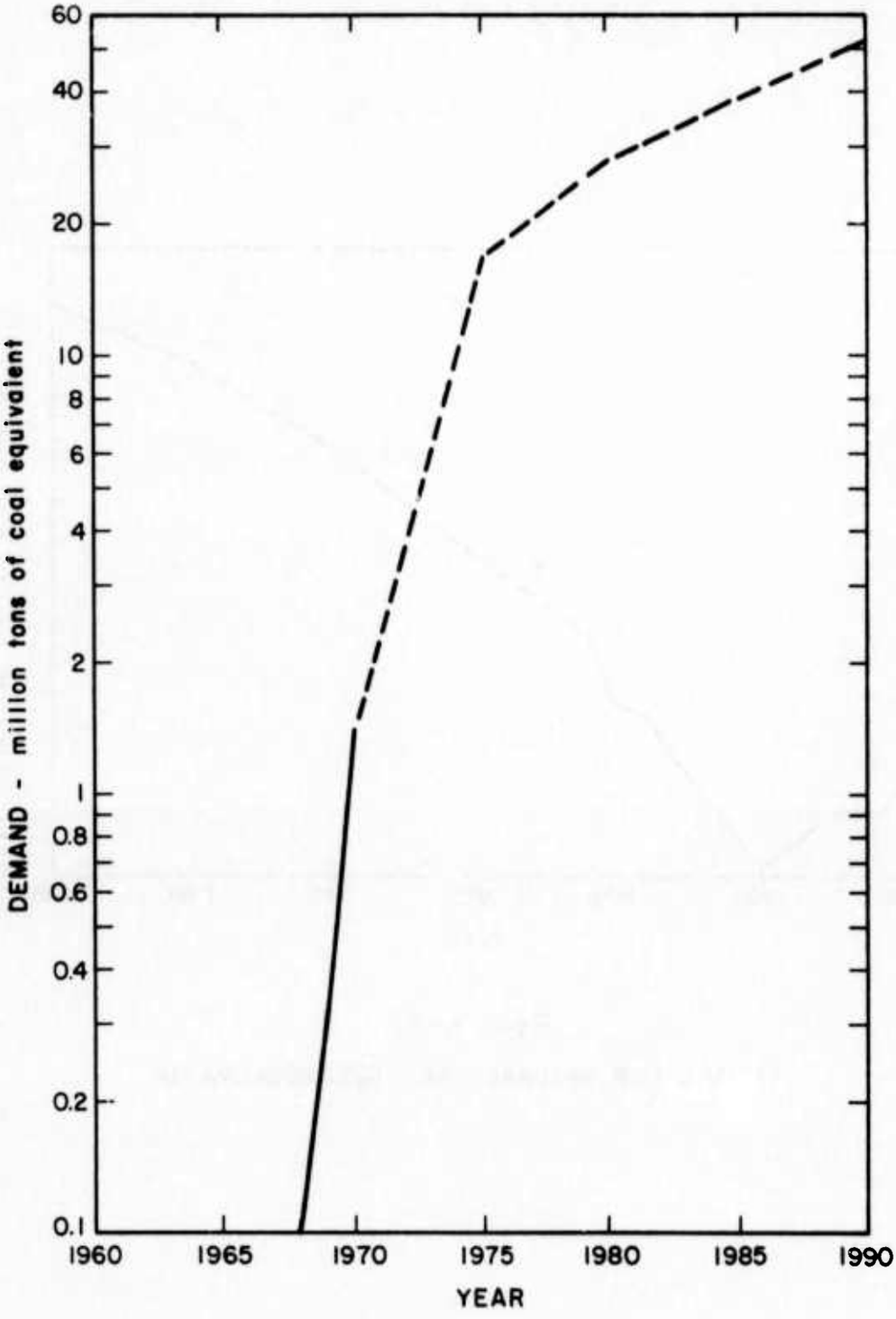

Figure A-55

DEMAND FOR NATURAL GAS--EAST GERMANY

d. Hungary

Natural gas reserves in Hungary at present are estimated at about 85 billion cubic meters. This resource base allows production levels of about 3.5 billion cubic meters per year.* It has been estimated that production could reach about 5.5 billion cubic meters by 1975. The richest gas accumulations are in the eastern part of the country; trunk pipelines for natural gas extend about 1,000 miles.

Production of natural gas is supplemented by small imports from Romania; during the last several years, they have totalled about 200 million cubic meters each year. An agreement has been reached with the USSR to supply gas by 1975 via an extension of the pipeline to Czechoslovakia. By 1975, it is possible that imports (from Romania and USSR) could amount to about 1.0 billion cubic meters. Thus, total supply in that year would be roughly 6.5 billion cubic meters, or about equal to the demand shown in Figure A-56.

About 90 percent of the gas consumed in Hungary goes to thermal electric generating plants and to the industrial sector (including petrochemicals). This pattern of use is expected to prevail through most of the forecast period. Gas use is anticipated to increase to nearly 8.0 billion cubic meters in 1980 and perhaps to 14.0 billion by 1990. At these levels, natural gas would account for about 22 to 27 percent of total primary energy consumption. Additional imports of Soviet gas will be required to achieve these predicted consumption levels.

e. Poland

Natural gas supplies have been developing faster than those of crude oil in Poland. As shown in the following tabulation, the country's

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* Actual production in 1970 was 3.5 billion cubic meters, and in 1971, 3.7 billion cubic meters.

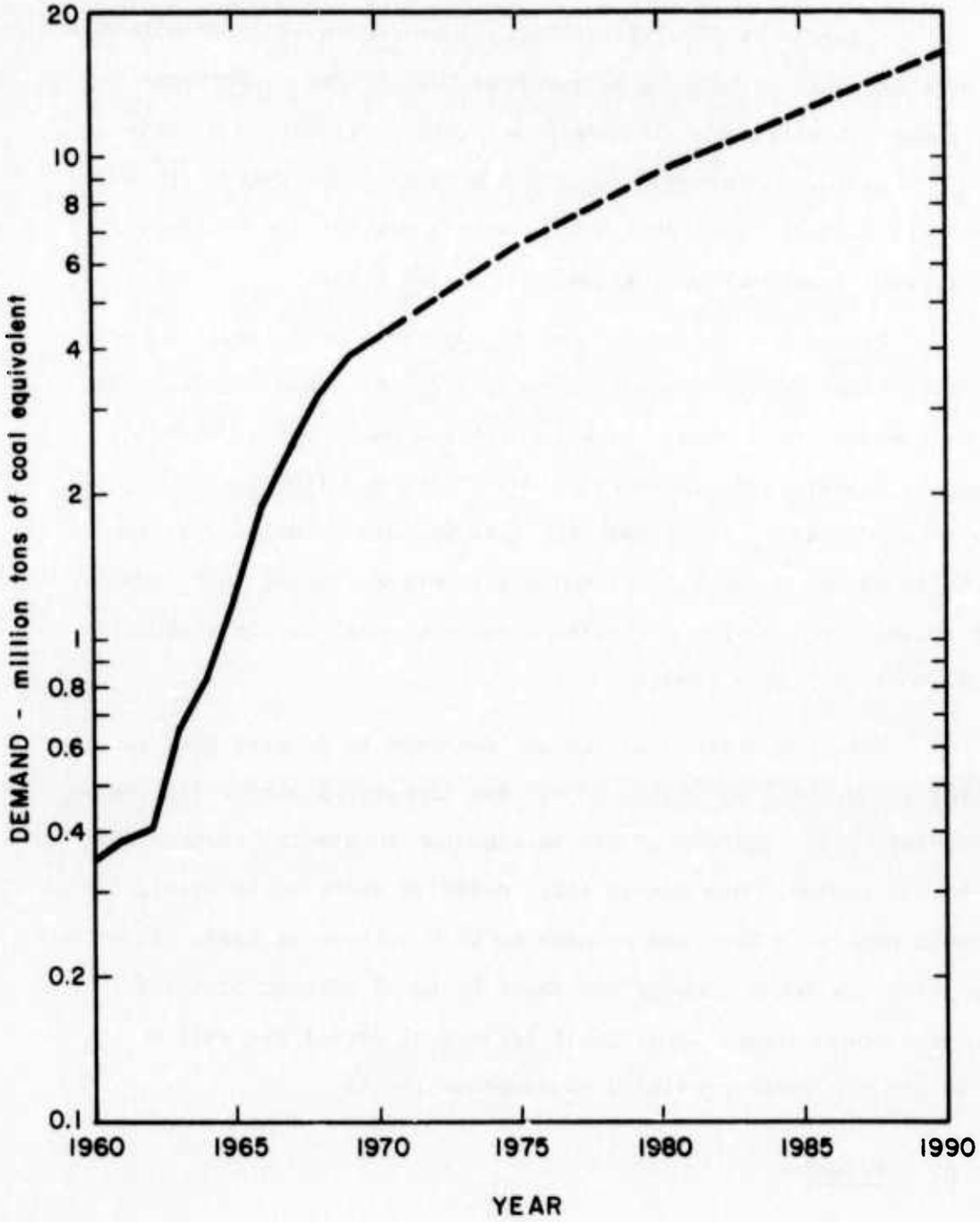

Figure A-56
DEMAND FOR NATURAL GAS -- HUNGARY

production has risen rapidly since 1965; with imports (all from the USSR), total gas supply has increased fourfold in the seven year period between 1965 and 1971:

	(Billion Cubic Meters)		
Year	Production	Imports	Total Supply
1965	1.4	0.4	1.8
1966	1.4	0.7	2.1
1967	1.6	1.2	2.8
1968	2.6	1.0	3.6
1969	3.9	1.0	4.9
1970	5.2	1.0	6.2
1971	5.4	1.5	6.9

By 1975, it is reported that production could be as high as 10 billion to 11 billion cubic meters, and total supplies (including imports) could be about 2 billion cubic meters higher than that. These increases would amount to another doubling (from 1970) in just a five-year period. A long term forecast indicates that minimum production by the mid-1980s would be about 22 billion cubic meters, and at that time, Poland could be one of Europe's largest producers.

The demand for natural gas in Poland to 1990 is shown in Figure A-57. As elsewhere in Eastern Europe, the main use of natural gas is in the industrial sector; in 1971, this sector used 4.1 billion cubic meters out of a total supply (after losses) of 6.7 billion cubic meters, or about 60 percent of the total. The electric power and petrochemical sectors each used another 1.1 billion cubic meters.

f. Romania

The production of natural gas in Romania has increased roughly three times between 1960 and 1970--from 8.9 billion cubic meters to 22.6 billion. There are minor exports--all to Hungary--of about 200

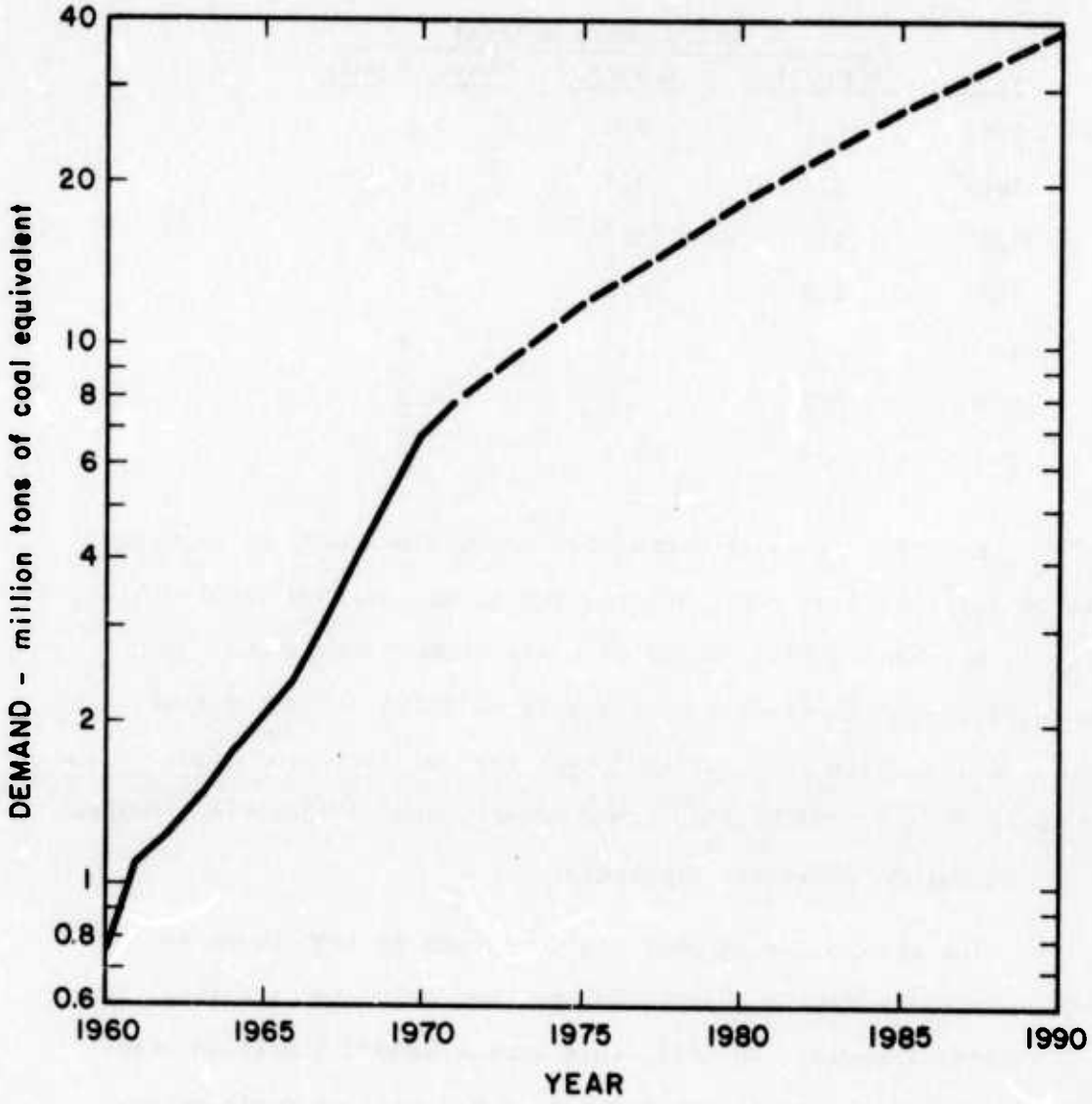

Figure A-57

DEMAND FOR NATURAL GAS - POLAND

million cubic meters per year, but most of the gas is consumed within the country. During the forecast period, it has been estimated that gas production can double again--that is, to about 40 billion cubic meters by 1990, but only if additional reserves are discovered and developed. The potential is quite good, but it is recognized that much of the country has already been explored for both gas and oil.

If the demand forecast for natural gas is to be met (Figure A-58), it will be necessary to import gas from the USSR. By 1980, the total would have to be about 10 billion cubic meters, and by 1990, as much as 30 billion cubic meters. If Romania's energy requirements are to be satisfied in the manner forecast by SRI, the decision to continue relying heavily on natural gas for its primary energy needs or to shift more to oil and coal will have to be made in the relatively near term. To the extent that the country does not import gas from the USSR, there will probably be greater reliance on oil.

The thermal electric power sector and the industrial sector together consumed about 17.5 billion cubic meters of natural gas in 1971. This was about 80 percent of total consumption, and it is typical of the pattern of gas use in the country for the past several years. The next largest consuming sector was petrochemicals, and this industry took 2.0 billion cubic meters in 1971, or between 8 and 9 percent of total gas use. This same pattern of gas use is anticipated for the forecast period.

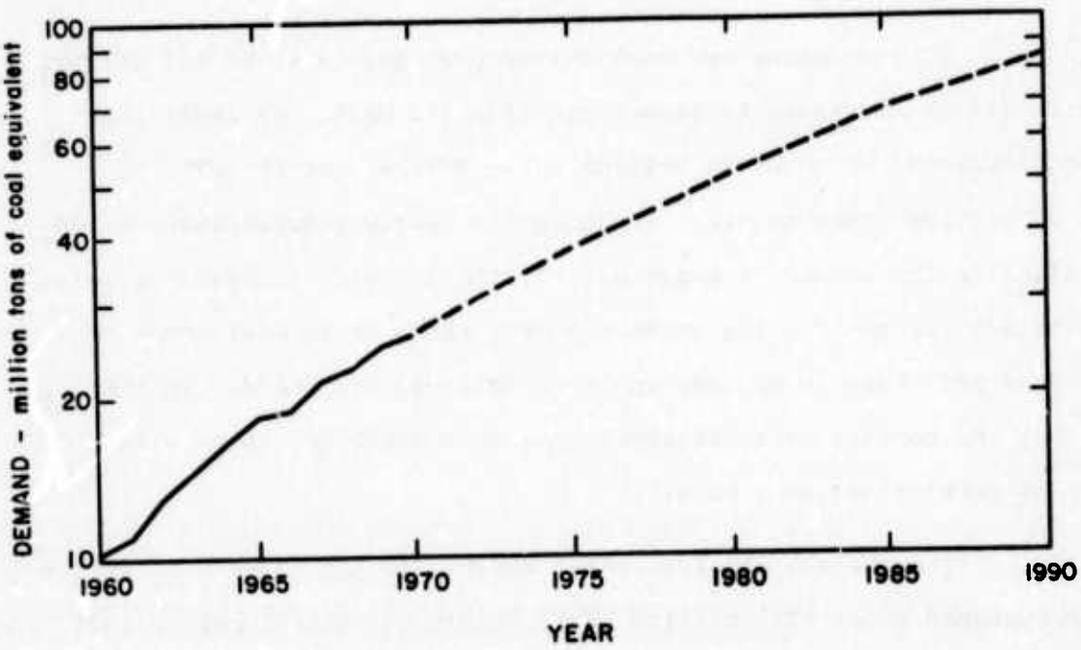

Figure A-58
DEMAND FOR NATURAL GAS--ROMANIA

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Source AFSCR 23-50, 11 May 70