DOE/RA/50211-T2

COAL SUPPLY/DEMAND, 1980–2000

Final Review Draft

Task 3-Resources Applications Industrialization System Data Base

By
William M. Fournier
Vaswati Hasson

October 10, 1980

Work Performed Under Contract No. AC01-80RA50211

TRW Energy Systems Planning Division
McLean, Virginia

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Prepared for the
Office of Energy Supply Transportation
Assistant Secretary Resource Applications

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EXECUTIVE SUMMARY

This report is a compilation of data and forecasts resulting from an analysis of the coal market and the factors influencing supply and demand. The analyses performed for the forecasts were made on an end-use-sector basis. The sectors analyzed are electric utility, industry demand for steam coal, industry demand for metallurgical coal, residential/commercial, coal demand for synfuel production, and exports.

The purpose of the report is to provide coal production and consumption forecasts that can be used to perform detailed, railroad company-specific coal transportation analyses. To make the data applicable for the subsequent transportation analyses, the forecasts have been made for each end-use sector on a regional basis. The supply regions are: Appalachia, East Interior, West Interior and Gulf, Northern Great Plains, and Mountain. The demand regions are the same as the nine Census Bureau regions. These regions are shown in Figures 1 and 2 in the Appendix.

Coal production and consumption in the United States are projected to increase dramatically in the next 20 years. This will occur due to increasing requirements for energy in the United States and the unavailability of other sources of energy to supply a substantial portion of this increase. Historically, oil and natural gas have supplied most of the increase in energy demand (see Figure 1), but it appears that world production of oil is becoming resource-limited. New finds of oil and gas are not keeping up with the increasing demand. Other sources of energy, such as nuclear, hydropower, geothermal, solar, etc., are not expected to be able to supply a major portion of the incremental energy demands within the time frame of this study (1980-2000). Coal comprises 85 percent of the U.S. recoverable fossil energy reserves and could be mined to supply the increasing energy demands of the U.S.

Oil competes with coal as a major source of energy. Enhanced coal utilization is considered to be one of the ways of mitigating the current energy/oil crisis. Because of this, three scenarios were constructed to test the effect of changes in the availability of oil. The baseline scenario has been constructed to be the "most likely scenario." In this scenario, it is assumed that oil will continue to be available from the

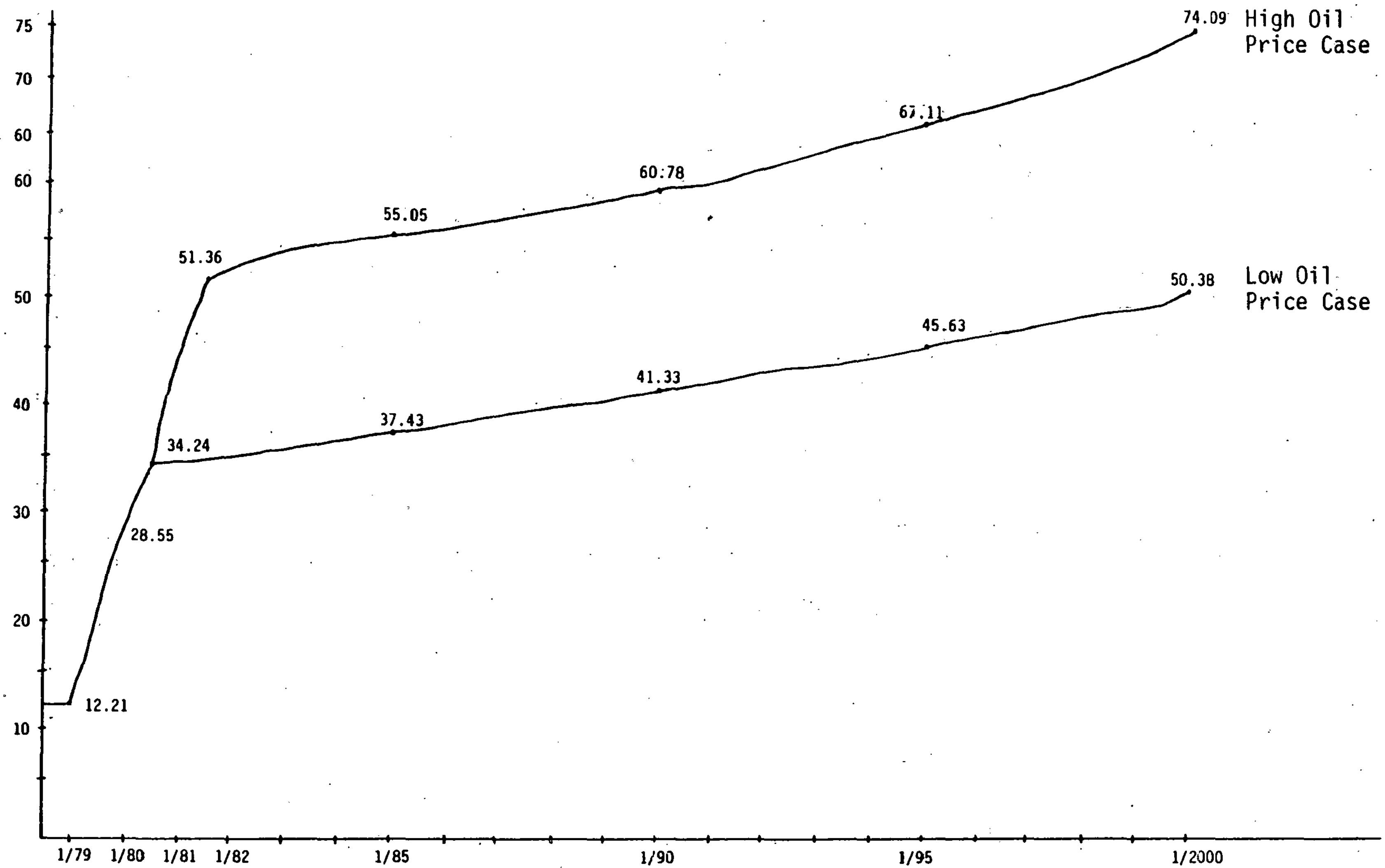
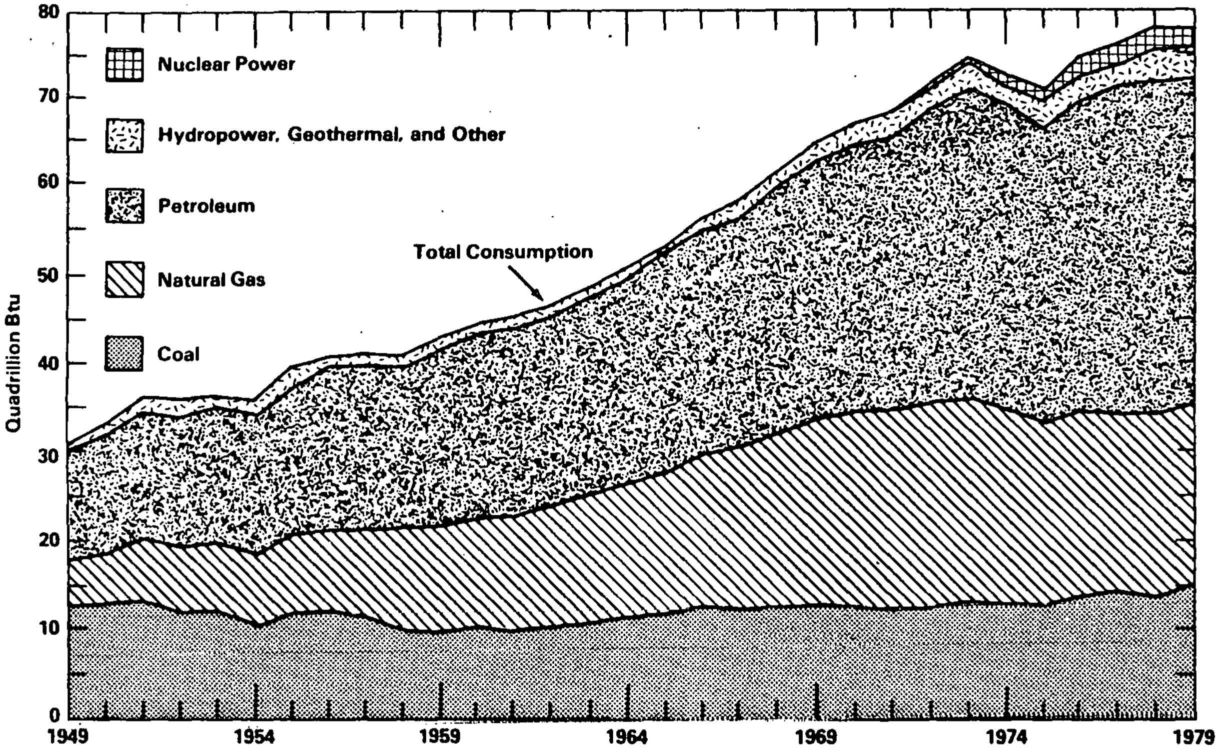


Figure 1. World Oil Price Projection - Baseline Scenario
(well head price - 1980 dollars per barrel)

current oil exporting countries at ever increasing real cost. Two cost levels are assumed to show the effect of different prices of world oil (see Figure 2).



Source: DOE/EIA, 1979 Annual Report to Congress

Figure 2. Consumption of Energy by Type

The low oil cost case is similar to the prices used in the DOE Energy Information Administration 1979 Annual Report to Congress for its middle world oil price scenario. Most of the analysis for the baseline scenario is performed for the low oil price case and the sensitivity of the forecast to the high oil price case is analyzed.

Table 1 shows a comparison of the results of the baseline scenario with other forecasts. The baseline scenario forecast of total coal consumption is at the high end of the range of the other forecasts. However, the range of all of the forecasts in any one year is less than 20 percent. The synfuel and industrial end-use sector forecasts appear to be

Table 1. Comparison of Forecasts of U.S. Coal Production
(millions of short tons)

	Forecast														
	Baseline Scenario Low Oil Price				EIA			LPDO			NCA		WOCOL		
End-Use Sector	1985	1990	1995	2000	1985	1990	1995	1985	1990	1995	1985	1990	1985	1990	2000
Electric Utility	731	894	1096	1347	737	884	1115	667	906	1080	733	959	617	825	1290
Industrial	147	213	278	346	-	-	-	111	159	233					
Residential/ Commercial	10	10	10	0	-	-	-	14	13	11					
Total R/C & Industrial	157	223	288	356	223	248	280	125	172	244	97	125	88	124	243
Metallurgical	77	77	77	77	74	78	79	74	78	76	75	75	94	99	121
Synfuels	14	109	178	302	12	27	101	15	113	184	0	1	0	6	221
Export	80	100	143	176	85	108	143	82	103	135	74	89	88	132	221
Total	1054	1413	1782	2258	1130	1343	1715	963	1372	1718	976	1260	887	1185	2095

EIA: Energy Information Administration—Preliminary 1985, 1990, 1995 Energy Forecasts for the Annual Report to Congress, 1979
LPDO: DOE/Leasing Policy Development Office, Preliminary National and Regional Coal Production Goals, for 1985, 1990, and 1995, July 24, 1980
NCA: National Coal Association - NCA Economics Committee, Long Term Forecast, February 22, 1980
WOCOL: Coal-Bridge to the Future, Report of the World Coal Study 1980

higher than most of the other forecasts. The synfuel forecast assumes that in the year 2000 coal-derived synfuels would equal 1.7 MMBDOE. This appears to be similar to the trend forecasted by the Leasing Policy Development Office (LPDO) and is about one-half of the goal set by the Energy Security Act (S930). The major reason for the high industry coal consumption forecast is the assumption that all boilers to be installed in new plants will be coal-fired.

The second scenario, low oil supply, assumes that an embargo by the Arab OPEC countries will be imposed during 1985 which would last for two years. All exports to the U.S. and western countries are embargoed. In the high oil supply scenario sufficient new oil fields are assumed to be discovered which will make the oil market competitive. These new oil discoveries will be spread over the world such that a new oil cartel could not be formed.

The results of the analyses for all of the scenarios show that coal production and consumption will increase dramatically in the next 20 years. Coal consumption (including exports) in the U.S. is projected to increase by 5 to 6 percent per year. Total U.S. energy consumption is projected to increase between 1 to 2 percent per year. Therefore a greater percentage of the energy consumed in the U.S. will be supplied by coal.

Table 2 shows the projections of regional coal supply for the baseline scenario low oil price case. Total coal production triples between 1979 and 2000. Western coal production in 2000 is 4.8 times the 1979 production with total tonnage increasing more in the Northern Great Plains region than in any other region. However, eastern coal production remains larger than the West with 53 percent total coal production. Table 3 shows coal demand by region and Table 4 shows the coal flow from production region to demand region. The amount of western coal consumed in the East rises from 35 million short tons in 1979 to 86 million short tons in 2000. Eastern coal consumed in the West increases from 19 million in 1979 to 54 million in 2000. This shows that coal produced in the West is consumed mainly west of the Mississippi River and eastern coal stays east.

Table 2. U.S. Regional Coal Supply - Low Oil Price
(millions of short tons)

Supply Region	1979	1985	1990	1995	2000
Appalachia	412.3	506	620	728	862
East Interior	130.0	182	225	275	337
West Interior and Gulf	40.1	68	98	133	178
Northern Great Plains	124.9	206	338	464	641
Mountain	55.2	93	132	182	241
Total	762.5	1,055	1,413	1,781	2,258

The main sensitivity analysis performed in the baseline scenario for each of the end-use sectors focuses the effect of the high oil price shown in Figure 1. Table 5 is a comparison of the end-use-sector forecasts for the low and high oil price cases.

Total coal consumption in the high oil price case increases only slightly over the low oil price case. The synfuel sector is the only sector showing a significant increase (approximately 10 percent) in coal consumption. The difference in coal consumed by the utility and industrial sectors between the low and high oil cases is due to the amount of coal that is substituted for oil and gas. In the low oil price case, the price of oil is high enough to cause conversion to coal where it can now be easily accomplished. However, the price differential between the low and high oil price cases is assumed to be too low to motivate the utilities and industry to overcome environmental and technological problems of converting to coal. However, the high oil price does make a small amount of conversion financially possible for some utilities and industries where the low oil price does not.

Table 3. U.S. Regional Coal Demand - Low Oil Price
(millions of short tons)

Demand Region	1979	1985	1990	1995	2000
New England	1.2	2	2	3	3
Mid Atlantic	79.9	98	126	145	171
South Atlantic	150.0	183	225	266	317
East North Central	235.4	307	364	440	531
East South Central	90.5	115	142	172	209
West North Central	80.7	126	177	228	301
West South Central	49.6	113	193	272	372
Mountain	66.2	100	156	210	290
Pacific	8.6	11	28	46	64
Total	762.1	1,055	1,413	1,781	2,258

Table 4. U.S. Coal Consumption and Distribution - Low Oil Price (thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1985			
New England	2,024	2,024				
Mid Atlantic	98,254	98,221	32		1	
South Atlantic	182,945	172,500	10,412	33		
East North Central	307,431	153,601	109,266	227	37,102	7,235
East South Central	114,743	74,367	38,089	83	1,534	670
West North Central	125,553	1,956	21,796	10,379	74,169	17,253
West South Central	112,792	2,855	2,255	56,556	47,997	3,149
Mountain	99,491			589	39,047	59,855
Pacific	11,311	20	3	24	6,148	5,116
Total	1,054,544	505,544	181,853	67,871	205,998	93,278
			1990			
New England	2,324	2,324				
Mid Atlantic	126,312	126,260	46		6	
South Atlantic	224,471	213,325	11,203	33		
East North Central	364,359	169,369	141,160	327	42,471	11,032
East South Central	141,740	96,369	41,859	105	2,679	728
West North Central	176,514	2,356	23,796	10,779	120,131	19,452
West South Central	192,489	9,855	7,218	86,001	85,612	3,803
Mountain	156,209			589	71,149	84,471
Pacific	28,445	20	3	24	15,639	12,749
Total	1,412,863	619,788	225,285	97,858	337,687	132,245

Table 4. U.S. Coal Consumption and Distribution - Low Oil Price (Continued)
(thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	2,624	2,624				
Mid Atlantic	144,699	144,628	60		11	
South Atlantic	265,687	253,547	12,107	33		
East North Central	440,244	204,325	170,819	427	49,012	15,661
East South Central	171,610	112,738	53,986	127	4,089	670
West North Central	227,742	2,756	25,796	11,179	165,945	22,066
West South Central	272,264	6,955	12,219	120,785	127,846	4,559
Mountain	210,298			589	81,318	118,391
Pacific	46,062	20	3	24	25,243	20,772
Total	1,781,230	727,493	274,990	133,164	463,464	182,119
			2000			
New England	2,884	2,884				
Mid Atlantic	171,364	171,272	80		12	
South Atlantic	317,030	303,895	13,102	33		
East North Central	530,622	239,914	211,701	517	57,163	21,327
East South Central	209,021	137,253	65,099	147	5,851	671
West North Central	300,863	3,216	27,876	11,549	233,048	25,174
West South Central	371,937	3,855	18,770	164,812	178,884	5,616
Mountain	290,291			589	130,813	158,889
Pacific	64,333	20	3	24	34,998	29,288
Total	2,258,345	862,309	336,631	177,671	640,769	240,965

Table 5. U.S. Coal Consumption
(millions of short tons)

End-Use Sector	1979	1985		1990		1995		2000	
		L	H	L	H	L	H	L	H
Electric Utility	529	731	735	894	899	1,096	1,121	1,347	1,377
Industry	66	147	147	213	225	278	290	346	358
Residential/ Commercial	9	10	10	10	10	10	10	10	10
Metallurgical	77	77	77	77	77	77	77	77	77
Synthetics	0	14	14	109	114	178	191	302	332
Export	65	80	--	100	110	143	143	176	176
Total	746	1,054	1,054	1,413	1,435	1,782	1,832	2,258	2,330

L - Low Oil Price

H - High Oil Price

Additional sensitivity analyses were performed which are presented in Section 2. One analysis of particular importance was performed for the industrial sector. It was assumed that all new industrial plants would use coal in 100 percent of their boiler applications. The Power Plant and Industrial Fuel Use Act of 1978 requires that all new boilers in major fuel-burning installations use coal or other alternative fuels. A study conducted by the American Boiler Manufacturers Association, about two years prior to the Fuel Use Act, indicated that by 1986, 80 percent of the industrial boilers to be sold would be coal-fired. However, this study also showed that the 1972-1976 trend of purchases of industrial coal-fired boilers was 10 percent of new boiler sales. If this trend were to continue, industrial coal consumption in the year 2000 would be 45 percent less than if all new industrial boilers were coal-fired. Table 6 shows the results of the sensitivity analysis that was performed by changing the market share of new boilers that would be coal-fired.

Table 6. Industrial Coal Consumption
(millions of short tons)

Market Share of New Coal-Fired Boilers	1985	1990	1995	2000
10	103	133	162	192
30	113	150	187	226
50	124	170	215	263
80	138	196	253	313
100	147	213	278	346

The results of the analyses performed for each scenario are presented by end-use sector in Table 7. In all three scenarios, the total coal consumed in the year 2000 is approximately three times the amount in 1979. Even when oil is plentiful in the high oil supply scenario, coal consumption nearly triples. The economic activity in the high oil supply scenario is assumed to be higher than either of the other two scenarios. This increase in GNP would bring about a higher total consumption of energy. Therefore, even if the amount of coal consumed in the high oil supply scenario is almost as much as the other scenario, the ratio of coal to total energy consumption is lower in the high oil supply scenario.

Table 7. End-Use Sector Coal Consumption
(millions of short tons)

Scenario	Year	Electric Utility	Industry	Residential/ Commercial	Metal- lurgical	Synfuels	Export	Total
Baseline (Low Oil Price)	1979	528.8	65.5	9.1	77.1	--	66.3	747.2
	1985	731	147	10	77	14	75	1055
	1990	895	213	10	77	109	110	1413
	1995	1096	278	10	77	178	143	1781
	2000	1347	346	10	77	302	176	2258
(High Oil Price)	1985	734	147	10	77	14	75	1055
	1990	899	225	10	77	114	110	1435
	1995	1121	290	10	77	191	143	1832
	2000	1378	358	10	77	332	176	2330
Constrained Oil Supply	1985	731	147	10	77	14	75	1055
	1990	787	176	10	62	169	83	1286
	1995	927	295	10	77	335	143	1787
	2000	1040	414	10	77	586	220	2347
High Oil Supply	1985	731	147	10	77	14	75	1055
	1990	833	221	9	77	0	56	1196
	1995	1065	315	9	77	0	56	1521
	2000	1448	395	9	77	0	56	1985

In all of the scenarios the electric utility sector continues to consume more coal than any other sector. Only in the constrained oil scenario does the combined nonutility sector consumption equal more than the utility sector. This is due mainly to the increased use of coal for synfuel production and the reduced electricity demand which reduces utility coal consumption.

The export and synfuel sectors exhibit the most change for the different scenarios. In the constrained oil scenario synfuels become a substitute for the highly priced oil, thereby, creating a high demand for coal. Synfuels are no longer competitive or necessary for national security in the high oil supply scenario causing coal consumption for synfuels to cease. Exports in this scenario also decrease due to a worldwide reduction in the need for coal.

The amount of coal supplied by each region for each of the scenarios is shown in Table 8. Coal production increases in all regions. Eastern coal production is higher than the West through 2000. However, in the baseline scenario, by 2000 the West produces 47 percent of total coal, whereas, in 1979 the West produced only 29 percent of the U.S. supply of coal. The Northern Great Plains region is the source of most of the increased western production. In the constrained oil supply scenario the regional share of coal supply does not change significantly. However, in the high oil supply scenario the West supplies 43 percent of U.S. coal. The percentage increase in western coal production is still much greater than eastern coal (290 percent western, 107 percent eastern).

Table 9 shows the demand for coal for each of the scenarios. In the constrained oil supply scenario, even though the total coal demand is lower than the baseline, some of the regions consume more coal. This is due to the fact that the supply of energy for these regions is mainly oil and gas and they are close to the coal supply regions. In the high oil supply scenario coal consumption is reduced in all regions except in the New England and East North Central regions. The additional coal consumption in these regions is due mainly to the higher level of industrial activity. A large portion of the higher utility demand in this region is supplied from the Northern Great Plains region. However, less than 10 percent of the eastern demand for coal is supplied by the West.

Table 8. Coal Supply
(millions of short tons)

Scenario	Year	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain	Total
Baseline (Low Oil Price)	1979	412.3	130.0	40.1	124.9	55.2	762.5
	1985	506	182	68	206	93	1055
	1990	620	225	98	338	132	1413
	1995	728	275	133	465	182	1781
	2000	862	337	178	641	241	2258
Constrained Oil Supply	1985	506	182	68	206	93	1055
	1990	549	207	114	307	110	1286
	1995	698	267	169	470	182	1787
	2000	881	366	223	635	241	2347
High Oil Supply	1985	506	182	68	206	93	1055
	1990	565	201	80	241	108	1196
	1995	697	237	84	357	146	1521
	2000	840	283	137	525	200	1985

By the year 2000 significant growth in coal flows should occur along the following corridors:

- Appalachia
  - Mid Atlantic
  - South Atlantic
- East Interior
  - East North Central
- Northern Great Plains
  - East North Central
  - West North Central
  - West South Central
  - Mountain

The additional traffic demands by 1985 may be met by the railways by way of improved signalization, shorter block sections, centralized traffic control, and other modernization methods without providing for heavy line capacity works. By 2000 the incremental traffic on some of the corridors mentioned above, is projected to increase very significantly and is likely to call for special line capacity works involving heavy investment.

Table 9. Coal Demand
(millions of short tons)

Scenario	Year	New England	Mid Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Mountain	Pacific	Total
Baseline (Low Oil Price)	1979	1.2	79.9	150.0	235.4	90.5	80.7	49.6	66.2	8.6	762.1
	1985	2	98	183	307	115	126	113	100	11	1055
	1990	2	126	225	364	142	177	193	156	28	1413
	1995	3	145	266	440	172	228	272	210	46	1781
	2000	3	171	317	531	209	301	372	290	64	2258
Constrained Oil Supply	1985	2	98	183	307	115	126	113	100	11	1055
	1990	2	108	203	325	128	158	199	152	12	1287
	1995	2	139	263	392	170	224	314	239	45	1787
	2000	3	169	343	509	212	297	415	336	63	2347
High Oil Supply	1985	2	98	183	307	115	125	113	100	11	1055
	1990	2	112	204	345	129	142	139	111	12	1197
	1995	3	134	240	438	157	193	190	149	16	1521
	2000	3	164	288	532	196	265	312	205	21	1985

Transportation of the amount of coal in all scenarios could be constrained if sufficient transportation capacity is not built by 2000. This capacity expansion would require large capital investments. The difficulties associated with increasing coal hauling capacity are not physical or technological. The financial health of the railroad companies, in light of current and future capacity requirement, will have to be studied to determine if this amount of coal can be brought to market.

1.0 INTRODUCTION

This report has been prepared in response to a request by the Department of Energy Office of Energy Supply Transportation. The report provides data and forecasts on coal supply and demand. These forecasts will be used by the Office of Energy Supply Transportation to perform detailed, railroad company specific coal transportation analyses. To make the data applicable for the subsequent transportation analyses, the forecasts have been made on a regional basis. The supply regions are: Appalachia, East Interior, West Interior and Gulf, Northern Great Plains, and Mountain. The demand regions are the same as the Census Bureau regions. The supply and demand regions are shown in Figures 1 and 2 in the Appendix.

The analyses performed for the forecasts were made on an end-use sector basis. Because the coal resource base in the United States is very large it was assumed that competition between the end-use sectors for coal supplies is negligible. Present coal production capacity is 13 to 25 percent above present demand. The no-competition assumption, therefore, simplifies the analysis because the forecasted demands for each sector can be added to arrive at total demand.

The end-use sectors analyzed were the electric utility, industry demand for steam coal, industry demand for metallurgical coal, residential/commercial, coal demand for synfuel production, and exports. Historical data and specific assumptions concerning the future use of coal by each end-use sector were used to forecast the consumption and the origin of the coal to be consumed. The data and assumptions are discussed in detail for each of the sectors.

Oil is one of the major sources of energy which competes with coal. Enhanced coal utilization is considered to be one of the ways of mitigating the current "energy/oil crisis." Because of this, three scenarios were constructed to test the effect of changes in the availability of oil. The baseline scenario has been constructed to be the "most likely scenario." In this scenario, it is assumed that oil will continue to be available from the current oil-exporting countries at ever increasing real cost. Two cost levels are assumed to show the effect of different prices of world oil.

The low oil cost case is similar to the prices used in the DOE Energy Information Administration 1979 Annual Report to Congress for its middle world oil price scenario. Most of the analysis for the baseline scenario is performed for the low oil price case and the sensitivity of the forecast to the high oil price case is analyzed.

The low oil supply scenario assumes that an embargo by the Arab OPEC countries will be imposed during 1985 and will last for two years. All exports to the U.S. and western countries will be embargoed. In the high oil supply scenario sufficient new oil fields are assumed to be discovered which will make the oil market competitive. These new oil discoveries will be spread over the world such that a new oil cartel could not be formed.

The final step in the analysis of the forecast of the coal flow from supply region to demand region was the performance of a transportation analysis.

This analysis entailed the comparison of forecasted transportation capacity to move coal with the baseline scenario forecast of coal supply/demand. This analysis was not performed in detail but provides an indication that the coal consumed in the baseline scenario could be transported if sufficient capital were available for increasing coal transportation capacity.

2.0 BASELINE SCENARIO

The continuing energy problems encountered by the U.S. stem from the supply, availability, and cost of liquid fuels. In 1979, the U.S. imported approximately 44 percent of its total petroleum needs. The Organization of Petroleum Exporting Countries (OPEC) supplied 29 percent of the total demand of 18.86 million barrels per day. Since the oil embargo of 1973-1974, OPEC has dictated the price of world oil, which has caused a significant cost increase. Table 2.0-1 shows the delivered cost of oil imported by the U.S.

Table 2.0-1. Delivered Cost of Imported Oil
(current dollars per barrel)

January 1973	4.15
December 1974	12.45
December 1978	14.03
March 1980	32.14

Source: DOE/EIA, 1979 Annual Report to Congress, June 1980
FEA, Monthly Energy Review, January 1976

Coal will have a critical role in meeting U.S. energy demand. It comprises 85 percent of U.S. recoverable fossil energy reserves and in 1977, U.S. coal consumption was 19 percent of total domestic energy supply. Because it is more difficult to transport and has a greater environmental impact, its use is a less attractive alternative to oil. However, if the oil supply is constrained or the cost differential between coal and oil becomes excessive, coal will be substituted for oil wherever possible.

Many factors impact the use of energy. The costs of various fuels influence which will be used and in what amount. Changes in technology and governmental regulation also effect energy usage. Assumptions concerning the future trend of these factors as well as those effecting the end-use consumption of coal are discussed in the next section.

2.1 ASSUMPTIONS

World oil cost projections have a high uncertainty because of the difficulty in forecasting OPEC courses of action. The range of world oil prices used in the baseline scenario is shown in Table 2.1-1.

Table 2.1-1. World Oil Price Projections - Baseline Scenario (wellhead price - 1980 dollars per barrel)

	Low	High
January 1979	12.21	12.21
January 1980	28.55	28.55
July 1980	34.24	34.24
January 1985	37.43	55.05
January 1990	41.33	60.78
January 1995	45.63	67.11
January 2000	50.38	74.09

Both world oil price cases assume that there will be no new political disturbance in the Middle East (i.e., war with Israel or overthrow of Saudi government, etc.). The low-price case assumes only a small real price increase of 2 percent annually throughout the forecast period. A survey* of industrial managers was performed which uncovered two views on future world oil prices. One group assumed that oil prices would be held to a level moderately increasing above inflation (2 percent real increase annually). This is based on the need for world economic stability and the potential for increasing non-OPEC production (alternate fuels and synfuels are starting to become competitive with world oil). The other group assumed that recent events will continue, resulting in massive price increases. The baseline scenario high-price case assumes a 50 percent real increase in the July 1980 price within the next year. Annual price increases are then held to 2 percent above inflation through 2000. The 50 percent increase is assumed to be a level at which alternatives to natural supplies of oil will be available in quantities sufficient to significantly decrease the demand for imported oil. Figure 2.1-1 shows the range of prices for the low- and high-price cases.

The low-price case is similar to the DOE Energy Information Agency (EIA) Medium-Oil-Price Case in the 1979 Annual Report to Congress (1979 ARC). The baseline scenario high-price case is approximately 30 percent higher in the 1981-1990 time frame than the EIA high-price case. By 1995 these two oil price projections are only 7 percent apart.

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*Assistant Secretary for Resource Applications, Analysis of Industrial Markets for Low- and Medium-Btu Coal Gasification, July 30, 1979.

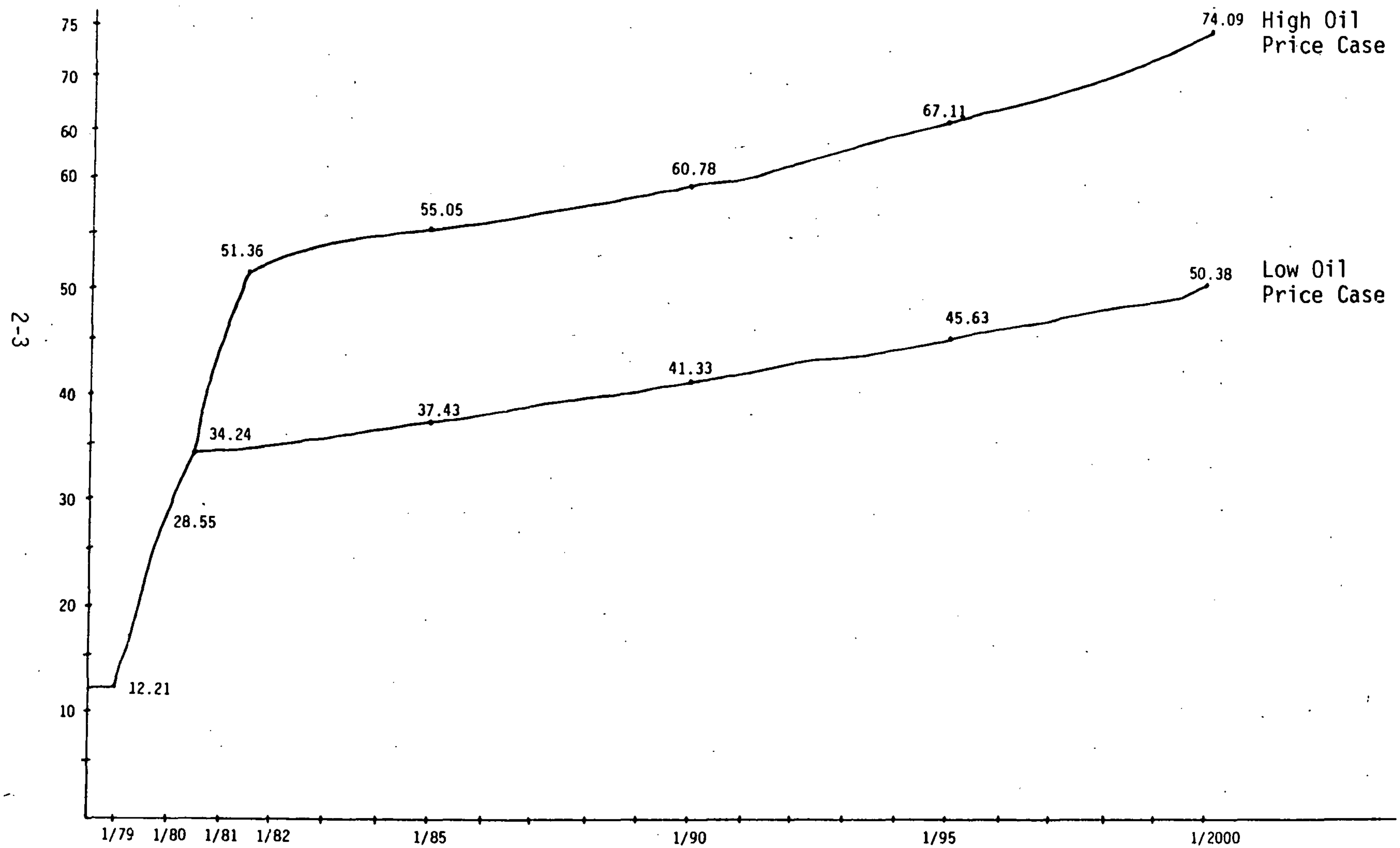


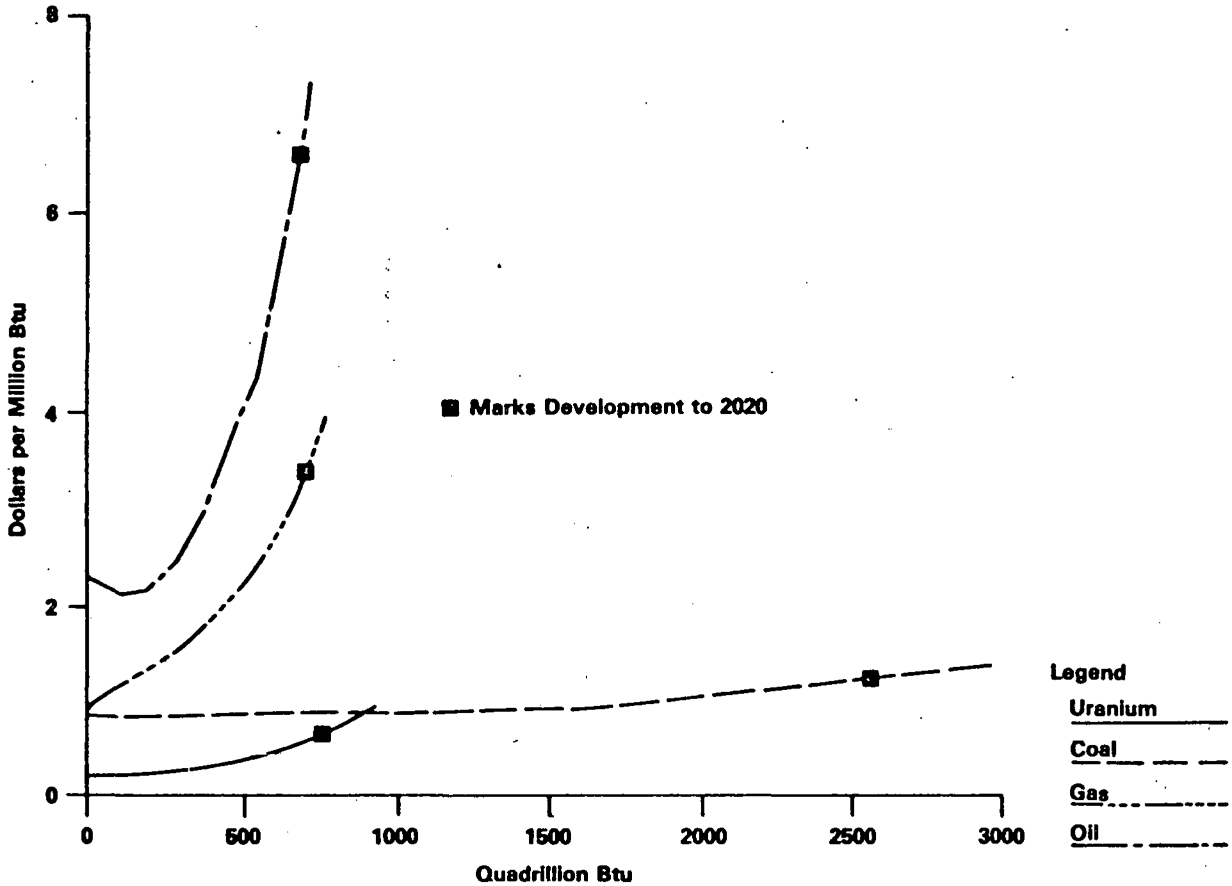
Figure 2.1-1. World Oil Price Projection - Baseline Scenario
(well head price - 1980 dollars per barrel)

Figure 2.1-2 shows an EIA estimate of the production costs of oil, natural gas, uranium, and coal. The supply curves represent the marginal cost per million Btu of production associated with each quadrillion Btu of additional resources committed to production. Lower cost resources are assumed to be developed first. When a mine is opened, the entire future production of that mine is assumed to be committed. The horizontal scale represents the cumulative commitments of a resource in quadrillion Btu from 1975 to some future date. As can be seen from these curves, the cost of production for coal does not increase appreciably. The 1978 production of coal was equal to 15 quadrillion Btu. It is assumed that there will be sufficient coal production capacity to meet demand and that the market will be in equilibrium. The price of coal, therefore, will be at the marginal mine cost, and coal supply will meet demand without a substantial increase in the real price of coal.

Because the cost of coal will not increase as rapidly as the world price of oil, its share of total energy consumption will increase. U.S. coal production and consumption are impacted by physical, technological, political, and economic factors, which are considered in the projection of coal consumption for each of the end-use sectors (electric utility, industry, residential/commercial, metallurgical, synfuels, and export). The assumptions on these factors for the end-use sectors are discussed below. Each end-use sector analysis will be based on the low world oil price case. The sensitivity of coal consumption to higher oil prices will be studied. This is similar to the analysis presented in the 1979 ARC.

Electric Utility

The total primary energy use by electric utilities is dependent mainly on demand for electricity and efficiency (heat rate) of the generating unit. Except for new technologies, the heat rate for new, conventional generating units is assumed to not differ significantly from equivalent existing plants. Therefore, a change in primary energy use would depend upon change in the load growth. The electric utility load growth prior to the 1973 oil embargo was approximately double the 3.5 percent growth rate experienced since 1973. The growth rate experienced during 1979 was only 1.9 percent. The load growth projected in the 1979 Annual Report to



Source: DOE/EIA, 1979 Annual Report to Congress

Figure 2.1-2. Prices of Primary Resources Increase with Cumulative Development (1979 dollars)

Congress is 3.2 percent annually through 1995. A growth rate lower than 3.5 percent appears reasonable due to the higher cost of fuel and the increasing cost of new power plants, which increase the cost of electricity. The 3.2 percent load growth, therefore, is assumed for the baseline scenario.

The utility's decision on the type of fuel to be consumed by generating capacity additions is based on the following factors:

- Type of generating capacity (base-load, intermediate, peaking)
- Economics

- Availability and assurance of fuel supply
- Government regulation (Fuel Use Act, nuclear power plant licensing, Clean Air and Clean Water Acts)

New base-load generating capacity is assumed to be coal or nuclear units except for those oil units which are under construction. New intermediate and peaking units can receive a permanent exemption from the Power Plant and Industrial Fuel Use Act of 1978 (PIFUA) to burn oil or natural gas. These units will have to be designed for utilization of coal liquids or gases as an alternative.

For existing plants PIFUA requires oil- and gas-burning units that previously burned coal to convert back to coal. Between 1965 and 1972 approximately 29,000 MW of coal-fired capacity was converted to oil, much of which could be converted back. It is assumed that the "oil back-out bill" (Power Plant Fuel Conservation Act of 1980) is passed and that 20,000 MW of converted capacity will convert back to coal by 1990.

Natural gas consumption will decline through the forecast period but will not be eliminated by 1990 as specified in the PIFUA. The gas power plants are assumed to receive permanent exemptions or the PIFUA is amended to allow gas consumption in existing plants.

Nuclear capacity additions that come on line through 1992 are assumed to be limited to those units which have already received construction licenses. After 1992 the growth in capacity is assumed to be very slow with the majority of the increase occurring in the later part of the 1992-2000 time frame. It is assumed that by 1985 regulatory problems with licensing and operating nuclear power plants will be solved. The installation time for a nuclear power plant will decrease to 10 years instead of the current 12-to-14-year lead time.

Industry

The PIFUA requires major fuel-burning installations to convert to coal if they are capable of using coal without substantial physical modification of the unit and if it is financially feasible to use coal or other alternate fuels. Exemptions can be obtained if there is a lack of alternate fuel, a site limitation, or an environmental constraint. Industrial plants that have always used oil and gas are assumed to be able to obtain permanent exemptions. It is assumed that the coal-capable plants also will be able to obtain permanent exemption. However, some industrial plants have switched to coal and it is assumed that there will be a small number of conversions through 1985.

New industrial plants are required by PIFUA to utilize coal or alternate fuel in all boiler applications. These new plants will tend to use coal, coal-derived fuels, and electricity instead of oil and gas. Where it is technically and environmentally feasible, industrial plants will utilize coal in both boiler and process heat applications. All new plants are assumed to use coal for boilers.

Residential/Commercial

Annual residential/commercial (R/C) and transportation use of coal has been under 10 million tons for the past 8 years. Coal consumption in this sector is assumed to remain very small (1 to 2 percent of total consumption). It also is assumed that the coal will be consumed in the same region in which it is produced.

Metallurgical

Metallurgical coal is used to make coke which is used in the production of steel. Coke consumption per unit of steel produced has decreased over the past decade and will continue to decline at a slower rate because of an increased expansion of continuous casting and electric furnace capacity and a decline in the amount of coke used per ton of steel produced. Metallurgical steel consumption will then increase at a lower rate than steel output. Because of an overall increase in international coal consumption, U.S. production of coke will become more competitive with imported coke and imports will not increase substantially.

Synfuels

Projections for coal-derived synfuels vary widely. The President's goal approximates the upper bound of these projections. If the goal of the daily production of 1.0 to 1.5 million barrels of coal liquids and gases were to be achieved by 1992, an additional 200 to 300 million tons of coal would be consumed. Approximately 80 to 90 percent of the synfuels produced will occur in the West and will utilize western coal. Western coal production was 216 million tons in 1979. Synfuel production based on coal will begin with high- and medium-Btu gas and methanol. Indirect coal liquefaction will produce coal liquids after 1985 with direct liquefaction producing syncrude in the latter part of the forecast time frame.

Environmental laws will not present an insurmountable obstacle to synfuel production but may delay the operation of a synfuel plant.

Export

In 1979 coal export equalled 65 million tons and the potential for increase is very high. Coal can be used as a frequent and increasingly more economical alternative to oil. The marginal cost of producing U.S. coal does not increase as rapidly as does foreign coal due to the large domestic resource base. However, increases in the cost of transportation and capacity limits of port facilities may present a constraint to its use.

Metallurgical coal exports will not increase as much as steam coal.

2.2 USE SECTOR ANALYSIS

This section contains detailed descriptions of the analyses performed and the coal demand forecasted for each of the end-use sectors. The relationships between energy and technical requirements, fuel use, cost, and regulation used for projecting coal demand are shown. The use sectors analyzed are: utility, industry, residential/commercial, metallurgical, synthetics, and export.

The analysis for coal demand in the utility sector is based on the electric utilities in the contiguous 48 states. No coal is produced or consumed in Hawaii, and of the less than 1 million tons produced in Alaska in 1979, none was used in the utility sector.

Industrial coal consumption can be classified as either metallurgical or other industry. Metallurgical coal is used in plants that produce coke for use of making steel. Metallurgical coal is a high-quality bituminous coal that has a higher cost than the steam coal used in boilers to produce steam for heat or electricity generation. In 1979 the metallurgical coal end-use sector was second only to the utility in coal consumption. Steam coal is the other industrial use for coal and the 1979 industrial demand was approximately 10 percent less than for metallurgical. However, the industry sector has a greater potential than the metallurgical sector for expanding coal use.

Recent coal consumption in the residential/commercial sector has been less than 2 percent of total U.S. coal consumption. Coal use in transportation is included in this sector and, for several years, has been less than 1 million tons per year. Consumption in this sector has not had a significant impact on total supply and demand and is not expected to increase.

Coal consumption forecasts for the production of synthetic gases and liquids have been widely diverse because of insufficient operating experience with the synfuel technologies in the production of high-Btu gas, low-/medium-Btu gas, and coal liquids. The economics, and in some cases, technical feasibility of the technologies have not been proven. Industry surveys performed for high-Btu gas, low-/medium-Btu gas, and methanol from coal and available expertise will be used to forecast synfuel use, and corresponding coal utilization will be calculated.

The export market has been supplied mainly by eastern metallurgical coal. With the advent of high world oil prices, export of U.S. steam coal is becoming an alternative to OPEC oil. The U.S. has export competitors (primarily Poland, Australia, and South Africa) and will have to keep prices competitive. Though the market for export steam coal may increase significantly, U.S. metallurgical coal exports appear to remain steady.

Detailed discussions of forecasts for the end-use sectors follow.

2.2.1 Utility Coal Demand

Background

The electric utility sector produces electricity for sale to its customers or rate payers. Due to the inefficiency and costliness of multiple electric distribution systems in a single district, only one utility provides electricity to a specified service area. Because of the resulting monopoly, utilities are regulated by both state and Federal agencies. Prior to establishment of the Department of Energy (DOE) the Federal Power Commission was empowered to regulate utilities. These duties were transferred to the Federal Energy Regulatory Commission (FERC) which is part of DOE. Each state regulates utilities through its Public Utility Commission (PUC) which is empowered to set consumer rates based on FERC guidelines. This is why the consumer is called the rate payer. The PUC also issues certificates of public convenience and necessity which permit the utility to add new generating capacity, transmission lines, substations, etc.

Since the rate payer does not use a constant amount of electricity throughout the day, the electricity demand (called load) and the amount of electricity will vary. There are three types of load for which the utility must plan: base-load, intermediate or cycling, and peaking. The configuration of a base-load unit is a steam boiler, a steam turbine, and a generator. The unit is designed to generate constant electricity unless there is a very low load or the unit is off-line for maintenance. A cycling unit is designed, however, to supply the swings in load that occur during the high demand periods of each day. This plant can be put on-line from a cold start in a half hour. Peaking plants are used only in cases of extremely high demand, such as in extreme temperatures when all base-load and cycling generation is on-line. The types of generating unit that supply base-load, intermediate, and peaking power are listed in Table 2.2.1-1.

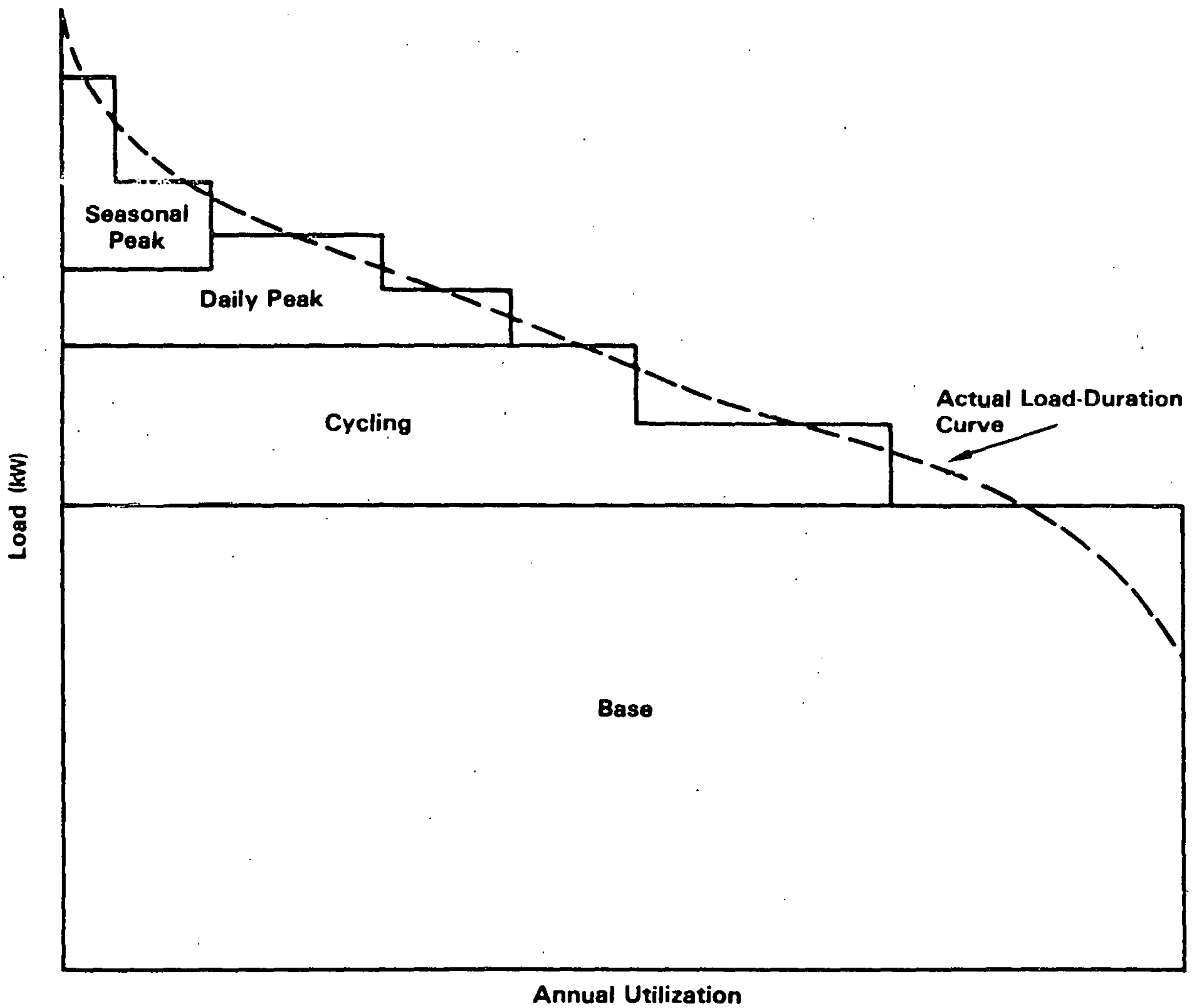
Table 2.2.1-1. Types of Generating Units

Base-load	Intermediate	Peaking
Steam turbine: coal nuclear, oil, gas	Steam turbine: oil, gas	Combustion turbine: oil, gas
Hydroelectric	Combined cycle: oil, gas	Internal combustion: oil
Geothermal	Pumped storage, geothermal	

Coal-fired generation is applicable mainly to base-load, whereas, oil and gas are used for all types of generation. A coal steam turbine generator could be used to supply intermediate load, but operating characteristics of the coal unit versus the oil or gas unit make the oil and gas unit preferable for cycling operation. Due to economic and operating characteristics, combustion turbines and internal combustion are the types of generator best suited for peaking operation.

Base-load generation supplies the majority of electricity produced. Figure 2.2.1-1 shows the relative amounts of each type of generation over one year. Table 2.2.1-2 shows that in the past 30 years, fossil fuel generation has comprised approximately 70 to 80 percent of the total electricity generated. The recent share for fossil fuel has been decreasing as nuclear generation has increased to 11.3 percent of total generation. Coal has provided the majority of the fossil fuel generation, fluctuating between 54 and 71 percent.

The ratio of coal generation to total fossil-generated electricity declined steadily from the late 1960s to 1973, during which time environmental concern strengthened and coal-fired units were encouraged to switch to a cleaner fuel, particularly oil. Between 1966 and 1973 there was a doubling of oil's share of fossil generation. Although domestic consumption was increasing, reserves were fairly stable and increased in 1970 due to discovery of Alaskan oil.



Source: DOE/EIA, 1979 Annual Report to Congress

Figure 2.2.1-1. Representative Electric Utility Load Duration Curve

From October 1973 to mid-March 1974, however, the United States experienced an embargo of oil shipments from the Arab exporting countries. In the previous 25 years, there were 3 occurrences of oil embargos of political origin, but 1973 was the first time that the U.S. was unable to compensate for the supply shortfall by additional domestic production. The amount of oil exported to the United States and other countries was reduced drastically, and simultaneously there was a rapid escalation of world prices for crude oil and petroleum products. Because of the long supply lines from the Middle East to the United States the impact of the embargo was not felt until January. As the embargo entered into 1974, however, the huge increase in oil prices (Figure 2.2.1-2) was followed by increased prices for coal and gas.

Table 2.2.1-2. Electricity Produced by Electric Utility by Fossil Fuels and Other Sources (thousands of GWh)

	Coal		Petroleum		Natural Gas		Total Fossil
	GWh	%	GWh	%	GWh	%	GWh
1950	155	66.2	34	14.5	45	19.2	233
1951	185	68.3	29	10.7	57	21.0	271
1952	195	66.3	30	10.2	69	23.5	294
1953	219	65.0	38	11.3	80	23.7	337
1954	239	65.7	32	8.8	94	25.8	364
1955	301	69.4	37	8.5	95	21.9	434
1956	331	70.9	36	7.5	104	21.8	478
1957	346	71.7	41	8.1	114	22.7	501
1958	344	68.1	40	7.9	120	23.8	505
1959	378	66.1	47	8.2	147	25.7	572
1960	403	66.4	46	7.6	158	26.0	607
1961	422	66.1	47	7.4	169	26.5	638
1962	450	66.0	47	6.9	184	27.0	682
1963	495	66.0	52	7.0	202	27.0	748
1964	526	65.5	57	7.1	220	27.4	803
1965	571	66.6	65	7.6	222	25.9	857
1966	614	65.0	79	8.4	251	26.6	944
1967	631	64.1	89	9.0	265	26.9	985
1968	685	62.6	104	9.5	304	27.8	1,094
1969	706	63.2	138	12.4	333	29.8	1,117
1970	704	56.3	179	14.3	367	29.4	1,250
1971	713	54.6	219	16.8	374	28.6	1,306
1972	771	54.3	273	19.2	376	26.5	1,419
1973	848	56.5	313	20.9	341	22.7	1,501
1974	828	58.6	299	20.6	320	22.1	1,448
1975	853	59.2	289	20.4	300	20.8	1,442
1976	944	60.6	320	20.5	295	18.9	1,559
1977	985	59.7	358	23.3	306	18.6	1,649
1978	976	59.3	365	22.2	305	18.5	1,646
1979	1,075	62.9	304	17.8	330	19.3	1,709

Note: Sum of components may not equal total or 100% due to independent rounding

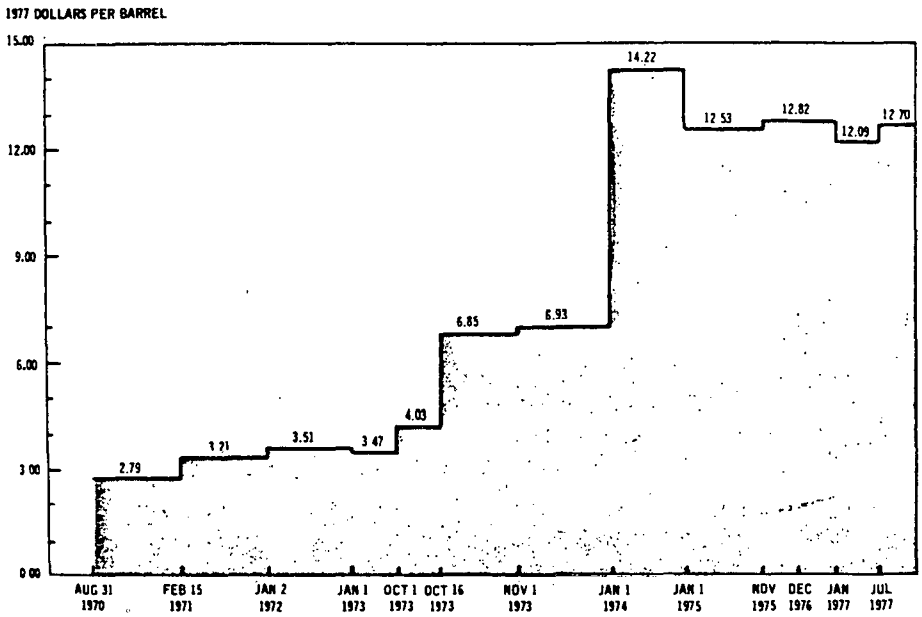
Source: DOE/EIA, 1979 Annual Report to Congress

Table 2.2.1-2. Electricity Produced by Electric Utility by Fossil Fuels and Other Sources (Continued) (thousands of GWh)

	Total Fossil		Hydroelectric		Nuclear		Geothermal & Other		Total Electricity
	GWh	%	GWh	%	GWh	%	GWh	%	
1950	233	70.8	96	29.2	0	--	--	--	329
1951	271	73.0	100	27.0	--	--	--	--	371
1952	294	73.7	105	26.3	--	--	--	--	399
1953	337	76.1	105	23.9	--	--	--	--	443
1954	364	77.1	107	22.9	--	--	--	--	472
1955	434	79.3	113	20.7	--	--	--	--	547
1956	478	79.5	122	20.5	--	--	--	--	601
1957	501	79.3	130	20.7	--	--	--	--	632
1958	505	78.3	140	21.7	--	--	--	--	645
1959	572	80.6	138	19.4	0	--	--	--	710
1960	607	80.6	146	19.4	1	0.1	--	--	753
1961	638	80.6	152	19.2	2	0.3	--	--	792
1962	682	80.0	168	19.7	2	0.2	--	--	852
1963	748	81.6	166	18.1	3	0.3	--	--	917
1964	803	81.6	177	18.0	3	0.3	--	--	984
1965	857	81.2	194	18.4	4	0.4	--	--	1,055
1966	944	82.5	195	17.0	6	0.5	--	--	1,144
1967	985	81.1	222	18.3	8	0.6	--	--	1,214
1968	1,094	82.3	223	16.8	13	1.0	--	--	1,329
1969	1,117	80.9	250	18.1	14	1.0	--	--	1,381
1970	1,250	83.8	247	16.6	22	1.5	1	0.1	1,520
1971	1,306	80.1	266	16.3	38	2.3	1	0.1	1,631
1972	1,419	81.8	273	15.6	54	3.1	2	0.1	1,750
1973	1,501	80.7	272	14.6	83	4.5	2	0.1	1,861
1974	1,448	77.6	301	16.1	114	6.1	3	0.2	1,867
1975	1,442	75.2	300	15.6	173	9.0	3	0.2	1,918
1976	1,559	76.5	248	12.2	191	9.4	4	0.2	2,038
1977	1,649	77.6	221	10.4	251	11.8	4	0.2	2,124
1978	1,646	74.6	280	12.7	276	12.5	3	0.1	2,206
1979	1,709	76.0	280	12.5	255	11.3	4	0.2	2,248

Note: Sum of components may not equal total or 100% due to independent rounding

Source: DOE/EIA, 1979 Annual Report to Congress



* Prices for Saudi Arabian light crude; one barrel equals 42 gallons.
** Prior to 1975, oil prices are designated as "posted" prices; 1975 and after, they are designated "government official" prices; GNP implicit price deflators are used to calculate 1977 dollar prices.

Source: Petroleum Intelligence Weekly

Figure 2.2.1-2. World Oil Prices - "Marker Crude"*
(1977 dollars per barrel)**

In anticipation of the coal miner's strike, utilities began to increase their coal stockpiles by purchasing increasing quantities in the spot market. Consequently, spot prices of coal jumped in late 1974, bringing the average price of coal delivered to the electric utilities to a peak in November 1974. By December the average prices of fuels used by steam-electric plants reached the levels shown in Table 2.2.1-3.

As the cost of fossil fuel for electricity generation increased in 1973-1974, there was a corresponding increase in the cost of electricity to the rate payer. As can be seen in Figure 2.2.1-3 and Table 2.2.1-4, from 1948 to 1973 the cost of electricity decreased in both constant and current dollars, with the exception of the residential sector which experienced an almost level current dollar cost. Simultaneously, the annual growth in

Table 2.2.1-3. Changes in the Average Delivered Fossil Fuel Prices (cents per MM Btu in current dollars)

Fuel Type	January 1973	December 1974	Percent Increase
Coal	37.8	88.9	135.2
Oil	67.0	204.6	205.4
Gas	29.9	55.0	83.9
Total	43.5	114.8	163.9

Source: Annual Summary of Cost and Quality of Steam-Electric Plant Fuels, 1973 and 1974, Federal Power Commission, May 1975

U.S. electricity consumption was almost 8 percent. Over the 1973-1979 time frame, in a time of increasing electricity costs, the annual load growth was less than 3.5 percent. However, the annual production of electricity by coal increased by more than 5 percent during this same period. Annual production of electricity by oil and gas decreased by approximately 0.5 and 0.55 percent, respectively.

The increasing cost of energy has resulted in conservation and higher energy efficiency in all end-use sectors. Since 1973 the OPEC cartel has dictated the world price of oil. Figure 2.2.1-4 shows the price increases that have occurred since January 1979. Since the 1973-1974 increase in coal prices, the annual U.S. average FOB mine cost has increased less than 1 percent in constant dollars. Prior to the embargo, coal was priced at approximately 75 percent of the cost of oil on a Btu basis. Currently, coal is generally priced at the marginal mine cost which is the cost of production from a new mine plus a return on investment; the world oil price is set by OPEC. Due to the large coal resource base, the operating cost for coal production is not expected to increase at a rate significantly greater than inflation. The resource base for oil is not as expansive as for coal, and as the oil resource is depleted, its cost should continue to increase at a much more rapid rate than inflation. However, the present world oil price is higher than the cost of exploration and production from any new oil well. Because oil is supply- rather than demand-limited, the difference in the cost of coal and oil will continue to widen until alternatives to petroleum becomes competitive. At that time, alternatives such as coal-derived liquids and gases, shale oil, alcohol fuels, etc. will impose an upper bound for the price of petroleum.

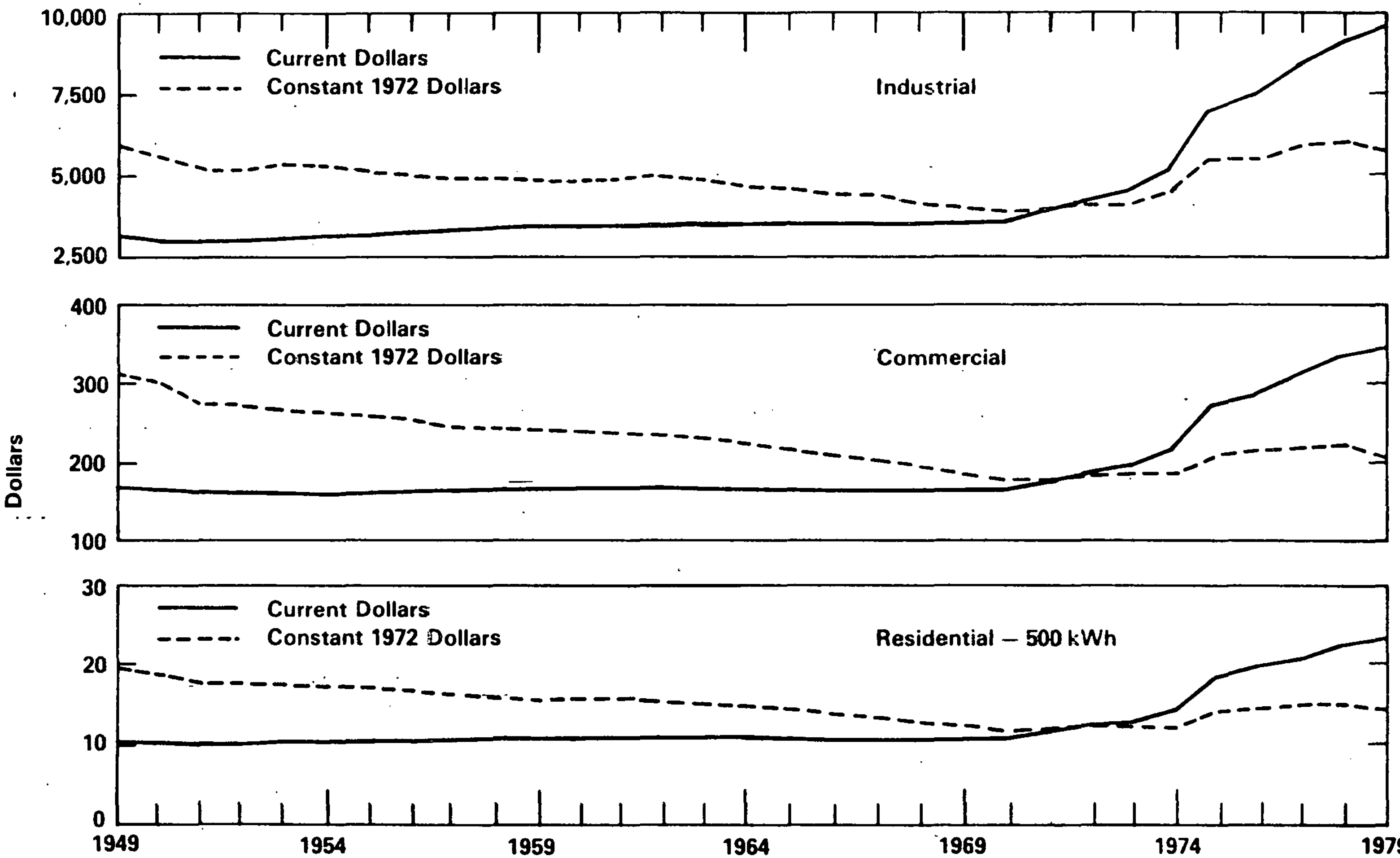
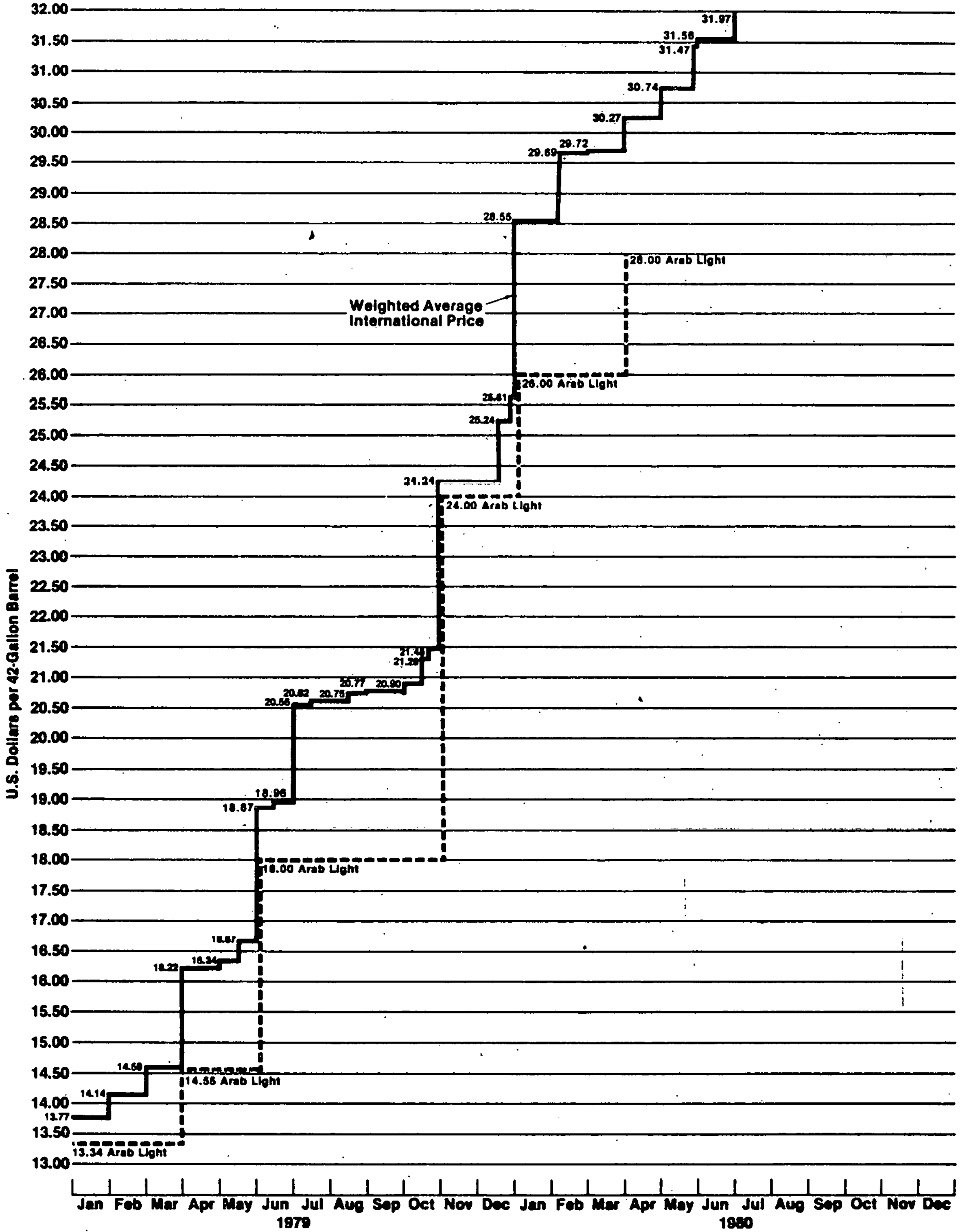


Figure 2.2.1-3. Weighted Average Monthly Electric Bill

Table 2.2.1-4. Weighted Average Monthly Electric Bill,[1] January 1, 1949-1979 (current and constant 1972 dollars)

Year	Residential—500 kWh[2]		Residential—750 kWh[3]		Commercial[4]		Industrial[5]	
	Current	Constant[6]	Current	Constant[6]	Current	Constant[6]	Current	Constant[6]
1949	10.22	19.43	NA	NA	165.0	313.7	3,105	5,904
1950	10.11	18.85	NA	NA	160.8	299.7	3,024	5,638
1951	10.02	17.50	NA	NA	158.1	276.0	3,011	5,258
1952	10.08	17.38	NA	NA	159.4	274.8	3,042	5,245
1953	10.20	17.32	NA	NA	158.0	268.4	3,154	5,357
1954	10.23	17.14	NA	NA	158.2	264.9	3,162	5,297
1955	10.30	16.89	NA	NA	159.2	261.0	3,168	5,195
1956	10.36	16.47	NA	NA	160.1	254.5	3,204	5,094
1957	10.39	15.98	NA	NA	160.7	247.2	3,235	4,975
1958	10.47	15.85	NA	NA	162.9	246.6	3,279	4,964
1959	10.51	15.57	NA	NA	163.5	242.1	3,283	4,862
1960	10.62	15.46	NA	NA	165.1	240.5	3,309	4,819
1961	10.64	15.36	NA	NA	164.1	236.9	3,337	4,817
1962	10.66	15.11	NA	NA	164.7	233.4	3,551	5,033
1963	10.64	14.86	14.65	20.46	164.4	229.7	3,442	4,808
1964	10.61	14.59	14.51	19.96	163.0	224.2	3,414	4,695
1965	10.41	14.01	14.34	19.30	161.0	216.6	3,423	4,606
1966	10.34	13.47	14.19	18.49	159.7	208.0	3,407	4,438
1967	10.37	13.12	14.21	17.98	160.1	202.6	3,422	4,330
1968	10.37	12.56	14.16	17.15	160.4	194.3	3,428	4,152
1969	10.32	11.90	13.97	16.11	160.9	185.5	3,436	3,962
1970	10.51	11.50	14.22	15.56	162.9	178.3	3,492	3,822
1971	11.13	11.59	14.99	15.61	171.9	179.1	3,774	3,930
1972	11.99	11.99	16.14	16.14	184.8	184.8	4,137	4,137
1973	12.56	11.87	16.96	16.03	193.7	183.1	4,402	4,161
1974	14.10	12.15	19.14	16.50	215.4	185.6	5,196	4,478
1975	17.93	14.10	24.72	19.44	268.7	211.3	6,883	5,413
1976	19.26	14.40	26.78	20.03	285.9	213.8	7,395	5,531
1977	20.86	14.72	29.22	20.62	310.0	218.8	8,224	5,804
1978	22.19	14.59	31.23	20.54	333.4	219.3	8,973	5,901
1979	23.05	13.93	32.72	19.77	343.9	207.8	9,408	5,685

[1] The U.S. average for each energy consumption level (end-use sector) is calculated by multiplying the bill for each city included in the typical bill report by the city's population and dividing the sum of the products for all cities by the sum of their populations. Bills are based on rates, fuel adjustments, and taxes in effect January 1, of each year.
[2] Weighted average monthly bill of residential consumers of 500 kilowatt hours.
[3] Weighted average monthly bill of residential consumers of 750 kilowatt hours.
[4] Weighted average monthly bill of commercial consumers who required 30 kilowatts of service for 6,000 kilowatt hours.
[5] Weighted average monthly bill of industrial consumers who required 1,000 kilowatts of service for 200,000 kilowatt hours.
[6] Constant 1972 dollars calculated using GNP implicit price deflators, 1972 = 100. See Units of Measure, Conversion Factors, and Energy Equivalents.
NA = Not available.
Sources: • 1949 through September 1977—Federal Power Commission, Form 3, "Typical Net Monthly Bills;" • October 1977 through September 1979—U.S. Department of Energy, Energy Information Administration, Federal Power Commission Form 3, "Typical Net Monthly Bills." • October 1979 through December 1979—U.S. Department of Energy, Energy Information Administration, Form 213, "Typical Net Monthly Bills."



Source: EIA, Weekly Petroleum Status Report

Figure 2.2.1-4. World Price of Oil

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[1]Internationally traded oil only

As a consequence of higher energy prices the GNP deflator (inflation) has increased and real GNP growth has decreased (Table 2.2.1-5). Along with conservation measures and increased cost of energy, the downturn in the economy has slowed the growth in energy consumption. The increase in total electricity generation from 1978 to 1979 was only 1.9 percent versus the 3.5 percent annual load growth from 1973 to 1979. Electric utility planning reflected this decreased growth rate, resulting in deferred installation of additional generating capacity and most other utility equipment for both transmission and distribution. Due to the increasing costs in electricity, the PUCs have been closely regulating the utilities and, in an effort to reduce electricity costs, have delayed the granting of rate increases, thus creating a lag between the time of capital expenditures and when these costs are included in the rate base.

Table 2.2.1-5. GNP Factors
(percent per year)

	GNP Deflator	Real GNP Growth
1965	1.8	6.4
1966	2.8	6.6
1967	3.2	2.6
1968	4.0	5.1
1969	4.8	2.9
1970	5.5	-0.5
1971	4.5	3.7
1972	3.4	6.7
1973	5.6	6.0
1974	10.2	-2.1
1975	9.6	-1.4
1976	5.2	6.1
1977	5.9	5.7
1978	7.4	4.6
1979	12.8	-1.5

Utilities have encountered additional regulatory difficulties with siting, constructing, and operating nuclear plants. Presently, the period to bring a nuclear plant to full operation is 12 to 15 years, beginning with a decision by a utility to start site-specific studies and continuing through issuance of an operating license by the Nuclear Regulatory Commission (NRC). This extended period has increased greatly the cost of new nuclear electric-generating plants, and the capital cost is projected to continue to be greater than that for fossil plants. Nuclear power is effected significantly by uncertainties associated with the time required for construction and the time required by NRC to process and grant construction permits. These uncertainties combined with the high capital cost and the low load growth have caused the utilities to not only defer construction of the plants but to cancel the plant entirely. In some instances the utilities have paid to manufacturers millions of dollars in cancellation fees for long lead items that were already on order.

In 1979 the Three Mile Island (TMI) nuclear incident cast even more uncertainty over the future of nuclear power. Its immediate effect was to decrease the amount of nuclear power generated from 276 GWh in 1978 to 255 in 1979, a decrease of 8.2 percent. Nuclear plants similar to TMI were ordered shut down by NRC and modifications made to avoid a similar accident. Additional costs may be incurred by the utilities to remedy problems as they arise. Table 2.2.1-6 shows the current status of U.S. nuclear power plants. Depending upon the considerations previously mentioned there is a high uncertainty concerning the timing and the number of reactors that will become operational. Those reactors closer to completion have a higher probability of going in service.

If the problems associated with siting, constructing, and operating nuclear power plants were solved in a manner favorable to increasing nuclear capacity, utilities would install more nuclear plants. Since it appears that there will be continuing problems with nuclear power, an increased amount of fossil-fueled generation capacity will be required. For the time frame of this study it is unlikely that geothermal and other sources of electricity will make a significant contribution to utility power generation. New fossil-fueled capacity will have to fill the gap between load growth and new nuclear capacity.

There are problems that will have to be addressed when deciding whether the new fossil generation will be coal, oil, or gas. The major consideration for coal is environmental impact. Oil and gas are premium fuels, cleaner to use, but more costly than coal. The use of oil and gas for new plants is restricted by the Federal government through the PIFUA. All new electric power plants must use coal synthetic or other alternate fuels (petroleum coke; shale oil; uranium; biomass, municipal, industrial,

Table 2.2.1-6. Status of U.S. Nuclear Power Plants as of 31 March 1980

Reactor Status	Boiling Water Reactors	Pressurized Water Reactors	Other[a]	Total Reactors	Net Megawatts Total Capacity
Operating[b]:	26	42	3	71	52,200
Construction Permit Granted:	28	60	0	88	96,700
10 Percent Complete or Better:	19	42	0	61	66,900
Less Than 10 Percent Complete:	6	11	0	17	19,300
No Construction:	3	7	0	10	10,500
Under Construction Permit Review:	7	6	1	14	16,300
Ordered:	0	3	0	3	3,500
Announced:	0	0	0	0	0
Totals:	61	111	4	176	168,700

[a]Including one high-temperature gas-cooled reactor (Fort Saint Vrain), one liquid metal fast breeder reactor (Clinch River), and two DOE-owned reactors (Shippingport and Hanford N).

[b]Includes two DOE-owned reactors with a combined capacity of 940 MWe, Three Mile Island (906 MWe) which was shut down due to an accident in March 1979, and Humboldt Bay (65 MWe) which was shut down for seismic modifications.

Based on Program Summary Report, U.S. Nuclear Regulatory Commission, NUREG-0380, Vol. 4, No. 4 March 1980.

Source: DOE/EIA, 1979 Annual Report to Congress

or agricultural wastes; wood; etc.) unless an exemption can be granted for environmental, financial or system service and reliability reasons.

The environmental legislation has imposed air requirements that may restrict the siting of coal power plants in a number of areas including a nonattainment area. This is an area in which air quality is worse than is required by Federal and state statutes. A new coal power plant equipped with the best available control technology would degrade further the air quality unless the utility offsets the amount of pollution emitted from the new power plant by a corresponding decrease from an existing facility. The PUC would not allow construction of a new plant in the nonattainment area. Similar environmental considerations would apply to the conversion of any existing unit from oil or gas to coal.

The PIFUA effects both new and existing oil and gas power plants. As mentioned above, new plant construction without the capability to use coal or other alternate fuel as a primary energy source is prohibited. Between 1981 and 1991 less than 2 percent of the new generating capacity to start operation is planned to be oil or gas. Compliance with that part of the PIFUA concerning new electric power plants will be nearly absolute. Existing oil and gas capacity for 1976 is shown in Table 2.2.1-7. The PIFUA requires units that are presently using oil to revert to coal if they previously used coal. To assist in the conversions, Congress is deliberating the passage of the Power Plant Fuel Conservation Act of 1980 (oil back-out bill). From 1965 through 1972, approximately 29,000 MW of coal-fired capacity was converted to oil, much of which could be converted back. An estimate of the maximum conversion under this program is approximately 20,000 MW which is 4.3 percent of total fossil generation capacity. However, this would require that local, state, and Federal regulatory agencies grant variances to certain air pollution standards to permit the burning of coal. Therefore, this amount of conversion is not expected to be complete until 1990.

Table 2.2.1-7. 1976 Electric Utility Oil and Gas Generating Capacity - Contiguous U.S. - National Electric Reliability Council Regions* (megawatts)

	Steam		Combustion Turbine		Combined Cycle	
	Oil	Gas	Oil	Gas	Oil	Gas
ECAR*	4,751	92	3,090	962	N/A	0
ERCOT	0	30,013	53	958	0	715
MAAC	12,985	0	7,709	232	120	0
MAIN	1,893	95	3,060	230	0	0
MARCA	628	235	2,446	46	72	0
NPCC	24,843	54	5,175	45	0	0
SERC	16,133	640	10,303	99	348	0
SPP	8,067	23,504	1,377	691	3	870
WSCC	23,886	2,121	4,256	241	622	224
Total	93,186	56,754	37,469	3,504	1,165	1,809

* For definition of National Electric Reliability Council Regions, see Appendix, Figure 4.

The PIFUA requires that all gas-fired generating capacity be retired by 1990. As can be seen in Table 2.2.1-7, the 1976 gas-fired capacity was in excess of 60,000 MW. In 1979 the gas-fired generation in Texas, Oklahoma, and Louisiana was approximately 75, 92, and 60 percent, respectively, of total generation in those states and more than 40 percent of the total gas-fired generation of the U.S. The conversion to coal or retirement of gas power plants in those states would be financially impossible under normal financing procedures for these utilities. The only alternative to continued gas utilization in these units would be conversion to oil, which is at odds with the national goal of decreasing dependence on oil imports through decreased consumption.

This background on the factors presently impacting the electric utilities will be the basis for forecasting future coal utilization.

Forecast

Projections of the amount of coal use by the electric utilities are heavily dependent on the amount of electricity which they generate. Therefore, the projected growth of electricity consumption (load growth) is very important. Recent annual load growth (1973-1979) is approximately

3.5 percent; however, last year's growth was only 1.9. This decreased consumption was accomplished through conservation fostered by the escalating cost of electricity (see Figure 2.2.1-3). Table 2.2.1-8 shows the electricity demand growth rates projected by the EIA in the 1979 Annual Report to Congress.

Table 2.2.1-8. Electricity Demand Growth Rates
Medium World Oil Price Scenario
(percent per year)

1978-1985	3.0
1985-1990	3.7
1990-1995	3.0
1978-1995	3.2

Since 1974 the cost of electricity for the residential customer has risen by 63 percent in current dollars, and the costs of coal, crude oil, and natural gas have risen by 58, 216, and 165 percent, respectively. As discussed in Section 2.1, Assumptions, the costs of oil and natural gas are projected to increase at a higher rate than coal. This escalation in oil prices will provide incentive for the increased utilization of coal by the utilities. Another positive aspect of coal utilization is assurance of coal availability through long-term contracts or captive coal operations (utility-owned coal mines). There is a corresponding increase between the cost of petroleum and the economic competitiveness of coal-derived synfuels.

Because the synfuels will meet ambient environmental standards, some electric utilities consider them as an alternative to the direct utilization of coal. Synfuels also may be preferable over petroleum or natural gas because of a greater assurance of supply. The majority of synfuels production, however, is projected to be utilized in other sectors.

In addition to the price increases previously mentioned, the Federal government is impacting the petroleum and natural gas consumption of the electric utilities. Through oil and gas decontrol, the cost of domestic fuels used by the utilities is increasing, and the PIFUA restrictions on oil and gas use have been imposed. These actions along with the proposed oil back-out bill will help decrease oil and gas consumption for the production of electricity.

The effect of these actions is forecasted by EIA in the 1979 Annual Report to Congress. The 1995 utility natural gas consumption decreases to 61 percent of the 1978 level (see Table 2.2.1-9). The utility oil consumption is projected to decrease to 34 percent of the 1978 level during the 1985-1990 time frame and to 5 percent by 1995.

Table 2.2.1-9. Electricity Fuel Consumption
Medium World Oil Price Scenario
(quadrillion Btu)

	1978	1985	1990	1995
Oil	3.8	1.3	1.3	0.2
Natural Gas	3.3	2.8	2.9	2.0
Total	7.1	4.1	4.2	2.2

Source: DOE/EIA, 1979 Annual Report to Congress

The generation capacity of oil- and gas-consuming units is projected by EIA and is shown in Table 2.2.1-10. The total generating capacity is not projected to decrease; however, some of the decrease in fuel consumption projected by EIA (Table 2.2.1-9) results from using those base-load oil and gas units as intermediate generating capacity. Oil consumption could be decreased by converting oil units to natural gas. However, not all oil units have this capability, nor is the conversion ability evenly distributed nationally. In the northeast almost none of the oil units can convert and in the California, Nevada, Arizona region almost all are capable. To reduce the amount of generation from the oil units to 5 percent of the 1978 electricity output it would be necessary to retire a significant amount of capacity. This does not appear likely due to the high capital cost of capacity replacement (~ $1000/kW).

Table 2.2.1-10. Electric Utility Oil and Natural Gas Generation Capacity
Medium World Oil Price Scenario
(gigawatts)

Turbine	1976	1985	1990	1995
Oil Steam	93	81	75	73
Gas Steam	57	65	63	63
Combustion	41	67	82	90
Total Oil and Gas	191	213	220	226

Source: National Electric Reliability Council
DOE/EIA, 1979 Annual Report to Congress

Any decrease in power generated by oil and gas power plants will have to be supplied by other forms of generation. Coal and nuclear power plants will supply almost all of this deficit and meet the growth in electricity consumption. Though the amount of power above current production for hydroelectric, geothermal, and other new technologies such as solar, is expected to increase, it will supply a decreasing percentage of total power generation.

In this study the following are calculated to project the amount of electricity generated by coal:

1. Total electricity demand using 1979 total generation and load growth projections
2. Nuclear generation
3. Decrease in oil and gas generation
4. Power supplied through hydroelectric and other capacity
5. Coal power generation from the data in the above steps.

The total electric generation in 1979 was 2,247,372 GWh. Generation resulting from use of a 3.2 percent growth rate throughout the time period is illustrated in Table 2.2.1-11.

Table 2.2.1-11. U.S. Net Generation of Electric Utilities (thousands of (GWh)

1979	2,247.4
1985	2,714.9
1990	3,178.0
1995	3,720.1
2000	4,354.7

The current nuclear capacity in the U.S. is 54,594 MW. With the current long lead time (12 to 14 years) for putting a nuclear plant in service, it appears unlikely that units without construction licences will be fully operational before 1995. Only those plants which have started site and design work are projected to be in full operation by 2000. (See Table 2.2.1-6 for details of the status of U.S. nuclear power plants.)

Table 2.2.1-12 is based on these assumptions and EIA projections. A generation capacity factor of 63.2 percent is used for the projections of electricity produced.

Table 2.2.1-12. Projected Nuclear Capacity and Generation

Year	MW	GWh x 10^3
1979	54,594	255.2
1985	86,000	476.1
1990	125,000	692.0
1995	151,300	837.6
2000	171,100	947.3

Most of the large (greater than 100 MW) oil and gas power plants have been constructed since the 1950s and, therefore, have not reached normal retirement age (40 or more years of service). The EIA projection of oil and gas consumption by electric utilities (Table 2.2.1-9) would require the early retirement of some of this capacity. Table 2.2.1-13 shows the projected amount of oil and gas generation used in this study.

Table 2.2.1-13. Oil and Natural Gas Generation (thousands of GWh)

	1978	1985	1990	1995	2000
Oil	364	244	125	104	83
Natural Gas	305	259	268	224	179
Total	670	504	393	328	262

The 1990 projection is based on the EIA 1979 Annual Report to Congress. The following are some of the assumptions used in the EIA projections.

> Electric utilities shift from using oil and natural gas for producing electricity to coal and uranium. Oil consumption in the middle world oil price scenario is 1.3 quadrillion Btu (34 percent of the 1978 oil consumption) in 1990. This reduction in oil consumption occurs because of the high price of imported oil, the low growth in projected electricity demand, and an assumption that natural gas continues to be available to utilities. In the past, utility planners projected demand growth rates of over 5 percent yearly and scheduled new coal-fired and nuclear power plant construction to meet this demand. As a result, excess capacity exists by 1985, unless the planned coal-fired power plants are delayed or cancelled due to lower demand or the unavailability of capital. This excess capacity is used to replace existing oil-fired power plants. Significant oil consumption continues until 1990 in New England and the West, because the new capacity currently planned for 1990 is not sufficient to displace all the oil required by utilities in those regions.

Natural gas consumption declines slowly until 1995, when additional coal capacity is available for its replacement. It is assumed that electric utilities receive 5-year exemptions to those provisions of the Powerplant and Industrial Fuel Use Act that require reduced natural gas consumption in existing facilities before 1990 and limit consumption to 20 percent of current usage by 1990. Conversions of existing plants from oil to gas are assumed to be acceptable, although construction of new gas-fired power plants is not permitted.

The EIA projection that oil consumption would decrease to 34 percent of the 1978 oil consumption by 1985 and remain stable until 1990 appears unlikely. Early retirement of existing capacity and replacement of this capacity with coal-fired units would place considerable financial strain on the utilities. There is no law requiring replacement of oil and gas capacity not coal capable with coal capacity and no such law is under consideration. The 1985 oil generation projection in Table 2.2.1-13 is an average between the 1978 and 1990 projections. It may be possible, assuming adequate rate relief, that by 1990 sufficient coal capacity can be added to allow those base-load oil units to be operated as cycling power plants. This could reduce oil generation to 34 percent by 1990.

The 1995 and 2000 forecasts are based on retiring existing oil and gas power plants as they reach normal retirement age. To simplify the calculations it is assumed that the capacity existing in 1990 was constructed between 1950 and 1980. In 1995, 12.5 percent of the 1990 capacity is assumed to be retired, with an additional 12.5 percent retired in 2000. This trend would not continue through 2020, however, because the remaining capacity is needed for intermediate and peaking generation.

The 1978 generation by hydroelectric and other capacity was 280,400 and 3,300 GWh, respectively. Table 2.2.1-14 shows the estimated generation from these sources based on EIA projections.

Table 2.2.1-14. Hydroelectric and Other Generation
(thousands of GWh)

	1978	1985	1990	1995	2000
Hydro	280	300	309	319	329
Other	3	10	41	103	196
Total	284	310	350	422	525

Using Tables 2.2.1-11 through 2.2.1-14 results in the following estimate of coal generation.

Table 2.2.1-15. Coal Generation

Year	GWh x 10^3	Annual Increase (percent)
1979	1,076	---
1985	1,426	4.8
1990	1,743	4.1
1995	2,133	4.1
2000	2,621	4.2

To estimate the amount of coal consumed to produce this power it is necessary to allocate the increased generation to specific national regions. This is required because the different regions will utilize different coal types. The western coal, which is a lower quality coal than eastern, will be used by western utilities. It has a lower Btu content and, therefore, more western coal than eastern would be consumed to produce the same amount of electricity.

In 1979, 266,751 GWh was generated by coal in states west of the Mississippi River. This was 24.8 percent of total U.S. coal generation. The 1979 regional coal generation and utility coal consumption are shown in Table 2.2.1-16.

Table 2.2.1-16. U.S. 1979 Coal Generation and Utility Coal Consumption

Region*	GWh	Thousands of tons
New England	2,900	1,043
Middle Atlantic	115,126	46,660
South Atlantic	228,243	90,592
East North Central	318,561	160,320
East South Central	144,031	71,802
Total East	808,860	370,417
West North Central	109,575	73,674
West South Central	53,482	43,281
Mountain	95,936	57,339
Pacific	7,758	5,063
Total West	266,751	179,357
Total U.S.	1,075,601	549,774

* See Appendix, Figure 2 for definition of region

Source: EIA Energy Data Report - Power Production, Fuel Consumption, and Installed Capacity Data for 1979; Bituminous and Subbituminous Coal and Lignite Distribution, Calendar Year 1979

The FERC performed a study on coal supply for new electric generating units that would be added between 1977 and 1986. It was determined that practically all of the new units in the West will utilize bituminous and subbituminous coal and lignite produced west of the Mississippi. Of the coal produced in the West for new coal power plants, 92.1 percent will go to the new units in the West. Because of the lower average heating value of western coals, the new western units will use more than their proportionate share of the incremental tonnage required for new coal power plants. The new capacity coming on-line in the West is 52.6 percent of U.S. new capacity and will require 64.4 percent of the total incremental tonnage. Table 2.2.1-17 contains a percentage breakdown by demand and supply regions of the coal required by the new units.

Table 2.2.1-17. Supply/Demand Allocation of Coal for New Units (in percent)

Demand Region	Total	Supply Region: Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
New England	0					
Mid Atlantic	5.1	5.1				
South Atlantic	8.7	8.4	0.3			
East North Central	13.9	4.2	4.4		3.1	2.2
East South Central	7.9	5.2	2.0		0.7	—
Total East	35.6	22.9	6.7		3.8	2.2
West North Central	17.1				16.0	1.1
West South Central	31.8		0.1	13.8	17.5	0.4
Mountain	14.2				5.2	9.0
Pacific	1.3	—	—	—	0.3	1.0
Total West	64.4	0	0.1	13.8	39.0	11.5
Total	100.0	22.9	6.7	13.8	42.8	13.7

Source: FERC, Status of Coal Supply Contracts for New Electric Generation Units, May 1978

Since the May 1978 publication of the FERC report a new coal plant has been announced for the New England region. This plant would consume 0.3 percent of the total incremental coal used for Table 2.2.1-17. It is assumed that the Appalachian region would supply the coal requirements for this plant.

Assuming that the coal for new utility plants will maintain a distribution similar to the one in Table 2.2.1-17, the coal used through the year 2000 can be estimated. Using a utility heat rate of 10,492 Btu/kWh for coal plants and the heat content for coal shown in Table 2.2.1-18, the coal consumption for incremental coal generation can be derived.

Table 2.2.1-18. Average Coal High Heating Value for Electric Utilities (Btu per pound)

Appalachia	12,200
East Interior	11,300
West Interior and Gulf	7,000
Northern Great Plains	10,000
Mountain	10,000

Table 2.2.1-19 shows the 1979 distribution of coal from the Bureau of Mines producing regions to the consuming regions. By adding the coal requirements for the incremental generation to the 1979 generation, the total coal consumption and distribution can be calculated. The results are shown in Table 2.2.1-20.

Sensitivity Analysis

The utility coal consumption projected in Table 2.2.1-20 is impacted by many factors, a number of which have been studied by EIA. Their effect on fuel consumption is shown in Table 2.2.1-21.

Table 2.2.1-19. 1979 Distribution of Bituminous, Subbituminous, and Lignite Coal to the Electric Utilities (thousands of short tons)

Bureau of Mines District of Origin*

Destination	1	2	3 & 6	4	7	8	9	10	11	12	13	14	15	16 & 17	18	19	20	21	22 & 23	Total
New England		21	1019			3														1043
Middle Atlantic	29862	7595	6098	1909	338	853					4								1	46660
South Atlantic	8639	231	12521	65	2206	56505	5176	2949	1232		1034		33							90592
East North Central	1698	2305	8613	32216	990	24823	8262	29731	18042			35	27	2970		14246	1392		14970	160320
East South Central		11	304	3056	547	20699	27055	2846	2625		13684	6	35	664			269			71801
West North Central	5	7	4	11	467	344	927	14323	93	637	35	142	8798	1870	270	20656	288	13360	11437	73674
West South Central	15					3						21	25040	38		16366			1797	43280
Mountain														9116	22311	17261	5137		3513	57338
Pacific																	13		5050	5063
United States	40219	10170	28559	37257	4548	103230	41420	49849	21992	637	14757	204	33933	14658	22581	68529	7099	13360	36768	549771

*For definition of Bureau of Mines Coal Districts see Appendix, Figure 3

Table 2.2.1-20. Electric Utility Coal Consumption and Distribution
(thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			Supply Region			
			1985			
New England	1,585	1,585				
Mid Atlantic	55,873	55,873				
South Atlantic	106,307	96,375	9,899	33		
East North Central	185,429	78,232	63,983	62	36,208	6,944
East South Central	86,072	47,694	36,139	41	1,534	664
West North Central	104,564	873	15,343	8,940	63,284	16,124
West South Central	100,725	18	180	49,990	47,979	2,558
Mountain	82,989				30,167	52,822
Pacific	7,411				5,605	1,806
Total	730,955	280,650	125,544	59,066	184,777	80,918
			1990			
New England	1,585	1,585				
Mid Atlantic	64,212	64,212				
South Atlantic	120,533	110,110	10,390	33		
East North Central	208,157	85,100	71,177	62	41,277	10,541
East South Central	98,989	56,196	39,409	41	2,679	664
West North Central	132,525	873	15,343	8,940	89,446	17,923
West South Central	152,722	18	343	72,555	76,594	3,212
Mountain	106,207				38,669	67,538
Pacific	9,537				6,096	3,441
Total	894,467	318,094	136,662	81,631	254,761	103,319

Table 2.2.1-20. Electric Utility Coal Consumption and Distribution (Continued) (thousands of short tons)

Demand Region	Total	Supply Region: Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	1,585	1,585				
Mid Atlantic	74,480	74,480				
South Atlantic	138.049	127,022	10,994	33		
East North Central	236,142	93,556	80,036	62	47,518	14,970
East South Central	114,895	66,665	43,436	41	4,089	664
West North Central	166,953	873	15,343	8,940	121,660	20,137
West South Central	216,747	18	544	100,339	111,828	4,018
Mountain	134,796				49,138	85,658
Pacific	12,154				6,700	5,454
Total	1,095,801	364,199	150,353	109,415	340,933	130,901
			2000			
New England	1,585	1,585				
Mid Atlantic	87,314	87,314				
South Atlantic	159,942	148,160	11,749	33		
East North Central	271,120	104,125	91,108	62	55,319	20,506
East South Central	134,775	79,750	48,469	41	5,851	664
West North Central	209,984	873	15,343	8,940	161,923	22,905
West South Central	296,770	18	795	135,066	155,866	5,025
Mountain	170,529				62,223	108,306
Pacific	15,425				7,455	7,970
Total	1,347,444	421,825	167,464	144,142	448,637	165,376

Table 2.2.1-21. Sensitivity of Electricity Fuel Consumption Projections - 1990

(10^{15} Btu)

Fuel Type	1978 Actual	1979 ARC Middle Oil Price	1979 ARC High Oil Price	Load Management	Limit On Gas Consumption	Nuclear Moratorium
Coal	10.3	18.5	18.6	18.9	18.5	18.8
Oil	3.8	1.3	1.1	1.2	2.7	1.4
Natural Gas	3.3	2.9	3.2	2.6	0.6	3.1
Nuclear	3.0	8.2	8.1	8.2	8.1	7.6
Hydro-electric	2.9	3.2	3.2	3.2	3.2	3.2
New Technologies	0.1	0.4	0.4	0.4	0.4	0.4
Total	23.3	34.5	34.7	34.6	33.6	34.5

Source: DOE/EIA, 1979 Annual Report to Congress

The following is extracted from the EIA 1979 Annual Report to Congress.

> The load management case assumes that time-of-use pricing for electricity is implemented, causing a shift in demand from the expensive peak hours of the day to off-peak hours. Generation from coal-fired power plants increases in response to the increased demand in the base mode, and generation from oil- and gas-fired turbines decreases with the lower peak demand. The price of electricity decreases 2 percent from the base case with the operation of more efficient plants and lower fuel costs resulting from the shift to coal. These cost savings more than offset the additional capital cost of changing meters to calibrate time-of-use rates.
>
> The nuclear moratorium case assumes that plants currently less than 10 percent complete will be cancelled. As a result, nuclear capacity additions decrease by 4 gigawatts in 1990. Electricity generation from coal, oil, and natural gas increase by 1.7, 9.0 and 4.5 percent, respectively, over the base case. The impacts of this moratorium however, are greater in 1995.

The limit-on-gas consumption case assumes that the Powerplant and Industrial Fuel Use Act will be strictly enforced. The act limits natural gas consumption in 1990 to 20 percent of the 1977 consumption, and, because utilities have fewer options, oil-fired power plants that were retired before the end of their useful lives continue to operate. The level of generation from oilfired power plants is double the base case projection. Oil consumption increases to 2.7 quadrillion Btu (71 percent of the 1978 level) in response to a limited gas consumption of 0.6 quadrillion Btu. The average price of electricity increases by 1.2 mills per kilowatt hour (kWh) over the base case because of increased fuel costs.

The projections in Table 2.2.1-20 assume a world oil price similar to the EIA Middle World oil projection. The high oil price described in the baseline scenario is approximately 25 percent higher than the high world oil price used by EIA. The effect of the high oil price in the EIA projection is to increase utility coal consumption from 0.5 percent in 1985 to 2.2 in 1995. Though the high oil price in the baseline scenario is higher than that in the 1979 Annual Report to Congress, the effect on coal consumption is not expected to be higher. Financial, regulatory, and environmental problems will continue to constrain the utilities from replacing existing oil and gas capacity with additional coal-fired plants.

Many power plants have the capability to switch between oil and gas without major modification. With a constrained supply of natural gas to electric utilities, oil consumption would have to increase to compensate for the shortfall. Power plants lacking the switching capability would be unable to supply the shortfall. At present natural gas costs less than oil, and though the price is increasing, it is not projected to reach that of oil. If gas is unavailable, the cost of producing electricity from oil and gas power plants would increase because additional higher cost oil would be consumed. The effect of a constrained gas supply on the amount of coal consumed would be similar to that projected for the high oil price case.

Nuclear power could be higher or lower than the projections for the baseline scenario, dependent upon both regulatory treatment and public opinion. For nuclear power use to increase during the 1990s, it will be necessary to streamline the regulatory process and decrease the power of intervenors to lengthen the licensing process. If this is not done, only those units under construction will be completed. If the regulatory problems are solved and the total time for installation of a nuclear plant decreases to 10 years, additional nuclear plants could be in operation by 2000. However, the major effect of this change in regulatory policy would be felt after 2000. The effect on utility coal consumption for these sensitivities is shown in Table 2.2.1-22.

Table 2.2.1-22. Utility Coal Consumption Sensitivities (thousands of short tons)

Year	Baseline Scenario	High Oil Price/ Constrained Gas	Low Nuclear	High Nuclear
1985	731,000	734,000	731,000	731,000
1990	894,500	899,000	894,500	894,500
1995	1,095,800	1,120,900	1,119,300	1,095,800
2000	1,347,400	1,377,000	1,415,400	1,385,000

There is a direct relationship between load growth and coal consumption. Table 2.2.1-23 shows the potential effect on utility coal projections were the load growth to be higher or lower than the 3.2 percent used for the baseline scenario. The figures in this table were derived assuming the all noncoal generation would remain as in the baseline scenario.

The results of these sensitivities show that only in the case of changing load growth and low nuclear growth will there be any significant change from the low oil price case in the amount of coal utilized by the utilities during the 1980-2000 time frame.

Table 2.2.1-23. Coal Projections for Various Load Growth
(thousands of short tons)

Load Growth percent/year	1985	1990	1995	2000
4.0	796,400	1,046,700	1,348,200	1,741,600
3.5	754,800	954,300	1,187,100	1,488,100
3.2	731,000	894,500	1,095,800	1,347,400
3.0	714,300	866,300	1,037,100	1,258,000
2.5	674,800	782,500	897,900	1,049,000

In the following table the baseline projections are compared with other projections.

Table 2.2.1-24. U.S. Utility Coal Projection Comparison
(millions of short tons)

	1985	1990	1995	2000
Baseline Scenario	731-734	895-899	1,096-1,121	1,347-1,378
EIA	737	884	1,115	
EPRI				1,300
NCA	733	959		
WOCOL	617	825		1,290

Source: EIA: Energy Information Agency, DOE, 1979 Annual Report to Congress
EPRI: Electric Power Research Institute, Overview and Strategy 1981-1985 Research and Development Program Plan
NCA: National Coal Association, Long-Term Forecast, February 22, 1980
WOCOL: World Coal Study, Coal-Bridge to the Future

Comparison of these projections shows that the baseline scenario projection is bounded by other projections except in the year 2000. The trend of the EIA and NCA projections indicates a higher projection of utility coal consumption for 2000 and would, therefore, put the baseline scenario projection within the bounds of the other forecasts.

2.2.2 Industry Coal Demand Forecast

The industrial sector historically has been a major consumer of energy in the U.S. In 1979, energy consumed by this sector amounted to over 28 quads, or about 37 percent of total U.S. energy consumption. Natural gas (dry) was the largest source of energy to this sector in 1979. Electricity, oil, and coal followed, with coal supplying only 12 percent (67 million tons) of total energy consumption. Over the past 25 years, coal use in the industrial sector has gradually declined, as manufacturing firms switched to cheaper and more plentiful oil and gas supplies. However, higher oil and natural gas prices, and, to a lesser extent, mandated coal conversion are expected to lead to greater industrial coal use in the future.

The industrial sector consists of four major subsectors. These are:

- Manufacturing
- Agriculture
- Mining
- Construction

Among these, the manufacturing subsector is by far the largest consumer of energy, and accounted for about 79 percent of the energy consumed by industry in 1974 (or 28 percent of the nation's energy use). This was followed by mining with 9 percent, construction with 7 percent, and agriculture with 6 percent. The major portion of the energy consumed by the manufacturing subsector is used to provide direct heat, process steam, and raw materials (feedstocks) for manufactured products. Eighty percent of the sector's energy consumption has been characterized according to functional use by various studies. Of this, a third is for direct heat, and one-half is split about evenly between process steam and raw materials usage. The remaining is for machine drive, electricity generation, electrolytic processes, coke production, space conditioning, and lighting. The 20 percent of energy consumption which has not been characterized is used mostly in small industries where machine drive, direct heat, and nonprocess energy uses such as heating, lighting, and air conditioning are relatively more important than in heavy industry. Figure 2.2.2-1 illustrates energy use in the manufacturing subsector for 1967, 1971, and 1974.

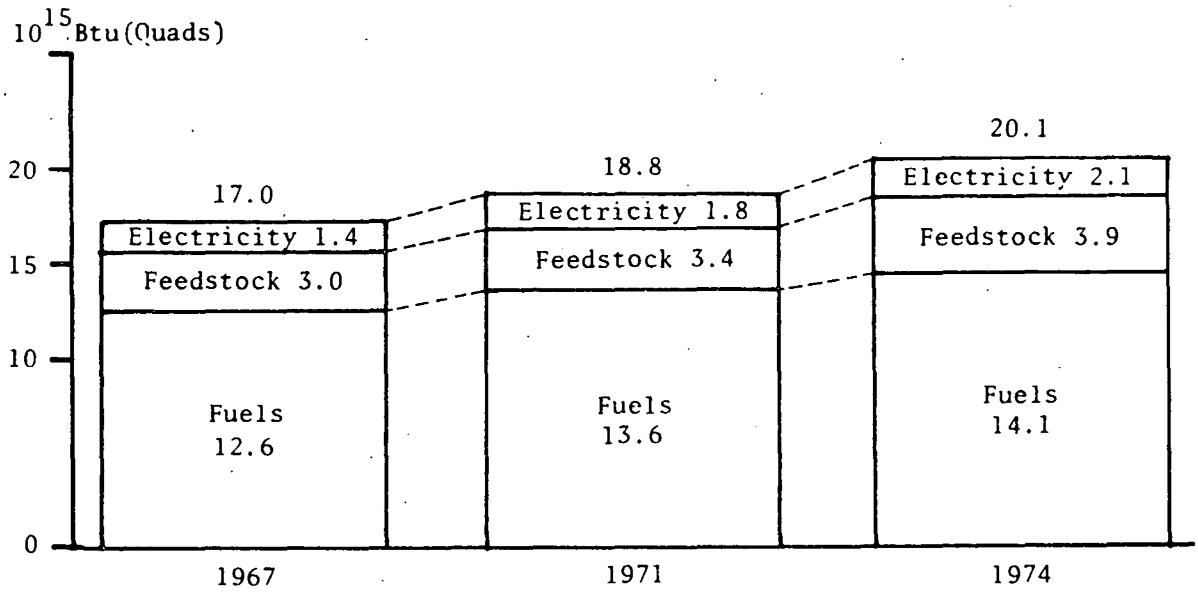


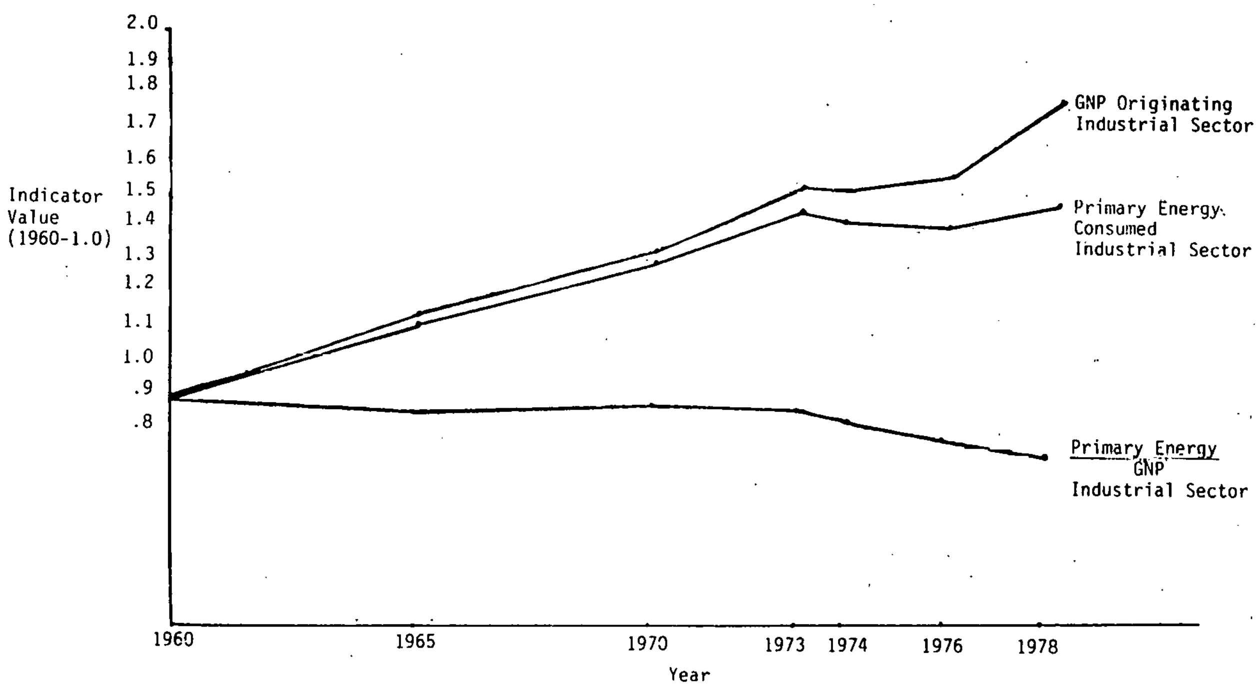
Figure 2.2.2-1. Energy Use in Manufacturing - 1967, 1971, 1974

The agricultural subsector accounted for approximately 2 percent of U.S. energy consumption in 1974. Over 50 percent of the energy consumed by this subsector is used to power farm vehicles; approximately 25 percent is used for machine drives (much of it for irrigation); and a considerable portion of the remaining 25 percent goes toward crop drying. The primary fuels used in the agricultural subsector are diesel and gasoline.

The mining subsector accounted for about 3 percent of U.S. energy consumption in 1974. About 75 percent of the energy used in the mining sector is for oil and gas extraction.

The construction subsector accounted for 2.5 percent of the nation's energy consumption for the same year. Working operations on construction sites and asphalt, the only raw material used that has an inherent, marketable energy content, consume most of the energy in this subsector.

Figure 2.2.2-2 shows the historical trends for some of the industrial indicators. Prior to the oil embargo, energy consumption grew at almost the same rate as real GNP originating in the industrial sector, which is similar to industrial production. Since 1973, conservation measures and improvements in production processes have caused a decrease in energy consumption per dollar of real GNP output, or industrial production.



Source: Conservation and Solar Strategy for Industrial Sector, August 1980

Figure 2.2.2-2. Industrial Indicators - 1960-1978

Additional improvements could be made to increase energy efficiency. Prime candidates for process efficiency improvements are the 10 most energy-intensive industries which consume over 85 percent of the energy used by the industrial sector. These industries, having developed during decades of abundant and low-cost energy, have remained, for the most part, unaltered in their modes of operation even to the present time. As a result, the technological base of these industries is virtually obsolete, and the industries themselves are among the most inefficient in the industrialized world. European and Japanese industries consistently use 20 to 25 percent less energy per unit of output than their U.S. counterparts.

The improvement in energy efficiencies that could be achieved by the year 2000 by new and existing plants is estimated to be 25 percent. The majority of this additional increase in energy efficiency would be achieved by new plants. This estimate was derived from data in the DOE Industry Energy Consumption Strategic Plan, July 1978 and the DOE/CS Industrial Energy Efficiency Annual Report published in 1979.

Figure 2.2.2-3 shows the amount of energy forecasted to be consumed by industry without and with additional increases in energy efficiency. The forecasted energy consumption, without increases in efficiency, is based upon a forecast of future industrial production by Predicasts Incorporated. If increases in efficiency were not to occur, energy consumption would increase at the same rate at production. However, because energy efficiency is forecasted to improve by 25 percent by 2000 the lower projection of energy consumption shown in Figure 2.2.2-3 will be used.

The major use of coal in industry is for steam production and direct heat. The total steam requirement of industry in 1968 was 41 percent of total fuel consumption. The steam is generated in boilers, and used in the processes and for electricity generation. Coal provided 23 percent of boiler and 26 percent of nonboiler energy consumption in 1968. Recent trends of the amount of new boilers that are coal-fired are shown in Table 2.2.2-1. This table shows that about 7 to 10 percent of boiler capacity that was sold between 1972 and 1976 was designed as coal-fired.

Table 2.2.2-1. Market Share of Coal-Fired New Boiler Sales

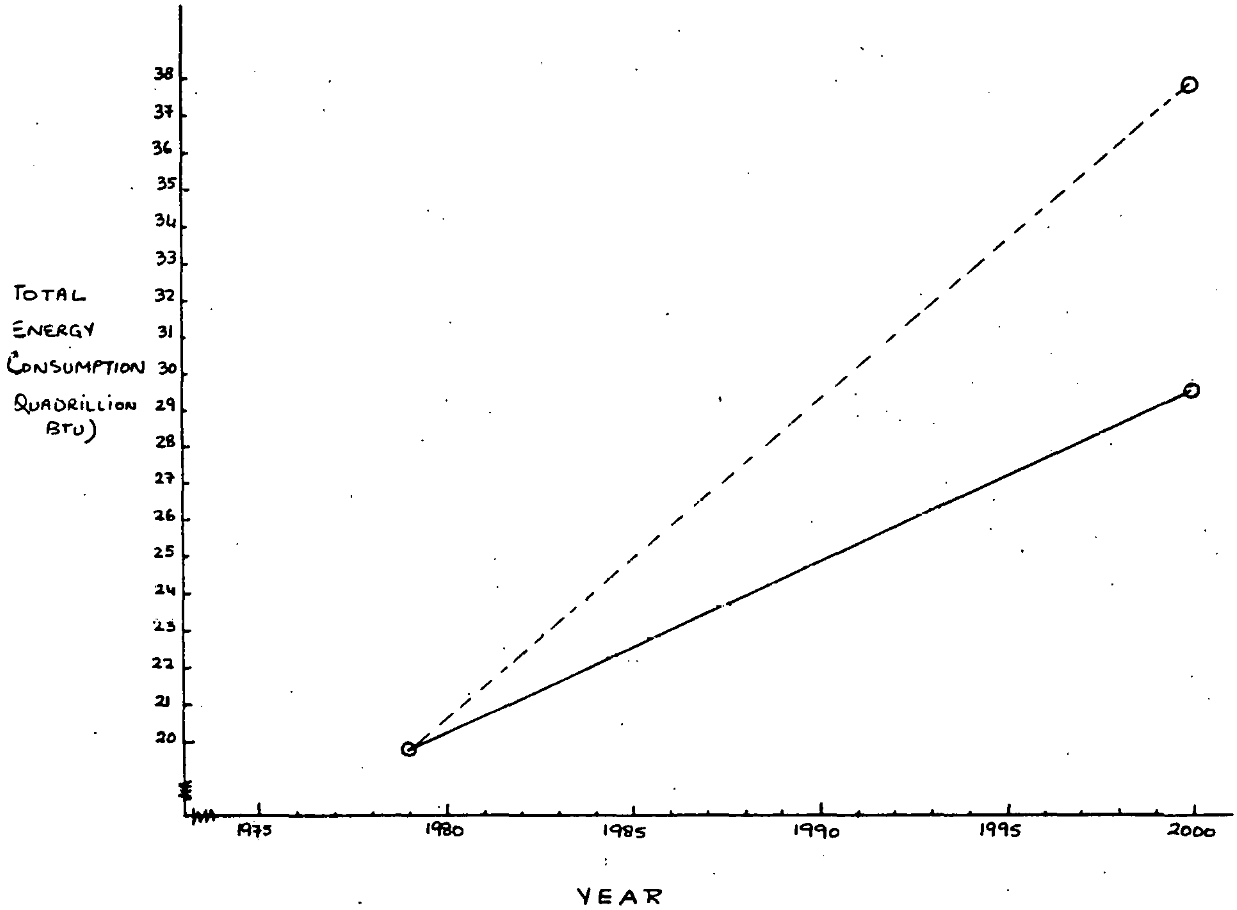
Year	Percent by Capacity
1972	5.1
1973	8.6
1974	7.7
1975	10.1
1976	7.0

Source: American Boiler Manufacturers Association

Several recent laws, however, complement the effects of high oil prices which would cause the market share for future coal-fired boilers to be much higher than is indicated by Table 2.2.2-1.

Several provisions of the National Energy Act of 1978 were designed to improve the competitiveness of coal through reducing its capital cost and increasing its fuel price advantage relative to other fossil fuel alternatives. In particular:

- The Energy Tax Act of 1978, which provides subsidies for capital investments in coal and renewable resource-based equipment



Legend:

--- Energy consumption growing at same rate as industrial production

— Energy consumption when industries become more energy efficient

From the Figure

Year	Total Energy Consumption
1980	20.3
1985	22.5
1990	24.8
1995	27.1
2000	29.5

---

[1]Metallurgical coal excluded. In 1979, total energy consumption was 19.7 quads.

Figure 2.2.2-3. Total Energy Consumption Forecast[1]
Industrial Sector

- The Natural Gas Policy Act of 1978, which increases the price of natural gas to most industrial customers

- The Power Plant and Industrial Fuel Use Act of 1978, which prohibits the use of oil and gas in new boilers with a firing rate of 100 million Btu per hour or greater, unless the cost of using coal is "substantially greater than" the cost of using imported oil. Exemptions from this requirement can be granted for reasons of environmental impact or coal supply constraints.

Another indication that the coal-boiler market share will be higher than the 1972-1976 trend is a study conducted by the American Boiler Manufacturers Association. This study, performed about two years before the Fuel Use Act was passed in 1978, indicates that by 1986 over 80 percent of the industrial boilers to be sold will be coal-fired (Table 2.2.2-2).

Table 2.2.2-2. Long-Range Industry Forecast of Market Share of Coal-Fired Boilers

Fuel	Capacity (thousand pph)*	Number of Units 1977	1981	1986
Coal	100-200	17	42	70
	200-300	17	42	70
	Over 300	16	42	70
	Total	50	126	210
Oil	100-200	45	25	20
	200-300	45	30	15
	Over 300	10	5	5
	Total	100	60	40
Natural Gas	100-200	10	5	5
	200-300	0	0	0
	Over 300	0	0	0
	Total	10	5	5
Total		160	191	255

*Thousands of pounds of steam per hour.

Source: American Boiler Manufacturers Association

In light of the Boiler Manufacturers Association projection of high coal-boiler installations and the requirements of the Fuel Use Act, it is assumed that 100 percent of the new boilers to be installed after 1980 will be coal-fired. Boilers are assumed to continue using 41 percent of the total energy consumed in industry. It is also assumed that the historical use of coal for nonboiler use (26 percent of total energy consumption) will continue throughout the forecast period. Coal is forecasted, therefore, to supply 67 percent of the incremental energy demand of industry after 1980.

Existing industrial plants have an incentive to convert to coal due to the high cost of oil and gas. However, even with the difference in cost between coal and oil, it may not be financially feasible for the plant to build a new coal boiler. The amount of coal conversion by industry was estimated based upon the Annual Survey of Manufacturers by the Census Bureau. This study performed for the 1977-1978 heating season shows the capability of manufacturers to use alternative energy. An analysis of this study showed that 12.6 million tons of coal could be used to substitute approximately 0.25 quads of oil and gas. Economic, environmental, and technical reasons are given for this limit on the amount of substitution.

Coal consumption in the industrial sector for existing plants, substitution of coal for oil and gas consumption, and new energy requirements are shown in Table 2.2.2-3. The coal flows for this projection are shown in Table 2.2.2-4.

Table 2.2.2-3. Industrial Coal Consumption Forecast (millions of short tons)

1979	67
1985	147
1990	213
1995	278
2000	346

Table 2.2.2-4. Industrial Coal Distribution and Consumption (thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1985						
New England	439	439	--	—	—	—
Mid Atlantic	17,648	17,615	32	—	1	—
South Atlantic	24,413	23,910	503	—	--	—
East North Central	63,575	36,580	25,895	165	644	291
East South Central	15,512	13,724	1,740	42	—	6
West North Central	12,467	1,033	5,121	969	4,515	829
West South Central	4,219	9	75	3,526	18	591
Mountain	7,143	—	—	--	2,750	4,393
Pacific	1,888	20	3	24	333	1,508
Total	147,304	93,330	33,369	4,726	8,261	7,610
1990						
New England	739	739	—	—	—	--
Mid Atlantic	25,767	25,715	46	—	6	—
South Atlantic	36,113	35,310	803	—	—	—
East North Central	96,375	55,480	39,195	265	944	491
East South Central	21,934	19,624	2,240	64	—	6
West North Central	17,467	1,433	7,121	1,369	6,315	1,229
West South Central	4,219	9	75	3,526	18	591
Mountain	8,143	—	--	—	3,150	4,993
Pacific	1,888	20	3	24	333	1,508
Total	212,645	138,330	49,483	5,248	10,766	8,818

Table 2.2.2-4. Industrial Coal Distribution and Consumption (Continued)
(thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			Supply Region			
			1995			
New England	1,039	1,039	—	—	—	—
Mid Atlantic	33,886	33,815	60	—	11	—
South Atlantic	47,813	46,710	1,103	—	—	—
East North Central	129,175	74,380	52,495	365	1,244	691
East South Central	28,356	25,524	2,740	86	—	6
West North Central	22,467	1,833	9,121	1,769	8,115	1,629
West South Central	4,219	9	75	3,526	18	591
Mountain	9,143	—	—	—	3,550	5,593
Pacific	1,888	20	3	24	333	1,508
Total	277,986	183,330	65,597	5,770	13,271	9,968
			2000			
New England	1,299	1,299	—	—	—	—
Mid Atlantic	42,387	42,295	80	—	12	—
South Atlantic	59,933	58,590	1,343	—	—	—
East North Central	163,345	94,070	66,405	455	1,594	821
East South Central	35,277	31,644	3,520	106	—	7
West North Central	27,557	2,293	11,201	2,139	9,955	1,969
West South Central	4,219	9	75	3,526	18	591
Mountain	10,203	—	—	—	3,960	6,243
Pacific	1,888	20	3	24	333	1,508
Total	346,108	230,220	82,627	6,250	15,872	11,139

Sensitivity Analysis

One of the major factors effecting the estimate of coal consumption is the number of boilers in new plants which would be coal-fired. It was assumed that 100 percent of new boilers would be coal-fired. A sensitivity analysis was performed to test the change in total industrial coal consumption if this factor was varied. Because the market share of coal-fired boilers sold between 1972 and 1976 was between 7 and 10 percent of total industrial boiler sales, one of the sensitivity analyses used 10 percent for future coal-boiler sales. Market shares of 30, 50, and 80 percent were also analyzed. The results of this analysis are shown in Table 2.2.2-5.

Table 2.2.2-5. Coal-Boiler Sensitivity Analysis
(millions of short tons)

New Coal-Fired Boiler Market Share (percent)	1985	1990	1995	2000
100	147	213	278	346
80	138	196	253	313
50	124	170	215	263
30	113	150	187	226
10	103	133	162	192

The effect of varying this parameter is a marked change in industrial coal consumption in the year 2000. In the 10 percent market share case, coal consumption is reduced by 45 percent.

A comparison of these forecasts with other forecasts is shown in Table 2.2.2-6.

Table 2.2.2-6. Comparison of Industrial Coal Forecasts (millions of short tons)

	1985	1990	1995	2000
Baseline Scenario				
(100% coal boilers)	147	213	278	346
(30% coal boilers)	113	150	187	226
EIA*	223	248	280	
LPDO	111	159	233	
NCA*	97	125		
WOCOL*	88	124		243

*Includes industrial and residential/commercial coal consumption

EIA: DOE/Energy Information Agency, 1979 Annual Report to Congress
LPDO: DOE/Leasing Policy Development Office, Preliminary National and Regional Coal Production Goals for 1985, 1990 and 1995, Draft Report, July 24, 1980
NCA: National Coal Association, Long Term Forecast, February 22, 1980
WOCOL: Coal-Bridge to the Future, Report of the World Coal Study, 1980

The comparison shows that the baseline scenario with a coal-fired market share of 100 percent for new boilers is at the high end of the projections. Even though the 1995 baseline forecast is lower than EIA, the baseline scenario growth rate from 1985 to 2000 is higher than the EIA forecast growth rate from 1985 to 1995. The WOCOL projection combines the industry and residential/commercial(R/C) coal consumption forecasts. Current R/C load demand is about 9 million tons per year. The 30 percent market share case, therefore, appears to be comparable to the WOCOL projection for 2000.

A more in-depth comparison of the EIA projection shows that conversions by existing plants from oil and gas to coal comprises most of the increased coal consumption from the 1979 amount of 67 million tons. The major increase in coal consumption in the baseline scenario is the coal consumed in new plants and mainly for boilers.

As is mentioned in the DOE Leasing Policy Development Office study (see Table 2.2.2-6), presently available techniques for forecasting industrial fuel demands produce estimates that are subject to a considerable degree of uncertainty. The LPDO study states that some forecasts are made with upper and lower bounds of future increases in industrial coal demand. However, the range bracketed by these bounds is wide (about 100 million tons between 1985 and 1990) and the specific time path of demand growth within these bounds cannot be predicted with confidence.

Even though the baseline scenario forecast is at the high end of the other forecasts shown in Table 2.2.2-6, the 100 percent market share for the new coal boiler case is within the uncertainty range specified by the LPDO study.

The effect of the high oil price case in the baseline scenario would be to increase the amount of conversion of existing plants from oil and gas to coal. However, the high oil price is assumed to be too low to motivate industry to make the capital and operating expenditures needed to overcome environmental and technological problems of converting to coal. The additional amount of coal conversion is projected to be similar to the coal conversion that is forecasted for 1980 to 1985. The results are shown in Table 2.2.2-7.

Table 2.2.2-7. Industrial Coal Consumption
(millions of short tons)

Baseline Scenario	1985	1990	1995	2000
Low Oil Price Case	147	213	278	346
High Oil Price Case	147	225	290	358

2.2.3 Residential/Commercial Coal Demand

In 1950, coal consumption by the residential/commercial (R/C) and transportation sectors was approximately one-third of total coal demand. However, by 1979 R/C was approximately 1.3 percent of total demand with an almost negligible transportation consumption. Table 2.2.3-1 shows this trend of decreased coal consumption in these sectors.

Table 2.2.3-1. Residential/Commercial and Transportation Coal Consumption
(millions of short tons)

Year	Residential/Commercial	Transportation	Total Coal
1950	114.6	63.0	494.1
1955	68.4	17.0	447.0
1960	40.9	3.0	398.0
1965	25.7	0.7	472.0
1970	16.1	0.3	523.2
1971	15.2	0.2	501.6
1972	11.7	0.2	524.3
1973	11.1	0.1	562.6
1974	11.4	0.1	558.4
1975	9.4	(1)	562.6
1976	8.9	(1)	603.8
1977	9.0	(1)	625.3
1978	9.5	(1)	625.2
1979	9.1	(1)	680.9

(1) Less than 50,000 short tons

Source: DOE/EIA, 1979 Annual Report to Congress

As seen in the table, in 1974 and 1979, when the costs of home heating oil and natural gas were increasing, the amount of coal consumed in the R/C sector increased slightly or decreased. This would indicate that coal is not a substitute for oil and gas in this sector. Annual R/C coal consumption appears to have stabilized at a level of 9 to 10 million tons, which is forecasted to continue throughout the 1980-2000 period and will not change in the high oil price case. Transportation coal consumption is assumed to be zero for the baseline scenario. The coal flow for the R/C sector is shown in Table 2.2.3-2.

Table 2.2.3-2. Residential/Commercial Coal Distribution and Consumption (thousands of short tons) 1985-2000

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
Middle Atlantic	730	730				
South Atlantic	1,270	1,260	10			
East North Central	2,710	1,830	630		250	
East South Central	1,520	1,310	210			
West North Central	1,710	50	420	470	470	300
West South Central	20			20		
Mountain	1,820				1,530	290
Pacific	220				210	10
Total	10,000	5,180	1,270	490	2,460	600

2.2.4 U.S. Metallurgical Coal Demand

Coal, like wood and peat, contains carbon, hydrogen, oxygen, nitrogen, sulfur, and other constituents in small quantities. The proportions in which the major constituents are present vary greatly in different grades of coal. The proximate analysis of coal involves the determination of four constituents: moisture; ash, the residue following complete combustion; volatile matter, consisting of gases or vapors driven off when coal is heated at 960°C for 7 minutes; and fixed carbon, the solid residue, less its ash content, after the volatile matter has been driven off. Metallurgical coal must have certain properties which enable it to be processed into metallurgical coke. Metallurgical coke is used in steel-making.

Carbonization is the process of converting coal into coke. Coal is heated without burning to separate its volatile matter from the carbon. In ordinary practice, coke-oven temperatures are maintained above 1650°F but may range anywhere from 950° to 1800°F. Coke produced for metallurgical purposes is processed by high-temperature (above 1650°F) carbonization. On the average, high-temperature coke yield represents about 65 to 70 percent by weight of the coal.

Not all coals are suitable for coking, nor are all coking coals suitable for metallurgical purposes. Designation of a coal as coking or noncoking depends on its action when heated in the absence of air. A coking or caking coal softens and eventually solidifies into a more or less solid cake; noncoking coal crumbles on heating or forms a weakly coherent mass. To be suitable for by-product coking, a coal must satisfy the following technical requirements: low ash, low sulfur, low coking pressure, and high coke strength. Because of these requirements and the nature of U.S. coal resources, coal which originates from any given mine is not likely to be charged alone into a by-product oven for conversion into coke. Some indication of the very limited extent to which single coals meet all technical as well as economic requirements is evidenced by the existence of only one U.S. by-product facility producing coke from a single coal.

To satisfy all four technical requirements and to yield a highly superior synthesized coal for charging to the coke ovens, two, three, or more widely differing coals are purchased and mixed at coke-plant coal-preparation facilities. Large reserves of low-ash, low-sulfur, and high-coking-strength-yielding coals are available in the low-volatile coal fields, but these coals produce high and unacceptable pressures. The reserves of medium-volatile coals all yield high coke strength but are generally unacceptable because of high ash, high sulfur, or high coking pressure. Large reserves of low-to-medium ash, low-to-medium sulfur, and low-coking-pressure coals are available in the high-volatile coal fields, but these coals usually yield low and unacceptable coke strengths.

Blended and prepared synthesized coals charged to the by-product coke ovens seldom exceed 8 percent ash and 1.0 percent sulfur. Most coke plants synthesize coal so that pressure against the oven walls during the process will not exceed 1.5 to 2.0 psi, and so that the product will be physically strong with coke stability indices greater than 50.

Hard coke for metallurgical purposes is produced from coals yielding between 18 and 32 percent volatile matter, but some coals outside this range may be used in blends. Sulfur content is important because the total sulfur in the coke is not very different from that in the coal which is carbonized. High sulfur content causes steel to become brittle and difficult to roll.

Table 2.2.4-1 shows the amount of coal recently consumed for the production of all types of coke.

Table 2.2.4-1. Annual Consumption of Coal by U.S. Coke Plants (thousands of short tons)

1970	96,000
1971	82,800
1972	87,300
1973	93,600
1974	89,700
1975	83,300
1976	84,300
1977	77,400
1978	71,394
1979	77,070

Source: DOE/EIA, 1979 Annual Report to Congress, Energy Data Report - Coke and Coal Chemicals

In addition to metallurgical coal, the coke plants produce coke which is used as a smokeless fuel for industry and residential heating. Also, when coal is carbonized, by-products such as coal tars, gases, and chemicals are produced and sold. However, the nonmetallurgical production of coke was less than 3 percent of the total production in 1979. Therefore, the growth rates for the amount of coal consumed for total coke production and for metallurgical coal consumption are assumed to be the same.

In 1977, 77.4 million tons of coal were carbonized in the U.S. Coking coal production in 1979 was 77 million tons for U.S. consumption and 52 million for export. Approximately 67 million tons are projected to be the new annual production capacity for metallurgical coal to be added between 1978 and 1987[1]. This amount of planned new capacity indicates that supply can continue to meet the demand for coking coal at a price equal to the marginal mine cost plus a premium for the high-quality characteristics of the coking coal.

The amount of metallurgical coal used domestically will be related to the amount of steel produced. The U.S. and European Common Market experienced average growth rates in steel production below the annual world average of 3.3 percent during 1973-1978. Between 1964 and 1974, U.S. steel production increased annually by approximately 1.4 percent. In the 1976 edition of Mineral Facts and Problems, the Department of Interior projected that the annual U.S. demand for steel would increase by 1.25 to 1.6 percent to the year 2000.

Though the production of steel has increased since 1965, the consumption of coal has decreased. This is a result of decreased coke rates. Coke rate is the number of pounds of coke consumed per ton of pig iron produced. In 1964 the rate was 1,326; in 1976 it was 1,173--a total decrease of 13 percent or 1 percent per year. Coke rates in the U.S. are inefficient by present world standards. The Japanese steel industry, considered the most efficient in the world, has a coke rate of only 880 pounds per ton. To compete for the world market, the U.S. will have to lower its coke rate in new replacement steel mills. This will hold growth in demand for metallurgical coals below the rate of growth in steel production. Table 2.2.4-2 shows projections of domestic coking coal consumption.

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[1] 1979 Keystone Coal Industry Manual

Table 2.2.4-2. Domestic Coking Coal Consumption
(millions of short tons)

	1985	1990	1995
National Coal Association (NCA)	75	75	--
Energy Information Agency (EIA)	74	78	79

Source: DOE/EIA, 1979 Annual Report to Congress
NCA, Long-Term Forecast, February 22, 1980

Both projections show virtually no change in the amount of coal consumed for coke production. The 1979 consumption of 77 million tons, an increase over the 1978 figure, is partly due to an increase in oil prices. Some of the heat required in the iron and steel making process can be supplied by either coke or oil. Depending on the cost of alternative fuels more coke can be used to decrease oil consumption. An annual coal consumption of 77 million tons will be used for the low world oil price baseline scenario for 1985-2000. This is based on the assumption that the coke rate will not decrease as rapidly as in the past 20 years due to the higher cost of oil and gas. Because coking coal consumption in 1977 was also 77 million tons, the projected coal flows, shown in Table 2.2.4-3, are assumed to be similar to those experienced in 1977.

Table 2.2.4-3. Coking Coal Distribution and Consumption - 1985-2000
(thousands of short tons)

		Supply Region			
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Mountain
Middle Atlantic	23,003	23,003			
South Atlantic	8,955	8,955			
East North Central	31,917	16,959	14,958		
East South Central	6,639	6,639			
West North Central	912		912		
West South Central	828	828			
Mountain	2,939			589	2,350
Pacific	1,800				1,800
Total	76,993	56,384	15,870	589	4,150

Source: Calculated from EIA Energy Data Reports, Coke and Coal Chemicals 1977; 1979 Keystone Coal Industry Manual.

Sensitivity Analysis

If the coke rate remains stable during any one year, a change in the amount of steel produced would have a corresponding change in the amount of coal consumed in the production of coke. In the high oil case, economic activity may be slowed, which may decrease the amount of steel produced. If oil prices are increased, there may be a corresponding increase in the coke rate. In the 1979 Annual Report to Congress, EIA showed the effect on coal consumption by domestic coke producers. Table 2.2.4-4 shows the results of the EIA high oil price case.

Table 2.2.4-4. U.S. Coking Coal Consumption
(millions of short tons)

Year	Medium World Oil Price	High World Oil Price
1985	74	73
1990	78	77
1995	79	79

Source: DOE/EIA, 1979 Annual Report to Congress

In the early time frame, a change in world oil price has minimal effect on coking coal consumption and no effect over the long term. It is assumed, therefore, that coal consumption will be the same in both the high and low oil price cases.

2.2.5 Coal Demand for Synfuels

To estimate the amount of coal consumed in the production of synfuels, it is first necessary to estimate the amount and type of synfuels that will be produced. Both gases and liquids could be derived from coal.

Low-, medium-, and high-Btu are the three types of gas which can be produced from a coal gasification plant. Low-Btu gas (80 to 150 Btu/scf) is used as a fuel near its point of generation since its low heating value makes it uneconomical to distribute over long distances. Medium-Btu gas (300 to 500 Btu/scf) can be used as a fuel and transported economically over distances of several hundred miles. It can also be used as a chemical feedstock for the production of methanol or gasoline, and it can be converted catalytically to substitute natural gas (high-Btu gas) having a heating value of about 1,000 Btu/scf. Medium-Btu gasification is integral to all indirect liquefaction technologies.

Many coal gasification technologies differ in design and operation depending on the type of coal used and the product desired. Low-Btu gasification processes have been used for years and are readily available. High- and medium-Btu gasification technologies using noncaking coals characteristic of U.S. western coals, are relatively well developed.

There are two basic methods of producing coal liquids. In indirect liquefaction coal is gasified and then turned into liquid. As in the high- and medium-Btu gasification technologies, western coals are more suited for indirect liquefaction. In direct liquefaction processes by which coal is converted directly into liquid products, both western and eastern coals can be used.

Projections of the amount of synfuels that can be produced by the year 2000 vary from very little to 15 million barrels per day of oil equivalent (MMBDOE). Total petroleum consumption averaged 18.4 million barrels per day in 1979. Daily imports averaged 8.4 million barrels day in 1979 with Arab OPEC imports equalling 3.0 million. To decrease petroleum imports the President announced a 1990 goal of producing 1.0 to 1.5 MMBDOE of coal liquids and gases. DOE plans for implementation of this goal would result in production of 1.0 MMBDOE of coal liquids, 0.5 of high-Btu gas, and 0.29 of low- and medium-Btu gas in 1992.

This 1992 coal synfuel goal of 1.79 MMBDOE is considered very optimistic by many people involved with the new synfuel industry. Table 2.2.5-1 shows a number of recent projections for the amount of synfuels that will be produced. The projections for 1985, 1990, and 1995 made by the DOE Leasing and Policy Development Office of Resource Applications (LPDO) are within the range shown in Table 2.2.5-1. Table 2.2.5-2 shows the results of an analysis performed by the LPDO on the allocation of coal supply to synfuel plants. Synfuel demands for coal are dependent upon demands for synthetic fuels, conversion technologies and costs, financial incentives offered by the Federal government, regulations, and other conditions. Together these factors determine the types and quantities of coal used to produce coal-derived synfuels. Because synfuel production capacity in 1985 is essentially predetermined by the number and size of plants currently planned, the synfuel demand in 1985 is held constant at 75,000 barrels per day of crude equivalent. If existing technologies, financial incentives, and policies are moderately sucessful, then the level of demand projected by LPDO is expected to be reached.

The approach for allocation of coal synfuels to the national demand regions was to supply coal to the plant expected to be available by 1985, and to determine on the basis of two criteria the most likely pattern of growth in regional plant capacity by 1990 and 1995: (1) coal availability/suitability; and (2) regional/technical diversity. The first criterion is considered a prerequisite for siting a plant because the economics of coal conversion and transportation favor a plant location near the coal fields serving that plant.

The second criterion becomes more critical because of the large number of plants required. While some coal demand regions contain sufficient coal reserves to serve several synfuel plants, the total plant capacity that can be sited in a single region may be limited by other factors such as water availability, storage and transportation, air quality standards, coal transportation facilities, and community impacts. Some of these constraints are likely to be binding in the sparsely populated arid regions of the West. To reduce the likelihood of exceeding these constraints as well as the technical and economic risks that accompany a regional concentration of synfuel plants, a dispersed regional siting pattern was assumed by the

Table 2.2.5-1. Projections of Coal Synfuels Production
(million barrels per day oil equivalent)

	1985		1990		1995		2000	
	L	G	L	G	L	G	L	G
[1] 1979 Annual Report to Congress	0	0.047	0	0.142	0.109	.331	0.666	_
[2] Office of Policy and Evaluation	-	0.024	0	0.024	-	-	1.5	1.18
[3] Office of Environment	-	-	0.35	0.23	0.6	0.4	-	-
[4] LPDO	0.075*		0.6*		1.0*			
[5] GRI	-	-	-	-	-	-	-	1.2
[6] TRW	-	-	-	0.6	0.5	0.7	1.0	0.7
Energy Security Act (S930) (President's Goal)	-	-	0.56	0.37	1.2	0.8	2.0	1.3

* Liquids and gases combined

1 Energy Information Agency, DOE, 1979 Annual Report to Congress

2 Assistant Secretary for Policy and Evaluation, Policy and Fiscal Guidance Energy Projections, February 1980, Best Estimate Case, July 24, 1980

3 Assistant Secretary for Environment, DOE, Synthetic Fuels and the Environment, June 1980

4 Leasing Policy Development Office, Resource Applications, DOE, Draft Preliminary National and Regional Coal Production Goals for 1985, 1990, and 1995 Medium Case, July 24, 1980

5 Gas Resource Institute, Briefing of the Federal Energy Regulatory Commission on the Gas Supply and Demand Outlook, April 25, 1980

6 TRW, Utilization of Synthetic Fuels: An Environmental Perspective, Draft Report, Nominal Production Scenario, July 14, 1980

Table 2.2.5-2. Regional Demand of Coal for Synthetic Fuel Plants (10^{15} Btu)

Coal Type and Demand Region	Medium 1985	Medium 1990	Medium 1995
Bituminous[a]			
Colorado			.167
Eastern Kentucky		.167	.167
Illinois	.083	.334	.500
Southern Ohio			.167
Texas		.083	.167
Utah			.167
Western Kentucky			.167
Western Pennsylvania		.167	.167
West Virginia		.167	.167
Subbituminous[b]			
Montana		.167	.334
New Mexico		.167	.167
Wyoming	.083	.334	.334
Lignite[c]			
North Dakota	.083	.334	.500
Texas		.083	.167
Total	.249	2.003	3.338

[a] 11,000 Btu/lb or 22 million Btu/st
[b] 9,000 Btu/lb or 18 million Btu/st
[c] 7,000 Btu/lb or 14 million Btu/st

Source: Leasing Policy Development Office, DOE, Preliminary National and Regional Coal Production Goals for 1985, 1990, and 1995, Draft Report, July 24, 1980

LPDO. Since such a pattern implies the use of several coal types and possibly different conversion technologies, the technical and economic risks would be lower than for a more concentrated pattern. The regional distribution of coal feedstock demands indicates that 60 percent of the total demand is generated by plants located west of the Mississippi River and 40 percent from plants located to its east. A higher western percentage was assumed because first-generation commercial plants are expected to operate more efficiently with noncaking western coal. Also, lignite deposits located in the Fort Union Formation and in Texas are better suited for conversion to synfuels than for electricity generation.

The type of coal specified for plants located in each demand region is the most abundant coal type found in the nearest supply region. Certain Texas plants plan to utilize bituminous coal from the East Interior region and, therefore, would deviate from this assumption.

Using the TRW projection for synfuel production in 2000 and the 1995 coal allocation in Table 2.2.5-2, the amount of coal supplied to the synfuel plants can be calculated. Table 2.2.5-3 shows the amount of coal utilized by the synfuel plants and the coal supply region.

Table 2.2.5-3. Regional Supply of Coal for Synfuels
(millions of short tons)

Region	1985	1990	1995	2000
Appalachia	--	23	30	52
East Interior	4	19	38	64
West Interior and Gulf	--	6	12	20
Northern Great Plains	11	52	73	124
Mountain		9	25	42
Total	14	109	178	302

A comparison of coal consumption forecasts for synfuel production is shown in Table 2.2.5-4.

Table 2.2.5-4 Comparison of Coal Consumption Forecasts for Synfuels
(millions of short tons)

	1985	1990	1995	2000
Baseline Scenario (Low Oil Price)	14	109	178	302
EIA	12	27	104	
LPDO	15	113	184	
NCA	0	1.2		
WOCOL	0	5.5		220

This table shows that the baseline scenario projection is at the high end of the range of the forecasts. However, because this coal forecast is based upon what appears to be a reasonable projection of coal-derived synfuel production, this forecast of coal consumption is a reasonable one.

From Tables 2.2.5-2 and 2.2.5-3, the coal flows in Table 2.2.5-5 can be calculated.

Sensitivity Analysis

Synfuels production is impacted by the cost of alternatives and the readiness of synfuel technologies. Petroleum and natural gas are major alternatives to the coal synfuel products. The projection of the amount of synfuels produced in Table 2.2.5-1 is for the low world oil price described in Section 2.1. The synfuel projection is also based on the assumption of moderate success of governmental financial incentives and policies and the activities of the Synthetic Fuels Corporation (SFC).

With an increase in the prices of oil and natural gas, as in the high world oil price case, there would be a corresponding increase in the economic competitiveness of coal-derived synthetic fuels. However, the readiness of the technology would not increase in the early years (1980-1990). More industry-sponsored development may occur during the 1980-1990 time frame if the high oil price were to occur. This would minimally increase synfuel production between 1990 and 2000 (5 to 10 percent). The 1990-2000 time frame represents a period of testing, proving, and improving the synfuel technology. Demonstration and commercial plants would be built and operated during this period, requiring large subsidies from the government and made available through DOE and the SFC. The higher world oil price will not substantially increase the amount of synfuels produced until the technologies have been proven (post-2000). Table 2.2.5-6 shows the projected impact of the high oil price case.

Table 2.2.5-5. Coal Consumption and Distribution for Synfuel Production
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1985						
New England						
Mid Atlantic						
South Atlantic						
East North Central	3,800		3,800			
East South Central						
West North Central	5,900				5,900	
West South Central						
Mountain	4,600				4,600	
Pacific						
Total	14,300		3,800		10,500	
1990						
New England						
Mid Atlantic	7,600	7,600				
South Atlantic	7,600	7,600				
East North Central	15,200		15,200			
East South Central	7,600	7,600				
West North Central	23,900				23,900	
West South Central	9,700		3,800	5,900		
Mountain	37,100				27,800	9,300
Pacific						
Total	108,700	22,800	19,000	5,900	51,700	9,300

Table 2.2.5-5. Coal Consumption and Distribution for Synfuel Production (Continued)
(thousands of short tons)

Demand Region	Total	Supply Region: Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1995						
New England						
Mid Atlantic	7,600	7,600				
South Atlantic	7,600	7,600				
East North Central	30,300	7,600	22,700			
East South Central	15,200	7,600	7,600			
West North Central	35,700				35,700	
West South Central	19,500		7,600	11,900		
Mountain	61,600				37,100	24,500
Pacific						
Total	177,500	30,400	37,900	11,900	72,800	24,500
2000						
New England						
Mid Atlantic	12,930	12,930				
South Atlantic	12,930	12,930				
East North Central	51,530	12,930	38,600			
East South Central	25,810	12,910	12,900			
West North Central	60,700				60,700	
West South Central	33,100		12,900	20,200		
Mountain	104,800				63,100	41,700
Pacific						
Total	301,800	51,700	64,400	20,200	123,800	41,700

Table 2.2.5-6. Coal Demand for Synfuel Production
(thousands of short tons)

Year	Low Oil Price	High Oil Price
1985	14	14
1990	109	114
1995	178	191
2000	302	332

Because synfuel production is an emerging technology it appears that, with the current government programs, the amount of synfuels produced will not deviate significantly from the projections for the low oil price case within the 1980-2000 time frame.

2.2.6 Export Coal Demand

Over the past 20 years, the export of coal has shown only slight growth. Even recently, in a time of rapidly increasing petroleum costs, coal exports have stagnated. Table 2.2.6-1 shows the history of coal exports.

Table 2.2.6-1. U.S. Coal Exports
(millions of short tons)

1960	38.0
1965	52.2
1970	72.4
1971	58.0
1972	57.2
1973	54.0
1974	61.1
1975	66.8
1976	60.6
1977	54.7
1978	41.0
1979	66.3

Source: DOE/EIA, 1979 Annual Report to Congress

The recent stagnation in coal exports is partly a result of the low economic growth resulting from high energy prices. The industrialized countries could reduce the cost of energy by switching from oil to coal. In 1978 the United States produced 17.1 percent of total international production or 37.9 percent of the non-Communist production. The United States has 30.7 percent of the world's recoverable coal reserves or 58 percent of those of the free world. As the industrial countries shift toward coal the U.S. is likely to supply some of the additional demand. Strong expressions of interest in steam coal purchases have been received by U.S. coal companies from a number of countries, and some purchases already made.

Two types of coal are presently being exported: metallurgical and steam. Of the 66 million tons exported in 1979, 50 million were metallurgical coal. Due to the decreasing coke rate and low growth rate of steel production (see Section 2.2.4, Metallurgical Coal Demand) it appears that metallurgical coal exports will remain at the 1979 level. On the other hand, steam coal exports have a high potential for growth. Table 2.2.6-2 shows a projection for coal exports from the National Security Council (NSC) study, Moving U.S. Coal to Export Markets.

Table 2.2.6-2. Projected U.S. Coal Exports
(millions of short tons)

Year	Total	Steam	Metallurgical
1979	66	16	50
1985	75	25	50
1990	110	60	50

Source: National Security Council, Moving U.S. Coal to Export Markets, Draft Report, June 10, 1980

A comparison of the NSC projection with others is shown in Table 2.2.6-3.

Table 2.2.6-3. Comparison of Coal Export Projections

	1985	1990	1995	2000
NSC	75	110		
EIA	85	108	143	
NCA	74	89		
WOCOL	88	132		220

Source: NSC, National Security Council, Moving U.S. Coal to Export Markets, June 10, 1980
EIA, Energy Information Administration, 1979 Annual Report to Congress
NCA, National Coal Association, Long-Term Forecast, February 22, 1980
WOCOL, Coal-Bridge to the Future, Report of the World Coal Study, 1980

The NSC projection was based on a study of the future world requirements of steam coal and the possible sources of supply. The projections for 1985 and 1990 are within the range of projections shown in the above table. The WOCOL projection for 1990 is significantly higher than the others. The estimate of 220 million tons for the year 2000 would require a growth rate from 1990 to 2000 which is 50 percent higher than the WOCOL 1980 to 1990 growth in export coal. The 1995 EIA forecast appears to follow the trend projected in the NSC study. This same trend is used for the projection of export coal in the year 2000. Table 2.2.6-4 shows the estimate of coal exports for the baseline scenario.

Table 2.2.6-4. Baseline Scenario Coal Export Projection (millions of short tons)

1956	75
1990	110
1995	143
2000	176

The projected rise in U.S. coal exports implies increased production in all major coal regions of the country. The supply regions for the projected coal exports are shown in Table 2.2.6-5.

Table 2.2.6-5. Coal Exports and Supply Regions (millions of short tons)

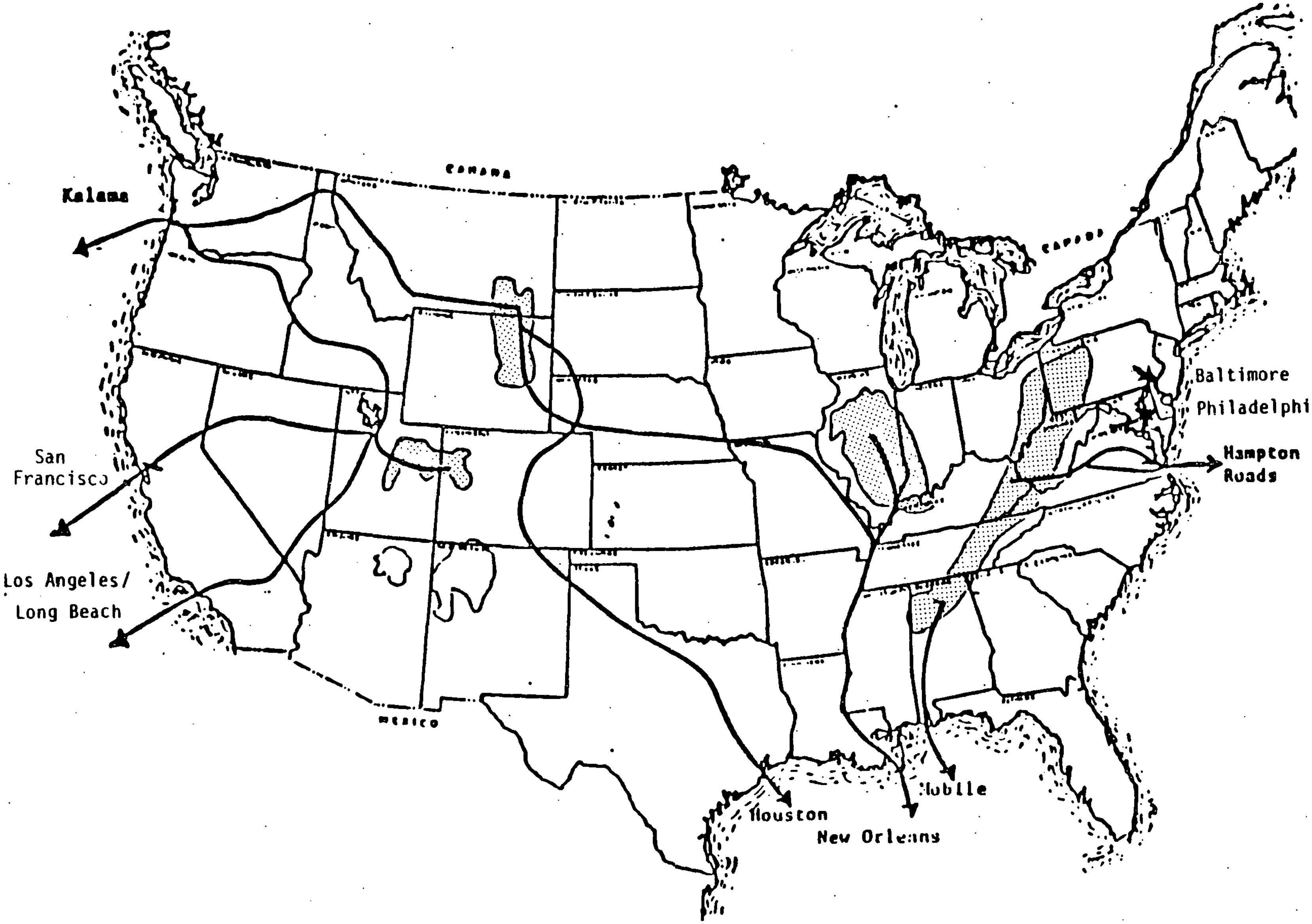
	1979	1985	1990	1995	2000
Appalachia	65.8	70	79	88	97
East Interior	@	2	3	4	5
West Interior and Gulf	0.2	3	4	5	6
Northern Great Plains	0	0	18	34	50
Mountain	@	@	6	12	18
Total	66	75	110	143	176

@ represents less than 50,000 tons

Source: DOE/EIA, Bituminous and Subbituminous Coal and Lignite Distribution, Calendar Year 1979
National Security Council, Moving Coal to Export Markets, June 10, 1980

As can be seen from this table a major new source of coal would be the Northern Great Plains and Mountain regions. Figure 2.2.6-1 shows the rail and waterway routes projected for coal movement to ports for export.

Appalachian coal presently is exported from ports in Philadelphia, Pennsylvania; Baltimore, Maryland; and Hampton Roads, Virginia; and from the Mississippi River and the Warrior River in Alabama to the Gulf of Mexico. Appalachian coal is exported to Canada via the Great Lakes. East and West Interiors and Gulf region coals are exported via the Mississippi River. East Interior region coal is also barged to the Great Lakes. Mountain region coal is transported by rail to Long Beach, California for loading on ships. Coal received in Philadelphia, Baltimore, and Hampton Roads is transported from the coal fields by railroad. In addition to



Source: National Security Council, Moving U.S. Coal to Export Markets

Figure 2.2.6-1. Principal U.S. Coal Basins and Inland Rail and Waterway Routes to Coal Ports expansion of existing harbors, plans are being considered or implemented at other U.S. ports to provide coal export loading capability.

These plans are in various stages of development. For example, within the next five years, the ports of Wilmington, Delaware; Brunswick, Georgia; Galveston, Texas; Houston, Texas; and Astoria, Oregon; expect to begin construction of new coal transfer facilities. Additionally, there are loading facilities at Port Reading, New Jersey, and La Hache, (Plaquemines Parish) Louisiana, that presently transfer steam coal for domestic seaborne movements, but where expansion is under active consideration for handling export shipments. Finally, some ports, such as Charleston, South Carolina, and Savannah, Georgia, have no plans for handling coal exports, but could transform existing bulk handling facilities to coal operations should the need arise.

Based on a projection of export coal requirements and existing and future port capacities, the NSC study projected the amount of coal that would be exported by each port. Table 2.2.6-6 lists the ports and projected amounts of exports.

Table 2.2.6-6. Projected U.S. Coal Exports

Region and Port	1979	1985	1990	1995	2000
Atlantic Philadelphia/ Baltimore/ Hampton Roads	41	43	55	67	79
East North Central Great Lakes	20	20	10	10	10
East South Central Mobile	4	5	7	10	13
West South Central Houston/New Orleans	1	7	23	20	29
Pacific Long Beach/Los Angeles/ San Diego/San Francisco/ Oakland/Seattle/Portland	-	-	15	30	45
Total	66	75	110	143	176

Source: National Security Council, Moving U.S. Coal to Export Markets, June 10, 1980

Coal exports via the Great Lakes decrease in 1990. This coal is exported only to Canada whose requirements for export coal are projected to decrease. All other exports are projected to increase, especially western coal. Table 2.2.6-7 shows the coal flows for both the low and high oil price cases.

In the 1979 Annual Report to Congress, EIA projects no change in the amount of exports for the low, middle and high oil prices. The coal importing countries presently are implementing a vigorous program to substitute lower cost coal for their oil imports. It is assumed that these programs would not be accelerated or increased if a higher world oil price were to be imposed. The coal flow projections shown in Table 2.2.6-7 therefore, are, similar for both the low and high oil price cases.

Table 2.2.6-7. Coal Consumption and Distribution for Exports (thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			Supply Region			
			1985			
New England						
Mid Atlantic	1,000	1,000				
South Atlantic	42,000	42,000				
East North Central	20,000	20,000				
East South Central	5,000	5,000				
West North Central	0					
West South Central	7,000	2,000	2,000	3,000		
Mountain	0					
Pacific						
Total	75,000	70,000	2,000	3,000		
			1990			
New England						
Mid Atlantic	5,000	5,000				
South Atlantic	50,000	50,000				
East North Central	10,000	10,000				
East South Central	5,000	5,000				
West North Central						
West South Central	25,000	9,000	3,000	4,000	9,000	
Mountain						
Pacific	15,000				9,000	6,000
Total	110,000	79,000	3,000	4,000	18,000	6,000

Table 2.2.6-7. Coal Consumption and Distribution for Exports (Continued)
(thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			Supply Region			
			1995			
New England						
Mid Atlantic	5,000	5,000				
South Atlantic	62,000	62,000				
East North Central	10,000	10,000				
East South Central	5,000	5,000				
West North Central						
West South Central	31,000	6,000	4,000	5,000	16,000	
Mountain						
Pacific	30,000				18,000	12,000
Total	143,000	88,000	4,000	5,000	34,000	12,000
			2000			
New England						
Mid Atlantic	5,000	5,000				
South Atlantic	74,000	74,000				
East North Central	10,000	10,000				
East South Central	5,000	5,000				
West North Central						
West South Central	37,000	3,000	5,000	6,000	23,000	
Mountain						
Pacific	45,000				27,000	18,000
Total	176,000	97,000	5,000	6,000	50,000	18,000

2.3 BASELINE SCENARIO FORECAST

In the previous section, each of the end-use sectors was analyzed and a coal supply and demand was forecast for two price levels for world oil. Table 2.3-1 is a composite of these forecasts.

Table 2.3-1. U.S. Coal Consumption
(millions of short tons)

End-Use Sector	1979	1985		1990		1995		2000	
		L	H	L	H	L	H	L	H
Electric Utility	529	731	735	894	899	1,096	1,121	1,347	1,377
Industry	66	147	147	213	225	278	290	346	358
Residential/ Commercial	9	10	10	10	10	10	10	10	10
Metallurgical	77	77	77	77	77	77	77	77	77
Synthetics	0	14	14	109	114	178	191	302	332
Export	65	80	--	100	110	143	143	176	176
Total	746	1,054	1,054	1,413	1,435	1,782	1,832	2,258	2,330

L - Low Oil Price

H - High Oil Price

Total coal consumption in the high oil price case increases only slightly over the low oil price case. The synfuel sector is the only sector which shows a significant increase (approximately 10 percent) in coal consumption. The difference in coal consumed by the utility and industrial sectors between the low and high oil cases is due to the amount of coal that is substituted for oil and gas. The amount of additional substitution that occurs in the high oil price case is not much greater than that in the low oil case. This is due to the fact that the low oil price is sufficiently high to cause conversion to coal where it can be easily accomplished. The high oil price is assumed to be too low to motivate the utilities and industry to overcome environmental and technological problems of converting to coal. However, the high oil price does make conversion financially possible for some utilities and industries where the low oil price does not.

The production of coal for the low oil price case is shown by region in Table 2.3-2. Total coal production triples between 1979 and 2000, and western production in 2000 is 4.8 times the 1979 production. Coal production in the Northern Great Plains increases more than any other region in the U.S. However, eastern coal production still remains larger than western with 53 percent of total coal production. Table 2.3-3 shows coal demand by region and Table 2.3-4 shows the coal flow from production region to demand. The amount of western coal that is consumed in the East rises from 35 million short tons in 1979 to 86 million short tons in 2000. Eastern coal consumed in the West increases from 19 million in 1979 to 54 million in 2000. This shows that coal produced in the West is consumed mainly in the West and eastern coal is consumed east of the Mississippi.

Table 2.3-2. U.S. Regional Coal Supply - Low Oil Price (millions of short tons)

Supply Region	1979	1985	1990	1995	2000
Appalachia	412.3	506	620	728	862
East Interior	130.0	182	225	275	337
West Interior and Gulf	40.1	68	98	133	178
Northern Great Plains	124.9	206	338	464	641
Mountain	55.2	93	132	182	241
Total	762.5	1,055	1,413	1,781	2,258

Table 2.3-5 is a comparison of the results of the baseline scenario with other forecasts. The baseline scenario forecast of total coal consumption is at the high end of the range of the other forecasts. However, the range of all the forecasts in any one year is less than 20 percent. The synfuel and industrial end-use sector forecasts appear to be higher than most of the others. The synfuel forecast assumes that in the year 2000, coal-derived synfuels would equal 1.7 MMBDOE. This appears to be similar to the trend forecasted by LPDO and is about one-half of the goal set by the Energy Security Act (S930). The major reason for the high industry and consumption forecast is the assumption that all boilers installed in new plants will be coal-fired.

Table 2.3-3. U.S. Regional Coal Demand - Low Oil Price
(millions of short tons)

Demand Region	1979	1985	1990	1995	2000
New England	1.2	2	2	3	3
Mid Atlantic	79.9	98	126	145	171
South Atlantic	150.0	183	225	266	317
East North Central	235.4	307	364	440	531
East South Central	90.5	115	142	172	209
West North Central	80.7	126	177	228	301
West South Central	49.6	113	193	272	372
Mountain	66.2	100	156	210	290
Pacific	8.6	11	28	46	64
Total	762.1	1,055	1,413	1,781	2,258

Table 2.3-4. U.S. Coal Consumption and Distribution
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1985			
New England	2,024	2,024				
Mid Atlantic	98,254	98,221	32		1	
South Atlantic	182,945	172,500	10,412	33		
East North Central	307,431	153,601	109,266	227	37,102	7,235
East South Central	114,743	74,367	38,089	83	1,534	670
West North Central	125,553	1,956	21,796	10,379	74,169	17,253
West South Central	112,792	2,855	2,255	56,556	47,997	3,149
Mountain	99,491			589	39,047	59,855
Pacific	11,311	20	3	24	6,148	5,116
Total	1,054,544	505,544	181,853	67,871	205,990	93,278
			1990			
New England	2,324	2,324				
Mid Atlantic	126,312	126,260	46		6	
South Atlantic	224,471	213,235	11,203	33		
East North Central	364,359	169,369	141,160	327	42,471	11,032
East South Central	141,740	96,369	41,859	105	2,679	728
West North Central	176,514	2,356	23,796	10,779	120,131	19,452
West South Central	192,489	9,855	7,218	86,001	85,612	3,803
Mountain	156,209			589	71,149	84,471
Pacific	28,445	20	3	24	15,639	12,759
Total	1,412,863	619,788	225,285	97,858	337,687	132,245

Table 2.3-4. U.S. Coal Consumption and Distribution (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	2,624	2,624				
Mid Atlantic	144,699	144,628	60		11	
South Atlantic	265,687	253,547	12,107	33		
East North Central	440,244	204,325	170,819	427	49,012	15,661
East South Central	171,610	112,738	53,986	127	4,089	670
West North Central	227,742	2,756	25,796	11,179	165,945	22,066
West South Central	272,264	6,855	12,219	120,785	127,846	4,559
Mountain	210,298			589	91,318	118,391
Pacific	46,062	20	3	24	25,243	20,772
Total	1,781,230	727,493	274,990	133,164	463,464	182,119
			2000			
New England	2,884	2,884				
Mid Atlantic	171,364	171,272	80		12	
South Atlantic	317,030	303,895	13,102	33		
East North Central	530,622	239,914	211,701	517	57,163	21,327
East South Central	209,021	137,253	65,099	147	5,851	671
West North Central	300,863	3,216	27,876	11,549	233,048	25,174
West South Central	371,937	3,855	18,770	164,812	178,884	5,616
Mountain	290,291			589	130,813	158,889
Pacific	64,333	20	3	24	34,998	29,288
Total	2,258,345	862,309	336,631	177,671	640,769	240,965

Table 2.3-5. Comparison of Forecasts of U.S. Coal Production
(millions of short tons)

	Forecast														
	Baseline Scenario Low Oil Price				EIA			LPDO			NCA		WOCOL		
End-Use Sector	1985	1990	1995	2000	1985	1990	1995	1985	1990	1995	1985	1990	1985	1990	2000
Electric Utility	731	894	1096	1347	737	884	1115	667	906	1080	733	959	617	825	1290
Industrial	147	213	278	346	-	-	-	111	159	233					
Residential/ Commercial	10	10	10	10	-	-	-	14	13	11					
Total R/C & Industrial	157	223	288	356	223	248	280	125	172	244	97	125	88	124	243
Metallurgical	77	77	77	77	74	78	79	74	78	76	75	75	94	99	121
Synfuels	14	109	178	302	12	27	101	15	113	184	0	1	0	6	221
Export	80	100	143	176	85	108	143	82	103	135	74	89	88	132	221
Total	1054	1413	1782	2258	1130	1343	1715	963	1372	1718	976	1260	887	1185	2095

EIA: Energy Information Administration-Preliminary 1985, 1990, 1995 Energy Forecasts for the Annual Report to Congress, 1979
LPDO: DOE/Leasing Policy Development Office, Preliminary National and Regional Coal Production Goals, for 1985, 1990, and 1995, July 24, 1980
NCA: National Coal Association - NCA Economics Committee, Long Term Forecast, February 22, 1980
WOCOL: Coal-Bridge to the Future, Report of the World Coal Study 1980

3.0 CONSTRAINED OIL SUPPLY SCENARIO

The purpose of this scenario is to study the effect on U.S. coal production and consumption of a disruption in the supply of Arab OPEC oil. Political instabilities appear to occur every five to six years. Six years before the 1973-1974 embargo, which was prompted by the Yom Kippur War, the Six Day War occurred. Five years after the embargo, the Iranian government was overthrown. Removal of the Shah of Iran in 1979 brought about the doubling of world oil prices by mid-1980. Considering the continued problems in the Middle East it is quite possible that there could be a political and/or military perturbation causing an embargo to be levied on all western countries. The following section details the assumptions relating to the embargo and its effects.

3.1 CONSTRAINED OIL SUPPLY SCENARIO ASSUMPTIONS

An embargo of Arab OPEC oil exports to all western countries would have a major impact on the United States. In 1979 these exports to the U.S. averaged 3 million barrels per day of petroleum. Total U.S. imports from OPEC and non-OPEC countries were 5.6 and 2.8 MM bbl/day, respectively. For 1979 total imports averaged 8.4 MM bbl/day, and total consumption averaged 18.4 MM bbl/day. Both imports and consumption have decreased in May 1980 to 6.0 and 16.6 MM bbl/day, respectively. Dependence on imported oil can decrease in the future as conservation, synfuel production, and coal utilization increase.

By 1985 electric utility power plants are assumed to have started conversion of coal-capable plants back to coal, and coal-derived synfuel production is assumed to have begun. This would enable reduction of U.S. dependence on foreign oil, but would not be significant prior to 1985 and would not be of major significance until 1990. Because of the five-to-six-year cycle of instability in the Middle East it is assumed that the embargo will occur during the latter half of 1985. A shortfall in petroleum supply would occur because it is assumed that the U.S. would still be importing a significant amount of oil from the Arab OPEC countries and that other sources would be unable to compensate for the amount of embargoed oil.

Because the Arab countries have accumulated large sums of money from the sale of oil since 1974, it is assumed that it would be economically feasible for the Arab OPEC countries to cease exporting for two years. A decrease in supply of this duration is assumed to double the cost of non-Arab oil exports.

The shortage of oil and its subsequently increased cost in the U.S. would cause a major reorientation in lifestyle. The "moral equivalent of war" would become evident to all Americans and would foster an energy consciousness that would significantly increase conservation. An increased cost of energy and gasoline rationing would impel conservation efforts. Alcohol fuel production for gasohol is assumed to receive a tremendous boost that would increase production to approximately 5 percent of petroleum consumption for transportation. Conservation in the forms of reduced driving; reduced residential use of electricity and, hence, reduced utility oil consumption; and reduced oil consumption in industry through substitution of natural gas and reduced production would compensate for the decreased supply of oil in the short term.

In the longer term, the utilization of coal, synfuel technologies, and nuclear power would be enhanced, and domestic oil and gas production would increase. The effect on coal supply and demand is analyzed in the following section.

3.2 COAL SUPPLY AND DEMAND

Under this scenario, it is assumed to be economical to use coal wherever technically feasible. An increase in demand for coal would start as soon as the embargo starts to become effective. This would occur about three months after the start of the embargo because of the long oil supply lines from the Middle East to the United States. The higher oil and gas prices are assumed to have the effect of reducing demand, but forced conservation measures such as gasoline rationing would become necessary. A discussion follows of the interaction of energy supply/demand and coal supply/demand for each end-use sector. All sectors are assumed to follow the same coal supply/demand pattern in the baseline scenario up to 1985.

3.2.1 Electric Utility

During 1974 and 1979 electricity demand increased by 0.3 and 1.9 percent, respectively. Cost was the major factor causing the low growth rate in 1974 and 1979. In 1985, in addition to an increased cost of electricity, a conversion mentality is assumed to develop which would help to keep energy consumption down. Therefore, between 1985 and 1990 the consumption of electricity is assumed to decrease and then increase such that the total loads in 1985 and 1990 will be the same. From 1990 to 2000 the annual load growth is assumed to be 3.2 percent.

If such an embargo occurs, the mixture of power plants generating electricity would be significantly different from that forecasted in the baseline scenario. Table 3.2.1-1 shows the assumed level of electricity generated from existing and new power plants.

Table 3.2.1-1. Electric Utility Generation (thousands of GWh)

Year	Oil		Natural Gas		Nuclear		Coal		Other		Total	
	B	C	B	C	B	C	B	C	B	C	B	C
1978	364.2	364.2	305.4	305.4	276.4	276.4	976.6	976.6	283.7	283.7	2206.3	2206.3
1985	244	244	259	259	476	476	1426	1426	310	310	2715	2715
1990	125	91	268	153	692	586	1743	1535	350	350	3178	2715
1995	104	18	234	76	838	856	2133	1806	422	422	3720	3178
2000	83	18	179	76	947	1076	2621	2025	525	525	4355	3720

B - Baseline Scenario (Low Oil Price Case)

C - Constrained Oil Supply Scenario

Coal consumption does not increase as rapidly in the constraint scenario as it does in the baseline because of the difference in the assumed load growth and the additional build-up of nuclear capacity. Coal power plants will be built in the West South Central region to replace oil and gas power plants. Nuclear capacity is built to replace oil and gas power plants in the New England, Middle Atlantic, and Pacific regions. The increase in generation requirements for nuclear and coal power plants is assumed to be equally divided. Oil generation in 1990 decreases to 25 percent of the 1978 generation and to 5 percent in 1995. Gas generation is assumed to decrease to 50 percent of the 1978 figure in 1990 and remains at 25 percent from 1995 through the end of the century. The other generation capacity, including hydroelectric, geothermal, and solar plants, is assumed to be the same as the baseline scenario. Table 3.2.1-2 shows the coal flows using the coal generation from Table 3.2.1-1 and the coal distribution methodology developed for the baseline scenario. Between 1985 and 1990 the only additional coal consumption is assumed to occur in the West South Central region due to the retirement of oil and gas generation capacity in that region. Tables 3.2.1-3 and 3.2.1-4 are comparisons of the total utility coal consumption of the baseline and constraint scenarios.

Table 3.2.1-3. Comparison of Utility Coal Supply Forecasts (millions of short tons)

			Supply Region									
Year	Total		Appalachia		East Interior		West Interior and Gulf		Northern Great Plains		Mountain	
	B	C	B	C	B	C	B	C	B	C	B	C
1985	731	731	281	281	126	126	60	59	185	185	81	81
1990	895	787	318	281	137	126	82	84	255	216	103	82
1995	1096	927	364	313	150	135	109	103	341	275	131	101
2000	1347	1040	422	339	168	143	144	119	449	324	165	117

B - Baseline Scenario

C - Constrained Oil Supply Scenario

The effect of the constraint scenario as compared to the baseline is to increase the ratio of western versus eastern coal supply. Total coal consumption decreases because of the lower load growth and the increased nuclear capacity. By the year 2000 coal consumption in the constraint scenario lags the baseline by approximately five years.

Table 3.2.1-2. Electric Utility Coal Consumption and Distribution
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1985			
New England	1,585	1,585				
Mid Atlantic	55,873	55,873				
South Atlantic	106,307	96,375	9,899	33		
East North Central	185,429	78,232	63,983	62	36,208	6,944
East South Central	86,072	47,694	36,139	41	1,534	664
West North Central	104,564	873	15,348	8,940	63,284	16,124
West South Central	100,725	18	180	49,990	47,979	2,558
Mountain	82,989				30,167	52,822
Pacific	7,411				5,605	1,806
Total	730,957	280,650	125,544	59,066	184,777	80,918
			1990			
New England	1,585	1,585				
Mid Atlantic	55,873	55,873				
South Atlantic	106,307	96,375	9,899	33		
East North Central	185,429	78,232	63,983	62	36,208	6,944
East South Central	86,072	47,694	36,139	41	1,534	664
West North Central	104,569	873	15,348	8,940	63,284	16,124
West South Central	157,225	18	180	74,700	78,850	3,477
Mountain	82,989				30,167	52,822
Pacific	7,412				5,606	1,806
Total	787,461	280,650	125,549	83,776	215,649	81,837

Table 3.2.1-2. Electric Utility Coal Consumption
and Distribution (continued)
(thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
				Supply Region		
			1995			
New England	1,585	1,585				
Mid Atlantic	62,991	62,991				
South Atlantic	118,449	108,099	10,317	33		
East North Central	204,830	84,094	70,124	62	40,535	10,015
East South Central	97,098	54,952	38,930	41	2,511	664
West North Central	128,436	873	15,348	8,940	85,616	17,659
West South Central	201,609	18	320	93,961	103,275	4,035
Mountain	102,808				37,425	65,383
Pacific	9,225				6,025	3,200
Total	927,031	312,612	135,039	103,037	275,387	100,956
			2000			
New England	1,585	1,585				
Mid Atlantic	68,772	68,772				
South Atlantic	128,311	117,621	10,657	33		
East North Central	220,587	88,855	75,112	62	44,049	12,509
East South Central	106,054	60,847	41,197	41	3,305	664
West North Central	147,821	873	15,348	8,940	103,754	18,906
West South Central	237,658	18	433	109,605	123,113	4,489
Mountain	118,915				43,320	75,595
Pacific	10,699				6,365	4,334
Total	1,040,402	338,571	142,747	118,681	323,906	116,497

Table 3.2.1-4. Comparision of Utility Coal Demand Forecasts (millions of short tons)

Demand Region	1985 B	1985 C	1990 B	1990 C	1995 B	1995 C	2000 B	2000 C
New England	2	2	2	2	2	2	2	2
Mid Atlantic	56	56	64	56	75	63	87	69
South Atlantic	106	106	121	106	138	118	160	128
East North Central	185	185	208	185	236	205	271	220
East South Central	86	86	99	86	115	97	135	106
West North Central	105	105	133	105	167	128	210	148
West South Central	101	101	153	157	217	202	297	238
Mountain	83	83	106	83	135	103	171	119
Pacific	7	7	10	7	12	9	15	11
Total	731	731	895	787	1096	927	1347	1040

B - Baseline Scenario

C - Constrained Oil Supply Scenario

3.2.2 Industry Coal Demand

Because of the embargo, the cost of energy is assumed to increase and economic activity is assumed to decrease. Industrial production in 1974 and 1975 decreased by 0.4 and 8.9 percent, respectively, mainly due to the 1973-1974 embargo and energy price increases. It is assumed that industrial production will decrease after 1985 and then increase such that production in 1990 will be the same as in 1985. However, it is likely that additional coal consumption would occur through 2000 due to conversions to coal once the demand for industry products increases. The amount of coal conversion is based upon a Census Bureau survey of manufacturers' alternative energy capabilities in 1976. The amount of fuel oil and natural gas that was reported to be nonsubstitutable due to nontechnological constraints is assumed to be substitutable when the oil supply becomes constrained and very costly.

After 1990 it is assumed that industrial production will continue to increase at the same rate as was projected in the baseline scenario. Increases in energy and coal consumption also are similar to the baseline scenario. Table 3.2.2-1 shows the coal flows, and Tables 3.2.2-2 and 3.2.2-3 show comparisons of the coal consumption of the constrained oil and baseline scenarios.

Even though the amount of industrial production after 1985 is lower in the constraint scenario, total coal consumption in 1995 and 2000 is higher than the baseline scenario. This is due to conversions of existing plants to coal. Without the very high increase in prices and unavailability of oil and gas these conversions would not have occurred. It should be noted that the West South Central region accounts for most of the difference between the two scenarios. This is due to the region's proximity to sources of coal, its high industrial energy consumption and the large percentage of energy use that is presently oil and natural gas.

3.2.3 Residential/Commercial

The major impact of the constraint scenario on the residential/commercial end-use sector would be an increased cost of oil, gas, and, to a lesser degree, electricity. These three energy sources currently supply 99 percent of the energy requirements in this sector. The substitutability of coal for other sources of energy is assumed to be zero. In this sector energy is consumed by heating, cooking, and operating appliances and equipment. Coal is applicable only for heating, but existing boilers are not convertable without major modification. Households and commercial establishments would not spend money for these conversions. There would be expenditures, however, to reduce oil, gas, and electricity consumption to increase conservation.

New residential or commercial property would be unlikely to utilize coal because other sources of energy will still be available due to the high priority associated with this sector. In addition, solar and wind installations would increase to provide the energy requirements for these new buildings.

The coal flow for this sector in the constraint scenario, therefore, is projected to be the same as in the baseline. This is shown in Table 3.2.3-1.

Table 3.2.2-1. Industry Coal Consumption and Distribution (thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1985			
New England	439	439				
Mid Atlantic	17,648	17,615	32		1	
South Atlantic	24,413	23,910	503			
East North Central	63,575	36,580	25,895	165	664	291
East South Central	15,512	13,724	1,740	42		6
West North Central	12,467	1,033	5,121	969	4,515	829
West South Central	4,219	9	75	3,526	18	591
Mountain	7,143				2,750	4,393
Pacific	1,888	20	3	24	333	1,508
Total	147,304	93,330	33,369	4,726	8,261	7,618
			1990			
New England	479	479				
Mid Atlantic	19,928	19,891	36		1	
South Atlantic	30,550	29,925	625			
East North Central	65,795	37,847	26,790	171	687	300
East South Central	17,977	15,904	2,018	49		6
West North Central	13,938	1,156	5,727	1,077	5,050	928
West South Central	18,074	39	321	15,106	77	2,531
Mountain	7,143				2,750	4,393
Pacific	2,453	26	4	31	434	1,958
Total	176,337	105,267	35,521	16,434	8,999	10,116

Table 3.2.2-1. Industry Coal Consumption and Distribution (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	847	847				
Mid Atlantic	31,849	31,785	57		7	
South Atlantic	57,227	56,099	1,128			
East North Central	102,261	58,859	41,582	281	1,025	514
East South Central	29,029	25,958	2,982	82		7
West North Central	21,391	1,762	8,736	1,658	7,742	1,493
West South Central	41,167	89	731	34,406	176	5,765
Mountain	8,143				3,150	4,993
Pacific	3,408	36	6	43	602	2,721
Total	295,322	175,435	55,222	36,470	12,702	15,493
			2000			
New England	1,215	1,215				
Mid Atlantic	43,770	43,679	78		13	
South Atlantic	83,904	82,273	1,631			
East North Central	138,727	79,871	56,374	391	1,363	728
East South Central	40,081	36,012	3,946	115		8
West North Central	28,844	2,368	11,745	2,239	10,434	2,058
West South Central	64,260	139	1,141	53,706	275	8,999
Mountain	9,143				3,550	5,593
Pacific	4,363	46	8	55	770	3,484
Total	414,307	245,603	74,923	56,506	16,405	20,870

Table 3.2.2-2. Comparison of Industry Coal Supply Forecasts
(millions of short tons)

Year	Total		Appalachia		East Interior		West Interior and Gulf		Northern Great Plains		Mountain	
	B	C	B	C	B	C	B	C	B	C	B	C
1985	147	147	93	93	33	33	5	5	8	8	8	8
1990	213	176	138	105	50	36	5	16	11	9	9	10
1995	278	295	183	175	66	55	6	37	13	13	10	16
2000	346	414	230	246	83	75	6	57	16	16	11	21

B - Baseline Scenario

C - Constrained Oil Supply Scenario

Table 3.2.2-3. Comparison of Industry Coal Demand Forecasts
(millions of short tons)

Demand Region	1985		1990		1995		2000	
	B	C	B	C	B	C	B	C
New England	0.4	0.4	0.7	0.5	1.0	0.8	1.3	1.2
Mid Atlantic	17.6	17.6	25.8	19.9	33.9	31.8	42.4	43.8
South Atlantic	24.4	24.4	36.1	30.6	47.8	57.2	59.9	83.9
East North Central	63.6	63.6	96.4	65.8	129.2	102.3	163.3	138.7
East South Central	15.5	15.5	21.9	18.0	28.4	29.0	35.3	40.1
West North Central	12.5	12.5	17.5	13.9	22.5	21.4	27.6	28.8
West South Central	4.2	4.2	4.2	18.1	4.2	41.2	4.2	64.3
Mountain	7.1	7.1	8.1	7.1	9.1	8.1	10.2	9.1
Pacific	1.9	1.9	1.9	2.5	1.9	3.4	1.9	4.4
Total	147.3	147.3	212.6	176.3	278.0	295.3	346.1	414.3

B - Baseline Scenario

C - Constrained Oil Supply Scenario

Table 3.2.3-1. Residential/Commercial Coal Distribution and Consumption (thousands of short tons) 1985-2000

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
Middle Atlantic	730	730				
South Atlantic	1,270	1,260	10			
East North Central	2,710	1,830	630		250	
East South Central	1,520	1,310	210			
West North Central	1,710	50	420	470	470	300
West South Central	20			20		
Mountain	1,820				1,530	290
Pacific	220				210	10
Total	10,000	5,180	1,270	490	2,460	600

3.2.4 Metallurgical

In this scenario, the oil embargo will have the effect of decreasing economic growth in the U.S. and the world. This will impact steel production and, in turn, reduce metallurgical coal consumption. The effect of the 1973-1974 oil embargo on the steel industry was to decrease production in 1975 by 20 percent. Due to the 1979-1980 increase in world oil price the 1975 and current levels of production are similar. Between 1975 and 1980 production increased by about 10 percent.

The effect of the oil embargo is projected to have a 20 percent decrease in coking coal consumption through 1990. It appears that requirements for metallurgical coal will not drop below a 20 percent reduction because of the requirements for steel for electric vehicles, new coal-utilizing industrial plants, and synfuel plants. It is projected that by 1995 metallurgical coal consumption will reach the level forecasted in the baseline scenario. Table 3.2.4-1 shows a comparison of coking coal consumption in the baseline and constraint scenarios.

Table 3.2.4-1. U.S. Coking Coal Consumption (millions of short tons)

Year	Baseline Scenario	Constrained Oil Supply Scenario
1985	77	77
1990	77	62
1995	77	77
2000	77	77

The reduction in coal consumption in 1990 is assumed to be equally divided among the supply and demand regions. The regional distribution and consumption is shown in Table 3.2.4-2.

3.2.5 Synfuels

Coal-derived liquids and gases are two of the few alternatives to foreign oil imports. By 1985 synfuel production in the baseline scenario is projected to be 75,000 BDOE, mainly for high- and medium-Btu gas. However, production of coal liquids is projected to start by 1986. It is highly likely that as soon as the embargo is imposed, industry would start a major effort in conjunction with an increased effort by the government to produce coal-derived synfuels. This high-level effort probably would result in achievement of the following Energy Security Act (S930) goal.

Table 3.2.5-1. Energy Security Act Coal Synfuel Production Goal (million barrels per day oil equivalent)

Year	Coal Liquids	Coal Gases	Total
1990	0.56	0.37	0.93
1995	1.2	0.8	2.0
2000	2.0	1.3	3.3

Table 3.2.5-2 contains a comparison of the synfuel production projections for the baseline and constraint cases.

Table 3.2.5-2. Comparison of Coal Synfuel Production (million barrels per day oil equivalent)

Year	Baseline Scenario	Constrained Oil Supply Scenario
1985	0.075	0.075
1990	0.6	0.93
1995	1.0	2.0
2000	1.7	3.3

Table 3.2.4-2. Coking Coal Distribution and Consumption (thousands of short tons)

1985, 1995, 2000

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
New England						
Mid Atlantic	23,003	23,003				
South Atlantic	8,955	8,955				
East North Central	31,917	16,959	14,958			
East South Central	6,639	6,639				
West North Central	912		912			
West South Central	828	828				
Mountain	2,939			589		2,350
Pacific	1,800					1,800
Total	76,993	56,384	15,870	589		4,150

1990

New England						
Mid Atlantic	18,402	18,402				
South Atlantic	7,164	7,164				
East North Central	25,534	13,567	11,967			
East South Central	5,311	5,311				
West North Central	730		730			
West South Central	662	662				
Mountain	2,271			471		1,800
Pacific	1,440					1,440
Total	61,514	45,106	12,697	471		3,240

This comparison shows that the embargo has the general effect of doubling coal synfuel production and will have a similar effect on coal consumption. The distribution ratios of coal from the supply to the demand regions are assumed to be the same as the baseline scenario. The resulting coal flows are shown in Table 3.2.5-3.

3.2.6 Export Coal Demand

The 1985-1987 embargo is assumed to be imposed on the United States, Western Europe, and Japan. It would appear that demand for U.S. coal by Europe and Japan would increase rapidly once a shortfall in oil occurs. However, a major increase in export coal demand is not projected to occur. The decrease in oil supplies would cause a sharp increase in the price of oil, causing a decrease in economic activity which in turn would decrease the demand for U.S. coal. For the U.S. electric utility and industrial sectors, the levels of economic activity were assumed to be the same in 1990 and in 1985. However coal consumption increased in 1990 over 1985 in both the utility and industry end-use sectors. Utility and industrial coal consumption increased by 8 and 20 percent respectively. It is assumed that exports will increase by by 10 percent in 1990. By 2000 it is assumed that more coal would be exported in the constrained oil scenario than in the baseline. The World Coal Study estimate of 220 million short tons is used for the year 2000.

Table 3.2.6-1 shows the coal flows and Tables 3.2.6-2 and 3.2.6-3 show a comparison between the constrained oil supply and the baseline scenarios.

Table 3.2.5-3. Coal Consumption and Distribution for Synfuel Production (thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			Supply Region			
			1995			
New England						
Mid Atlantic	15,200	15,200				
South Atlantic	15,200	15,200				
East North Central	40,600	15,200	25,400			
East South Central	30,400	15,200	15,200			
West North Central	71,400				71,400	
West South Central	39,000		15,200	23,800		
Mountain	123,200				74,200	49,000
Pacific						
Total	335,000	60,800	55,800	23,800	145,600	49,000
			2000			
New England						
Mid Atlantic	25,080	25,080				
South Atlantic	25,080	25,080				
East North Central	100,010	25,080	74,930			
East South Central	50,120	25,080	25,040			
West North Central	117,830				117,830	
West South Central	64,250		25,040	39,210		
Mountain	203,440				122,490	80,950
Pacific						
Total	585,810	100,320	125,010	39,210	240,320	80,950

Table 3.2.5-3. Coal Consumption and Distribution for Synfuel Production (Continued) (thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England						
Mid Atlantic	15,200	15,200				
South Atlantic	15,200	15,200				
East North Central	60,600	15,200	25,400			
East South Central	30,300	15,200	15,200			
West North Central	71,400				71,400	
West South Central	39,000		15,200	23,800		
Mountain	123,200				74,200	49,000
Pacific						
Total	355,000	60,800	75,800	23,800	145,600	49,000
			2000			
New England						
Mid Atlantic	25,080	25,080				
South Atlantic	25,080	25,080				
East North Central	100,010	25,080	74,930			
East South Central	50,120	25,080	25,040			
West North Central	117,830				117,830	
West South Central	64,250		25,040	39,210		
Mountain	203,440				122,490	80,950
Pacific						
Total	585,810	100,320	125,010	39,210	240,320	80,950

Table 3.2.6-1. Export Coal Consumption and Distribution
(thousands of short tons)

Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
				Supply Region		
1985						
New England						
Mid Atlantic	1,000	1,000				
South Atlantic	42,000	42,000				
East North Central	20,000	20,000				
East South Central	5,000	5,000				
West North Central						
West South Central	7,000	2,000	2,000	3,000		
Mountain						
Pacific						
Total	75,000	70,000	2,000	3,000		
1990						
New England						
Mid Atlantic	1,100	1,100				
South Atlantic	46,200	46,200				
East North Central	22,000	22,000				
East South Central	5,500	5,500				
West North Central						
West South Central	7,700	2,200	2,200	3,300		
Mountain						
Pacific						
Total	82,500	77,000	2,200	3,300		

Table 3.2.6-1. Export Coal Consumption and Distribution (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England						
Mid Atlantic	5,000	5,000				
South Atlantic	62,000	62,000				
East North Central	10,000	10,000				
East South Central	5,000	5,000				
West North Central						
West South Central	31,000	6,000	4,000	5,000	16,000	
Mountain						
Pacific	30,000				18,000	12,000
Total	143,000	88,000	4,000	5,000	34,000	12,000
			2000			
New England						
Mid Atlantic	7,700	7,700				
South Atlantic	95,400	95,400				
East North Central	15,400	15,400				
East South Central	7,700	7,700				
West North Central						
West South Central	47,800	9,200	6,200	7,700	24,700	
Mountain						
Pacific	46,000				27,700	18,300
Total	220,000	135,400	6,200	7,700	52,400	18,300

Table 3.2.6-2. Comparison of Export Coal Supply Forecasts
(millions of short tons)

Year	Total B	Total C	Appalachia B	Appalachia C	East Interior B	East Interior C	West Interior and Gulf B	West Interior and Gulf C	Northern Great Plains B	Northern Great Plains C	Mountain B	Mountain C
1985	75	75	70	70	2	2	3	3				
1990	110	83	79	77	3	2	4	3	18		6	
1995	143	143	88	88	4	4	5	5	34	34	12	12
2000	176	220	97	135	5	6	6	8	50	52	18	18

B - Baseline Scenario

C - Constrained Oil Supply Scenario

Table 3.2.6-3. Comparison of Export Coal Demand Forecasts
(millions of short tons)

Demand Region	1985 B	1985 C	1990 B	1990 C	1995 B	1995 C	2000 B	2000 C
New England								
Mid Atlantic	1	1	5	1	5	5	5	8
South Atlantic	42	42	50	46	62	62	74	95
East North Central	20	20	10	22	10	10	10	15
East South Central	5	5	5	6	5	5	5	8
West North Central								
West South Central	7	7	25	8	31	31	37	48
Mountain								
Pacific	—	—	15	—	30	30	45	46
Total	75	75	110	83	143	143	176	220

B - Baseline Scenario

C - Constrained Oil Supply Scenario

3.2.7 Constrained Oil Supply Total Coal Flow

Table 3.2.7-1 shows the total coal flow for all of the end-use sectors. Even with the lower economic growth assumed for this scenario, coal consumption in the year 2000 is 63 million tons or 2.7 percent higher than the baseline scenario. This increased coal consumption is due to the higher demand for coal in the industry and synfuel sectors.

Table 3.2.7-1. Constrained Oil Supply Scenario Coal Consumption and Distribution (thousands of short tons)

Demand Region	Total	Supply Region: Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1985						
New England	2,024	2,024				
Mid Atlantic	98,254	98,221	32		1	
South Atlantic	182,945	172,500	10,412	33		
East North Central	307,431	153,601	109,266	227	37,102	7,235
East South Central	114,743	74,367	38,089	83	1,534	670
West North Central	125,553	1,956	21,796	10,379	74,169	17,253
West South Central	112,792	2,855	2,255	56,536	47,997	3,149
Mountain	99,491			589	39,047	59,855
Pacific	11,311	20	3	24	6,148	5,116
Total	1,054,544	505,544	181,853	67,871	205,998	93,278
1990						
New England	2,064	2,064				
Mid Atlantic	107,813	107,776	36		1	
South Atlantic	203,271	192,704	10,534	33		
East North Central	325,028	153.476	126,930	233	37,145	7,244
East South Central	128,160	87,499	38,367	90	1,534	670
West North Central	157,992	2,079	22,225	10,487	105,849	17,352
West South Central	198,716	2,919	8,591	102,271	78,927	6,008
Mountain	151,728			471	77,537	73,720
Pacific	11,525	26	4	31	6,250	5,214
Total	1,286,297	548,543	206,687	113,616	307,243	110,208

Table 3.2.7-1. Constrained Oil Supply Scenario Coal Consumption and Distribution (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	2,432	2,432				
Mid Atlantic	138,773	138,709	57		7	
South Atlantic	263,101	251,613	11,455	33		
East North Central	392,318	186,942	152,694	343	41,810	10,529
East South Central	169,686	109,059	57,322	123	2,511	671
West North Central	223,849	2,685	25,416	11,068	165,228	19,452
West South Central	313,624	6,935	20,251	157,187	119,451	9,800
Mountain	238,910			589	116,305	122,016
Pacific	44,653	36	6	43	24,837	19,731
Total	1,787,346	698,411	267,201	169,386	470,149	182,199
			2000			
New England	2,800	2,800				
Mid Atlantic	169,055	168,964	78		13	
South Atlantic	342,920	330,589	12,298	33		
East North Central	509,351	227,995	222,004	453	45,662	13,237
East South Central	212,114	137,588	70,393	156	3,305	672
West North Central	297,117	3,291	28,425	11,649	232,488	21,264
West South Central	414,816	10,185	32,814	210,241	148,088	13,488
Mountain	336,257			589	170,890	164,778
Pacific	62,712	36	8	55	35,045	27,568
Total	2,347,142	881,448	366,020	223,176	635,491	241,057

4.0 HIGH OIL SUPPLY SCENARIO

This is the third and final scenario studied for this project. The baseline scenario, discussed in Section 2, is basically a business-as-usual scenario. The constrained oil supply scenario (Section 3) is based upon a low supply of oil due to a two-year embargo; whereas, the high oil supply scenario assumes that the worldwide supply of oil will be large enough to decrease the real price of world oil.

Many areas of the world have not been explored for petroleum. It is possible, therefore, that there could be large new finds of previously unexplored petroleum. The following section details the assumptions relating to a high supply of oil and its effects on the coal end-use sectors.

4.1 HIGH OIL SUPPLY SCENARIO ASSUMPTIONS

In this scenario it is assumed that by 1985 sufficient reserves of new oil will be discovered which will make the world oil market competitive. These new oil fields will have the effect of depressing the world oil price imposed by OPEC. The cost of extracting, transporting, and refining the new oil is assumed to be similar to the costs of light oil presently being produced. The new oil fields are assumed to be distributed over the world such that no limited group of countries will be able to set the price of world oil. U.S. domestic oil reserves will increase as will domestic production; however, the U.S. will continue to use imported oil. Imports are assumed to decrease along with the cost of imports. The balance of trade would shift in favor of the U.S. The large size and number of the assumed new oil fields would end the world oil crisis because the supply of oil at an acceptable price would be assured. If the oil price decreases there would not be as much incentive to use coal. The cost of coal is assumed to remain lower than oil on a Btu basis, but the cost of transportation will increase at a higher rate than coal or oil, thereby decreasing the difference in the delivered cost of coal and oil. Environmental standards for the utilization of fossil fuels are assumed to continue to remain strict. This has a negative effect on the utilization of coal because the environmental control equipment required for the environmentally acceptable utilization of coal is much greater than for burning oil.

The cost of energy is assumed to be higher than that experienced prior to the 1973 embargo. Energy conservation would continue to have an impact on total energy consumption; however, the amount of conservation would be less than the conservation efforts in the baseline scenario.

During 1975 through 1978 electricity demand increased by approximately 4.2 percent annually. The load growth during the 1985-2000 time frame is assumed to be 4.2 percent per year with the 1980-1985 load growth assumed to be similar to the baseline scenario - 3.2 percent annually. Total industry energy consumption is assumed to increase at a rate higher than the baseline scenario because industrial production is assumed to be greater. During 1977 and 1978, in a time of stable world oil prices, industrial production increased by 5.9 and 5.7 percent, respectively. A growth rate of 6.0 percent per year is chosen for the 1985-2000 time frame. Industrial energy efficiency for 1985-2000 is assumed to be similar to the efficiency calculated for the 1980-1985 period in the baseline scenario. It is assumed that the technology to attain this energy efficiency would be available and cost-effective for any new industrial plants built during the 1985-2000 period.

Coal consumption in the residential/commercial end-use sector is assumed to be similar to the amount consumed in the baseline scenario. This coal would be consumed very close to coal mines where transportation and distribution costs are low. Metallurgical coal consumption would decrease due to a 25 percent decrease in the coke rate and the introduction of iron and steel production which does not require metallurgical coke. Synfuel production after 1985 is assumed to decrease to zero. Synfuels are no longer competitive or necessary for national security.

Based upon the above assumptions, coal supply and demand were analyzed, the results of which are presented in the following section.

4.2 COAL SUPPLY AND DEMAND

The discovery of new major supplies of petroleum would have a significant effect on the patterns of energy utilization. If these new oil fields were in sufficient quantities and dispersed over the world, the price of oil would decrease. Because the production of oil from these new oil reserves is assumed to begin in 1985, all of the coal end-use sectors would have the same coal supply/demand pattern in 1985 as the baseline scenario.

4.2.1 Electric Utility

In the 5-year period prior to the 1973-1974 embargo, load growth was approximately 7 percent per year. Since that time, annual load growth has varied from 0.3 to 6.2 percent. From 1973 to the present, the price of oil has experienced two dramatic increases. As was shown in the baseline scenario, these increases in price had the effect of decreasing the amount of electricity generated. The forecasted annual load growth for 1980-1985 is 3.2 percent. If oil once again becomes plentiful in 1985 it is likely that the annual load growth would increase. After the 1974 increases in oil price the load growth averaged 4.2 percent per year until the 1979 increase in oil prices. For the electric utilities this 1975-1978 period could represent the trend of what could occur after 1985 when more oil becomes available. A 4.2 percent per year load growth will be used for the 1985-2000 time frame.

If more domestic and international oil is found, as is assumed for this scenario, the utilities would not be required to convert to coal or build plants which utilize only coal, nuclear or other alternative fuels. The need for nuclear plants to reduce foreign oil imports would decrease and the problems associated with nuclear power would not be as quickly resolved as assumed in the baseline scenario. The amount of nuclear capacity is assumed to be similar to the low nuclear case in the baseline scenario.

In the baseline scenario oil and gas consumption is projected to decrease throughout the study period. However, in the high oil supply scenario after 1985 the existing oil and gas power plants are assumed to operate at a higher load factor and, therefore, produce more electricity.

New oil and gas power plants are assumed to be built in present areas of high oil and gas consumption, i.e., New England, Pacific, and West South Central. It is assumed that the hydro, geothermal, and other generation will be the same as the baseline scenario. These technologies do not consume fuels and are assumed to be economic to build once they are technologically feasible. The impact of these new technologies becomes significant after 1990.

Table 4.2.1-1 shows the assumed level of electricity generated from existing and new power plants for both the baseline and high oil supply scenarios.

Table 4.2.1-1. Electric Utility Generation
(thousands of GWh)

Year	Oil		Natural Gas		Nuclear		Coal		Other		Total	
	B	H	B	H	B	H	B	H	B	H	B	H
1978	364.2	364.2	305.4	305.4	276.4	276.4	976.6	976.6	283.7	283.7	2206.3	2206.3
1985	244	244	259	259	476	476	1426	1426	310	310	2715	1715
1990	125	364	268	305	692	692	1743	1623	350	350	3178	3335
1995	104	396	234	363	838	780	2133	2136	422	422	3720	4097
2000	83	428	179	420	947	780	2621	2880	525	525	4355	5032

B - Baseline Scenario (Low Oil Price Case)

H - High Oil Supply Scenario

Coal generation is lower in the high oil scenario in 1990 due to the availability of oil and gas and, therefore, the generation of electricity from oil and gas power plants. However, by 2000 the coal generation is higher on the high oil scenario due to the higher load growth. Table 4.2.1-2 shows the coal flows using the coal generation from Table 4.2.1-1 and the coal distribution methodology developed for the baseline scenario. Tables 4.2.1-3 and 4.2.1-4 show comparisons of the total utility coal consumption of the baseline and high oil supply scenarios.

Table 4.2.1-2. Electric Utility Consumption and Distribution (thousands of short tons)

Demand Region	Total	Supply Region: Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1985						
New England	1,585	1,585				
Mid Atlantic	55,873	55,873				
South Atlantic	106,307	96,375	9,899	33		
East North Central	185,429	78,232	63,983	62	36,208	6,944
East South Central	86,072	47,694	36,139	41	1,534	664
West North Central	104,564	873	15,343	8,940	63,284	16,124
West South Central	100,725	18	180	49,990	47,979	2,558
Mountain	82,989				30,167	52,822
Pacific	7,411				5,605	1,806
Total	730,955	280,650	125,544	59,066	184,777	80,918
1990						
New England	1,585	1,585				
Mid Atlantic	61,065	61,065				
South Atlantic	115,163	104,926	10,204	33		
East North Central	199,580	82,508	68,462	62	39,364	9,184
East South Central	94,114	52,987	38,175	41	2,247	664
West North Central	121,976	873	15,348	8,940	79,572	17,243
West South Central	133,098	18	281	64,039	65,795	2,965
Mountain	97,444				35,460	61,984
Pacific	8,735				5,911	2,824
Total	832,761	303,962	132,470	73,115	228,349	94,864

Table 4.2.1-2. Electric Utility Consumption and Distribution (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1995						
New England	1,585	1,585				
Mid Atlantic	74,570	74,570				
South Atlantic	138,201	127,169	10,999	33		
East North Central	236,387	93,630	80,113	62	47,573	15,009
East South Central	115,033	66,756	43,471	41	4,101	664
West North Central	167,257	873	15,340	8,940	121,940	20,156
West South Central	184,324	18	545	67,600	112,136	4,025
Mountain	135,045				49,229	85,816
Pacific	12,177				6,706	5,471
Total	1,064,579	364,601	150,476	76,676	341,685	131,141
2000						
New England	1,585	1,585				
Mid Atlantic	94,138	94,138				
South Atlantic	171,581	159,398	12,150	33		
East North Central	209,718	109,745	96,994	62	59,467	23,450
East South Central	145,344	86,706	51,145	41	6,788	664
West North Central	232,866	873	15,348	8,940	183,329	24,376
West South Central	306,334	18	927	120,548	179,281	5,560
Mountain	189,526				69,179	120,347
Pacific	17,164				7,857	9,307
Total	1,448,256	452,463	176,564	129,624	505,901	183,704

Table 4.2.1-3. Comparison of Utility Coal Supply Forecasts (millions of short tons)

Year	Total		Appalachia		East Interior		West Interior and Gulf		Northern Great Plains		Mountain	
	B	H	B	H	B	H	B	H	B	H	B	H
1985	731	731	281	281	126	126	59	59	185	185	81	81
1990	895	833	318	304	137	133	82	73	255	228	103	95
1995	1096	1065	364	365	150	151	109	77	341	342	131	131
2000	1347	1448	422	453	168	177	144	130	449	506	165	184

B - Baseline Scenario

H - High Oil Supply Scenario

Table 4.2.1-4. Comparison of Utility Coal Demand Forecasts (millions of short tons)

Demand Region	1985		1990		1995		2000	
	B	H	B	H	B	H	B	H
New England	2	2	2	2	2	2	2	2
Mid Atlantic	56	56	64	61	75	75	87	94
South Atlantic	106	106	121	115	138	138	160	172
East North Central	185	185	208	200	236	236	271	290
East South Central	86	86	99	94	115	115	135	145
West North Central	105	105	133	122	167	167	210	233
West South Central	101	101	153	133	217	184	297	306
Mountain	83	83	106	97	135	135	171	190
Pacific	7	7	10	9	12	12	15	17
Total	731	731	895	833	1096	1065	1347	1448

B - Baseline Scenario

H - High Oil Supply Scenario

The results of these tables show that coal will continue to be the single most important fuel in the production of electricity by the utilities. The amount of coal utilized is lower until 1995 in the high oil scenario than the baseline scenario. This is due to the fact that, even with a higher load growth, the existing and some new oil and gas power plants will supply a large amount of the increased electricity demand. However, after 1995 new coal plants will be needed to supply the growth in electricity.

4.2.2 Industry

In the light of lower energy costs, resulting from high supplies of oil after 1985, economic activity from 1985 to 2000 would increase resulting in an increased demand for industrial products. During the 1976-1978 time frame when oil prices stabilized, increases in industrial production averaged approximately 6 percent per year. Gross National Product and industrial growth are assumed to be approximately 6 percent during the 1985-2000 time frame. Utilizing the same methodology to calculate industrial energy consumption in industry as was used in the baseline scenario results in Table 4.2.2-1.

Table 4.2.2-1. Total Industrial Energy Consumption

	(10^{15} Btu)	Annual Increase (percent)
1980	20.3	--
1985	22.5	2.1
1990	27.4	4.0
1995	33.3	4.0
2000	40.5	4.0

In the baseline scenario it was assumed that all new industrial boilers would use only coal. However, recent trends show that the market share of coal-fired new boilers ranges from 5 to 10 percent (see Section 2.2.2). It is assumed, therefore, that after 1985 coal boilers will supply only 10 percent of new boiler capacity. Coal utilization for nonboiler energy uses is assumed to be 26 percent of total energy consumption. This assumption is similar to the baseline scenario and is based on historical coal consumption for nonboiler uses.

Coal is assumed, therefore, to provide 36 percent of the energy requirements for new plants. Applying the coal distribution methodology used in the baseline scenario results in the coal flow in Table 4.2.2-2. Tables 4.2.2-3 and 4.2.2-4 show comparisons of the total industrial coal

Table 4.2.2-2. Industrial Coal Distribution and Consumption (thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1985			
New England	439	439				
Mid Atlantic	17,648	17,615	32		1	
South Atlantic	24,413	23,910	503			
East North Central	63,575	36,580	25,895	165	644	291
East South Central	15,512	13,724	1,740	42		6
West North Central	12,467	1,033	5,121	969	4,515	829
West South Central	4,219	9	75	3,526	18	591
Mountain	7,143				2,750	4,393
Pacific	1,888	20	3	24	333	1,508
Total	147,304	93,330	33,369	4,726	8,261	7,618
			1990			
New England	778	778				
Mid Atlantic	26,830	26,775	48		7	
South Atlantic	37,615	36,773	842			
East North Central	100,606	57,906	40,902	278	1,003	517
East South Central	22,758	20,381	2,304	67		6
West North Central	18,108	1,484	7,378	1,420	6,546	1,280
West South Central	4,219	9	75	3,526	18	591
Mountain	8,271				3,201	5,070
Pacific	1,880	20	3	24	333	1,500
Total	221,065	144,126	51,552	5,315	11,108	8,964

Table 4.2.2-2. Industrial Coal Distribution and Consumption (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	1,117	1,117				
Mid Atlantic	35,972	35,895	64		13	
South Atlantic	50,817	49,636	1,181			
East North Central	157,637	99,232	55,909	391	1,362	743
East South Central	30,004	27,038	2,868	92		6
West North Central	23,749	1,935	9,635	1,871	8,577	1,731
West South Central	4,219	9	75	3,526	18	591
Mountain	9,399				3,652	5,747
Pacific	1,880	20	3	24	333	1,500
Total	314,794	214,882	69,735	5,904	13,955	10,318
			2000			
New England	1,423	1,423				
Mid Atlantic	45,981	45,879	88		14	
South Atlantic	65,000	63,624	1,464			
East North Central	197,869	122,415	72,287	497	1,774	896
East South Central	38,152	34,244	3,786	116		6
West North Central	29,744	2,477	12,086	2,307	10,743	2,131
West South Central	4,219	9	75	3,526	18	591
Mountain	10,647				4,135	6,512
Pacific	1,880	20	3	24	333	1,500
Total	395,003	270,091	89,789	6,470	17,017	11,636

Table 4.2.2-3. Comparison of Industry Coal Supply Forecasts
(millions of short tons)

Year	Total		Appalachia		East Interior		West Interior and Gulf		Northern Great Plains		Mountain	
	B	H	B	H	B	H	B	H	B	H	B	H
1985	147	147	93	93	33	33	5	5	8	8	8	8
1990	213	221	138	144	50	52	5	5	11	11	9	9
1995	278	315	183	215	66	70	6	6	13	14	10	10
2000	346	395	230	270	83	90	6	6	16	17	11	11

B - Baseline Scenario

H - High Oil Supply Scenario

Table 4.2.2-4. Comparison of Industry Coal Demand Forecasts
(millions of short tons)

Demand Region	1985		1990		1995		2000	
	B	H	B	H	B	H	B	H
New England	0.4	0.4	0.7	0.8	1.0	1.1	1.3	1.4
Mid Atlantic	17.6	17.6	25.8	26.8	23.9	36.0	42.4	46.0
South Atlantic	24.4	24.4	36.1	37.6	47.8	50.8	59.9	65.1
East North Central	63.6	63.6	96.4	100.6	129.2	157.6	163.3	197.9
East South Central	15.5	15.5	21.9	228	28.4	30.0	35.3	38.2
West North Central	12.5	12.5	17.5	18.1	22.5	23.7	27.6	29.7
West South Central	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Mountain	7.1	7.1	8.1	8.3	9.1	9.4	10.2	10.6
Pacific	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Total	147.3	147.3	212.6	221.1	278.0	314.8	346.1	395.0

B - Baseline Scenario

H - High Oil Supply Scenario

consumption of the baseline and high oil supply scenarios. These comparison tables show that the amount of coal consumed by industry would be almost the same as in the baseline scenario because increased industrial production offsets the amount of coal used per production item.

4.2.3 Residential/Commercial

With an assured supply of acceptably priced oil and gas, the only incentives for using coal would be that the cost is very low and it is readily and conveniently available. This would occur only if the coal was produced very close the to consumer. The amount of coal consumed by this end-use sector in the baseline scenario was 10 million tons throughout the 1980-2000 period. The 1985 projection in the high oil scenario is similar to the baseline scenario. The 1990-2000 projection is also similar to the baseline projection except that coal not produced in the same area in which it is consumed is deleted from the coal flow. These coal flows are shown in Table 4.2.3-1.

4.2.4 U.S. Metallurgical Coal Demand

As discussed in section 4.2.2, the effect on an increase in energy supplies at a lower cost would increase industrial production. This increase in production would also effect the requirements for iron and steel which in turn would effect metallurgical coal requirements. Existing steel-making capacity is presently underutilized. It is assumed that the demand for steel above present production will not increase metallurgical coal consumption due to an offsetting decrease in the coke rate. It is also assumed that new plants would be built using new technology such as electric or direct reduction blast furnaces which do not require coke. The coal flow for metallurgical coal is projected to be similar to the baseline scenario and is shown in Table 4.2.4-1.

Table 4.2.3-1. Residential/Commercial Coal Consumption and Distribution (thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1985						
New England						
Mid Atlantic	730	730				
South Atlantic	1,270	1,260	10			
East North Central	2,710	1,830	630		250	
East South Central	1,520	1,310	210			
West North Central	1,710	50	420	470	470	300
West South Central	20			20		
Mountain	1,820				1,530	290
Pacific	220				210	10
Total	10,000	5,180	1,270	490	2,460	600
1990-2000						
New England						
Mid Atlantic	730	730				
South Atlantic	1,260	1,260				
East North Central	2,460	1,830	630			
East South Central	1,520	1,310	210			
West North Central	940			470	470	
West South Central	20			20		
Mountain	1,820				1,530	290
Pacific						
Total	8,750	5,130	840	490	2,000	290

Table 4.2.4-1. Coking Coal Distribution and Consumption
(thousands of short tons)

		Supply Region			
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Mountain
Middle Atlantic	23,003	23,003			
South Atlantic	8,955	8,955			
East North Central	31,917	16,959	14,958		
East South Central	6,639	6,639			
West North Central	912		912		
West South Central	828	828			
Mountain	2,939			589	2,350
Pacific	1,800				1,800
Total	76,993	56,384	15,870	589	4,150

4.2.5 Coal Demand For Synfuels

The purpose of the national goal for synfuel production is to reduce U.S. dependence on foreign oil. At present, the U.S. has a negative balance of trade, which is mainly due to the high price of world oil. In the high oil supply scenario, the cost of imported oil is assumed to decrease from today's price in real dollars. Because the supply of oil is assumed to be dispersed among many nations, the threat of an oil embargo would no longer cause a shortfall in oil supply. Large domestic reserves, which can decrease total oil imports, are also assumed to be discovered. Therefore, synfuels would no longer be needed nor would they be economically feasible to produce.

The production of synfuels in 1985 would not continue once these new supplies of oil and gas become available. It is assumed, therefore, that coal consumption would go to zero by 1990. Table 4.2.5-1 shows the coal flow for synfuels in 1985.

Table 4.2.5-1. Coal Consumption and Distribution for Synfuel Production - 1985 (thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
New England						
Mid Atlantic						
South Atlantic						
East North Central	3,800		3,800			
East South Central						
West North Central	5,900				5,900	
West South Central						
Mountain	4,600				4,600	
Pacific						
Total	14,300		3,800		10,500	

4.2.6 Export Coal Demand

The increase in coal exports projected in the baseline scenario was for steam coal. This steam coal was assumed to be a substitute for high-price oil. Because oil is assumed to become plentiful and cheaper in the high oil supply scenario, demand for U.S. export coal will not increase in the 1990-2000 period. It is assumed that coal exports will approximate the average amount of exports in the 1970-1979 period. Exports to Canada from the East North Central region are projected to decrease by 10 million tons from 1985 to 1990 in the baseline scenario. The exports for 1990 to 2000 are assumed to be similar to the 1979 exports except for this 10 million ton per year decrease. The coal flows are shown in Table 4.2.6-1.

4.2.7 High Oil Supply Total Coal Flow

Table 4.2.7-1 shows the total coal flow for all of the end-use sectors. As would be expected, total coal demand decreases from the coal consumed in the baseline scenario. The decrease is only 273 million tons or 12.1 percent of the coal demand in 2000 for the baseline scenario.

Table 4.2.6-1. Export Coal Distribution
(thousands of short tons)

Demand Region	Total	Supply Region: Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
1985						
New England						
Mid Atlantic	1,000	1,000				
South Atlantic	42,000	42,000				
East North Central	20,000	20,000				
East South Central	5,000	5,000				
West North Central						
West South Central	7,000	2,000	2,000	3,000		
Mountain						
Pacific						
Total	75,000	70,000	2,000	3,000		
1990-2000						
New England						
Mid Atlantic						
South Atlantic	41,000	41,000				
East North Central	10,000	10,000				
East South Central	4,000	4,000				
West North Central						
West South Central	1,000	800		200		
Mountain						
Pacific						
Total	56,000	55,800		200		

Table 4.2.7-1. High Oil Supply Scenario Coal Consumption and Distribution
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1985			
New England	2,024	2,024				
Mid Atlantic	98,254	98,221	32		1	
South Atlantic	182,945	172,500	10,412	33		
East North Central	307,431	153,601	109,266	227	37,102	7,235
East South Central	114,743	74,367	38,089	83	1,534	670
West North Central	125,553	1,956	21,796	10,379	74,169	17,253
West South Central	112,792	2,855	2,255	56,536	47,997	3,149
Mountain	99,491			589	39,047	59,855
Pacific	11,311	20	3	24	6,148	5,116
Total	1,054,544	505,544	181,853	67,871	205,998	93,278
			1990			
New England	2,363	2,363				
Mid Atlantic	111,628	111,573	48		7	
South Atlantic	203,993	192,914	11,046	33		
East North Central	344,563	169,203	124,952	340	40,367	9,701
East South Central	129,031	85,317	40,689	108	2,247	670
West North Central	141,936	2,357	23,638	10,830	86,588	18,523
West South Central	139,165	1,655	356	67,785	65,813	3,556
Mountain	110,474			589	40,191	69,694
Pacific	12,415	20	3	24	6,244	6,124
Total	1,195,568	565,402	200,732	79,709	241,457	108,268

Table 4.2.7-1. High Oil Supply Scenario Coal Consumption and Distribution (Continued)
(thousands of short tons)

		Supply Region				
Demand Region	Total	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain
			1995			
New England	2,702	2,702				
Mid Atlantic	134,275	134,198	64		13	
South Atlantic	240,233	228,020	12,180	33		
East North Central	438,401	221,651	151,610	453	48,935	15,752
East South Central	165,773	105,743	46,549	133	12,678	670
West North Central	192,858	2,808	25,895	11,281	130,987	21,887
West South Central	193,191	1,655	620	74,146	112,154	4,616
Mountain	149,203			589	54,411	94,203
Pacific	15,857	20	3	24	7,039	8,771
Total	1,532,493	696,797	236,921	866,659	366,217	145,899
			2000			
New England	3,008	3,008				
Mid Atlantic	163,885	163,750	88	33	14	
South Atlantic	287,851	274,237	13,614			
East North Central	531,964	260,949	184,869	559	61,241	24,346
East South Central	195,655	132,899	55,141	157	6,788	670
West North Central	264,452	3,350	28,346	11,707	194,542	26,507
West South Central	312,401	1,655	1,002	124,294	179,299	6,151
Mountain	204,932			589	74,844	129,499
Pacific	20,844	20	3	24	8,190	12,607
Total	1,984,992	839,868	283,063	137,363	524,918	199,780

Because of the increased economic activity assumed in this scenario, utility and industry coal consumption increased by 7.4 and 14.1 percent, respectively. However, because synfuel production is zero and export coal demand is reduced by 68 percent in the year 2000, the total coal demand is lower.

5.0 TRANSPORTATION ANALYSIS

In this section the baseline scenario low oil price case coal supply/demand forecasts for the United States are compared with the projections of coal movement of the National Transportation Policy Study Commission[1] (NTPSC). The purpose of this comparison is to broadly identify whether the coal projected to be consumed could be transported to the consumer. The comparison showed that potential transportation constraints could be mitigated with sufficient financing for capital expenditures.

Table 5-1 shows the amount of coal that was assumed to be transported in the NTPSC study. Total coal flow in the year 2000 was 2,621 million tons. The transportation analysis performed by NTPSC was based upon the 173 Bureau of Economic Analysis (BEA) regions. These regions are shown in the Appendix, Figure 5. Because the regional flows in the NTPSC did not include the intra-BEA coal flows, they were adjusted in order to be on the same basis as the baseline scenario forecast. Table 5-2 shows the adjusted NTPSC and baseline scenario coal flow forecasts. The NTPSC Interior region includes the East Interior and West Interior regions used in the baseline scenario. Figures 5-1 and 5-2 show the NTPSC supply and demand regions. Figure 1 in the Appendix shows the baseline scenario production regions.

The incremental regional coal-flow map (Figure 5-1), which is based on the NTPSC forecasts, indicates that from 1979 to 1985, Appalachia's total coal production is expected to increase by 372 million tons, of which 114 million tons is expected to flow to Mid-Atlantic, 108 million tons to South Atlantic, and approximately 70 million tons to East South Central and East North Central regions.

Interior's flow into East South Central and West South Central is likely to decrease for the period under consideration. In 1985 the only coal flow from the Interior is expected to be of the magnitude of 49 million tons to the East North Central States. The flow of coal from Great

[1] National Transportation Policies Through the Year 2000, Final Report, June 1979.

Table 5-1. Coal Production and Movement Projections, 1975 to 2000 (millions of short tons)

Forecast Type	Year	Appalachia	Interior	Great Plains	Rocky Mountain	Total
		Regions				
Total Production	1975	447	134	60	19	660
	1985	719	166	228	84	1197
	2000	968	371	1122	160	2621
Transported Production* (inter-regional flows)	1975	228	106	48	18	400
	1985	429	140	184	77	830
	2000	486	262	504	147	1399

*Does not include local, intra-regional movements

Source: NTPSC forecasts, 1979

Plains to West North Central and West South Central is anticipated to increase by 57 and 55 millions tons, respectively. The other demand regions appear to pose no problems.

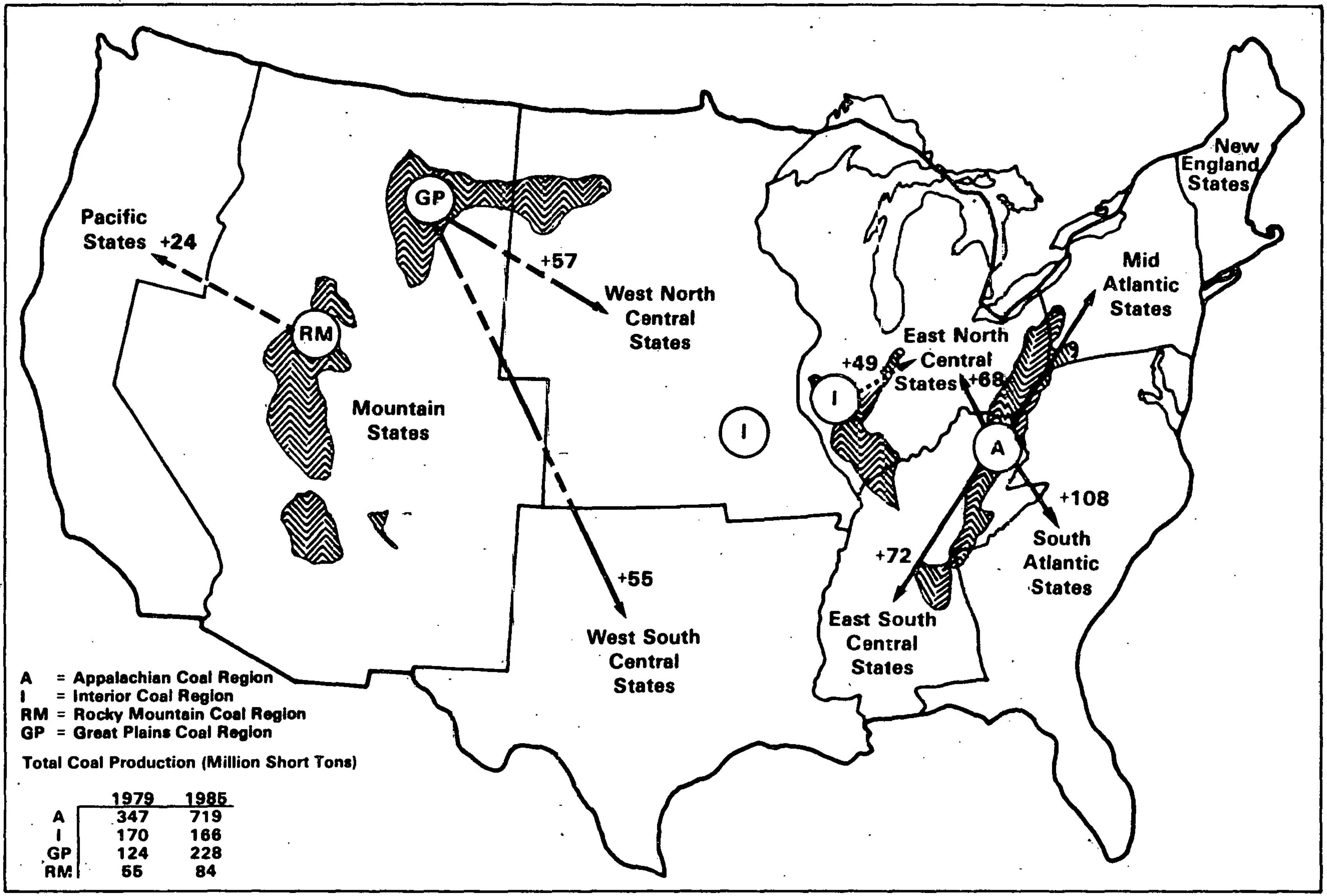
To summarize, from 1979 to 1985 there should occur a significant growth in coal flows along the following corridors:

- Appalachia to
  - Mid Atlantic
  - South Atlantic
  - East South Central
  - East North Central
- Interior to
  - East North Central
- Great Plains to
  - West North Central
  - West South Central

By 2000 (Figure 5-2) the pressure on transportation requirements along the Appalachia to Mid-Atlantic and South Atlantic corridors is expected to ease up, since an additional 100 million tons of coal flow to each of the above mentioned demand regions is going to be spread out over 15 years

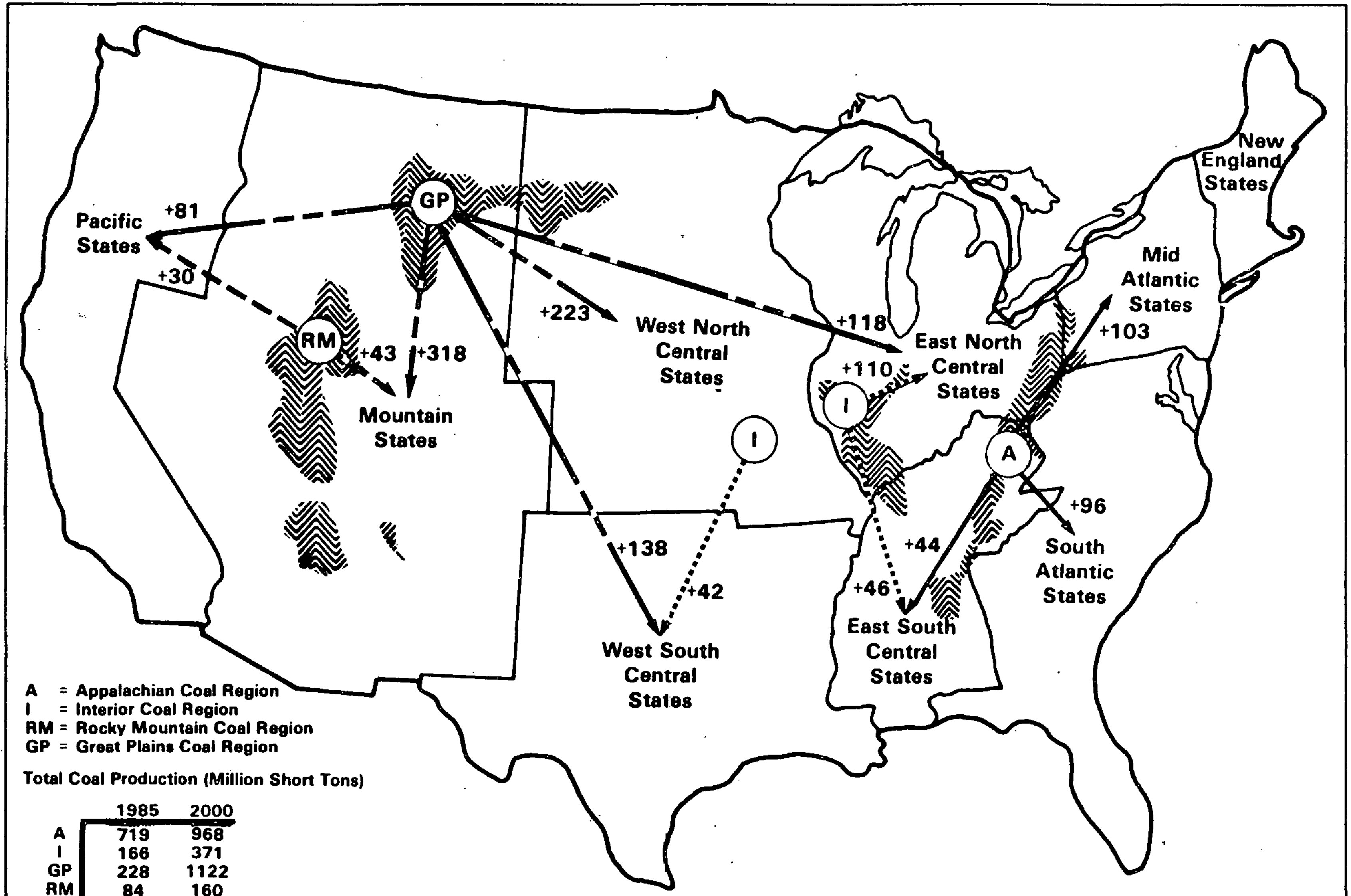
Table 5-2. NTPSC U.S. Regional Coal Flow Forecast - 1985 and 2000 (millions of short tons)

		Production Regions				
Demand Regions	Year	Appalachia	Interior	Great Plains	Rocky Mountain	Total
New England	1979	1.17				1.17
	1985	13.1				13.1
	2000	16.0		0.1		16.1
Middle Atlantic	1979	79.89				79.91
	1985	193.6				193.6
	2000	296.2		0.7		296.9
South Atlantic	1979	99.35	9.60			108.95
	1985	207.8				207.8
	2000	304.0	0.1	0.3		304.4
East North Central	1979	112.57	68.90	29.51	4.45	215.42
	1985	180.3	117.7	16.1		314.1
	2000	184.0	227.8	133.7		545.5
East South Central	1979	52.05	33.49		0.94	86.48
	1985	123.8	28.1	0.8		152.7
	2000	167.7	74.1	16.4		258.2
West North Central	1979	1.64	28.27	47.91	2.87	80.69
	1985		2.8	105.4		108.2
	2000		9.5	328.2		337.7
West South Central	1979	0.5	29.12	18.18	0.84	48.63
	1985		17.7	73.3	13.1	104.1
	2000		59.4	211.2	16.0	286.6
Mountain	1979			23.18	42.82	66.19
	1985			26.0	43.7	69.7
	2000			343.8	86.4	430.2
Pacific	1979			5.40	3.20	8.65
	1985			6.7	27.3	34.0
	2000			87.6	57.3	144.9
Totals	1979	347.18	169.7	124.2	55.1	696.2
	1985	718.6	166.3	228.3	84.1	1197.3
	2000	967.9	370.9	1122.0	159.7	2620.5



Source: National Transportation Policies Through the Year 2000, Final Report, June 1979

Figure 5-1. U.S. Incremental Regional Coal Flow - 1979 to 1985
(millions of short tons)



Source: National Transportation Policies Through the Year 2000, Final Report, June 1979

Figure 5-2. U.S. Incremental Regional Coal Flow - 1985 to 2000
(millions of short tons)

(1985-2000). Interior's flow of coal to East North Central is expected to increase by 110 million tons during the 15 years under consideration. By 2000, total coal production of Great Plains is projected by NTPSC to increase by approximately 800 to 900 million tons, of which 318 million tons is anticipated to be demanded by the Mountain region, 223 by West North Central, 138 by West South Central, 118 by East North Central, and 81 by Pacific.

In only one instance is there expected to be a major shift in the traditional relationship between a source and a demand region. By the year 2000, the East North Central region is projected by NTPSC to shift from Appalachia to Great Plains and Interior sources to meet its coal needs.

Thus, by the year 2000 significant growth in coal flows should occur along the following corridors:

- Appalachia
  - Mid Atlantic
  - South Atlantic
- Interior
  - East North Central
- Great Plains
  - East North Central
  - West North Central
  - West South Central
  - Mountain

The NTPSC study found that the additional traffic demands by 1985 may be met by the railways by the way of improved signalization, shorter block sections, centralized traffic control, and other modernization methods without providing for heavy line capacity works. But by 2000 the incremental traffic on some of the corridors mentioned above, was projected to increase very significantly and is likely to call for special line capacity works involving heavy investment. To be able to move the coal forecasted by NTPSC, sufficient financing would be required to be able to build additional railroad capacity. Assuming that this capital will be available, the NTPSC forecast could be used as the future capacity of the U.S. transportation system to move coal. This capacity can be then compared with the baseline scenario forecasts to determine if this coal could be transported. Table 5-3 shows the comparison of the NTPSC and baseline scenario forecasts. Constraints in 2000 appear to occur between the Interior and West South Central regions and within the Rocky Mountain region.

The Interior region, as seen in Figures 5-1 and 5-2, does not indicate any coal production in Texas. Coal production in this area was 38 million tons in 1979. The baseline scenario forecast for coal production in the West Interior and Gulf region is 178 million tons in 2000. This accounts for the difference between the Interior projections and would relieve the constraint between the Interior and West South Central regions shown in Table 5-3.

In the baseline scenario, the demand for coal from the Northern Great Plains is 57 percent of the NTPSC projection. This is due to the fact that more coal is projected to be produced in the Interior and Mountain regions which decreases the demand for coal from the Northern Great Plains. Transportation capacity requirements for coal from the Northern Great Plains is therefore decreased. Assuming that the transportation capacity could be built for coal produced in the Mountain area instead of the Northern Great Plains, the constraint on moving the Mountain region coal would be relieved. But, as was previously mentioned, major constraints would occur in most regions if financing for capacity expansions could not be made available.

Table 5-3. Regional Coal Flow Forecast - 1985-2000
(millions of short tons)

Production Regions

Demand Regions	Year	Appalachia NTPSC	Appalachia Base	Interior NTPSC	Interior Base	Great Plains NTPSC	Great Plains Base	Rocky Mountain NTPSC	Rocky Mountain Base	Total NTPSC	Total Base
New England	1985	13.1	2.0							13.1	2.0
	2000	16.0	2.9			0.1				16.1	2.9
Mid-Atlantic	1985	193.6	98.2							193.6	98.3
	2000	296.2	171.3			0.7				296.9	171.4
South Atlantic	1985	207.8	172.5		10.4					207.8	182.9
	2000	304.0	303.9	0.1	13.1	0.3				304.4	317.0
East North Central	1985	180.3	153.6	117.7	109.5	16.1	37.1		7.2	314.1	307.6
	2000	184.0	240.0	227.8	212.2	133.7	57.2		21.3	545.5	530.6
East South Central	1985	123.8	74.4	28.1	38.2	0.8	1.5		0.7	152.7	114.7
	2000	167.7	137.3	74.1	65.2	16.4	5.9		0.7	258.2	209.0
West North Central	1985		2.0	2.8	32.2	105.4	74.2		17.2	108.2	125.6
	2000		3.2	9.5	39.4	328.2	233.0		25.2	337.7	300.2
West South Central	1985		2.9	17.7	58.8	73.3	47.0	13.1	3.1	104.1	112.8
	2000		3.9	59.4	183.6	211.2	178.9	16.0	5.6	286.6	371.9
Mountain	1985				.6	26.0	39.0	43.7	59.9	69.7	99.5
	2000				.6	343.8	130.8	86.4	158.9	430.2	290.3
Pacific	1985					6.7	6.1	27.3	5.1	34.0	11.3
	2000					87.6	35.0	57.3	29.3	144.9	64.3
Total	1985	718.6	505.5	166.3	249.7	228.3	206.0	84.1	93.3	1197.3	1054.5
	2000	967.9	862.3	370.9	514.2	1122.0	640.8	159.7	241.0	2620.5	2258.3

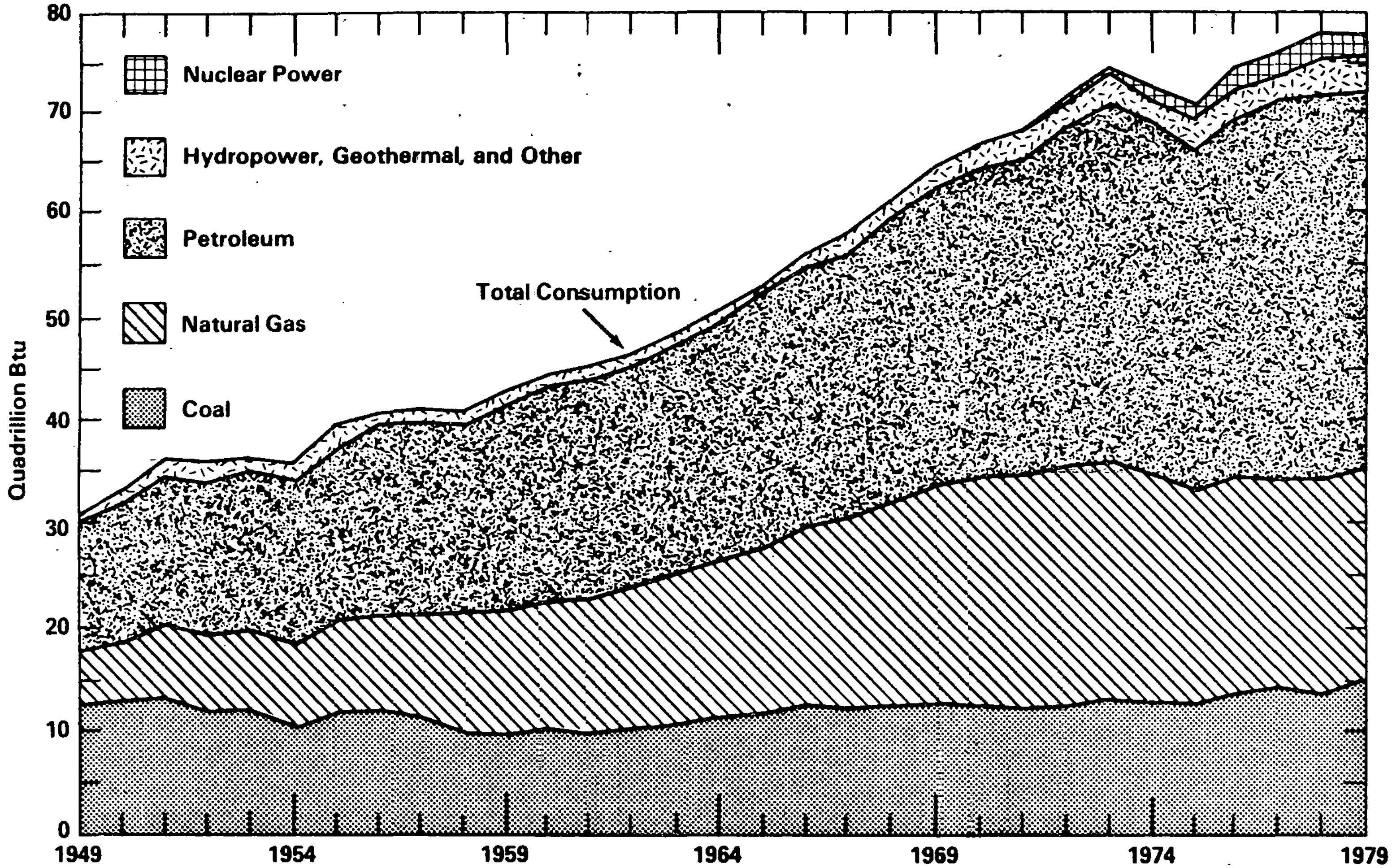
Base - Baseline Scenario (Low Oil Price Case)

6.0 CONCLUSIONS

Coal production and consumption in the United States are projected to increase dramatically in the next 20 years. This will occur due to increasing requirements for energy in the United States and the unavailability of other sources of energy to supply a substantial portion of this increase. Historically, oil and natural gas have supplied most of the increase in energy demand, (see Figure 6-1) but it appears that world production of oil is becoming resource-limited. New finds of oil and gas are not keeping up with the increasing demand. Other sources of energy such as nuclear, hydropower, geothermal, solar, etc. are not expected to be able to supply a major portion of the incremental energy demands within the time frame of this study (1980-2000). Coal comprises 85 percent of the U.S. recoverable fossil energy reserves and could be mined to supply the increasing energy demands of the U.S.

The results of the analyses performed for each coal end-use sector for each scenario are presented in Table 6-1. In all three scenarios, the total coal consumed in the year 2000 is approximately three times the amount in 1979. Even when oil is plentiful in the high oil supply scenario, coal consumption nearly triples. The economic activity in the high oil supply scenario is assumed to be higher than either of the other two scenarios. This increase in GNP would bring about a higher total consumption of energy. Therefore, even if the amount of coal consumed in the high oil supply scenario is almost as much as the other scenarios, the ratio of coal to total energy consumption is lower in the high oil supply scenario.

In all of the scenarios the electric utility sector continues to consume more coal than any other sector. Only in the constrained oil scenario does the combined nonutility sector consumption equal more than that of the utility sector. This is due mainly to the increased use of coal for synfuel production and the reduced electricity demand which reduces utility coal consumption.



Source: DOE, EIA, 1979 Annual Report to Congress

Figure 6-1. Consumption of Energy by Type

Table 6-1. End-Use Sector Coal Consumption
(millions of short tons)

Scenario	Year	Electric Utility	Industry	Residential/ Commercial	Metal-lurgical	Synfuels	Export	Total
Baseline (Low Oil Price)	1979	528.8	65.9	9.1	77.1	—	66.3	747.2
	1985	731	147	10	77	14	75	1055
	1990	895	213	10	77	109	110	1413
	1995	1096	278	10	77	178	143	1781
	2000	1347	346	10	77	302	176	2258
(High Oil Price)	1985	734	147	10	77	14	75	1055
	1990	899	225	10	77	114	110	1435
	1995	1121	290	10	77	191	143	1832
	2000	1378	358	10	77	332	176	2330
Constrained Oil Supply	1985	731	147	10	77	14	75	1055
	1990	787	176	10	62	169	83	1286
	1995	927	295	10	77	335	143	1787
	2000	1040	414	10	77	586	220	2347
High Oil Supply	1985	731	147	10	77	14	75	1055
	1990	833	221	9	77	0	56	1196
	1995	1065	315	9	77	0	56	1521
	2000	1448	395	9	77	0	56	1985

The export and synfuel sectors exhibit the most change for the different scenarios. In the constrained oil scenario, synfuels become a substitute for the highly priced oil, thereby, creating a high demand for coal. Synfuels are no longer needed in the high oil supply scenario causing coal consumption for synfuels to cease. Exports in this scenario also decrease due to a worldwide reduction in the need for coal.

The amount of coal supplied by region is shown in Table 6-2. Coal production increases in all regions. Eastern coal production is higher than the West through 2000; however, in the baseline scenario, by 2000 the West produces 47 percent of total coal, whereas in 1979, the West produced only 29 percent of the U.S. supply of coal. The Northern Great Plains region is the source of most of the increased western production. In the constrained oil supply scenario the regional share of coal supply does not change significantly. However, in the high oil supply scenario the West supplies 43 percent of U.S. coal. The percentage increase in western coal production is still much greater than eastern coal (290 percent, western; 107 percent, eastern).

Table 6-2. Coal Supply
(millions of short tons)

Scenario	Year	Appalachia	East Interior	West Interior and Gulf	Northern Great Plains	Mountain	Total
Baseline (Low Oil Price)	1979	412.3	130.0	40.1	124.9	55.2	762.5
	1985	506	182	68	206	93	1055
	1990	620	225	98	338	132	1413
	1995	728	275	133	465	182	1781
	2000	862	337	178	641	241	2258
Constrained Oil Supply	1985	506	182	68	206	93	1055
	1990	549	207	114	307	110	1287
	1995	698	267	169	470	182	1787
	2000	881	366	223	635	241	2347
High Oil Supply	1985	506	182	68	206	93	1055
	1990	565	201	80	241	108	1196
	1995	697	237	84	357	146	1521
	2000	840	283	137	525	200	1985

Table 6-3 shows the demand for coal for each of the scenarios. In the constrained oil supply scenario, even though the total coal demand is lower than the baseline scenario some of the regions consume more coal. This is due to the fact that the supply of energy for these regions is mainly oil and gas and they are close to the coal supply regions. In the high oil supply scenario coal consumption is reduced in all regions except in the New England and East North Central regions. The additional coal consumption in these regions is due mainly to the higher level of industrial activity. A large portion of the higher utility demand in this region is supplied from the Northern Great Plains region. However, less than 10 percent of the eastern demand for coal is supplied by the West.

By the year 2000 significant growth in coal flows should occur along the following corridors:

- Appalachia
  - Mid Atlantic
  - South Atlantic
- Interior
  - East North Central

- Great Plains

  - East North Central
  - West North Central
  - West South Central
  - Mountain

The additional traffic demands by 1985 may be met by the railways by way of improved signalization, shorter block sections, centralized traffic control, and other modernization methods without providing for heavy line capacity works. But by 2000 the incremental traffic on some of the corridors mentioned above was projected to increase very significantly, and is likely to call for special line capacity works involving heavy investments.

The transportation of the amount of coal in all of the scenarios could be constrained if sufficient transportation capacity is not built by 2000. This capacity expansion would require large capital investments. The difficulties associated with increasing coal-hauling capacity is not physical or technological. The financial health of the railroad companies in light of current capacity and future capacity requirement will have to be studied to determine if this amount of coal can be brought to market.

Table 6-3. Coal Demand
(millions of short tons)

Scenario	Year	New England	Mid Atlantic	South Atlantic	East North Central	East South Central	West North Central	West South Central	Mountain	Pacific	Total
Baseline (Low Oil Price)	1979	1.2	79.9	150.0	235.4	90.5	80.7	49.6	66.2	8.6	762.1
	1985	2	98	183	307	115	126	113	100	11	1055
	1990	2	126	225	364	142	177	193	156	28	1413
	1995	3	145	266	440	172	228	272	210	46	1781
	2000	3	171	317	531	209	301	372	290	64	2258
Constrained Oil Supply	1985	2	98	183	307	115	126	113	100	11	1055
	1990	2	108	203	325	128	158	199	152	12	1287
	1995	2	139	263	392	170	224	314	239	45	1787
	2000	3	169	343	509	212	297	415	336	63	2347
High Oil Supply	1985	2	98	183	307	114	126	113	100	11	1055
	1990	2	112	204	345	129	142	139	111	12	1196
	1995	3	134	240	438	157	193	190	149	16	1521
	2000	3	164	288	532	196	265	312	205	21	1985

APPENDIX

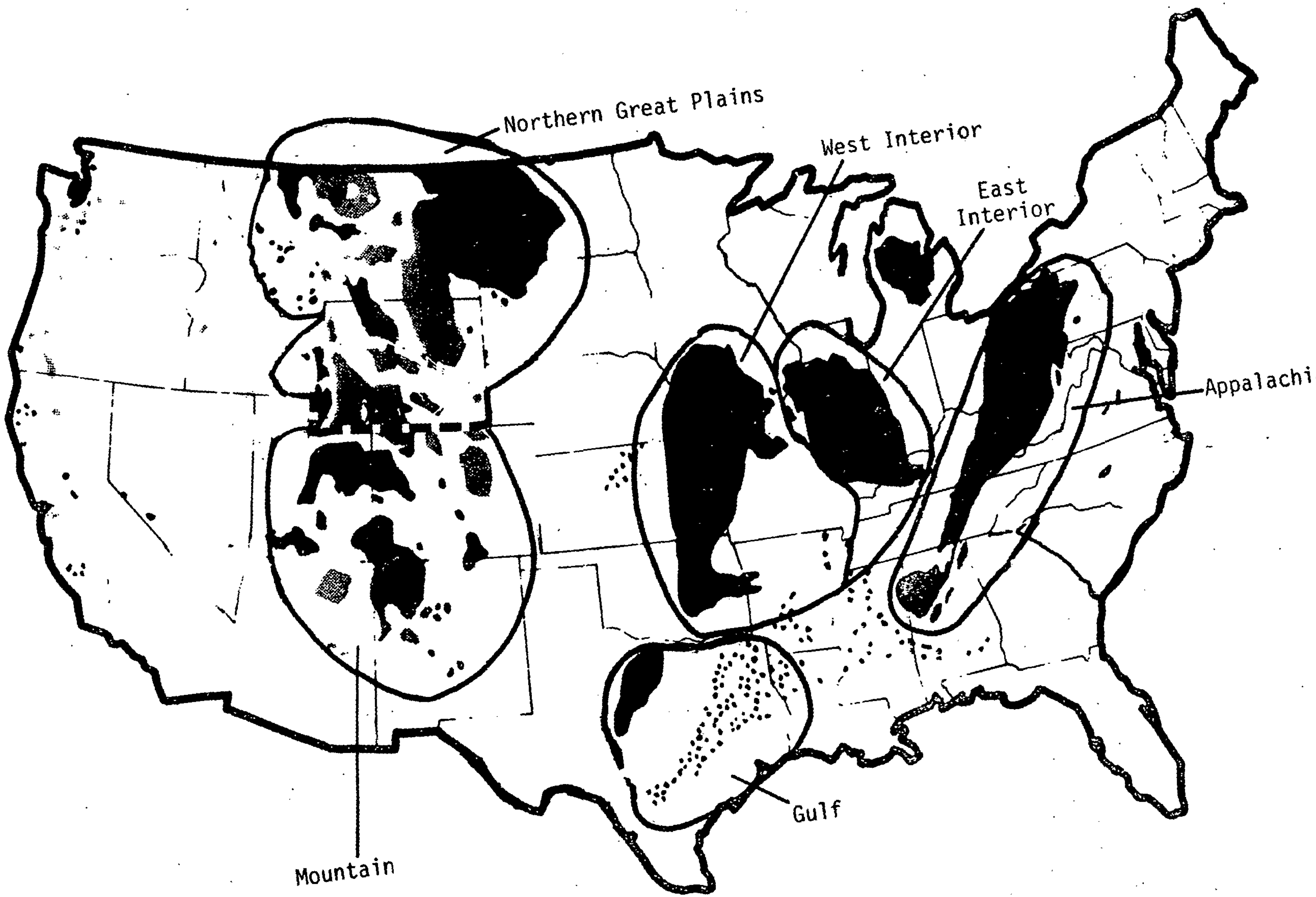


Figure 1. Coal Producing/Supply Regions

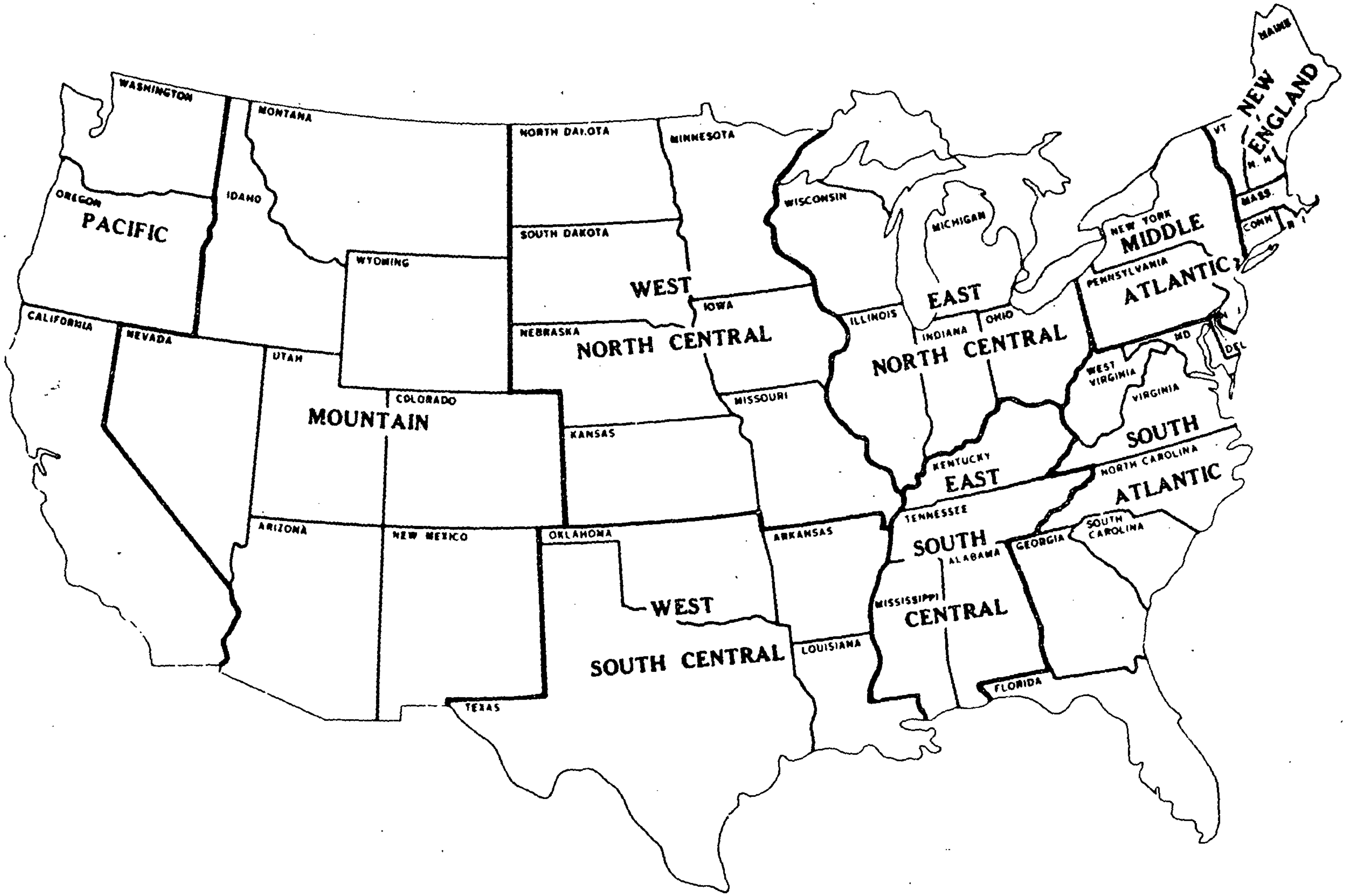
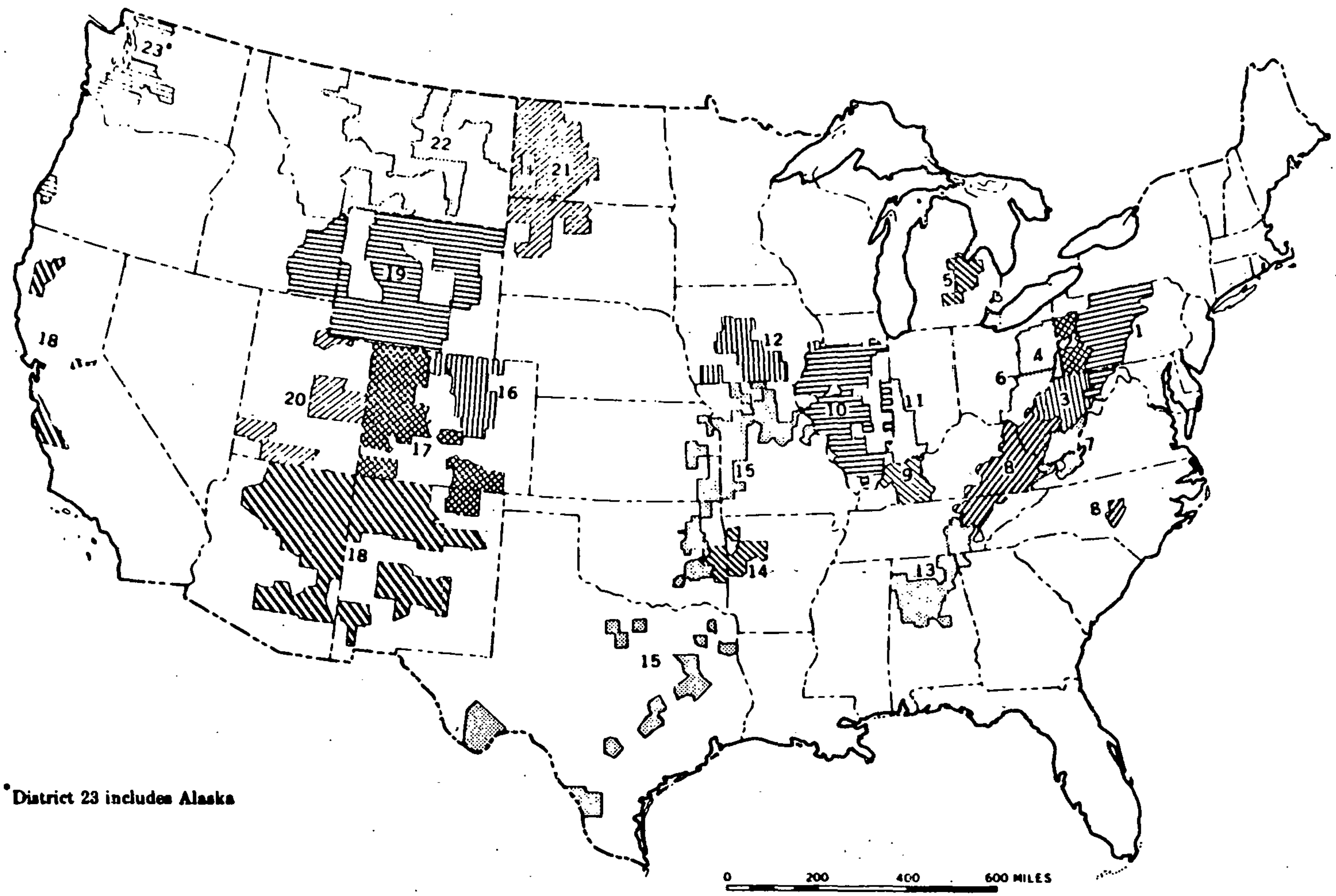


Figure 2. Census Bureau/Demand Regions



Bituminous Coal Producing Districts as Defined in the Bituminous Coal Act of 1937 and Amendments

The districts were originally established to aid in formulating minimum prices of bituminous coal and lignite. Because much statistical information was compiled in terms of these districts, their use for statistical purposes has continued since the abandonment of that legislation in 1943.

Figure 3. Bureau of Mines Coal Districts

DISTRICT 1.

Maryland-
All mines in the State

Pennsylvania-
All mines in the following counties:

Bedford	Centre	Forest	McKean
Blair	Clarion	Fulton	Mifflin
Bradford	Clearfield	Huntingdon	Potter
Cambria	Clinton	Jefferson	Somerset
Cameron	Elk	Lycoming	Tioga

Selected mines in the following counties:
Armstrong County (part).-All mines east of the Allegheny River, and those mines served by the Pittsburgh & Shawmut Railroad located on the west bank of the river.
Fayette County (part).-All mines located on and east of the line of Indian Creek Valley branch of the Baltimore & Ohio Railroad.
Indiana County (part).-All mines not served by the Saltsburg branch of the CONSOLIDATED RAIL CORPORATION.
Westmoreland County (part).-All mines served by the CONSOLIDATED RAIL CORPORATION from Torrance, east.

West Virginia-
All mines in the following counties:

Grant	Mineral	Tucker

DISTRICT 2.

Pennsylvania-
All mines in the following counties:

Allegheny	Butler	Lawrence	Venango
Beaver	Greene	Mercer	Washington

Selected mines in the following counties:
Armstrong County (part).-All mines west of the Allegheny River except those mines served by the Pittsburgh & Shawmut Railroad.
Fayette County (part).-All mines except those on and east of the line of Indian Creek Valley branch of the Baltimore & Ohio Railroad.
Indiana County (part).-All mines served by the Saltsburg branch of the CONSOLIDATED RAIL CORPORATION.
Westmoreland County (part).-All mines except those served by the CONSOLIDATED RAIL CORPORATION from Torrance, east.

DISTRICT 3.

West Virginia-
All mines in the following counties:

Barbour	Jackson	Randolph	Webster
Braxton	Lewis	Ritchie	Wetzel
Calhoun	Marion	Roane	Wirt
Doddridge	Monongalia	Taylor	Wood
Gilmer	Pleasants	Tyler	
Harrison	Preston	Upshur	

Selected mines in the following county:
Nicholas County (part).-All mines served by or north of the Baltimore & Ohio railroad.

DISTRICT 4.

Ohio-
All mines in the State.

DISTRICT 5.

Michigan-
All mines in the State.

DISTRICT 6.

West Virginia-
All mines in the following counties:

Brooke	Hancock	Marshall	Ohio

DISTRICT 7.

Virginia-
All mines in the following counties:

Montgomery	Pulaski	Wythe	Giles	Craig

Selected mines in the following counties:
Buchanan County (part).-All mines in that portion of the county served by the Richlands-Jewell Ridge branch of the Norfolk & Western Railroad and in that portion on the headwaters of Dismal Creek east of Lynn Camp Creek (a tributary of Dismal Creek).
Tazewell County (part).-All mines in those portions of the county served by the Dry Fork branch to Cedar Bluff and from Bluestone Junction to Boissevain branch of the Norfolk & Western Railroad and Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

West Virginia-
All mines in the following counties:

Greenbrier	Mercer	Monroe	Pocahontas	Summers

DISTRICT 7. Continued

West Virginia- (continued)

Selected mines in the following counties:
Fayette County (part).-All mines east of Gauley River and all mines served by the Gauley River branch of the Chesapeake & Ohio Railroad and mines served by the Norfolk & Western Railroad.
McDowell County (part).-All mines in that portion of the county served by the Dry Fork branch of the Norfolk & Western Railroad and east thereof.
Raleigh County (part).-All mines except those on the Coal River branch of the Chesapeake & Ohio Railroad and north thereof.
Wyoming County (part).-All mines in that portion served by the Guyandot branch of the Norfolk & Western Railroad lying east of the mouth of Skin Fork of Guyandot River and in that portion served by the Virginia division main line of the Norfolk & Western Railroad.

DISTRICT 8.

Kentucky-
All mines in the following counties in eastern Kentucky:

Bell	Greenup	Lawrence	Morgan
Boyd	Harlan	Lee	Owsley
Breathitt	Jackson	Leslie	Perry
Carter	Johnson	Letcher	Pike
Clay	Knott	McCreary	Rockcastle
Elliott	Knox	Magoffin	Wayne
Floyd	Laurel	Martin	Whitley

North Carolina-
All mines in the State.

Tennessee-
All mines in the following counties:

Anderson	Cumberland	Overton
Campbell	Fentress	Roane
Claiborne	Morgan	Scott

Virginia-
All mines in the following counties:

Dickinson	Russell	Wise
Lee	Scott	

Selected mines in the following counties:
Buchanan County (part).-All mines in the county, except in that portion on the headwaters of Dismal Creek, east of Lynn Camp Creek (a tributary of Dismal Creek) and in that portion served by the Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.
Tazewell County (part).-All mines in the county except in those portions served by the Dry Fork branch of the Norfolk & Western Railroad and branch from Bluestone Junction to Boissevain of Norfolk & Western Railroad and Richlands-Jewell Ridge branch of the Norfolk & Western Railroad.

West Virginia-
All mines in the following counties:

Boone	Kanawha	Mason	Wayne
Cabell	Lincoln	Mingo	
Clay	Logan	Putnam	

Selected mines in the following counties:
Fayette County (part).-All mines west of the Gauley River except mines served by the Gauley River branch of the Chesapeake & Ohio Railroad.
McDowell County (part).-All mines west of and not served by the Dry Fork branch of the Norfolk & Western Railroad.
Nicholas County (part).-All mines in that part of the county south of and not served by the Baltimore & Ohio Railroad.
Raleigh County (part).-All mines on the Coal River branch of the Chesapeake & Ohio Railroad and north thereof.
Wyoming County (part).-All mines in that portion served by the Guyandot branch of the Norfolk & Western Railroad and lying west of the mouth of Skin Fork of Guyandot River.

DISTRICT 9.

Kentucky-
All mines in the following counties in western Kentucky:

Butler	Hancock	McLean	Todd
Christian	Henderson	Muhlenberg	Union
Crittenden	Hopkins	Ohio	Warren
Daviess	Logan	Simpson	Webster

DISTRICT 10

Illinois-
All mines in the State.

DISTRICT 11

Indiana-
All mines in the State.

DISTRICT 12

Iowa-
All mines in the State.

DISTRICT 13.

Alabama-
All mines in the State.

Georgia-
All mines in the State.

Tennessee-
All mines in the following counties:

Bledsoe	Marion	Sequatchie	White
Grundy	McMinn	Van Buren	
Hamilton	Rhea	Warren	

DISTRICT 14.

Arkansas-
All mines in the State.

Oklahoma-
All mines in the following counties:

Haskell	Le Flore	Sequoyah

DISTRICT 15.

Kansas-
All mines in the State.

Missouri-
All mines in the State.

Oklahoma-
All mines in the following counties:

Coal	Latimer	Okmulgee	Rogers	Wagoner
Craig	Muskogee	Pittsburg	Tulsa	

Texas-
All mines in the State.

DISTRICT 16.

Colorado-
All mines in the following counties:

Adams	Douglas	Jackson	Larimer
Arapahoe	Elbert	Jefferson	Weld
Boulder	El Paso		

DISTRICT 17.

Colorado-
All mines except those included in District 16.

New Mexico-
All mines except those included in District 18.

DISTRICT 18.

Arizona-
All mines in the State.

California-
All mines in the State.

New Mexico-
All mines in the following counties:

Grant	McKinley	Sandoval	San Miguel	Socorro
Lincoln	Rio Arriba	San Juan	Santa Fe	

DISTRICT 19.

Idaho-
All mines in the State.

Wyoming-
All mines in the State.

DISTRICT 20.

Utah-
All mines in the State.

DISTRICT 21.

North Dakota-
All mines in the State.

South Dakota-
All mines in the State.

DISTRICT 22.

Montana-
All mines in the State.

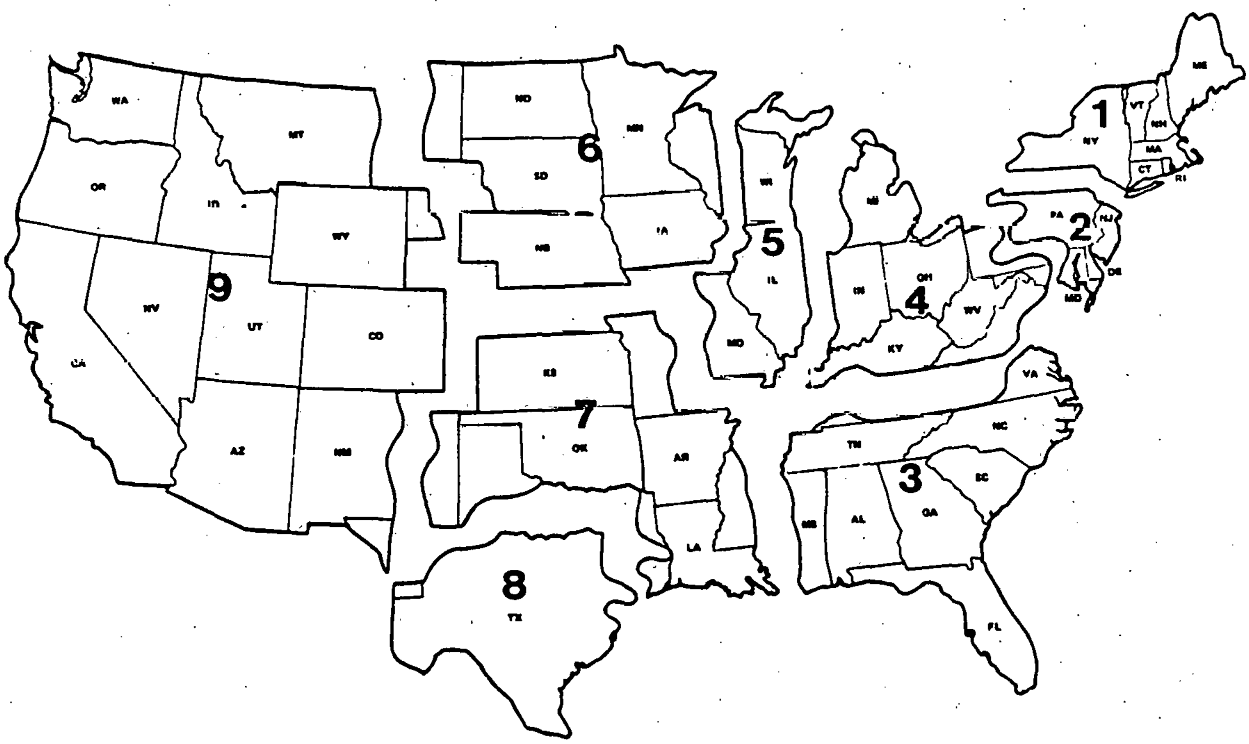
DISTRICT 23.

Alaska-
All mines in the State.

Oregon-
All mines in the State.

Washington-
All mines in the State.

Figure 3. Bureau of Mines Coal Districts (Continued)



1	NPCC	Northeast Power Coordinating Council
2	MAAC	Mid-Atlantic Area Council
3	SERC	Southeastern Electric Reliability Council
4	ECAR	East Central Area Reliability Coordination Agreement
5	MAIN	Mid-America Interpool Network
6	MARCA	Mid-Continent Area Reliability Coordination Agreement
7	SPP	Southwest Power Pool
8	ERCOT	Electric Reliability Council of Texas
9	WSCC	Western Systems Coordinating Council

Source: National Electric Reliability Council

Figure 4. Regional Boundaries of the Electric Utility Industry in the Contiguous United States

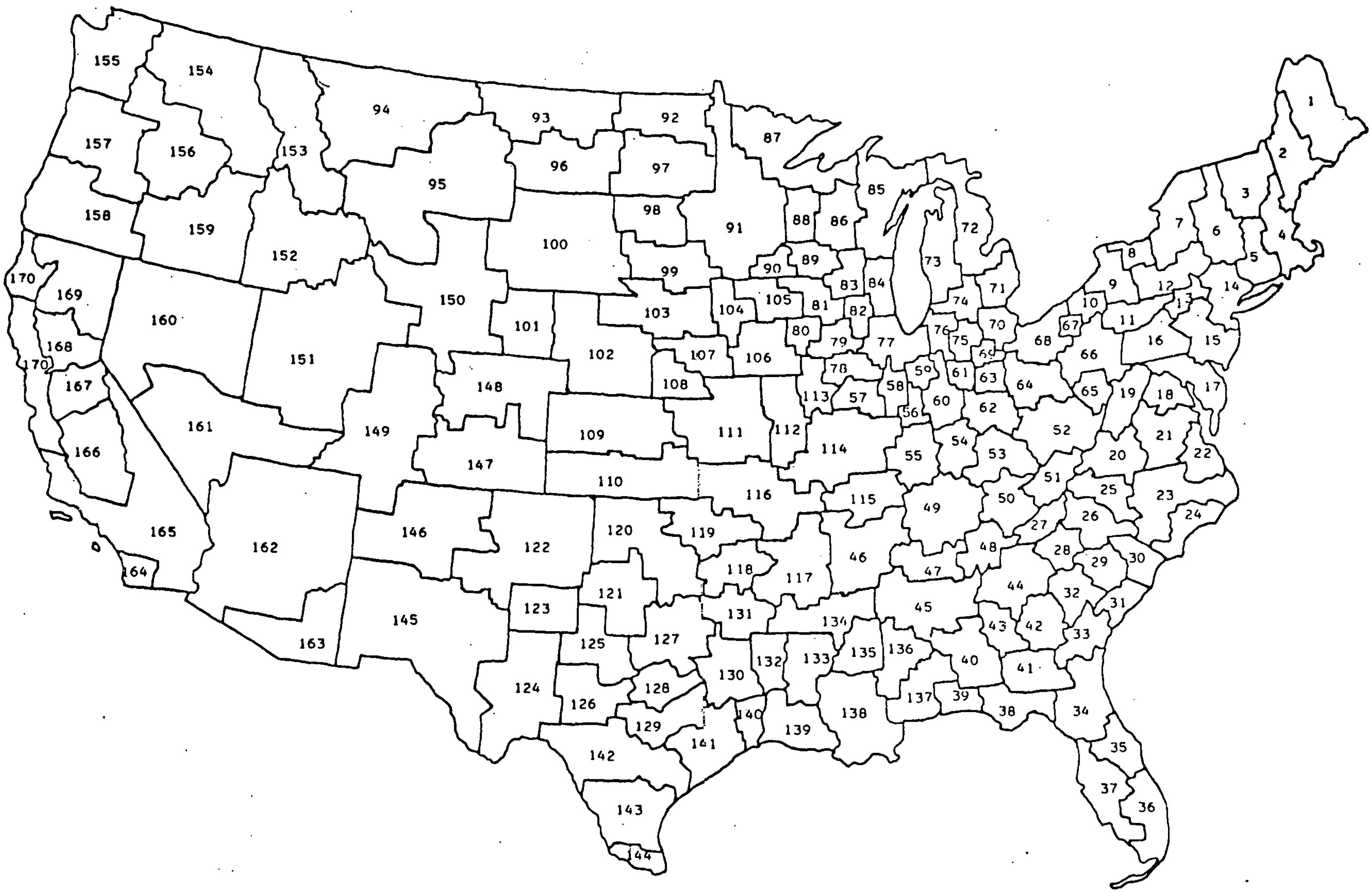


Figure 5. Bureau of Economic Analysis Regions

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