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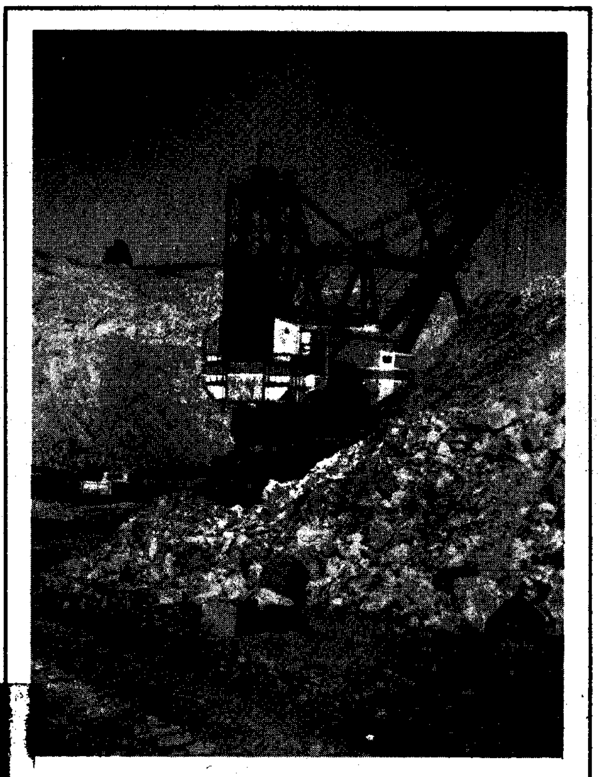
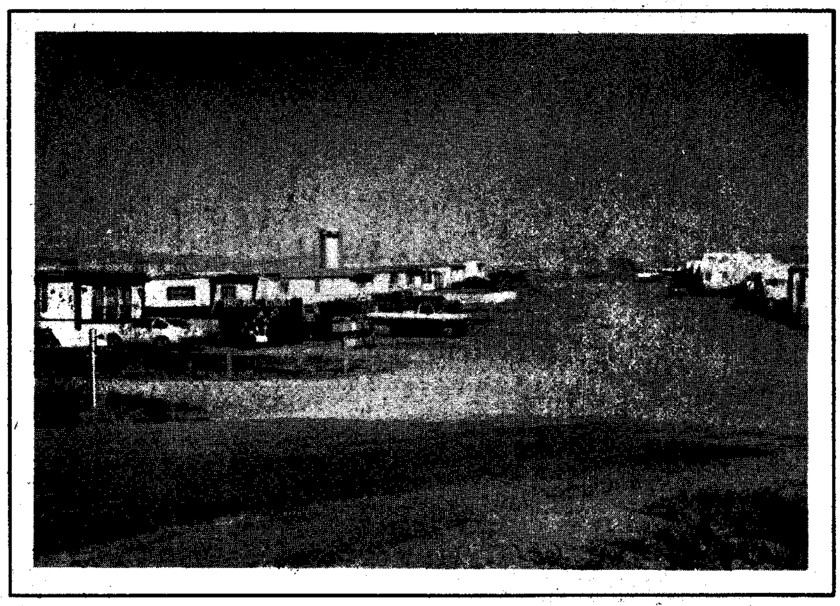
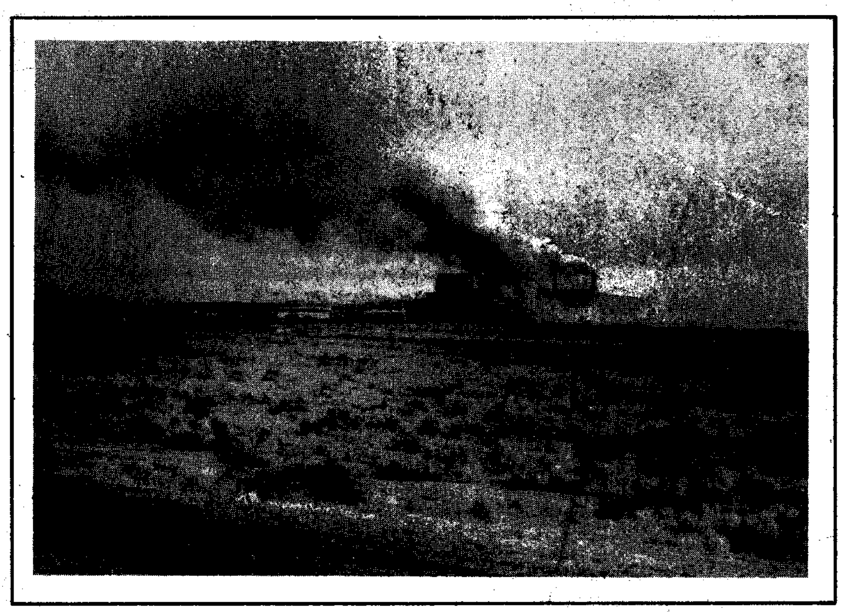
INFRASTRUCTURE AND HIGHWAY SUPPORT NEEDS OF REGIONS AFFECTED BY ENERGY ACTIVITIES







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16. Abstract
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INFRASTRUCTURE AND HIGHWAY SUPPORT NEEDS OF REGIONS AFFECTED BY ENERGY ACTIVITIES

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ABSTRACT

The population increases and additional personal travel by highway expected to result from additional energy production in the period in 1977-85 are indicated for each of the lower 48 states. The forces that affect capability of the local infrastructure to cope with strains from such population increases are addressed. It is concluded that the heaviest stresses will result from exploitation of coal. The regional implications for possible Federal support needs are assessed on a relative basis; strains on local infrastructures are likely to be particularly heavy in the Western Mountain and Great Plains states and in the coal counties of Appalachia.

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OF

REGIONS AFFECTED BY ENERGY ACTIVITIES

1.0 INTRODUCTION

1.1 Purpose of Report

This report has been prepared for the Federal Highway Administration (FHWA) of the United States Department of Transportation pursuant to FHWA responsibilities under Section 153 of the 1976 Federal-Aid Highway Act. A separate paper reports on an analysis of near-term (1985) energy forecasts and their methodology, sensitivity to basic assumptions, degree of regionalization, and interpretation of results.

The present report emphasizes the load placed on highways (within the 1985 time-frame) by population shifts expected to occur as a result of energy development within states and localities. While noted as part of the general problem, the extent and effects of hauling energy products and materials by highways are not analyzed in this report.

The study was intended to accomplish the following objectives:

a. Identify and discuss the factors which govern the capability of state and local governments to cope with infrastructure needs generated by energy developments;

b. Present the predominant characteristics of the major energy production technologies which interact with the features of the locality involved to influence the nature of the infrastructure problems created and the locality's capability to respond;

c. Estimate the required work force for each major energy activity in terms of the units of energy extracted;

d. Review possible approaches to meeting infrastructural road network requirements attributable to energy development;

e. Assess on a relative basis the probable extent of energy-related impacts on the major regions of the United States and the resultant stresses on highway needs and local infrastructures.

The scope of the study did not extend to an analysis in quantitative or in absolute terms of the degree to which any locality, state or region would be impacted. Nor was the study intended to analyze at such a level of detail the capability of individual states or localities to respond to highway needs and other infrastructural stresses. However, at a rather generalized level the infrastructural characteristics are surveyed in the report for those regions (e.g., Appalachia, Western Great Plains States, etc.) deemed likely to receive the most severe stresses.

1.2 Approach and Structure

The current study utilizes a twofold approach; (1) examination of the expected energy development and attendant population increase on a regional, state and even local basis and simultaneously (2) an analysis of the factors which influence stress on local infrastructures and capabilities of the states and other governmental subdivisions to cope with highway needs. Selected case studies of methods for planning to meet highway needs supplement the general analysis.

The results of the study are reported here in five sections, with details presented in three appendices. Section 2 identifies the general highway needs likely to exist as a result of expanded energy technology development. These are categorized as to those resulting from primary* or secondary** development.

Section 3 examines the expected population load and the extent to which these may stress existing highway and infrastrucutre capabilities of the principal regions and states affected.

The analysis is based on a state-by-state consideration (with attention to particular areas most heavily affected) of the following factors:

- Projected energy development;
- Projected local population influx, both from work forces and from indirect and induced employment;
- Estimated resulting traffic load, compared to present capabilities;
- Consideration of local conditions that influence ability of infrastructure to respond to stress.

Sections 4 and 5 analyze the factors (on a general rather than a site-specific basis) development which affect highway needs and influence local capabilities to cope with infrastructure stresses.

---

*I.e., those reflecting population increase of energy industry workers and their families.

**I.e., those reflecting population increase from indirect and induced employment.

1.3 Summary of Findings

The conclusions presented somewhat tentatively in Section 3 provide the major findings of the study. These are based on the assumption that highway and infrastructure stresses within a given state will depend largely on two factors:

a. The size of the population shifts involved: i.e., the number of persons who will take up new abodes within that state as a result of both direct participation in energy activities and employment in secondary positions created by this activity (the primary and secondary impacts identified in Section 2);

b. The characteristics of the affected regions which govern the capabilities of states and localities to respond to the stresses which additional travel will place on their highway systems and infrastructures (as discussed for the principally affected regions in Subsection 3.8 and in general terms in Section 5).

On this basis, it was concluded that the most severely-stressed region would be the Western Mountain and Great Plains states, where massive coal exploitation will take place, as well as uranium mining and milling. Impacts are also likely to be severe in the coal counties of Appalachia, particularly in rural West Virginia and Kentucky. Other areas may incur heavy additional travel loads but are deemed better able to cope with the problems because of a greater population base, more highly developed infrastructures, and/or a dispersal of energy-related activities throughout the states involved.

Among the various energy sources and technologies (the characteristics of which are briefly discussed in Section 4) it can be concluded that coal mining and construction of electric generating plants will be the largest contributors to populations shifts and travel increases. Of the two, coal mining is likely to produce the more severe stresses because of its extension over a long period of time and - more importantly - its concentration in isolated rural areas. In individual situations, however, there may be severe impacts from construction projects, where a large work force typically peaks in the second or third year of a four to five year cycle and then drops off to leave a very small number of operating personnel. Such effects may occur not only from construction of power plants but also from processing plants for synthetic fuels, for the uranium cycle, and for natural gas and petroleum.

2.0 IDENTIFICATION OF NEED SOURCES

2.1 Background

The U. S. demand for energy has more than doubled since 1950, jumping from about 35 quadrillion BTU (quads) to an estimated 72.1 quads in 1972 (Falkie, 1976; ERDA, 1975). Despite the 2.2 percent decrease between 1973 and 1974 - the first in more than 20 years - energy demands are expected to reach a minimum of 95.5 quads by 1985 and may indeed total more than 105 quads (ERDA, 1975).

In the past, much of the increasing energy requirement of the United States was met by expanding the use of petroleum and natural gas. Until recently, first both domestic and later foreign sources were able to satisfy incremental demand at relatively low cost. Now the situation has changed dramatically. Between 1973 and 1975, the cost of imported petroleum increased from $8 billion to $25 billion annually. Further, worldwide reserves of petroleum and natural gas are of limited duration, and costs are expected to rise continually. Of the remaining options open to the U. S. (e.g., nuclear, coal, geothermal, solar, etc.), there is a strong movement toward the use of domestic coal for direct combustion and for conversion to synthetic fuels.

In 1974, Project Independence (FEA, 1974) estimated an annual coal production of 1.2 billion tons by 1985, up from about 640 million tons in 1976 (FEA, 1974). This doubling in coal production is expected to involve new mining in the Western coal rich states of

North Dakota, Montana, Wyoming, Colorado, and Utah as well as increased production in Appalachia and the Interior Coal Regions of the Mid-West. Although such a goal may not indeed be achievable in view of technologic difficulties, manpower and capital shortages, and institutional and environmental constraints, it is clear that coal will play the major role in meeting U. S. energy needs with less dependence on foreign oil and gas. Much of this coal will be burned directly in electric generating plants and other industrial facilities (reversing the previously-established trend towards oil and gas).

Over half of the U. S. coal reserves are located in the East. Western coal has the attraction, however, of low sulfur content and relatively easy availability through surface mining. Another important factor in regard to Western coal is that much of it is located on public lands. This situation can facilitate production through leasing arrangements under Federal programs. However, complications could result for the states and localities included.

Lesser contributions to meeting U. S. energy needs will result from increased use of nuclear energy and enhanced production from the nation's dwindling oil and gas reserves. While U. S. oil shale (particularly in the Colorado, Wyoming and Utah regions) has a very high potential in the amount of crude oil that could theoretically be produced, all indications are that any program for synthetic fuels from oil shale and tar sands would not be well-advanced by 1985.

Hence, the emphasis in this report is on highway needs and infrastructure stresses associated with increased extraction and processing of coal. Attention is also paid to oil and gas, electric power generation and the cycle of producing nuclear fuel from uranium ore.

Energy commodities and power produced in the United States must typically be moved from one location to another. Regardless of whether the energy is in the form of electricity, gas, oil or coal, its consumption often takes place at a considerable distance from the place where it is produced. In providing energy to the final consumer a variety of ways are employed, from electric transmission networks and pipelines to rail, river barge, and highways.

2.2 Primary Impacts

Of particular concern in this study are the effects on highway and road networks created by the movement of workers and the increased traffic generated by the labor force and their dependents. These requirements are particularly heavy during the construction phase of power plants and other facilities (e.g., gasification facilities and refineries). But whether or not they relocate within the immediate vicinity, daily and weekly commuting by construction workers to the job site from their residences places a primary load on the road network of the area. In order to deal with the increased traffic volume and the movement of construction equipment, state and local authorities are typically confronted with the need to rebuild roads and bridges, relocate streets and create new ones, expand turn lanes, install new signalling devices, and undertake other highway and road improvements.

Officials in states likely to be heavily involved in energy development foresee heavy impacts on highway support needs during an energy project's construction and operation. The consequence of these impacts, as contended by governmental officials in representative areas as widely separated geographically as North Dakota and Kentucky, is that their road networks will require expansion, modification and additional maintenance during energy development and afterward. The concern is that state and local funds normally budgeted for highways and roads will become increasingly inadequate. Additional funding from traditional sources may be inadequate, due to limitations on taxing powers and the competition from other nonhighway governmental programs. Some state and local governmental officials see the need for some form of Federal assistance or some other outside* support to areas experiencing impacts from energy development.

During the operational phase of an energy activity, highway needs are generated by the movement of working personnel to the mine, plant, or other facility, as well as by the transfer of supplies and equipment to the site and, in some activities, the disposition of solid wastes at landfills or other locations. In power plants,

*I.e., from other than the normal state and local tax base.

refineries, and other processing facilities the required operating force tends to be significantly less than the size of the construction force (from one-half to much less than one-tenth, as shown in a later section).

In terms of outside support, the highway needs generated during the operational phase of energy development may be more critical. A separate construction phase may precede operation of the facility by from two to five or more years. This timing makes it more difficult to plan for and incorporate outside support in time to be effective. The later operating phase tends to build up to a fairly level work force that continues throughout the 20 to 30 or more years of the facility's expected life. Outside support over this longer time period can more easily be planned and provided.

2.3 Secondary Impacts

Secondary impacts result chiefly from increased population from indirect and induced employment as the terms are explained below. Each dollar spent on labor or material required for an energy activity within a region generates secondary demand for goods and services. Payroll money is spent on housing, food and clothing for the workers and their families, and other necessity and luxury items. As a result, employment is created in commercial establishments catering to needs of the labor force as consumers. Such employment is termed "indirect." A "ripple" effect is also created in the regional economy as money paid out for wages and materials in business supplying the workers in turn leads to further demand, and so on. Motels in the area expand and new ones are built. Commercial establishments such as retail stores and service-related activities appear. In addition, the energy operations may attract industries into the area to provide equipment to the energy operations. These second and third order effects are included under ther term "induced employment."

No distinction is made in this report as to the effect of indirect and induced employment. The point is that all of the secondary supporting activities require people (whether in what is termed "indirect" or "induced" employment) and as a result the entire area is likely to experience an influx. They will require housing and gradually the area becomes increasingly more urbanized. There is more widespread use of automobiles and need for an augmented road network to serve movement of the population for business purposes, routine trips to meet family needs and recreational activities. The increased traffic load necessitates upgrading and repairs to existing highway facilities as more roads are widened, lanes are added, bridges and other supporting structures are strengthened, and more frequent resurfacing is required.

3.0 REGIONAL ASSESSMENT OF HIGHWAY NEEDS THROUGH 1985

3.1 General Summary of Additional Energy Development

This section presents the major findings of the study in terms of the implications of energy development upon highways. The extent of energy development, the anticipated population increases, and the additional traffic volumes projected are shown for the lower 48 states (i.e., those contiguous within the continental United States, and hence exclusive of Alaska and Hawaii).

The basic results are shown in graphic and tabular form through a series of maps (Figures 3-1 through 3-5) and statistical listings (Tables 3-1 through 3-22). The implications for financial assistance to highways likely to be required within states and regions principally affected are discussed in separate subsections. The conclusions presented take into account* the factors affecting capabilities of the local infrastructure to meet highway needs and other stresses of energy development (analyzed in more depth in Sections 4 and 5 and in the Appendices).

It will be noted that the assessment of oil and gas production is in less detail than for coal (and its products), uranium mining, power generation, and the various types of processing plants. There are several reasons for this. Hard data is less readily available

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*To the extent possible within the scope of the study which did not permit detailed level assessments.

TABLE 3-1

ESTIMATES OF CUMULATIVE ADDITIONAL ENERGY CAPACITY 1977-1985

BY STATE

STATE	COAL MINES TOTAL PRODUCTION INCREASE (1976-85) 10^6 TONS/YR. 1, 3 (b)	POWER PLANTS CAPACITY MEGAWATTS 1, 4	COAL CONVERSION PLANTS GAS/LIQ/AMMONIA 1, 5, 6 (a)	OIL SHALE 10^3 bbls/day 1	GEOTHERMAL FACILITIES POTENTIAL # 1	URANIUM MINES/ URANIUM MILLS # OF FACILITIES 1	OIL REFINERY 10^3 bbls/day 1, 2	NATURAL GAS PROCESSING 10^6 ft^3/day 1, 2
Alabama	14.05	3542					2	
Arizona	5.0	7366						30
Arkansas	0.1	6243						
California		18898			5		350	
Colorado	45.6	5471	250/ 0/ 0	355.5	11	1/0		
Connecticut		1610	3.2/ 0/ 0					
Delaware		504						
Florida		11120						
Georgia		6224						
Idaho		1318						

TABLE 3-1 (cont.)

STATE	COAL MINES TOTAL PRODUCTION INCREASE (1976-85) 10^6 TONS/YR. 1, 3 (b)	POWER PLANTS CAPACITY MEGAWATTS 1, 4	COAL CONVERSION PLANTS GAS/LIQ/AMMONIA 1, 5, 6 (a)	OIL SHALE 10^3 bbls/day 1	GEOTHERMAL FACILITIES POTENTIAL # 1	URANIUM MINES/ URANIUM MILLS # OF FACILITIES 1	OIL REFINERY 10^3 bbls/day 1, 2	NATURAL GAS PROCESSING 10^6 ft^3/day 1, 2
Illinois	27.8	10071	214.0/ 3900/ 0				6.7	
Indiana	7.1	1160					16.9	
Iowa	0.1	4406						
Kansas	0.25	5937						
Kentucky	44.3	1195	80/ - /0				107	
Louisiana		6455					235	1610
Maine		600						
Maryland	1.8	2289	60/ 0/0				200	
Massachusetts		2701						
Michigan		1379						

TABLE 3-1 (cont.)

STATE	COAL MINES TOTAL PRODUCTION INCREASE (1976-85) 10^6 TONS/YR. 1, 3 (b)	POWER PLANTS CAPACITY MEGAWATTS 1, 4	COAL CONVERSION PLANTS GAS/LIQ/AMMONIA 1, 5, 6 (a)	OIL SHALE 10^3 bbls/day 1	GEOTHERMAL FACILITIES POTENTIAL # 1	URANIUM MINES/ URANIUM MILLS # OF FACILITIES 1	OIL REFINERY 10^3 bbls/day 1, 2	NATURAL GAS PROCESSING 10^6 ft^3/day 1, 2
Minnesota		4308						
Mississippi		1216					25	
Missouri		7081						
Montana	48.2	4397	1400/ 150 1000					
Nebraska		4217						
Nevada		2500			4			
New Hampshire		1150						
New Jersey		1409	125/ 0/ 0					
New Mexico	77.7	1340	1785/ 0/ 0		2	12/3		
New York		14571	125/ 0/ 0					

TABLE 3-1 (cont.)

STATE	COAL MINES TOTAL PRODUCTION INCREASE (1976-85) 10^6 TONS/YR. 1, 3 (b)	POWER PLANTS CAPACITY MEGAWATTS 1, 4	COAL CONVERSION PLANTS GAS/LIQ/AMMONIA 1, 5, 6 (a)	OIL SHALE 10^3 bbls/day 1	GEOTHERMAL FACILITIES POTENTIAL # 1	URANIUM MINES/ URANIUM MILLS # OF FACILITIES 1	OIL REFINERY 10^3 bbls/day 1, 2	NATURAL GAS PROCESSING 10^6 ft^3/day 1, 2
North Carolina		8282						
North Dakota	42.6	2820	2125/ 0/ 0					
Ohio	9.0	6490	111.6/ 2600/ 0				2.4	
Oklahoma	0.25	6951					15	242
Oregon		4409			12	1/0	86	700 LNG STORAGE
Pennsylvania	26.7	3765	250/ 0/ 0				50.1	
Rhode Island		--						
South Carolina		1140						
South Dakota		1308						700 LNG STORAGE
Tennessee	3.85	3502					4.7	

TABLE 3-1 (concluded)

STATE	COAL MINES TOTAL PRODUCTION INCREASE (1976-85) 10^6 TONS/YR. 1, 3 (b)	POWER PLANTS CAPACITY MEGAWATTS 1, 4	COAL CONVERSION PLANTS GAS/LIQ/AMMONIA 1, 5, 6 (a)	OIL SHALE 10^3 bbls/day 1	GEOTHERMAL FACILITIES POTENTIAL # 1	URANIUM MINES/ URANIUM MILLS # OF FACILITIES 1	OIL REFINERY OIL REFINERY 10^3 bbls/day 1, 2	NATURAL GAS PROCESSING 10^6 ft^3/day 1, 2
Texas	46.0	27807				11/0	688	530
Utah	64.5	9904	864/ 0/ 0	125	2	3/0		
Vermont		518						
Virginia	7.7	1050					420.2	
Washington	2.0	15838				1/1		
West Virginia	47.8	—	250/ 0/ 0					
Wisconsin		2498						
Wyoming	139.8	4994	1300/ 0/ 1			11/5	3	60
TOTAL U.S.	662.2	241954	8692.8/ 6650/ 1001	480.5	38	40/9	2355.	3872

[a]Gasification is in 10^6 ft^3/day; liquefaction is in 10^3 bbls/day; an hydrous ammonia is in tons/day.

[b]Includes mine additions in 1975.

Note that coal will be used for power plant electric generation, and coal conversion. These values cannot therefore be totaled for an overall output in some common unit (such as quads) for each State. Note also that geothermal and uranium facility values are given as only the number of facilities, not in energy units.

[1]USBM, 1976a (Corsentino).

[2]The Oil and Gas Journal (Cantrel), 1976.

[3]Campbell, 1976.

[4]FPC, 1976.

[5]ERDA, 1976a.

[6]USBM, 1976d

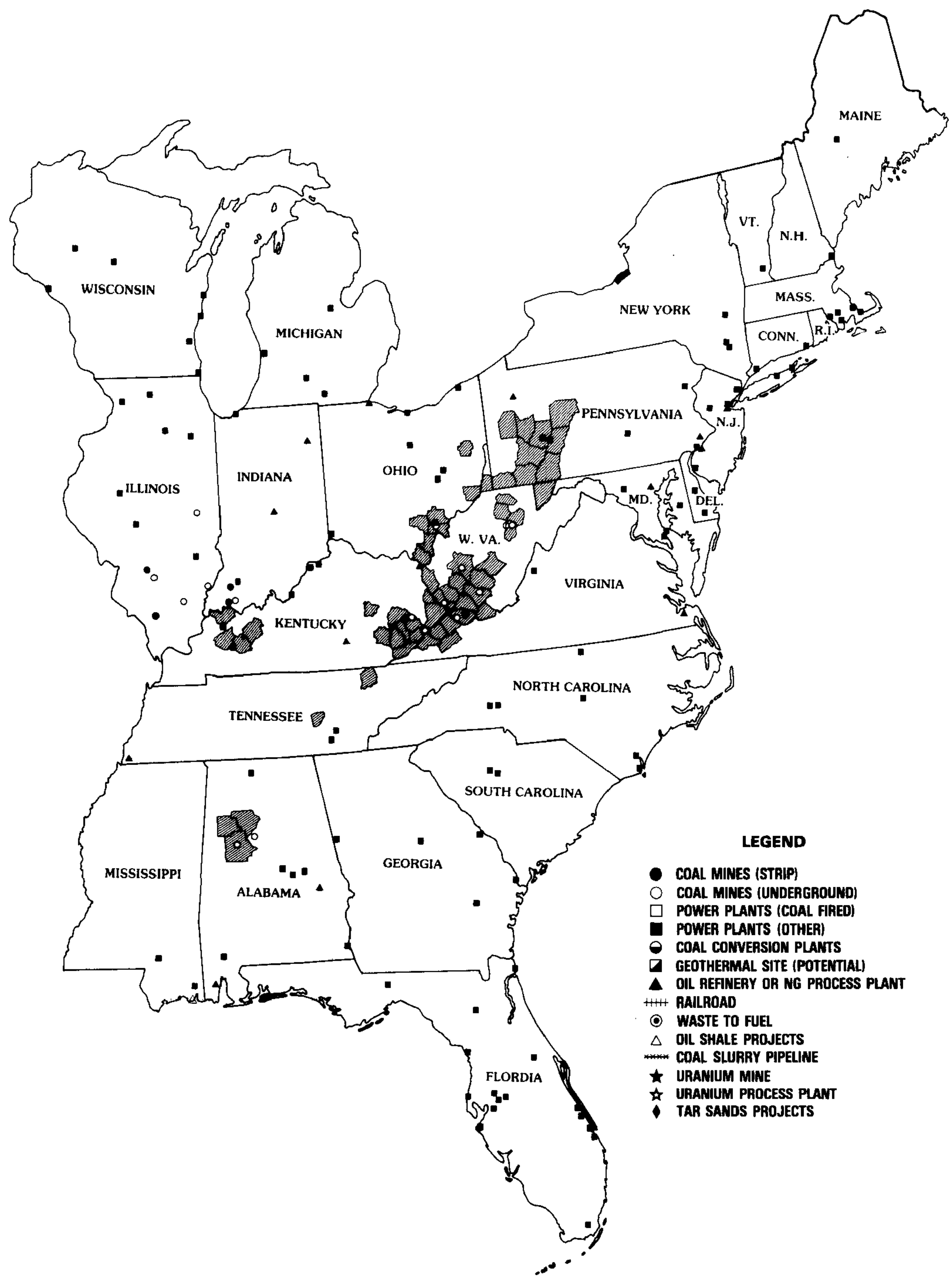


FIGURE 3-1
PLANNED ENERGY SITES THROUGH 1985
EASTERN REGION

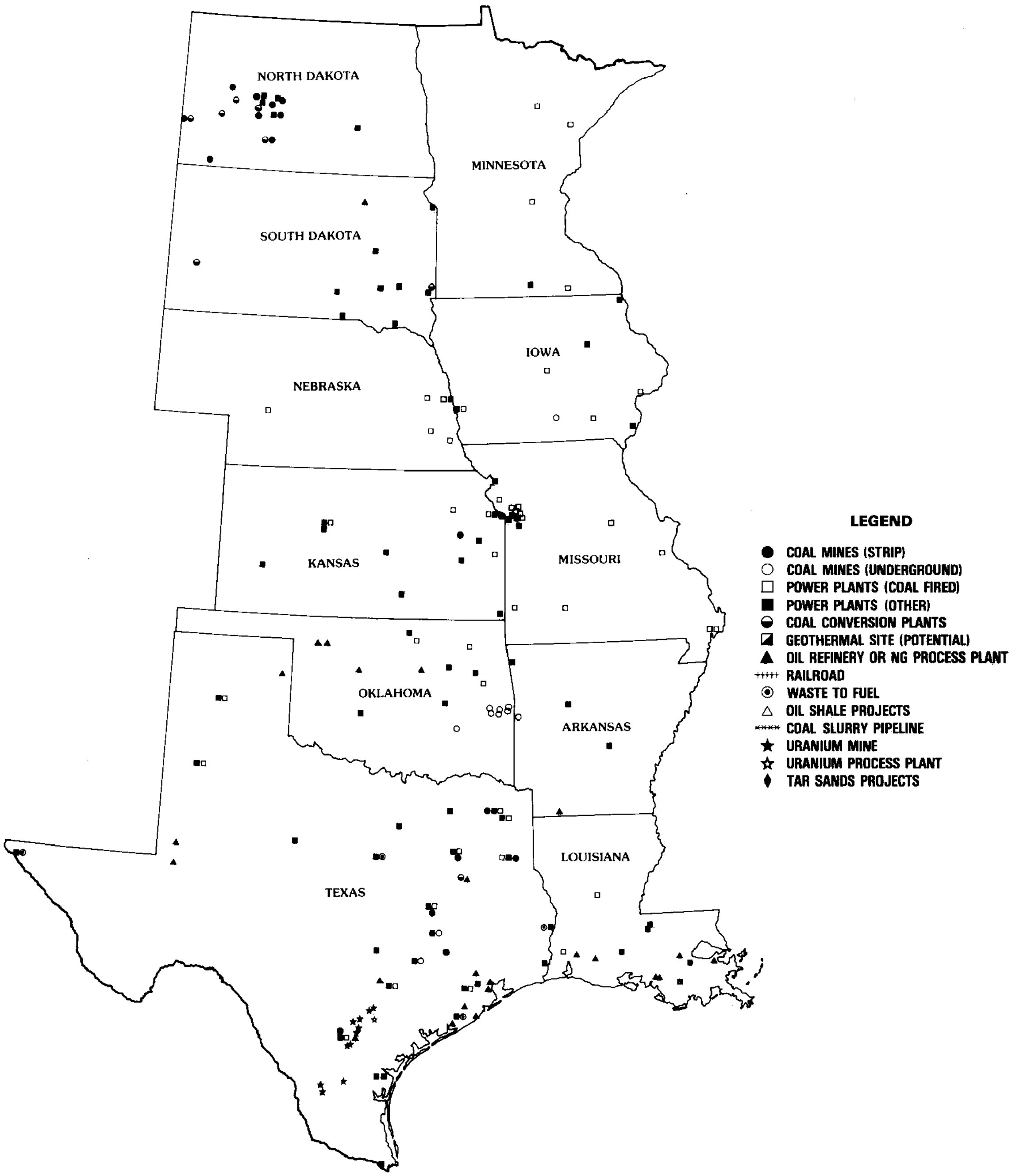


FIGURE 3-2
PLANNED ENERGY SITES THROUGH 1985
CENTRAL REGION (West of Mississippi)

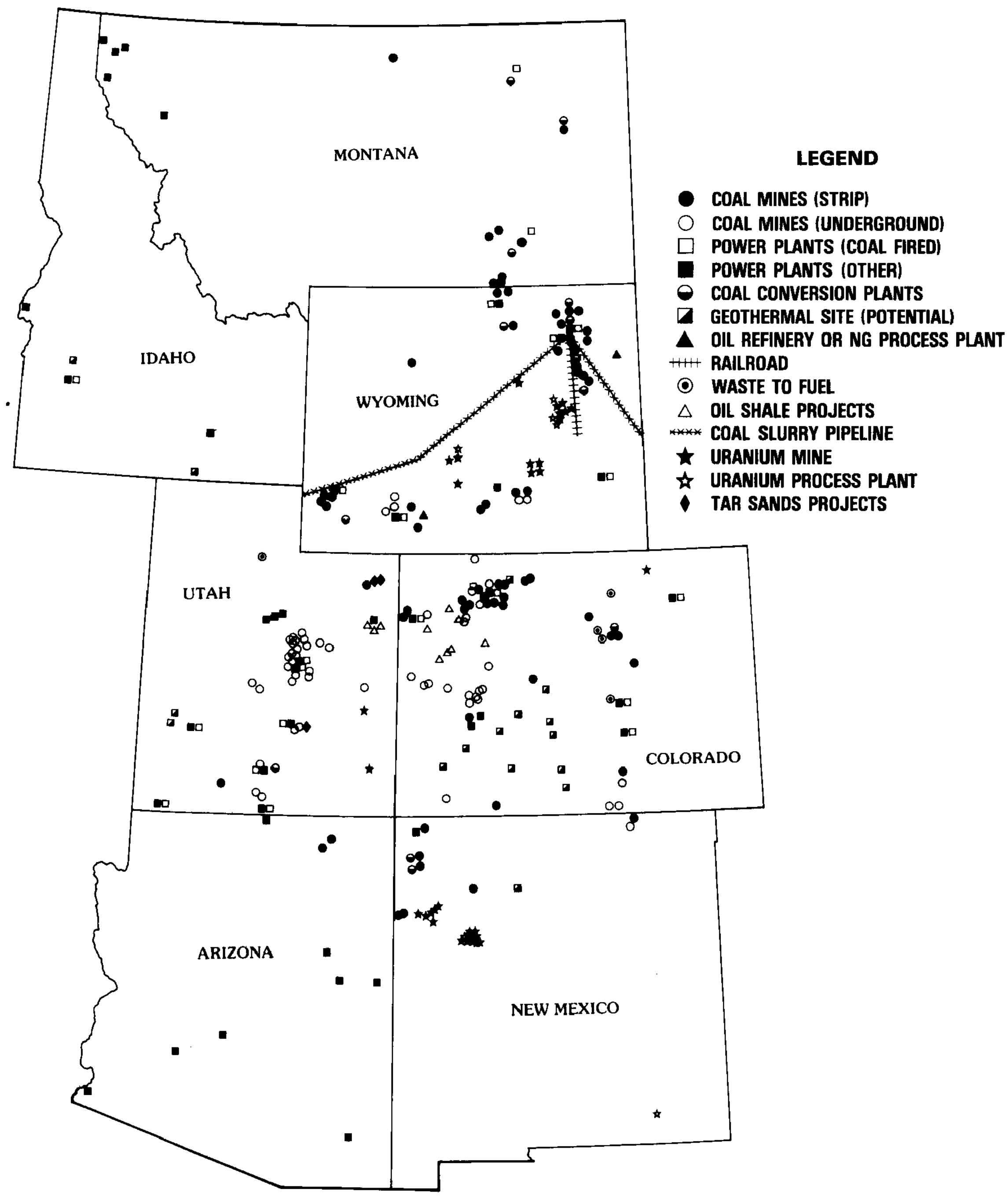


FIGURE 3-3
PLANNED ENERGY SITES THROUGH 1985
WESTERN MOUNTAIN REGION

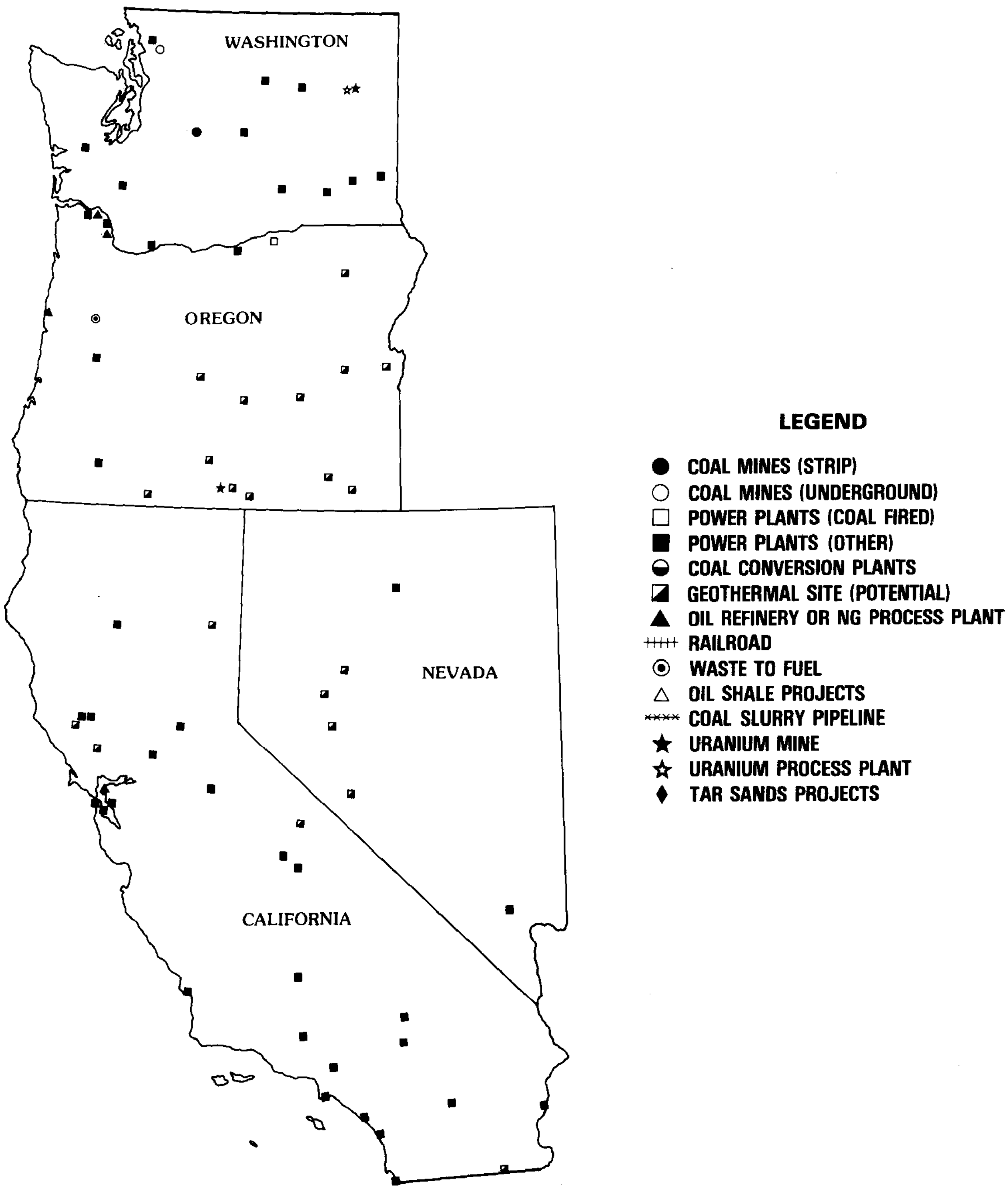
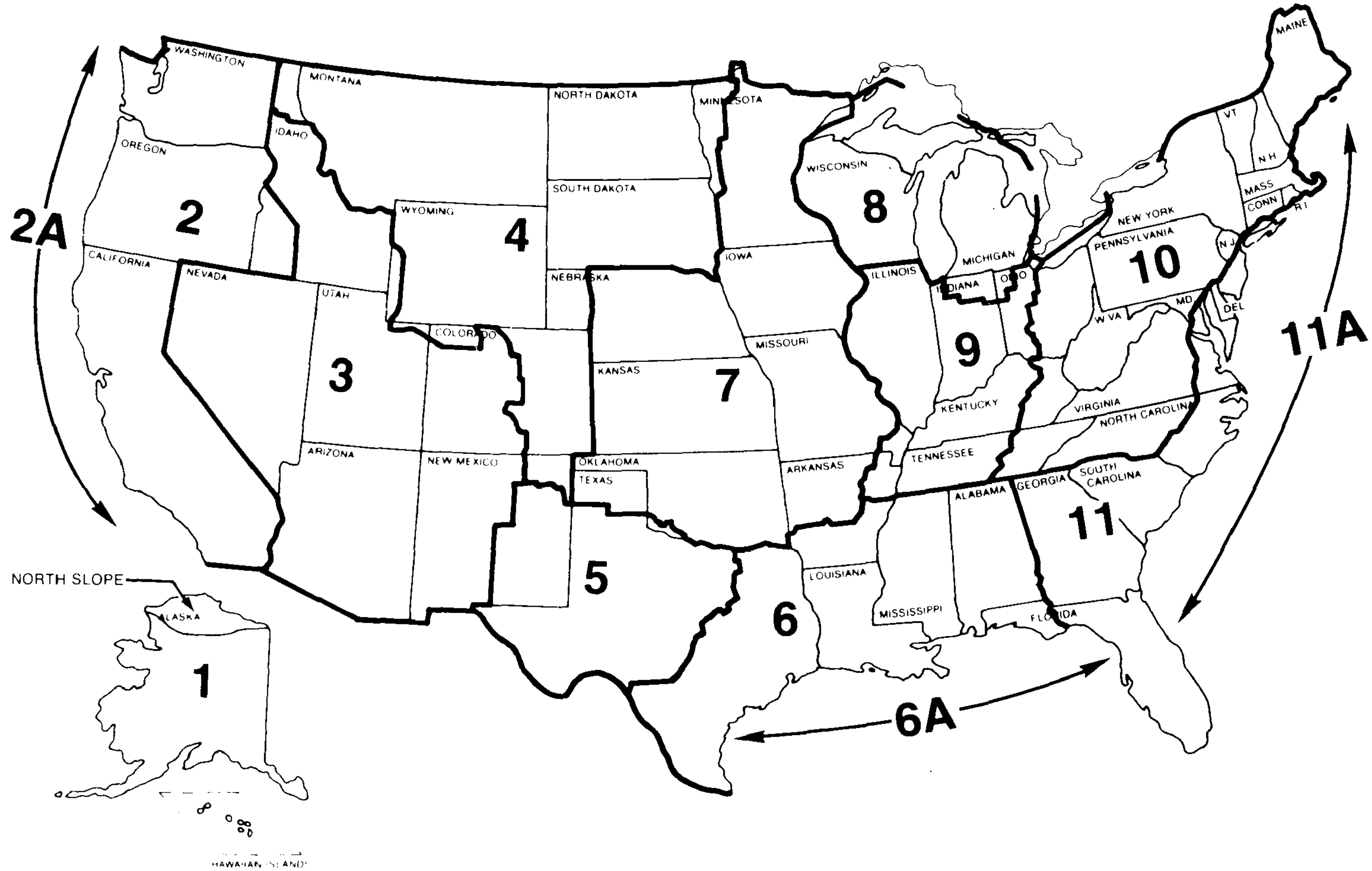


FIGURE 3-4
PLANNED ENERGY SITES THROUGH 1985
PACIFIC REGION



Regional Boundaries: Region 1 – Alaska and Hawaii, except North Slope; Region 2 – Pacific Coast States; Region 2A – Pacific Ocean, except Alaska; Region 3 – Western Rocky Mountains; Region 4 – Eastern Rocky Mountains; Region 5 – West Texas and Eastern New Mexico; Region 6 – Western Gulf Basin; Region 6A – Gulf of Mexico; Region 7 – Midcontinent; Region 8 – Michigan Basin; Region 9 – Eastern Interior; Region 10 – Appalachians; Region 11 – Atlantic Coast; Region 11A – Atlantic Ocean.

Source: National Petroleum Council, U.S. Energy Outlook (1973).

FIGURE 3-5
PETROLEUM PROVINCES OF THE UNITED STATES

TABLE 3-2

ESTIMATED CHANGES IN REGIONAL OIL AND GAS PRODUCTION

REGION (as shown in FIGURE 3-5)	1971 PRODUCTION		1985 ESTIMATE OF CHANGE FROM 1971							
	CRUDE OIL (in 10^6 bbl/day)	TOTAL WELL HEAD GAS PRODUCTION (10^9 SCF)	CRUDE OIL				TOTAL WELL HEAD GAS PRODUCTION			
			HIGH		LOW		HIGH		LOW	
			AMOUNT (in 10^6 bbl/day)	PERCENT	AMOUNT (in 10^6 bbl/day)	PERCENT	AMOUNT (in 10^9 SCF)	PERCENT	AMOUNT (in 10^9 SCF)	PERCENT
2	0.886	549	-0.053	-06	-0.092	-10	-175	-32	-324	-59
2A (offshore)	0.060	39	+0.662	+1,103	+0.246	+410	+212	+543	+71	+182
3	0.118	712	-0.006	-05	-0.044	-37	+67	+09	-290	-41
4	0.619	490	-0.042	-06	-0.324	-52	+266	+54	-78	-16
5	2.298	2,933	-0.272	-11	-0.492	-21	+497	+17	-1,179	-40
6	2.640	9,010	+0.137	+05	-0.358	-14	-560	-06	-5,647	-63
6A (offshore)	1.087	3,395	+0.180	+16	-0.437	-40	+4,823	+142	+1,182	+35
7	0.885	4,104	-0.189	-21	-0.242	-27	-1,267	-31	-2,521	-61
8-10	0.228	460	+0.183	+80	-0.009	-04	+253	+55	-65	-14
11	0.019	1	+0.041	+215	+0.003	+16	+44	+4,400	+12	+1,200
11A (offshore)	--	--	+0.117	NA	+0.037	NA	+421	NA	+102	NA
Total Lower 48 States	8.809	21,694,	+0.758	+08	-1.712	-19	+4,581	+21	-8,757	-40

Source: National Petroleum Council, 1973.

TABLE 3-3
1977 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	POPULATION OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	6,848	6,348	48,787	459,855
Alaska	--	--	--	--
Arizona	5,332	1,524	23,747	239,949
Arkansas	3,005	214	11,041	113,726
California	13,894	1,461	51,755	525,911
Colorado	4,507	3,784	29,419	290,410
Connecticut	0	64	239	2,239
Delaware	908	24	3,206	33,271
Florida	12,414	1,577	47,715	486,500
Georgia	9,465	221	32,768	337,486
Hawaii	--	--	--	--
Idaho	583	191	2,733	27,787
Illinois	26,467	8,078	118,403	1,187,435
Indiana	2,044	3,975	21,732	209,888
Iowa	3,603	194	13,071	135,208
Kansas	3,937	185	14,184	146,817
Kentucky	2,181	14,990	63,430	601,000
Louisiana	7,789	1,204	30,932	315,734
Maine	1,315	0	4,501	46,790
Maryland	1,801	538	8,080	81,428
Massachusetts	2,276	376	9,026	91,501
Michigan	8,143	31	27,324	280,533
Minnesota	1,671	280	6,708	68,346
Mississippi	2,380	255	9,055	92,920
Missouri	5,321	412	19,451	199,065
Montana	3,325	165	12,078	125,329
Nebraska	3,803	64	13,334	138,780
Nevada	357	0	1,230	12,824
New Hampshire	686	0	2,324	24,031
New Jersey	5,558	377	19,952	203,502
New Mexico	1,711	316	7,077	72,568
New York	13,622	1,794	52,175	529,526
North Carolina	14,562	566	51,353	528,567
North Dakota	4,217	48	14,963	157,164
Ohio	13,238	7,546	72,342	716,821
Oklahoma	7,123	1,200	28,654	292,158
Oregon	1,198	417	5,609	56,450
Pennsylvania	7,000	18,518	92,588	887,787
Rhode Island	0	0	--	--
South Carolina	4,121	18	14,037	145,160
South Dakota	1,175	200	4,875	50,446
Tennessee	5,675	2,409	28,033	280,065
Texas	38,865	4,045	145,450	1,482,629
Utah	2,273	12,789	55,616	528,819
Vermont	432	264	2,469	24,661
Virginia	0	4,799	17,958	168,214
Washington	24,432	55	82,930	857,326
West Virginia	0	23,578	88,237	826,506
Wisconsin	3,634	10	12,207	125,501
Wyoming	7,592	3,310	38,511	388,330

TABLE 3-4
1978 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	POPULATION OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	4,551	11,384	57,905	556,752
Alaska	--	--	--	--
Arizona	9,177	1,639	37,188	378,474
Arkansas	2,670	643	11,504	116,912
California	18,800	1,851	69,557	707,175
Colorado	6,855	4,648	40,591	402,710
Connecticut	0	64	239	2,239
Delaware	847	24	2,995	31,082
Florida	11,787	1,694	46,040	468,815
Georgia	9,791	266	34,039	350,446
Hawaii	--	--	--	--
Idaho	302	17	1,106	11,496
Illinois	24,470	15,174	138,308	1,367,964
Indiana	4,645	3,975	30,452	299,616
Iowa	2,866	306	10,964	112,857
Kansas	5,429	583	20,782	213,904
Kentucky	2,022	19,275	78,930	745,688
Louisiana	12,532	1,204	47,023	482,295
Maine	847	134	3,402	34,847
Maryland	2,637	1,088	12,957	129,782
Massachusetts	4,471	376	16,371	167,012
Michigan	8,579	41	--	--
Minnesota	2,895	280	10,851	111,192
Mississippi	1,228	255	5,134	52,269
Missouri	8,758	412	31,019	318,321
Montana	5,008	165	17,887	185,984
Nebraska	6,260	184	22,244	231,211
Nevada	537	0	1,852	19,314
New Hampshire	1,715	0	5,809	60,078
New Jersey	3,846	377	14,240	144,876
New Mexico	1,713	829	9,004	90,618
New York	8,251	1,794	34,250	345,536
North Carolina	11,786	857	43,054	441,771
North Dakota	5,513	487	21,126	219,977
Ohio	12,678	10,410	81,198	798,118
Oklahoma	8,500	1,318	33,768	344,652
Oregon	2,033	665	9,363	94,341
Pennsylvania	720	26,451	101,380	951,730
Rhode Island	0	0	--	--
South Carolina	2,542	37	8,754	90,431
South Dakota	1,373	122	5,276	55,011
Tennessee	2,647	3,871	23,357	226,936
Texas	37,636	6,625	150,987	1,530,691
Utah	2,605	13,050	57,728	549,753
Vermont	0	264	989	9,264
Virginia	0	7,703	28,828	270,025
Washington	27,048	129	92,065	951,512
West Virginia	0	34,292	128,332	1,202,071
Wisconsin	5,645	10	18,942	194,765
Wyoming	9,718	3,503	46,512	470,765

TABLE 3-5
1979 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	1,330	15,427	62,205	586,863
Alaska	--	--	--	--
Arizona	12,295	1,763	48,204	491,894
Arkansas	3,503	1,071	15,942	161,338
California	23,410	2,107	85,872	873,642
Colorado	7,800	8,152	56,891	558,449
Connecticut	0	64	239	2,239
Delaware	545	115	2,301	23,496
Florida	12,531	1,888	49,273	504,466
Georgia	7,993	571	29,114	298,509
Hawaii	--	--	--	--
Idaho	646	20	2,311	24,068
Illinois	20,225	23,093	153,802	1,500,529
Indiana	6,028	4,837	38,316	377,556
Iowa	1,823	461	7,974	81,156
Kansas	6,841	583	25,622	264,251
Kentucky	1,303	23,258	91,417	860,397
Louisiana	11,906	1,335	45,392	464,928
Maine	0	134	503	4,714
Maryland	3,305	1,981	18,547	184,275
Massachusetts	5,305	376	19,164	195,723
Michigan	7,676	52	25,840	265,225
Minnesota	3,706	280	13,597	139,596
Mississippi	788	372	4,074	40,845
Missouri	9,137	471	32,515	333,531
Montana	4,576	1,129	20,013	204,349
Nebraska	7,711	299	27,673	287,359
Nevada	679	0	2,341	24,412
New Hampshire	3,427	0	11,609	120,059
New Jersey	1,092	711	6,305	62,323
New Mexico	998	829	6,539	64,911
New York	10,386	2,734	44,892	451,611
North Carolina	9,829	857	36,440	373,429
North Dakota	6,103	132	21,867	229,292
Ohio	10,951	11,122	78,108	764,057
Oklahoma	8,166	1,542	33,470	340,738
Oregon	3,175	665	13,222	134,206
Pennsylvania	0	29,308	109,680	1,027,360
Rhode Island	0	0	--	--
South Carolina	507	321	2,921	29,042
South Dakota	1,264	163	5,051	52,463
Tennessee	0	4,807	17,989	168,504
Texas	35,159	7,709	146,737	1,483,214
Utah	2,864	13,050	57,728	549,753
Vermont	0	264	989	9,264
Virginia	1,017	8,836	36,498	345,158
Washington	18,796	973	67,282	692,170
West Virginia	0	48,157	180,218	1,688,084
Wisconsin	6,301	148	21,656	222,194
Wyoming	10,088	4,250	50,566	509,993

TABLE 3-6
1980 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	POPULATION OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	400	18,866	71,947	675,180
Alaska	--	--	--	--
Arizona	12,119	1,867	47,998	489,390
Arkansas	2,112	1,498	12,801	127,144
California	23,159	2,268	85,640	870,730
Colorado	8,137	17,446	92,807	895,923
Connecticut	0	64	239	2,239
Delaware	0	115	431	4,033
Florida	11,699	1,888	46,469	472,551
Georgia	7,562	591	27,732	284,174
Hawaii	--	--	--	--
Idaho	1,553	20	5,449	56,863
Illinois	16,459	26,156	152,715	1,479,197
Indiana	6,182	5,698	42,055	413,058
Iowa	1,373	461	6,430	65,094
Kansas	6,603	757	25,459	261,878
Kentucky	513	26,737	101,782	954,995
Louisiana	7,727	1,562	32,064	326,134
Maine	0	134	503	4,714
Maryland	3,488	2,462	20,963	207,486
Massachusetts	4,803	395	17,553	179,099
Michigan	5,361	52	18,105	185,781
Minnesota	4,583	444	17,181	176,063
Mississippi	0	372	1,391	13,026
Missouri	7,541	631	27,740	283,744
Montana	3,591	5,873	34,340	334,737
Nebraska	7,224	459	26,595	275,485
Nevada	679	54	2,543	26,305
New Hampshire	4,116	0	13,942	144,186
New Jersey	265	746	3,675	35,213
New Mexico	642	1,780	8,875	85,489
New York	11,696	2,734	49,265	496,499
North Carolina	9,066	1,026	34,491	352,679
North Dakota	5,024	132	18,111	189,934
Ohio	8,672	11,480	71,856	698,749
Oklahoma	7,121	1,764	30,756	311,832
Oregon	4,967	780	19,710	200,833
Pennsylvania	1,024	32,314	124,333	1,167,619
Rhode Island	0	0	--	--
South Carolina	0	321	1,201	11,251
South Dakota	896	191	3,864	39,844
Tennessee	0	5,277	19,746	184,962
Texas	25,865	11,803	130,895	1,306,082
Utah	8,209	33,072	151,783	1,450,156
Vermont	0	264	989	9,264
Virginia	2,040	11,493	49,894	473,932
Washington	13,999	1,165	51,761	530,975
West Virginia	0	54,659	204,552	1,916,017
Wisconsin	5,491	290	19,475	199,281
Wyoming	6,979	13,244	73,536	713,935

TABLE 3-7
1981 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	POPULATION OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	307	19,682	74,689	700,547
Alaska	--	--	--	--
Arizona	10,122	1,867	41,238	419,512
Arkansas	0	1,498	5,605	52,504
California	18,945	3,163	74,949	758,121
Colorado	4,209	17,996	81,581	777,939
Connecticut	0	64	239	2,239
Delaware	0	115	431	4,033
Florida	10,475	2,590	44,974	454,649
Georgia	7,154	591	26,355	269,960
Hawaii	--	--	--	--
Idaho	2,038	149	7,611	78,934
Illinois	13,741	27,677	149,352	1,439,653
Indiana	4,635	6,560	40,091	389,869
Iowa	229	603	3,041	29,300
Kansas	4,737	759	19,072	195,443
Kentucky	1,031	29,386	113,439	1,065,814
Louisiana	5,106	1,905	24,453	246,097
Maine	0	134	503	4,714
Maryland	2,243	2,462	16,769	164,232
Massachusetts	3,178	395	12,115	123,195
Michigan	2,807	373	10,774	109,396
Minnesota	5,473	446	20,205	207,324
Mississippi	0	372	1,391	13,026
Missouri	5,437	988	21,997	223,287
Montana	3,432	7,473	39,756	384,742
Nebraska	4,992	539	19,207	198,133
Nevada	1,969	54	6,987	72,658
New Hampshire	3,773	0	12,780	132,171
New Jersey	0	746	2,791	26,146
New Mexico	0	2,402	8,988	84,188
New York	13,270	2,734	54,515	550,389
North Carolina	6,499	1,316	26,900	273,191
North Dakota	4,235	1,840	21,732	220,631
Ohio	6,964	11,589	66,571	644,187
Oklahoma	3,684	1,764	19,096	191,154
Oregon	6,380	780	24,488	250,194
Pennsylvania	2,051	33,616	132,624	1,248,293
Rhode Island	0	0	--	--
South Carolina	0	321	1,201	11,251
South Dakota	476	278	2,718	27,348
Tennessee	0	5,277	19,746	184,962
Texas	21,592	12,000	117,305	1,165,574
Utah	12,653	30,448	157,127	1,515,599
Vermont	0	264	989	9,264
Virginia	3,060	12,113	55,657	531,209
Washington	13,055	1,368	49,322	505,018
West Virginia	0	54,817	205,142	1,921,545
Wisconsin	3,661	364	13,621	138,831
Wyoming	5,950	15,894	79,915	769,938

TABLE 3-8
1982 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	102	19,703	74,078	694,208
Alaska	--	--	--	--
Arizona	5,851	2,240	281,183	283,198
Arkansas	0	1,498	5,605	52,504
California	16,562	3,194	67,124	677,770
Colorado	1,476	18,092	72,696	685,771
Connecticut	0	64	239	2,239
Delaware	0	115	431	4,033
Florida	7,827	2,618	36,157	363,623
Georgia	6,049	654	22,864	233,692
Hawaii	--	--	--	--
Idaho	1,229	149	4,811	49,677
Illinois	8,351	28,396	134,087	1,280,703
Indiana	1,622	7,882	34,936	322,266
Iowa	0	630	2,358	22,083
Kansas	2,386	1,357	13,254	132,607
Kentucky	1,547	32,319	126,149	1,186,489
Louisiana	2,389	1,905	15,233	150,655
Maine	0	134	503	4,714
Maryland	1,443	2,659	14,814	143,367
Massachusetts	634	713	4,793	4,683
Michigan	0	694	2,598	24,332
Minnesota	3,524	610	14,218	144,813
Mississippi	0	372	1,391	13,026
Missouri	1,804	988	9,771	97,241
Montana	2,127	8,716	39,951	382,036
Nebraska	3,325	658	13,912	142,453
Nevada	3,367	167	12,226	126,848
New Hampshire	2,571	0	8,709	90,068
New Jersey	0	746	2,791	26,146
New Mexico	0	2,402	8,988	84,188
New York	11,023	2,734	47,018	473,439
North Carolina	3,887	1,316	18,068	181,936
North Dakota	1,654	4,236	21,652	209,487
Ohio	3,846	11,947	57,523	550,203
Oklahoma	2,510	1,773	15,150	150,280
Oregon	6,797	780	25,895	264,735
Pennsylvania	3,078	33,869	136,990	1,292,198
Rhode Island	0	0	--	--
South Carolina	0	321	1,201	11,251
South Dakota	0	278	1,039	9,732
Tennessee	0	5,277	19,746	184,962
Texas	17,326	17,345	123,003	1,205,744
Utah	19,383	32,962	189,508	1,842,213
Vermont	0	264	989	9,264
Virginia	2,853	12,113	54,959	524,001
Washington	9,961	1,644	39,878	406,362
West Virginia	0	55,528	207,803	1,946,468
Wisconsin	1,967	603	8,846	88,902
Wyoming	2,162	17,380	72,462	686,497

TABLE 3-9
1983 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	POPULATION OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	0	19,703	73,734	690,663
Alaska	--	--	--	--
Arizona	2,786	2,240	17,812	175,994
Arkansas	0	1,498	5,605	52,504
California	9,803	3,914	47,307	472,137
Colorado	553	22,037	84,341	791,835
Connecticut	0	64	239	2,239
Delaware	0	115	431	4,033
Florida	6,352	2,618	31,190	312,393
Georgia	4,732	959	19,561	198,506
Hawaii	--	--	--	--
Idaho	0	272	1,018	9,535
Illinois	7,048	28,396	129,747	1,236,191
Indiana	0	7,882	29,496	276,284
Iowa	0	630	2,358	22,083
Kansas	1,094	1,402	8,992	88,105
Kentucky	1,441	36.510	141,476	1,329,720
Louisiana	2,391	2,190	16,309	160,750
Maine	0	134	503	4,714
Maryland	0	265	9,952	93,217
Massachusetts	0	713	2,670	25,008
Michigan	0	694	2,598	24,332
Minnesota	1,325	796	7,468	74,324
Mississippi	0	372	1,391	13,026
Missouri	550	1,318	6,784	65,288
Montana	1,077	10,154	41,722	394,819
Nebraska	404	658	3,857	37,602
Nevada	4,622	333	17,172	177,770
New Hampshire	513	278	2,778	27,712
New Jersey	0	746	2,791	26,146
New Mexico	0	2,402	8,988	84,188
New York	8,323	2,734	38,008	380,950
North Carolina	2,649	1,316	13,882	138,679
North Dakota	1,017	4,236	19,428	186,152
Ohio	2,559	11,947	53,236	506,234
Oklahoma	501	1,989	9,123	87,124
Oregon	6,178	780	23,798	243,072
Pennsylvania	2,871	34,032	136,908	1,290,819
Rhode Island	0	0		
South Carolina	0	321	1,201	11,251
South Dakota	0	278	1,039	9,732
Tennessee	0	5,277	19,746	184,962
Texas	11,666	18,320	107,676	1,044,678
Utah	19,789	33,339	192,303	1,869,798
Vermont	0	264	989	9,264
Virginia	1,836	12,133	51,601	489,270
Washington	4,311	1,919	21,780	218,225
West Virginia	0	55,648	208,253	1,950,690
Wisconsin	0	603	2,256	21,136
Wyoming	1,052	16,719	66,189	623,808

TABLE 3-10
1984 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	POPULATION OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	0	19,703	73,734	69,663
Alaska	--	--	--	--
Arizona	0	2,825	10,572	99,030
Arkansas	0	1,498	5,604	52,504
California	7,401	4,305	40,764	403,740
Colorado	365	22,037	83,704	785,253
Connecticut	0	69	239	2,239
Delaware	0	115	431	4,033
Florida	3,411	2,938	22,483	221,469
Georgia	2,241	959	11,153	111,703
Hawaii	--	--	--	--
Idaho	0	272	1,018	9,535
Illinois	4,730	28,510	122,449	1,160,974
Indiana	0	7,882	29,496	276,284
Iowa	0	630	2,358	22,083
Kansas	0	1,556	5,825	54,558
Kentucky	928	40,396	154,295	1,448,185
Louisiana	0	2,190	8,195	76,766
Maine	0	134	503	4,714
Maryland	0	2,659	9,952	93,217
Massachusetts	0	713	2,670	25,008
Michigan	0	694	2,598	24,332
Minnesota	0	959	3,587	33,603
Mississippi	0	372	1,391	13,026
Missouri	0	1,394	5,219	48,882
Montana	672	10,230	40,621	383,083
Nebraska	0	658	2,464	23,079
Nevada	4,012	446	15,493	159,804
New Hampshire	0	278	1,039	9,737
New Jersey	0	746	2,791	26,146
New Mexico	0	2,402	8,988	84,188
New York	4,046	3,083	25,043	246,696
North Carolina	529	1,898	8,888	84,983
North Dakota	436	4,943	20,039	189,543
Ohio	1,108	12,306	49,743	469,219
Oklahoma	0	1,984	7,424	69,535
Oregon	4,322	780	17,527	178,279
Pennsylvania	1,847	34,360	134,732	1,267,436
Rhode Island	0	0	--	--
South Carolina	0	321	1,201	11,251
South Dakota	0	278	1,039	9,732
Tennessee	0	5,277	19,746	184,962
Texas	9,788	18,320	101,380	979,897
Utah	17,269	43,419	221,428	2,133,884
Vermont	0	264	989	9,264
Virginia	0	12,133	45,406	425,310
Washington	2,586	1,919	15,940	157,830
West Virginia	0	56,004	209,584	1,963,151
Wisconsin	0	603	2,256	21,136
Wyoming	219	18,205	68,890	646,118

TABLE 3-11
1985 DAILY TRAFFIC INCREASE AND CONTRIBUTING POPULATION
(UPPER BOUND)

STATE	POPULATION CONS	OP'G	NO. OF TRIPS	VEHICLE MILES
Alabama	0	19,703	73,734	690,663
Alaska	--	--	--	--
Arizona	0	2,825	10,572	99,030
Arkansas	0	1,498	5,605	52,504
California	4,110	4,633	31,028	302,803
Colorado	0	22,401	83,831	785,236
Connecticut	0	64	239	2,239
Delaware	0	115	431	4,033
Florida	564	2,938	12,894	122,571
Georgia	1,442	959	8,458	83,885
Hawaii	--	--	--	--
Idaho	0	272	1,018	9,535
Illinois	698	28,510	109,018	1,023,228
Indiana	0	7,882	29,496	276,284
Iowa	0	630	2,358	22,083
Kansas	0	1,556	5,825	54,558
Kentucky	0	48,373	181,025	1,695,646
Louisiana	0	2,321	8,686	81,357
Maine	0	134	503	4,714
Maryland	0	2,659	9,952	93,217
Massachusetts	0	713	2,670	25,008
Michigan	0	694	2,598	24,332
Minnesota	0	959	3,587	33,603
Mississippi	0	372	1,391	13,026
Missouri	0	1,394	5,219	48,882
Montana	441	10,829	42,059	395,666
Nebraska	0	658	2,464	23,079
Nevada	2,580	558	10,977	112,265
New Hampshire	0	278	1,039	9,737
New Jersey	0	746	2,791	26,146
New Mexico	0	2,430	9,093	85,173
New York	673	3,433	15,093	143,394
North Carolina	0	1,898	7,101	66,515
North Dakota	0	4,943	18,497	173,264
Ohio	0	12,306	46,052	431,367
Oklahoma	0	1,984	7,424	69,535
Oregon	2,263	970	11,281	113,049
Pennsylvania	0	34,487	129,061	1,208,900
Rhode Island	0	0	--	--
South Carolina	0	321	1,201	11,251
South Dakota	0	278	1,039	9,732
Tennessee	0	5,277	19,746	184,962
Texas	6,800	18,586	92,352	886,087
Utah	7,572	53,695	226,784	2,150,480
Vermont	0	2,641	989	9,264
Virginia	0	12,133	45,406	425,310
Washington	516	2,057	9,447	90,190
West Virginia	0	56,572	211,708	1,983,050
Wisconsin	0	603	2,256	21,136
Wyoming	443	18,205	69,664	654,210

TABLE 3-12

TOTAL TRIPS (1977-1985) ASSOCIATED WITH TYPES OF ENERGY DEVELOPMENT
(UPPER-BOUND CASE, ALL STATES COMBINED)

ENERGY TYPE	TRIPS
Coal Production	4,115,897
Power Plant Construction and Operation	3,972,381
Oil Refining, Gas Processing, Production of Synthetic Fuels	550,669
Uranium Production	102,492
TOTAL	8,741,439

TABLE 3-13
LOWER BOUND TRAFFIC LOAD, BY STATE (1977)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	24280.	277870.
ALASKA	0.	0.
ARIZONA	17426.	187054.
ARKANSAS	9673.	101153.
CALIFORNIA	41653.	438175.
COLORADO	16047.	181795.
CONNECTICUT	293.	3290.
DELAWARE	2968.	30855.
FLORIDA	38906.	410302.
GEORGIA	29238.	304070.
HAWAII	0.	0.
IDAHO	2078.	22392.
ILLINOIS	81921.	882059.
INDIANA	8303.	102380.
IOWA	11793.	123060.
KANSAS	12864.	134110.
KENTUCKY	14760.	214468.
LOUISIANA	25030.	264332.
MAINE	4239.	43916.
MARYLAND	7118.	76072.
MASSACHUSETTS	7032.	74560.
MICHIGAN	24192.	251040.
MINNESOTA	5382.	57030.
MISSISSIPPI	7680.	80661.
MISSOURI	16461.	172467.
MONTANA	11081.	115529.
NEBRASKA	12555.	130345.
NEVADA	1176.	12181.
NEW HAMPSHIRE	2135.	22134.
NEW JERSEY	16644.	174277.
NEW MEXICO	5826.	61686.
NEW YORK	41340.	436442.
NORTH CAROLINA	45414.	473268.
NORTH DAKOTA	14729.	152701.
OHIO	42811.	474354.
OKLAHOMA	22985.	243288.
OREGON	3983.	43161.
PENNSYLVANIA	36351.	450796.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	12871.	133492.
SOUTH DAKOTA	4299.	45555.
TENNESSEE	18370.	200494.
TEXAS	119049.	1251202.
UTAH	14287.	200754.
VERMONT	1577.	17535.
VIRGINIA	2551.	45922.
WASHINGTON	75995.	787960.
WEST VIRGINIA	20723.	311610.
WISCONSIN	10886.	112938.
WYOMING	26867.	292374.

TABLE 3-14
LOWER BOUND TRAFFIC LOAD, BY STATE (1978)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	20018.	254240.
ALASKA	0.	0.
ARIZONA	29430.	311993.
ARKANSAS	8898.	95062.
CALIFORNIA	56299.	591767.
COLORADO	23776.	265462.
CONNECTICUT	462.	5042.
DELAWARE	2769.	28790.
FLORIDA	37065.	391729.
GEORGIA	30270.	314968.
HAWAII	0.	0.
IDAHO	1019.	10633.
ILLINOIS	83675.	928628.
INDIANA	16122.	183455.
IOWA	9483.	99643.
KANSAS	17943.	188476.
KENTUCKY	16593.	250985.
LOUISIANA	39878.	418224.
MAINE	2818.	29805.
MARYLAND	10504.	113441.
MASSACHUSETTS	13587.	142540.
MICHIGAN	25492.	264563.
MINNESOTA	9189.	96486.
MISSISSIPPI	4034.	42877.
MISSOURI	26928.	280987.
MONTANA	16665.	173358.
NEBRASKA	20723.	215502.
NEVADA	1771.	18346.
NEW HAMPSHIRE	5339.	55335.
NEW JERSEY	11589.	121843.
NEW MEXICO	6130.	66995.
NEW YORK	25463.	271762.
NORTH CAROLINA	37013.	387483.
NORTH DAKOTA	19487.	204005.
OHIO	42650.	484171.
OKLAHOMA	27370.	289268.
OREGON	6742.	72916.
PENNSYLVANIA	24647.	360939.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	7956.	82630.
SOUTH DAKOTA	4914.	51483.
TENNESSEE	10107.	120881.
TEXAS	116794.	1238503.
UTAH	15513.	214602.
VERMONT	179.	3050.
VIRGINIA	4114.	73993.
WASHINGTON	84178.	873105.
WEST VIRGINIA	29760.	449272.
WISCONSIN	16908.	175379.
WYOMING	33841.	365475.

TABLE 3-15
LOWER BOUND TRAFFIC LOAD, BY STATE (1979)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	12431.	192136.
ALASKA	0.	0.
ARIZONA	39184.	413648.
ARKANSAS	11833.	127414.
CALIFORNIA	69997.	734948.
COLORADO	28576.	329548.
CONNECTICUT	638.	6857.
DELAWARE	1847.	19646.
FLORIDA	39462.	417434.
GEORGIA	24935.	261007.
HAWAII	0.	0.
IDAHO	2172.	22590.
ILLINOIS	77928.	900623.
INDIANA	20742.	234866.
IOWA	6216.	66502.
KANSAS	22514.	235838.
KENTUCKY	20322.	305948.
LOUISIANA	38004.	399382.
MAINE	89.	1523.
MARYLAND	12017.	132836.
MASSACHUSETTS	16079.	168387.
MICHIGAN	22818.	236879.
MINNESOTA	11712.	122642.
MISSISSIPPI	2719.	29770.
MISSOURI	28119.	293594.
MONTANA	15839.	168949.
NEBRASKA	25578.	266326.
NEVADA	2239.	23189.
NEW HAMPSHIRE	10669.	110582.
NEW JERSEY	3663.	41075.
NEW MEXICO	3771.	42562.
NEW YORK	32335.	347053.
NORTH CAROLINA	30962.	324751.
NORTH DAKOTA	21285.	220945.
OHIO	37957.	438397.
OKLAHOMA	26468.	280913.
OREGON	10271.	109501.
PENNSYLVANIA	18912.	312864.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	1793.	20013.
SOUTH DAKOTA	4564.	48058.
TENNESSEE	2672.	47602.
TEXAS	109985.	1172492.
UTAH	16341.	223176.
VERMONT	179.	3050.
VIRGINIA	7843.	117244.
WASHINGTON	59019.	615923.
WEST VIRGINIA	31122.	520298.
WISCONSIN	18959.	197261.
WYOMING	35462.	385485.

TABLE 3-16
LOWER BOUND TRAFFIC LOAD, BY STATE (1980)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	11456.	196057.
ALASKA	0.	0.
ARIZONA	38707.	409156.
ARKANSAS	7702.	86546.
CALIFORNIA	69358.	729017.
COLORADO	34586.	429751.
CONNECTICUT	299.	3352.
DELAWARE	75.	1294.
FLORIDA	36921.	391082.
GEORGIA	23622.	247478.
HAWAII	0.	0.
IDAHO	5203.	53974.
ILLINOIS	71141.	842490.
INDIANA	21664.	247932.
IOWA	4757.	51392.
KANSAS	21859.	229835.
KENTUCKY	22318.	340838.
LOUISIANA	25067.	266291.
MAINE	89.	1523.
MARYLAND	12380.	138859.
MASSACHUSETTS	14591.	153036.
MICHIGAN	15946.	165604.
MINNESOTA	14547.	152758.
MISSISSIPPI	224.	3913.
MISSOURI	23358.	244929.
MONTANA	15358.	184394.
NEBRASKA	24088.	251631.
NEVADA	2274.	23799.
NEW HAMPSHIRE	12813.	132805.
NEW JERSEY	1242.	16113.
NEW MEXICO	3146.	40092.
NEW YORK	36208.	387230.
NORTH CAROLINA	28710.	302154.
NORTH DAKOTA	17611.	182907.
OHIO	40308.	464216.
OKLAHOMA	23343.	249515.
OREGON	15888.	168233.
PENNSYLVANIA	21540.	356715.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	210.	3604.
SOUTH DAKOTA	3294.	35046.
TENNESSEE	2925.	52147.
TEXAS	84359.	923808.
UTAH	44794.	601777.
VERMONT	179.	3050.
VIRGINIA	12400.	175270.
WASHINGTON	44216.	463283.
WEST VIRGINIA	32336.	565303.
WISCONSIN	16625.	173679.
WYOMING	30566.	372925.

TABLE 3-17
LOWER BOUND TRAFFIC LOAD, BY STATE (1981)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	11614.	201034.
ALASKA	0.	0.
ARIZONA	32508.	344907.
ARKANSAS	994.	17032.
CALIFORNIA	57518.	610033.
COLORADO	22735.	309175.
CONNECTICUT	165.	2195.
DELAWARE	75.	1294.
FLORIDA	33628.	360037.
GEORGIA	22368.	234475.
HAWAII	0.	0.
IDAHO	6911.	72259.
ILLINOIS	58758.	720300.
INDIANA	17472.	207968.
IOWA	1152.	14686.
KANSAS	15822.	167300.
KENTUCKY	27876.	409312.
LOUISIANA	17079.	185021.
MAINE	89.	1523.
MARYLAND	8285.	96411.
MASSACHUSETTS	9738.	102708.
MICHIGAN	8563.	90430.
MINNESOTA	17320.	181506.
MISSISSIPPI	224.	3913.
MISSOURI	17175.	182386.
MONTANA	15717.	194980.
NEBRASKA	16800.	176504.
NEVADA	6525.	67829.
NEW HAMPSHIRE	11745.	121738.
NEW JERSEY	460.	8003.
NEW MEXICO	1379.	24385.
NEW YORK	40859.	435464.
NORTH CAROLINA	20957.	223078.
NORTH DAKOTA	16017.	174230.
OHIO	41283.	474725.
OKLAHOMA	12589.	138050.
OREGON	20258.	213533.
PENNSYLVANIA	27599.	424707.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	210.	3604.
SOUTH DAKOTA	1885.	20868.
TENNESSEE	2925.	52147.
TEXAS	71636.	792731.
UTAH	57334.	720216.
VERMONT	179.	3050.
VIRGINIA	15865.	213712.
WASHINGTON	41413.	435133.
WEST VIRGINIA	30639.	548357.
WISCONSIN	11192.	117661.
WYOMING	28740.	365246.

TABLE 3-18
LOWER BOUND TRAFFIC LOAD, BY STATE (1982)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	11006.	194814.
ALASKA	0.	0.
ARIZONA	19497.	211689.
ARKANSAS	994.	17032.
CALIFORNIA	50534.	537725.
COLORADO	14329.	222457.
CONNECTICUT	68.	1193.
DELAWARE	75.	1294.
FLORIDA	25560.	276508.
GEORGIA	19012.	199966.
HAWAII	0.	0.
IDAHO	4208.	44261.
ILLINOIS	41404.	548154.
INDIANA	9158.	127254.
IOWA	430.	7326.
KANSAS	8609.	95258.
KENTUCKY	26100.	402937.
LOUISIANA	8572.	96847.
MAINE	89.	1523.
MARYLAND	5966.	73236.
MASSACHUSETTS	2337.	27344.
MICHIGAN	429.	7469.
MINNESOTA	11361.	120475.
MISSISSIPPI	224.	3913.
MISSOURI	6112.	67687.
MONTANA	12288.	164781.
NEBRASKA	11397.	121089.
NEVADA	11205.	116809.
NEW HAMPSHIRE	8004.	82959.
NEW JERSEY	460.	8003.
NEW MEXICO	1379.	24385.
NEW YORK	34218.	366589.
NORTH CAROLINA	12876.	139313.
NORTH DAKOTA	8579.	107885.
OHIO	38325.	445506.
OKLAHOMA	8923.	100101.
OREGON	21546.	226878.
PENNSYLVANIA	37178.	524989.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	210.	3604.
SOUTH DAKOTA	215.	3580.
TENNESSEE	2925.	52147.
TEXAS	61766.	712433.
UTAH	80240.	968028.
VERMONT	179.	3050.
VIRGINIA	15229.	207118.
WASHINGTON	31973.	338520.
WEST VIRGINIA	31027.	555293.
WISCONSIN	6274.	67721.
WYOMING	17232.	252287.

TABLE 3-19
LOWER BOUND TRAFFIC LOAD, BY STATE (1983)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	10695.	191592.
ALASKA	0.	0.
ARIZONA	9987.	113120.
ARKANSAS	994.	17032.
CALIFORNIA	31114.	339376.
COLORADO	13623.	231319.
CONNECTICUT	68.	1193.
DELAWARE	75.	1294.
FLORIDA	21056.	229821.
GEORGIA	15156.	161330.
HAWAII	0.	0.
IDAHO	185.	3157.
ILLINOIS	36076.	492899.
INDIANA	4280.	76671.
IOWA	430.	7326.
KANSAS	4456.	52432.
KENTUCKY	26218.	425805.
LOUISIANA	8763.	100079.
MAINE	89.	1523.
MARYLAND	1556.	27518.
MASSACHUSETTS	443.	7696.
MICHIGAN	429.	7469.
MINNESOTA	4639.	51625.
MISSISSIPPI	224.	3913.
MISSOURI	2500.	31677.
MONTANA	9697.	144056.
NEBRASKA	1790.	21576.
NEVADA	15451.	161537.
NEW HAMPSHIRE	1781.	19702.
NEW JERSEY	460.	8003.
NEW MEXICO	1379.	24385.
NEW YORK	26237.	283807.
NORTH CAROLINA	9045.	99606.
NORTH DAKOTA	6392.	85244.
OHIO	22920.	285833.
OKLAHOMA	2774.	37302.
OREGON	19628.	206997.
PENNSYLVANIA	41860.	574137.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	210.	3604.
SOUTH DAKOTA	215.	3580.
TENNESSEE	2925.	52147.
TEXAS	45282.	545482.
UTAH	81773.	985563.
VERMONT	179.	3050.
VIRGINIA	12115.	174923.
WASHINGTON	14588.	159545.
WEST VIRGINIA	31092.	556468.
WISCONSIN	383.	6630.
WYOMING	13279.	208605.

TABLE 3-20
LOWER BOUND TRAFFIC LOAD, BY STATE (1984)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	10695.	191592.
ALASKA	0.	0.
ARIZONA	1720.	30011.
ARKANSAS	994.	17032.
CALIFORNIA	24291.	270286.
COLORADO	13039.	225262.
CONNECTICUT	68.	1193.
DELAWARE	75.	1294.
FLORIDA	12281.	140247.
GEORGIA	7496.	81923.
HAWAII	0.	0.
IDAHO	185.	3157.
ILLINOIS	29332.	423428.
INDIANA	4280.	76671.
IOWA	430.	7326.
KANSAS	1020.	17526.
KENTUCKY	25362.	432878.
LOUISIANA	1276.	22483.
MAINE	89.	1523.
MARYLAND	1556.	27518.
MASSACHUSETTS	443.	7696.
MICHIGAN	429.	7469.
MINNESOTA	621.	10700.
MISSISSIPPI	224.	3913.
MISSOURI	872.	15132.
MONTANA	8444.	131419.
NEBRASKA	459.	7791.
NEVADA	13514.	141978.
NEW HAMPSHIRE	183.	3146.
NEW JERSEY	460.	8003.
NEW MEXICO	1379.	24385.
NEW YORK	13803.	156338.
NORTH CAROLINA	2862.	38091.
NORTH DAKOTA	4831.	72240.
OHIO	14618.	212529.
OKLAHOMA	1206.	21056.
OREGON	13891.	147535.
PENNSYLVANIA	36596.	520930.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	210.	3604.
SOUTH DAKOTA	215.	3580.
TENNESSEE	2925.	52147.
TEXAS	39638.	486959.
UTAH	79286.	1001406.
VERMONT	179.	3050.
VIRGINIA	6471.	116412.
WASHINGTON	9225.	103954.
WEST VIRGINIA	31286.	559936.
WISCONSIN	383.	6630.
WYOMING	11418.	195575.

TABLE 3-21
LOWER BOUND TRAFFIC LOAD, BY STATE (1985)

STATE	NUMBER OF DAILY TRIPS	DAILY VEHICLE MILES
ALABAMA	10695.	191592.
ALASKA	0.	0.
ARIZONA	1720.	30011.
ARKANSAS	994.	17032.
CALIFORNIA	14820.	173451.
COLORADO	12115.	217221.
CONNECTICUT	68.	1193.
DELAWARE	75.	1294.
FLORIDA	3588.	50118.
GEORGIA	5041.	56475.
HAWAII	0.	0.
IDAHO	185.	3157.
ILLINOIS	17486.	300557.
INDIANA	4280.	76671.
IOWA	430.	7326.
KANSAS	1020.	17526.
KENTUCKY	26858.	480997.
LOUISIANA	1359.	23928.
MAINE	89.	1523.
MARYLAND	1556.	27518.
MASSACHUSETTS	443.	7696.
MICHIGAN	429.	7469.
MINNESOTA	621.	10700.
MISSISSIPPI	224.	3913.
MISSOURI	872.	15132.
MONTANA	8021.	129618.
NEBRASKA	459.	7791.
NEVADA	8869.	94368.
NEW HAMPSHIRE	183.	3146.
NEW JERSEY	460.	8003.
NEW MEXICO	1397.	24698.
NEW YORK	4040.	56573.
NORTH CAROLINA	1227.	21139.
NORTH DAKOTA	3272.	56106.
OHIO	8014.	144068.
OKLAHOMA	1206.	21056.
OREGON	7647.	83648.
PENNSYLVANIA	24301.	398621.
RHODE ISLAND	0.	0.
SOUTH CAROLINA	210.	3604.
SOUTH DAKOTA	215.	3580.
TENNESSEE	2925.	52147.
TEXAS	30818.	396643.
UTAH	54231.	785035.
VERMONT	179.	3050.
VIRGINIA	6471.	116412.
WASHINGTON	2879.	38793.
WEST VIRGINIA	31596.	565474.
WISCONSIN	383.	6630.
WYOMING	12167.	203333.

TABLE 3-22

SUMMARY OF STATES' CAPABILITY TO ABSORB ENERGY-RELATED EXPANSION

STATE	PATTERN OF FACILITY LOCATION	ABILITY TO HANDLE LOAD	COMMENTS
Alabama	Poly-Clusters	Fair	Heavy concentration in mountainous coal area.
Alaska	--	--	--
Arizona	Dispersed	Good	Coal mines in northeast need special attention.
Arkansas	Dispersed	Good	Power plants are near settlements.
California	Dispersed	Good	Construction at geothermal sites needs special attention.
Colorado	Poly-Clusters	Fair	Coal mines in northwest need special attention.
Connecticut	Dispersed	Good	Low activity level and facilities near urban areas.
Delaware	Dispersed	Good	Low activity level has already reached its peak.
Florida	Poly-Clusters	Good	Construction is near urban areas.
Georgia	Dispersed	Good	Activity has already reached its peak.
Hawaii	--	--	--
Idaho	Dispersed	Good	Gas plant near Bridge is poorly connected to I-80N.
Illinois	Dispersed	Good	Coal mine near Jamestown is poorly connected to I-70.
Indiana	Dispersed	Good	Coal mine near Francis has below-normal connections to US-41.
Iowa	Dispersed	Good	No major problems apparent.
Kansas	Dispersed	Good	Electric plants near Hays may congest I-70 locally.
Kentucky	Poly-Clusters	Poor	Major connectivity problems in Appalachian area.
Louisiana	Poly-Clusters	Fair	Heavy activity level in late 1970's will strain coastal area.
Maine	One site	Fair	Peak construction load has now passed.
Maryland	Dispersed	Fair	Dickerson and Calvert Cliffs thinly connected to arterials.
Massachusetts	Concentrated	Good	Adequate road net; peak occurs in 1979.
Michigan	Dispersed	Good	Peak in 1978; possible trouble in Hillsdale area: no primary arterials.
Minnesota	Dispersed	Good	Peak in 1981; power plant near Wells thinly connected.
Mississippi	Poly-Cluster	Good	Power plant in Vancleave poorly connected to I-10.
Missouri	1 Cluster	Good	Power plant cluster around Kansas City is within SMSA.
Montana	Poly-Cluster	Poor	Northwestern power plants and southeastern coal fields virtually isolated.
Nebraska	1 Cluster	Good	All facilities near cities or Interstate highways.
Nevada	Dispersed	Poor	All sites isolated except power plant near Las Vegas.
New Hampshire	1 Site	Good	Low effort level in built-up area.
New Jersey	Dispersed	Good	All sites near cities except power plant in SW near Hancocks Bridge.
New Mexico	Poly-Clusters	Poor	All sites except process plant near Carlsbad isolated in rugged terrain.
New York	1 Cluster	Good	All sites near cities except one thinly connected near Freehold in Catskills.
North Carolina	Dispersed	Good	Western power plant sites close to I-40 but no large town.
North Dakota	Clustered	Fair	Mercer-Oliver Counties area is critical; see discussion.
Ohio	Clustered	Fair	Coal producing area shares common Appalachian regional problem.
Oklahoma	Poly-Clusters	Fair	Coal producing area sparsely connected to first-class highways.
Oregon	Dispersed	Fair	One uranium and some geothermal sites isolated.
Pennsylvania	Clustered	Poor	Appalachian coal area critically in need of first-class roads. (1)
Rhode Island	--	--	No activity foreseen.
South Carolina	Clustered	Fair	Power plant sites rural and thinly connected to I-26.
South Dakota	Dispersed	Fair	Many sites near state borders could cause jurisdictional tensions.
Tennessee	Dispersed	Fair	Appalachian coal region is isolated.
Texas	Poly-Clusters	Good	Power plant sites excellently connected; mine sites thinly connected.
Utah	Clustered	Poor	Kaiparowits and Uintah isolated; Carbon County crowded and heavily stressed.
Vermont	1 Project	Good	State Route 30 may need improvement between site and I-91.
Virginia	Clustered	Fair	Appalachian region heavily stressed for existing road network.
Washington	Dispersed	Poor	Access to all except western sites nearly non-existent.
West Virginia	Clustered	Poor	Appalachian region heavily stressed for existing road network.
Wisconsin	Dispersed	Good	Western sites thinly connected.
Wyoming	Clustered	Poor	Gillette area good; other project areas isolated and heavily stressed.

[1] Averages over the time-frame 1977-85 of the increased daily travel. Computed from daily trip and mileage figures in Appendix B. Construction mileage is temporary, approaching zero as project nears completion, whereas operation mileage continues throughout life of the of the energy facility.

for new wells than for the other types of energy development so that it was not feasible to obtain the same level of detail for oil and gas production within the time-frame of the study. All evidence indicates that the contribution of increased domestic production of oil and gas to U.S. energy needs (with the possible exception of the Alaska source, not treated in this study) will be small. Any major increases depend on exploitation drillings in the Atlantic (a new source) and major enlargement of the small operations which have taken place offshore of California.* Moreover, the impact of highway needs by 1985 of these contingent operations is likely to be small (as discussed in Oil and Gas Technology Attributes in Section 4.6) compared to the impacts of other energy operations development. Estimates of the increase in domestic oil and gas, both offshore and onshore, are therefore summarized on a regional basis as given in Figure 3-5 and Tables 3-7.

Activities for other forms of energy development are shown state by state in the regional maps (Figures 3-1 through 3-4). These maps show the location of mines, generating plants and processing facilities as given by the sources cited. In the map of the Eastern states (Figure 3-1), the projected coal development within Appalachia is shown by shading of the counties involved. This arrangement reflects

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*California production was reported as 50.2 billion standard cubic feet (SCF) of natural gas in 1972 while the petroleum shipped from Pacific offshore operations was reported as 163.2 million barrels (Bureau of the Census, 1975a).

both the data (which was available on a county basis) and the graphic considerations of convenience in viewing the concentration of mines.

Table 3-1 lists the projected increase in energy output by 1985 for each of the lower 48 states by basic type. It is clear from this tabulation that major impacts can be expected from coal development, and from construction of power plants (largely fossil-fuel and nuclear). Increased output from coal is projected at about 662 million tons - an upper or "worst case" figure in comparison with FEA projections, for example, as is discussed below. Power plants are projected as yielding an additional capability (from new construction and expansion of facilities) which totals 241,954 Megawatts electrical (MWe). By contrast, the output from projected coal conversion plants (third in size) and the small number of uranium facilities, oil shale operations, and oil and gas processing plants are easily seen as small. It may be, however, that the local impact of some of these facilities will be out of proportion to their total number in the national framework. Coal conversion plants and uranium facilities show a heavy concentration in the Western states where the work forces and accompanying in-migration will be significant in these less populous states, as is discussed in the regional assessment below (Section 3.6 and following).

The projected energy outputs by state, shown in Table 3-1, were derived by summing the relevant source material. These included USBM (1976a) data for states west of the Mississippi, and for states east of the Mississippi, data of Campbell (1976); FPC (1976); USBM (1976d);

Cantrell (1976), respectively, for coal, power plants, synthetic fuel plants, and refineries.

Comparison of other sources of new coal mine capacity data projected for 1985 shows a trend in the Table 3-1 data to overestimate future coal production. Sources used in the comparison were the available projections from the FEA (1976), and the article "Coal Mine Development Survey Shows 492.6 Million Tons of New Capacity by 1985", by George Nielson (of the Keystone Coal Industry Manual) in the February 1976 issue of Coal Age magazine. Data used in developing Table 3-1 resulted in an estimated cumulative increase of approximately 662 million tons per year by 1985. The FEA data projects a cumulative coal production increase of approximately 393 million tons per year by 1985. The Coal Age data indicates an increase of approximately 436 tons per year by 1985 (the figure 492.6 million tons in the title includes 1975 increase). Compared with the other data, the figures in Table 3-1 are consistently high in the states of Colorado, New Mexico, Texas, Utah, and Wyoming. One difference between the Coal Age figures and those in Table 3-1 is that the former source takes into account planned mine retirements. The discrepancy may also reflect the fact that in each of these states large numbers of proposed projects which were included in developing Table 3-1 are not definite. Maximum planned capacity, as outlined by the USBM (1976a), for all proposed mines were included in this analysis in an effort to show maximum conditions that could occur within each of the states.

It is also true that the estimated additional power plant capacity may be higher than that which is ultimately provided. Experience (e.g., in Mendocino, California and more recently in the Kaiparowits Plateau region of Utah) has shown that concerted citizen opposition can be a formidable barrier forcing planned construction to be cancelled. The increasing problems with obtaining capital can also operate to delay expansion of power facilities. Again, the projections of electric generation facilities based on the available data are likely to represent a picture of growth by 1985 that is near maximum.

3.2 Population Shifts and Travel Increase

3.2.1 Nature of Tables

Tables 3-3 through 3-21 summarize the results of calculations which predict the population in each state associated with energy-related activities and which also expand the population shifts into total daily trips and daily vehicle miles generated for personal transportation. It should be noted that these figures represent "shifts" of the population and not necessarily increases at the state level. That is, much of the labor force (together with families) which will fill both direct and secondarily-generated positions in a particular locality may come from elsewhere within the same state. As a result pressures for highway and road improvements will be generated within the state at the places where the energy activity occurs. Daily trips and vehicle miles listed in the last two columns of the table include both commutation to and from work and travel for other purposes such as shopping and local recreation. (See the next subsections for distinctions between the upper and lower bound cases).

Figures in Tables 3-3 through 3-11 and 3-13 through 3-21 relate only to population and additional travel after 1976. They do not include the pre-1976 base. The amounts in each table are not cumulative, because they give totals that exist for a single specific year. The figures show the predicted amounts by which energy-related population and associated travel will in a given year exceed the 1976 level. The totals reflect activity which first occurred in an earlier year and is still continuing. Thus, for example, 1979 figures represent not just new population shifts and vehicle usage for that year but also any additions first reported in 1977 and 1978. In many instances, the figures for a given state and year will represent a decline over the preceding year, reflecting the expectation that some energy-related activity (principally plant construction) will have been completed and hence the total population associated with energy development has been reduced.

Basic data for population expansions came from the United States Department of Commerce, Bureau of Economic Analysis (1976), for secondarily-created positions, and Federal Highway Administration (1972a,b), for trips and vehicle miles. Details of how the projections were made are given in Appendix B.

3.2.2 Distinction Among the Tables

There are two sets of tables, giving effectively an upper and lower bound on the population and the travel increases associated with energy development. The upper bound results are further divided into (1) total figures combining all forms of energy for each year 1977-1985 for each state (Tables 3-3 through 3-11 and 3-13 through 3-21); and (2) a summary table for all states and years showing the results predicted for the different energy types (coal production, power plants, etc.). These summary results are given in Table 3-12. This table resulted from an additional computer run made in order to obtain some measure of the relative potential for impacts on highways which increases in the different forms of energy development would have. The run computed the total trips (for all states and years combined) associated with four categories: coal production; power plants; uranium; and oil refining, natural gas processing, and production of synthetic fuels. Because work force and population factors for production of oil and natural gas had not been incorporated into the data base used in generating travel projections (as noted in Section 3.1), travel associated with these energy activities were not included.

The results, shown in Table 3-12, tend to confirm the intuitive conclusions. The travel estimates are, of course, approximately proportional to the volume of activity involved in the development of additional capability in each type of energy. As can be seen, the additional travel associated with coal production and power plants is an order of magnitude higher than that associated with the other two.

Uranium production will, according to these projections, generate by far the least additional travel of any of the four types of development included in the runs.

Tables 3-3 through 3-12 represent the upper-bound. They are based on the assumption that of the total energy-associated population (workers and families) given in the first two columns 80% of both the direct labor force and the secondary positions will be filled by in-migration: i.e., that workers (with their families) will move into the locality from other parts of the state or nation. In these tables the total additional trips and vehicles miles represent all such travel which is undertaken by workers (and their families) filling primary or secondary positions resulting from energy development.

It follows that the travel figures in Tables 3-3 through 3-12 include trips that might have been undertaken anyway by local families whose bread-winner remained in the area in some other line of employment. The total trips and vehicle miles reflect (as explained in Appendix B) different assumptions for local and nonlocal workers. However, as would be expected, from the fact that all travel by local and non-local workers is included, the results derived in Tables 3-3 through 3-12 by the procedures used are relatively insensitive to different values for the parameter percent of positions filled by local workers. To test sensitivity to this one parameter an additional computer run was made totaling trips and vehicle miles for each state from all forms of energy development combined and assuming 60 percent local labor in all categories. The maximum change in these results (not published in this report) from the original results presented in Tables 3-3 through 3-11 for any state was 1.2 percent.

For the lower-bound situation (Tables 3-13 through 3-21), however, a very different set of assumptions were made, resulting in a much lower estimate of population shift and additional travel. It is true, of course, that the absolute lower bound would be given by the situation (which could occur in individual localities, although rarely) in which NONE of the workers migrated from elsewhere: ALL persons in the direct labor force and in secondarily-created positions (and their families) represented residents of the immediate vicinity who commuted to their jobs. But such a situation is deemed thoroughly unrealistic on any state-wide basis. The PRACTICAL lower bound was considered to be provided by the following assumed conditions:

(1) Sixty percent of all direct labor positions for each form of energy development are considered to represent workers who migrate from elsewhere. This is slightly less than the results obtained in a study of construction workers at 14 sites in the Western Plains and Mountain states undertaken for the Old West Regional Commission (Mountain West Research Inc., 1975).

(2) The work-related trips and vehicle miles for ALL members of the direct labor force are counted under additional travel, because such trips represent a shift in transportation pattern that can be properly ascribed to energy development. However, other household

trips by local workers and their families are not counted as additional travel, because such trips would have taken place even without energy development.

(3) As an overall average, 3/8 or 37.5 percent of the total of secondary positions created by energy development were assumed to be filled by outside migration. This assumption reflected the considerations that goods and services are already being provided to the local direct labor force (40 percent) and their families and that any increase could be provided by minimal expansion of existing commercial facilities. On the other hand, most of the secondary positions created by the 60 percent of the workers who migrate into the locality would be filled by outside migration. All travel of this fraction (3/8) of the secondary work force and their families--work-related and other trips--can then be ascribed to energy development and included in the travel increases. No travel of the local secondary workers (62.5 percent of the labor force) and their families is counted as related to energy development because it is considered that such travel would have occurred anyhow.

The lower-bound projections (Tables 3-13 and following) represent a reduction in the states with heaviest travel to levels of around 60 to 90 percent of the upper-bound figures for daily trips and vehicle-miles. It will be noted that population figures are not repeated in these tables; since the population statistics represent total persons involved in energy-related activities regardless of where they came from, they are taken to be the same in both situations. The reduction in travel over the upper-bound projections are not linear but vary greatly from state to state because of the secondary employment factors used which were different for type of energy activity within each individual state. The significance of the projections in all of these tables lies largely in the indication of relative travel increases. From this point of view, the lower-bound projections--while representing drastic reductions in some of the upper-bound figures--add little to the conclusions that can be drawn from the upper-bound case. The relative magnitude of increased travel in both situations is essentially the same. This situation necessarily results from the fact that to estimate the time constraints on this study did not allow the development of local factors to estimate possible differences in the proportion of direct and secondary workers who would migrate from outside the locality. The discussions of the areas expected to receive the heaviest stresses from energy development attempt to apply judgmental considerations that take the probable extent of outside migration into account.

3.2.3 Range Between Upper and Lower Bounds

It is impossible to say, without site-specific studies that are far beyond the scope of the present effort, precisely where within the range between upper and lower bounds the population shift and travel increase of any particular locality or state will fall. A number of conditions affect the extent to which the local populace can supply the direct and indirect energy-related labor and hence how much in-migration will be involved. Among the most important conditions the following may be listed (some discussion is provided in Section 5 below):

1. Size of the indigenous population, and particularly the presence of urban centers which afford a base of workers who can commute from their existing homes to the site of new positions;

2. Proportion of labor that is non-agricultural (since most of the positions will be drawn from construction, other industrial, and mercantile skills);

3. Median family income, since in localities where earnings are already high it may be more difficult to recruit workers for new positions;

4. Existing level of unemployment--a factor which, as the last two years have shown, may be liable to rapid change.

5. Regional growth, since persons possessing the necessary potential skills tend to gravitate towards localities which are expanding. Conversely, areas which have recently shown population losses are likely to have experienced out-migration of eligible workers, leaving behind the less skilled, the older persons for whom retraining is more difficult, the handicapped, and the otherwise less readily employable.

Additionally, there are strictly site-specific conditions which can alter the proportion of local and non-local workers employed. Choice of contractor firms may make a difference, particularly in regard to construction labor. A local firm is--other things being somewhere near equal--more likely to recruit local labor whereas outside firms not infrequently move some of the same crew from site to site when the occasion permits. Even union practice in regard to seniority and the tendency to recruit and train unskilled labor can have an effect.

Estimating what will happen in a particular place is further complicated by the fact that few localities are homogeneous in regard to all of the factors listed above. Many areas may have fairly high unemployment, yet be losing much of their potential labor force. Rural areas tend to have low unemployment and also low median income, as well as a relatively small non-agricultural work force from which prospective mining and industrial workers can be recruited. Conditions within states can vary widely. For example, Michigan has large population centers where presently there is a high rate of unemployment among industrial workers, yet areas of the Upper Peninsula have for years shown an economic depression and much of the population there is rural with a relatively low level of industrial skills. Furthermore, the population shifts and resulting travel increases that are at issue are not statewide but highly local; it makes no difference (for present purposes) whether the new population comes from a large urban center in the same state only 150 miles away or from all over the country.

All that can be said with reasonable confidence is that the lower bound in population shift and additional travel will be approached in those areas where there is a large population and a high degree of urbanization (to provide the base of workers and skills), particularly if the current unemployment rate is high. These conditions are much more likely to be realized in Eastern and Coastal states (such as California) with a high degree of industrialization. Without detailed assessment of site-specific situations, it may also be said that the conditions are more likely within a state when the energy development is fairly well distributed, rather than when the activities are clustered in a few locations. A look at the maps (Figures 3-1 through 3-4) shows that, for example, energy activities are well dispersed in Illinois and California, and heavily clustered in Wyoming and Utah as well as in the coal counties of Pennsylvania, West Virginia, and Kentucky.

The upper bound conditions in population shift and travel increase are most likely to be approached in rural states which are sparsely populated with few large urban centers and relatively little unemployment and industrialization to provide the basis of a work force. Clearly, this situation best fits the Western Mountain and Plains States. For example, Wyoming has the smallest total population of any of the lower 48 states and in 1974 had a labor force of 166.5 thousand with an unemployment rate of 3.6 per cent. (Department of Labor, 1975.) Under these conditions, the upper bound figures are not unreasonable.

On the other hand, the upper-bound peak estimate may well be excessive for Illinois, where in 1974 the number of unemployed was totaled at 233 thousand. (Department of Labor, 1975).

Some details regarding the particular areas within states that can be expected to be affected by especially heavy population shifts are discussed below in subsections that treat the various regions.

3.2.4 Caution in Interpreting Results

In interpreting the results tabulated in Tables 3-3 and following, some precautionary considerations should be emphasized. It has already been noted (in the previous subsection) that there is no way of determining how close to either the upper or lower bound conditions any particular state may come (although some discussion is provided under the regional assessments in this Section). Further, it should be stressed that the results are largely--if not indeed exclusively--relative. Both the figures on population shifts and travel increases and the discussion of probable resulting highway stresses can do no more than indicate which of the 48 states considered are likely to be most heavily impacted by energy development. There is no way within the scope of the present study that any absolute assessment of needs can be made. The study reflects an implicit assumption that in general, the highway needs and effects on infrastructure that can be expected will be proportional to the amount of population associated with energy development and the additional travel generated (as shown in Tables 3-3 through 3-22).

The largest daily travel increases (over one million vehicle miles in any year) will occur in the coal-producing states. Texas will also have very great increases, due principally to construction requirements of power plants, refineries and uranium mines. Illinois will also experience over one million additional vehicle miles per day. These figures on highway travel tell only part of the story. They do not show how much the highways of any state can actually handle without increases and improvements. As with population shifts, a true assessment is possible only with detailed study of the locality.

Statistics on current road capacity within particular states were not available to the study. The Highway Capacity Manual (Highway Research Board, 1966) shows that a Class C Service level (which is defined as stable traffic flow at speeds equal to or greater than 40 miles per hour) would provide for a miximum volume <u>under ideal conditions</u> of 1400 vehicles per hour per traffic lane on multi-lane highways or 1400 vehicles in both directions on a two-lane road with a basic limiting value for the ratio of service volume to capacity $\leq$ 70 percent. But these general figures must be scaled down in terms of lane width, lateral clearance, condition of the shoulders, attainable speed and passing sight distance. As speed decreases to 45 mph, this ratio of service volume to ideal capacity drops to a maximum of 51% and may be as low as 12% (or 168 vehicles in both direction). At speeds below 45 mph, unstable flow sets in, approaching the bumper-to-bumper inching forward which is periodically encountered during severe traffic congestion.

Neither statistics on highway capability nor details on road conditions from which to compute capability were available within the scope of the present study. Therefore, some tendency may be noted in the discussions of regional problems to use figures on current usage; these statistics are offered not so much as a surrogate for actual capacity as an indicator of the travel conditions under which some state roads have been maintained. What is implied by low-volume country roads is a set of conditions adequate for very light traffic. As travel increases significantly, pressures are likely to mount for improvement of overall surfacing, widening and addition of lanes, removal of lateral obstructions, grading and elimination of curves to provide greater visibility and facilitate higher speeds. There is no guarantee that a road carrying only a few hundred vehicles per day could not handle up to 1000 per hour under peak conditions. However, a consideration of the circumstances that typically distinguish high-volume throughways from lightly-traveled country roads supports the inference of a direct relationship between the percentage increase in vehicle usage and the need for major improvement.

How these reservations affect interpretation of results in Tables 3-3 and following may be illustrated by a few specific references. For example, although California may experience nearly 875,000 additional vehicle-miles of travel in 1979 due to energy-related activity, this activity is scattered throughout the state. While at first glance, the additional peak mileage may seem a large number, it is a small fraction of the 126.5 billion miles logged in 1972 by California's nearly 13 million registered motor vehicles (California, Department of Transportation, 1976). Further, the largest concentration of facilities is in or near the San Francisco and Los Angeles areas, where infrastructure is strong enough to absorb the extra load. For example, Los Angeles County logged nearly 37 billion vehicle miles in 1972 and Alameda and San Mateo Counties recorded a total of over 10 billion.

Ohio provides a similar illustration. Although coal-related development in the southeastern part of the state is significant, its buildup is already underway and is predicted to be relatively gradual after 1978. Power generation plants account for the bulk of the construction force, but these are widely scattered and located near settlements, putting the state in a good position to absorb this portion of the energy related population growth.

Heavy travel in the Western Mountain and Great Plains States is, however, likely to represent a different situation. Examination of Wyoming provides a case in point, as Figure 3-3 and Tables 3-3 through 3-11 show. Rock Springs, a striking example of the boom-town syndrome, is scheduled for more development. The Gillette area has experienced a long cycle of phased construction, permitting the usually transient building tradesmen to become semipermanent residents. This pattern will continue. Surface mining of up to 5 1/2 million tons of coal per year is projected from two mines within 15 miles of Rawlins (population 7,855). These mines lie south of Interstate 80 which pases through Rawlins; present access is provided only by an unimproved road. A potential trouble spot is the cluster of uranium mines near Shirley Basin, a hamlet of only 300 population at present. Without good highway planning and timely construction this could become another transportation bottleneck along the lines of the Resource City scenario (Appendix A). In contrast with current road usage in the San Francisco and Los Angeles areas previously cited, energy-related travel will represent a significant increase in these areas of Wyoming. Traffic counts at Highway Station 1040 near Gillette (U.S. 14 and 16) showed in 1975 an average daily volume was about 3,600 vehicles (Wyoming State Highway Department, 1976). At nearby Muddy Gap Junction, north of the Continental Divide, average daily count was only 1,500, although taken on major highway U.S. 287-Wyoming 789.

Population increases and travel loads can be seen as heavy in the states of Appalachia. A peak load is expected to fall on West Virginia--with a maximum of 55,000 energy associated population in 1985, as a result of which over 200,000 daily trips covering nearly two million additional miles will be generated.

As has already been noted (in connection with estimates of coal production, Section 3.1) the figures used on expected energy development are not those of the FEA projections. This situation reflects the extensive body of fairly "hard" data already available to the study from a variety of sources (as given in the notes to Table 3-1).

These data may or may not ultimately prove to be more accurate than the modeling predictions from the FEA but they have the important advantages of being more precise and more geographically specific. Without the use of these data, it would hardly have been possible to show the locations of major energy activities state by state that appear in Figures 3-1 through 3-4 or to present specific facts on coal production by counties and on the scope of activities in particular localities within a state.

The basic data used on expected energy reflected plans of energy developers. In many instances, expected labor forces were provided by the sources used, in addition to figures on output. Thus the extent to which general work-force factors had to be used was minimized. To point out this fact does not derogate the use of such planning factors for broad purposes such as state-wide totals (and indeed, in many instances, such as the labor involved in plant construction and operation, these factors had to be used in the absence of site-specific data). Nevertheless, it is certainly true that where site-specific estimates of work forces can be totaled, some gain in precision results over the use of general factors. Because in regard to the most significant form of energy development - coal production - the figures used reflect higher totals than do the FEA predictions, the data employed is free of the most serious criticism that might otherwise have been made: namely, an underestimation of population and land associated with energy development.

3.3 General Regional Assessment of Impacts

The areas in the United States most heavily affected by energy development will be those areas of major coal developments. These include the following regions and the affected states within those regions:

- Green River Region--Northwest and West Central Colorado, East Central Utah, and Southwest-South Central Wyoming.
- Powder River Region--Northeast Wyoming and Southeast Montana.
- Four Corners Region--affected by both coal and uranium mining, in New Mexico, Arizona and Utah.
- Fort Union Region--West Central North Dakota, Northeast Montana and the northwest corner of South Dakota.
- Appalachia coal regions--Western Pennsylvania, West Virginia, Eastern Ohio, Eastern Kentucky, and Northern Alabama.

These are regions where the expected population growth required for coal mining (accompanied in the West by synthetic fuel plants and uranium facilities) will bear most heavily on highway needs and local infrastructure. Population density is comparatively low, especially in the rural areas of the Western Mountain and Plains States. Infrastructure development has not been geared to support large industrial projects. Although the Eastern States are more populous, the coal-mining areas are among those which prior to the early 1970's had been in a period of relative economic decline and infrastructure had not been maintained.

In addition, several other areas may experience large-scale development that may be significant although of lesser impact than those listed above.

- Eastern Interior Region--including Illinois, Indiana, and Western Kentucky, due to coal development.

- Areas north and east of Denver, Colorado; due to coal, coal conversion, and waste processing plants.

- Western Interior Region in Eastern Oklahoma due to coal development.

- Southern Louisiana due to development of refineries, gas processing plants, oil, and power plants.

Table 3-22 provides a judgmental assessment of each state's capability to respond to the additional travel load (as given in tables 3-3 through 3-11 and 3-13 through 3-21), pattern of facility location, and superficial indications of highway network within the most affected areas. It should be stressed that because of the time constraints of the study this summary tabulation was made without benefit of any specific information on the state of local roads.

3.4 Coastal States

This subsection addresses the states bordering the Atlantic (except for those mountainous sections of Maryland, Virginia, and Pennsylvania, which are treated under Appalachia); the Gulf Coast; and the Pacific (excluding Alaska and Hawaii). For various reasons, the highway problems attendant upon energy development in these areas are not expected to be heavy compared to other regions.

The energy development of the coastal regions is expected to be principally in the form of electric power generation and the production and processing of oil and gas. Domestic oil and gas production has represented a declining trend which is unlikely to be significantly reversed in the period up to and including 1985. Moreover, the coastal regions of the United States are among the most highly populated, with a high degree of urbanization and relatively well-developed infrastructures for dealing with temporary population increases. This particularly is true of the highly urbanized Northeast and California. Gulf states--Louisiana and Texas--have a long history of dealing with oil and gas production and should be relatively well-equipped to deal with whatever increases occur.

While the figures of Tables 3-1 through 3-6 show large projected increases in power plants for California, Texas and New York, the population shifts involved are relatively small for these populous states.

The state of Washington is also experiencing a large growth in generating plants, as nuclear power becomes an increasing power source to supplement the heavily-committed hydroelectric resources on which the Pacific Northwest has previously been able to rely. The population shift involved in constructing power plants with a capacity of nearly 16,000 MWe (Table 3-1) may be heavy for this state, compared to those with much larger populations. Many of the plants projected for post-1976 operation are already being constructed. The feasibility of providing outside highway support to meet the approximately five-year construction period in any of the regions of the U.S. (as has been noted) is somewhat questionable. There is simply not as much time to plan the outside support or to set in motion the mechanisms by which it could be accomplished. In contrast, the operational phases of energy development and production, which can be expected to continue over twenty or thirty years, provide a much longer time span within which outside financial support could be effected.

According to projections of the U.S. Energy Outlook for Oil and Gas (National Petroleum Council, 1973), significant prospects for increase in oil and gas from the coastal regions lie principally in off-shore development. The changes anticipated here affect particularly the Pacific Coast, with modest production in the past, and the Atlantic, where no off-shore production currently exists. California is predicted to increase its oil production from all sources including off-shore development to approximately 1.95 million barrels a day in 1975 (FEA, 1976); this figure represents an annual production of approximately 21 billion gallons (assuming 250 production days per year). This production level would represent approximately a three-fold increase over the 1972 output of 163 million barrels or roughly 7 billion gallons (U.S. Bureau of the Census, 1975). Natural gas production in California is actually expected to decrease from a total of 595 billion standard cubic feet (SCF) in 1972 to 451 billion (SCF) in 1980 (U.S. Bureau of the Census, 1975; FEA, 1976). Atlantic production is estimated to total 138.4 thousand barrels per day of oil (about 1.5 billion gallons per year) and 40.4 billion SCF of natural gas (FEA, 1976).

The principal effects of offshore oil and gas production are likely to be in the on-shore fabrication of platforms. Existing shipyards (currently in a low state of production) could be used for this purpose, with the platforms subsequently towed into place. As noted in the profiles of technology (Section 4.1 below), operating crews--many of whom commute from regular places of residence over their typical work cycle of two weeks on and two off--are not likely to pose a significant population increase, certainly in contrast to mining and plant construction labor forces. Nor are the onshore support facilities likely to represent a significant problem (compared to what may result from coal and processing plant construction). One or a few such facilities can support operations over large water areas, as is now done for the approximately 2000 platforms in the Gulf of Mexico. Strong citizen opposition has developed in California to the possible environmental effects that could result from offshore drilling adjacent to that state. While this situation could pose a problem in community interaction if large-scale development comes about, it increases uncertainty as to the extent of future production.

For all these reasons, it must be concluded that impacts on the community infrastructure and the need for highway support attendant on energy development is likely to be much less in the coastal region than inland.

3.5 Appalachia

New coal production in the Appalachian region is expected to reach 150.3 million tons per year by 1985 over 1975 production (Campbell, 1976). The rate of coal production increase will fall from a projected 31.4 million tons added in 1976 to 3.4 million tons to be added in 1982. This rate is expected to remain fairly constant until 1985 when a slight surge in new coal production is expected to raise new tonnage to 7.7 million tons added in that year. Most new coal production (76%) in the Appalachian region will come from West Virginia (32%), Kentucky (26%), and Pennsylvania (18%).

From this data it appears that the period from 1976 to 1981 will be the most critical in terms of the influx of new miners, and the associated populations that will come with them. The existing labor force, according to the Appalachian Regional Commission (1976), is heavily committed, necessitating the influx of large numbers of workers from outside the region.

Those counties that will experience an increase in coal production in the Appalachian region are shown in the map of the eastern United States (Figure 3-1). Increased coal production in this region will involve many mines and localities so that the impact on the area will be county wide. West Virginia, Pennsylvania, and Kentucky alone have plans for 118 major new or expanded mines by 1985 (derived from Nielson, 1976). In addition, many small independent operations will take place. The traffic-generating effects of these developments will place significant burdens on county secondary roads subjected to commuting miners and service population, as well as from coal haulers using those roads as haul roads out of small independent operations.

The Appalachian Region will bear a heavy impact of energy development; the stresses will probably be second only to those in the Western Plains and Mountain States. This conclusion is based largely on the volume of coal exploitation (Table 3-1 and Figure 3-1) concentrated into those counties of the Eastern States which in terms of population and urbanization have an infrastructure least resilient to heavy stress. The Southwestern counties of Pennsylvania will be heavily mined to produce a projected increase of 26.7 million tons. States likely to receive particular stress are West Virginia and Kentucky (the latter state having coal deposits in both the Appalachian and the Eastern Interior Coal Regions) which are expected to provide the largest increase in coal output east of the Mississippi. Kentucky recently estimated a need for $1.5 billion to provide what officials there deemed an adequate rehabilitation of their road network statewide (Kentucky Department of Transportation, 1976). West Virginia had a very high net population loss of 14.2 percent (ERDA, 1975; Bureau of the Census, 1973). Coal-mining counties like Somerset in Pennsylvania and Bibb in Alabama (the states projected to have the third and fourth highest eastern coal production) which have had high net migration loss and low urbanization also represent critical areas. (The significance of net population change and of urbanization are discussed in Section 5).

Within Kentucky and West Virginia, the localities to face heavy stress include Breathitt, Knott and Perry Counties in Kentucky which are expected to produce a total of 20 million additional tons of coal per year by 1985; and Boone, and Nicholas Counties in West Virginia expected to be adding respectively 5.0 and 6.8 tons annually. These five counties have relatively small population and experienced net migration losses between 1960 and 1970 ranging from 20.8 percent (in Boone) to 42.8 percent (in Perry); also they are largely rural, except for Perry County which is 21.2 percent urbanized. Raleigh County, West Virginia, will contribute an expected 10.35 million tons per year in additional coal by 1985. Its larger population (70,080 compared to roughly one-third of that number in Boone and Nicholas Counties) and 28.4 percent urbanization may enable Raleigh County to cope better with the stresses of energy development. (See Section 5.1 for discussion of the significance of population size, migration loss and urbanization.)

The extent to which such counties are likely to experience heavy population influx is indicated by the projected requirements for the peak years. In 1985, the state of Kentucky will have an estimated total energy-related population of some 48,000 (Table 3-11). Assuming that the proportion within the counties of Knott, Perry and Breathitt is the same as the percent of the coal produced there (45.5 percent), about 22,000 persons would be expected to be involved--as workers or families--with positions created directly or indirectly by energy development (coal). This figure greatly exceeds the total labor force (12,500) of these counties in 1970 and represents about 40 percent of the total population of 55,600 in that year (Bureau of the Census, 1973).

Figures for Boone and Nicholas Counties, while less dramatic, are also striking. As computed by the same procedure, these counties could be expected to have a total energy-related peak population of about 14,000 persons--nearly a quarter of the 1970 population. These counties in West Virginia may, however benefit from their proximity to the urban center of Charleston, the state capital.

West Virginia is projected to have a peak load of over 211,000 additional trips in 1985 and Kentucky about 181,000. Some idea of the percentage increase represented when much of it is concentrated in the coal counties can be obtained by comparing current travel figures. Traffic counts in Boone County, West Virginia, in 1975 were as low as 2,225 vehicles per day along the corridor between Whitesville and Racine, served by State Route 3 and in Nicholas County were around 1,400 in the Route 43 corridor near Craigsville (Rural Traffic Flow Map, West Virginia Department of Highways, 1976). In Breathitt, Knott, and Perry Counties, Kentucky, State Route 451 northwest from Hazard showed an average of 300 vehicles per day; average of counts was as low as 230 vehicles on State Route 28 between Buckhorn and Booneville and on State Route 110 joining Route 28 east of Buckhorn (Kentucky State Highway Map, 1975). Of course these counties may have much unused highway capacity. But as discussed in Section 3.2 above it is unlikely that the roads are currently structured for high-volume travel.

3.6 Interior Coal Region

Additional coal mine production from the Eastern Interior coal region is expected to be about 40.3 million tons per year (over the 1975 level of production) for 1985 over 1975. The three states in this region include Illinois with 69% of the additional forecast coal production, Indiana (18%), and western Kentucky (13%) (derived from Nielson, 1976). Additional production is expected to reach a peak in 1977 of 10.2 million tons, then taper off to 7.5 million tons added in 1978 and 8.25 million tons in 1979 (Nielson, 1976). The coal production rate of increase will decline after 1979 to 1 million tons of new capacity per year in 1982. The major flux of incoming miners will occur by 1980, according to these data.

As can be seen from Table 3-1, the extent of energy development (largely from coal) in the Eastern Interior Coal Region is large and the impacts may be significant. However, the total impact and the stress in local infrastructure are likely to substantially less than in either Appalachia or the Western coal states.

In the Eastern Interior Region, the brunt of increased coal production will fall on Illinois, already the most populous coal-producing state in the nation and one of the largest in terms of annual tonnage (ERDA, 1975). Production is expected (as shown in Figure 3-2) to be spread over much of the state. Because of its large population (fifth in the U.S.), high degree of urbanization (83 percent compared to 52.4

percent for Kentucky and only 39 percent for West Virginia) and the dispersion of activities throughout the state (Figure 3-1), Illinois should be better able to cope with infrastructure stresses than most of the other coal-producing states. See Section 5.1 for the significance of population and urbanization. Of course there may still be problems within rural counties of Illinois. The problems expected in Kentucky (whose fields in the southwestern corner of the state are included in the Eastern Interior Coal Region) have already been noted in Section 3.4.

In the Western Interior Region, the only area of possible heavy energy development is in the Counties of Haskell and Le Flore in Oklahoma. Here six large, but unspecified, underground mines are proposed, but no schedule has been finalized for five of them. Some small communities would be affected, e.g., McCurtain (population 575), Bokoshe (population 588) and Poteau (population 5,500).

3.7 Western Mountain and Great Plains States

The Western Mountain and Great Plains Region comprises the States of Montana, the Dakotas, Wyoming, Colorado, Utah, New Mexico and Arizona. As can be seen from Table 3-1 and Figure 3-4, heavy production is expected in these states of coal and synthetic fuels derived from it. The States of Wyoming, Montana, Utah and New Mexico are expected to provide the largest increase in coal output of any of the lower 48 states; North Dakota and Colorado have projected increases in production which are among the highest. Additionally, new uranium production is projected to be heavily concentrated in New Mexico and Wyoming. Low population density and basically rural employment patterns throughout much of this region--especially in the areas where energy projects will concentrate (Figure 3-4)--imply large in-migration.

The Western Mountain and Plains States represent the region likely to be most severely impacted by energy development and to face the heaviest stress on highways and infrastructure generally. The effect of the enormous increases in coal output projected and the planned synthetic fuel plant (Table 3-1) in the states which have the lowest population density among the lower 48 states could be massive. In addition to very high rates of in-migration for large energy projects compared to other sections of the country, the infrastructure will inevitably suffer severe pains from the effects on a rural life style, much of it invested in farming and ranching, of converting to coal mining and industry as major activities. The location of projected activities at isolated communities such as Hazen and Beulah, North Dakota; Gillette, Wyoming; Farmington, New Mexico; and the Powder River and Fort Union coal regions of Eastern Montana and Wyoming implies heavy stress on existing road facilities. North Dakota recently estimated that it would cost the state about $87 million to correct the likely adverse highway impacts (North Dakota State Highway Department, 1976).

Wyoming, which has a population of only about 353,000 (49th in rank among the states) and is one of the least urbanized states in the union, will be particularly hard hit in producing the largest estimated increase in coal of any of the states (Table 3-1).

The capabilities of the states ultimately to finance the necessary highway improvements is at this point problematic. Expansion of the infrastructure to support large construction projects typically draws from the increased tax base provided by major capital improvements on real property. Often, these come after the need has already been felt for local roads and highways to serve the increase population associated with construction. With coal, a severance tax may be charged on the tonnage extracted. A recent Rand study (Washington Post, 1976a) sees the tax policies of the Northern Great Plains States as capable of providing adequate funding for highway needs. The extent to which large sums collected from coal-severance taxes will be applied to highway improvements in contrast with other requirements seen by the states is not yet clear. In any event, there may well be a transition period during which road and highway networks will look to outside support. In the Four Corners Region, particularly in New Mexico, the tax source is complicated by the fact that much of the coal deposit lies on Indian lands. Similar difficulties occur in portions of Montana, Wyoming, Utah and the Dakotas where coal underlies Indiana reservations.

Some details on the major coal areas of the Western Mountain and Plains States are provided in the following subsections.

3.7.1 Fort Union

In the Fort Union region of the Great Plains, major energy development will occur principally in Western North Dakota and Northeastern Montana. There is coal in the northwest corner of South Dakota but no specific data on proposed mines (USBM, 1976a). Counties in North Dakota which will be affected include Dunn, Mercer, Golden Valley, McLean, Oliver, and Grant. The only town of major size in that area of North Dakota is Dickinson (population 12,405). Small towns likely to experience a significant influx of people include Beach (population 1,408); New Hradeck (population 65); Dunn Center (population 107); Killdeer (population 615); Beulah (population 1,344); Stanton (population 517); Underwood (population 781); Center (population 619); and Almont (109). Roadways through this area consist of Interstate 94 traveling east-west, and scattered state roads through the coal region. Often over 20 miles separate state and county roads. These spaces are accessed somewhat by small improved and unimproved local roads.

In Montana, two towns in the Fort Union region will be principally affected by coal development, coal conversion, and coal-fired generating projects: Glasgow (population 4,700) and Circle (population 964). The area, including the Counties of Valley and McCone, is connected by U.S. Route 2 and major state routes 13, 200 and 16. Other state and local roads are similar to the situation in Western North Dakota. The clustering of the projects around the two towns mentioned above indicates that these will likely receive most of the commuter and other traffic associated with energy development.

3.7.2 Powder River

The Powder River Region of Montana and Wyoming is expected to experience some of the most intensive energy development in the West due to coal and uranium mining, conversion and processing. In addition several coal-fired power plants are to be constructed in the region.

In Montana, the counties involved will include Big Horn, Rosebud and Treasure Counties. Towns likely to be influenced will include Colstrip (population 2,400); Busby (population 300); Decker (population less than 50); Hardin (population 2,733).

In Wyoming, the counties of the Powder River Region include Sheridan, Campbell, Converse, and Johnson. Several towns, of which the largest is Sheridan (population 10,856), are expected to have a significant influx of people. Smaller communities include Buffalo (population 3,395); Rawlins (population 7,855); Gillette (population 7,194); Douglas (population 2,677); Glenrock (population (1,515).

Roads throughout the area of the Powder River Region are similar to those in the Fort Union Region. Interstate 90 extends through the Powder River Region. In Montana the only major highway through the region is U.S. Route 212 running east-west. In Wyoming, Routes 14 and 16 join Sheridan, Buffalo, and Gillette. Traveling north-south through Gillette, secondary Route 59 provides the only transportation route out for many of the proposed mines in the region. In both Montana and Wyoming, there are scattered improved and unimproved roads in the region.

3.7.3 Green River

The Green River region of Wyoming, Colorado, and Utah is an area of low population density where large energy development is anticipated. In Wyoming, the counties with projects proposed or planned include Lincoln, Uintah, Sweetwater, Carbon, and Fremont. Towns near future energy projects include Kemmerer (population 2,292); Rock Springs (population 11,657); Point of Rocks (population 35); Shirley Basin (population 300); and Jeffrey City (population 700). Interstate 80 travels east-west through the coal region. Off Interstate 80, generally going north-south are several major highways (89, 30, 187, 789, 30-287, and 287-789). Other roads are largely unimproved local roads with a scattering of improved-surface roads.

In Colorado, the counties expecting major energy development by 1985 in the Green River region include Moffat, Routt, Rio Blanco, Garfield, Mesa, Delta and Grand. Grand Junction (population 20,170) is the only major town likely to be influenced. Small communities likely to be affected include Rangely (population 1,591); Meeker (population 1,597); Craig (population 4,205); Hayden (population 763); Walden (population 907); Oak Creek (population 492); Rifle (population 2,150); Grand Valley (population 270); Glenwood Springs (population 4,106); Fruita (population 1,822); Cedaredge (population 581); Paonia (population 1,161); Carbondale (population 726); and Montrose (population 5,496). There are several major highways through the area such as Interstate 70, U.S. 40, U.S. 50, State Routes 13-789 and 624;

otherwise the road system is very limited with relatively few secondary roads, either improved or unimproved. However, most of the proposed mines are located in areas with more than average road development.

Utah has a large number of mines expected to open by 1980. In Carbon and Emery Counties, the most intensive coal development will occur. Other counties in the Green River region of Utah expected to experience some energy development include Sevier, Grant, Wayne, Utah, and Uintah Counties. Towns and small communities likely to receive significant influx of workers include Price (population 6,218); East Carbon City (population 2,900); Wellington (population 922); Helper (population 1,964); Castle Dale (population 541); Salina (population 1,494); and Escalante (population 638). The present road system in Utah is better suited (than is the network in neighboring states) for increased energy development because of the numerous U.S. and state highways such as 6/50, 10, 29, 31, 96, 89 and 28 which give access north and south between Salt Lake City and I-70.

3.7.4 Four Corners

In the Four Corners region, New Mexico has the largest concentration of energy development proposed. There is a clustering of mines and facilities near the Utah-Arizona border, and scattered development in Colorado. Uranium mining and processing is expected in McKinley and Valencia Counties, with coal mining and coal conversion projects also planned in San Juan and McKinley Counties. Among the communities subject to heavy population inflow are Newcomb (population 90), Casa Blanca (population 350), Laguna (population 600), and Waterflow (population 50); Farmington (population 8,768), Gallup (population 13,779) and Grants (population 8,768), are larger centers that may be affected. The road system in the lower uranium mining sector is transected by Interstate 40. Improved and unimproved roads exist in the proposed mining area. Access to the coal mining sector to the north is by U.S. Route 66 and State Route 44. State Route 64 runs east and west through the area.

3.8 Regional Infrastructures

Within the time and scope of the present study, only very general assessment was possible of the infrastructures within the regions expected to bear a heavy load from energy development. The summaries presented below reflect review of a number and variety of sources consulted in reviewing infrastructural conditions, as cited in the references given for each sub-section.

3.8.1 Appalachian Region

The existing infrastructural framework throughout the Appalachian coal producing region is limited and in many situations poorly suited to serve the needs of most of its residents. Consequently, without extensive expansion and updating, the current infrastructure may not be able to provide accommodations for the anticipated growth in future mining employment (Boyd, 1976; Gilley, 1976).

Several factors contribute to Appalachia's limited infrastructural base and why it may remain so in the future. One major reason is due to the topographical and geographical isolation of the coal fields themselves. Extremely hilly terrain coupled with many small enclaves of population settlements have made it difficult and expensive to construct road networks, sewer and water systems and other community facilities. Historically, the entire Appalachian coal producing region has been rather deficient in terms of infrastructure. Also Appalachia's relatively low tax rates have kept the coal producing counties financially weak. Expensive sewer and water systems, public buildings and other governmental owned and operated facilities have not been affordable by many of this region's communities.

Additional circumstances, acting collectively, have tended to limit the availability of public services. For instance, housing and urban amenities in this region have historically been provided by the coal mining companies for their workers in the form of company towns. This phenomenon has long been a part of this area's culture, society and economy. The coal mining industry has tended to provide for their work force rather elemental living quarters and services. Close political ties to area, county and state politicans are reported as having often influenced these officials to keep property taxes low and infrastructure expenditures to a minimum (Harrington, 1962; Caudill, 1963).

In recent years most of the mining companies have gotten out of the housing business and the old company houses have been sold to individuals or have been torn down. Few replacements are being constructed and shortages, always significant, are more apparent now than ever before. Compounding the shortages of housing, urban amenities and infrastructure, much of the land is owned by the coal companies who have been reluctant to sell their property for housing developments, fearing that to do so on a large scale would lose any remaining control over the mining labor force (Spence and Tuck, 1976).

Mining employment has increased in the Appalachian region in recent years. Due to the lack of housing and infrastructure in the immediate coal mining regions, the bulk of this new generation of miners have been living in the more urban centers and commuting on a daily basis to their points of employment. This habit has placed greater burdens on the road network throughout the coal region. In addition, the increased commuter traffic along with ever expanding coal haulage via trucks, has severely deteriorated many of the roads in the already structurally weak Appalachian road system.

There is little positive evidence on which to anticipate significant improvement. Given the topography patterns of population settlement, relative poverty of the area, generally unsympathic local political situation and coal company management, it appears unlikely that the infrastructural base in this region will soon be improved. A logical conclusion is that the situation reflects in large degree what people in this region have come to accept as a fact of life. It is true, on the other hand, that many of the mining companies are changing their philosphy. Some Appalachian coal mining companies doing business in the Western coal states are beginning to provide housing, amenities and infrastructure for their workers there because state agencies and local communities are requiring the firms to do so prior to the granting of mining permits. The extent to which this practice becomes widespread in Appalachia will influence how far the infrastructural base is likely to remain as it currently is. (Boyd, 1976; Caudill, 1963; Gilley, 1976; Harrington, 1964; Spence and Tuck, 1976).

3.8.2 Interior Region

The Interior Region's infrastructural base is less likely to receive severe strains as a result of the increased energy production than are other major coal regions. By and large, the bulk of this region's coal will continue to be produced through strip mining, particularly in the states of Illinois and Indiana. There appear to be relatively few infrastructure problems which will be associated with anticipated future coal production. The Eastern part of the regions, where coal production will be greatest, is heavily urbanized. For instance, the State of Illinois has a population density of 199 people per square mile in contrast with Western states, such as Montana, which has only 4.8 people per square mile (Glover, 1976; Miska, 1976; The World Almanac, 1975).

3.8.3 Northern Great Plains

Generally speaking, the infrastructure in the Northern Great Plains states of Montana and North Dakota containing the Fort Union and part of the Powder River coal fields has been very elemental; however, the infrastructure has been adequate to serve the needs of the farm and ranch society. The region is sparsely populated; most towns are quite small, in the population range from 100 to 3000 residents. The infrastructure reflects the frontier spirit which still prevails with families striving for self-sufficiency in providing for their own requirements. The life-style has been somewhat austere; the infrastructure and associated public services reflect an inherent frugality of the population.

As there is no large indigenous labor pool within the area from which the workers required for extensive coal development could be drawn, most of the work force will necessarily come from outside the region. There will inevitably be a heavy load on schools, medical facilities, and other public services. In educational expenditures per pupil, Montana ranked 16th in the U.S., whereas North Dakota ranked 26th with an average of $714, only slightly behind the national average of $783. However, rural school facilities which have been adequate for small school-age populations will face heavy loads from worker families. In medical services and facilities, both states are well behind the national level. Police protection has also been maintained at a level which is low compared to the National average, with some counties having as few as 4 full-time employees per 10,000 population; while fully adequate in view of the crime rates which are among the lowest in the U.S., the base is poor for expansion to meet a large population influx.

It is somewhat uncertain to what extent the citizens, public officials and energy developers in these plains states can effectively utilize public planning to mitigate the impact of absorbing a large population increase where in the past facilities have been maintained at a level commensurate with a population density of about 4 persons per square mile. As an example of the self-reliance with which the region is facing anticipated demands on its infrastructure, the State of North Dakota recently declined an offer for prepayment of property taxes. This offer was made by the American Natural Resources company of Detroit, which plans to construct a 250 million SCF/day synthetic natural gas plant in Mercer County. Despite a desire for acceptance by the county, the state rejected the offer in favor of maintaining its own precedures for meeting citizen needs. On the one hand, this action of course indicates a commendable confidence in existing capabilities. On the other hand, it does not necessarily indicate that an adequate infrastructural base for expansion actually exists or that available mechanisms for mitigating potential stresses will be realistically used. (Conners, 1976; ERDA, 1975a; Groff, 1976; Mujadin, 1976).

3.8.4 Western Mountain Region

The Western Mountain States of Colorado, Utah, and Wyoming appear to have somewhat weak infrastructures in areas outside their widely-scattered population centers. The Powder River coal region of Wyoming is known to be deficient in health facilities. Wyoming, with a population density of about 3.4 people per square mile (World Almanac, 1975), particularly may find the rudimentary infrastructure maintained for its ranching communities severely stressed as energy development continues to build up. Adverse socioeconomic effects have already been experienced in the boom-town development of Rock Springs and Gillette. The problems of a small infrastructure which provides a poor basis for expansion appear to have been exacerbated by a frontier psychology of letting newcomers fend for themselves. Statewide, Colorado is ahead of the national average in medical services and facilities, whereas Utah, like Wyoming, lags the national level. However, conditions are much less favorable in the coal and oil shale counties of Colorado. Both Colorado and Utah appear to be making more effective use than Wyoming of advance planning to mitigate the potential stresses of energy development. For example, the state of Utah developed a master plan to house the anticipated work force at the site of the proposed Kaiparowitz electrical generation facility (subsequently abandoned by its management consortium). (ERDA, 1975a; Koch, 1976; Mininer, 1976; Rapp, 1976; SERNCO, 1974).

3.8.5 Four Corners

The Four Corners coal region includes northern counties of New Mexico and Arizona plus portions of southern Utah and Colorado. Most of this land area is sparsely populated, with Indian reservations occupying significant amounts of territory. A lack of water has limited industrial development and population growth. Based on available information at a fairly gross level, the state of the existing infrastructure must be judged poor. All counties have been marked by net migration losses as high as 38.7 percent in Dolores County, Colorado; 41.5 percent in Apach County, Arizona; and 44.6 percent in San Miguel County, Colorado. Population density ranges from as low as one person per square mile in several counties to as high as 10 in Dolores County, Colorado and 12.3 in Washington County, Utah. Although the states themselves have low overall population densities, most counties have densities below the state level. All counties are below the state average in urbanization; some counties such as Apache in Arizona; Dolores, San Juan and San Miguel in Colorado; Sandoval in New Mexico; and San Juan in Utah, are entirely rural. Such conditions are all typically associated with an infrastructure which is weak in terms of providing a basis for expansion to meet population influx.

In particular, there is a low educational level in these counties, with a high percentage of illiteracy, especially on the Indian reservations (e.g., from 25 to 40 percent among the Navaho); poor health conditions exist. Arizona, New Mexico and Utah are all below the national level in hospital beds and medical personnel and the situation is reported as inferior to the state-wide conditions in the Four Corners Region. The Four Corners counties contain a high percentage of substandard housing, especially in New Mexico and Arizona where the rate runs as high as 11 times the state average. (ERDA, 1975; Sheffer, 1976; Southwest Energy Study, 1972).

4.0 TECHNOLOGY ATTRIBUTES AND THEIR INTERACTION

Highway support needs generated by energy development are strongly influenced by the characteristics of the technology employed and by the way these characteristics interact with the particular features of a locality.

4.1 Profile of Industry Technologies

The principal aspects of a given technology which influence highway travel and determine the stress on infrastructure of a locality relate to the character of the work force required. These features are summarized in matrix form in Table 4-1.

This table shows important parameters of the major activities associated with energy development, based on representative-sized operations. The size of the work force required (third column of Table 4-1) is the most obvious feature of a technology and in most instances is the easiest to determine. However, the character of the work force is also important. The skills necessary affect the extent to which local labor can be recruited. The difference between a largely transient work force (i.e., able to complete the task within three or four years) and one employed in operating a plant or coal mine over a period measured in decades is also highly significant. Considerations such as these determine how much in-migration will result and whether the people who move in will integrate into the community. Ability to recruit locally and degree of transience of the

TABLE 4-1
PROFILES OF ENERGY TECHNOLOGIES

ENERGY TECHNOLOGY	REPRESENTATIVE SIZE	WORK FORCE	ABILITY TO RECRUIT LOCALLY	DEGREE OF TRANSIENCE	LIFE EXPECTANCY OF OPERATION
POWER PLANT CONSTRUCTION[1]					
Nuclear	1000 MWe	1000	Only partially, even where non-agricultural workers available	High	5 years
Fossil Fuel (coal)	1000 MWe	1000			5 years
POWER PLANT OPERATION[1]					
Nuclear	1000 MWe	100	Good with training. Some specialization required	Mostly Permanent Force	25-30 years
Fossil Fuel (coal)	1000 MWe	100			25 years
COAL					
Extraction[2]-Western Surface Mine	6x10^6 T/yr.	215	Difficult; available force largely committed	Mostly Permanent Force	25 years
Extraction[2]-Eastern Surface Mine	5.32x10^6 T/yr.	250			15 years
Extraction[2]-Eastern Underground	2.66x10^6 T/yr.	640			
Gasification-High Btu Construction[3]	2.5x10^8 SCF/Day	2500-3000	Only partially, even where non-agricultural workers available.	High	3-4 years
Operation[2]		589	Partially, with training	Mostly Permanent Force	20 years
Gasification-Low Btu[3]	2.5x10^9 SCF/Day			High	3-4 years
Construction		860	Fair, where non-agricultural workers available		
Operation		325	Good with training	Mostly Permanent Force	20 years
Liquefaction-SRC Process[3]	3.5x10^4 bbl/day				
Construction[3]		1300	Partially, where non-agricultural workers available	High	5 years
Operation[2 3]		180-600	Good, with training	Mostly Permanent Force	20 years
Liquefaction-Other Direct[3]	5x10^4 bbl/day				
Construction		1300	Partially, where non-agricultural workers available		
Operation		554	Partially, with training	Mostly Permanent Force	20 years
OIL SHALE[3]					
Surface Processing	5x10^4 bbl/day				
Construction		1220-1470	Only partially, even where non-agricultural workers available	High	3 years
Operation		1062-1430		Mostly Permanent Force	20 years
Modified in Situ Processing	5x10^4 bbl/day				
Construction		1827	Only partially, even where non-agricultural workers available	High	3 years
		1157		Mostly Permanent Force	20 years
OIL AND GAS PRODUCTION LAND[4]	Oil: 10.63x 10^3 bbl/well/yr. Gas: 249.5x 10^6 SCF/well/yr.	Per 100 wells			
Exploration Services		250	Largely mobile force	High	3-7 years[5]
Development and Exploitation		33	Good. Additional development largely expected where operation already in progress	Low	15-20 years

TABLE 4-1 (CONCLUDED)

ENERGY TECHNOLOGY	REPRESENTATIVE SIZE	WORK FORCE	ABILITY TO RECRUIT LOCALLY	DEGREE OF TRANSIENCE	LIFE EXPECTANCY OF OPERATION
OFFSHORE	Oil: 133.52x 10^3 bbl/well/yr[6]. Gas: 2.48×10^9 SCF/well/yr[6]. 24 Wells	per platform handling 24 wells[6]			
Exploration and Services		175[6]	Largely mobile force	High	3-5 years
Development and Exploitation		75-90[6]	Good, where development in progress. Poor for new areas.	Low	15 years
OIL REFINERIES	2×10^5 bbl/day				
Construction		2000-2200[1]	At least partially, where non-agricultural workers available	High	3-4 years
Production Operation		360-565[6]	Good	Low	30 or more years
NATURAL GAS PROCESSING[6]	5×10^8 SCF/day				
Plant Construction		300-350[6]	Good	High	2-3 years
Operation		47-55[6]	Good	Low	30 or more years
URANIUM PRODUCTION					
Mining[2 3]	1.600 MT/day of ore	240-416	Good	Low	10 years
Milling-Plant[8] Construction	960 MT/yr. U_3O_8	1000	Good, where non-agricultural workers available	High	2-3 years
Milling-Plant[2] Operation	960 MT/yr. U_3O_8	138		Mostly Permanent	≥20 years
Enrichment-Plant[8] Construction	8.75×10^6 SWU/yr.	4000 (peak)	Partial, where non-agricultural workers available	High	7 1/2 years
Enrichment-Plant[8]	8.75×10^6 SWU/yr.	1200		Mostly Permanent	≥30 years
Fuel Fabrication[9] Construction	600-800 MT/yr. UO_2	1200	Partial, where non-agricultural workers available	High	1 1/2 years
Operation and Maintenance	600-800 MT/yr. UO_2	500		Mostly Permanent	30 years
Fuel Reprocessing[10] and Conversion					
Plant Construction	1500 MT/yr. Uranium	2500	Partial, where non-agricultural workers available	High	3-5 years
Plant Operation	1500 MT/yr. Uranium	600-900		Mostly Permanent	30-40 years

[1]USBM, 1976a.
[2]Bechtel, 1976.
[3]ERDA, 1975.
[4]U.S. Bureau of Census, 1975 (except where otherwise indicated).
[5]USBM, 1976b.
[6]Council of Environmental Quality, 1974.
[7]U.S. Geologic Survey, 1976.
[8]ERDA, 1976b (except where otherwise indicated).
[9]General Electric Co., 1976.
[10]Allied Chemical Co., 1976.

work force are assessed qualitatively in Table 4-1. The average duration of the activity is in many instances given as a range of years.

The phasing of the work force is also important. In construction projects the labor requirements typically peak and then decline. For most construction (as in processing plants and electric generating stations) planning engineers frequently estimate the peak requirements at about twice those of the average labor force.* Such a work force increases the danger of boom and bust, when introduced into a largely rural community where the total population there does not greatly exceed the number of additional jobs temporarily created. By contrast, the requirements for operation of a facility over a long term (coal mines and processing plants) build up sharply and level off to a steady-state requirement that endures over the life of the facility.

A peak-load work force is associated with another difficulty for the local infrastructure. Construction requirements typify the situation in which the additional population enters a community before the local tax base has been increased through improvements in real property. In rural communities at a low level of economic development the new tax base may eventually represent a large multiple of that which previously existed.** However, the need for expanding the

*Allied Chemical, 1976.

**E.g., in Claiborne County, Mississippi, the tax base resulting from implementing a large nuclear facility at Grand Gulf was estimated at up to 20 times the previous tax base.

infrastructure may be greatest before that time during construction. It is typical for the labor force required for construction of processing and generating plants to greatly exceed that required on a quasi-permanent basis for operation. For example, the construction force in power plants and uranium mills is at least ten times that of the expected operating staff.

Resource requirements determine the movement of material into and out of a locality. Although the volume of movement has obvious implications for highway needs, movement of the energy resource during the operational phase will not - as previously noted - be analyzed in the present report. Construction requires large volumes of material to be moved to a site; in some instances, earth excavated is hauled away for landfill elsewhere. Power plant operation requires fuel to be moved into the locality. The mass load is greatest for a coal-fired plant which may require from two to more than three million tons (depending on the Btu content of the coal) annually for a 1000 MWe plant* whereas the volume required for nuclear generation is relatively light (175 tons/year). Much of the movement takes place on the site; secondary processing steps are often located near a mine (notably for uranium mills and for conversion of coal to electricity at the mouth of the coal mine). Refineries and synthesization plants involve heavy movements in both directions, as the product changes form. Fluid products are transported principally

*The actual amount depends on the heat content of the coal. The fuel requirements are calculated from the standard factor of 8800 Btu per kilowatt-hour of electric energy and assume a 75% load factor.

by pipeline. Coal to be converted may move by slurry pipelines, although the principal vehicle is expected to be provided by unit trains, supplemented and supported by truck haulage.

4.2 Power Plants

The major stress to the infrastructure from power plants results during the typical five-year construction period; as shown in Table 4-1, a large work force peaks (generally at the third year) and then phases out. The staff required to operate the facility is smaller than the construction force by at least one order of magnitude. In a rural community which is economically underdeveloped, this pattern of population increase followed by a potential decline can trigger the familiar boom-and-bust cycle. For instance, construction of the 2600-Mwe nuclear facility at Fort Gibson, Mississippi is expected to employ a peak construction force of about 2600 men, whereas only 85 are estimated as necessary to run the two-reactor plant (AEC, 1973). Indeed, the increased population associated with running a power plant is so small as to pose no problem even in the most undeveloped area. More difficult to guage, however, is the possibility that introduction of the new facility in such a locality will indirectly open up the area to increased economic development. That is, industrial developers, their attention seized by what is happening, will invest in what they hope is the initial curve of a sharply-rising economic growth pattern and install whole new industrial and commercial facilities. The result - often sought by businessmen and planners of the area - will effectively prevent the "bust" phase of the cycle.

A 1000-MWe power plant requires about 48,000 tons of steel in various forms; 500 tons of copper, slightly more than 600 tons of other metals - chiefly aluminum, chromium and manganese - and 67,000 cubic yards of concrete (FEA, 1974).

4.3 Coal Extraction

In coal extraction, a large semi-permanent work force is required throughout the life of the mine(s) which is typically amortized over a 20 or 30-year period. This type of energy exploitation avoids the short-term boom-and-bust cycle of the five-year (or less) construction force, as the typical phasing of labor is that of operations. The labor requirements are less for strip mining than for deep-shaft or underground extraction: i.e., 36 per million tons for Western strip mining, 47 per million tons for Eastern strip mining, and 190 per million tons for deep mining, as shown in Table 4-1.

Manpower requirements vary widely with the characteristics of the coal seam(s) being removed. Work force estimates in Table 4-1 represent an overall average, based on annual output of coal per miner in 1975 for the U. S. as a whole (Bechtel, 1976). Population estimates tabulated in Section 3 reflect production figures derived by the sources cited for particular states and localities. As an example of the variations by major coal-producing areas, the work factors used in the Draft Environmental Statement of the Synthetic Fuels Commercialization Program may be found in Table 4-2 (ERDA, 1975).

There are a number of operational steps involved in the extraction of coal. After background studies have been made, the site acquired and permits and clearances obtained, construction proceeds. In a typical mine, construction involves the preparation of the site, erection of structures, installation of equipment, and conveyor system, interior and exterior finishing (with plumbing, painting, etc.), construction of track for a rail siding, and dewatering of the area. Large western strip mines (output greater than one million tons per year) typically require from 100 to 200 workers for construction over a two-year period. Unlike power plants and processing facilities, the construction force is less than the operating force as shown for representative mines for which permit application has been made (see Table 4-3).

In underground mines, the time requirements for construction are somewhat higher. From 2 to 5 years is a reasonable range of elapsed time from design to full production. Labor force requirements are comparable to those of a surface mine (USBM, 1976c).

Compared to construction of power plants, requirements for material to be transported to the site for a coal mine are not large. About 1400 tons of concrete and 6000 tons of steel are estimated to be required for a typical underground mine producing 3 million tons

TABLE 4-2

REPRESENTATIVE MANPOWER REQUIREMENTS FOR MINING COAL

REGIONAL COAL	PRODUCTIVITY RATE (tons/man-day)	REPRESENTATIVE SEAM THICKNESS	REPRESENTATIVE HEATING VALUE Btu/lb (x 10^3)	Classification
Appalachia				
underground	11.2	5-7 feet	13-14	Bituminous
surface	29.7			
Eastern Interior	37	5-8 feet	11-12	Bituminous
(surface)	37			
Powder River (surface)	100	60 feet	8.3	Sub-Bituminous
Fort Union (surface)	100	20 feet	7.3	Lignite
Four Corners (surface)	82	11.8 feet	9.4	Sub-Bituminous

Source: ERDA, 1975.

TABLE 4-3

MANPOWER FOR SELECTED MINES

MINE	COAL OUTPUT (Metric tons/yr.)	CONSTRUCTION PERIOD (Years)	NUMBER OF WORKERS		REFERENCE
			CONSTRUCTION	OPERATION	
North Rawhide (Powder River Region)	9.2	≈2	150-200	300	Department of Interior, 1974
Black Thunder (Powder River Region)	10	≈1.5	200	300	Department of Interior, 1974
(Colorado)	3	N/A	100	186	Colorado, Inc. 1974

per year. For a surface mine with a 5-million-ton annual output, the estimated requirements for concrete are the same, whereas steel requirements are estimated at about 11 thousand tons (USGS, 1975).

4.4 Production of Synthetic Fuels from Coal

In developing synthetic fuels from coal, the main impact on highway needs and infrastructure can be expected from requirements of the work force, particularly during construction (as shown in Table 4-1). Peak labor force may run as high as 3000 workers for constructing a representative high-Btu gasification plant of the type envisioned (ERDA, 1975). The operational labor requirements are significantly less, but are still sizable (compared for example to power plants). More than twice as many married workers employed in operating a plant are expected to bring their families than is true of construction workers; thus the total in-migration involved in plant operation could be considerable. On the other side of the picture, the prospect for recruiting and training local workers for the long-term requirements of plant operation is likely to be better than in the 4-5 years involved in constructing plants. Also, the fact that operational workers are quasi-permanent provides a better basis for their incorporation into the life of the community. By contrast, a short-term construction worker may think of himself as an outsider, with requirements to be met by the infrastructure, rather than as contributing to it.

In comparing the similarities and differences among the types of synthesization plants expected (as shown in Table 4-1), it can be seen that construction times are similar. The highest labor requirements for construction and operation are in the high-Btu gasification plant. By contrast, the low-Btu gasification plant has the lowest estimates for construction work force. The low-Btu plant would be operated close to the source of the coal extracted; its synthetic fuel product would be used to support a 1000-MWe power plant. The requirements for movement of bulk product would thus be relatively low in such a plant and would not complicate the load placed on highways by increased traffic from additional population. The attendant work force and other population associated with a complex of activities would, however, represent a large load on the locality. In a relatively remote rural area, such as the vicinity of Hazen and Beulah, N. D., the cumulative effect might be disproportionately great on highway needs and other features of the infrastructure.

4.5 Oil Shale

Oil shale operations would place a large load on local infrastructure through the requirements of large work forces. These will be heaviest in the modified in-situ processing, where the dropoff from peak construction to the operational phase will also be heavier than in surface processing. The water requirements for surface processing are great. There will be particularly heavy land requirements for permanent disposal of spent shale. However, it is unlikely that oil shale exploitation will be well advanced within the time frame of this study (prior to 1985). The features of this technology will not be analyzed here.

4.6 Oil and Gas Production

Comparatively speaking, oil and gas production is not expected to have a major impact on highway needs or local infrastructures. The largest population concentrations are likely to result from construction of oil refineries. In the field exploration and field development phases, manpower requirements are relatively light as can be seen in Table 4-1. These figures represent the overall average of employees per well or sets of wells (the basis on which they were derived from U. S. Bureau of the Census data, 1975). However, they do not convey a realistic picture of the phasing. A more detailed matrix with qualitative estimates of labor needs appears as Table 4-4.

Typically the labor requirements of early exploration involving field mapping, seismic investigations, field remote sensing (chemical), and aerial photographs are light. Labor intensivity builds up to a peak during exploratory drilling and reservoir delineation, in which test wells are sunk so that the extent and geologic/economic characteristics of the underlying field can be diagnosed. The exploration phase, which may typically extend over about 5 years for a large field, will vary with the lease arrangements. In some states, the mineral rights revert after a fixed length of time (e.g., 7 years in Louisiana). The ceiling for offshore oil is 5 years under terms of leasing regulations.

TABLE 4-4

LABOR REQUIREMENTS OF OPERATIONAL ACTIVITIES ASSOCIATED WITH DEVELOPMENT OF OIL AND GAS

OPERATIONAL ACTIVITY	RELATIVE LABOR REQUIREMENTS	DEGREE OF CONCENTRATION
Exploration	Fairly Light	Labor dispersed and mobile in mapping, seismic activity, other geologic analysis of potential areas. Small teams predominate.
Exploratory Drilling	Heavy	Labor concentrated temporarily in specific locality in establishing existence of oil and gas.
Delineation	Heavy	Labor concentrated temporarily in selective well drilling to determine extent and characteristics of underlying field.
Production	Light	Labor may be dispersed throughout extensive field(s) over long period of production (may exceed 30 years).
Enhanced Recovery	Moderate to Heavy	Labor build-up may begin after a few years production, in application of technologies stimulating additional flow of fluid through porous rock horizons into producing wells
Gathering	Light	Labor is required for movement by small-well yields for transportation from central point(s) but force is dispersed geographically
Transportation	Light	Labor is required for movement by pipelines, barges, tankers and rail but is dispersed geographically
Refining (oil) and Processing (gas)	Construction requirements Heavy in constructing oil refineries; moderate to heavy in gas processing plants. Light to moderate in operating plants	Labor force concentrated: short-term for construction (2-4 years); long-term (30 years) for operation

After exploration and delineation, production wells are drilled. During continuous production, labor requirements are minimal; many wells continue pumping with only periodic attention for check purposes. Enhanced recovery techniques may be employed early in production in order to expedite the flow rate into the producing horizons (typically layers of sandstone containing the oil) by injection wells, waterflooding or steam injection, and thus into selected producing wells that continue to be pumped. When such techniques are used, labor requirements build up again. Transportation, which emphasizes pipeline flow supplemented by movement via water (and sometimes rail), does not place heavy requirements in terms either of labor or of highway usage except to terminal facilities. (USBM 1976b; U.S. Geological Survey, 1976

In offshore oil production, initial exploratory drilling may be completed within about 9 months to a year after the lease is secured. When the first well actually comes in, a small number (typically 3 to 5) of additional exploratory and delineation wells may be drilled over a period of two to three years. To determine whether oil and gas that has been discovered is commercially-exploitable, further delineation and "step-out" wells are drilled to establish the economic feasibility of production. If the economics are acceptable, large platforms are fabricated onshore (with about a 1½ to 2-year lead time), and floated to the field (USGS, 1976).

Personnel requirements are not heavy in offshore oil operations. One floating or fixed drilling rig is estimated to be able to drill an average of four offshore wells per year and to require 50 to 75 men on board at a time depending on the configuration of the rig, distance from shore, and depth of well. About another 100 would be involved in transportation and other onshore back-up operations. For each platform used in production of oil and gas, employment requirements are estimated at 75-90 persons. In practice, the number of slots for production wells per platform have ranged from only a few each (in older technology) up to as many as 48, with 24 being taken as a reasonable average from which manpower estimates may be scaled (Council of Environmental Quality, 1974). As offshore crews rotate work on a basis of long-term shifts (e.g., two-weeks on and two off), many are able to live at a distance from the site of operations and commute once a month. Crews as well as equipment often move to and from shore by helicopter, seaplane or crew boat. Platforms are typically fabricated at a distant facility and towed to the location where they will operate. A few onshore staging points (or even a single one) at which all off-site support personnel and facilities are concentrated may support all offshore operations within a very wide water area, e.g., the approximately 2,000 platforms in the Gulf of Mexico can be supported from a single location (U.S. Geological Survey, 1976).

Oil and gas exploration and development are estimated to require, per thousand feet of drilling, from 30 to 35 tons of steel, about 16 to 17 tons of concrete, around 10 tons of barite, and 3 to 4 tons of bentonite. Some 100 million feet of drilling per year through 1985 are expected. An indication of the material transportation involved in constructing refineries and processing plants is given by estimates for a 200,000 barrel-per-day gasoline refinery. These include about 100 thousand tons of steel, 7700 tons of concrete, 1800 tons of asbestos, 1700 tons of refractories, 1200 tons of copper, and a few hundred tons each of manganese, chromium and nickel (U.S. Geological Survey, 1975).

4.7 Uranium Extraction and Processing

Nuclear energy at the present time is largely derived from the fission of ^{235}U which is extracted from ore having a relatively low content (around 0.21 percent) of uranium as U_3O_8. A variety of mining methods are employed, both underground and in open pits. Mills - often located adjacent to or on mine-site property to minimize transfer requirements - concentrate the uranium by hydrometallurgical processes. Mill concentrates are then sent to refineries for conversion, typically to some intermediate form such as UO_3 or UF_4. Isotopic enrichment of the ^{235}U fraction then takes place in gaseous diffusion plants, followed by fuel fabrication. Used reactor cores are recycled in order to convert the fission products for long-term storage and to recover the remaining usable ^{235}U (and transuranic elements) (Eisenbud, 1973). The major steps of the process are shown in Table 4-1.

Major impacts can be expected from the extensive mining operations required and secondarily from milling. Because of the low percentage of U_3O_8, enormous amounts of ore must be mined; for example 480,000 metric tons (MT) of ore are typically required to produce 960 MT of U_3O_8 (ERDA, 1976b). A mine with a daily output of 1600 MT of ore will occupy 3,000 acres, including about 250 acres of which are taken up with waste accumulation during the life of the mine. Eventually, the waste will be returned to the mine as refill (ERDA, 1976b). Large transportation and support requirements are expected to exist in connection with mining and milling. The hauling load will be reduced by the tendency to co-locate both operations. While extensive movement will occur between the geographically-dispersed facilities in subsequent processing steps, a much smaller bulk will be involved.

Major work forces are required to construct and operate the plants required for the uranium cycle (as shown in Table 4-1). In particular the labor requirements of constructing an enrichment plant over an estimated 7½ year period are massive. Because of the size and structural complexity necessitated for such a facility by the operations involved and the radioactive properties of the material processed, the labor needs are greater both in time and magnitude than for any other processing facility (as shown in Table 4-1). By contrast, the requirements for constructing a fuel fabrication plant are light. Such a plant can be built within a relatively short time (as shown in Table 4-1). For example, the General Electric plant at Wilmington, North Carolina, was constructed in about 18 months (General Electric, 1976).

There is a potential for environmental impacts on a community from a plant involved in the uranium processing cycle. The danger that radioactive wastes may be released inadvertently at a rate beyond the threshold of safety is likely to be frequently in the minds of residents. While the problem may be largely psychological, citizen concern could increase the difficulties of adjusting to installation of a new plant. In some situations, planning for housing and other infrastructure needs could be complicated by real or fancied problems regarding safe locations.

Requirements for transportation of material in the uranium production cycle are heaviest in construction of an enrichment plant because of the expensive reinforcement necessary to properly contain the radioactive material. A model plant processing 8.75 million separative work units per year is estimated to require nearly 100,000 tons of steel (including steel pipe), 300,000 cubic yards of concrete, and 1.5 tons of organic coolant (ERDA, 1976b).

5.0 FACTORS AFFECTING INFRASTRUCTURE STRESS

The extent to which support to highways is required in connection with energy activities depends on how a general set of factors applies to the locality. These determine not only the load placed on roads and highways within the area, but also the stresses to which the infrastructure is subjected and local capabilities to cope with transportation needs. It is the purpose of this section to identify the factors.

5.1 Basic Factors

The principal factors governing highway and other infrastructure needs may be viewed as conditions which, when present, increase the capability of the locality to respond positively to the pressures of energy development. Conversely, their absence increases the stress on the infrastructure and interferes with effective local action. These factors reflect both the characteristics and requirements of the energy technologies themselves and the conditions - chiefly demographic and socioeconomic - of the locality where development occurs.

While no listing of factors is likely to be exhaustive, the following set represents the principal conditions that govern highway needs and local capability to respond, particularly in relation to the stresses placed on infrastructure by population increases.

5.1.1 Existing Population

It is clear that the size of the indigenous population is a basic determinant of how well a locality can respond to the needs of an energy activity for a labor force and for supporting personnel to fill secondary positions. There is much more chance of finding the skills needed among a large local population than among a small one. Hence, in populous localities there is likely to be small in-migration to fill energy-related jobs and secondarily-created positions. In a well-populated locality, the arrival of even a major work force from outside can more easily be absorbed* within the infrastructure and life-style of the community. Rural communities where the population is measured in hundreds or does not exceed a few thousand can be overwhelmed by a construction project requiring 2500 workers at peak. However, such a labor force may create only a small percent of increase in the existing population in more densely settled areas.

For example, in the Kentucky coal mining counties of Knott, Perry and Breathitt, the total energy-related population (direct and indirect workers plus families) in the peak year of 1985 is projected as representing about 40 percent of the total population that existed in those counties in 1970. There is obviously no way that with normal population growth these counties can avoid a large influx from coal-related activities by 1985.

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*"Population influxes such as those that could occur in the sparsely populated Western coal regions, for example, could cause extremely rapid urban growth (hyperurbanization). A five percent annual growth rate appears to be the maximum that can be comfortably absorbed in semirural areas. Boom-town type growth would occur as average annual increases approached seven to ten percent. Yearly population increases in excess of ten percent could probably not be absorbed by expansion of existing institutions and structures; such rapid increases would require creation of new towns" (ERDA, 1975).

5.1.2 Proximity to Urban Centers

Proximity to urban centers is closely related to the first factor cited, since a locality with high population density is almost by definition urbanized. However, an energy activity may actually be sited in a sparsely-settled rural county which is in turn adjacent to one or more urban centers from which workers may be drawn. Also, workers with special skills not available within commuting distance can often locate in such an urban area where housing and other amenities exist. Conversely, the absence of any nearby urban centers increases the extent of in-migration expected and places a disproportionate load on the infrastructure.

For example, Sweetwater and Fremont Counties in the Green River region of Wyoming are many miles from any sizable city from which workers on energy projects could reasonably commute. The same is true of Golden Valley County at the western extreme of that portion of the Fort Union coal field which lies in North Dakota; the nearest town of any size, Dickinson, is some 40 miles away but has a small population of only about 12,000. The impact of energy development on Mercer County, North Dakota, is likely to be affected to a considerable degree by the feasibility of commuting to the Hazen-Beulah area from the urban center around Bismarck and Mandan (population about 46,000), some 60 miles away. By contrast, power plants in the northern part of Illinois (Figure 3-1) can draw for their construction force on such urban centers as Rockford; Elgin; Dubuque, Iowa; Aurora; and (in the eastern part) even Chicago. Coal mines in the southern part of Illinois are better situated (than are coal mines in the Mountain and Plains states) relative to urban centers, with such cities within possible commuting range as Alton, St. Louis, Danville, Urbana-Champaign, and Terre Haute, Indiana.

5.1.3 Availability of Work Force

The ability to recruit (and as necessary train) workers locally depends heavily on the size of the existing population. But there are other considerations as well. The presence of particular skills which can be readily transferred to constructing a plant or operating mines is an important determinant. Construction and operating forces are drawn from what are broadly classified as non-agricultural workers who are currently unemployed or can be induced to switch jobs or transfer upon completion of their current work. This fact does not imply that farmers, ranchers, etc., cannot be retrained for the needs of energy activity; however, such adjustment is more difficult and when necessary is likely to be associated with perturbations of community life style. Thus, the number of non-agricultural workers (in relation to the required work force) within commuting distance of an hour or two (a maximum of 60 to 90 miles) is one indicator of the extent to which the infrastructure will be stressed by population increase. In the rural counties of the West where farming and ranching are part of the life-style, the available nonagricultural work force is obviously much less than in industrialized sections. In North Dakota and Montana, for example, the percentages are 71 and 73 percent respectively, as contrasted with 89 percent for Ohio and Illinois (Department of Labor, 1975).

5.1.4 Economic and Commercial Base

An economic and commercial base within the locality is important to the resiliency of the infrastructure and its capacity to handle the load placed upon it by increased population. Absence of such a base will be reflected directly in highway needs through increased travel time for commuting and for the purchase of goods and services required. Indirectly, the infrastructure can be strained severely in seeking the resources required for highway requirements and for police and fire protection, education, medical facilities and the other amenities of the new residents. The secondary population increase will be greater if restaurants, stores, filling stations and the like have to be provided to meet worker needs, in contrast to the situation in which such facilities already exist. In a depressed or economically undeveloped community, the payroll of a large construction, mining or operating force has a much larger impact which can lead to inflation, land-grabbing and other disruptive effects; the danger of boom-and-bust is increased where the wage-scale of energy activities is excessive compared to that previously existing.

5.1.5 Net Gain from Migration

A factor which is related to those discussed above is population growth. There are several reasons why a net gain from migration (as shown in comparative census figures) is a general indicator of a flourishing community, which - other things being somewhat near equal - is better able (than one which has suffered net migration loss) to provide the required workers and to bear potential stresses on the infrastructure. As already briefly noted in Section 3.2, a growing community tends to attract potential workers as migrants seeking a remunerative market for their various skills. Often these persons will have left their home areas where job opportunities and/or pay scales are lower and these communities, in turn, will show a net migration loss associated with a potential labor deficiency.

Of course, many local factors may, in specific situations, provide exceptions. It is not necessarily true that those who migrate out of a community are the persons who would best fill energy-related jobs; nor is it certain that the remaining population will not include a high percentage of potential miners, construction workers, and persons who would find employment in secondarily-generated positions. But it certainly is true that those with marketable skills find it easy to migrate, whereas the old, the infirm, those less readily recruited for positions elsewhere are likely to remain.

It is also true that a growing community (as shown by net gain from migration) is already in process of having to cope with local increase of population and is more likely to be gearing up for the expansions required in the infrastructure. Conversely, there is little pressure to strengthen the infrastructure that serves a declining population and a sudden shift with a large demand for workers will tend to represent an acute stress.

It is also significant that a high correlation is likely to exist between population growth from migration and the existing commercial and economic base. New residents are attracted to localities that are expanding economically and commercially, where job and business opportunities are good and rewards high. On the other hand, outward migration tends to occur from depressed localities where the economy is poor. Cause as well as effect is involved in both situations. As population growth continues, the newcomers contribute to economic expansion and the net gain in migration is both an indicator and an agent of an improving commercial and economic basis. In the opposite situation, as residents migrate from a declining economy, the demand for goods and services is further depressed.

Thus, net gain in migration is one indicator that a locality may not require a high percentage of outside workers to fill energy-related jobs as well as that it may have the capacity to absorb the outsiders who who do migrate in. Conversely, net migration loss is more likely to be associated with a need for a large influx of workers and of a resultant strain on the infrastructure.

5.1.6 Adequacy of Existing Highways

Where the network of roads and highways can handle the additional travel, the extent of additions and improvements necessary is obviously reduced. In contrast, in a rural area with poorly surfaced roads and only two-lane highways it may be difficult to handle the increased requirements. Particularly important is the existence of all-weather roads suitable for commuting from nearby towns where adequate housing is available. Without easy commuting, providing housing immediately adjacent to an energy facility presents problems to the infrastructure of a rural community.

5.1.7 Scheduling of Energy Construction

Developers of energy activities have only limited flexibility in planning and scheduling major construction projects. An electric generating station, a refinery, or plant for fabricating fuel represents a major commitment of capital; the developers are under considerable pressure to complete it within the shortest feasible time so as to realize a return on their investment. However, where multiple projects are planned within the same general area they may be scheduled so as not to overlap and intensify the burden on local communities and their infrastructure. Often the beginning of a new project can be timed to coincide with the concluding stages of an earlier one, enabling some of the same workers to shift over. The competition for scarce labor is diminished with decrease in the attendant strain on local wage-scales and economic stability; where the distances permit, workers may be able to commute to both projects and the extent of population pressure is reduced. Scheduling in the broad sense encompasses adequate notification to local officials and community leaders and joint planning with them in advance of actually launching the project.

5.1.8 Reserve Capacity of Existing Infrastructure

The capacity of the existing infrastructure denotes the extent to which the locality involved with an energy activity can absorb a population increase and provide the newcomers with the amenities required. This factor reflects aspects of some of the conditions already noted. Where schools are inadequate, highways run down, social and protective services spread thin, central water and sewage facilities lacking, and the tax base scanty, reserve capacity of a community's infrastructure may clearly be deemed poor. Rural communities with a highly stable population and economy typically lack an infrastructure that can respond to the sudden needs of an energy activity. A growing community that has planned ahead to enlarge its transportation, educational, protective and water facilities will much more likely have the ability to absorb population increases and other pressures without severe strain to its infrastructure.

5.1.9 Social Dynamics and Effective Community Planning

"Social dynamics" is used here in reference to somewhat intangible factors of community pride that enable leaders and citizens to develop a solid infrastructure and to strengthen it when faced by the need to absorb a significant population influx. A community with good social dynamics seeks to provide services and facilities of adequate magnitude and timing to meet the needs of newcomers, to make them feel at home and integrate them into the life and culture of the locality. The quality of social dynamics is manifested through an active community life with widespread citizen participation to upgrade social services, public safety, education and the other amenities without which outside workers and other newcomers become restive and even hostile. Social dynamics is an essential concomitant of effective community planning, especially in less urbanized localities without large professional planning staffs. Through effective planning, the problems to be faced with a new energy activity can be identified in time to undertake preventive action. Resource needs can be faced, sources of revenue canvassed, enlargement of facilities undertaken, zoning changes made; joint action can be taken with project management, union leaders and others directly involved with the energy activity to provide housing, social life and other amenities for the newcomers.

5.1.10 Social Consciousness of Project Management

A project management which is socially conscious represents the other half of the partnership required to make social dynamics and community planning work. Such a management approach works early and closely with community leaders - especially in a sparsely populated locality dependent on citizen participation - to diagnose and address potential problems. It is important for the developers to understand the attitude of the local populace toward a forthcoming project, to allay fears by a concern for pride in the local life style, and to develop rapport with religious and civic groups as a basis to cooperate with them in providing means to bring together the residents and newcomers. Project management can take steps to recruit and as necessary train local workers, where an adequate pool of potential labor exists, thus diminishing the population influx and giving the local citizenry a sense that the project is part of the community. It is often possible for the developers to provide subsidized housing, recreational facilities, and other amenities that may strain or exceed local resources. Additionally, in construction projects the developers may sometimes cooperate through arrangements to prepay taxes or to make the facilities progressively part of the tax base prior to completion.

The importance of planning and of utilizing available support programs is discussed generally in the next two subsections. Further details as they apply to problems of specific localities are presented in the case studies summarized in Appendix A.

5.2 Role of Planning

It is generally acknowledged that prior planning coupled with strong joint action by the community and the energy developer(s) can avoid or minimize adverse socioeconomic effects of energy projects. However, prior planning has not been widely practiced during energy development by communities or developers.

Planning is often defined as the systematic application of established goals and objectives. The adequacy of planning depends on how well the needs of the population are anticipated. It also depends on how strongly people view the thesis that controlling the future through planning is more advantageous than muddling or approaching problems in an incremental manner. Consequently, the adequacy of planning varies considerably between localities from virtually no planning to highly comprehensive programs.

Planning can serve several functions for a community about to be the recipient of an energy project. First, it can anticipate the number of outside workers and dependents expected on any given energy project. Using various planning factors to estimate the workers' needs for community services, health care, recreation, housing and education, planning can determine the adequacy of existing facilities, staff, equipment and funds to supply the services needed. Where deficiencies exist, planning can alert city officials, project management and the public in general to the best approach in providing action. If no action is deemed necessary, planning can nevertheless serve the community in helping to satisfy the citizens' need to know. If no adverse impacts are anticipated as a result of studies, the general public should be so informed to give them a peace of mind.

In situations where social and economic problems accompany large-scale energy development projects they can be minimized through planning. Some of the problems are more easily alleviated than others.

For instance, conflicts sometimes arise between old-timers and newcomers, leading to the alienation of one or both groups. Problems of this nature often take personal adjustments which planning cannot directly correct. On the other hand, there are problems which tend to be exclusively financial. This is where planning can directly affect a community's ability to obtain the funds in order to maintain or improve its services and infrastructure during periods of rapid population influxes.

Energy developments pose special planning problems because they typically:

a. lead to very high population growth rates (e.g., large construction facilities such as power plants, coal synthesization plants, and nuclear fuel enrichment plants);
b. occur in isolated, previously rural communities. For example, Figure 3-4 maps the extent to which coal development will occur in the sparsely settled sections of the Northern Great Plains states;
c. place demands on the community for support to the activity and its associated population while contributing very little to the infrastructure;
d. take place in communities which are "tax poor" and their major impact is often (in construction) before the tax base has increased.

In addition there are factors which prevent local governments from carrying out their traditional roles in expanding governmental services. These factors include:

a. limited access to information about the extent of the energy development anticipated

b. very little expertise to measure the need for extra services and infrastructure during energy-prompted expansion

c. limited access to capital in order to finance the extra cost

d. low ability to pay.

In examining the areas where energy projects are built, it may be seen that stress on the infrastructure and socioeconomic changes will vary. Coal development in the West will largely take place in very rural and sparsely populated areas. The people who presently inhabit these rural areas are ranchers; farmers; Indians who may be both; some miners; and residents of towns, including merchants who are oriented to supplying agricultural needs.

Power plants have often been sited on the edge of urban areas where substantial increases in electrical loads have occurred and are expected to continue. Management is then able to find adequate workers, many of whom commute between the project site and their homes on a daily basis. In such a situation, fewer adverse socioeconomic problems are created on the adjacent area during construction. The maps in Figures 3-1 through 3-4 show the extent to which projected power plants will be so located.

However, many power plants are located in rural areas far from major load centers. In the West, a number of plants are planned in the Plains and Mountain states with power to be transmitted long distances to supply consumers in California. Even in the more industrialized East examples can be found of remote locations.

5.3 Infrastructure Planning

5.3.1 Basic Requirements and Problems

Conventionally, rapidly developing areas suffer problems in financing municipal services. These problems result from the fact that tax collection generally runs 18 months or more behind the determination of the need. The planning process is particularly important in regard to the question of municipal financing, since needs must be anticipated on the basis of reasonably accurate projections.

The infrastructure problems faced by a community where major energy development occurs are broad and extensive and planning must be sufficiently comprehensive to deal with the range. Each of the community services required has different characteristics in terms of capital and operating costs, sponsor, lead-time expansion requirements, potential of being financially self-sustaining and priorities for action.

Table 5-1 lists the various characteristics of community ser-

TABLE 5-1

COMMUNITY SERVICE CHARACTERISTICS

COMMUNITY SERVICES	CAPITAL COST FOR FACILITIES			ANNUAL OPERATING COSTS			FEASIBLE FINANCING ALTERNATIVES											FISCAL SHORTFALL CHAR'TICS	
	HIGH	MOD	LOW	HIGH	MOD	LOW	GEN TAX REVENUES	INTERGOV'T REVENUES	SPEC. IMPROV. DISTRICTS	GEN. IMPROV. DISTRICTS	DEVELOPER CONTRIBUTION	NONPROFIT CORPS	USER FEES	PRIVATE UTILITIES	G.O. BONDS	REVENUE BONDS	LEASING	HIGH	LOW
Education	X			X			O	C,O			C	C			C		C	X	
Police		X		X			O	C,O			C	C			C		C		X
Fire	X			X			O	C			C	C	O		C		C		X
Hospitals	X			X			O	C,O		C		C,O	C,O	C,O	C	C	C		X
Health Services		X		X			O	C				C,O	C,O	C,O		C	C		X
Ambulance Service		X			X		O	C					C,O	C,O			C		X
Transportation																			
-County Roads		X			X		C,O	C,O	C		C				C	C		X	
-City Streets																			
-Local			X		X		C,O	C	C	C	C				C			X	
-Major Thoroughfares	X			X			C,O	C,O	C	C	C				C			X	
-Public Transit	X			X			C,O	C,O				C	C,O	C,O	C	C	C	X	
-Airport	X				X		C,O	C,O				C	C,O		C	C		X	
Electricity	X			X			C,O	C			C	C	C,O	C,O	C	C		X	
Natural Gas	X				X		C,O	C			C	C	C,O	C,O	C	C		X	
Telephone	X				X							C	C,O	C,O	C	C		X	
Water	X			X			C,O	C	C	C,O	C	C	C,O	C,O	C	C		X	
Sewer	X			X			C,O	C	C	C,O	C	C	C,O	C,O	C	C		X	
Flood Protection																			
-Major Tributaries	X				X		C,O	C	C	C,O	C	C	C,O		C	C		X	
-Local Drainage Sts.			X			X	C,O	C	C	C,O	C	C	C,O		C	C			X
Solid Waste																			
-Collection			X		X		C,O	C				C	C,O	C,O	C	C	C		X
-Disposal		X			X		C,O	C				C	C,O	C,O	C	C	C		X
Parks																			
-Neighborhood			X		X		C,O	C		C	C				C				X
-Community		X			X		C,O	C		C	C				C				X
Recreation		X			X		C,O	C		C	C	C	C,O	C,O	C	C	C		X
Housing	X				X		C,O	C,O			C	C	C,O	C	C	C	C	X	
Welfare Human Resources			X	X			C,O	C,O											X
Library		X			X		C,O	C,O			C	C	O		C		C		X
Gen. Adm. Service		X		X			C,O	C,O										X	
Cultural Facilities		X			X		C,O	C		C		C	C,O	C,O	C	C	C		X
Governmental Bldgs.	X				X		C,O	C			C						C		X

C = Capital costs
O = Operating costs

TABLE 5-1 (continued)

COMMUNITY SERVICE CHARACTERISTICS

SERVICE SPONSOR						SIGNIFICANT NON-LOCAL FUNDING OPPORTUNITIES		LEAD TIME EXPANSION REQUIREMENTS (months)		POTENTIAL OF BEING FINANCIALLY SELF-SUSTAINING		PRIORITIES FOR ACTION*	COMMUNITY SERVICES
CITY	COUNTY	STATE	FEDERAL	DISTRICT	PRIVATE	CAPITAL	OPERATIONS	PLANNING	OPERATIONS	CAPITAL	OPERATIONS	RAPID GROW.	
				X	X		X	12	6-18			2	Education
X	X					x		6-12	6			2	Police
X				X				6-12	6-12			2	Fire
X	X			X	X	X		12-18	12-24		X	3	Hospitals
X	X			X	X		X	6-12	6		X	2	Health Services
X	X			X	X			6	3		X	3	Ambulance Service
													Transportation
	X						X	6	6			2	-County Roads
													-City Streets
X						X	X	3	6	X		2	-Local
X						X	X	6	12			1	-Major Thoroughfare
X	X			X	X	X		6	6			2	-Public Transit
X	X					X	X	6-12	12		X	3	-Airport
X					X	X	X	6-12	6	X	X	2	Electricity
X					X	X	X	6-12	6	X	X	2	Natural Gas
					X	X	X	6-12	6	X	X	2	Telephone
X				X	X	X		12	6-12	X	X	1	Water
X				X		X		12	6-12	X	X	1	Sewer
													Flood Protection
X	X	X	X	X		X		12	12	X		2	-Major Tributaries
X	X					X		3	6	X		3	-Local Drainage Sts.
													Solid Waste
X	X				X	X		3-6	3-6	X	X	3	-Collection
X	X				X	X		6	3-6	X	X	2	-Disposal
													Parks
X				X		X		3-6	3-6	X		3	-Neighborhood
X	X			X		X		6	6-12			3	-Community
X	X	X	X	X	X			6	3-12		X	3	Recreation
X	X				X	X	X	12-18	12			1	Housing
X	X	X					X		3-6			3	Welfare Human Resources
X								6-9	6-18			3	Library
X	X						X		3-6			1	Gen. Adm. Service
X	X				X			6-12	12		X	3	Cultural Facilities
X	X							6-12				3	Governmental Bldgs.

*1 = Plan and design immediately (before new people arrive)
2 = Plan but start when people arrive
3 = Plan in general details and development after people arrive

vices that need to be planned and provided during rapid population growth. Some services require large capital outlays and high annual operating costs, such as educational, hospital, sewer and water facilities. Others such as public parks are less costly. Adequate police protection involves only moderate capital outlays for facilities, but high operating costs, as do health services. Another important facet is what is termed in Table 5-1 "Fiscal Short Fall Characteristics" -- i.e., the urgency of funding. In general, there is a correlation between a rating of "high" in this characteristic and one in capital cost of facilities. For example, school buildings and other physical requirements in education are costly. As soon as new population arrives, the children must have schools and the need for them is relatively immediate.

Another important facet of infrastructure planning is the lead time required for determining and designing expansion in services. Three orders of priority are distinguished in the last column of Table 5-1. The adequacy of planning, then, can be evaluated on how well the services appear when they are needed. Some services need to be planned and designed before new people arrive, such as major thoroughfares, water and sewer systems, and housing. Other services can be planned ahead and the required action initiated as the newcomers begin arriving. These services include education, public safety, health and various utilities such as natural gas and electricity. Once the great bulk of population has arrived, development of a third type of service is required to implement the general planning. These services include hospitals, ambulance services, parks, recreation and governmental buildings.

5.3.2 Need for Flexibility in Planning

Community planning requires an awareness of a community's need to monitor its current ability to provide a satisfying environment for all its residents. At the same time, it requires a certain amount of flexibility so that it can quickly adjust to changes that were not anticipated earlier. The lack of a comprehensive national energy plan makes local planning a difficult and somewhat uncertain activity. This uncertainty is striking in regard to oil shale development. Interest in obtaining oil from shale has fluctuated for many years. The people who live in oil shale areas can hardly be otherwise than confused about the prospect of any sudden oil shale industry developing soon. Development of synthetic fuels from coal, which is highly dependent on Federal support, is caught in a web of uncertainty as to what Congressional action will eventually authorize.

Many communities have also seen coal mining come and go. Periods of economic depression that have overtaken coal regions of Appalachia as mining has slumped (most recently after World War II) are familiar in the East. In the West, one can ride up many dry washes or canyons and see here and there the coal seams exposed; often such a canyon has been known since frontier days by some such name as "Coal Creek" or "Coal Canyon." Although some coal mining has been done, only recently has the extraction of this coal at a very large scale been seriously contemplated. Now prospects look different with such option as:

- large-scale coal mining via the continuous-wall process and strip-mining methods,
- coal gasification and transmission out of the region via pipelines and unit trains,
- and coal-fired electrogenerating plants in the wake of uncertainties regarding foreign oil and gas and environmental concern over nuclear fuel.

Consequently, energy development projects that were economically unattractive in the past have, in the face of the 1973-1974 energy crisis, become very attractive options. Energy resources, whose existence has been known for generations but for which there was no interest in large-scale extraction, have suddenly become a sought-after commodity.

The need for a flexible planning program can be dramatically illustrated at a site in Wyoming where the number of coal trains passing through to points further east is steadily increasing. The small eastern Wyoming cattle community of Lusk, which has 2,000 residents and a single non-coal freight a day, was informed recently by officials of the Chicago and North Western Railroad that by 1980 the railroad plans to run 44 unit trains (consisting of over 100 cars per train) a day along the tracks that cut across U. S. Route 85, the town's Main Street. "We get one freight a day through here now and that ties up traffic coming in and out of town," say Lusk Mayor William Hammond. "What do we do if there's a fire or if someone has a heart attack on the other side of the tracks once these unit trains start running? We just don't know what's going to happen." (Washington Post, 1976b).

5.3.3 Competing Needs

The large number of requirements placed on a community -- as shown in Table 5-1 -- constitutes a constraint on the ability to provide for highway needs. All of these services are competing with roads and highways for support, often from the same funds. More populous, urbanized communities with a broader tax base, larger planning staffs, and a previous pattern of growth and development should have correspondingly a greater reserve strength and flexibility for coping with the variety of needs. The small rural communities of the Mountain and Plains states may not only have proportionately far greater needs for highway expansion but also are in danger of being overwhelmed by competing stresses on the less flexible infrastructures of their counties and small towns. In Appalachia, despite a larger base population, similar conditions can be anticipated. The coal regions of these Eastern states have, to a considerable extent, been in a period of economic decline accompanied by population losses. West Virginia and Pennsylvania, for example, suffered net migration losses between 1960 and 1970 of over 14 and 3 percent, respectively. These losses tended to be particularly heavy in coal counties (such as Somerset, Pennsylvania). Although Maryland gained statewide 12.4 percent in migragion, Allegheny and Garrett Counties lost over five percent. The coal counties of Bibb and Jefferson in Alabama suffered net migration losses in excess of the statewide average (ERDA, 1975a; Bureau of the Census, 1973). Also, coal counties are typically much less urbanized than is true of the state as a whole. For these reasons, infrastructure stress will be heavy throughout the coal regions; the competition for services will make the pressure for financial support to highways in coal counties especially critical. Some of the same problems will be faced by localities where uranium mining occurs; however, the volume of uranium mining will be much less than that of coal mining.

APPENDIX A

SUMMARY OF RESULTS OF CASE STUDIES REFLECTING PAST PROBLEMS WITH HIGHWAY NEEDS AND PLANNING REQUIREMENTS

APPENDIX A

SUMMARY OF RESULTS OF CASE STUDIES REFLECTING PAST PROBLEMS WITH HIGHWAY NEEDS AND PLANNING REQUIREMENTS

A.1 Western Situation--The "Resource City" Scenario

This scenario was presented as a Working Paper* for a symposium "Energy Boom Areas" at the Annual Meeting of the Federation of Rocky Mountain states, September 4, 1974. Although the scenario does not accurately describe any specific boom area, it includes all the problems encountered during energy development in a typical small Western locality. Judging from the comments of the panel of regional experts who discussed it, the scenario accurately reflects conditions in Western "boom town" areas.

A number of specific transportation issues and problems are illustrated:

1. The original town layout, along a creek bed, had one main street and a "few" dead-end cross streets.
2. A traffic increase of 500 percent in four years produced:
   a. Congested movement at all hours of the day; free flow was never realized
   b. Increased rate of accidents
   c. Increased road maintenance cost
3. New roads increased overload on the town's so-called "main street"
4. Heavy trucks hauling equipment and construction material along the main street resulted in breaking the light-duty surface.

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*Federation of Rocky Mountain States, Inc.

5. A potential trouble spot developed at the railroad crossing, where unit trains hauled (at the time of writing) mineral output at the rate of two per day.* Under full production, the rate is expected to be two trains per hour, stopping traffic through the town for up to 20 minutes every hour.
   a. An underpass is planned, as a part of a general road-upgrading program.
   b. Three years are estimated to be needed to build these improvements, but the unit trains will be up to full schedule in less than two years.
6. To avoid the "downtown" congestion, over half the workers commute 70 miles each way to work, and must go 150 miles for specialized medical care.
7. One of the private development companies plans to reroute a portion of the state highway, to provide a better separation of flow between construction traffic and general traffic.
8. A bypass highway is also planned, to relieve congestion along "main street."

The Resource City scenario assumed a very sparse initial population, and a thin road network. The scenario illustrates a number of effects:

1. There is a wide circle of impact, at least 70 miles in radius. Significant population expansion may be expected in places far from the facility itself.

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* A unit train is assumed to be 100 cars of 100 tons each.

2. A study of separate highway networks indicates:

   a. Those near the facility carry employees to work, heavy equipment, and material for the site

   b. Those near residential areas carry residence-generated traffic, e.g., trips to work, shopping, schools, etc.

3. High construction costs are associated with infrastructure and network road improvement to accomplish the following:

   a. Relieve congestion generally

   b. Carry construction equipment and materials: in one sense this is a one-time burden, but is spread out over the multi-year construction period.

   c. Separate product transportation from local transportation, which often must share the same corridor because of local terrain features. Projects like road/rail grade separation, grade-separated road intersections, and new road sections for mineral hauling are implied as necessary.

A.2 Eastern Situation--The Fairless Works Scenario*

The study of the U.S. Steel Corporation's Fairless Works in Lower Bucks County, Pennsylvania is a particularly well-documented study of what happens to an urban fringe community or a whole metropolitan region, in response to a major development in a high population area. The Fairless Works were constructed in the 1950's in Lower Bucks County, which lies between Philadelphia and New York. Since that entire corridor was already heavily industrialized and populated, the Fairless

* A study done for the Navy Bureau of Docks and Yards by the Bureau of Urban Research, Princeton University, 1965.

plant can be said to have been more of a catalyst of the socio-economic and cultural impacts and problems that occurred, rather than the creator of them. Should a power plant or other energy facility be sited in an urban area the effect can be expected to be similar.

This study illustrates a number of points which are likely to apply to energy development in the East and indeed anywhere in the vicinity of a metropolitan area or large urban center(s):

Size of Development

- Peak Construction Employment--10,000+ (2-3 year construction time)
- Operating Employment--5,000+
- Many other industries and businesses came into the area.

Financing

- Taxes--Although the figures were not disclosed it is known that local government work rose 40% during construction.
- Grants and Loans--Federal housing assistance under CDHA* provisions
- Other--Initially, U.S. Steel subsidiary built some houses, but that was soon discontinued to avoid "company town" image.

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*CDHA: Critical Defense Housing Area (Section 101, Public Law 139, 82nd Congress). Assistance usually includes low interest loans, critical materials availability, sewer and water assistance.

Specific Impacts

- Relocation--Sited on truck farmland. Some gentlemen farmers and an artist's colony moved out.
- Schools and Churches--Ex post facto development was good, but a gap of several years was critical. New buildings used for community activities.
- Transportation--Very bad congestion, no public transit. Fairless, however, had no trouble getting spur lines.
- Recreation--Only swimming pools existed in densely-populated residential neighborhoods.
- Housing--Levittown, Fairless Hills, other private developments for 100,000 people. Many trailers. Developers generally built sewers and swimming pools then leased them to local governments.
- Real Estate--Prices increased 3 to 5 times over earlier levels.
- Crime--Average--550% increase in police "problems."
- Conclusion: The study-suggested recommendation: Integrated planning, early financial assistance

A.3 Planning Problems in an Isolated Western Area--The Hazen-Beulah Scenario

This situation does not represent a "scenario" in the sense of the other two but represents rather the conditions before development and the problems associated with planning. Planning highway needs for energy development is difficult in view of prevailing state and local methodologies.

The towns of Hazen and Beulah are two very small communities in central North Dakota, approximately 60 miles northwest of Bismarck. They are located close to coal fields where heavy exploitation is expected and are served only by secondary roads. There is no interstate highway closer than U.S. 94 about 30 miles almost due south near Hebron, N.D. Their situation is typical of that throughout much of the agricultural West where roads to serve rural populations have proved adequate for 40 years and no major improvements have been made. It is also true that similar conditions exist in some Eastern energy regions; particularly in Appalachia the infrastructure, including highways, atrophied during the period of economic depression and housing areas adjacent to mines are served only by winding, narrow roads.

Problems exist for the localities and for state highway authorities in regard to planning. Reaction times for highway improvement ranges from 2 to 6 years. Funds for highways (planning and construction) are limited. The typical situation is that they have proved barely adequate for meeting current needs where only light traffic passes over rural roads. Often the necessary data may not be available. Further, detailed statistics on actual volumes are somewhat sketchy for such secondary networks. In particular, they do not support extrapolation to the quantum jump in travel that will be associated with intensive energy development.

To contend with this situation, the State of North Dakota undertook recently two studies relating to the Hazen-Beulah situation (North Dakota State Highway Department, 1976; Argonne National Laboratory, 1976). These studies illustrate the level of detailed planning as well as the data requirements and methodology for projecting highway usage and needs associated with energy development. The studies appear to address the same predicted energy activity, a 250 million cubic feet-per-day coal gasification plant and strip mining of the estimated 2 billion tons of recoverable lignite reserves as feed stock for the plant. Highlights of this site-specific study are:

- The gasification plant will require 2000 workers at its construction peak, but only 600 workers during operation. The total population will rise from a baseline of 6175 residents at the beginning of construction to a peak of 14,000 residents five years later. It then falls to a level of 9200 people after eight years, and remains stable at that point.
- Traffic will increase by an average of 150 percent on all functionally classified roads during the year of peak construction. Arterials feeding construction and shopping centers will experience heavier increases. For example, N. D. Route 200 between Hazen and Beulah will increase from the present traffic level of 1075 average trips per

day (ADT) to an estimated 3760 ADT, an increase of 350 percent. N. D. Route 22 between N. D. 200 and Interstate 94 will increase from 850 ADT to 4995 ADT, an increase of 590 percent. The capacities of these roads were not available to the present study. Much of the traffic will consist of trucks hauling equipment and materials to the building site, with possible gross loads exceeding 130 tons. The roads in this area require imposition of seasonal load restrictions during the spring thaw, typically 8 to 10 weeks long. A total cost of $13,756,000 for improvement of 54.8 miles of county- and state-maintained roads is estimated (North Dakota State Highway Department, 1976).

APPENDIX B

METHODOLOGY OF DERIVING POPULATION INCREASE AND ADDITIONAL TRIP MILES

APPENDIX B

METHODOLOGY OF DERIVING POPULATION INCREASE AND ADDITIONAL TRIP MILES

B.1 Population Expansion

In many situations, the estimated work force for constructing a power plant or processing facility or for operating a coal mine or other form of energy activity was given by the source used. Where this was not true, work factors were applied. The general methodology is explained in the next subsections.

B.1.1 Algorithmic Procedure

The expected population increase is calculated in several stages. For any given locality (i), the increase is calculated separately for each specified activity (j) associated with development of a particular form of energy (k). The appropriate results are then combined into a sum which expresses the total increase expected for exploitation of all energy sources within the state. Actually, the expected population increase (P_{ijk}) for a specific locale, activity, and form of energy has two components: direct and indirect. These must be individually calculated as a function of specified variables and then summed: i.e., $P_{ijk} + I_{ijk}$.

B.1.1.1 Direct Population Increase

Direct population increase (D_{ijk}) will result from that part of the estimated work force which is not already within the geographic locality of interest, plus the dependents of the outside workers who move with them. D_{ijk} is calculated as follows:

(1) The first step is to determine the estimated size of the work force (W_{ijk}) for a particular activity. In many situations this value was given by the product of two factors, $W_{ijk} = w_{ijk} \cdot q_{ijk}$, where

- w_{ijk} = the work force required per basic unit of output (e.g., personnel per 100 MWe output of an electric generating plant, personnel required to mine 1,000 tons per day of coal, etc.); values for w_{ijk} are tabulated in Table 4-1 of text.

- q_{ijk} = the quantitative output anticipated (e.g., rated capacity of electric generating plant in 100's of MWe, thousands of tons of coal per day, average output of oil in 1,000 bbl per day from coal liquefaction plant, etc.).

Calculation of W_{ijk} in this way implicitly assumes that the number of workers is a linear function of the size of the activity. That is, if it takes 100 workers to mine x tons of coal or to construct a power plant of y MWe output, then 200 workers will be required in an activity twice as large. This assumption works reasonably well in estimating the work force anticiapted in large energy programs where a number of different activities are aggregated. Some estimates are provided on this basis, including many of those in the Bureau of Mines survey of energy programs (1976a; 1976d) as well as the factors provided in the next subsection. However, the assumption is not strictly accurate in all situations, because economies of scale are often possible, and because the requirements of individual projects differ. Where specific estimates of work forces required for particular activities (mines, processing facilities, etc.) were available, these were used in obtaining the results reported in Section 3.

(2) From the standpoint of the resulting population increase, the members of the work force consists of three categories:

1. Single persons
2. Married individuals without family
3. Heads of households who are accompanied by their families

The number of individuals in each category is determined, as well as the average size of the family involved in the third group. The total direct population increase is then computed as the sum of the increase in each category:

$$D_{ijk} = W_{ijk} \cdot p_{ijk} \left[(1 - m_{ijk}) + m_{ijk}\,(1 - r_{ijk}) + m_{ijk} \cdot r_{ijk} \cdot \frac{f_{ijk}}{h_{ijk}} \right]$$

where* $p \leq 1$ = fraction of work force estimated to represent labor from outside the geographic boundary regarded as "local;"

$m < 1$ = fraction of such workers estimated to be married;

$f > 1$ = estimated average size of family unit for each married worker;

$r \leq 1$ = estimated ratio to total married workers of number who will move their families with them to the locality where the activity will occur;

$h \geq 1$ = average number of members of the work force per household.

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*For convenience, the subscripts--which apply equally to all terms --have been omitted in this tabulation.

The factor, h_{ijk}, is required to avoid any danger of inflating the estimate for number of family members that will accompany each married worker. A value of 1.3 for h_{ijk} was applied throughout in the calculations. A value of 0.75 was used everywhere as an overall average for m_{ijk} and 3.5 for f_{ijk}, (Bureau of the Census, 1973). For r_{ijk} 0.4 was used for construction workers and 1.0 for operating personnel, (Gilmore, et. al, 1973).

Of these factors, p_{ijk} is very difficult to determine and depends to a very large extent on the particular demographic and economic conditions that prevail in the locality where the activity takes place. In a practical situation it will vary for different activities and particular localities. Because data on which to determine local values was not available to the study, an overall average value was assumed of 80% in the upper bound runs and 60% in the lower bound.

B.1.1.2 Indirect Population Increase

In addition to direct population increase, any industrial activity can also be expected to cause indirectly some imigration into the locality as discussed in Section 2 of the text. The basic means of representing this secondary effect in economic analysis is by means of "multiplier." The multiplier expresses the ratio of secondary positions created to the size of the industrial work force (W_{ijk}). This ratio is of course equivalent to the average number of additional jobs created per industrial worker.

(1) The first step in calculating the indirect population increase is therefore to obtain the appropriate value of the multiplier, M_{ijk}, for a particular activity associated with a given energy source for the appropriate state from Table B-1 provided in the next subsection.*

The multipliers in Table B-1 were actually obtained as <u>income</u> multipliers, rather than true employment multipliers. In general, income and employment multipliers are not the same. In order for them to be equated, the assumption must be made that the ratio of employment change to gross output change in every sector of the economy is the same (i.e., for any given sector, a $1.00 increase in output will require exactly the same increase in employment). This assumption requires that the type and amount of labor and capital requirements per dollar of output are the same for all sectors. This, in turn, requires that wages, productivity, dependence on imports, and other factors are invariant through the economy.

While these assumptions often do not fit particular conditions that exist, it is also true that at the level of aggregation involved in the present situation (where a number of predictions as to different planned activities within each state are combined into one set of

*In some states, past activity was apparently not sufficient to provide a basis for calculating a state multiplier. It may also be noted that separate regional multipliers are listed, which are larger than the corresponding multipliers of the individual states within the region. Regional multipliers were not used in the calculations made in the study.

estimates), the loss in precision is not likely to be significant. For planning purposes, income and employment multipliers are often used as if they were equivalent.

(2) The product of the previously determined work force, W_{ijk}, and the multiplier, M_{ijk}, yields the total number of secondary positions expected (S_{ijk}).

$$S_{ijk} = M_{ijk} \cdot W_{ijk}$$

(3) Factors representing the movement of dependents are applied to the indirect work force as was done for the direct force. Conceptually, these factors are the same as used in computing D_{ijk}, but the actual values may be different. To eliminate inadvertent double-counting an estimate of the average number of indirectly-created positions per household (θ_{ijk}) of 1.3 (the same value assumed for h_{ijk}) was applied. Other values used are given in Table B-2.

It is assumed that all married workers (or heads of households) involved in the indirectly-created positions will bring their families with them. Therefore, only two categories of workers are involved in the indirect population increase: single and married.

The calculations yielding the total indirect population increase (I_{ijk}) associated with a particular energy activity are as follows:

$$I_{ijk} = S_{ijk} \, \pi_{ijk} \left[(1 - \mu_{ijk}) + \mu_{ijk} \frac{\phi_{ijk}}{\theta_{ijk}} \right]$$

where:

θ_{ijk} = average number of positions per household;

π_{ijk} = fraction of positions filled by persons moving from outside the locality;

μ_{ijk} = fraction of such workers estimated to be married;

ϕ_{ijk} = estimated average size of family unit for married worker.

Like its counterpart in computing direct population increase, π_{ijk} is virtually impossible to estimate reasonably without detailed local data. Therefore, the value of π_{ijk} was assumed estimated as a nationwide average and was taken to be the same as p_{ijk}.

B.1.1.3 Total Population Increase

The total population increase expected from a particular activity associated with a specific energy source in a given locality is the sum of the direct and indirect increases, i.e.,

$$P_{ijk} = D_{ijk} + I_{ijk}.$$

Where multiple activities occur in one state the population increase is found by summing the values for each activity. Thus the total population increase, P_i, expected in a given state is given by the expression

$$P_i = \sum_j \sum_k P_{ijk}.$$

B.1.2 Application of Factors

Where locally applicable work factors were not available, the general factors described above were multiplied by the projected size of the energy activity. The total work force from all activities was summed for each state. State-by-state employment multipliers supplied by the

Bureau of Economic Analysis, U.S. Department of Commerce, as listed in Table B-3 were then applied in a computer program which derived estimates of the secondary (indirect and induced) employment for the state as a whole. The percent of married workers with and without families and average family size applied as explained above. Population figures listed in the first two columns of Tables 3-3 through 3-11 denote the total involved in energy-related activity, regardless of whether such persons represent local citizens or migrants from elsewhere.

In the complete absence of more specific data which would be generally applicable, assumptions had to be made regarding the percent of local and "outside" workers. In Tables 3-3 through 3-12 an overall average of 80 percent "outside" workers was somewhat arbitrarily assumed. This conjecture was based on the assumption that in-migration would represent movement of workers both within and outside of the state to the localities where the energy activity would occur. There is little reason to defend this exact figure (rather than any other);* it simply seemed that a worst-possible-case assumption of 100 percent outside workers was too high and an overall average of 50 percent or

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*It has been suggested that this value may be too low for many communities. For example, the experience in The Western Plains and Mountain States showed that some construction projects had employed over 95% labor from outside the locality (Mountain West Research, Inc., 1975). However, as the scope of the study did not permit a detailed level of geographical differentation, an overall average was sought which would serve as an upper-bound approximation.

less was too low, particularly for those localities where infrastructure stress will be greatest. Hence, the 80 percent figure was judgmentally taken as a reasonable point near the middle of the acceptable range.

It is important to note that the particular value assumed for this parameter has (in the upper-bound runs reported in Table 3-3 through 3-12) little effect on the computations for estimated trips and vehicle miles that can be ascribed to energy activities. This condition results from the fact that all travel, is counted, whether by original residents or by immigrants, associated with energy development. To test the sensitivity, a set of runs was made on the computer facility in which only the value for the parameter percent of outside workers was varied. In the second set of runs the value was arbitrarily set at one-half the original--i.e., 40 percent outside workers. The maximum differenceiin the two sets of runs between cumulative totals of vehicle miles for any state was 1.21 percent.

In the lower-bound runs (results of which are reported in Tables 3-13 through 3-21) a different set of assumptions was used regarding local workers versus those migrating into the locality. As noted in Section 3, 40 percent of the direct labor force required for all energy activities was assumed to represent local labor. This is based on the overall average of outside labor employed in 14 construction projects in the 9 Western Mountain and Plains States. (Mountain West Research, Inc., 1975). The work-related trips of all the labor force was included in the additional travel associated with energy development. Of the secondary labor force, it was assumed that three-eighths of the total represented outside migration to the localities. Only the travel of this fraction (together with their families) was included in additional travel, both work-related and for other family pruposes.

B.2. Calculation of Additional Travel

Given the estimated population increase, it was then required to compute estimates of the total number of trips and vehicle-miles per day which would result from the energy activity. The total population involved was categorized as follows:

(1) "native" construction workers (i.e., indigenous workers),
(2) immigrant construction workers,
(3) "native" operating workers,
(4) immigrant operating workers,
(5) immigrant induced employment,
(6) families of each category,
(7) single workers in each category,
(8) married construction workers who do not bring their families.

Study Volumes 7 and 8 (Federal Highway Administration, 1972) were then applied (as shown in Table B-3). There were various considerations which led to selection of the particular factors applied (as listed in Table B-3). No regional factors were available to the study.

Distance factors supplied by the Federal Highway Administration were used for work trips by single workers and by all operating personnel, as well as for other (i.e., non-work related personnel) trips.

For work-related travel by workers migrating into the locality, no authoritative statistics on average trip milage were available. Studies show that the travel distance of workers who move into the locality are regularly greater than that of native workers.

The question has been raised as to whether the reverse might not be true--that native construction workers who are switching from other jobs may happen to live farther away from the new work site, whereas those who move in will be searching for housing conveniently situated and may be expected to locate closer to their jobs. This thought reflects a logical line of reasoning, but the results of observed experience are in this instance counter-intuitive. Housing appears to be so scarce in the immediate vicinity of large construction projects that those who do not already have it are forced to commute relatively long distances. As noted below, the Rock Springs experience showed an average commuting distance to work of 50 miles. In rural Mississippi the Grand Gulf nuclear power plant is being built partly by native workers (most of whom had previously commuted to work some distance outside the immediate vicinity) making short work trips from their homes in Claiborne County and partly by outside labor commuting from population centers in Vicksburg, Natchez, and Jackson--up to 60 miles away. (Personal conversation with officials of Mississippi Power and Light Co., and county officials of Claiborne County, Mississippi, February, 1973). The Western experience incorporated in the Resource City scenario (Appendix A) showed migrant workers commuting up to 70 miles to their jobs.

Figures reflecting such distances were deemed too high for the present purposes. In an effort to use an average which would be reasonable on an overall basis to cover both the extreme rural situation and that in which a plant is being built closer to an urban center that affords better housing opportunities, the figure of 20.2 miles (Table B-1) was judgmentally chosen. It is believed to represent a reasonable approximation but there was no information available on which to defend it as a specific value rather than some other comparable figure such as 18, 25 or 30 miles.

Because of the greater uncertainties inherent in estimating vehicle miles, additional trips must be taken as the much more reliable of the two measures of travel increases expected.

The following assumptions were made in calculating travel:

1. Rural tables were used because much of the new effort (and the most significant) will occur there.

2. Shorter time-to-work factors were assigned to native workers and operating workers.

3. Other trips, not tied to work-place, were assumed equal to the overall rural average for such travel.

Total trips and travel lengths were then computed for each state, using a Fortran program run on an IBM 370/145 computer.

The data employed were the best available, within the time available of the study contract. Very little hard data have been compiled on traffic patterns around large rural construction projects. The result is submitted as representing reasonable overall estimates of population increase and additional travel expected, where variations of individual local situations tend to be smoothed out. They cannot possibly compare in accuracy, however, with results that would be achieved from site-by-site study of actual conditions. The data were used with awareness that many considerations can make them inaccurate for specific localities. In particular, the following points should be noted:

1. A specialized population is involved, in which the number of transients is high and the in-migrants tend to have different habits of living from the natives.

2. The personal experience of various planners suggests longer commutation and local-travel distances in rural Western settings.

3. Eastern settings are probably more closely represented, because of better-developed infrastructure and shorter distances which tend to reduce trip lengths.

4. Operating personnel, looking forward to an indefinitely long stay, probably conform more closely to the averages reported than do construction workers and their families.

5. State and regional figures gloss over large variations known to exist at specific sites. In contrast to the figures on trip lengths in Table B-3, it is known for example that:

    (a) in the Rock Springs, Wyoming, area, the average distance for commuting to work was on the order of 50 miles;

    (b) in the Hazen-Beulah area, North Dakota workers are expected to commute an average distance of 12 to 15 miles, depending on which particular projects are implemented.

TABLE B-1

MULTIPLIERS

INDIRECT MULTIPLIERS REGIONS AND STATES	COAL MINING	CRUDE PETROLEUM, GAS MINING	POWER PLANT CONSTRUCTION	POWER PLANT OPERATION (ELECTRIC UTILITIES)	OIL AND GAS WELL CONSTRUCTION	OIL AND GAS WELL EXPLORATION	ALL OTHER CONSTRUCTION	PETROLEUM REFINING
NEW ENGLAND	2.149	1.002	2.753	1.160	2.243	1.550	2.188	0.772
Maine	--	--	1.353	0.793	1.000	0.921	1.130	--
New Hampshire	--	0.712	1.744	0.792	1.202	0.991	1.366	0.451
Vermont	--	--	1.310	0.705	0.887	0.860	1.093	--
Massachusetts	1.952	0.920	2.392	1.056	1.908	1.405	1.950	0.704
Rhode Island	--	--	1.903	0.813	1.589	1.082	1.540	0.524
Connecticut	1.883	0.926	2.361	0.980	2.120	1.380	1.933	0.727
MIDDLE ATLANTIC	3.140	1.368	3.326	1.618	3.027	2.015	2.768	1.463
New York	2.324	1.224	2.600	1.254	2.392	1.769	2.250	1.265
New Jersey	2.126	1.089	2.628	1.157	2.289	1.646	2.227	1.006
Pennsylvania	2.617	1.045	2.848	1.381	2.535	1.676	2.356	1.269
SOUTH ATLANTIC	2.701	1.153	2.599	1.425	2.235	1.659	2.221	1.065
Florida	1.848	0.976	2.016	0.952	1.664	1.386	--	0.916
Delaware	1.388	0.723	1.271	0.826	1.268	1.097	1.221	0.833
Maryland	1.768	0.892	2.007	0.976	1.954	1.307	1.739	0.736
Virginia	2.086	0.885	1.914	1.001	1.597	1.275	1.652	0.665
West Virginia	1.867	0.730	1.952	1.065	1.761	1.183	1.639	1.933
North Carolina	1.589	0.743	1.827	0.875	1.457	1.130	1.566	0.576
South Carolina	--	0.725	1.713	0.834	1.324	1.070	1.483	0.646

TABLE B-1 (continued)

MULTIPLIERS

INDIRECT MULTIPLIERS REGION AND STATES	COAL MINING	CRUDE PETROLEUM, GAS MINING	POWER PLANT CONSTRUCTION	POWER PLANT OPERATION (ELECTRIC UTILITIES)	OIL AND GAS WELL CONSTRUCTION	OIL AND GAS WELL EXPLORATION	ALL OTHER CONSTRUCTION	PETROLEUM REFINING
Georgia	1.694	0.856	1.914	0.970	1.599	1.250	1.670	0.744
EAST NORTH CENTRAL	2.808	1.082	3.179	1.491	2.805	1.838	2.627	1.429
Ohio	2.499	0.988	2.730	1.312	2.436	1.598	2.272	1.481
Indiana	2.044	0.755	2.271	1.094	2.021	1.319	1.912	0.863
Illinois	2.524	1.041	2.733	1.321	2.460	1.630	2.273	1.352
Michigan	1.913	0.772	2.513	1.072	2.115	1.390	2.075	0.938
Wisconsin	--	0.669	2.346	0.945	1.795	1.185	1.816	0.555
EAST SOUTH CENTRAL	2.291	0.880	2.570	1.177	2.189	1.421	2.095	1.422
Kentucky	1.939	0.671	2.125	0.999	1.713	1.196	1.752	1.180
Tennessee	1.953	0.748	2.313	0.869	1.779	1.280	1.873	0.624
Alabama	1.980	0.743	2.100	1.069	1.863	1.251	1.736	0.903
Mississippi	1.298	0.612	1.543	0.800	1.232	1.019	1.312	1.665
WEST NORTH CENTRAL	1.702	0.776	1.865	0.958	1.598	1.201	1.611	1.115
Minnesota	1.499	0.645	1.749	0.865	1.437	1.090	2.437	0.599
Iowa	1.200	0.479	1.311	0.671	0.952	0.827	1.153	0.420
Missouri	1.849	0.847	2.058	1.021	1.726	1.268	1.743	0.734
North Dakota	0.885	0.303	0.616	0.461	0.621	0.595	0.621	0.877
South Dakota	--	0.277	0.720	0.486	0.644	0.589	0.683	--
Nebraska	1.111	0.508	1.163	0.598	0.996	0.818	1.032	0.526

TABLE B-1 (continued)

MULTIPLIERS

INDIRECT MULTIPLIERS REGIONS AND STATES	COAL MINING	CRUDE PETROLEUM, GAS MINING	POWER PLANT CONSTRUCTION	POWER PLANT OPERATION (ELECTRIC UTILITIES)	OIL AND GAS WELL CONSTRUCTION	OIL AND GAS WELL EXPLORATION	ALL OTHER CONSTRUCTION	PETROLEUM REFINING
Kansas	1.355	0.692	1.312	0.780	1.223	0.993	1.223	1.588
WEST SOUTH CENTRAL	2.024	1.193	2.382	1.168	2.030	1.581	2.069	2.493
Arkansas	1.275	0.719	1.502	0.709	1.223	0.957	1.269	1.295
Louisiana	--	0.800	1.672	0.926	1.545	1.316	1.554	2.086
Oklahoma	1.536	0.868	1.679	0.849	1.454	1.136	1.461	1.788
Texas	1.955	1.161	2.277	1.122	2.020	1.539	1.998	2.416
MOUNTAIN	2.137	1.066	2.077	1.183	1.828	1.358	1.737	2.163
Montana	1.216	0.516	0.919	0.703	0.826	0.797	0.847	1.348
Idaho	--	0.449	1.038	0.679	0.892	0.806	0.964	0.408
Wyoming	1.374	0.505	1.013	0.830	0.918	0.866	0.943	1.477
Colorado	1.998	0.994	1.765	1.079	1.710	1.229	1.519	1.900
New Mexico	1.590	0.766	1.141	0.873	1.138	1.019	1.067	1.669
Arizona	1.615	0.782	1.786	0.886	1.438	1.114	1.448	0.646
Utah	1.815	0.830	1.444	0.994	1.739	1.141	1.422	1.805
PACIFIC	2.250	1.277	2.757	1.241	2.268	1.749	2.272	2.192
Nevada	--	0.704	1.150	0.800	1.240	0.993	1.096	--
Alaska	1.315	0.627	0.953	0.754	0.902	0.876	0.931	1.509
Hawaii	--	0.682	1.140	0.779	1.137	1.047	1.087	0.554
Washington	1.640	0.795	1.760	0.839	1.667	1.204	1.508	0.650

TABLE B-1 (concluded)

MULTIPLIERS

INDIRECT MULTIPLIERS REGIONS AND STATES	COAL MINING	CRUDE PETROLEUM, GAS MINING	POWER PLANT CONSTRUCTION	POWER PLANT OPERATION (ELECTRIC UTILITIES)	OIL AND GAS WELL CONSTRUCTION	OIL AND GAS WELL EXPLORATION	ALL OTHER CONSTRUCTION	PETROLEUM REFINING
Oregon	1.541	--	1.832	0.907	1.499	1.100	1.502	0.553
California	2.196	1.281	2.736	1.204	2.228	1.720	2.255	2.348

Source: Regional Industrial Multiplier System, Regional Economic Analysis Division, Bureau of Economic Analysis.

TABLE B-2

FAMILY MOVEMENT FACTORS FOR INDIRECT POPULATION INCREASE

FACTOR	SYMBOL	VALUE	SOURCE
Fraction of Workers Estimated to Be Married	μ_{ijk}	0.75	Bureau of Census (1974)
Average Size of Family Unit for Married Workers	ϕ_{ijk}	3.5	Bureau of Census (1974)
Fraction of Married Workers Who Will Move Families	ρ_{ijk}	1.0	Bureau of Census (1974)

TABLE B-3

DAILY TRIP FACTORS

Worker Population Class	Work Trips: Number Per House	Work Trips: Length, Miles	Work Trips: Pass Per Veh.	Other Trips: Number Per House	Other Trips: Length, Miles	Other Trips: Pass Per Veh.
Native Single Construction	1	11.2	1.3	2.8	8.75	N/A*
Immigrant Single Construction and Immigrant Married Con-construction, without Family	1	20.2	1.3	2.8	8.75	N/A*
Native Married Construction	1.3	11.2	1.3	2.8	8.75	N/A*
Immigrant Married Construction, with Family	1.3	20.2	1.3	2.8	8.75	N/A*
Single Operating	1	11.2	1.3	2.8	8.75	N/A*
Married Operating	1.3	11.2	1.3	2.8	8.75	N/A*
Immigrant Single Induced	1	20.2	1.3	2.8	8.75	N/A*
Immigrant Married Induced	1.3	20.2	1.3	2.8	8.75	N/A*

* Passengers per vehicle taking other trips are immaterial because these trips must be taken in any event.

Source: Federal Highway Administration National Personal Transportation Analysis, 1972.

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APPENDIX C

PLANNING AND FINANCING HIGHWAY NETWORK IMPROVEMENTS

APPENDIX C

PLANNING AND FINANCING HIGHWAY NETWORK IMPROVEMENTS

1.0 Problem Overview

The main report has indicated those states which can expect major problems in providing adequate highway service in connection with energy facilities. The trouble comes most often from one or more of the following six causes:

a. The facility is being built in an isolated area, where only a few poor roads, if any, now exist;

b. Highway traffic load during construction will be seven to ten times greater than traffic during operations;

c. Distribution of traffic during construction will be spread over an area four to six times larger than during operations;

d. Reactivation of dormant mines and altered life style of the new generation of miners overstresses a road network that was marginally adequate twenty years ago and has been allowed to deteriorate since that time;

e. The facility site, lay of the land, and existing road network will locate population in a political jurisdiction (state, county) different from the energy facility itself;

f. Great conflicts exist between two or more competing demands for the same land: e.g., housing and highways.

This Appendix takes a summary look at the economic and jurisdictional structures available to public officials charged with the responsibiltiy of avoiding or mitigating these problems.

The list divides itself into problems along a continuum from those of a physical nature, determined by the shape of the land and the type of energy facility being operated, to those of an institutional nature, determined by the structure of local government, the vitality of local institutions, the placement of political boundaries, and the attitudes of local people. Somewhere in the middle of this continuum lies the subject of economics, which considers the market forces driving development of the facility, the competition between public and private sectors for scarce resources (e.g., land), and the ways in which government can raise the money necessary to pay for needed additions to the public road network.

2.0 Illustrative Examples

As Tables 3-3 and the following tend to show, a few areas will be subject to heavy adverse effects of energy development. Examples in addition to the Mercer County, North Dakota coal processing facility would include:

a. The Appalachian counties in Kentucky, West Virginia, and Virginia, where coal is being revitalized. These places present difficult problems to design engineers, leading either to inexpensive but winding, dangerous roads cut along hillsides or to expensive roads with many bridges, cuts and fills, Expanding the capacity of existing roads is difficult for the same reasons. The Appalachian Highway System has alleviated this problem to some extent, but these roads serve only the major arterial function, and do not address the collection, distribution, and local access functions which are perhaps more important than arterials in serving traffic generated by coal miners. Land use competition is very strong here: coal producers own much of the best land for housing, and prefer to keep it undeveloped in anticipation of future strip mining operations (Spence and Tuck, 1976). The remaining suitable land is often under pressure both for home sites and for highway right-of-way, being the only level ground in the area.

Attitudes among local residents are a problem in Appalachia. A long tradition of conflict between absentee coal company managers and miners has hardened ideas on both sides to a point where cooperation is arranged only after long, hard negotiation. These attitudes will not change quickly among long-time residents, although a strong influx of new people may present the opportunity to avoid past mistakes through a constructive approach. Good planning, cooperation among state and county officials across political boundaries, and careful management of tax revenues can make a difference here, but the effects may be slow in coming.

b. The clusters of development in the Rocky Mountain states present a problem similar in some respects to Appalachia. Like Appalachia, good roads are expensive to build in the rugged terrain, and coal seams cut across political boundaries. Unlike Appalachia, the attitude is more hopeful. Regional bodies like the Federation of Rocky Mountain States give witness to a "can-do" spirit felt among the region's people. A complicating factor here is the question of mineral extraction on Indian land, which may slow or even halt development in some places. Good planning before the machines move in is stressed constantly in papers and workshops (FRMS, 1974; FEA, 1976).

3.0 Economics of the Problem

The above catalogued factors determine the "demand" side of the economic balance, by controlling the availability of land for roads, determining traffic patterns, and setting the price-per-mile of highway construction. On the "supply" side, the most important element is a county or state's ability to raise revenues to meet the demand. For an individual jurisdiction in the throes of a development boom, this ability may be severely hampered in one or more of three ways;

a. Uncertainties in the marketplace may have shortcircuited the normal local planning and building cycle, which typically requires four to five years from start to finish. When an energy company sees a favorable fluctuation in the market for coal (or gas, or oil), it must act within 2 to 3 years to bring a new facility into production. During this time, as market conditions change, efforts may be accelerated, retarded or curtailed altogether at a particular site. The result, from the local planner's vantage point, is often a series of rapid shifts in traffic quantity and patterns on the roads, as the labor force rises and falls. Once a mine is operating, with a firm contract for its output, the traffic patterns become regular again, at a higher level than before production began.

b. Inability to collect taxes on a non-productive facility. The normal way to make an energy facility pay for the loads it imposes on roads is to tax it appropriately, e.g., severance tax on coal, property tax on a power or gas plant. But these revenues come years after the need for them arises, and the local jurisdiction must either borrow huge sums (if its credit permits), raise taxes on local residents, or suffer a significant deterioration of highways and other services.

c. High peak load on highways, followed by a more moderate continuing load. The construction force is large but it typically stays only for two or three years (Puget Sound P & L, 1975; Argonne National Laboratories, 1976). The operating force is approximately one-tenth as numerous. (Coal mines build slowly toward a sustained high level, and do not usually have a "construction peak" effect).

Some analysts have shown that, over the life of an energy project, enough revenue is raised for the public sector through standard tax mechanisms to pay all infrastructure costs, including those for highways (Lindauer, 1974). These revenues often will not be raised in the jurisdiction needing them, however, and some continuing form of regional revenue sharing between counties and between states is critical to the success of this approach.

One specific revenue-sharing plan, proposed by Lindauer, and amenable to Federal participation, is a regionally-administered revolving loan fund. Payments would be made into the fund from coal severance taxes and property taxes on energy processing plants. Loans would be made from the fund, on favorable terms, to local jurisdictions impacted by energy development. Assurances would be needed that the loans could be repaid on schedule, and that the money would be used wisely. A regional planning body would be required to oversee use of the loan fund, to help local jurisdictions assess their needs, make plans to satisfy the needs, and cooperate with each other to share both burdens and benefits of energy development.

3.1 Federal Participation

Federal participation in highway improvement could take several forms. More highway planning money could be given to the affected State Highway Departments, through an addition to the present one-and-one-half-percent formula (23SPUSCSP307(c)(2)), which earmarks this amount of the Federal contribution to state highway budgets for planning and research. A Federal contribution to, or guarantee of loans from, a regionally-administered revolving loan fund could be arranged. A new category of Federal-aid highway could be established, allowing direct Federal support of raods at the county arterial and collector level, not presently part of any Federal-aid system. Each of these measures has advantages and disadvantages.

3.1.1 Highway Planning for an Energy Facility

Highway planning is one facet of the larger problem of fitting the energy facility into the existing infrastructure. The Highway Department must provide roads to the site for workers and heavy equipment movement, and roads in the residential areas for access to essential services. Other state or regional agencies must give the highway planners such parameters as expected time phasing of the project; size of the work force; location of anticipated residential, service, and recreational areas; and expected construction budget limitations. The planners themselves must work in a predictive rather than reactive mode, designing road improvements to handle anticipated traffic increases rather than observed, measured increases already on the network. Predictive planning is an unusual activity for a State Highway Department, and can require more support than just an increased budget, necessary as this is. Planners may need workshop instruction in the methods and shortcomings of prediction, ways to deal with the uncertainties inherent in any plan based on forecasts, and ways to interact with the other agencies involved with the project. Along with a new mechanism for supplying planning funds, the FHWA might consider ways to assess and supply this need for new operating practices in energy-impacted states. New methods may also be needed to shorten the time between the perceived need for a new road section and the opening of this section to traffic. The shorter this time period can be made, the more closely can the road network be brought into conformity with the actual needs of the project.

3.1.2 Revolving Loan Fund

According to (Lindauer 1975) and others, a regional revolving loan fund is one of the most powerful devices available to states and counties heavily impacted by energy development. It could spread these impacts over the entire affected region, make funds quickly available to localities needing them, and avoid the severe problems of crossing political and jurisdictional boundaries with significant amounts of money. This concept could greatly assist any Federal-level participation in energy highway financing, by providing a single, region-wide, responsible agency with which FHWA could deal.

The major drawback to the idea is that no such agency exists at present, and FHWA can have only an indirect role in creating one. The regional development commissions created by Title V of 42 USC 3181 could provide the framework within which an energy impacts loan fund could be administered, or a regional alliance such as the Federation of Rocky Mountain States could provide this service to its members. FHWA could encourage local initiatives along this line and coordinate its efforts with other Federal agencies to establish a competent regional jurisdiction along the lines of the Appalachian Regional Commission.

One development worth watching is an evolving consensus among the Rocky Mountain state governments that the Western Governors' Conference should assume a more substantial role in regional leadership than it has taken in the past. Using the Federation of Rocky Mountain States as an ad-hoc staff, the Governors' Conference has commissioned a paper now in preparation that explores ways to implement this role. The paper should be published by February, 1977, and will be available through the Federation's office, Suite 300-B, 2480 West 26th Avenue, Denver, Colorado, 80211.[1] It will furnish information about the current status of the regional organizing process in the Rocky Mountains.

3.1.3 New Federal-Aid Highway Category

Ample precedent exists to request the Congress to enact a new category of Federal-Aid highway covering energy-related traffic flows. To avoid expensive overbuilding, the following points should be stressed in any proposed legislation:

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[1]Personal communication with Ms. Sharon C. Wescott, Research Assistant, Federation of Rocky Mountain States.

a. Federal matching should be enough to facilitate construction, but not so generous that it encourages the States to neglect useful planning. In the absence of a regional cost-sharing arrangement, a matching level of up to 70 percent Federal, 30 percent State money might be necessary. With regional cost-sharing, the Federal share should be no more than 50 percent.

b. Adequate provision should be made for planning of improvements, with review by a competent authority before construction begins. This review should be thorough, looking for well-considered alternative or contingency plans to cover sudden changes in the level of effort on the part of the energy developer, but should not take longer than four to six weeks. Responsiveness to a situation subject to rapid changes is important for energy-related planning.

c. As long as the energy development proceeds within the envelope of contingencies covered in the plans submitted for review, no more than a standard audit should be required during the highway construction phase, to insure that Federal funds are being spent as intended. If the developer should change the time schedule or size of his effort enough to depart from the planned contingency range, a new planning and review cycle should be initiated, taking into account work already under way or under contract.

3.2 Prior and Continuous Planning

The need for adequate prior planning and continuous monitoring of progress cannot be overstated (FRMS, 1974; Argonne National Lab, 1976; Lindauer, 1975). An entire life style is radically affected by large energy developments, and all public sectors must be coordinated to absorb the changes without being thrown into chaos. A complaint is often voiced that State and Federal agencies have taken over so many of the functions of local government that no capability is left there to deal with large-scale changes. For this reason, the approach to planning for energy development should be to encourage local initiatives to the maximum extent possible, while taking care that no essential services, such as highways, are forgotten. State highway departments should be encouraged to act first in an advisory role to local authorities, but to keep well enough posted on the situation to move quickly if local planning bogs down.

Any Federal initiative should stress and encourage the highway planning and coordination functions at the state level. Energy facilities will be well under way, with people pouring into the area, before the end of a normal four-to-five-year planning-and-construction-bidding cycle. Plans should be continuously updated, and construction should be well advanced within two years after a decision is made to locate an energy facility in a given place. New procedures will be needed to insure that quality workmanship standards and low costs are maintained, even if bidding cycles are cut short. Federal funds might profitably be allocated for planners' workshop and management seminars, to insure that skills are available in the affected States to handle the changed atmosphere. If extra planning funds are made available to states, one of the items checked during routine audits might be the uses to which these funds are actually put.

3.3 Jurisdictional Problems

Jurisdictional boundaries are often a problem in energy development. While one county or state reaps the tax benefits of an energy facility, an adjacent county or state must house, transport, and serve the people who construct and operate the facility. Highway departments have no direct way to change this situation, but they have a key role in data collection and planning for new construction that can serve to illuminate these imbalances. If they can be encouraged to assume informal responsibilities of coordination among affected jurisdictions, and persuasion of responsible officials, these problems could be on the way to an effective solution.

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15. Supplementary Notes

16. Abstracts

The population increases and additional personal travel by highway expected to result from additional energy production in the period in 1977-85 are indicated for each of the lower 48 states. The forces that affect capability of the local infrastructure to cope with strains from such population increases are addressed. It is concluded that the heaviest stresses will result from exploitation of coal. The regional implications for possible Federal support needs are assessed on a relative basis; strains on local infrastructures are likely to be particularly heavy in the Western Mountain and Great Plains states and in the coal counties of Appalachia.

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