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Regional Socioeconomic Impacts of Alternative Energy Scenarios for the Ohio River Basin Energy Study Region - Phase II

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REGIONAL SOCIOECONOMIC IMPACTS OF ALTERNATIVE ENERGY SCENARIOS FOR THE OHIO RIVER BASIN ENERGY STUDY REGION

by

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1.0 Introduction

The Ohio River Basin Energy Study (ORBES) has as its purpose the analysis of the impacts of alternative energy futures in the ORBES region. The purpose of this report is to describe the projected socioeconomic impacts of the ORBES energy futures, defined as eleven scenarios, on the region.

We begin the report with a description of the scenarios and the potential future conditions they attempt to describe. The scenarios were delineated in a manner which would allow the comparison of impacts associated with various economic growth assumptions, energy policies, environmental policies, and energy conversion technologies. The scenarios encompass conditions from the mid-1970's to the year 2000.

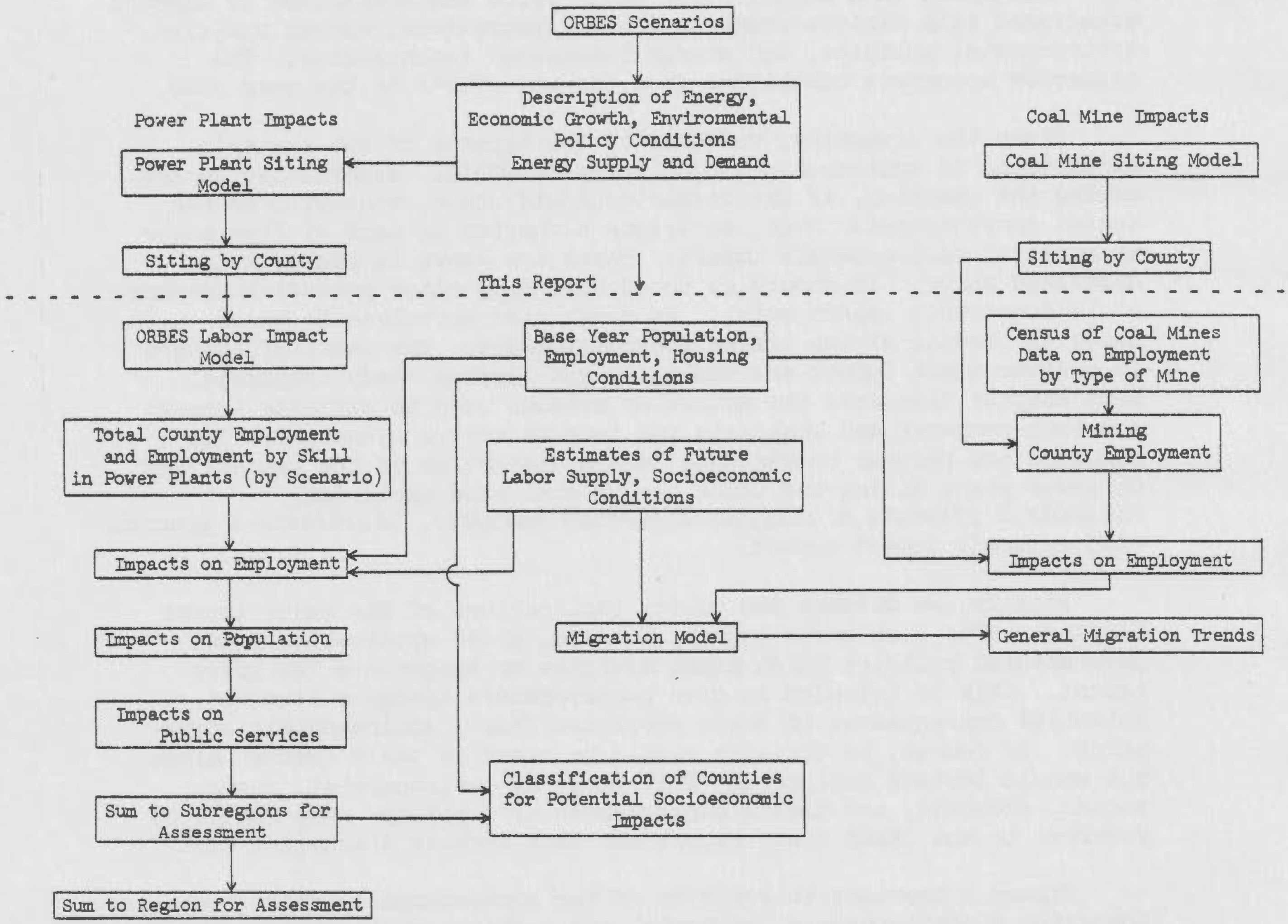
Given the scenarios, we describe the impacts of the scenario assumptions on socioeconomic conditions in ORBES. Essentially we are asking the question, if the scenario should occur, what will be the social consequences? Here, we devote a chapter to each of five major measures of socioeconomic impact. These are shown in Figure 1 and discussed below. It should be noted that many other potential measures of socioeconomic impact exist. We restricted ourselves to these measures because of the limitations of the data, the state-of-the-art in socioeconomic impact and analysis, and limited study resources. Each chapter discusses the method or methods used to estimate impacts and then compares and contrasts the impacts across scenarios. The chapters are further broken down into a discussion of the impacts due to power plant siting and those due to coal mine expansion. Appendix B presents a slightly different analysis, discussing a general socioeconomic impact method.

Finally, we discuss the policy implications of the major impact findings. For each major impact, we note, where applicable, those governmental policies which might mitigate or exacerbate the given impact. This is intended to give policy-makers insights into the potential consequences of their decisions from a socioeconomic standpoint. Of course, no decision should be based on these factors alone but should instead analyze the full range of environmental, energy, social, economic, and health consequences of a policy. The reader is referred to the ORBES final report for this overall discussion [1].

Figure 1 provides an overview of the socioeconomic impact analysis. Scenarios describe energy, economic, and environmental policies and conditions for the future in ORBES. These, in turn, are translated into quantitative representations of energy demand and supply. The ORBES project then focuses mainly on the impacts of power plants and coal mines. Siting models allocate the demand to counties. For the power plants, this is in terms of the amount of electricity generated in 650 MWE coal plants or 1000 MWE nuclear plants. For coal mines, this is in terms of amount of new coal mining activity by number of

Figure 1

FlowChart of Socioeconomic Impact Analysis



tons mined per year.

Given these pieces of information for each scenario, we begin the socioeconomic impact analysis process. For power plants, we developed an impact model called the ORBES Labor Impact Model (OLIM) to project total county employment over time by scenario. This employment projection is compared to current levels of employment and estimates of the supply of skilled labor to obtain potential employment impacts. New employees are translated into population to obtain impacts on population and public services. These analyses begin at the county level but are then summed to subregional and regional levels to give a better picture of the magnitude and distribution of the impacts. In addition, the base year data are used to classify each of the candidate power plant counties into groups with similar potential for each of the types of impacts.

A similar procedure is followed for coal mining employment impacts. Here, a set of employment multipliers is developed using existing data. County level and regional employment changes are forecast using a range of multipliers. The mining employment data are also used in conjunction with a set of other forecasts to look at general migration trends in ORBES.

Each box in Figure 1 below the dotted line essentially represent a section of this report. Referral to this flowchart may help the reader to place each section in perspective.

2.0 Scenarios

The ORBES scenarios are based on a set of regionally based economic models.* The scenarios look at combinations of assumed energy conversion technologies, environmental control standards, and economic growth levels. The scenarios are keyed in time to a base period in the mid-1970's through the year 2000.

Table 1 provides a summary of the scenarios and those that are analyzed in this report. Scenarios are first constructed in terms of fuel emphasis. One set of scenarios emphasizes fossil fuels, a second, nuclear fuel, and a third, alternative fuels. The base case scenario is scenario 2. This is essentially a "business as usual" (BAU) scenario where there is a continuation of current environmental policies, current emphasis on coal fired power plants, and a projection of relatively high economic growth. Within the fossil fuel category, all scenarios represent a conventional coal plan except for scenario 4 where a natural gas emphasis is assumed. Both the coal and nuclear scenarios have a scenario which emphasizes exports of electricity -- scenario 2a and 2b respectively.

The economic growth rates for the scenarios also varies. For many scenarios, a high growth rate is assumed. This corresponds to a 2.47% annual increase in ORBES GRP (Gross Regional Product) and 3.26% nationwide and is based on historic experience. The low growth rate for scenario 5 is assumed to be only 2.1% per year between 1976 and 2000.

The most complex of the assumptions are related to environmental controls. Two environmental control levels for air, water, and land were assumed. These were the strict and base case levels. Strict controls for air quality mean that the stringent emission standards in state implementation plans (SIPs) for urban areas would be applied throughout the state. The base case controls apply these same controls in urban areas only while current rural standards in the SIPs are maintained. New source performance standards are applied to all new sources under both types of conditions.

Base case conditions for water mean current standards for industrial and municipal facilities. Strict controls involve the extensive recirculation of water and a reduction in base case effluents of 95%.

Strict controls for land resources involves interim and permanent performance standards under the Surface Mining Control and Reclamation Act of 1977. Base case controls for land are pre-1977 federal standards.

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*See [1] for further discussion. This section is taken, in part, from that report.

TABLE 1 BASIC DESCRIPTION OF ORBES SCENARIOS

Scenario	Technology	Environmental controls	Economic growth	Socioeconomic impacts analyzed
Fossil fuel emphasis				
1	conventional, coal emphasis	strict	high	Yes
1a	conventional, coal emphasis	strict (very strict air quality), dispersed siting	high	Yes
1b	conventional, coal emphasis	strict (very strict air quality), concentrated siting	high	Yes
1c	conventional, coal emphasis	strict (strict agricultural land protection), dispersed siting	high	No
1d	conventional coal emphasis	strict (strict agricultural land protection), concentrated siting	high	No
2	conventional, coal emphasis	base case	high	Yes
2a	conventional, coal-fired exports	base case	high	Yes
2a2	conventional, coal-fired exports	base case, plants on Ohio main stem with once-through cooling	high	No
2d	conventional, coal emphasis	base case (lax air quality standards)	high	No
2i	conventional, coal emphasis	base case, plants on Ohio main stem with once-through cooling	high	No
4	conventional, natural gas emphasis	base case	high	Yes
5	conventional, coal emphasis	base case	low	Yes
5a	conventional, coal emphasis	base case	very high	No
6	conventional, coal emphasis	base case	high (very low energy growth)	Yes
7	conventional, coal emphasis	base case	high (high electrical energy growth)	Yes
7a	conventional, coal emphasis	base case (least emissions dispatch)	high (high electrical energy growth)	No
Nuclear fuel emphasis				
2b	conventional, nuclear-fueled exports	base case	high	Yes
2b1	conventional, nuclear-fueled exports	base case, plants on Ohio main stem with once-through cooling	high	No
2c	conventional, nuclear emphasis	base case	high	No
Alternative fuel emphasis				
3	alternative	base case	high	Yes

These combinations produce 7 major scenarios and 13 subscenarios as shown in Table 1. Table 1 also shows that only selected subscenarios are investigated in this report. Differences between the socioeconomic impacts of the scenarios evaluated and not evaluated were found to be minimal.

3.0 Impacts on Employment

The socioeconomic impact analysis begins with the siting of both power plants and coal mines. This siting is described elsewhere and will not be repeated here [2,3]. Each siting gives us the total number of plants or mines for each county in the ORBES region between now and the year 2000 for each scenario. In the case of power plants, we also know the on-line date or date on which operation would have to begin in order for the scenario electrical energy demand to be met. For coal mines, we have no such time distribution but only scenario by scenario year 2000 totals. In each case, however, we can estimate the total new employees required for construction and operation of the facility. This can be compared to total estimated supply of workers to get the relative impact of each scenario on employment. Power plant construction employment demand can also be broken out into several critical skill categories for further examination.

The sections below first explicate our methods for calculating expected labor supply and total employment. Then, we delineate the employment impacts of each scenario. The scenarios are compared in terms of these impacts.

3.1 Employment for Power Plant Construction and Operation

Given the distribution and timing of power plant construction, the next step is to calculate the employment induced by these activities. For this purpose, we calibrated the ORBES Labor Impact Model (OLIM). This model takes the schedule of on-line dates and megawatt sizes of generating units for a given scenario and translates them into a schedule of construction and operation labor requirements. The population migration impacts of these demands are also calculated by the model.

OLIM is fully documented in Appendix A of this report and so it will not be discussed in detail here. What is of note at this point are the outputs of OLIM. Table 2 lists these outputs. For each county where a power plant is sited in a particular scenario (host county), the model generates the construction and operation work force and an estimate of total immigrants to the county. At the regional level, the model gives total workers demanded by year and a breakdown of these demands by skill. Our impact analysis begins with these outputs.

3.2 Labor Supply in Construction by Skill

The ORBES Labor Impact Model (OLIM) provides estimates of regional power plant labor demand for eight skill categories: boilermakers, pipefitters, electricians, laborers, ironworkers, carpenters, operating engineers and other skilled workers. (See Appendices A and C for a detailed explantion of data sources and methods used to

TABLE 2

Outputs From the ORBES Labor Impact Model

Scale	Item	Description
County	Construction workers	Workers demanded in each county where there is siting for each year between 1975 and 2000.
	Operation workers	Workers to operate the plant(s) after the construction is completed. Listed on an annual basis.
	Construction workers immigrating	Number of construction workers expected to migrate into the host county rather than to commute to work.
	Total inmigrants	The sum of inmigrating construction and operation workers.
	Power plants	The type (coal or nuclear), size, and number of plants sited in each county
Regional	Total workers	Demand for construction and operation workers for ORBES for each year between 1975 and 2000.
	Workers by skill	Construction workers demanded in each of eight skill categories by year.

derive this skill breakdown of labor demand). Total labor demand is almost useless for attempting to estimate possible labor shortages associated with energy development. Very highly-trained, skilled workers are required to build power plants. Shortages are relevant only within skill groups such as those listed above. Unfortunately, labor supply information is not available or inconsistent for five out of the eight skill groups included as output from OLIM. The remaining three --- boilermakers, pipefitters and electricians --- are among the four skill categories with the largest labor demands that are required for power plant construction. State level data for these three groups was taken from the 1970 U.S. Census of Population [4]. Comparisons with demand required further adjustments of the employment data. These are discussed below.

Although state level data is a fairly good representation of employment in Illinois, Indiana, Kentucky, Ohio, and West Virginia (employment for ORBES portions of states would most likely include that available in the non-ORBES portion since construction workers are very mobile) the data for Pennsylvania would significantly overestimate the workers available for ORBES - Pennsylvania. Both the size of the non-ORBES portion and the average distance between the two portions of Pennsylvania indicate that the state's employment would be an inappropriate estimate of the supply available to the ORBES portion. Population data for 1970 [5] was used to estimate the proportion of employment that was attributed to ORBES-Pennsylvania. The Pennsylvania estimates were summed with the state level data for the five other states to produce a regional employment for the three skill categories.

It should be noted here, that ideally a labor supply model by skill would give the best estimates of future supply and thus a closer estimate of labor shortages. However, neither supply data nor a supply model were available. Checks with labor unions and government agencies lead us to the conclusion that the Census employment data are the only estimating tool currently available. Therefore, we estimate labor supply by skill based on these employment data.

Projections of supply were necessary to compare with the demand estimates which are output from OLIM as annual requirements, 1975 to 2000, for each scenario. It was not possible to employ vigorous projection methods because of data and time limitations. Instead, a simple linear projection to 1980 and 1990 was made using the 1960 to 1970 growth rate. This method assumes that the 1960-1970 rate remains constant over the three decades (1960-1990). This assumption is appropriate as a baseline with which to compare our projections. However, it is not a "prediction" of what will take place in the labor market.

The labor demand for boilermakers, electricians and pipefitters estimated by OLIM does not incorporate demand created by any activities other than power plant construction. The "supply" (employment) data include supply of skills for all purposes. To adjust "supply" so that only potential power plant workers are included several assumptions had to be made. First, we assumed that the number of skilled workers predicted by the model for 1975 was a reasonable estimate of the proportion of the 1975 supply of skills that were available for power plant construction. In other words, we assume that in 1975 supply and demand of labor for the three skill categories was in equilibrium. Second, we assumed that the proportion of power plant workers in each skill group remain constant over the projected period. Any change in the proportion over time would have been arbitrarily chosen since there was no justification for any other method. Making these assumptions yields a set of "supply" and demand data for skilled workers in power plants. Any shortage of workers does not imply an overall shortage in the industry but instead implies a shift of these skilled workers away from other industries toward building power plants. Unless more skilled workers are trained or there is a decline in demand for such workers in other industries, such a shortage means construction delays either in power plant construction or in other construction. Data and models currently available do not allow an estimate of conditions in the overall labor market.

Given these assumptions, the final adjustments to the employment data were accomplished by the following procedures:

1. OLIM was used to estimate 1975 construction worker requirements by skill for ORBES. Information concerning the power plants under construction in 1975 was taken from [6].

2. The 1975 supply of labor in the skill categories, boilermakers, electricians and pipefitters, was determined by making a linear interpolation between the actual 1970 data and the 1980 projected supply.

3. The 1975 estimate of skilled power plant workers was divided by the appropriate 1975 supply estimate (for each of the three skill categories) to yield a proportion or percentage of supply in each skill category.

4. These percentages were applied to the 1980 and 1990 projected supply to obtain an estimate of the supply of skilled workers available for power plant construction.

The resulting figures of estimated supply for ORBES are shown in Table 3.

3.3 Labor Demand in Coal Mining

A computer model was not used for the calculation of labor demand in coal mining. However, a similar procedure was followed to arrive at mining employment estimates. The most critical question in these calculations involves the estimate of future labor productivity in coal mines. Rather than use one or more disparate estimates of

TABLE 3

Supply of Skilled Labor Data and Estimates for Three Categories

ORBES - 1960 to 1990

Skill Category	Actual Supply		Projected Supply		Adjusted for Power Plant Workers	
	1960	1970	1980	1990	1980	1990
Boilermakers	6138	6755	7430	8173	2348	2583
Electricians	73068	97230	129413	172249	2718	3617
Pipefitters	65677	75936	87782	101475	3687	4262

Source: U.S. Census Bureau, 1970 U.S. Census of Population productivity, we base our work on actual productivity data.

The source of our data is the Keystone Coal Mine Census tape (7). This computer tape contains information on the location (county), type of mine employment levels, and production of most mines in the ORBES region for 1976-1977. As such, the data reflect the full range of productivity now occurring in the region. On one hand, we would expect older mines using older technologies to show a higher level of employment per unit of coal produced. The newest mines or mines with the newest technologies would show the lowest employment needs per unit of coal produced or the highest productivity. The future will continue to be a mix of older and newer mines.

Productivity will vary according to the technology used, the rate of capital investment in new equipment, and any labor difficulties the industry might experience. Rather than try to forecast each of these variables, we decided to use a range of productivity estimates based on data from the Census of Coal Mines.

First, we tabulated data on all coal mines in ORBES by type (deep versus strip), employment levels, and production. There are a large number of very small, inefficient mines in the region. They make up only a small part of regional production and are not likely to be important in the future. Thus, we eliminated these from further consideration.

Next, we looked at the range of productivity estimates from the remaining mines. In order to do this, we standardized production to the unit of 1 million tons per year by apportioning employment upwards or downwards as necessary relative to the actual annual production of each mine to 1 million tons. This yielded a frequency distribution of mines by productivity across the region reflecting all the differences in currently available technology, capital, and labor. The maximum and minimum of these estimates should encompass the "real" productivity the ORBES region will experience between now and 2000.

Unfortunately, a rather large range of productivity is found in current ORBES mines. For deep mines the figures range from 150 to 1185 employees per year per million tons mined. For strip mines the range is 105 to 360 employees per year. The wide range in existing deep mines presents a problem in trying to project coal mine impacts. However, these ranges are still used to project the coal mining employment changes in ORBES in the year 2000.

In order to put these figures in perspective, we might compare them with one industry estimate of productivity. For a continuous deep mine operation, the total employment is estimated to be 187 persons/million tons/year (8,15). This might be considered the "best" currently available technology in ORBES in terms of productivity. This is 25% higher than our low estimate and only 16% of our high estimate based on current data. Conventional mining techniques, currently more prevalent, and possibly in wide use through 2000 have a much lower productivity. The mix of technologies will determine where the final average lies. It appears from this admittedly limited comparison that our high estimate for deep mining is probably too high and that the midpoint of the range (668) is probably closer to the "real" productivity.

For strip mines, industry figures indicate 133 employees for a 1 million ton per year mine. This is 27% above our low estimate and is 37% of our high estimate. This range is less problematic since it is much narrower.

Given the many unknowns concerning mining technology and productivity, it seems appropriate to analyze the impacts on employment using the ranges given above bearing in mind the relationship between the low and high estimates, industry figures, and an average figure.

Using three multipliers, the minimum, maximum, and average of these ranges, we calculated mining employment growth as a function of the number of new mines and their related production from the coal mine siting work. (See 33 for siting description and data). These data were only provided for scenario 1, 2, 2a, 2b, 3, 4, and 5 so that these are the only scenarios analyzed with respect to coal mine employment and related impacts.

3.4 Employment Impacts of Power Plants

3.4.1 Total Labor Demand Impacts

The overall employment impacts were calculated for each of the scenarios indicated in Table 1. The impacts are given in Table 4. Scenario 7, the scenario based on NERC energy growth assumptions represents the largest single impact. This is , of course, because of the extremely large number of power plants which would have to be built in order to achieve this level of growth.

The next highest employment impacts are in the "energy-by-wire" or wheeling scenarios 2a and 2b. The policy of producing electrical energy in ORBES and transferring it to the Eastern United States would require the construction of a larger number of plants than in many scenarios. Even so, the labor demands remain significantly lower than for scenario 7. Scenario 2b exhibits a slightly higher labor demand because of the longer time period and greater amount of labor used in nuclear power plant construction.

Next in the total man-years required are the strict, environmental controls scenarios. The main reason for this is the larger number of plants with scrubbers. These units are labor intensive especially in operation. As is indicated in Appendix B, a scrubber facility for a

Table 4

Total Man-Years Required by Scenario
1975 - 1995

Scenario		Total Man-Years Required
1	(high growth, strict controls)	349,309
1A	(very strict air, dispersed)	356,642
1B	(very strict air, concentrated)	346,637
2	(high growth, lax controls)	326,534
2A	(coal exports)	394,083
2B	(nuc exports)	412,219
3	(alternate)	267,437
4	(natural gas)	203,742
5	(coal, low growth)	288,533
6	(high eco. growth, low energy growth)	185,286
7	(high eco. growth, NERC energy growth)	433,032

typical 650 MW coal plant can require 27 - 54 full time workers per year. This translates into a large number of man years across the ORBES region since the strict scenarios imply that all plants have scrubbers. In the "**lax**" scenarios, only the so-called conjured plants (those not announced by the utilities) have scrubbers. The larger labor benefits for strict controls are interesting in light of the dispute over flue gas desulfurization systems. The combined labor benefits deriving from utility employment and the fact that the high sulfur coals in ORBES would be competitive and keep miners employed should be compared with the costs of building such systems. To date, only the air pollution benefits and capital costs have been explored in any depth.

Following these scenarios in labor demand is scenario 2, lax, high growth. This scenario essentially represents current environmental standards and high economic growth.

The final scenarios exhibit conditions of low energy growth conditions, alternate energy use, or a natural gas emphasis and thus require a significantly lower amount of labor for power plant construction and operation. However, these figures are misleading in terms of the overall labor/energy policy tradeoffs being made. The reason for this is the large labor requirements associated with retrofitting buildings to conserve enough energy to meet the constraints of the low growth scenario or to provide the labor for alternative energy systems.

Quantitative estimates made of the amount of labor required for these purposes are very tentative and untested. Several estimates have been made however.* In testimony before the Congressional Subcommittee on Energy, several experts appear to agree that solar energy and conservation practices will generate more jobs than the provision of conventional energy.

There may be no negative tradeoff, in terms of jobs, between alternate energy or conservation scenarios and conventional energy production even though this is implied by Table 4.

Another way of comparing the impacts of the power plant construction and operation on labor is to look at the time distribution of labor demands. Figures 2 and 3 display this for most of the scenarios. Here, one can see that the most extreme growth in demand is associated with scenarios 7, 2a, and 2b. In each case, the scenario forecast of electrical generating capacity increases produces a dramatic change in employment demand between 1980 and 1990. By far, the greatest increase occurs with Scenario 7. Such rapid changes imply a short term labor shortage followed by a surplus as experienced workers have a choice of jobs and then few choices. Since these numbers are region-

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*See 9-14.

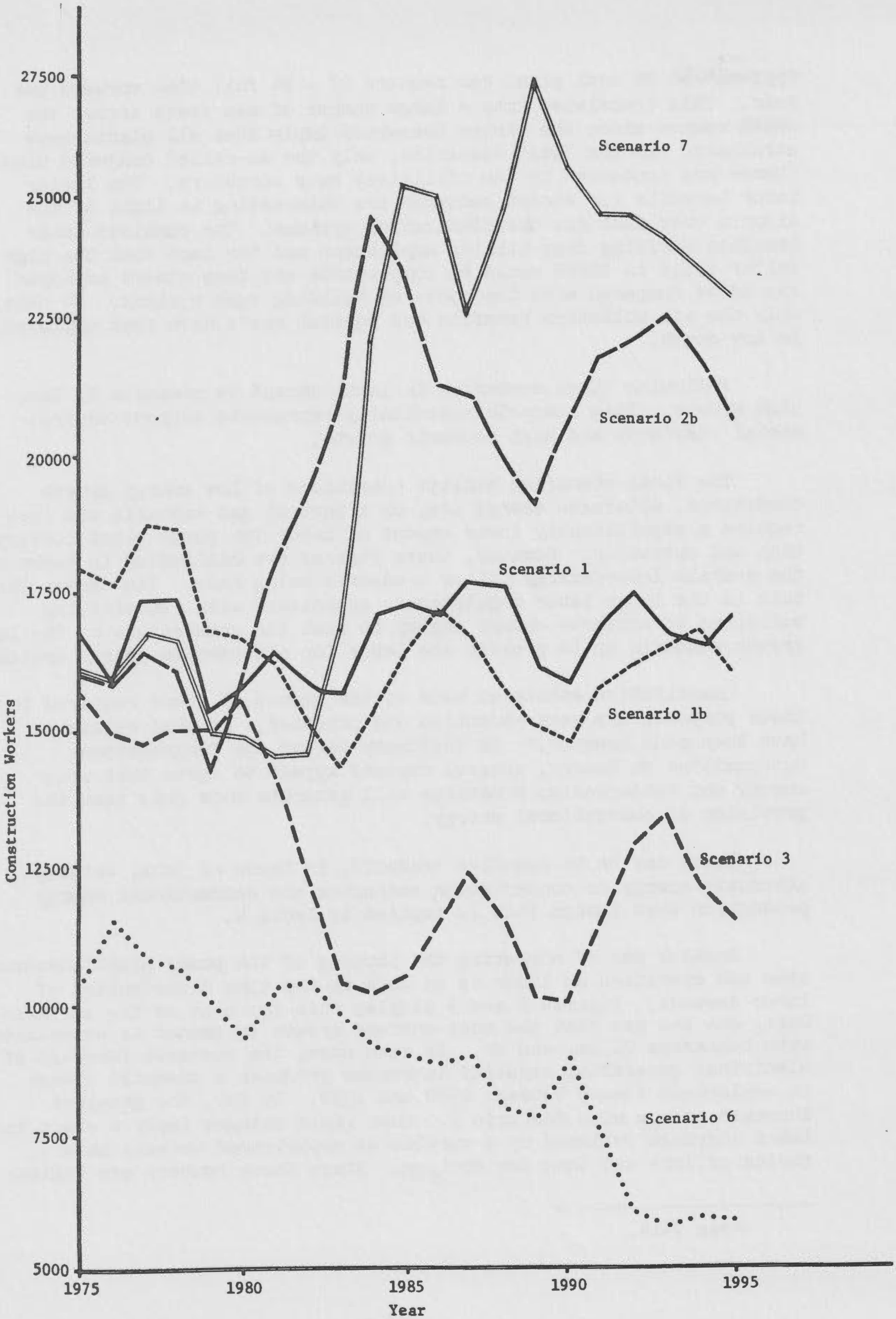

Figure 2. Construction Workers Required, 1975-1995
Scenarios 1, 1b, 2b, 3, 6, 7

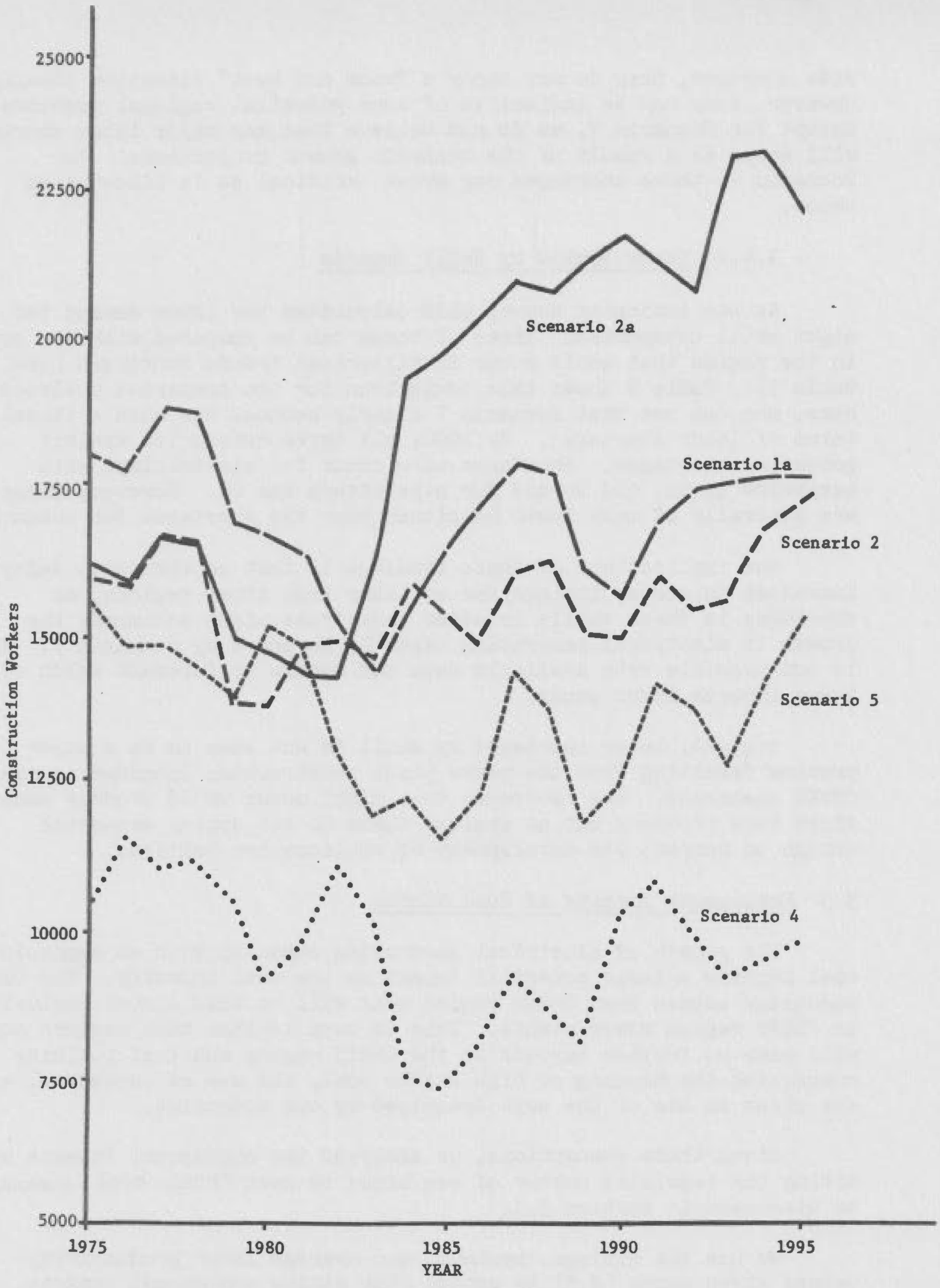

Figure 3 Construction Workers Required, 1975-1995
Scenarios 1a, 2, 2a, 4, 5

wide averages, they do not imply a "boom and bust" situation locally. However, they may be indicative of some potential regional problems Except for Scenario 7, we do not believe that any major labor shortages will occur as a result of the scenario growth projections. For Scenario 7, these shortages may prove critical as is illustrated below.

3.4.2 Labor Demand by Skill Impacts

As was indicated above, OLIM calculates the labor demand for eight skill categories. Three of these can be compared with the supply in the region that would occur if historical trends continued (see Table 3). Table 5 shows this comparison for the scenarios analyzed. Here, one can see that scenario 7 clearly becomes the most critical in terms of labor shortages. By 1990, all three categories exhibit potential shortages. Shortages also occur for electricians with scenarios 1, 2a, and 2b and for pipefitters for 2b. However, these are generally of much lower magnitude than the shortages for scenario 7.

The implications of these findings is that construction delays, increases in costs, inmigration of labor from other regions, or shortages in these skills in other industries might accompany the growth in electrical generating capacity forecast by scenario 7. It is not possible with available data and models to forecast which of these impacts might occur.

Overall, labor shortages by skill do not seem to be a major problem resulting from the power plant construction imbedded in the ORBES scenarios. The shortages that might occur would produce some short term problems but at present these do not appear extensive enough to warrant the development of ameliorative policies.

3.5 Employment Impacts of Coal Mining

The growth of electrical generating capacity with an emphasis on coal implies a large potential impact on the coal industry. The ORBES scenarios assume that ORBES region coal will be used almost exclusively in ORBES region power plants. This in turn implies that western coal will make no further inroads in the ORBES region and that policies concerning the burning of high sulfur coal, the use of scrubbers, etc. are given as one of the ways described by our scenarios.

Given these assumptions, we analyzed the employment impacts of siting the requisite number of new mines to meet ORBES coal demands as discussed in section 3.3.

We use the minimum, maximum, and average labor productivity values given above (3.3) to project the mining employment impacts. The scenario implications of this range for ORBES are illustrated by Table 6. Here, one can see that for the seven scenarios analyzed, scenario 2a

Table 5

Supply & Demand for Boilermakers, Electricians and Pipefitters
By Scenario, 1980 and 1990

		Boilermakers		Electricians		Pipefitters	
		1980	1990	1980	1990	1980	1990
Supply		2348	2583	2718	3617	3687	4262
Demand							
Scenario	1	2152	2579	2296	2435	3251	2726
	1A	2315	2563	2448	2420	3417	2710
	1B	2315	2425	2448	2293	3417	2569
	2	1980	2437	2042	2302	2732	2581
	2A	1976	3565	2131	3356	3071	3730
	2B	2179	2806	2310	3011	3234	4243
	3	2109	1619	2256	1539	3207	1749
	4	1179	1700	1304	1591	1948	1748
	5	2050	2039	2201	1931	3146	2177
	6	1171	1463	1327	1371	2056	1508
	7	2008	4225	2162	3945	3104	4302

Notes (1) Supply of skilled labor was estimated by a) calculating the percentage of workers in each skill category that were estimated to be working at power plant sites in 1975 (using OLIM and Generating Unit Inventory) and b) applying this proportion to projections of skilled labor in 1980 and 1990.

(2) Underlined numbers indicate potential skill shortage situations.

Table 6

Total ORBES Coal Mining Employment

Increase by Scenario

Scenario	Total ORBES Mining Employment Increase Low Estimate	Total ORBES Mining Employment Increase High Estimate	Increase as a % of 1970 Mining Employment Low Est. %	Increase as a % of 1970 Mining Employment High Est. %
1	109,146	701,228	76.5	491.8
2	107.159	688,456	75.2	482.8
2A	118,098	759,171	82.8	532.4
2B	107,423	690,159	75.3	484.0
3	91,983	590,962	64.5	414.4
4	70,105	450,401	49.2	315.9
5	98,159	630,639	68.8	442.3

Note: ORBES 1970 Mining Employment = 142,593. Only available data included miners other than coal miners.

Source: U.S. Bureau of the Census, 1970 Census of Population.

implies the largest increase in ORBES mining employment.* This is, of course, because of the coal based power generation assumption with a large proportion of the electrical energy exported from the region. Scenarios 1, 2, and 2b are all next in magnitude followed by scenarios 5, 3, and 4. The other conventional scenarios, 1, 2, and 2b all require a similar demand for coal and thus a similar amount of labor. Scenario 5 is next with a lower projected rate of economic growth. Scenario 3 is still lower with an emphasis on natural gas while scenario 4 requires much less coal with an alternative fuel emphasis.

The implications of these figures are first of all that under all of the conditions hypothesized by the ORBES scenarios, a substantial growth of the regions coal industry would occur. Differences across scenarios result from the rate of penetration of alternative fuels, lower economic growth, and/or lower energy growth.

Tables 7 - 13 show these potential employment impacts in greater detail. These tables show the number and percentage of ORBES counties that would fall in various growth categories using our minimum, maximum, and average potential labor productivity figures. Here, one can see that the higher coal mining growth scenarios, 1, 2, 2a, and 2b, will place fewer counties in a low employment growth situation and many counties in a situation where employment grows by 25% or more. This growth would in turn bring indirect economic benefits to the coal mining counties in terms of service availability, service employment, local tax receipts, etc. In some counties, an extreme rate of growth might also bring some "boom town" type of growth effects. Since very few studies have been performed which monitor the impacts of large growth rates on small communities, there is not general agreement on the amount of growth which might produce a "boom town". Gilmore and Duff (16, p. 6) that "a five percent growth rate is about all that a small community can absorb." Gilmore (17) cites 15% growth as the indicator of a boom-town situation. This figure is also used in the <u>Natural Coal Utilization Assessment</u> at Oak Ridge National Laboratory (18).

Looking back at Tables 7 - 13, we see that even under an average labor assumption, a large number of counties exhibit a mining labor force growth of 25% or more. For example, in scenario 1 (Table 7), only 9 of the 152 ORBES candidate mining counties have a projected average mining labor force growth of less than 25%. Translating this into a proportion of base year population, 31 counties would have a "boom-town" growth rate of >15%. This assumes that the newcomers bring no families. If one assumes the average family size to remain what it was according to the 1970 Census, 3.3 persons per household, then even more counties would surpass the >15% growth criterion. In general,

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*Since coal mines were not sited for scenario 7, the employment impacts could not be analyzed.

Table 7

Growth in Mining Employment in ORBES Coal Counties to the Year 2000, Scenario 1

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	9	5.9	5	3.3	7	4.6
10.0-24.9	13	8.6	3	2.0	2	1.3
25.0-49.9	34	22.4	1	.7	8	5.3
50.0-74.9	38	25.0	8	5.3	12	7.9
75.0-99.9	16	10.5	6	3.9	6	3.9
100.0-149.9	15	9.9	11	7.2	12	7.9
150.0-199.9	6	3.9	3	2.0	23	15.1
200 and over	21	13.8	115	75.7	82	54.0

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

Table 8

Growth in Mining Employment in ORBES
Coal Counties to the Year 2000, Scenario 2

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	9	5.9	6	3.9	7	4.6
10.0-24.9	16	10.5	3	2.0	2	1.3
25.0-49.9	32	21.1	1	.7	9	5.9
50.0-74.9	38	25.0	8	5.3	11	7.2
75.0-99.9	19	12.5	6	3.9	7	4.6
100.0-149.9	13	8.6	11	7.2	14	9.2
150.0-199.9	6	3.9	3	2.0	23	15.1
200 and over	19	12.5	114	75.0	79	52.0

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

Table 9

Growth in Mining Employment in ORBES
Coal Counties to the Year 2000, Scenario 2A

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	9	5.9	5	3.3	7	4.6
10.0-24.9	11	7.2	3	2.0	2	1.3
25.0-49.9	33	21.7	1	.7	8	5.3
50.0-74.9	36	23.7	7	4.6	9	5.9
75.0-99.9	20	13.2	5	3.3	9	5.9
100.0-149.9	13	8.6	13	8.6	7	4.6
150.0-199.9	5	3.3	3	2.0	22	14.5
200 and over	25	16.5	115	75.7	88	57.9

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

Table 10

Growth in Mining Employment in ORBES
Coal Counties to the Year 2000, Scenario 2B

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	9	5.9	5	3.3	7	4.6
10.0-24.9	15	9.9	3	2.0	2	1.3
25.0-49.9	33	21.7	2	1.3	9	5.9
50.0-74.9	38	25.0	8	5.3	11	7.2
75.0-99.9	20	13.2	6	3.9	7	4.6
100.0-149.9	12	7.9	11	7.2	14	9.2
150.0-199.9	5	3.3	3	2.0	14	9.2
200 and over	20	13.2	114	75.0	88	57.9

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

Table 11

Growth in Mining Employment in ORBES
Coal Counties to the Year 2000, Scenario 3

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	9	5.9	5	3.3	8	5.3
10.0-24.9	22	14.5	3	2.0	2	1.3
25.0-49.9	38	25.0	4	2.6	13	8.6
50.0-74.9	38	25.0	11	7.2	12	7.9
75.0-99.9	15	9.9	6	3.9	5	3.3
100.0-149.9	9	5.9	8	5.3	21	13.8
150.0-199.9	5	3.3	10	6.6	28	18.4
200 and over	16	10.5	105	69.1	63	41.5

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

Table 12

Growth in Mining Employment in ORBES
Coal Counties to the Year 2000, Scenario 4

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	12	7.9	7	4.6	8	5.3
10.0-24.9	32	21.1	2	1.3	6	3.9
25.0-49.9	57	37.5	8	5.3	17	11.2
50.0-74.9	20	13.2	13	8.6	8	5.3
75.0-99.9	6	3.9	6	3.9	16	10.5
100.0-149.9	9	5.9	13	8.6	33	21.7
150.0-199.9	4	2.6	22	14.5	22	14.5
200 and over	12	7.9	81	53.3	42	27.6

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

Table 13

Growth in Mining Employment in ORBES
Coal Counties to the Year 2000, Scenario 5

% Growth in Mining Employment (1)	Using Minimum Potential Labor		Using Maximum Potential Labor		Using Average Potential Labor	
	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties	Number of Counties	Percentage of Counties
0	0	0	0	0	0	0
0.1-9.9	9	5.9	5	3.3	8	5.3
10.0-24.9	20	13.2	3	2.0	1	.7
25.0-49.9	36	23.7	2	1.3	13	8.6
50.0-74.9	35	23.0	10	6.6	9	5.9
75.0-99.9	19	12.5	8	5.3	6	3.9
100.0-149.9	11	7.2	8	5.3	21	13.8
150.0-199.9	3	2.0	8	5.3	25	16.5
200 and over	19	12.5	108	71.1	69	45.4

(1) Calculated as projected year 2000 employment divided by 1976 employment x 100%.

for the ORBES coal counties, this turns out to be those counties with a coal mine employment growth of 200% or more. Thus, we will use this category as an indicator of potential boom-town conditions in ORBES coal counties.

Comparing scenarios, using average labor productivity, we see that scenarios 2A and 2B have the largest number of counties with growth over 200% (88) followed closely by scenarios 1 and 2. Scenarios 3 and 5 have fewer counties in this situation, 63 and 69 respectively, with the minimum number, 42 or 28% of the counties, coming in scenario 4. Even if we are extremely optimistic about productivity and use the minimum figures, over 10% of the counties might experience boom-town conditions under most scenarios.

Thus, some efforts toward ameliorating negative socioeconomic impacts are indicated. Obvious economic benefits occur with a coal emphasis but these benefits also bring some potential economic and social costs. These negative effects could be ameliorated to some degree through careful planning. Economic costs occur to coal mining with an alternative energy emphasis. As was discussed above, there are also labor benefits in other industries accruing to these technologies. However, these labor demands will have a different geographic distribution. Thus, the energy technology decisions affect not only the quantity of jobs created but their location as well.

These tradeoffs must also be weighed against the costs and benefits in terms of capital costs, the environment, human health, and etc. Some of these comparisons are made in the ORBES summary report (1).

4.0 Population Impacts

The population impacts of the ORBES scenarios must be viewed at the subregional rather than the regional scale. The reason for this is simply because the impacts of population growth are only really meaningful for smaller areas. Several thousand migrants mean nothing to a region the size of ORBES but are quite significant in a community with 10,000 persons.

Our population impact analysis looks first at general, internal migration trends associated with industrial, commercial, and coal mining developments. Then, we focus more specifically on direct impacts from power plants and coal mines by scenario and at a subregional level of analysis.

4.1 General Migration Trends

Implicitly, the ORBES scenarios assume that all industrial and commercial activities other than coal mining and power plant siting will remain in the same locations where they exist in the base year. This assumption is made primarily because of the difficulty of deriving a method to make such allocations. For the purpose of our migration analysis, we chose to examine the impacts of alternative future industrial and commercial location decisions on general internal migration trends.

In order to perform such an analysis, it was necessary to derive a model of internal migration in ORBES. This was accomplished using multiple linear regression techniques with data obtained from the Appalachian Regional Commission (ARC) and the U.S. Census. These data showed migration flows and other related conditions for 44 subregions approximating the boundaries of ORBES. A full discussion of the model and its derivation is given elsewhere (19). The remainder of this section reports the findings associated with the use of this migration model.

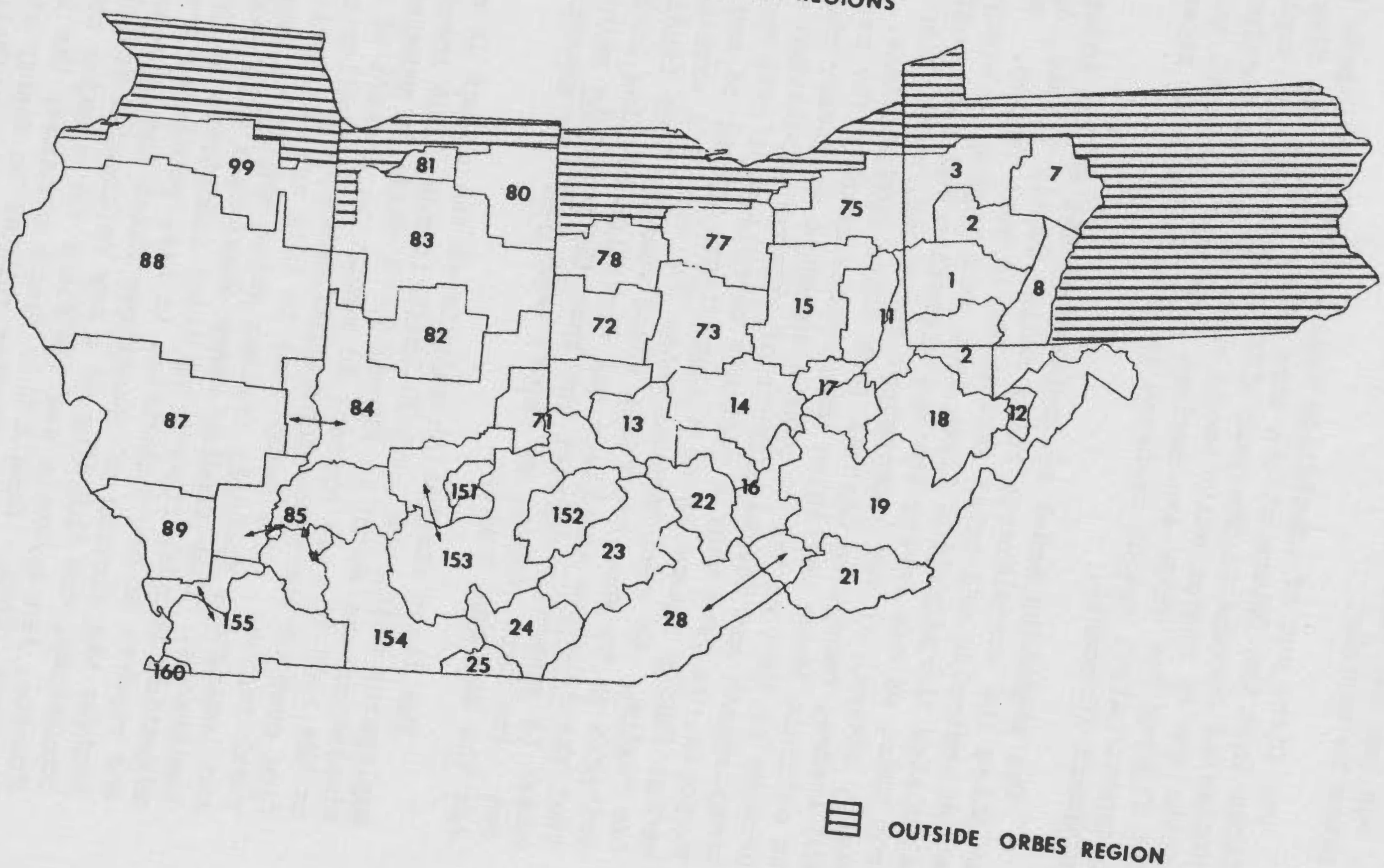
Figure 4 shows the migration regions for which data were available from the ARC. For the purposes of ORBES, these regions do not entirely make sense. However, data availability dictated that we use them and it appears that this geographic breakdown is sufficient for our purposes.

In order to simulate the migration impacts of continued trends in the various economic sectors, we first derived a set of "shift" factors showing changes in the proportion of ORBES region employment in each sector residing in each region. These shift factors reflect the historical trends in industrial and business location across the ORBES region. It may be, for example, that over the recent past, manufacturing has shifted its location from one part of the region to another. These shifts, in turn, mean a change in the location of employment, population, and pollution residuals. Using the shift

ORBES REGION

FIGURE 4

ARC MIGRATION REGIONS



factors to model future movements of industries implies that the same factors that have caused changes of location in the past will continue into the future. The shift factors for ORBES are shown in Table 14. Here, one can see that the economy of ORBES is indeed shifting from one place to another.

Our first set of simulation runs assumes that these trends continue into the future at the same rate. Thus, our five year rate is projected forward to the year 2000 to give the new employment distribution by region which would occur if trends continued. Our total figures for ORBES are derived from the I-O model and a set of employment/output ratios reported in (19). Table 15 shows these employment forecasts.

The migration model we implemented has as its independent variables the unemployment rate, median family income, distance between region centroids and total employment in each region. The model then calculates the migration flows from each region to every other region. From this, we can derive the net migration for each region. Unfortunately, several of the independent variables, particularly unemployment and income, cannot be derived from other ORBES models. Thus, we had to estimate these variables using other means. The result of this problem is that we had to make a somewhat arbitrary choice as to the unemployment and income effects of various population shifts. For our purposes, we felt that a region's unemployment rate would go down and median family income up as a significant number of new jobs came into the region. We used several rates for each and several decision criteria as to when the rates would change. Our findings indicate that the relative magnitude and direction of flow indicated by our model is generally correct but that the absolute values are probably not. For this reason, we report here only the general flow trends and not the absolute numbers.

The first simulation calculated the change in manufacturing employment using the 1965-70 shift trends. The results of this simulation are shown in Figure 5. A shift in manufacturing employment at the 1965-70 rate appears to result in a shift of population away from most of the major population areas to smaller urban areas and to rural regions. The exceptions to this are the Indianapolis, Indiana and Lexington, Kentucky regions which are still forecast to have net inmigrants. This finding seems consistent with recent urban-rural migration trends, reports of older industries in urban areas closing, and reports of new industries in less populated areas. Examples include the closing of Youngstown Sheet and Tube and U.S. Steel in Youngstown, the building of a new Volkswagen assembly plant in New Stanton, Pennsylvania and the plans for a major steel facility in Conneaut, Ohio. Should this trend continue, the implication for ORBES is that changes in population related to energy growth will be reinforced by changes in the location of manufacturing concerns. Thus, the combined impacts may in fact be larger than we may anticipate.

Table 14

PERCENT CHANGE IN EMPLOYMENT WITHIN EACH REGION FROM 1965 TO 1970 FOR VARIOUS SECTORS

REGION	MINING	CONSTRUCTION	MANUFACTURING	WHOLESALE	RETAIL	FINANCIAL	COMBINED WHOLESALE RETAIL FINANCIAL	SERVICES
1	0.1	-0.2	-1.3	-0.1	-0.1	-0.5	-0.7	-0.8
2	-0.2	0.8	-0.1	-0.0	-0.1	-0.2	-0.2	-0.0
3	-0.1	0.1	-0.2	-0.1	-0.1	-0.0	-0.2	0.0
7	-0.5	-0.1	0.1	-0.0	-0.1	-0.1	-0.2	-0.0
8	0.0	0.2	-0.1	-0.0	-0.1	-0.1	-0.2	-0.0
11	1.0	-1.2	-0.3	-0.2	-0.0	-0.1	-0.3	-0.1
12	-0.3	0.0	-0.0	-0.0	-0.0	0.0	-0.0	-0.0
13	0.1	0.1	0.0	-0.0	0.0	0.0	0.1	0.0
14	-0.3	0.0	0.1	0.0	-0.0	0.1	0.0	0.0
15	0.7	0.1	0.1	-0.0	-0.1	0.1	0.0	0.0
16	-0.3	-0.1	-0.1	-0.2	-0.1	-0.1	-0.4	0.0
17	-0.1	0.3	0.0	0.0	-0.1	0.0	-0.0	0.0
18	-0.8	0.3	-0.0	-0.1	-0.1	-0.0	-0.3	-0.1
19	-0.1	0.8	-0.3	0.0	-0.2	-0.0	-0.1	-0.1
21	2.6	0.0	0.0	-0.1	-0.1	-0.0	-0.2	-0.0
22	-0.1	-0.0	0.0	0.1	-0.0	0.0	0.1	0.1
23	-0.1	-0.1	0.1	0.1	0.1	0.0	0.1	-0.0
24	-0.0	0.0	0.1	-0.0	0.0	0.0	0.0	-0.0
25	-0.0	0.0	-0.0	0.0	-0.0	0.0	0.0	0.0
28	-0.2	-0.0	0.1	0.1	0.0	0.0	0.1	0.2
70	-0.0	0.0	0.1	0.1	0.0	0.0	0.1	-0.0
71	0.0	0.6	0.2	0.7	-0.0	-0.2	0.5	0.2
72	0.1	-0.8	0.3	-0.3	0.4	0.2	0.3	0.1
73	-0.1	-0.2	0.1	-0.0	0.6	0.6	1.2	0.5
75	-0.2	-0.1	-0.1	0.1	0.2	0.1	0.4	-0.2
77	-0.0	0.0	0.1	-0.0	0.1	-0.0	0.0	-0.0
78	-0.0	0.2	0.2	0.1	-0.1	-0.0	-0.0	-0.0
80	0.1	0.1	0.2	0.0	0.1	0.1	0.2	0.1
81	-0.0	0.0	0.0	0.0	-0.0	0.0	0.0	-0.0
82	0.1	0.4	-0.1	0.4	0.3	0.1	0.7	0.2
83	-0.0	-0.3	-0.3	-0.3	-0.1	-0.2	-0.6	-0.1
84	-0.1	0.5	-0.1	-0.1	-0.1	0.0	-0.1	0.1
85	-2.1	-0.7	0.1	-0.0	-0.1	-0.1	-0.2	0.1
87	0.8	-0.5	-0.2	-0.3	-0.2	-0.1	-0.6	0.3
88	-0.3	-0.3	-0.0	-0.3	-0.3	0.1	-0.6	-0.1
89	0.1	-0.1	0.1	-0.0	0.0	0.0	0.0	-0.0
99	-0.1	0.5	-0.0	-0.0	0.1	0.0	0.1	0.0
151	0.0	-0.8	0.7	0.1	0.2	0.0	0.3	-0.1
152	0.0	-0.0	0.3	0.1	-0.0	0.1	0.2	-0.1
153	0.0	0.1	0.2	0.1	0.0	0.0	0.2	0.0
154	0.6	0.3	0.2	0.2	0.0	0.1	0.3	0.1
155	-0.0	-0.1	0.1	0.1	-0.1	0.0	-0.0	0.1
160	0.0	-0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0

Table 15

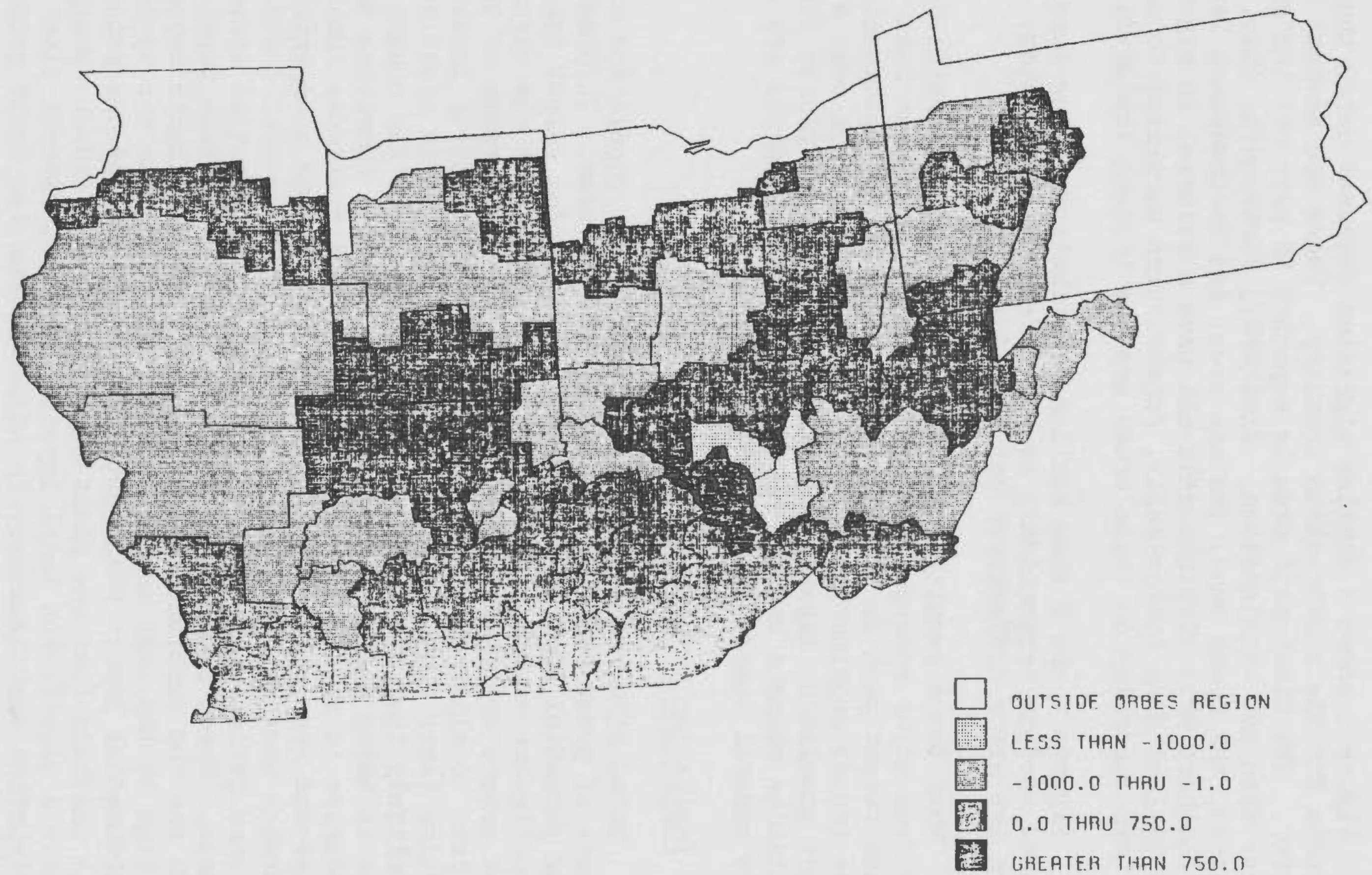
1995 Estimated Employment for ORBES Region

REGION	CONSTRUCTION	MANUFACTURING	UTILITIES	WHOLESALE	RETAIL	FINANCIAL	SERVICES
1	93390	624527	83389	102543	264100	88530	264879
2	18060	83143	13857	9329	41595	7684	26691
3	8534	92022	9868	6456	28751	7033	25263
7	3516	42812	5036	3200	11193	1935	9389
8	6445	53058	8154	5746	20968	4255	19742
11	10421	98303	11864	8547	36425	8447	29558
12	0	855	445	123	470	78	162
13	4213	9611	2614	1198	10423	1958	4000
14	4182	31994	5122	3192	17877	3591	10884
15	6563	70829	8125	6600	24695	5111	17830
16	10980	57406	8712	8362	27048	7153	19359
17	7480	39464	5068	4662	14187	3203	11689
18	7903	35384	9075	5184	18174	3935	16317
19	18029	52595	18046	14542	36564	11308	31878
21	4021	10371	4272	5567	15967	4137	13695
22	5276	24378	3300	2916	9039	2486	8166
23	2423	19634	2651	2852	13111	2002	7810
24	1539	9937	1149	1153	5095	1070	2408
25	249	1346	107	294	1246	182	712
28	7359	15999	5746	7047	25721	5189	22277
70	1677	13240	881	1404	6208	2184	4335
71	60742	442392	57155	78867	171340	64813	162504
72	31215	331225	26214	32172	119741	27590	100455
73	43317	258043	37653	45858	146701	60201	126671
75	56027	581780	52663	55179	185728	42476	143153
77	10239	126807	10221	8039	37955	8294	26218
78	10380	86134	5906	9438	28450	6845	19457
80	16505	160474	15876	23297	56483	18439	39025
81	1028	8698	1015	914	4410	828	2840
82	50638	285459	41484	65601	135093	63920	107988
83	22881	297341	17830	18442	98882	22574	54039
84	23382	174186	16465	17903	74602	16499	41853
85	17280	112861	14376	15670	49123	11270	40823
87	23901	145628	21310	15991	72911	19039	59110
88	55373	325165	46411	55078	182384	59661	148394
89	4735	30186	4852	3614	17901	3933	10938
99	13638	85033	10149	10037	44345	7331	26797
151	35543	260014	30721	42943	96058	36108	88381
152	16622	63056	8968	10805	34127	11932	32388
153	9320	45571	8205	7368	28393	5693	15961
154	11427	60292	5777	7022	26898	5981	16929
155	8440	44869	6598	8510	23838	6692	17307
160	151	1617	130	726	1146	211	585

FIGURE 5

ORBES REGION

SCENARIO NO. 1 : MANUFACTURING SHIFT



However, these impacts may be more easily ameliorated than otherwise might be the case because growth in some areas will be more stable.

Figure 6 shows a similar migration forecast using the same criteria for the construction industry. There are several differences however. The Cincinnati area is expected to have net inmigration rather than net outmigration. Similarly, Portsmouth, Ohio, Central Illinois, the South Bend, Indiana area, and Northwestern Pennsylvania, and Southern West Virginia will all have a reversal in migration. This implies that historically, construction unrelated to manufacturing has been occurring in these areas and has induced inmigration.

Figures 7 and 8 show similar distributions using services and finance sectors respectively as the forecasting variables. Here again, there are minor differences but no major changes.

What these results indicate is that a general shift of population away from major metropolitan areas to rural areas has been occurring in the recent past in conjunction with shifts in employment. Should these trends continue into the future, they may have some effect on the direct population impacts of coal mines and power plants since the population changes brought about by these developments are additive to these general trends discussed above.

4.2 Population Impacts of Power Plants

Using OLIM, we were able to simulate the population migration impacts of power plant construction and operation. In order to assess these potential impacts, we summarized the model output for six groups of contiguous counties where plants were sited for the various scenarios. These groups are illustrated in Figure 9. The purpose of this aggregation is first to allow consideration of the many potential locations of the existing labor supply and of areas where inmigrants might settle. It is unlikely that all labor will either come from the county where the plant is being built or settle in that county. Commuting across county boundaries is relatively easy as long as the distances remain reasonable. The second reason for looking at these six groups of counties is to determine whether power plant construction in several counties over the same period would create any significant potential synergistic impacts. Here, synergistic is being defined as those population impacts which are the combination of impacts of several plants being built at one time in the same area. This is in contrast to the typical Environmental Impact Statement which only looks at one project at a time. It is unlikely that one plant taken alone will induce enough inmigrants to have a significant local impact. However, several plants under construction simultaneously in adjacent counties could produce more significant impacts.

Our results indicate that the population impacts of power plant construction and operation are generally not significant although they

FIGURE 6

ORBES REGION

SCENARIO NO. 1 : CONSTRUCTION SHIFT

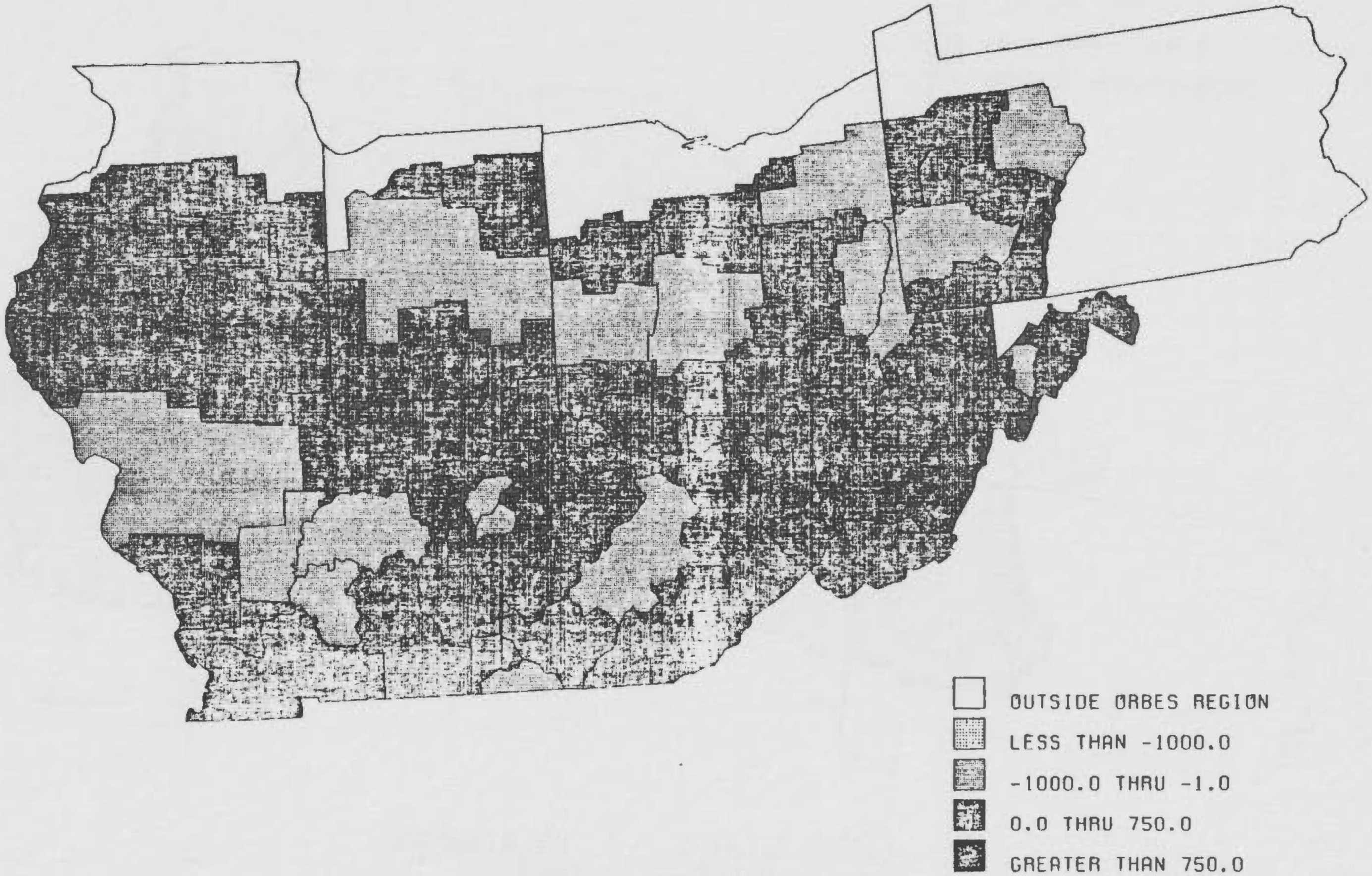


FIGURE 7

ORBES REGION

SCENARIO NO. 1 : SERVICE SHIFT

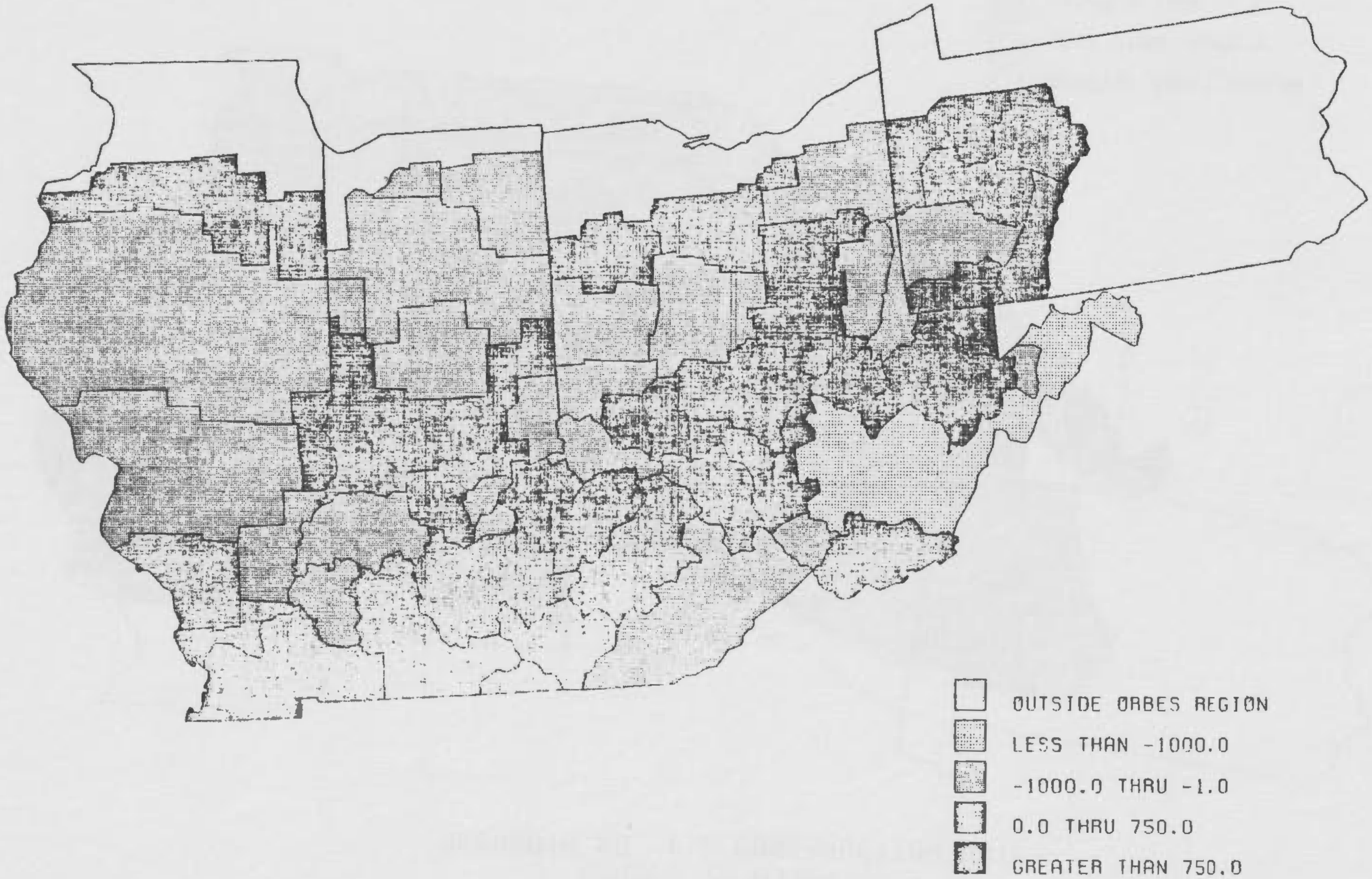


FIGURE 8

ORBES REGION

SCENARIO NO. 1 : FINANCIAL SHIFT

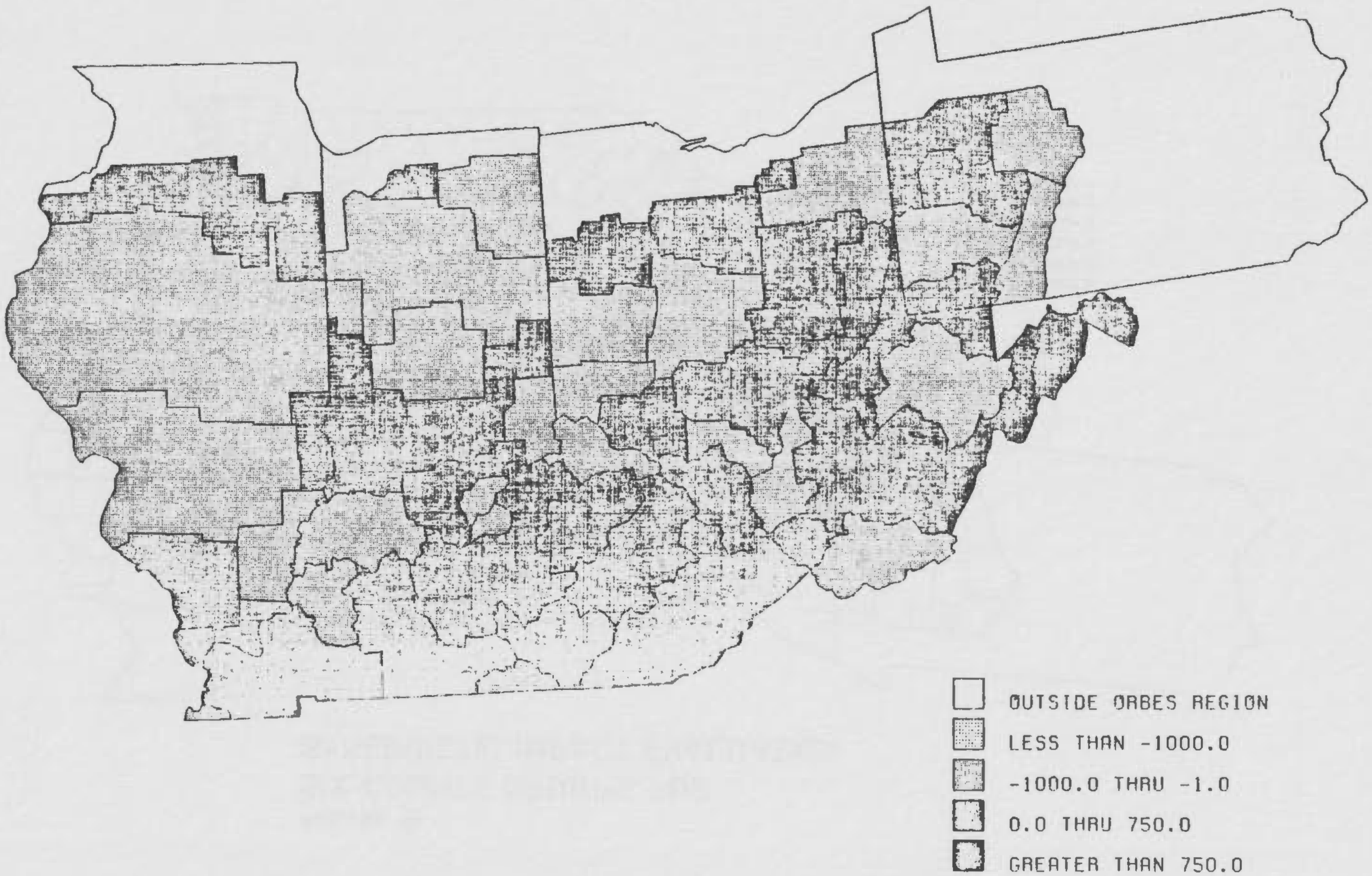
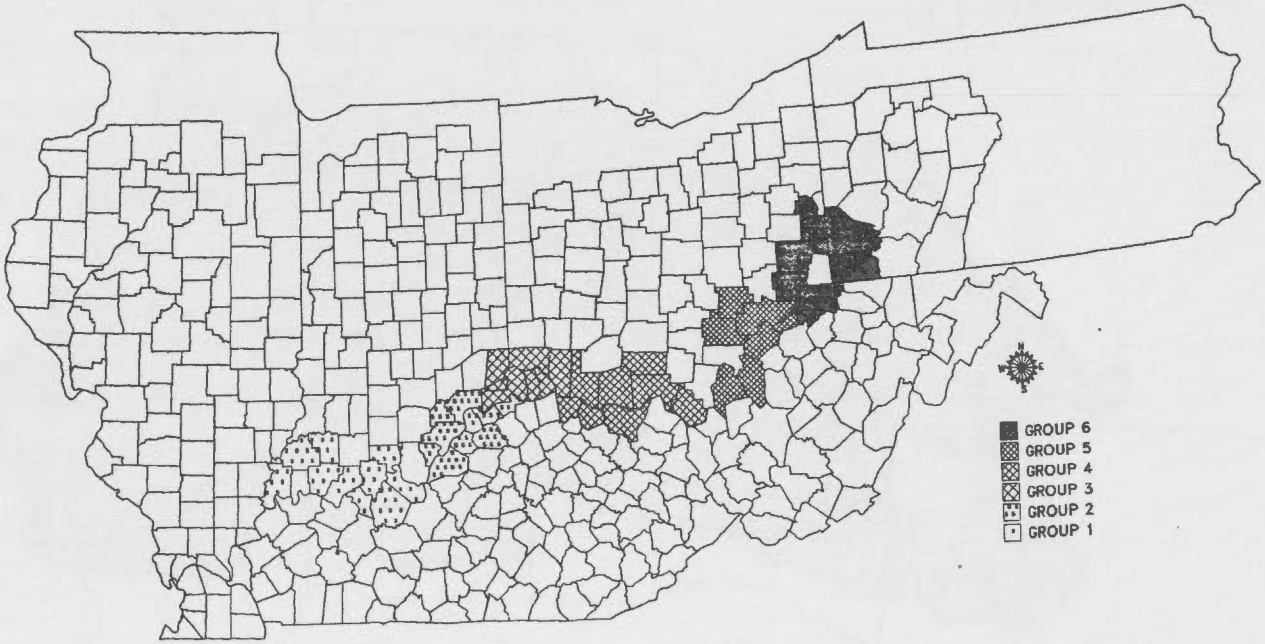


FIGURE 9
SIX COUNTY GROUPS FOR SYNERGISTIC IMPACT EVALUATION



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could become so if a large number of workers chose to settle in the same communities. Table 1 shows that for each scenario, inmigrants induced by power plant construction and operation are always less than 5% of the county group 1970 population.[1] Since the county group population during the impact period of 1980-2000 will be even greater, the percentages would actually be smaller.[2]

Looking at Table 16, one can see that the largest population impacts occur with scenarios 1A and 1B where a large number of plants end up sited in county groups 1 and 4. Still, these remain less than 5% of the 1970 population. It is interesting to note that groups 1 and 4 almost always end up with a larger concentration of plants in the shortest time period and therefore also the greatest migration impacts.

Another way of viewing the population impacts is by looking at the number of construction and operation workers as a percentage of the 1970 county group labor force. Here, the proportions are greater going up to a maximum of 15.4% for group 4 in scenarios 1A and 1B. This illustrates the economic benefits as measured by employment and related income growth. Here again groups 1 and 4 are most heavily impacted.

4.3 Population Impacts of Coal Mining

The population impacts of new coal mining employment demands can be viewed in several ways. First, we may look at the sub-regional impacts of coal mining employment changes on migration. Figures 10, 11, and 12 show the induced migration from three ORBES scenarios where the amount and distribution of coal mining employment changes are significant. Using the migration model discussed above (see ref. 19 , we simulated the impacts of mining employment changes assuming all other sectors would remain relatively unchanged. An increase in mining employment over 1,000 persons was simulated as reducing unemployment and increasing local income.

As one can see by Figures 10-12, the migration model is not sensitive to these changes in coal mining employment. This is to say that there are only minor differences in the predicted net migration across scenarios. The major reason for this is that the model regions tend to be quite large, many encompassing several coal mining counties. Even though the overall coal demand varies significantly from scenario to scenario, the subregional changes tend to be equal relative to the

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[1]Recall that Gilmore and Duff (17) cite this as the amount of change a small community can readily absorb.

[2]Please see the Appendices for an explanation of how the calculations in Table 16 were made.

Table 16

Maximum Number of Construction Workers and Associated Population Increases, 1975 - 2000 By Scenario & Group

Scenario	Group	Maximum Workers	Workers as a % of '70 Labor Force	Maximum Inmigrants	Inmigrants Plus Families as % of '70 Population
1	1	3735	11.9	2196	2.5
	2	4248	1.3	3677	.4
	3	2356	0.6	2911	.3
	4	4304	12.7	3197	3.2
	5	3604	10.0	1696	1.6
	6	2157	3.9	1456	.9
1A	1	3498	9.6	3755	3.6
	2	3904	1.3	2209	0.3
	3	2468	0.6	2421	0.2
	4	3780	15.4	2707	3.6
	5	3721	9.2	2488	2.1
	6	2157	3.9	5524	1.0

Table 16 (Cont'd)

Scenario	Group	Maximum Workers	Workers as a % of '70 Labor Force	Maximum Inmigrants	Inmigrants Plus Families as % of '70 Population
1B	1	3498	9.6	4734	4.6
	2	3904	1.3	2209	0.3
	3	2468	0.6	2911	0.3
	4	3780	15.4	3686	4.9
	5	4077	10.1	3956	3.3
	6	1963	3.8	1946	1.3
2	1	5416	9.0	3985	2.2
	2	4018	1.2	3197	0.4
	3	4288	0.9	3564	0.3
	4	3081	4.0	3859	1.6
	5	3445	3.7	3067	1.2
	6	3072	1.5	3454	0.6

Table 16 (Cont'd)

Scenario	Group	Maximum Workers	Workers as a % of '70 Labor Force	Maximum Inmigrants	Inmigrants Plus Families as % of '70 Population
2A	1	5416	10.2	4027	2.5
	2	4159	1.3	3124	0.4
	3	7239	1.6	4122	0.4
	4	4468	5.8	5645	2.4
	5	3259	3.5	3661	1.4
	6	5154	2.6	5524	1.0
2B	1	5416	9.0	4036	2.3
	2	3635	1.1	3051	0.4
	3	4472	1.0	4198	0.4
	4	4611	5.9	3694	1.6
	5	3602	3.9	3172	1.2
	6	5157	2.6	4068	0.7

Table 16 (Cont'd)

Scenario	Group	Maximum Workers	Workers as a % of '70 Labor Force	Maximum Inmigrants	Inmigrants Plus Families as % of '70 Population
3	1	2403	4.6	2304	1.5
	2	3635	1.2	2646	0.4
	3	4438	1.0	3388	0.3
	4	3153	6.7	2952	2.1
	5	3008	4.9	2437	1.4
	6	2915	2.0	2475	0.6
4	1	2648	8.5	1588	1.8
	2	3463	1.2	2498	0.3
	3	3458	0.8	2898	0.3
	4	2281	4.8	2218	1.6
	5	3008	4.9	2245	1.3
	6	2075	1.6	1111	0.3

Table 16 (Cont'd)

Scenario	Group	Maximum Workers	Workers as a % of '70 Labor Force	Maximum Inmigrants	Inmigrants Plus Families as % of '70 Population
5	1	4652	7.7	3265	1.8
	2	3554	1.2	2437	0.3
	3	4251	1.0	3388	0.3
	4	2997	5.7	3197	2.0
	5	3602	3.9	2927	1.1
	6	3259	1.8	3069	0.6
6	1	2648	8.1	1583	1.8
	2	2544	0.9	1433	0.2
	3	2985	0.7	2408	0.2
	4	2281	8.1	1973	2.4
	5	2728	4.5	1703	1.0
	6	1127	0.9	621	0.2
7	1	5813	9.4	4525	2.6
	2	4764	1.5	3380	0.4
	3	7654	1.6	3877	0.3
	4	4207	5.4	3931	1.7
	5	3930	4.2	3172	1.2
	6	5122	2.5	3803	0.7

FIGURE 10

ORBES REGION

SCENARIO NO. 1 : NET MIGRATION

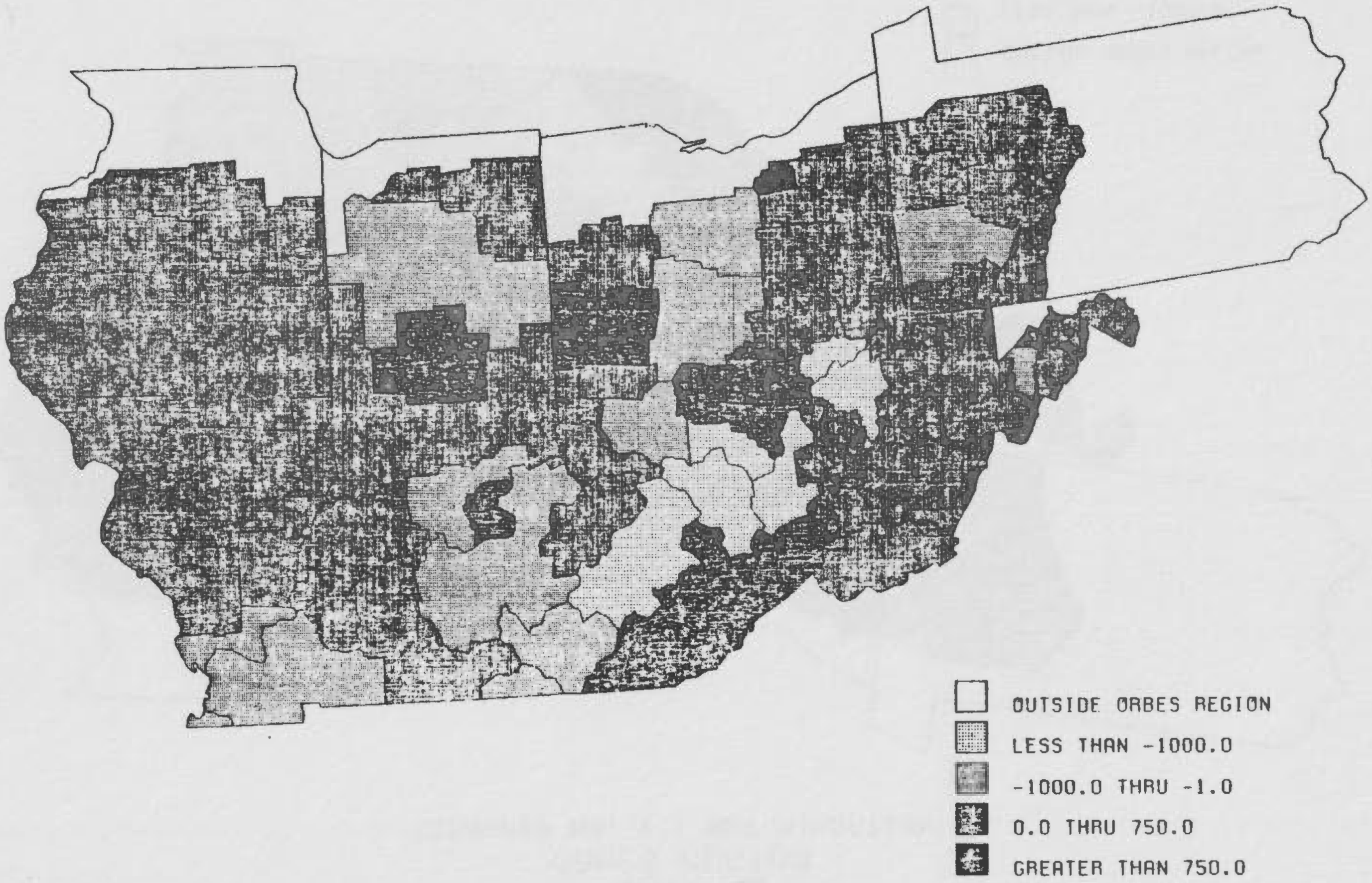


FIGURE 11

ORBES REGION

SCENARIO NO. 4 : NET MIGRATION

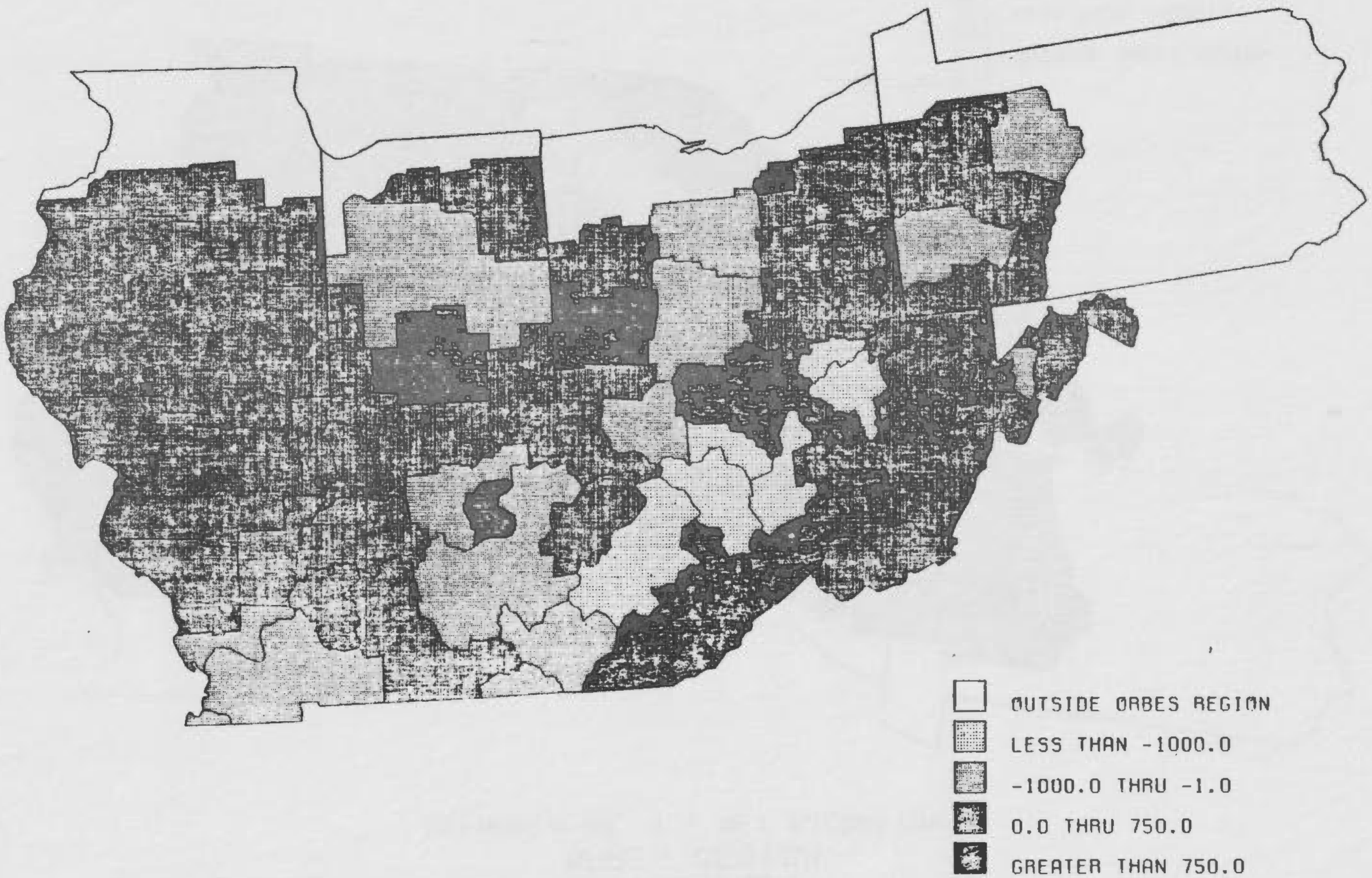
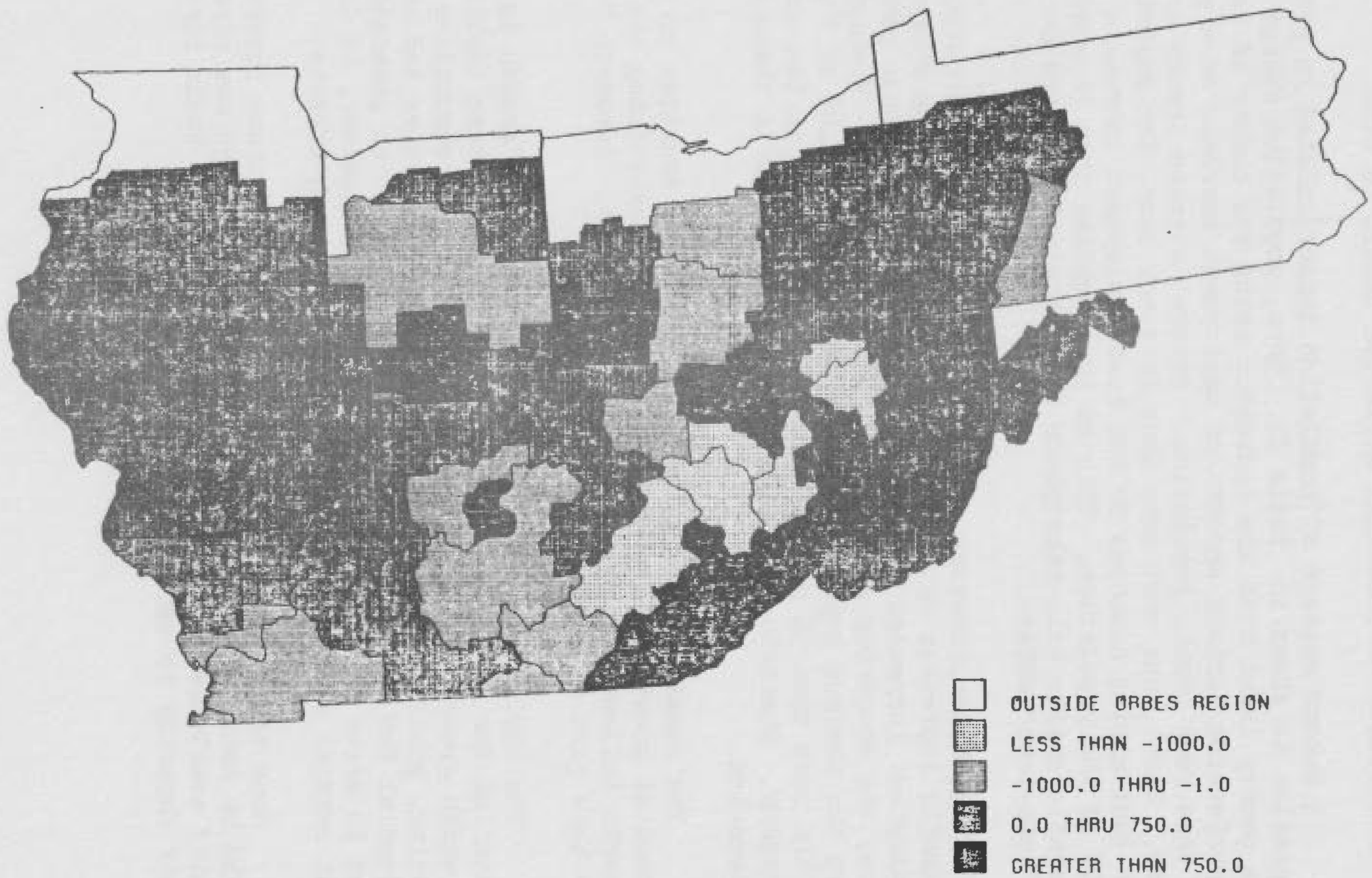


FIGURE 12

ORBES REGION

SCENARIO NO. 5 : NET MIGRATION



change criteria. The employment change criterion would have to be put at over 10,000 or more new employees in order to significantly effect model results. We feel that is artificially high and that instead, other measures of potential migration should be used.

A second measure of population impact related to potential migration is shown in Table 17. Here, population change is viewed at the county level with the indicator being the number of counties experiencing various amounts of employment increase as a percentage of base year county population. Several notable trends are exhibited here. First, one must note that in every case, the majority of the 152 coal mining counties do not have employment increases greater than 5.0% of the population. This in turn implies that in most counties no dramatic shifts will take place that strain local services or create a "boom-town" effect.

There are, however, always a large number of counties in which dramatic increases do occur. These are the counties where the employment increases are 5% or 15% or more of the base year population. Here, the scenarios also exhibit some differences. Scenarios 1 and 2A have the maximum population impact with almost 43.4% of the counties in the more than 5% category, and 21.0 and 22.4% in the more than 15% category. Scenario 2 follows with 41.4 and 21.0 in these same categories.

The remaining scenarios have many fewer counties in these high potential growth categories with scenario 4 exhibiting the smallest impacts followed by scenario 3 and scenario 5. Scenario 7 was not run for this part of our analysis.

The implications of these large amounts of growth is a greater potential for boom-town types of impacts. This term implies a situation in which growth outstrips the ability of local communities to provide housing, public services, schools, health facilities and etc. The potential for these impacts in the ORBES region is generally much lower than in areas in the Western United States. However, it is apparent that several areas in ORBES may experience such impacts.

Some effort should be made to ameliorate these impacts. This could be done by anticipating the opening of large new mines and making nomies available to local communities to upgrade their services before their capacity is exceeded.

Table 17

Average Potential Mining Employments Increase as a Percentage of 1970 Population, ORBES Coal Counties

Percent Increase	Scenario 1 Number of Counties	Scenario 1 % Counties	Scenario 2 Number of Counties	Scenario 2 % Counties	Scenario 2A Number of Counties	Scenario 2A % Counties
0.00-4.99	86	56.6	89	58.6	86	56.6
5.00-9.99	20	13.2	17	11.2	17	11.2
10.00-14.99	14	9.2	14	9.2	15	9.9
15.00-19.99	9	5.9	9	5.9	8	5.3
20.00 or greater	23	15.1	23	15.1	26	17.1
Summary						
Increases 5.0 or greater	66	43.4	63	41.4	66	43.4
Increases 15.0 or greater	31	21.0	31	21.0	34	22.4

Table 17
(continued)

Percent Increase	Scenario 3 Number of Counties	Scenario 3 % Counties	Scenario 4 Number of Counties	Scenario 4 % Counties	Scenario 5 Number of Counties	Scenario 5 % Counties
0.00-4.99	93	61.2	100	65.8	92	60.5
5.00-9.99	21	13.8	20	13.2	19	12.5
10.00-14.99	10	6.6	11	7.2	11	7.2
15.00-19.99	10	6.6	10	6.6	10	6.6
20.00 or greater	18	11.8	11	7.2	20	13.2
Summary						
Increases 5.0 or greater	59	38.8	52	34.2	60	39.5
Increases 15.0 or greater	28	18.4	21	13.8	30	19.7

5.0 Impacts on Public Services

5.1 Water and Sewer Systems

With the inmigration of power plant workers and the associated increases in the housing stock are new demands on public services. Two of the most important public services for population expansion are the public water and sewer systems. Both systems have physical capacities which limit the amount of water or sewerage they can handle on any given day. When these public systems are available, several alternatives exist, each with its own drawbacks.

Many counties in the ORBES region have never had public sewer systems. These county residents rely on septic tanks, cesspools or privies for sewage disposal. Depending on soil characteristics, depth to water table and the amount of waste disposed by these methods, water quality can be severely affected. The capital investment necessary to install or expand a public sewer system is often beyond the budget and the taxing capacity of small rural counties. If an influx of population does occur in a county with an insufficient public sewer system the area must be able to either absorb the effects of alternative sewer systems or the effects of public outlay for new services in the form of an increased tax burden.

Public water systems are much more prevalent in ORBES than public sewer systems. Alternatives to public water systems are private wells and cisterns. When public water systems are at or near capacity the amount and pressure of water available to all consumers may be decreased. One effect of low supply is the disincentive that it provides for businesses and industries that may have located in the county. If excess capacity is available it remains the resident's responsibility (in most cases) to pay the costs of new hook-up lines to their residence. The installation or expansion of public water systems would require capital investments by county or local jurisdictions. Funding would come from the purchase of bonds with the help of a tax levy. The burden for the supply of services to meet new demands would fall on both existing and new residents.

From the ORBES Labor Impact Model (see Appendix A for a description of model inputs and outputs) the number of inmigrants for each county, for each scenario is derived by year of the scenario. Given information on water and sewer system capacities and use we should be able to make some statements regarding county level impacts for these public services. However, this information is not available for all counties, nor is it in a comparable or consistent form. In fact, data on local public sewer systems is almost non-existent. For the Site-Specific Study (20) we attempted to put together data on water system capacities and average daily use for the seven case study counties. Even this small data collection task could not be completed. However, some data were available for Jasper County, Illinois (21), Jefferson

County, Indiana (22), Adams County, Ohio (23), Beaver County, Pennsylvania (24) and Mason County, West Virginia (25). We had planned to use the information on the case study counties to make some generalizations about the remaining ORBES counties (using the classification techniques described in Appendix B of this report). County level data on water capacity and average daily use revealed considerable excess capacity for all the case study counties. This seemed unlikely until we realized there were three problems with this approach: 1) water capacity was either undefined or inconsistently defined (i.e. water treatment plant capacity, pumping station capacity or total ground water dependable pumpage) 2) average daily use is not the appropriate variable, rather the peak or 'maximum daily use' should be used, 3) using county level data does not reveal potential demand-supply problems for local water systems within the county. The first two of these problems could not be resolved for most of the case study counties. We were able to look at individual local water systems within several of the counties. At that level, two systems appeared to be at or near 'capacity.' For example, the New Haven-Hartford-Mason service area in Mason County was reported as having a daily excess of 20,000 gallons per day (25): Using the 'rule of thumb' estimate of 100 gallons of water required per person per day this water system could handle only 200 additional residents. The Cresville Heights water system in Beaver County is reported as serving 10,500 users with .85 mgd capacity. These figures indicate that, at capacity, only 81 gallons per day is available per person -- well below the 'rule of thumb' as mentioned above. An influx of new users would further reduce the amount of water available per person for all users in this local service area.

The most complete data source on water systems that was available to us was that produced by the Ohio Department of Natural Resources (23). From this report we gathered data for all Ohio counties on maximum daily use and plant system capacity. Again, we estimated excess capacity. We hypothesized that there would be a relationship between excess capacity and population size of the county. That is, we expected small counties to have less excess capacity than more populated counties. We could then use the relationship defined for Ohio counties in generalizing to all ORBES counties. Using 1975 population data (26) for this correlation analysis we were unable to define a significant relationship between population size and excess water capacity. At the county level there was no evidence of any lack of capacity. Locally, for individual systems within counties, potential problem areas were evident.

In general, what we can say is that both sewer and water impacts will be very localized and difficult to predict. In particular we need to know the exact localities that will be affected by the growth of new housing, the system excess capacities and the plans that may have already been made for installation or expansion of these systems. The impacts of new public service demands such as public water and sewer services can take the following forms:

1) installment or expansion of facilities with increased sewer or water charges

2) expansion of septic tanks, cesspools and privies with associated potential decrease in water quality

3) decreased water available to all users -- leading to decreased water pressure, disincentives for new business or industry to locate there

4) little or no change in water quantity or quality because of excess capacity or because of the magnitude of new service demands is small

Clearly, we cannot predict which of these impacts may occur in the future given the lack of data and the uncertainty of future population movements. This section should point out though that any major shifts in population could result in several environmental and economic problems. It does not appear that power plants require enough labor to be the primary driving force behind such impacts. However, new coal mines with large labor demands may indeed result in severe service shortages and their requisite problems. Only careful planning for such expansion can serve to avoid or at least mitigate some of these problems.

5.2 Other Public Services

There are several other local public services that can be adversely impacted by energy development projects. These include schools, health services, social services, police and fire services, garbage collection, and transportation services. As was the case with sewer and water, the nature and extent of these impacts depends upon existing level of service, excess system capacity, etc. These impacts, if they occur will be local rather than regional in scope. Their quantitative definition was not undertaken for the same reasons as those outlined above for sewer and water.

One additional local impact associated with these which may have regional significance is the fiscal impact of service demands. Our site specific report (20) illustrated that the timing and distribution of revenues from power plant siting may not be congruent with the costs and locations of service demands. In particular, most local assessment practices will yield a minimal amount of community property tax income at the time when the peak employment and related public service demands occur. In addition, commuting of workers across municipal boundaries will produce service demands in jurisdictions different from those where taxes on the energy project are collected. The result may be that local impacts will be exacerbated. There may be several ways of ameliorating this problem some of which involve the sharing of tax base and of service costs across larger geographic areas. The policies which may be implemented to ameliorate these impacts are discussed in the final chapter of this report.

6.0 Policy Implications

Given the nature and extent of potential socioeconomic impacts, it is important to conclude this report with a review of some of the policies that may avoid or ameliorate some of those impacts. Before discussing these policies it is important to note that the socioeconomic impacts although important, may not be equal in weight to environmental, national security, or other considerations associated with energy development and its impacts. The relative weights of the various issues must be left for decision in the political arena. What we discuss below are those policies that might be followed to ameliorate socioeconomic impact if the actual, future energy, environmental and/or economic conditions approach those of our scenarios and thus would lead to those impacts discussed in previous chapters.

6.1 Siting Policies

In our opinion, siting will continue to be predominantly influenced by physical, environmental, and cost constraints. For this reason, we do not feel that a siting policy based on the avoidance of socioeconomic impacts is entirely practical. However, it may well be that choices will arise among sites that are essentially equal in physical, environmental, and cost terms but quite different in terms of potential socioeconomic impacts. Under these circumstances it would be feasible to choose those sites for energy facilities where adverse socioeconomic impacts are minimized and positive impacts are maximized.

Implementation of this policy could take many forms:

1) Leaving siting decisions in private hands (i.e., private utilities) but giving a stronger emphasis to socioeconomic considerations in the site review, EIS, and related processes.

2) Forming some type of oversight agency for siting which utilized socioeconomic criteria (as well as others) in making siting decisions.

Various combinations of these approaches might also be undertaken. Discussion of the legal and institutional aspects involved in such siting is beyond the scope of this report. Readers are referred to the ORBES Phase II Final Report for other discussion on this matter (1).

6.2 Ameliorative Policies

Given that a siting decision has already been made and that there may be some adverse socioeconomic impacts, there are an additional set of ameliorative policies which might be implemented. Although a few could be implemented at the federal or regional level, most would take state and/or local actions. These policies are discussed in turn below.

6.2.1 Service Subsidies

One of the major ways the state and federal government could help to offset the impacts of energy development would be by giving direct aid to those areas which are most impacted by sudden growth. Several programs of this nature are already in existence. For example, the U.S. Department of Energy provides monies to energy "boom town" areas to help pay for the costs of increased public services demanded over a short period of time. The Department of Housing and Urban Development has also given special housing assistance in such cases.

Within ORBES, however, there will probably be few such "boom towns". A more general and persistent problem will arise in communities where there will be short term, significant impacts on public service demand, low tax revenues while the project is under construction, and no available forms of assistance. Under these circumstances, several types of programs could be used to aid communities at the time of peak service demand. These might include short term, low interest loans to help pay for service costs, or direct subsidies. Subsidies could be made either through new programs or by giving higher priorities for assistance under existing programs to communities that are impacted.

Alternatively, a policy could be formulated that forced the utility company and thus indirectly its customers, to pay more of the front end, indirect costs of energy facility development. Such a program would probably be less popular from the viewpoint of pushing up the cost of utility bills which are already increasing apace.

6.2.2 Tax Policies

Alternatives to helping offset the local impacts of energy development revolve around tax policies. Here, both the timing and distribution of tax receipts are critical. In the long run, local tax receipts from a power plant greatly exceed the costs for public services. However, during construction this is not the case. One tax policy that could ameliorate this problem is one of prepayment of taxes by utilities to pay the cost for services during the peak construction period. This has been tried in one or two unique cases but has not been widely implemented.

Similarly, the tax receipts do not always come to all the communities being impacted simply because of the boundaries of taxing districts. One method of circumventing this problem is that of tax base sharing. This policy has been implemented in Minnesota with respect to all property taxes. Essentially, the program involves redistributing tax receipts not only to the host community for facilities but also to surrounding communities that are impacted in terms of schools, sewer, water, police, and other public services. This provides a more equitable spatial distribution of costs and benefits and helps to ameliorate many of the social impacts of large scale developments such as energy facilities.

6.2.3 Land Use and Related Local Policies

The local impacts of energy development are often exacerbated because of their occurrence in rural communities with little or no control over land use and building codes. This means that new development can often locate anywhere in the community regardless of its impacts on service costs, the conflicts it may produce with existing uses, and thus its impacts on local health and welfare. Under these conditions, communities could choose to institute some form of land use controls to help prevent such impacts. However, the zoning, subdivision, building, and other codes that would need to be put into place require some degree of experience and knowledge as well as a significant administrative cost. Most rural communities find out too late that such policies would be of benefit to them. Alternatively, they put them in place but are unable to provide for adequate enforcement resulting in the same levels of community impacts.

For these reasons, it is important to provide technical assistance, monies to offset administrative costs, and other incentives to help local communities deal with these problems. The only alternatives to such a policy would be to maintain the status quo or have some other level of government undertake the responsibility for land use controls. The latter is probably politically infeasible while the former fails to deal with the socioeconomic impacts of land development.

6.2.4 Administrative Actions

Aside from the possible implementation of new policies and programs, much can be done under current operating procedures to prevent and ameliorate adverse socioeconomic impacts associated with energy development. These actions really involve tighter control on current regulatory and administrative procedures affecting the socioeconomic impacts.

The first of these administrative actions involves a more careful and more timely property tax assessment of energy facilities. Assessment procedures and practices vary widely across the region. In some cases, local assessors do not revalue energy facility sites until the third or fourth year of construction. This practice means that the local community foregoes the extra income it might otherwise receive.

A similar problem occurs with regard to the amount of the assessment. Our efforts to obtain data on the tax burden associated with typical power plants in ORBES revealed that most local assessors do not know, that the state assessment offices are either unwilling or unable to provide the information, and that the utilities are generally unwilling to provide the information. Under these circumstances, it is impossible to obtain a picture of the accuracy, timeliness, and fairness of these assessments. Thus, some effort should be made to tighten up this process and to put the information in a more easily accessible form.

Finally, we must note the administrative problems associated with some types of land use controls. For zoning and subdivision regulations, it is frequently possible for developers to obtain variances. To the extent that this adversely impacts the community, the regulations become ineffectual. Local communities that adopt such regulations must make an effort to carefully evaluate variance requests in order to avoid these impacts. With building regulations, special ordinances for trailer parks, signs, etc. the problem is more frequently one of inadequate inspection and enforcement. Communities where growth has occurred slowly in the past are frequently unprepared to handle the administrative activity associated with rapid development. Such preparations must be made if adverse impacts are to be avoided.

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APPENDIX A

The ORBES Labor Impact Model

The ORBES Labor Impact Model (OLIM) takes the schedule of on-line dates and megawatt sizes of generating units for a given scenario and translates them into a schedule of construction and operation labor requirements with associated migration figures. Requirements for operation of the model are very simple: scenario specific information about the size, type and on-line date for each generating unit and migration assumptions for three commuting zones around the host county. Implicit inputs in the model are: ratios of workers per megawatt, distribution of workers over a schedule and a skill breakdown of workers required. These inputs are interior to the model but can be modified with relative ease. Outputs of the model include: a county-by-county listing of construction workers, operation workers, and number of inmigrating workers by year of the scenario and for ORBES as a whole, a listing of construction and operation workers by year as well as a breakdown of the construction workers into eight skill categories. The inputs and outputs of OLIM will be discussed below.

Input Requirements

The first set of input requirements are the assumptions concerning the proportion of construction workers that will migrate to the host county. Three proportions vary depending on the proximity of the centroid of the host county to the nearest SMSA: the host is an SMSA county, within 50 miles of the centroid of the nearest SMSA county, and greater than 50 miles from the nearest SMSA county. Generally, increasing proportions of workers will be assumed to migrate with increasing distance from an SMSA. In most of the ORBES scenario runs 5, 10 and 30 percent were the proportions used for these three categories. These are congruent with values in the literature (1,2). All operation workers are assumed to migrate to the county.

The second set of input requirements are detailed information concerning each generating unit in the scenario. This information includes:

a) state and county identification code
b) whether the county is an SMSA county,within 50 miles of the centroid of the nearest SMSA or greater than 50 miles from the nearest SMSA
c) the type of unit: coal-fired less than 1000 MW, coal-fired 1000MW or greater or nuclear unit
d) the size of the unit in megawatts
e) the on-line date projected for the unit
f) whether the unit is a single unit (no other plants existing or planned for the site) or part of a multiple unit site
g) whether scrubbers are planned for the unit or not

The state-county identification code combines a one-digit code (1-6 for ORBES states in alphabetical order) with the county FIPS code, a census-designated code which has been used for county identification throughout the ORBES study. The distances from centroids of counties to centroids of SMSA counties was roughly estimated using straight line distances on U.S. Geological Survey state maps. The remaining information is simply derived from the scenario information provided by the siting study (3) and the generating unit inventory prepared by Steve Jansen (4).

Implicit Inputs

The implicit inputs to the model are those parameters (factors, ratios, proportions) which are exogeneously determined but entered as part of the model for simplicity's sake. The first set of implicit inputs are ratios of construction manpower requirements per megawatt. Ratios were derived for the following types of energy facilities:

coal, single unit, no scrubbers	3.53 workers/MW
coal, part of multiple unit, no scrubbers	2.97
coal, single unit, scrubbers	4.23
coal, part of multiple unit, scrubbers	3.56
nuclear	4.98

Ratios were also derived for computing operating work force requirements; these are:

coal, scrubbers	.21 workers/MW
coal, no scrubbers	.12 workers/MW
nuclear	.09 workers/MW

The exact methods and data sources used to derive these ratios is included in a memo from S. Gordon dated June 19, 1979 included in this report as Appendix B.

Construction schedules are included in the model for three types of units: coal-fired, less than 1000 MW; coal-fired 1000 MW or greater; and nuclear units. These schedules are listed on Table A-1.

The third set of implicit inputs concerns the breakdown of construction requirements into skill categories. The percentage of workers in each skill category is included in the model for nuclear construction requirements and coal-fired construction requirements. Eight skill categories are utilized for both types of plants: boilermakers, electricians, pipefitters, laborers, operating engineers, carpenters, ironworkers and other skilled workers. The derivation of the percentages and the data sources used are outlined in detail in Appendix B. The percentages are listed on Table A-2.

Output from the model includes county tables, one for each county hosting a planned power plant, and two tables for the ORBES region as a

Table A-1

Construction Schedules Used in ORBES Labor Impact Model

Unit Type	Construction Period	Percent of Total Work Force by Year 1	2	3	4	5	6	7
coal, < 1000 MW	5 yrs.	2.7	15.4	41.0	36.9	4.0		
coal, ≥ 1000 MW	6 yrs.	3.0	11.5	27.9	34.0	21.2	2.3	
nuclear	7 yrs.	1.9	11.5	23.0	28.5	21.4	11.6	2.1

Table A-2

Percentage of Workers in Eight Skill Categories
Nuclear and Coal-Fired Units

Skill Category	Coal	Nuclear
Boilermakers	16.6%	7.2
Pipefitters	16.9	28.7
Electricians	15.5	12.5
Laborers	12.1	17.4
Iron Workers	8.2	9.7
Carpenters	6.9	7.9
Operating Engineers	7.9	7.9
Other	15.9	8.7

whole. All output lists the results for each year of the scenario. The first two columns of the county tables list the construction workers and operation workers required for each year of the scenario. For each county, workers for all units concurrently under construction are summed together for the annual listing. The same is done for concurrent operating workers within the same county. Also listed on the county tables are two columns of figures which indicate a) the number of construction workers that are expected to migrate to the county, and b) the total number of workers (construction and operation) that are expected to migrate.

The regional tables produced by the model provide a) the total number of construction workers required annually in the ORBES region, b) the total number of workers required annually in the ORBES region, and c) an annual breakdown of total construction workers by the eight skill categories mentioned above.

To illustrate how the model works we have fabricated a two-county region with planned generating units for a scenario lasting from 1980 to 1995. County I has two units planned: a nuclear unit to be on-line in 1990 and a coal-fired unit to be on-line in 1988. County I is within 50 miles of an SMSA. The characteristics of the planned units are listed on Table A-3. County II, a rural county located more than 50 miles from an SMSA, has two units planned: two coal-fired units on the same site with on-line dates of 1989 and 1992 respectively. Unit characteristics are listed in Table A-3. Together with the unit characteristics, we need to specify our migration assumptions for input to the model. These assumptions are 5 percent for SMSA counties, 10 percent for those counties within 50 miles of an SMSA and 30 percent for those outside this range.

The first step in the model is to compute the total number of construction worker-years needed to complete the unit. The appropriate worker-years per megawatt ratio and total worker-years for each unit is listed on Table A-4. Also listed in the table are the ratios used to compute total operation workers.

The next step is to allocate the total number of worker-years to a schedule based on the specific unit's characteristics. Then the annual requirements are summed to the county level and number of immigrants are computed using the assumptions as input to the model. For County I, 10 percent of the construction work force is assumed to move to the county, 30 percent for County II. One hundred percent of operation workers are assumed to be immigrants. Construction and operation worker requirements per unit, county sums and number of immigrants are shown on Table A-5. Notice that the seven-year schedule was used for the nuclear unit, the six-year schedule for the coal unit which was greater than 1000 MW and the five-year schedule for the two coal 800 MW units.

Table A-3

Planned Unit Characteristics for Fabricated Counties

	County I		County II	
Type of Unit	Nuclear	Coal-Fired	Coal-Fired I	Coal Fired II
Size (MW)	1000	13000	800	800
On-line date	1990	1988	1989	1992
Multiple unit status	Single	Single	Unit 1 of plant	Unit 2 of plant
Environmental controls	No	Scrubbers	Scrubbers	Scrubbers

Table A-4

Total Number of Worker-Years for Each Unit and Ratios Used to Serve Them

	County I		County II	
	Nuclear	Coal	Coal I	Coal II
Construction worker per MW ratio 1	4.98	4.23	3.56	3.56
Total no. of worker years	4.980	5499	2949	2848
Operation worker per MW ratio	.09	.21	.21	.21
Total Number of Operation worker years	90	273	168	168

Table A-5

Total Construction and Operation Worker Requirements for Each Generating Unit 2nd County, Total Number of County in Migrants

County I

	Nuclear		Coal		Total County I		
	Construction workers	Operation workers	Construction	Operation	Construction	Operation	Inmigrants
1980							
1981							
1982			170		170		17
1983	95		632		727		73
1984	573		1534		2107		211
1985	1145		1870		3015		302
1986	1419		1166		2585		259
1987	1066		126		1192		119
1988	578			273	578	273	331
1989	105			273	105	273	284
1990		90		273		363	363
1991		90		273		363	363
1992		90		273		363	363
1993		90		273		363	363
1994		90		273		363	363
1995		90		273		363	363

Table A-5 (Cont.)

County I

	Nuclear		Coal		Total County I		
	Construction workers	Operation workers	Construction	Operation	Construction	Operation	Inmigrants
1980							
1981							
1982							
1983							
1984	77				77		23
1985	439				439		132
1986	1168				1168		350
1987	1051		77		1128		338
1988	114		439		553		166
1989		168	1168		1168	168	518
1990		168	1051		1051	168	483
1991		168	114		114	168	202
1992		168		168		336	336
1993		168		168		336	336
1994		168		168		336	336
1995		168		168		336	336

The final computations in the model involve regional totals of construction and operation workers and the breakdown of construction requirements into skill categorics. The original totals are simply the sum of the county totals of construction and operation workers. These totals are shown on Table A-6. In order to apply the percentages for skill categories we need a breakdown of the regional total of construction workers into those working at nuclear unit sites and those working at coal unit sites. This breakdown is also shown on Table A-6. The appropriate skill percentages are applied to the coal and nuclear construction requirements to yield the final table produced by the model. This table is shown for our fabricated region as Table A-7.

Table A-6

Regional Totals of Construction Requirements by Type of Unit and Totals Operation Workers

	Construction	Operation	Coal Construction	Nuclear Construction
1980				
1981				
1982	170		170	
1983	727		632	95
1984	2184		1611	573
1985	3454		2309	1145
1986	3753		2334	1419
1987	2320		1254	1066
1988	1131	273	553	578
1989	1273	441	1168	105
1990	1051	531	1051	
1991	114	531	114	
1992		699		
1993		699		
1994		699		
1995		699		

Table A-7

Regional Totals of Construction Workers Required by Skill Category

	Boilermakers	Pipefitters	Electricians	Laborers	Iron Workers	Carpenters	Operation Engineers	Other
1980								
1981								
1982	28	29	26	21	14	12	13	27
1983	112	134	110	93	61	52	58	108
1984	308	436	322	295	188	156	172	306
1985	465	719	501	478	300	249	272	467
1986	489	801	539	529	329	273	296	494
1987	285	518	327	337	206	171	183	292
1988	134	259	158	168	101	84	90	138
1989	202	227	194	159	106	89	100	195
1990	174	177	163	127	86	73	83	167
1991	19	19	18	14	9	8	9	18
1992								
1993								
1994								
1995								

References

1) Tennessee Valley Authority, Regional Planning Staff, "Brown's Ferry Nuclear Plant Construction Employment Impact, July, 1973" Knoxville, Tennessee, May, 1974.

2) Tennessee Valley Authority, Regional Planning Staff, "Cumberland Steam Plant Construction Employment Impact, April, 1973." Knoxville, Tennessee, July, 1973.

3) ORBES Siting Report, forthcoming.

4) Steven D. Jansen, Electrical Generating Unit Inventory 1976-1986, Prepared for ORBES, Washington D.C.: U.S.E.P.A., November, 1978.

APPENDIX B

A Classification of ORBES Counties for Potential Socioeconomic Impacts

Several studies performed a taxonomy or classification of counties in order to forecast the potential socioeconomic impacts associated with major new developments such as energy facilities. The basic premises behind such a classification can be summarized as follows:

1) Rural areas supply fewer services to their residents and/or services of lower overall frequency or quality than do urban areas. Rural areas also have a lower availability of housing.

2) Rural areas tend to have less slack in their service capacities than urban areas.

3) Rural areas have a smaller resident labor pool and fewer skilled laborers than urban areas.

4) Labor demanded for energy facility construction and operation is largely skilled, is concentrated in urban areas and thus must migrate or commute to rural areas where such projects are undertaken. This labor demands urban services.

5) The greatest potential impacts on service demands, housing, local taxes and revenues, social structure etc. (i.e. socioeconomic impacts) will occur in those areas that are most rural, furthest from urban labor centers, provide the fewest services, and have the smallest populations, and available housing stock.

For very undeveloped areas of the country, almost all of these generalizations are true. However, ORBES is somewhat unique in that its rural areas are often quite close to highly urbanized, manufacturing oriented centers. In addition, many federal and state programs have subsidized the replacement or development of many basic urban services such as highways, sewer and water, health and social services, housing rehabilitation, etc. These programs include those of U.S.E.P.A., the Appalachian Regional Commission, the Department of Housing and Urban Development, and the Department of Health Education and Welfare with their related, state counterparts. The result is that several of the generalizations in the above list do not seem to hold across the board. That is, not all services have capacity problems, not all rural areas have housing shortages (in fact some urban areas have worse such problems) etc.

For these reasons, we feel that many of the attempts at classifying counties based on potential socioeconomic impacts have generalized to the point of not being very useful. This chapter first reviews some of these past attempts. We then go on to report our own attempt at classification with an eye toward greater specificity.

Classification Efforts

It follows from the discussion above, that classification of counties based on similarities in demographic, economic, and social attributes will yield groups of counties with similar propensities to be impacted. This type of classification work can be traced back to so-called "urban ecology" studies undertaken by geographers, sociologists, and others in the 1960's and early 1970's. Brian Berry performed many such factorial ecology or social area analysis studies. Berry and Rees (1) utilized this approach to differentiate urban subpopulations in Calcutta based on social rank, stage in the life cycle, ethnic segregation, and other variables. Similarly Abler, Adams and Gould classify households, housing, units, and urban census tracts in American cities (2).

More recently, the same techniques have been utilized to classify the nature of the environment and quality of life in major U.S. cities. Urban Systems Research and Engineering (3) uses factor analysis to group 262 SMSA's (Standard Metropolitan Statistical Areas) based on 200 variables measuring ambient environmental quality, urban form and the physical environment, pollution residuals and demographic characteristics. The method is used to identify representative cities to be used for further study reflecting the characteristics of different groups. Once the classification is completed, one implicitly notes those areas where the environment is "bad" as reflected by the environmental quality variables. What is good or bad is based somewhat on scientific evidence of the health impacts of certain pollutants but is also a matter of personal judgement.

If the variables selected for such a classification represent some accepted measure of potential socioeconomic impact, then the results could theoretically be applied to delineate areas where the most adverse impacts might occur. Based on this premise, Argonne National Laboratory used a classification scheme to group counties where energy facilities might be sited (4). The variables chosen for this analysis were:

1) The size and age/sex composition of the population
2) The population density of the county and surrounding areas.
3) The amount of service employment relative to basic (or industrial) employment in the county.
4) The size and location of nearby regional trade centers.

One might note that these variables are attempts to measure potential impacts related to the basic premises of classification for impact analysis cited above. The size, age/sex composition and population density of the area all reflect the size of the local labor market vis-a-vis workers for energy facility construction and operation. The amount of service versus industrial employment attempts to measure both the sensitivity of the area to increased demands on services and to the direct economic impacts of energy facilities. Finally, the size and location of nearby regional trade centers measures the available labor market in the vicinity of the potential new energy facilities. The closer the area to existing, large trade centers, the fewer people that need to migrate into the impact county versus commuting from their existing residence and therefore the lower the potential adverse socioeconomic impacts. The further away or smaller are such trade centers, the greater the number of immigrants making demands on local services and housing.

In operation, ANL used the following variables in their analysis:

1) Population density at the time of impact;
2) Population density of the county and surrounding areas;
3) Distance in miles to the nearest regional trade center;
4) Relationship between basic and service employment.

The potential impacts of coal development on candidate counties was derived from a classification based on these variables. A multivariate Euclidean distance algorithm was used to put counties into one of three groups. A "high probability of adverse socioeconomic impact from energy development" is associated with the first group of counties (30, p. 8-16). Less chance of adverse impacts is associated with the second group of counties because they have moderate assimilative capacities. The third group can accomodate large increases in coal development without major impacts.

Table B-1 shows the county groupings for those states studied by ANL that are also in ORBES. These groupings will be compared later to those derived by other means.

A parallel project by Oak Ridge National Laboratories took a different approach to socioeconomic impact analysis. For their direct impact assessment, Oak Ridge researchers took an approach similar to ours as reported in previous chapters of this report. Using assumptions related to power plant construction and operation work force, mining employment, and proportions of workers that migrate into the county, they calculated the population growth induced by energy development. They then calculated the growth rate relative to the base year population. As one of their indicators of socioeconomic impact, they identified those counties with more than a 15% growth rate as having a high probability of social impact, 5% - 15% as a moderate probability, and less than 5%, as a low probability.

Table B-1

County Potential Socioeconomic Impact
In Argonne and Oak Ridge National Laboratory Studies

ILLINOIS

	County	ANL Group or ORNL Service Base Index
1.	Bond	High Impact
2.	Bureau	Moderate
3.	Calhoun	High
4.	Cuss	High
5.	Christian	Moderate
6.	Clinton	Moderate
7.	Douglas	High
8.	Edgar	Moderate
9.	Fayette	High
10.	Franklin	Moderate
11.	Fulton	Moderate
12.	Gallatin	High
13.	Greene	High
14.	Grunely	Moderate
15.	Hamilton	High
16.	Jackson	Low
17.	Jefferson	Moderate
18.	Jersey	High
19.	Kankakee	Low

ILLINOIS - (cont'd)

	County	ANL Group or ORNL Service Base Index
20.	Knox	Low
21.	LaSalle	Low
22.	Lawerence	High
23.	Livingston	Moderate
24.	Macoupin	Low
25.	Madison	Low
26.	Marshall	High
27.	Menard	High
28.	Montgomery	Moderate
29.	Morgan	Moderate
30.	Peoria	Low
31.	Perry	High
32.	Putnam	High
33.	St. Clair	Low
34.	Saline	Moderate
35.	Sangamon	Low
36.	Shelby	Moderate
37.	Vermillion	Low
38.	Washington	High
39.	White	High
40.	Williamson	Low

Table B-1 (cont'd)

OHIO

	County	ANL Group or ORNL Service Base Index
1.	Athens	Low
2.	Belmont	Low
3.	Brown	Moderate
4.	Carroll	Moderate
5.	Columbiana	Low
6.	Coshocton	Moderate
7.	Gallia	Moderate
8.	Guernsey	Moderate
9.	Harrison	High
10.	Hocking	High
11.	Holmes	Moderate
12.	Jackson	Moderate
13.	Jefferson	Low
14.	Lawrence	Low
15.	Mahoning	Low
16.	Meigs	High
17.	Miami	Low
18.	Monroe	High
19.	Morgan	High
20.	Muskingham	Low
21.	Noble	High
22.	Perry	Moderate
23.	Pickaway	Moderate

Table B-1 (cont'd)

OHIO - (cont'd)

	County	ANL Group or ORNL Service Base Index
24.	Ross	Low
25.	Scioto	Low
26.	Stark	Low
27.	Tuscarawas	Low
28.	Vinton	High
29.	Washington	Low
30.	Wayne	Low

INDIANA

	County	ANL Group or ORNL Service Base Index
1.	Allen	Low
2.	Clay	Moderate
3.	Elkhart	Low
4.	Floyd	Low
5.	Fountain	High
6.	Franklin	High
7.	Gibson	Moderate
8.	Greene	Moderate
9.	Harrison	High
10.	Jasper	High
11.	Knox	Moderate
12.	Morgan	Low
13.	Owen	High
14.	Parke	High

Table B-1 (cont'd)

INDIANA - (cont'd)

County	ANL Group or ORNL Service Base Index
15. Pike	High
16. Posey	Moderate
17. Spencer	High
18. Starke	High
19. Sullivan	High
20. Switzerland	High
21. Vermillian	High
22. Vigo	Low
23. Warrick	Moderate

KENTUCKY

1. Boone	184
2. Boyd	213
3. Breathkitt	36
4. Carroll	109
5. Elliott	41
6. Floyd	68
7. Hancock	87
8. Harlan	71
9. Hopkins	118
10. Knott	199
11. Leslie	60
12. Letchen	39

Table B-1 (cont'd)

KENTUCKY - (cont'd)

County	ANL Group or ORNL Service Base Index
13. Lewis	61
14. Livingston	65 & 66
15. Martin	38
16. Mason	112
17. McLean	67
18. Meade	109
19. Mahlenberg	96
20. Ohio	77
21. Perry	71
22. Pike	71
23. Trimble	70
24. Union	104
25. Webster	89

WEST VIRGINIA

County	ANL Group or ORNL Service Base Index
1. Barbour	74
2. Boone	67
3. Braxton	89
4. Brooke	157
5. Clay	45
6. Fayette	83
7. Gilmer	48
8. Lewis	96

Table B-1 (cont'd)

WEST VIRGINIA - (cont'd)

	County	ANL Group or ORNL Service Base Index
9.	Lincoln	56
10.	Logan	96
11.	McDowell	79
12.	Marshall	136 & 137
13.	Mason	94
14.	Mingo	75 & 85
15.	Nicholas	85
16.	Pleasants	88
17.	Pocahontas	54
18.	Putnan	146
19.	Raleigh	107
20.	Tyler	87
21.	Upshur	98
22.	Webster	46
23.	Wetzel	122
24.	Wyoming	89

Another ORNL indicator of the amount of impact was derived by calculating a service base index score relative to six socioeconomic variables. This index was derived by first obtaining a weight for each variable using a factor analysis of the variables on a sample of 267 counties in their study region. The resulting weights are really a classification of the "importance" of each variable in explaining differences among the 267 counties. The index is

$$I_j = \{ \sum_{i=1}^{6} [w_i (\frac{X_{ij} - \bar{X}_i}{Sd_i}) + K \} 100$$

where

I_j = the index value for the county, j = 1, ... 267

w_i = the weight of the ith variable, where i ranges from 1 - 6

X_{ij} = the level of the ith variable in the jth county

$\bar{X}_i$ = the mean or average level of its variable

Sd_i = the standard deviation of the ith variable

K = a constant that is added to attach a certain level of the index to a desired point of comparison. (5, p. 9-35, 9-36

As implemented, the index was set up such that the value would be zero if all the X_{ij} are zero and the value would be 135 if the value of all the X_{ij} equal the mean. The interpretation of the index is that those counties with values below the mean have a relatively lower ability to absorb growth. The variables used in the index are:

1970 population ($x10^3$)

percentage urban population, 1970

median family income, 1970

SMSA county (yes or no, 1 or 0)

Population density, 1970

retail wholesale service trade, 10^6 \$ (1972).

Although the index is put forward as another indicator of potential impacts, the authors caution that it is not a complete index and thus should not be too heavily relied upon.

Table B-1 also indicates values of the service base index for counties in the ORBES region studied by ORNL.

Classification of ORBES Candidate Counties

Rather than use only the four or six variables employed in previous studies as measures of potential socioeconomic impact, we have used 25 variables in five different categories as proxies for potential socioeconomic impact. These are shown in Table B-2. The reason for utilizing such a large number of variables is to attempt to better measure the potential impact. We wish to avoid over-generalization as much as possible. By employing a large number of variables, there is a higher probability that we will include those that are critical in each particular situation.

A two step statistical technique was used to classify the candidate counties. In the first step, the variables are grouped using factor analysis. This serves to create a new variable set, called factors, which put the initial variables into groups with similar characteristics. The results of this step yielded five new factors which explained 90% of the original variance. These factors are uncorrelated, a prerequisite for the next step. Each of the counties could now be represented by a set of factor scores showing the relationship between each county and each factor.

In the second step of the analysis, the candidate counties were placed in groups using a distance algorithm called H-group (32). The final result was the placement of the candidate counties into four groups.

Another statistical technique was used in order to test the efficiency of the first method. Here, the original variables for all candidate counties were input to a discriminant analysis program. The discriminant analysis program derived three linear discriminant functions (mathematically analagous to factor analysis) and tested the ability of the functions to correctly classify the candidate counties. Of the 114 candidate counties, only seven were found to be "incorrectly" classified. After changing these seven to the correct group, the analysis was repeated resulting in discriminant functions placing 96% of the counties into the correct group.

Using either method of classification then, the vast majority of candidate counties were placed into groups which represent their difference with respect to the socioeconomic variables. Table B-2 shows the variables input for this analysis. Variables on population, income, housing, employment, and natural resources were used in the analysis. The percent land in forest variable did not seem to differentiate any counties and so was dropped after the initial runs.

The results of the overall analysis are shown in Table B-3 and Figure B-1.

Table B-3 describes the size and content of each group. In looking at these data, it becomes apparent that although the means of each group are somewhat distinct across many variables, the ranges of the groups yield overlaps among members of different groups. For example, the percent older houses variable has a distinct, mean difference across the groups with values of 62.9, 60.0 58.2, and 40.0 percent for groups 1 - 4 respectively. Initially, one would think this indicates that the fewest older housing units lie in group 4 with progressively more until one reaches group 1. This would then lead one to conclude that the potential for housing problems vis-a-vis the market ability to respond to sudden new demands, might be lower in these counties. However, when we look at the range associated with this variable for group members, we see that groups 1, 2, and 3 all have some members with similar values of percent older homes.

Similar overlap problems occur with many variable as a result of the averaging that takes place in the classification process. For this reason, the classification does not yield a distinct set of groups for which impact interpretations can be made. In order to circumvent this problem, we reformulated the classification based on four different groups of variables -- population, housing, income, and employment. The results are shown in table B-4 and figures B-2 through B-5. Table B-4 shows the mean values for each variable using each classification scheme. It is immediately apparent that major differences in results are associated with the choice of classification variables. A much more distinct pattern of differences occurs for each group of variables when that group is used as the sole means of classification. For example, the percent old housing variable has means of 64.8, 61.6, 54.2, and 40.0% for groups 1-4 respectively when the classification is based on housing. The differences among groups narrow when other variables are used in the classification -- 62.6, 61.5, 58.4, and 44.9 when income variables are used; 62.5, 58.9, 58.0, and 40.0 when population variables are used; 62.7, 60.1, 57.6, and 40.0 when employment variables are used. What these differences in classification mean is that to the extent that these census variables are proxies for potential impacts, some counties have different impact potentials for housing, employment, income, and population.

Table B-5 shows our interpretation of these potential impacts for the three major groups. Group 4 is almost always a set of large urban counties where we would expect all of the socioeconomic impacts of energy facility siting to be relatively insignificant. Looking at table B-5 one can see that these are very distinct differences in the potential impacts on the groups for different variables. For example, group 1 counties are smallest in population and thus have the potential for high impacts on population due to the siting of major energy facilities. On the other hand, many of these rural counties also have

Table B-2

Variables Used in the Taxonomy of Candidate Counties

Variable Type	Variable	Source	Comments
Population	Total 1970 Population	1970 Census	
	Net Migration 1970-76	1970 Census and Census Estimates	
		Derived from Census	Population 0-14 + 65 and Over Divided by Population 15-64
	Total Urban Population	1970 Census	
	Population Density 1975	1975 Census Population Estimates	
Income	Median Family Income	1970 Census	
	% Families Below Poverty Level		
	% Persons on Public Assistance - Aid to Dependent Children	City and County Data Book, 1972	
	% Persons on Public Assistance - Old Age	City and County Data Book, 1972	
	Median Effective Buying Income	Sales Management, 1975	
Housing	% of Housing Units Built before 1939	1970 Census	Measure of Housing Age
	% of Housing Units Built 1960-70	1970 Census	
	% of Housing Units With Public Water		Measure of Service
	% of Housing Units with Public Sewer		Measure of Service
	% of Housing Units Vacant Year Round		Measure of Vacancy
	Total Housing Units		
	% Housing Units Lacking Some Plumbing		Measure of Housing Quality
	% Housing Units with 71.51 Persons per Room		Measure of Crowding
Employment	Total Employment 1970	1970 Census	
	% Workers Employed in Agriculture	1970 Census	
	% Workers Employed in Services	1970 Census	
	% Workers Employed in Mining	1970 Census	
	% Workers Employed in Manufacturing	1970 Census	
	% Workers Employed as Craftsmen	1970 Census	
Natural Resources	% Land in Forest		

Table B-3

Descriptive Statistics on Groupings Derived Using All Variables

	Group 1 N=22		Group 2 N=48		Group 3 N=42		Group 4 N=2	
Variable	Mean	Range	Mean	Range	Mean	Range	Mean	Range
% Older Houses	62.9	26.2	60.0	45.4	58.2	58.8	40.0	10.8
% New Houses	15.8	10.6	16.0	23.1	19.2	32.8	24.5	4.6
% Houses Served by Public Sewers	46.9	58.5	38.0	64.9	47.8	83.9	85.2	15.5
% Houses Vacant	6.5	10.2	8.2	16.0	7.2	8.7	4.8	0.5
% Lacking Some Plumbing	12.3	26.6	18.2	47.0	15.2	33.0	3.4	0.6
% Families Below Poverty	11.2	11.4	15.6	30.5	12.3	31.2	8.6	0.6
% Net Migration '70-'76	1.6	23.5	3.5	35.8	2.2	25.1	-7.0	3.3
Dependency Ratio	71.2	15.0	68.2	40.9	68.3	23.9	63.7	1.7
Total Urban Population (1000's)	8.0	120.8	18.7	159.6	16.2	77.0	773.0	230.1
Total Population (1000's)	31.1	156.3	49.1	206.7	34.0	102.6	809.5	229.0
Median Family Income	8463.0	3418.0	7667.6	5746.0	8099.3	4890.0	10153.0	667.0
Total Employment (1000's)	11.4	57.3	16.4	73.6	12.3	36.3	311.2	85.1
% Manufacturing Workers	24.0	28.3	32.0	50.2	32.4	27.9	32.3	0.4
% Agricultural Workers	15.3	24.6	5.3	16.5	8.2	26.4	0.5	0.1
% Mining Employees	2.3	11.9	4.4	24.2	1.9	11.3	0.1	0.1

Sources: 1970 Census of Population and Housing and
1976 Population Estimates of Bureau of the Census

Table B-4

Group Statistics for Selected Variables Using Alternative Classification Schemes

Variable	Classification Based on Housing: Group 1 N=28 Mean	Group 2 N=46 Mean	Group 3 N=38 Mean	Group 4 N=2 Mean	Classification Based on Income: Group 1 N=21 Mean	Group 2 N=44 Mean	Group 3 N=42 Mean	Group 4 N=7 Mean
% Old Housing	64.8	61.6	54.2	40.0	62.6	61.5	58.4	44.9
% New Housing	14.7	15.4	21.2	24.4	15.3	15.6	19.2	22.3
% Housing Vacant	6.2	8.7	7.0	4.8	6.1	8.2	7.9	3.9
% Net Migration '70-'76	1.6	3.4	2.5	-7.0	1.4	2.8	3.4	-1.9
Total Urban Population (1000's)	8.0	15.4	21.5	773.0	15.3	15.1	12.5	255.4
Median Family Income	8450.	7420.	8328.	10153.	8481.	7473.	8023.	10112.0
Total Employment (1000's)	11.4	14.7	14.7	311.2	13.0	14.8	10.3	117.4
% Manufac. Employees	30.5	30.4	30.9	32.3	25.7	31.2	31.9	34.5
% Agricultural Employees	11.3	8.6	5.9	0.5	13.5	5.7	9.2	2.3

Table B-4 (Cont'd)

Variable	Classification Based on Population: Group 1 N=38 Mean	Group 2 N=47 Mean	Group 3 N=27 Mean	Group 4 N=2 Mean	Classification Based on Employment: Group 1 N=29 Mean	Group 2 N=46 Mean	Group 3 N=37 Mean	Group 4 N=2 Mean
% Old Housing	62.5	58.9	58.0	40.0	62.7	60.1	57.6	40.0
% New Housing	16.4	16.6	19.3	24.5	16.2	16.4	18.9	24.5
% Housing Vacant	6.8	8.0	7.5	4.8	7.7	7.3	7.5	4.8
% Net Migration '70-'76	1.0	3.2	4.1	-7.0	3.2	2.0	3.1	-7.0
Total Urban Population (1000's)	9.5	21.6	13.9	773.0	5.4	24.3	13.0	773.0
Median Family Income	8359.	7667.	8015.	10152.	7498.	8039.	8301.	10152.
Total Employment (1000's)	11.4	17.7	10.7	311.2	7.0	19.2	12.7	311.2
% Manufacturing Employment	28.5	31.8	31.5	32.3	23.9	33.5	32.2	32.3
% Agricultural Employees	12.6	4.4	9.2	0.5	17.8	3.4	7.1	0.5

Table B-5

Description of the Classification of Candidate Counties and Potential for Socioeconomic Impacts

Variable Type	Group	Group Descriptions	Potential for Impact
Population	1	Smallest populations, density, most rural	High
	2	Largest populations, density, most urban, lowest dependency ratio	Low
	3	Medium size, density, dependency ratio	Medium
Housing	1	Fewest units, lowest vacancy, many with public sewer, water least crowded units	Medium to High
	2	Largest # units, largest vacancy, most crowding, fewer with public sewer, water	Low
	3	Medium # units, vacancy, crowding, most with public sewer, water	Medium to High
Income	1	Fewest below poverty, largest median income, largest buying income, fewest old age on assistance, largest ADC*	Low
	2	Highest families below poverty, lowest median income, lowest buying income, medium # persons on public assistance	High
	3	Median income between year 2 & 3, families below poverty, ADC, buying income, highest old age public assistance	Medium
Employment	1	Most people in agriculture, lowest workforce, lowest in manufacturing, services, craftsman	Highest- Induced migration but lowest employment benefits
	2	Fewest in agriculture, most manufacturing, mining, total employees, medium in services	Lowest, induced migration, highest employment benefits
	3	Medium in agriculture, total employees, craftsmen, manufacturing, highest in services, lowest in mining	Medium

FIGURE B-1
COUNTY IMPACT GROUPS USING
ALL VARIABLES

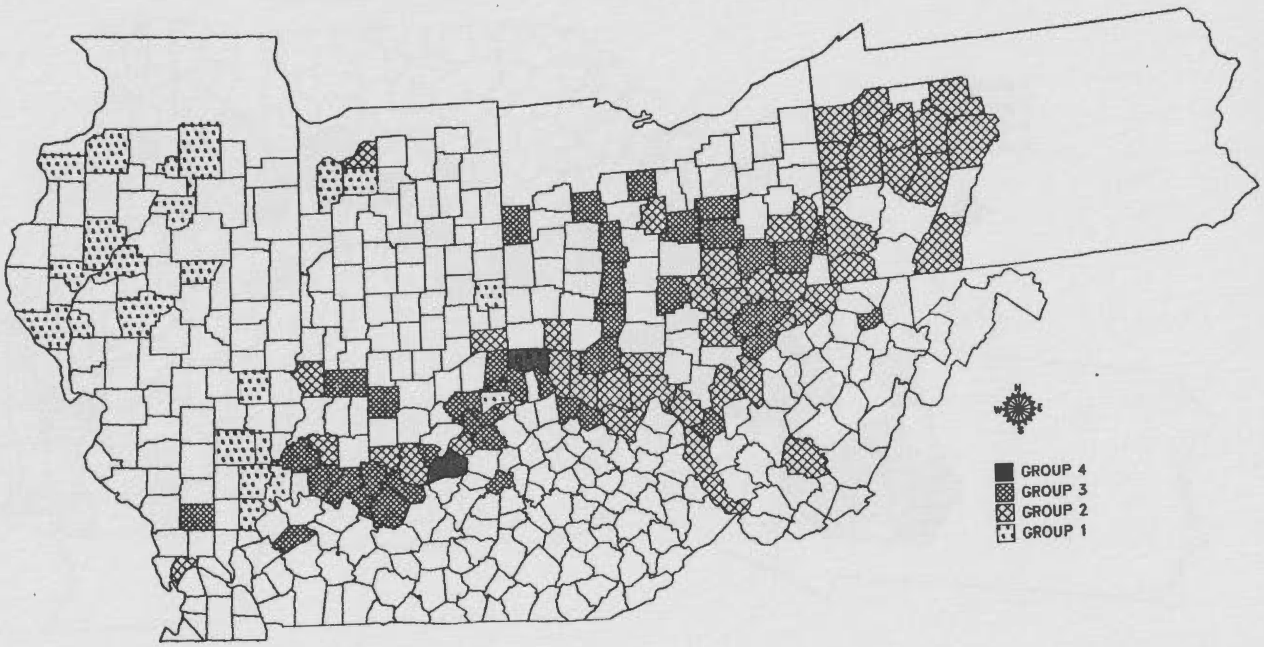

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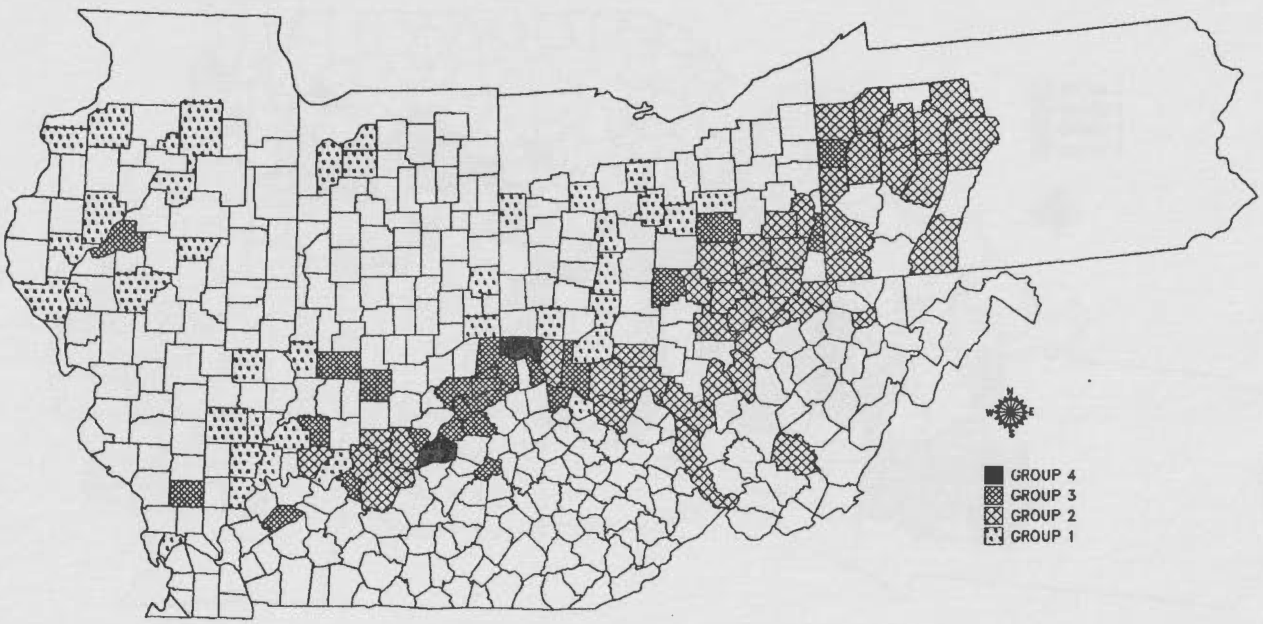
FIGURE B-2
COUNTY IMPACT GROUPS USING POPULATION VARIABLES



PREPARED FOR OHIO RIVER BASIN ENERGY STUDY
BY CAGIS/UICC, MARCH, 1980

FIGURE B-3
COUNTY IMPACT GROUPS USING HOUSING VARIABLES

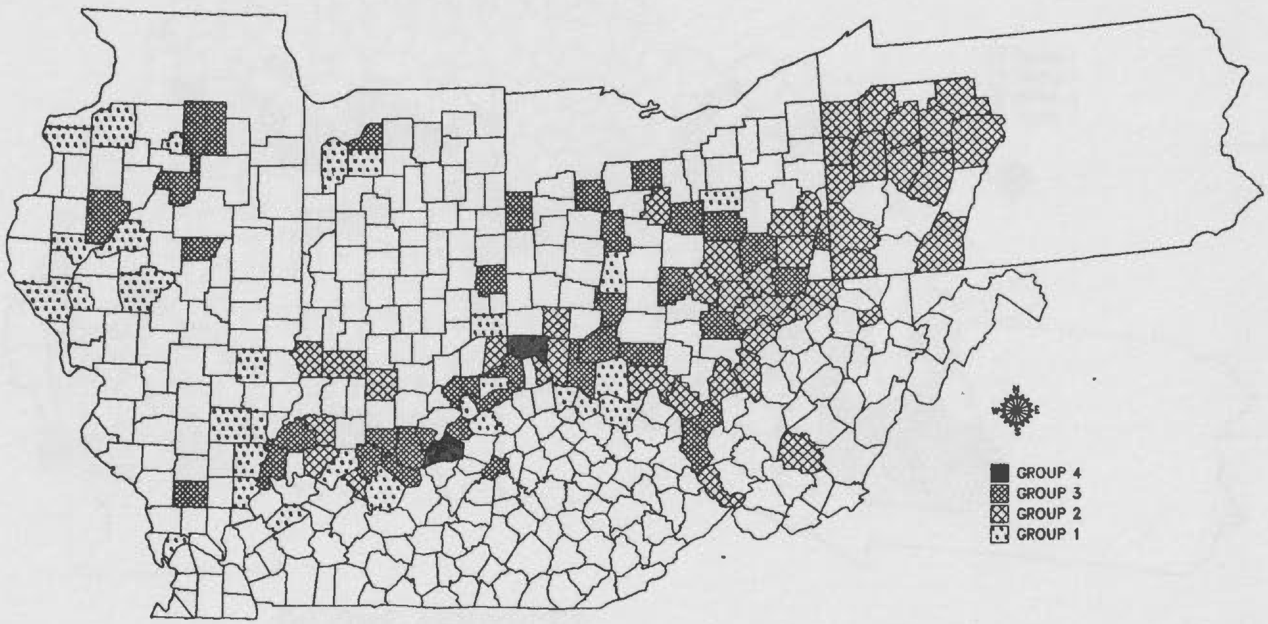


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FIGURE B-4
COUNTY IMPACT GROUPS USING INCOME VARIABLES

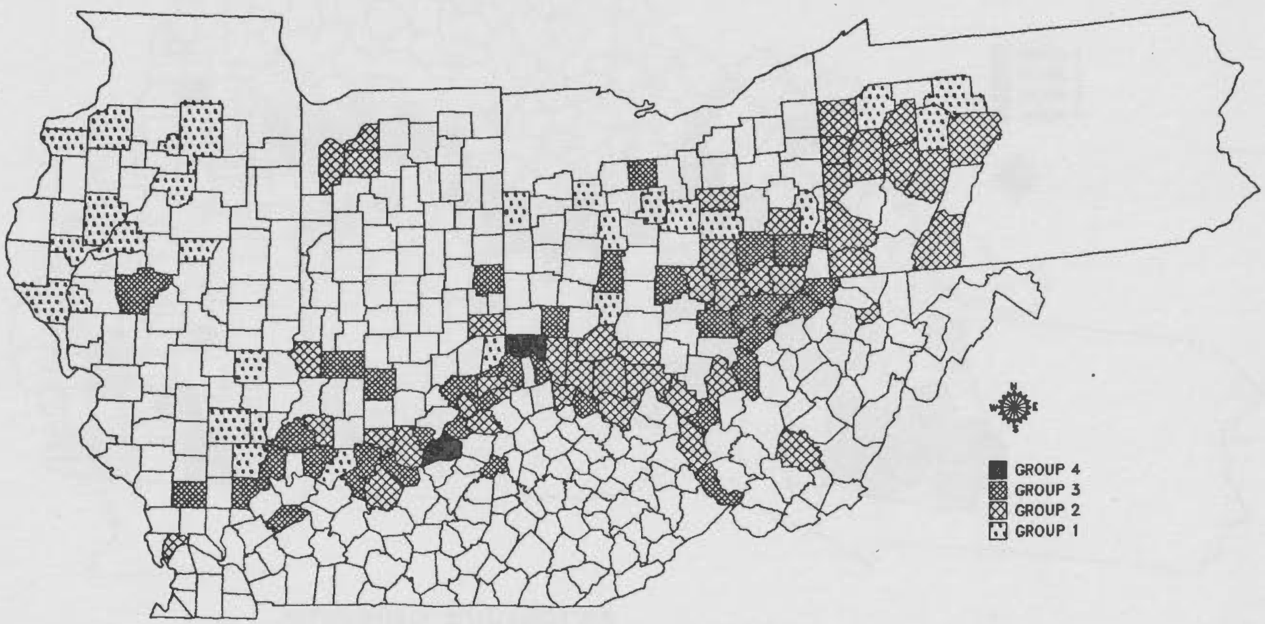

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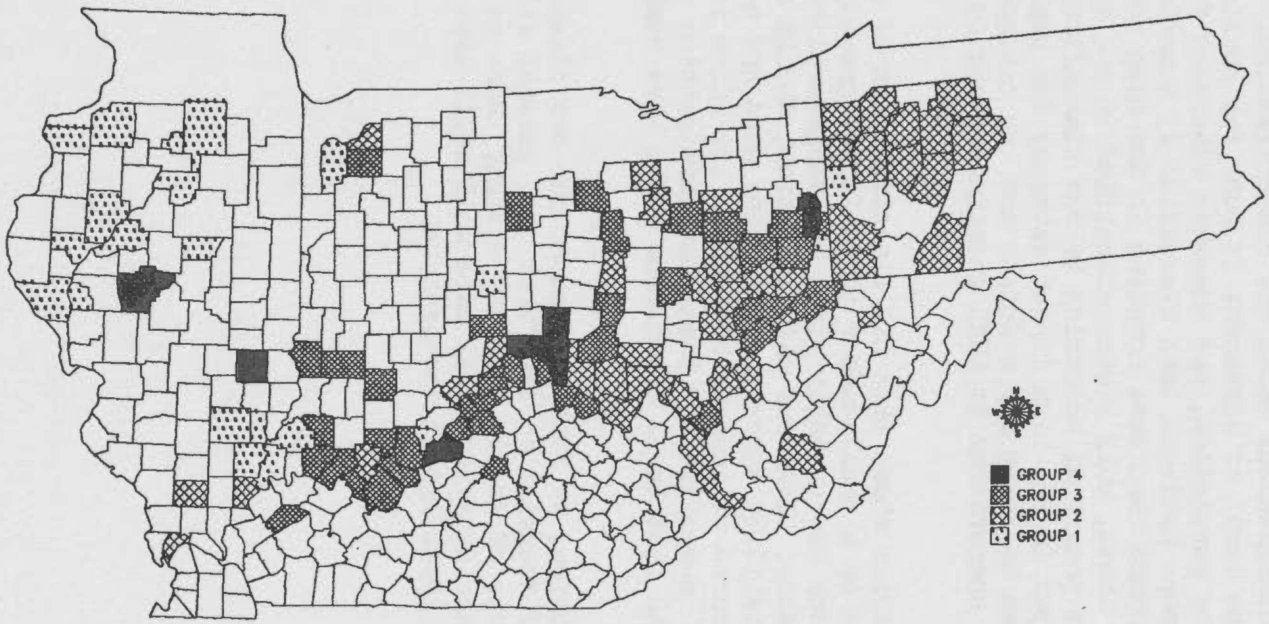
FIGURE B-5
COUNTY IMPACT GROUPS USING EMPLOYMENT VARIABLES



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the fewest families below poverty level and largest median incomes therefore making the income impacts (which might be considered positive) lower in these counties.

It is useful to compare our results with those of ANL and ORNL. This is shown in tables B-6 and B-7. Here, we have tabulated, for those counties that both sets of projects evaluated, the amount of agreement or disagreement among the classification. In table B-6, we see that the level of agreement is poor for housing and income, pretty good for population, and somewhat inbetween for employment impacts. Argonne National Labs classified 13 counties that also happen to be ORBES candidate counties in the high potential impact category. Of these, only 2 were classified in the high category for housing impact potential according to our classification. On the other hand, 8 were put in the high impact category for population. Similar conclusions can be drawn for moderate and low categories. Table B-7 shows similar comparisons to ORNL groupings based on their service base index.

This analysis shows that the classification of a large number of counties based on a small number of variables greatly oversimplifies local conditions and probably gives an overgeneralized picture of potential impacts. Even our classification, though more involved, has a limited reliability since the variables used are not the only potential measures of impacts but only a set which is readily available. One must also recognize that these data are getting old being from the 1970 Census and that local conditions could have changed radically since then.

In conclusion, we might recommend our own classification system as a method of focusing on the first cut, general regional socio-economic impacts of energy facility siting. More reliable, more recent, and more detailed local data will still have to be used to make accurate local impact assessments.

Table B-6

Comparison for ORBES Impact Classifications with ANL

ORBES County Impact Potentials

ANL Impacts		Housing			Income			Population			Employment		
Level	Number	H	M	L	H	M	L	H	M	L	H	M	L
High	13	2	0	11	5	6	2	8	2	3	5	4	4
Moderate	10	8	0	2	4	5	1	3	3	4	2	5	3
Low	11	5	0	6	5	3	3	2	2	7	2	3	6

Table B-7

Comparison of ORBES Impact Classifications
with ORNL

ORBES County Impact Potentials

ORNL Impacts *		Housing			Income			Population			Employment		
Level	Number	H	M	L	H	M	L	H	M	L	H	M	L
High	9	4	1	4	0	4	5	6	3	0	7	0	2
Moderate	4	0	0	4	0	4	0	2	1	1	1	2	1
Low	2	0	0	2	0	2	0	0	2	0	1	1	0

Table B-8

ORBES Candidate County Groupings

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
			Group Using				
17039	Illinois	DeWitt	1	1	1	1	3
17047	"	Edwards	1	1	1	1	1
17057	"	Fulton	1	1	1	1	3
17059	"	Gallatin	1	3	2	1	1
17073	"	Henry	1	1	1	1	1
17079	"	Jasper	1	1	4	1	1
17099	"	La Salle	1	1	1	1	3
17125	"	Mason	1	1	1	3	1
17131	"	Mercer	1	1	1	1	1
17149	"	Pike	1	1	1	1	1
17153	"	Puluski	2	2	2	1	1
17155	"	Putram	1	1	1	1	1
17167	"	Sangamon	1	3	4	1	1
17169	"	Schuyler	1	1	1	1	1
17171	"	Scott	1	1	1	1	1

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
17191	Illinois	Wayne	1	1	1	1	1
17193	"	White	1	1	1	1	1
17199	"	Williamson	3	3	2	3	3
17203	"	Woodford	1	1	1	1	3
18025	Indiana	Crawford	2	2	3	2	3
18029	"	Dearborn	3	1	2	3	2
18043	"	Floyd	3	3	1	3	3
18047	"	Franklin	2	2	3	1	1
18051	"	Gibson	3	3	1	1	3
18055	"	Greene	3	3	3	3	2
18061	"	Harrison	2	2	3	2	3
18073	"	Jasper	1	2	1	1	1
18077	"	Jefferson	3	3	2	3	3
18093	"	Lawrence	3	3	3	3	2
18115	"	Ohio	3	3	3	3	3
18123	"	Perry	3	3	2	2	3

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
18125	Indiana	Pike	2	2	3	3	2
18129	"	Posey	1	3	1	1	3
18131	"	Puluski	1	2	3	1	1
18147	"	Spencer	3	1	3	1	1
18149	"	Starke	2	2	2	1	3
18153	"	Sullivan	2	2	3	1	2
18155	"	Switzerland	1	2	3	3	1
18173	"	Warrick	3	3	3	2	2
18177	"	Wayne	1	3	1	1	3
21005	Kentucky	Anderson	3	3	3	3	3
21015	"	Boone	3	3	3	3	3
21023	"	Bracken	3	2	3	3	1
21027	"	Breckinridge	3	2	3	2	1
21037	"	Campbell	3	3	3	3	2
21041	"	Carroll	3	3	3	3	3

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
21077	Kentucky	Gallatin	2	2	2	3	3
21091	"	Hancock	3	3	3	3	2
21103	"	Henry	3	2	3	3	1
2111	"	Jefferson	4	4	4	4	4
21135	"	Lewis	2	2	2	2	1
21161	"	Mason	3	3	3	1	1
21163	"	Meade	3	3	3	2	3
21185	"	Oldham	2	3	3	3	3
21223	"	Trimble	3	2	3	3	1
21233	"	Webster	3	3	3	3	1
39001	Ohio	Adams	2	2	2	2	1
39009	"	Athens	2	3	2	2	3
39013	"	Belmont	3	3	3	2	2
39015	"	Brown	2	2	2	3	3
39025	"	Clermont	2	2	4	2	2

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
39025	Ohio	Clermont	2	2	4	2	2
39031	"	Coshocton	3	1	3	3	3
39033	"	Crawford	3	3	2	1	3
39045	"	Fairfield	3	3	3	3	3
39047	"	Fayette	3	1	3	1	3
39059	"	Guernsey	3	3	3	2	3
39061	"	Hamilton	4	4	4	4	4
39065	"	Hardin	3	1	3	1	3
39067	"	Harrison	2	2	3	2	2
39071	"	Highland	3	2	3	1	3
39075	"	Holmes	3	2	2	1	1
39081	"	Jefferson	2	1	4	2	2
39083	"	Knox	3	1	3	1	3
39087	"	Lawrence	2	2	2	2	2
39097	"	Madison	3	3	2	1	1
39107	"	Mercer	3	1	3	1	3

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
39111	Ohio	Monroe	2	2	2	2	3
39115	"	Morgan	2	2	2	2	2
39117	"	Morrow	2	1	2	1	2
39119	"	Muskingam	2	2	2	2	2
39121	"	Noble	2	2	2	2	2
39127	"	Perry	2	2	2	2	2
39131	"	Pike	2	2	2	2	3
39145	"	Scioto	2	2	2	2	2
39159	"	Union	3	1	3	1	3
39165	"	Warren	2	3	4	1	2
39167	"	Washington	3	3	3	2	2
42005	Penn.	Armstrong	2	2	2	2	2
42007	"	Beaver	2	2	1	2	2
42019	"	Butler	2	2	2	2	2
42031	"	Clarion	2	2	2	2	2

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
42033	Penn.	Clearfield	2	2	2	2	2
42047	"	Elk	2	1	2	2	2
42059	"	Greene	2	2	2	2	2
42063	"	Indiana	2	2	2	2	2
42065	"	Jefferson	2	1	2	2	2
42073	"	Lawrence	2	2	2	3	2
42085	"	Mercer	2	2	2	2	2
42111	"	Somerset	2	2	2	2	2
42121	"	Venango	2	1	2	2	2
42125	"	Washington	2	2	2	2	2
54009	W. Vir.	Brooke	3	1	3	3	2
54011	"	Cabell	3	3	3	2	3
54019	"	Fayette	2	2	2	2	2
54035	"	Jackson	2	3	2	2	2
54053	"	Mason	2	2	2	2	2

Table B-8 (cont'd)

Fips Code	State	County	All Variables	Housing	Income	Population	Employment
54059	W. Vir.	Mingo	2	3	2	2	2
54069	"	Ohio	3	3	1	3	3
54073	"	Pleasants	2	3	2	2	2
54091	"	Taylor	3	2	2	2	2
54095	"	Tyler	2	3	3	2	2
54099	"	Wayne	2	2	2	2	3
54103	"	Wetzel	2	3	3	2	2
54107	"	Wood	3	3	3	2	2

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APPENDIX B

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Appendix C

Memo from S. Gordon and A. Graham to Core and Management teams concerning ORBES Labor Impact Model, June 19, 1979.

OSU

The Ohio State University

Department of City
and Regional Planning
289 Brown Hall
190 West 17th Avenue
Columbus, Ohio 43210
Phone 614 422-6046

June 19, 1979

MEMORANDUM

TO: ORBES Core and Management Teams

FROM: Steve Gordon and Anna Graham

SUBJECT: ORBES Labor Impact Model

I. Introduction

The purpose of this memo is to explicate the methods and data sources used to develop the ORBES labor impact model and to demonstrate how our manpower estimates compare with other modeling efforts.

Our requests to the Advisory Committee for actual manpower data were answered only by Jene L. Robinson of the Illinois Power Company (abstracts of existing reports), Dana Limes of Columbus and Southern Ohio Electric (portions of EIS's and Conesville scrubber operation employment) and J.J. Albert of ECAR (man-years per megawatt figures for four plants and other information - see attached correspondence). Other sources of data used to develop the labor impact model are:

- .Environmental Reports
- .Environmental Impact Statements
- .Published Reports and Handbooks
- .B. von Rabenau's ORBES Support Study (forthcoming)
- .The Energy Supply Planning Model (ESPM), Bechtel Corp.
- .Construction Manpower Demand System (CMDS), U.S. Dept. of Labor

The complete data base with references is shown in Tables 1-3.

The data taken from ECAR, ESPM and CMDS were used to develop our impact model and to compare with our model results. Specifically, we have compared:

1) ECAR's estimates of man-year per megawatt of net capability for scrubber and non-scrubber coal plants, and nuclear plants with the estimates used in our model for the same types of plants;

Table 1
Available Data on Manpower Requirements for Coal-Fired Electric Power Plants

Plant Name	Source	Nameplate MW[a]	Number Units	Years Lag Time[a]	Scrubbers	Operation Manpower Total	Operation Manpower Person yrs./MW
Conesville	Limes (8)	1995	6	-	part	412	.21
East Bend 1 & 2	EIS (9)	1200	2	4	no	80	.07
Gavin	Rabenau (26d)	2600	2	1	no		
Ghent 1	Rabenau (26c)	550	1	-	no		
Ghent 2	Rabenau (26c)	550	1	-	no		
Ghent 3 & 4	Rabenau (26c)	1100	2	2	no		
Killen	Rabenau (26b)	1200	2	3	no	150	.13
Merom	Gordon and Darling (14)	980	2	1	yes	120	.12
New Haven	FEIS (20)	1300	1	-	?	150	.12
Pleasants	FEIS (11)	1252	2	1	?	140	.11
Rockport	ER (1)	2600	2	1	no	335	.13
Seward 7	ER (13)	690[c]	1	-	yes	245	.36
Spurlock 2	FEIS (12)	500	1	-	yes		
Trimble	FEIS (23)	2340	4	-	yes	350	.15

Notes:
a. Nameplate MW and on-line dates for individual units taken from Electrical Generating Unit Inventory 1976-1986, by Steven D. Jansen for ORBES, November 1978.
b. Total person-years was derived by multiplying the average number of workers per year times the construction period.
c. Total MW for this plant taken from Environmental Report for Seward Generating Station, Unit 7 by General Public Utilities Corporation, October 1977.

Table 1 (continued)
Available Data on Manpower Requirements for Coal-Fired Electric Power Plants

Plant Name	Construction Manpower		Construction Schedule								
	Total	Person yrs./MW	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Conesville											
East Bend 1 and 2											
Gavin	7139	2.75	229	1215	2958	2383	354				
Ghent 1	1382	2.51	31	190	560	559	42				
Ghent 2	1103	2.01	12	65	286	587	153				
Ghent 3 and 4	2518	2.29	56	307	834	947	365	9			
Killen	2530	2.11	130	300	400	400	400	400	250	250	
	2330	1.94	30	75	125	150	350	450	350	350	100
Merom	3016	3.08	48	400	730	875	825	138			
New Haven											
Pleasants	4123[b]	3.29									
Rockport	8404	3.23	466	756	2225	2988	1819	150			
Seward 7											
Spurlock 2	1100[b]	2.20									
Trimble											

Notes: b. Total person-years was derived by multiplying the average number of workers per year times the construction period.

Table 2 (part I)

Available Data on Manpower Requirements for Nuclear Electric Power Plants

Plant Name	Source	Nameplate MW[a]	Number Units	Years Lag[a]	Operation Manpower Total	Operation Manpower py/MW
Erie[b]	Ohio Edison (2)	2400	2	2	253	.11
Limerick	Isard (15a)	2130	2	2	125	.06
Marble Hill	Rabenau (26c)	2260	2	2	155	.07
Susquehanna	PP&L (17)	2100	2	2		
Zion[c]	Isard (15b)	2196	2	1	186	.08
3-Mile Island	Rabenau (26a)	1745	2	4		

Table 2 (part II)

Plant Name	Construction Manpower Total	Construction Manpower py/MW	Construction Schedule Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Erie	14764[b]	6.15[b]	372	1693	2380	2615	2658	2208	1967	817	54	
Limerick	8810	4.14	100	1100	2460	2500	1900	600	150			
Marble Hill	8215	3.63	7	180	923	1820	2154	1864	244			
Susquehanna	11950	5.69	300	1800	2300	2500	2400	1500	800	250	100	
Zion	6441[c]	2.93[c]	169	674	1174	1843	1363	1058	160			
3-Mile Island	13400	7.68	600	1500	2500	2000	1500	2000	1500	900	500	400

Notes: a. (same as on Table 1)
b. Schedule figures and total person-years are yearly peaks and not averages.
c. An additional 20% manpower was added to the original manpower figures to account for supervisory personnel.

Table 3

Data Available from ECAR, U.S. Dept. of Labor and Bechtel Corporation

<u>ECAR</u>

Plant A - 2 coal-fired units with scrubbers on a new site	4.0 person-years per net MW capacity
Plant B - 2 coal-fired units without scrubbers on a new site	3.23 person-years per net MW capacity
Plant C - 2 coal-fired units without scrubbers on existing site	2.17 person-years per net MW capacity
Plant D - 2 coal-fired units without scrubbers on existing site	2.72 person-years per net MW capacity
Plant E - 2 nuclear units on a new site	3.64 person-years per net MW capacity

<u>CMDS, U.S. Department of Labor</u>

1) 600 MW coal-fired plant with scrubbers	9.64 workhours per kilowatt (1977) 10.43 workhours per kilowatt (1981)
2) 600 MW coal-fired plant without scrubbers	7.99 workhours per kilowatt (1977) 8.64 workhours per kilowatt (1981)
3) 1243 MW coal-fired plant with scrubbers	8.10 workhours per kilowatt (1977) 8.76 workhours per kilowatt (1981)
4) 1243 MW coal-fired plant without scrubbers	6.73 workhours per kilowatt (1977) 7.28 workhours per kilowatt (1981)

<u>ESPM, Bechtel Corporation</u>

1) 800 MW coal-fired low Btu plant	5700 thousand workhours
2) 800 MW coal-fired high Btu plant	4800 thousand workhours

Sources: ECAR correspondence, March 26, 1971
U.S. Dept. of Labor, <u>Forecasts of Cost, Duration and Manual Man-Hour Requirements for Construction of Electric Generating Plants 1977-1981</u>, Construction Manpower Demand System, January 1978.
Bechtel Corporation, <u>Energy Supply Planning Model</u>, Vol. I and II.
PB245 382, PB245 383, (Springfield, Va.: NTIS) 1975.

2) ESPM's total work-hour estimates for an 800 MW coal plant with model results for this size plant; and

3) CMDS's work-hour per kilowatt estimates for a 600 MW and 1243 MW plant with our model results.

These comparisons show that the ORBES labor impact model (with regard to coal data) is fairly consistent with the ECAR data, underestimates labor requirements based on the CMDS model, and slightly underestimates manpower based on the ESPM. There are several problems involved in making these comparisons due to unknown assumptions concerning plant characteristics, the incompatibility of some known characteristics, and the time frame for which the manpower requirements in the other models were derived. The basic data base used to derive our model labor requirements are taken from ER's and EIS's - utility estimates of construction labor demand. This may explain why the ECAR estimates are closer to our model estimates than ESPM or CMDS. The utility estimates of manpower requirements are consistently lower than those of Bechtel (ESPM) or USDOL (CMDL). Our conclusion was that the ORBES labor impact model underestimates labor requirements and that it is necessary to increase the person-year per megawatt estimates used in the model. This increase has been achieved by averaging the model, CMDS and ESPM estimates.

II. Construction Manpower Requirements

The manpower required to construct an electric generating power plant is a function of many factors. Some of these factors are: the plant design, available infrastructure, transportation access, size of the plant, pollution control equipment, water supply and waste removal systems, labor and materials supply, and any legal, political or social constraints. We have derived manpower estimates that vary according to the type of plant (coal or nuclear), the size of the plant (in megawatts), whether the plant contains a single or multiple unit(s) (advantage of sharing costs of site preparation, infrastructure, transportation, water supply and waste removal systems), and the use of scrubbers. By averaging across the schedules of plants on Tables 1 and 2, and by incorporating some of the information provided on Table 3, we should be able to average across all the plant designs and construction conditions that are associated with these plants.

An estimate of person-years (py) per nameplate megawatt (MW) was made for the following conditions:

Type 1.	coal fired	single unit	no scrubbers
Type 2.	coal fired	multiple units	no scrubbers
Type 3.	coal fired	single unit	scrubbers
Type 4.	coal fired	multiple units	scrubbers
Type 5.	nuclear	any number of units	

Although we suspect that the requirements for small units of power stations (less than 400 MW) would be higher per megawatt than the average-sized units (400 to 1000 MW), we have no evidence that this is the case. There are no data available for these units, and, therefore, the model does not take these variations into account.

Coal Units Without Scrubbers

Data for a single unit coal-fired plant without scrubbers were not available. However, we were able to determine, from the information given as part of the Construction Manpower Demand System (CMDS, see Table 3), that a 600 MW plant would require 19% more manpower per megawatt than a 1243 MW plant. Assuming that the 1243 plant is a multiple unit plant and the 600 MW plant, a single unit plant, we have applied the 19% increase to our estimate for a multiple unit coal-fired plant without scrubbers. The basis for these estimates are:

Rockport	2.23 py/MW	(person-years per megawatt)
Killen	2.11 py/MW	
Ghent 3&4	2.26 py/MW	
Gavin	2.75 py/MW	

The average ratio for these plants is 2.59 py/MW. The ratio we will use for single unit plants is then 3.08 py/MW (or 2.59 X 1.19):

Type 1.	coal fired	single unit	no scrubbers	3.08 py/MW
Type 2.	coal fired	multiple unit	no scrubbers	2.59 py/MW

Coal Units With Scrubbers

Data on plants with scrubbers are also scarce. Our two representative plants, Spurlock 2 (2.20 py/MW) and Merom (3.08 py/MW), are not consistent with our non-scrubber estimates because they are too low. The CMDS data on Table 3 indicate a 20.3 to 20.7% increase in manpower required for plants with scrubbers. Data from ECAR can also be used to estimate this percentage increase. However, because ECAR's py/MW figures are for net capacity rather than name-plate, we must first convert their figures to be comparable with ours. Data on Ghent units (non-scrubber) and Seward 7 (scrubbers) will be used to determine the loss of capacity for these two types of plants:

Ghent units-non-scrubber-	gross rating	550 MW
	net rating	525 MW
	loss of capacity	5%
Seward 7-scrubber-	gross rating	690 MW
	net rating	625 MW
	loss of capacity	9%

ECAR's plant A (see Table 3), the scrubber plant, and plant B, the non-scrubber plant, will be assumed to be 1200 MW gross rating. By using the appropriate capacity loss figures above, plant A has a net rating of 1092 and plant B, 1140 MW. The total manpower required for each would be:

plant A   4.0 py/net MW * 1092 MW - 4368 py

plant B   3.23 py/net MW * 1140 MW - 3682 py.

To convert to a py/gross MW figure:

plant A 4368 py/1200 gross MW = 3.64 py/MW

plant B 3682 py/1200 gross MW = 3.07 py/MW.

Finally, the percentage increase in manpower requirements for plant A over B (scrubbers over non-scrubbers) is 18.6%, very close to the CMDS estimates of 20.3-20.7%. The average of these three figures, 19.9%, is used to compute the py/MW estimates for single and multiple unit coal-fired plants with scrubbers:

Type 3.	coal fired	single unit	with scrubbers	3.69 py/MW
Type 4.	coal fired	multiple unit	with scrubbers	3.11 py/MW.

Nuclear Units

The nuclear manpower estimates were derived by averaging data from four nuclear plants on Table 2:

Marble Hill	3.63 py/MW
3 Mile Island	7.68 py/MW
Susquehanna	5.69 py/MW
Zion	2.93 py/MW
Average	4.98 py/MW.

The ratio used in the ORBES labor impact model is therefore:

Type 5. nuclear units   4.98 py/MW

Comparisons with CMDS, EPSM and ECAR

Although we have no exact figures for the number of work hours per person-year, we were able to compute an estimate of 1825 work hours (wh) per person-year from data on the Erie plant. This is equivalent to 36.5 hours per week for 50 weeks, which seems to be reasonable, or at least in the ball park. Using 1825 wh/py as a conversion factor we can compare EPSM's total manpower estimates with our model estimates:

ORBES Labor Impact Model

800 MW coal	non-scrubber	single	2464 py	3.08 py/MW
	scrubber	single	2952 py	3.69 py/MW
	non-scrubber	multiple	2072 py	2.59 py/MW
	scrubber	multiple	2488 py	3.11 py/MW

EPSM

800 MW coal	low Btu	5,700,000 wh	3123 py	3.90 py/MW
	high Btu	4,800,000 wh	2630 py	3.29 py/MW

The EPSM model estimates appear to be slightly higher than ours. There may be several reasons for this:

1) our conversion factor was too low
2) the EPSM estimates are rounded to the nearest hundred thousand worker hours which may indicate very rough estimates and probably overestimates of labor requirements, and
3) the assumptions concerning plant characteristics are not known and may be significant.

Using the same assumptions, we can compare CMDS estimates of manpower requirements with the labor impact model results:

ORBES Labor Impact Model

600 MW coal	non-scrubber	single	1848 py	3.08 py/MW
	scrubber	single	2214 py	3.69 py/MW
1243 MW coal	non-scrubber	multiple	3219 py	2.59 py/MW
	scrubber	multiple	3866 py	3.11 py/MW

CMDS (1977)

600 MW coal	non-scrubber	7.99 wh/kw	2628 py	4.38 py/MW
	scrubber	9.64 wh/kw	3168 py	5.28 py/MW
1243 MW coal	non-scrubber	6.73 wh/kw	4587 py	3.69 py/MW
	scrubber	8.10 wh/kw	5517 py	4.44 py/MW

The CMDS estimates seem extremely high. Note, for instance, that the only plants listed on Table 1 requiring greater than 4,000 person-years are Rockport and Gavin. These two plants are both 2600 MW plants, greater than twice the size of the 1243 MW plant above. Thus, it appears that CMDS overestimates labor requirements. One must consider the fact that the CMDS model is "forecasting" labor requirements to 1977. The estimates of person-year per megawatt used in the ORBES labor impact model are derived from actual and expected manpower requirements for plants built between 1974 and 1999.

According to the Construction Manpower Demand System, labor requirements per megawatt are increasing with time. Ratios are presented for two years, 1977 and 1981 (See Appendix). We do not know if the manpower estimates reported by the utilities and used to derive the ratios for the ORBES model were developed based on current or projected requirements per megawatt. However, even if we backfit the CMDS ratios to 1969 the results are still higher than the ORBES model results, for example:

600 MW	coal	non-scrubber	3.67 py/MW
1243 MW	coal	non-scrubber	3.08 py/MW.

The ECAR data is presented in Table 3. These figures are for 2-unit plants, differentiated according to 'new' or 'existing' sites. ECAR labor requirements are listed per megawatt net capability rather than nameplate (as we have used in the ORBES labor impact model). The difference between nameplate and net ratings was shown in the previous section on scrubber plants. The ORBES labor impact model differentiates between single unit plants and multiple unit plants: - single unit plants are those that contain only one unit and are on a site to themselves - a new site.

- multiple unit plants include all those units which are on a site that is currently or will be used for additional units.

For the model, units are considered separately due to the wide variation in lag time between units. The ECAR labor requirement ratios for 2-unit plants on an existing site would be too low to compare with ours directly and the labor requirement ratios for new sites could be too high (some plants have more than 2 units on a site). For comparison purposes we have listed the ECAR ratios for <u>nameplate</u> megawatt ratings below:

ECAR

plant A	coal fired	2-unit	scrubbers	new site	3.64 py/MW
plant B	coal fired	2-unit	no scrubbers	new site	3.07 py/MW
plant C	coal fired	2-unit	no scrubbers	existing site	2.06 py/MW
plant D	coal fired	2-unit	no scrubbers	existing site	2.58 py/MW

The average ratio of plants B, C and D will be used to compare with the averaged non-scrubber ratios in the ORBES model. This ECAR non-scrubber average is 2.57 py/MW. Considering that the difference between the ratios for a new and an existing site is approximately 24% (from ECAR data above), the contrived ratio for a scrubber plant on an existing site would be 2.77 py/MW (76% of 3.64). The average of the ECAR scrubber ratios is then 3.21 py/MW.

ECAR

1) coal-fired two-unit average non-scrubber ratio 2.57 py/MW
2) coal-fired two-unit average scrubber ratio 3.21 py/MW

The comparable ORBES labor impact model averages are listed below:

ORBES Labor Impact Model

	coal-fired	single unit	non-scrubbers	3.08 py/MW
	coal-fired	multiple unit	non-scrubbers	2.59 py/MW
1)	coal-fired	average	non-scrubber	2.84 py/MW
	coal-fired	single unit	scrubber	3.69 py/MW
	coal-fired	multiple unit	scrubber	3.11 py/MW
2)	coal-fired	average	scrubber	3.40 py/MW

The labor impact model averages are slightly higher than those of ECAR but they are quite close.

The ratio used in the ORBES model for nuclear units is 4.98 py/MW. ECAR's only example of nuclear plant has a ratio of 3.64. The wide discrepancy here might be expected since the variation between the ratios of plants used to compute the model ratio was extremely great as well (2.93 to 7.68 py/MW). We have no other comparisons for nuclear plants.

Conclusions

Both the CMDS and the ESPM manpower estimates for coal fired plants are higher than those of ECAR or the ORBES impact model. Both ECAR and the ORBES impact model estimates were derived primarily or entirely from manpower data provided by utilities themselves. It is hypothesized that utilities may be consistently underestimating manpower requirements. We think it is necessary to revise our model estimates for coal plants to account for this apparent bias in our data. To do this we first computed a combined ratio for the labor impact model, CMDS, ESPM, and CMDS plus ESPM:

	model	ESPM	CMDS	CMDS + ESPM
	3.08	3.90	4.38	3.60
	3.69	3.29	5.28	4.45
	2.59		3.69	
	3.11		4.44	
combined ratio	3.12 py/MW	3.60 py/MW	4.45 py/MW	4.03 py/MW

The average of the combined ratios for the model (3.12) and CMDS + ESPM (4.03) was 3.58 py/MW. This average is 14.6% higher than the original combined ratio for the model so the components of the combined ratio will be adjusted upward by this amount. Finally, the ratios used in the ORBES labor impact model for coal-fired units are:

Type 1	single unit	non-scrubber	3.53 py/MW
Type 2	multiple unit	non-scrubbers	2.97 py/MW
Type 3	single unit	scrubbers	4.23 py/MW
Type 4	multiple unit	scrubbers	3.56 py/MW

Note that these figures are now comparable to those of the ESPM and roughly halfway between those of CMDS and ECAR. The ratio used in the ORBES model for nuclear units will remain the same because it was decided that one comparison was not enough to require revision. This ratio is:

Type 5 nuclear units 4.98 py/MW.

III. Construction Schedules

The length of time it takes to build a plant also varies, not only because of plant characteristics but because of outside influences such as labor and material supply, strikes, government regulations or citizen opposition. The best we can do here is to review our data base for appropriate construction periods. Units of a plant are considered separately due to the variation in lag time between construction of each individual unit (0-5 years). The construction periods chosen are:

a) coal fired units less than 1000 MW 5 years
b) coal fired units 1000 MW or more 6 years
c) nuclear units all sizes 7 years

The distribution of person-years over the construction period was derived by taking the average of the distributions of representative plants (see table 4).

Table 4
Distribution of Person-Years for Construction Periods of Coal and Nuclear Power Plants

Construction Period	Plant Name	Percent of Total Workforce by Year 1	2	3	4	5	6	7
5 years	Ghent 1	2.2	13.7	40.5	40.4	3.0		
	Gavin	3.2	17.0	41.4	33.4	5.0		
	Average	2.7	15.4	41.0	36.9	4.0		
6 years	Rockport	5.5	9.0	26.5	35.5	21.6	1.8	
	Ghent 3&4	2.2	12.2	33.1	37.6	14.5	0.4	
	Merom	1.6	13.2	24.2	29.0	27.3	4.6	
	Average	3.1	11.5	27.9	34.0	21.2	2.3	
7 years	Limerick	1.1	12.5	27.9	28.4	21.6	6.8	1.7
	Zion	2.6	10.5	18.2	28.6	21.2	16.4	2.5
	Average	1.9	11.5	23.0	28.5	21.4	11.6	2.1

IV Operation and Maintenance Employment

The operation and maintenance employment is also derived by using a ratio of person-years per megawatt. The ratio used for all coal units without scrubbers is .12 py/MW, the average of the following:

Rockport	.13 py/MW
Killen	.13 py/MW
Chent 3&4	.09 py/MW.

For coal plants with scrubbers the ratio is .21 person-years per megawatt, taken from the average of:

Seward 7	.36 py/MW
Trimble	.15 py/MW
Merom	.12 py/MW.

For purposes of comparison, Dana Limes of C&SOE provided us with the operation manpower requirements for the scrubber system of a unit at the Conesville plant. For a gross rating of 800 MW the scrubber system required approximately 19 operators per shift and 13 administrative and maintenance personnel (not including sludge stabilization personnel). This can be restated as 70 person-years (assuming 3 shifts) or .09 py/MW.

In a report on FGD system costs by Battelle Columbus Laboratories (6, p. 76), Louisville Gas and Electric data for the Cane Run plant show that 1.5 persons per shift per 100 MW of scrubber capacity is needed for operation of its scrubber, excluding supervisors and lime unloading. So, at a minimum, 4.5 workers per 100 MW or .045 py/MW are required to operate the scrubber system of the plant for three shifts a day.

Manpower requirements for operation of a scrubber system will vary with the type of system, the amount of scrubber material required, the sludge or waste disposal methods utilized, etc. Since our scenarios do not specify the exact scrubber methods to be used in the plants, an average figure will be sufficient. The C&SOE and Battelle data indicate that at least .045 to .09 py/MW is needed to run a scrubber system. Our average of .21 py/MW for the total operation workforce of a scrubber plant is .09 py/MW greater than the ratio used for non-scrubber plants (.12 py/MW). The ratio used in the labor impact model, therefore, appears to be reasonable.

The ratio used for nuclear plants is the average of:

Marble Hill	.07 py/MW
Erie	.11 py/MW
Average	.09 py/MW.

To summarize, three ratios were estimated for operation and maintenance personnel requirements:

1) coal-fired no scrubbers .12 py/MW
2) coal-fired scrubbers .21 py/MW
3) nuclear .09 py/MW

V. Construction Skill Requirements

The labor impact model, in addition to estimating the total manpower requirements for power plant construction, also provides an estimate of the regional labor demand by skill for each year of the scenario. Seven skill categories (plus the category 'other') were chosen for this purpose. The percentage of total workforce that each skill represents is shown on Table 5. The skill breakdown for coal units was taken from data on the Gavin plant (25d) and from ECAR (correspondence attached); for nuclear units, the Zion plant data was used (15b).

Table 5
Skill Categories for Coal and Nuclear Power Plants
As a Percent of Total Workforce

Skill Category	Coal	Nuclear
Boilermakers	16.6%	7.2%
Pipefitters	16.9	28.7
Electricians	15.5	12.5
Laborers	12.1	17.4
Iron Workers	8.2	9.7
Carpenters	6.9	7.9
Operating Engineers	7.9	7.9
Other	15.9	8.7
Total	100.0%	100.0%

VI. Summary

To summarize we have put together several tables showing the ORBES labor impact model results when applied to the ORBES 'standard' units of a coal or nuclear plant. There are five tables, one for each of the following conditions:

Table 6	Type 1.	coal fired	single unit	no scrubbers	650 MW
Table 7	Type 2.	coal fired	multiple unit	no scrubbers	650 MW
Table 8	Type 3.	coal fired	single unit	scrubbers	650 MW
Table 9	Type 4.	coal fired	multiple unit	scrubbers	650 MW
Table 10	Type 5.	nuclear	single unit		1000 MW

SG/AG/br
cc: Owen Lentz and J.J. Albert (ECAR), Dana Limes (C&SOE), Dane Mazzitti (AEP), John Barcalow and Jene L. Robinson (Illinois Power Co.)
encl.

Table 6
Type 1. Coal-fired, Single Unit, Non-scrubber, 650 MW

Total Manpower Requirements:

3.53 py/MW * 650 MW = 2295 py

Construction Schedule:

Year 1	Year 2	Year 3	Year 4	Year 5
62	353	941	847	92

Operation and Maintenance Manpower:

.12 py/MW * 650 MW = 78 py

Construction Skill Requirements

Boilermakers	381
Pipefitters	388
Electricians	356
Laborers	278
Iron Workers	188
Carpenters	158
Operating Engineers	181
Other	365
Total	2295

Table 7

Type 2. Coal-fired, Multiple Unit Plant, No Scrubbers, 650 MW

Total Manpower Requirements:

2.97 py/MW * 650 MW = 1931 py

Construction Schedule:

Year 1	Year 2	Year 3	Year 4	Year 5
52	297	792	713	77

Operation and Maintenance Manpower:

.12 py/MW * 650 MW = 78 py

Construction Skills:

Boilermakers	321
Pipefitters	326
Electricians	299
Laborers	234
Iron Workers	158
Carpenters	133
Operating Engineers	153
Other	307

Table 8

Type 3. Coal-fired, Single Unit, Scrubbers, 650 MW

Total Manpower Requirements:

4.23 py/MW * 650 MW = 2750 py

Construction Schedule:

Year 1	Year 2	Year 3	Year 4	Year 5
74	424	1127	1015	110

Operation and Maintenance Manpower:

.21 py/MW * 650 MW = 137 py

Construction Skills:

Boilermakers	457
Pipefitters	465
Electricians	426
Laborers	333
Iron Workers	226
Carpenters	190
Operating Engineers	217
Other	436

Table 9

Type 4. Coal-fired, Multiple Unit Plant, Scrubbers, 650 MW

Total Manpower Requirements:

3.56 py/MW * 650 MW = 2314 py

Construction Schedule:

Year 1	Year 2	Year 3	Year 4	Year 5
62	356	949	854	93

Operation and Maintenance Manpower:

.21 py/MW * 650 MW = 137 py

Construction Skills:

Boilermakers	384
Pipefitters	391
Electricians	359
Laborers	280
Iron Workers	190
Carpenters	160
Operating Engineers	183
Other	367

Table 10
Type 5. Nuclear, 1000 MW

Total Manpower Requirements:

4.98 py/MW * 1000 MW = 4980 py

Construction Schedule:

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
95	573	1145	1419	1066	578	104

Operation and Maintenance Manpower:

.09 py/MW * 1000 MW = 90 py

Construction Skills:

Boilermakers	359
Pipefitters	1429
Electricians	623
Laborers	867
Iron Workers	483
Carpenters	393
Operating Engineers	393
Other	433

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Appendix D

Materials on Other Labor Impact Models

OWEN LENTZ, Executive Manager

ECAR

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May 7, 1979

Mr. Steve Gordon
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Dear Steve:

This is in response to your letter of April 2, 1979. First let me say that my comment that there were no "real life" equivalents in ECAR must be viewed in its proper perspective. I initiated my data gathering effort following your request for a review of the information contained in Table IV of your May 22, 1978, memorandum entitled, "Analysis of The Impacts of the NEP Scenario." My comment applied to the 1,000 MW unit size which was selected for that particular analysis and was not meant to reflect on current ORBES scenarios. You may recall that when I contacted you in early June 1978 for additional information on the data sources used for your scenario, you indicated that precise construction manpower figures would have little if any impact on your results. Thus, I did not feel that there was any urgent need for the information which I was attempting to develop.

The information which you forwarded on June 14, 1978 identified the sources for the alternative plant schedules used in your analysis, although it did not identify which source went with which plant development. All of the sources identified in your memorandum were not available to me, but I was successful in obtaining the information provided by Mr. R. M. Winston, Jr. of Kentucky Utilities with respect to the Ghent Plant. As noted in my March 26 letter, it appeared that the data set which you developed for the Ghent station was based on the unit gross rating of 556 MW rather than the 525 MW net rating.

Answers to the specific questions raised in your April 2, 1979, letter are as follows:

1. The figures which I provided are based on the total net rating for the two-unit developments. As noted during

our recent telephone conversation, you should expect a minimum difference of five percent in the net rating for two otherwise identical units when one unit is equipped with a scrubber and the other is not. In addition, the unit with the scrubber may require certain other facilities that are unique to the site. This could include, for example, facilities for the unloading, storing, and handling of limestone, as well as special sludge handling facilities. The auxiliary power requirements for these facilities at some sites may be substantial.

2. When I undertook this task, it was my intent to determine whether or not the numbers which appeared in your May 22, 1978, memorandum were reasonable. As such, I did not consider a plot of the manpower requirements during the very early stages and the final stages of construction as being particularly significant for my purposes. Thus the graph which I provided was intended to illustrate significant differences during the construction period and did not indicate some of the early work at new site developments where very few construction workers were involved. I took this liberty because comparable data was not specifically identified at the existing site developments although I was assured that it was reflected in the total manpower figures. Thus, your original information on construction periods was correct.

3. I do not have any data for single unit plants, nor do I have any information on units in the 100 to 400 MW size range. It would be reasonable to expect, however, that the man-years per megawatt for the smaller units would be somewhat higher than that shown for the larger size units.

4. Plant A is the only unit equipped with scrubbers. Plants B, C, D, and E do not have scrubbers

5. The only plant for which information was available with respect to craft breakdowns was Plant D. Therefore, I can only speculate about the breakdown for the other plants in this sample. I can say, however, that the craft requirements for a particular plant are a function of the plant design. A plant which utilizes steam-driven boiler feed pumps would require more boiler makers and pipe fitters than would a plant which utilizes electric motor driven boiler feed pumps. The latter plant, in turn, would have a greater requirement for electricians than for boiler makers and pipefitters. I feel confident that the differences which you noted can be attributed to such factors. Plants are different and you should expect that the craft requirements will also be different.

Very truly yours,

J. J. Albert
J. J. Albert
Staff Engineer

JJA:dlw
cc: J. J. Stukel, ORBES Project Office

OSU

The Ohio State University

Department of City
and Regional Planning
289 Brown Hall
190 West 17th Avenue
Columbus, Ohio 43210
Phone 614 422-6046

April 2, 1979

J.J. Albert
Staff Engineer
ECAR
P.O. Box 102
Canton, Ohio 44701

Dear Mr. Albert:

Thank you for your letter of March 26 detailing the manpower requirements for power plant construction. We have a number of questions regarding these data. First, we question your assumption that the plants envisioned in the ORBES scenarios have no "real life" equivalents in ECAR. In reviewing the data you have supplied in the context of the ORBES generic plants, it would appear that they are indeed extremely similar. Can you explain in more detail why you feel that our scenarios are not representative? We have attached a description of our generic plants.

Several other more specific questions arise in reviewing your figures:

1) Plant A and B are similar plants with the major difference that plant A has scrubbers and plant B does not and that plant B has four additional months between on-line dates. Your figures indicate a 23.8% increase in manpower/MW for plant A. Our contact with Columbus and Southern Ohio Electric and review of impact statements shows this to be a quite a bit larger difference than we would have expected. Can you give us a better idea where these figures were derived, their degree of reliability, and any potential sources of difference between plants leading to a range of differences around your figures?

2) Though we do not know the total megawatt size of the plants used for deriving your figures (this would, by the way, be quite helpful) we assume that they are large units (approx. 400-800 MW each). The construction periods as noted on your graph show, for coal-fired two unit plants, a construction period of 19-22 quarters, 57-66 months or approximately 5-5 1/2 years. Thus, construction period for a single unit plant would be in the neighborhood of 4 years. Can we assume these are correct? Analysis of our generating unit inventory, reviewed by each utility

in ORBES, shows that many units required a five year period for a single unit and 6 years for a two unit plant. This is illustrated by Attachment 1. Please comment on the relationship between these data and your own.

3) Do you have any data for smaller single unit plants (100-400 MW in size)? Are the man years/MW required higher for these smaller units than for the average sized unit (i.e. 401-800 MW)?

4) Should we assume that Plants C and D have no scrubbers?

5) Your craft breakdown data differ slightly from those of two other plants for boiler makers and electricians. This is shown in Attachment 2. What are the possible reasons for these differences? Is it because Plant D was built on an existing site? Would there be any but minor differences in the distribution of crafts for your other example plants?

We would appreciate a prompt reply to these questions so that we may incorporate the data you have supplied into our analysis.

Sincerely,

Steven I. Gordon
Asst. Professor

SIG/br
encl.

cc: J.J. Stukel
Owen Lentz

Attachment 1
Coal-Fired Plants Reviewed

Plant Name	#Units	Interval (years)	Construction Period (Years)	Scrubbers	Nameplate[e] MW	Source
Cheswick	1	-	5	no?	570	a
Killen	2	3	8-9	no	1200	a,b
Montour	2	1	6	no?	1625	a
Ghent 1	1	-	5	no	550	a,b
Ghent 2	1	-	5	no	550	a,b
Ghent 3 & 4	2	2	6-7	no	1100	a,b
Gavin	2	1	5	?	2600	a
Merom	2	1	5-6	yes	980	b,c
Spurlock #2	1	-	4 1/2	?	500	b
New Haven	1	-	4 1/2	no	1300	d
Pleasants	2	1	7	?	1252	b
Patriot	2	?	9-10	yes	1300	a,c

Sources:

a Preliminary data collected by B. v. Rabenau for ORBES Support Study on Induced Migration.

b Final Environmental Impact Statements.

c John Gordon and David Darling, The Economic Impact of the Hoosier Energy Plant on Sullivan County, Indiana. CES Paper No. 14, November, 1976, Purdue University.

d Draft Environmental Impact Statement

e Steven D. Jansen, Electrical Generating Unit Inventory 1976-1986 Ohio River Basin Energy Study Region Phase II March, 1978, Preliminary Report.

Attachment 2
Boilermakers and Electricians as a Percentage
of Construction Workforce

Plant	Boilermakers	Electricians
ECAR	19%	14%
Gavin	14.9%	18.8%
Patriot	14.0%	18.2%

Source: B. v. Rabenau, "Chapter II - Scheduling of Construction and Operations Labor Force for Energy-Related Facilities" of ORBES Support Study still in progress.

ORBES Phase II Standard Units

Coal Fired Unit

--650 MWe installed capacity

--198 meter (650 foot) stack height

--30.47 meters per second (100 feet per second) exit velocity

--338 K (65 C, 150 F) exit gas temperature

--7.8 meter (25.6 foot) stack diameter

--10,200 Btu per kilowatt hour heat rate

--if 2 units, a common stack is used

--1.2 pounds of SO_2 per 1,000,000 Btu (for siting purposes)

--0.1 pounds of particulates per 1,000,000 Btu (for siting purposes)

Nuclear-Fueled Unit

--1,000 MWe installed capacity

--both pressurized and boiler water reactors will be considered in a ratio of nine to one

--material and requirements as specified in the Teknekron standard plants handed out at the Core Team meeting of 5/4-5/78 (Nashville); this includes major raw materials input, major finished product output and air, water and solid wastes

--in conformance with existing regulatory constraints

Source: Minutes of Core Team Meeting, Columbus, Ohio January 4-5, 1979

OWEN LENTZ, Executive Manager

ECAR

EXECUTIVE OFFICE: P. O. BOX 102, CANTON, OHIO 44701
PHONE (216) 456-2488

March 26, 1979

Mr. Steve Gordon
Ohio State University
Department of City & Regional Planning
289 Brown Hall
190 West 17th Avenue
Columbus, Ohio 43210

Dear Steve:

I contacted a number of utilities in the ECAR region, per your request, to obtain information that would be suitable for developing realistic construction manpower estimates for the Ohio River Basin Energy Study (ORBES). It was obvious that there have been no "real life" plant developments in ECAR of the type envisioned in the ORBES scenarios so I was forced to concentrate my efforts on obtaining representative data that had been reduced to a common base so that significant differences could be readily identified. The information deemed suitable for this purpose was obtained from various sources within the ECAR member systems. It was necessary to supplement the initial data response in order to assure a uniform base and to verify the significant differences.

I also reviewed the information which you included in your memorandum dated June 14, 1978. It appears that the manpower rate that you developed from the data provided for the Ghent Station of Kentucky Utilities is based on the unit gross rating of 556 MW. ECAR records show that the net demonstrated rating for the first two units at Ghent is 525 MW each. Since the electrical requirement for plant auxiliary equipment is charged to the plant operation and since the electrical demand for these auxiliaries is a function of the plant design, the difference between net and gross ratings is variable and can be significant. All of the construction manpower figures which I have developed are based on the net rating.

The information that was available for this analysis was for two-unit plant developments and each of these developments had significant differences in terms of the facilities provided. The results have been summarized as follows:

Plant A - 4.0 construction man-years per megawatt of net capability.

Two coal-fired units at a new site with 12-month interval between operating dates of the units. These units are equipped with cooling towers and scrubbers. Facilities which must be provided at a new site include such items as coal unloading, coal handling, water intake structures, ash and sludge disposal areas, potable water supply, sanitary facilities, laboratory and office equipment, building crane, and maintenance equipment. Site development requirements include such items as grading, access roads, and landscaping.

Plant B - 3.23 construction man-years per megawatt of net capability.

Two coal-fired units at a new site with 16-month interval between operating dates of the units. These units have cooling towers but do not have scrubbers. The new site development requirements are comparable to those of Plant A.

Plant C - 2.17 construction man-years per megawatt of net capability.

Two coal-fired units at an existing site with 12-month interval between the operating dates of the units. These units have a once-through cooling cycle and utilize the same coal unloading facilities as the existing units. This development did require limited additions to the existing coal handling and ash disposal facilities.

Plant D - 2.72 construction man-years per megawatt of net capability.

Two coal-fired units at an existing site with 18-month interval between operating dates of the units. These units have cooling towers and did require limited additions to the existing coal handling facilities.

Plant E - 3.64 construction man-years per megawatt of net capability

Two nuclear units at a new site with 16-month interval between operating dates of the units. These units have cooling towers and the manpower figure includes the site development requirements associated with a nuclear plant.

The attached figure depicts the distribution of the manpower requirements during the construction period. These plots must be interpreted in light of the significant differences that were identified above. Remember, too, that the manpower requirements are based on a two-unit installation. This inherently provides some opportunity for more efficient use of manpower by crafts than can be realized with a one-unit project. I have also included a table which gives an estimated breakdown of the construction man-power, by crafts, for the Plant D development.

I trust that this information will prove adequate for your requirements. I apologize for taking so long to respond to your request but the press of normal work duties did not permit an earlier completion.

Very truly yours,

J. J. Albert

J. J. Albert
Staff Engineer

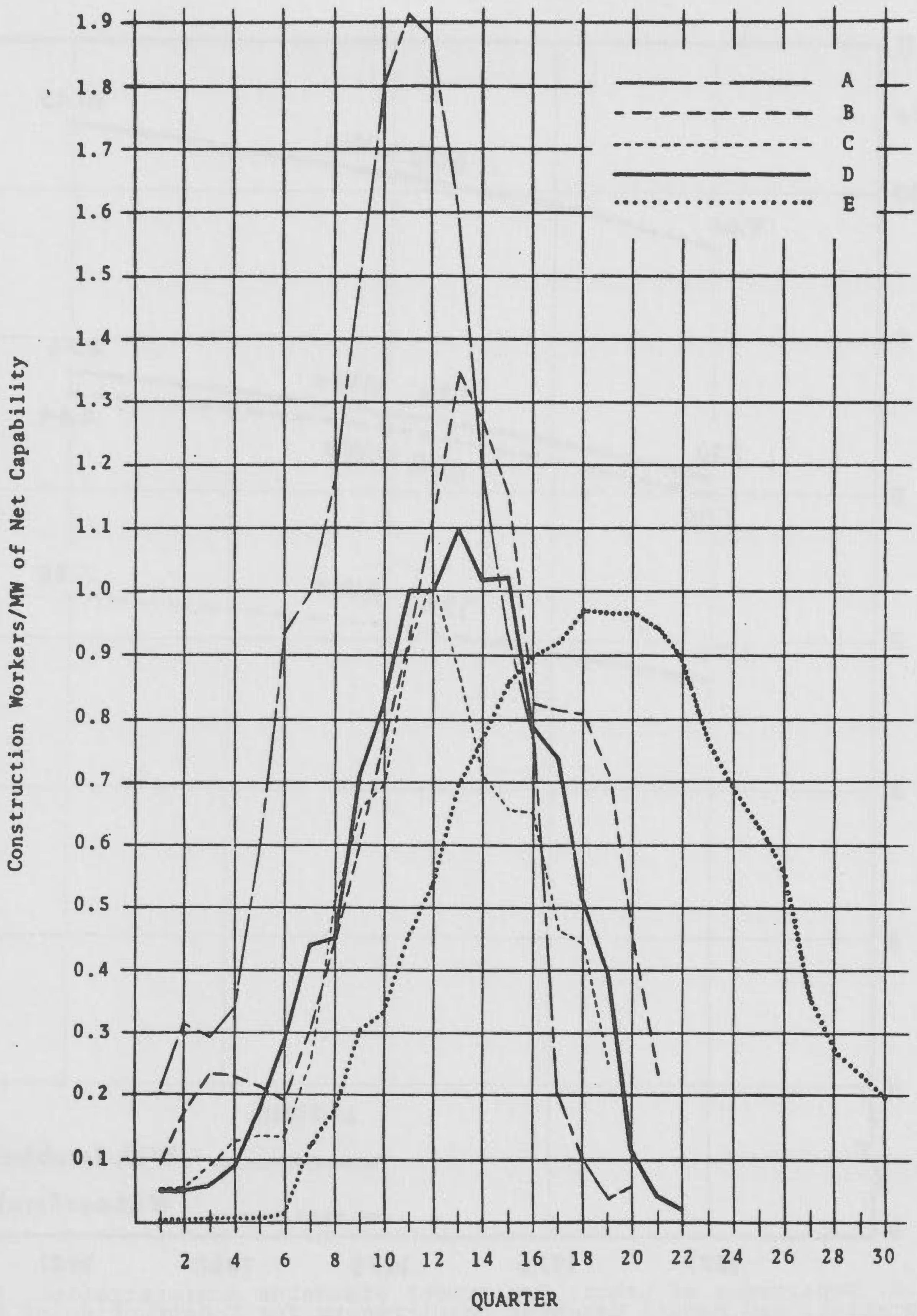
JJA:dlw

cc: J. J. Stukel, ORBES Project Office
O. A. Lentz, ECAR

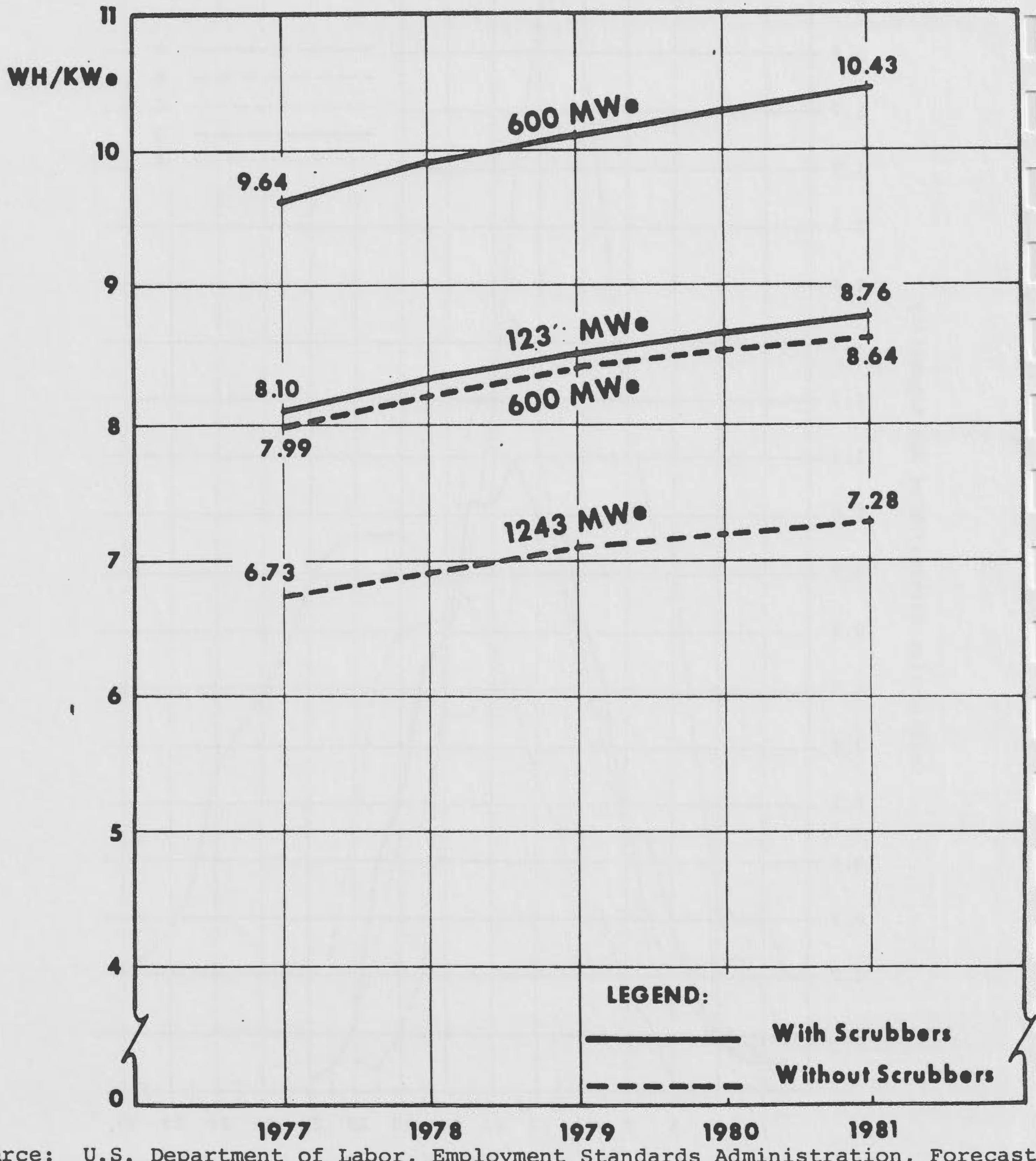
ESTIMATED CONSTRUCTION MANPOWER REQUIREMENTS BY CRAFTS

CRAFT	% OF TOTAL MANHOURS
Carpenters	6%
Laborers	7%
Operating Engineers	7%
Iron Workers	11%
Boiler Makers	19%
Pipe Fitters	18%
Electricians	14%
Millwrights	4%
Insulators	4%
Other	10%
	100%

ECAR
GENERATING STATION
CONSTRUCTION MANPOWER REQUIREMENTS
(2-UNIT DEVELOPMENTS)



Forecasted Work-Hours per Kilowatt in the Construction of Coal-fired Power Plants, United States



Source: U.S. Department of Labor, Employment Standards Administration, Forecasts of Cost, Duration, and Manual Man-Hour Requirements for Construction of Electric Generating Plants, 1977-1981, Jan. 1978.

ESPM Information

· ENERGY FAC ,TY INVESTMENT RESOURCES 02/28/79

50 SOLID WASTE COLLECTION/SEPARATION PT.(335 T/D)
51 OIL-FIRED POWER PLANT (800 MWE)
52 RECONVERSION OF OIL PLANT TO COAL (250 MWE)
53 COAL FIRED POWER PLANT-LOW BTU (800 MWE)
54 COAL FIRED POWER PLANT-HIGH BTU (800 MWE)
55 COAL/WASTE POWER PLANT-LO BTU COAL (350 MWE)
56 COAL/WASTE POWER PLANT-HI BTU COAL (350 MWE)

CONSTRUCTION LABOR REQUIREMENTS (THOUSAND PERSON-HOURS)

		50	51	52	53	54	55	56
53	CHEMICAL ENGINEERS	0,000	0.000	0,000	0.000	0.000	0.000	0.000
54	CIVIL ENGINEERS	2,200	148.000	0,600	208.000	178,000	210.000	190.000
55	ELECTRICAL ENGINEERS	2,400	108,000	0,400	152,000	130.000	150.000	130.000
56	MECHANICAL ENGINEERS	5,000	84,000	0,300	118,000	101,000	110,000	110.000
57	MINING ENGINEERS	0,000	0.000	0,000	0.000	0,000	0.000	0,000
58	NUCLEAR ENGINEERS	0,000	0.000	0,000	0.000	0,000	0.000	0.000
59	GEOLOGICAL ENGINEERS	0,300	0.000	0,000	0.000	0,000	0.000	0.000
60	PETROLEUM ENGINEERS	0,000	0.000	0,000	0.000	0.000	0.000	0,000
61	OTHER ENGINEERS	1,100	0.000	0,000	0.000	0.000	0.000	0.000
62	ENGINEERS TOTAL	11,000	390,000	1,300	478,000	409,000	470.000	430.000
63	DESIGNERS & DRAFTSMEN	4,700	136,000	0,500	192,000	164,000	190.000	170.000
64	SUPERVISORS & MANAGERS	3,800	64,000	0,200	90.000	77.000	80.000	80.000
66	NON-MANUAL, TECHNICAL TOTAL	19,500	540.000	2,000	760.000	650.000	740.000	680.000
67	NON-MANUAL, NON-TECHNICAL	2.500	260.000	1.000	360.000	310.000	160.000	120.000
70	NON-MANUAL TOTAL	22.000	800.000	3.000	1120.000	960.000	900.000	800.000
71	PIPEFITTERS	0,000	720.000	0,500	916.000	768,000	410.000	350.000
72	PIPEFITTER/WELDERS	0,000	324,000	0.400	412.000	346,000	190.000	160.000
73	ELECTRICIANS	8,800	504,000	2.400	641.000	538,000	280.000	240.000
74	BOILERMAKERS	0,000	540,000	0,300	687,000	578,000	300,000	260,000
75	BOILERMAKER/WELDERS	5,000	180,000	0,100	229,000	192,000	100.000	90,000
76	IRON WORKERS	26,700	252,000	2,000	321,000	249,000	150.000	120.000
77	CARPENTERS	7,000	252,000	2,300	321,000	268,000	150.000	130.000
78	EQUIPMENT OPERATORS	3,600	180,000	1.800	229,000	192,000	100,000	90,000
79	LINEMEN	0,000	0.000	0,000	0.000	0.000	0.000	0,000
80	TEAMSTERS & LABORERS	17,400	432,000	3,600	549,000	461,000	200,000	160,000
81	OTHER	3,600	216,000	1,600	275,000	230,000	120.000	100,000
82	MANUAL TOTAL	72,100	3600,000	15,000	4580,000	3840,000	2000,000	1700,000
85	CONSTRUCTION LABOR TOTAL	94,100	4400,000	18,000	5700.000	4800,000	2900,000	2500,000

Source: Bechtel Corp., Energy Supply Planning Model NTIS PB 245 382, August 1975.