27
2-8-79

ORNL/TM-6668

MASTER

Regional Economic/Demographic Projections for Energy Policy Analysis

David J. Bjornstad

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION · FOR THE DEPARTMENT OF ENERGY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy \$4.50; Microfiche \$3.00

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, contractors, subcontractors, or their employees, makes any warranty, express or implied, nor assumes any legal liability or responsibility for any third party's use or the results of such use of any information, apparatus, product or process disclosed in this report, nor represents that its use by such third party would not infringe privately owned rights.

Contract No. W-7405-eng-26

REGIONAL ECONOMIC/DEMOGRAPHIC PROJECTIONS
FOR ENERGY POLICY ANALYSIS

David J. Bjornstad
Regional Economics Group
Energy Division
Oak Ridge National Laboratory

Sponsored by the Economic Development Administration
of the U.S. Department of Commerce
and the Office of Policy and Evaluation
of the Department of Energy

Date Published: January, 1979

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISSEMINATION OF THIS DOCUMENT IS UNLIMITED

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	v
FOREWORD	vii
PART 1: STATEMENT OF DAVID J. BJORNSTAD BEFORE THE JOINT ECONOMIC COMMITTEE.	1
PART 2: PREPARED IN SUPPORT OF A STATEMENT BEFORE THE JOINT ECONOMIC COMMITTEE.	9
I. INTRODUCTION.	11
II. PROJECTING SUBNATIONAL ECONOMIC AND, DEMOGRAPHIC CONCENTRATIONS FOR ENERGY POLICY.	12
III. ENERGY POLICY IMPACTS ON EXISTING REGIONAL SOCIOECONOMIC PATTERNS.	18
Energy Price Impacts on Industrial Location.	20
Coal Production and Regional Growth	26
V. POLICY IMPLICATIONS	31
REFERENCES	33

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ABSTRACT

This paper examines the importance of adequate population and employment projections for regional policy analysis related to energy and asks whether energy policy may significantly modify existing trends. It is concluded that energy is less likely to create new subnational socioeconomic tendencies than to enhance or retard existing trends, but that to analyze these circumstances a growth policy format is desirable. It is emphasized that a lack of past experience with many new energy technologies will make impact analysis difficult. For this reason, attempts should be made to anticipate possible impacts well in advance of technology deployment.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

FOREWORD

This volume is divided into two parts. The first consists of testimony delivered to the Joint Economic Committee of the U. S. Congress on June 1, 1978, and the second consists of a supporting document which develops the arguments presented in testimony in more detail than was possible during oral exposition. Although this material will also be available through the Committee, a number of requests for it have been received at Oak Ridge National Laboratory (ORNL). It was therefore felt appropriate to make it available as an ORNL publication.

It should be emphasized that these papers were prepared primarily as a vehicle through which to transfer policy-related opinions to the committee. As a result, many of the arguments and conclusions have been drawn from ongoing and partially completed analyses, and supporting documents for much of the discussion are not yet available. These will be made available as ORNL publications as they are prepared.

Finally, to the extent that this document is in part founded on opinion, it is by nature somewhat speculative. Neither ORNL nor the sponsoring agencies should be expected to share in the responsibility for this speculation. Moreover, I will welcome comments, suggestions, or criticisms related to the material presented herein.

David J. Bjornstad
Regional Economics Group

Part 1

Statement of David J. Bjornstad
before the
Joint Economic Committee

Presented
June 1, 1978

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

My comments today will be focused on the issue of projecting future regional concentrations of demographic and economic activity for energy policy studies, with particular reference to energy policy as it relates to technology deployment; the need for these projections; the uncertainties associated with them; and the limited evidence at hand to judge whether energy activities will significantly modify regional settlement patterns. With regard to this latter topic, I will rely primarily on research now underway at Oak Ridge, with the disclaimer that much additional work is underway elsewhere.

In the course of these comments, I would like to share with you three concerns I have regarding the study of energy and regional socioeconomic issues. My first concern centers on the general lack of a national perspective in viewing regional energy issues, in other words, the lack of a growth policy perspective. My second concern lies in the basic need for improving projections of socioeconomic activity that go into energy studies, or at least in recognizing the frailty of projection series as time periods and geographic specificity increase. My third concern lies in the increased demand for knowledge as to the probable impact of energy policies on future regional settlement patterns, and the limited quantity of knowledge available to meet these demands. Because of these limits, most responses to these queries have been speculative, and I will add to this speculation by suggesting that based on my own limited research, things may not change greatly at the regional level as a result of energy price changes and coal developments. But let me also emphasize that what is needed is systematic inquiry into the range of possible energy development on regional growth and change. In this area, researchers have only begun to scratch the surface.

Although energy policy issues range from the very short run, for example, natural gas availability next winter, to the very long run, the introduction of fusion technology, it is perhaps safe to say that the major portion of policy options under present scrutiny lie in deploying technologies over the mid- to long-term, from 1985 to the turn of the century, or perhaps to 2020. Thus it is the length of the time horizon, rather than the need for projections, which distinguishes energy

policy analysis from other such analysis. This time period arises from the long lead times necessary to put large capital facilities in place and also from the lag times associated with market penetration of small scale technologies currently available. The year 1985 may be the earliest point at which current policy will make a substantial impact, and the year 2000 is perhaps a better reference point for taking stock of accumulated impacts. However, over time periods this length, many things can change. It is therefore reasonable to ask how well we can project regional change and what steps we should take to factor uncertainty into the analysis. Although policy is formulated at the national level, it tends to be implemented at the regional level. If, for example, we wish to deploy energy production or distribution apparatus to meet the needs of a growing region, can we do so, confident that this growth will occur, or should we lay our plans with circuit-breaker provisions that will provide a red flag, if not an alternative course, if our conception of a specific growth path is faulty. A simple example may illustrate this.

If one decomposes national energy consumption changes in the residential/commercial sector between 1960 and 1970 into components due to changes in per capita consumption and due to population change, it is clear that significant changes in consumption behavior have occurred. This is true to the degree that if we tried to predict 1974 consumption based on the trends in population increase observed during the 1960s, the error due to consumption shifts would overwhelm any error due to change in population growth rates. But, if the same data are examined at the state level, for perhaps 20% of the states, population shifts that deviate from the 1960 trends are nearly as important as energy shifts. For several states, change in population growth patterns exceed deviations from per capita energy consumption trends.

Thus, while "on average" changes in subnational population and economic activity concentrations are regular, enough exceptions occur that this issue must be as much the subject of energy analysis as energy behavior itself. Moreover, I sense a growing demand for projections of even finer spatial definition to conduct water analysis, pollution analysis, and economic analysis at levels well beneath the state level. In fact, we at Oak Ridge produce a number of such series.

I believe that to use projections effectively, one should neither consider spatial units in isolation nor projection series individually. Instead, one should seek a range of alternative forecasts that indicate deviations which could reasonably occur. However, recognizing that these shifts may occur suggests that flexibility must also be built into energy development plans. We might even wish to rank technologies as to their sensitivity to this type of change. For example, the possibilities for power exchange make electrical generating facilities less sensitive than crude oil handling facilities, but nonetheless more sensitive than soft technologies that individual households may implement.

I would like to turn now to the question, will energy activities and policies modify future regional settlement patterns?

Energy activities influence regional development both in the economic activity they stimulate when produced and in the manner in which their price and availability influences the location of firms and households who consume energy as an intermediate product. Conventional wisdom suggests that the availability of particular fuels in large quantities is a primary factor in regional development. More recently, at least one regional economist has suggested that fuel prices are a major determinant of the resurgence in Southern development. President Carter, in fact, asked just this question regarding Southern development of one of our regional economists who spoke to him during his recent visit to Oak Ridge. But one may as well ask how environmental restrictions associated with energy will modify development patterns; how increased conservation efforts, increased solar utilization, cogeneration, coal conversion or waste heat recovery systems will modify regional development? Perhaps more appropriately, one might ask how will these factors interact to bring about change? The simple answer is: there is no simple answer. And, for many such questions, there is no firm answer at all. Nonetheless, I would like to share with you preliminary results from two studies currently underway at Oak Ridge, both of which lend support for my own speculative response to this question. This response is that energy changes will probably not cause major new trends in regional development. But they may well cause areas prime for development to grow more rapidly than they otherwise would have. And they may also cause the opposite.

My first example derives from the fact that when other factors permit, firms will seek out lower costs. This also holds for energy, and we have evidence that firms will respond to energy price change. The question is, will they relocate to new areas rapidly in response to energy cost change?

To understand this issue, it is useful to examine the components of cost for the average manufacturing firm. For this average firm in 1974 direct labor costs comprised 40% of total costs; capital costs, profits, and indirect labor costs comprised 46% and energy costs excluding feedstocks, 4%. Thus, for this average firm, a 50% increase in energy costs would increase total unit costs by 2%. Stated differently, the average plant manager should be indifferent to a 10% increase in labor costs and a 100% increase in energy costs, because they would each affect his overall operating costs identically.

There is surprising stability in these percentages across regions and gross industrial classifications. Thus, although it may be oversimplification, I conclude there does not appear to be a major cost impetus for firms to relocate in general due to energy costs, but I qualify that by saying surely certain high energy using industries, such as aluminum, will be more sensitive. There are also other factors I have not taken into account.

My second example is drawn from a series of simulations we conducted examining a high rate of growth in coal production versus the slow rate projected at the beginning of the decade. Simply stated, our computerized model told us that the major impact would be a general tightening of labor markets in areas that would receive large influxes of coal employment, but that with few exceptions, no mass migrations of people or jobs would occur, even in the sparsely populated West.

In many cases coal employment would replace other employment opportunities. And, in a number of cases, nearby regions linked economically to producing regions would benefit.

Again, these findings are limited, and they address only a few of the many complex questions surrounding energy development and policy,

and then only in a most simple manner. But they do suggest that one must consider energy policy in the light of traditional determinants of economic growth, and regional growth, and I believe this is an appropriate conclusion.

Finally, how should we address energy planning issues? Two common methods of analyzing the impacts of energy development are now being used. The first lies at the national level where macroeconomic and other national and global issues are addressed. This is an appropriate starting point. However, as I stated earlier, policies are usually formulated at the national level, but implemented at the regional level. It is at the regional level where most impacts will be visible. To address regional energy issues, a second method, one provided by the National Environmental Protection Act (NEPA), is usually applied.

Simply stated, this method assumes a point source of pollution, economic activity, water consumption and the like, and asks, "How will the relevant environments be affected?" In principle, this approach could provide the gaps in knowledge I indicated before. But, in general, I believe this approach is better suited to analysis of the physical environment than the socioeconomic environment. The primary reason for this belief lies in the fact that the NEPA format tends to deal with regions and technologies in isolation, and in terms of small units.

Physical science is better equipped to grapple with the distribution of such elements as pollution and water consumption at this level than are the social sciences. For this reason, all too often, these latter components receive only a cursory treatment.

It is therefore my belief that regional analysis for national policy might better be conducted by viewing the nation as a system of regions and asking whether certain regions will be benefited at the expense of others as policies are developed. Once developed, trends in socioeconomic patterns should be tracked and modifications made if over time the patterns diverge from historic trends.

I do not mean to suggest by this that the strictly local issues identified through the NEPA format, such as the assaults to an isolated community of opening a massive strip mine are unimportant. I instead suggest that we must factor out national-regional issues from the more local issues and deal with each separately.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

Part 2

Prepared in Support of a Statement
Before the
Joint Economic Committee

Submitted
June 1, 1978

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

I. INTRODUCTION

Recent changes in energy supply conditions have spawned a great deal of expert commentary regarding the manner in which trends in regional distributions of people and jobs will influence energy policy needs as well as how these trends may themselves be modified by strategies modifying energy consumption and supply. They have also spawned a perhaps equal amount of speculation, expert and otherwise, simply because of the limited knowledge available to predict future regional settlement patterns. That these matters are important is unmistakable. The long lead times of technology development and capital emplacement required in the energy arena means plans are frequently laid across decades rather than years.

It is unlikely that in the near future a broad consensus will develop over how existing regional changes in economic and demographic activity will affect energy policy, nor how energy policy will modify existing patterns. The material in this paper retains an element of speculation, because it attempts to characterize work-in-progress regarding subnational distributions of socioeconomic activity and their relation to energy policy. Discussion is centered around two questions:

- Do we understand the forces governing regional shifts in economic and demographic behavior well enough to focus solely on the market-related determinants of energy consumption when making plans to deploy technology or otherwise implement energy policy?
- Should we expect energy conditions and policy to cause marked change in the patterns and trends in regional socioeconomic activity distributions we have recently observed?

In each case, the evidence presented argues for a qualified negative. Regarding the first issue, it is clear that at the national level population change is much more regular and predictable than energy change. But as the spatial grid of interest becomes finer, it is apparent that changes in human settlement patterns may outweigh changes in energy consumption patterns.

The second issue hinges on how one defines "marked change" and with what confidence one is willing to infer future behavior from that which was observed in the past, sometimes under quite different circumstances. It would appear that energy price changes alone may be insufficient to modify industrial location patterns in the foreseeable future; yet there is still little reason to believe one can predict changes that will accompany new technologies with which there is little or no past experience. The advent of the automobile, for example, demonstrated conclusively the manner in which technological change can alter socioeconomic activity distributions in unexpected ways over a relatively brief period of time.

Moreover, it should be noted that in a very real sense regions compete with one another to attract new activities. To the extent one region grows more rapidly than the nation as a whole, a second region (or group of regions) must grow more slowly, or even decline. This points to the insufficiency of assuming development will automatically accompany a decision to deploy capital facilities, even though numerous single-region studies do just this. It is therefore argued that a regional systems approach explicitly constraining the sum of regional activity to a consistent national total provides an appropriate format for systematic impact analysis.

The bottom line to this discussion is that when attention is focused on how national policies impact on individual segments of the nation, one must take utmost care to outline the range of feasible outcomes. When substantial uncertainty exists, it should be factored into this range. With current knowledge, choosing a "most likely" time path on which to base policy within this range will remain speculative; but the eventual outcome will not be entirely surprising.

II. PROJECTING SUBNATIONAL ECONOMIC AND DEMOGRAPHIC CONCENTRATIONS FOR ENERGY POLICY

The importance of generating long-term regional distributions of demographic and economic activity for energy policy analysis lies in the long lead times required for technology deployment and the importance of assessing the environmental and social impacts of this deployment. For

example, one difficulty that arose in analyzing the Administration's energy plan of April 1977 was that in the short term (i.e., through 1985) little change could occur through technological innovation.¹ This means that 1985 may be a starting point rather than the terminal point for many energy-related projections. Moreover, it is an accepted practice in environmental and water impact analysis to concern oneself with relatively small spatial units, for example, air quality control regions or water subareas. One might therefore ask if the uncertainty associated with the assessment process is compounded by uncertainty in which people and jobs will locate in the future, or if one can say with some assurance these distributions can be projected with reasonable confidence. This is a particularly important concern, because analysts frequently state simply the projection series used and go on to conduct their analyses. Stated differently, can we build pipelines to serve growing regions of the country, confident that this growth will occur? Or, should we lay our plans with circuit-breaker provisions that provide a red flag and an alternative path if our conception of a specific time path proves faulty but our knowledge of the range of time paths secure? This issue may be illustrated by examining population change and energy consumption change at the state level over the recent past.

Energy use in the residential/commercial sector of the economy grew from 11.2 quadrillion Btu (quads) to 16.9 quads between 1960 and 1970 and to 17.5 quads between 1970 and 1974.² Population growth was a significant determinant of this change as the nation increased from 180 million persons in 1960 to 204 million in 1970 and 211 million in 1974. In per capita terms, energy use increased from 62.4 million Btu in 1960 to 83.1 million Btu in 1970 but dropped to 82.8 million Btu in 1974. Thus, over the period 1970-1974, a period spanning the oil embargo, an abrupt shift in energy consumption patterns occurred.

This shift is reflected in the growth rates of energy consumption relative to population. Population increased at an average rate of 1.25% per year during the decade of the 1960s but declined to .92% per year between 1970 and 1974. This change was partly dictated by the age structure of the population but also resulted from a decline in birth rates which is still under study by demographers. A part, but not all,

of the decline in energy consumption growth can therefore be related to change in population. In contrast, the rate of growth in energy consumption by the residential/commercial sector was 2.9% per year between 1960 and 1970. This growth fell to .80% for the 1970-1974 period, which, because it was below the population growth rate, yielded a per capita decline in consumption.

For practical purposes, this means the following: If one has perfect knowledge of energy consumption changes, applying the population growth rate of the 1960s would yield a 1.33% error in predicting 1974 energy consumption. If, on the other hand, one knew 1974 population levels and applied the per capita consumption growth rate from the 1960s, an error of 8.58% in predicting 1974 energy consumption would be generated. Thus, when the concern is to predict national energy change, the analyst may deal confidently with population change.

This conclusion follows from the fact that at the national level population change is primarily dictated by births and deaths, phenomena which over time bear relatively stable relationships to the age and sex characteristics of the population. Immigration tends not to introduce instability into the rate of change because it is closely regulated. However, at the subnational level, movements of people and jobs may be much more volatile and as the spatial unit under concern grows smaller, they may outweigh changes in energy consumption. If this occurs, the importance of employing carefully considered projections of demographic and economic change increases. This prospect may be demonstrated by examining these same data at the state level.

For the sake of this exercise, we will pose the general question, given trends in population and per capita energy consumption during the 1960s, how well can we predict 1974 per capita consumption? Three calculations will be made to address three questions:

- Given actual 1974 per capita energy consumption, how well does the average population growth rate of the 1960s predict 1974 consumption?

- Given actual 1974 population, how well does the average energy growth rate of the 1960s predict 1974 consumption?
- Given the population growth rate of the 1960s and the per capita energy growth rate of the 1960s, how well can we predict actual 1974 consumption?

Each of these series will be compared with the actual 1974 consumption data. Based on the national data, one should expect that uncertainties associated with per capita changes should once again lead to the conclusion that understanding energy change is more important than population change, and, indeed, this is the conclusion that results. However, for some states it would appear that changes in population trends can lead to projection errors as large as do those associated with per capita energy consumption shifts.

For the average state, trended population and actual per capita consumption levels yielded a 3.0% error in predicting 1974 energy consumption in the residential sector. The error ranged from .15% in Alaska to 7.32% in Idaho. This error is substantially exceeded by the average 15.6% error that would be generated using the average per capita consumption figure from the 1960s and the actual population level. Here the errors range from .49% to 57.33%. When the trends in both population and energy are used to project population, the errors begin to average out. Here, the consumption level for the average state is in error by an average 15.52%.

It is not surprising to find that the recent volatility in per capita energy consumption carries through to the state level. Nor should it be unremarkable to suggest that the energy consumption analyst would do well to focus his attention on predicting how consumption behavior will change apart from population.

What is somewhat surprising, however, is the degree of overlap between the errors from each source. For example, for Arizona a 15% error is generated from projecting 1974 energy using both trended population and energy per capita. Of this, 6% can be attributed to population and 9% to energy behavior. For California, a 12% total error can be decomposed into 5% due to population and 7% due to energy behavior. In Connecticut,

Minnesota, Nevada, and Rhode Island, the error due to population would exceed that due to energy behavior change. What this suggests is that, on the average, the analyst may deal with energy behavior and draw a population number from a convenient projection series to complete his calculations. But, for perhaps 20% of the states, this practice may hide the fact the population shifts will approach and in some cases exceed variation in energy consumption behavior. Failure to account for these shifts may lead to ill-considered policy at best and perhaps inappropriate policy.

Of course the analyst need not simply choose a single off-the-shelf projection series; a variety of series are available which sometimes give quite different answers. If, for example, the 1960 to 1970 and 1970 to 1974 population trends are extrapolated to 1985 and compared with several available projection series, these differences become evident. This exercise is equivalent to measuring differences in projected 1985 energy levels, if the same energy per capita measure is used in each case. It should also be noted that the extrapolated trend is used as a basis of comparison and not a standard. Each projection series provides substantially more information than the simple population number, and one would in general attach more credibility to the formal series than to the simple extrapolation.

The result of carrying out these calculations is shown in Table 1. As this table shows, the recently prepared DOE and ORNL³ projections more closely resemble the 1970-1974 trend, while the older Census and OBERS projections appear to follow the trends of the 1960s. The range of largest differences, however, points to the need to conduct more detailed analysis than the simple trend extrapolation would permit.

The conclusion one should draw from this discussion is that as the degree of regional specificity increases, the importance of understanding changes in socioeconomic variables also increases. At the state level, a number states showed greater deviation from population growth trends than energy consumption trends. If attention were focused beneath the state level, it is likely that this issue would grow in importance.

Table 1. Percent differences between state projection series for 1985 and 1960-1970 and 1970-1974 benchmark extrapolation

	1960-1970 Extrapolation			1970-1974 Extrapolation		
	Average difference	Largest difference	State of largest difference	Average difference	Largest difference	State of largest difference
Census ^a	4.6	30.2	Nevada	11.8	34.8	Arizona
DOE ^b	8.4	26.3	Nevada	4.4	16.5	Colorado
ORNL ^c	8.6	27.5	Nevada	4.2	17.8	New Hampshire
OBERS ^d	7.3	37.1	Nevada	11.0	32.1	Arizona

^aU.S. Bureau of Census, *Current Population Reports*, Series P-25, No. 477.

^bUnpublished series.

^cMULTIREGION projection series TOPS.R2.OBERS72.

^dU.S. Water Resources Council, *1972 OBERS Projections: Economic Activity in the U.S.*, U.S. G.P.O., April 1974.

Moreover, although population was used as the current example, it is probable that the same results would obtain for other sectors of the economy. What this means is that if targets are set for energy consumption at the regional level, changes in socioeconomic activity may directly affect whether or not targets will be achieved. It would be unfortunate if the choice of a particular projection series would in itself place a ceiling on regional growth by limiting total available energy to a level beneath that which would be necessary to support the level of growth the market would provide.

III. ENERGY POLICY IMPACTS ON EXISTING REGIONAL SOCIOECONOMIC PATTERNS

Despite the relatively small amount of analysis which has addressed the issue of energy policy and regional change, a great amount of speculation has been focused on whether or not energy policy will cause significant changes in regional settlement patterns to occur. Once again, the importance of this issue is unmistakable. If policies that are adopted to combat energy difficulties have serious implications for the spatial distribution of people and jobs, some portions of the nation will be benefited at the expense of others.

Until recently, the technological issues embodied in energy policy were largely considered the domain of scientists and engineers. In such a circumstance, engineering efficiency is given priority over social efficiency. Once a decision to deploy is made, the impacts of the technology on the area in which it will be sited are assessed, usually through the NEPA process. To the extent undesirable outcomes occur, modifications to the system to lessen impact may be necessary. In many cases local socioeconomic impacts are also addressed within the NEPA format. The environmental issue is, simply stated: Given a point source of pollution, how will the local (or perhaps broader) physical environment be affected? A natural extension becomes: Given a point source of economic activity, how many jobs will be created? How many people will migrate? How will local schools be affected? Unfortunately, the NEPA format is not well suited to address the larger, and perhaps more important, question: Given

a national policy for energy that impacts unequally on regions, how will the relative distributions of people and jobs change? To the extent that significant interregional change may occur, it may be reasonable that growth policy, rather than engineering optimality, should receive priority attention in technology deployment.

To address this issue, it is useful to note that energy holds three distinct roles in regional development. First, it is a final demand product. Households and commercial activities consume it for its direct benefits. This use of energy as an impetus to locational decisions will not be discussed at this time other than to note that the close locational ties between household locations and commercial locations suggest the two should be studied in unison. Second, it is an intermediate product. Industrial firms consume it as a means to an end rather than an end in itself. To the extent that these units behave rationally, they will seek out favorable energy supply markets if other considerations permit. Favorable supply markets can be further decomposed into two conditions: energy availability (i.e., the assurance of continued supply), exclusive of price; and energy price, the cost which a consuming unit must pay for energy. To consider how intermediate product use decisions may influence socioeconomic concentrations, we will examine briefly the possible impact energy prices and, implicitly, what effect price policies may have on industrial locations.

The third role energy plays is that of basic regional development, where basic development implies the opening of firms which produce energy products for resale. To the extent that energy products are tied to natural resource formations, the regional impact of choosing one energy form over another will have distinct implications for regional development. In the simple case, the decision of whether or not to build a single project, such as Oak Ridge's well-known breeder reactor, is important in a local sense, but not really of great importance in the larger regional sense. A decision to substitute coal for imported oil, however, might have more far-reaching implications for broad regions since large, new coal mining areas must be developed. To illustrate basic developmental impacts of energy policy, we will examine the coal issue and question whether significant regional change is likely to occur.

Energy Price Impacts on Industrial Location

The justification for asserting that energy prices will play a more important role in the future than in the past in determining industrial location can be succinctly stated. Firms engage in enterprise to make profits, and profits grow when costs are reduced. Increasing energy prices should, therefore, cause firms to locate in areas where energy prices are lowest when other considerations permit.

Taken on face value, this argument is logical, but one might question whether this impetus is sufficient to, as some have suggested, play a major role in the shift of industrial location from snowbelt to sunbelt⁴ or if certain regions may simply be limited in their ability to attract energy-intensive industry in the future.⁵ It is usually assumed that energy-intensive industries will respond most quickly to energy price changes. Energy intensity, however, is an elusive concept. One method is to simply rank industries as to which uses the most energy. However, based on this criterion the conclusion one would derive could well be simply the result of which industry was the largest. A relative measure is, therefore, more desirable since this would control for size and would, moreover, better approximate the firm's desire to consider relative costs.

One such measure of relative energy intensity is shown in Fig. 1. These data measure the average quantity of energy per worker for heat and power (i.e., excluding feedstocks) for the manufacturing sector in 1971. Thus, petroleum refining is shown by this measure to be the most energy intensive, chemicals the second most energy intensive, paper the third, and so on. The information in this figure could potentially lead one to a number of policy-relevant conclusions, for example, that the chemicals industry would be perhaps 12 times as sensitive to overall changes in energy costs than would be the fabricated metals industry. Unfortunately, this information is only partial, because firms hire additional factors as well in the production process and respond to changes in relative costs rather than making decisions based on absolute relationships. For this reason, a still better measure of energy intensity is desirable.

This alternative measure is shown in Fig. 2. Here, value added by manufacture, divided into labor costs (direct payrolls), energy costs (for heat and power), and capital costs (including worker benefits and

Fig. 1.
National fuel use per worker for heat and power, 1971 (billions of Btu's).
Source: Bureau of the Census, Annual Survey of Manufactures, 1972.

ORNL-DWG 78-18126

Fig. 2. United States
Components of value added
(1974)

Source: Bureau of the Census, Annual Survey of Manufactures, 1975.

and indirect costs, profits, and taxes), is displayed, and a much different picture of the role of energy in the firm's decision to locate emerges.⁶ The significance of this breakdown can be explained in the following way: From the point of view of the firm, total factor costs (including profits) are equal to value added, and a factor's share of value added multiplied times the change in the price of that factor indicates to the firm the degree to which its average costs will increase as factor prices increase. For the average manufacturing firm, where energy accounts for 4% of total costs, a 50% increase in the cost of energy would cause a 2.0% increase in total costs. Thus, a manager can reduce his average costs by 2.0% if he is willing to relocate his plant in an area where energy costs half as much as his current location, assuming capital costs and payroll costs are equal. But, what if other things are not equal? Again, using the average firm, because payroll costs are 40% of total costs, the plant manager should be roughly 10 times more sensitive to labor costs than to energy costs. Stated differently, the plant manager would be indifferent to a 10% savings in payroll costs and a 100% change in energy costs, because each would affect the average unit cost of his product equally. Viewed in this light, it is clear the firm may have an incentive to seek out lower energy costs, but clearly, this component may not be the overriding issue when relocation is contemplated.

Also evident from this figure is the fact that measures of energy intensity can be misleading. The share of energy costs in value added ranges from 1% to 11%, while in Fig. 1 the range of energy quantity per worker was much larger. This simply says that the choice of statistics is important and potentially misleading. Fabricated metals, shown by the per worker measure to be relatively nonenergy intensive, are shown by the cost measure to be among those industries most sensitive to energy costs.⁷

Because of historical differences in energy prices among regions, one might expect substantial differences in the share each component comprises of total costs in each region. However, Figs. 3 and 4, which present this same data for the oil- and gas-producing regions (Texas, Louisiana, Oklahoma, New Mexico, Arkansas) and New England, indicate this does not appear to be the case.

ORNL-DWG 78-18124

Fig. 3. New England
(FEA Region 1)

Components of value added (1974)

Source: Bureau of the Census, Annual Survey of Manufactures 1975.

ORNL-DWG 78-18125

Fig. 4. Gas and oil producers
(FEA Region 6)

Components of value added (1974)

Source: Bureau of the Census, Annual Survey of Manufactures 1975.

For New England the share of energy costs of total costs is 3% as opposed to 5% for the oil- and gas-producing region, an outcome largely accounted for by the presence of the petroleum refining industry in the latter region. For several industries the energy share of value added in New England exceeds that of the oil and gas region. Note, however, that this share is composed of two components: the price of energy and the quantity of energy consumed. Because prices in New England have historically exceeded those in the South, the tendency may be to use a somewhat larger quantity in the South.

How should we interpret this? Based on the information presented, it would appear that the incentive for manufacturing industry to relocate due to changing energy prices is easily overstated. To be sure, industry will respond to higher energy prices; we have mounting evidence to this effect.⁸ And, highly specialized energy users, such as aluminum producers, may have added incentives to respond. But rather than seeking out new trends in industrial location, it may be wiser to study existing trends to determine if energy policy will enhance or retard ongoing developments.

The final form which energy policy will take remains uncertain, and policy-induced shifts are therefore difficult to predict. It is, however, worth noting that, as well as increasing oil and gas prices somewhat, current policy is attempting to substitute coal in large amounts. Coal is a relatively inexpensive fuel in terms of purchase price, but one which will require additional capital outlays to meet environmental standards. Thus, one outcome of energy pricing policy might be to modify capital costs upward, while raising one portion of energy costs through tax levies, but lowering another portion through the forced movement to a less expensive fuel.

Coal Production and Regional Growth

To meet the Administration's goal of substituting significant amounts of coal for oil and natural gas will require heightened levels of coal mining in traditional mining centers and rapid opening of new western mining centers. One consequence of this activity could be to bring about substantive changes in population and employment patterns in favor of areas with coal reserves. An extension of the analogy that links

economic development in Texas to the development of an oil industry might project a new, coal-dominated Houston on the site now occupied by Billings, Montana. However, it is well to note also that many oil-producing areas did not experience this type of development. Thus, systematic analysis should be undertaken to discover if significant pressures for economic development will accompany western coal development.

The overall impact of coal production is dependent on a number of factors, including where coal will be mined, what mining techniques will be used, and how rapidly development will occur. An additional consideration is the economic condition of the area itself and its proximity to other regional centers. With regard to regional economic conditions, it is noteworthy that many eastern areas remain relatively depressed from the bust that followed the last great coal boom. In contrast, western areas with coal reserves have frequently been subject to out-migration, as increased farm productivity has left fewer opportunities for agricultural employment. A final issue concerns whether or not resource-laden areas are currently experiencing rapid in-migration. Once again, we may be well advised to view energy policy as holding the potential to enhance or retard existing trends but perhaps less likely to initiate new ones.

As a first look at the possible impacts of coal development on various regions, ORNL has generated projections of population and employment based on two sets of coal development assumptions, using an ORNL-developed population/employment simulation model referred to as MULTIREGION.⁹ The results at this time are tentative and intended to illustrate the direction rather than the level of change; they are nonetheless instructive.

The first assumption of coal development we examined was that total national coal employment would decline over time, but that the national share in each region would remain constant. This is admittedly a simplistic assumption, but one which is perhaps a not too unrealistic depiction of how the coal mining industry was evaluated at the beginning of the decade. Our second assumption regarding coal development was that extraction activities would increase rapidly. Much of the new coal in this case would come from western strip mines, but eastern activities would also be substantially expanded. In essence, this assumption is

designed to parallel the Administration's projections through 1985 and to extrapolate from these projections through 2020. Neither assumption represents an attempt to forecast the future. The simulation model into which we programmed these assumptions operates on groups of counties called BEA functional economic areas, with the U.S. divided into 173 such areas. The overall purpose of the exercise is to compare the resulting levels of population and employment that emerge from the two "scenarios" in terms of direction of change and overall development implications.

Perhaps the major impact evident from this analysis derives directly from the input assumptions. This is the shift of certain major coal centers from the east to the west. As is shown in Fig. 5, the 11 largest coal employment regions under the low coal case are centered in Appalachia and the East. Under the high coal case, four of the eastern mining areas are replaced by western centers.

The model-derived conclusions from this analysis are somewhat mixed. The major common impact is a general tightening of labor market conditions in mining areas. In other words, total employment relative to available labor supply increases, and the economic health of the region increases. This is not a surprising finding. What is, however, at least a nonintuitive finding is the degree to which various regions respond differently to increased coal activity.

The largest induced employment/population effect appears to occur in the Grand Junction region (BEA 149), where total employment change doubles the level of new coal employment and population change is nearly three times larger than the coal employment increase. Lesser employment increases in the West are evident in the Billings, Albuquerque, and Las Vegas areas. These results suggest that a major outcome of coal mining activities may be to replace other employment opportunities which would have occurred, except in special instances. The circumstance that differentiates Grand Junction is the rapid rate of growth that was projected in the absence of coal activity. The model is therefore telling us that this type of employment stimulus will tend not to bring about major new employment centers unless forces are already at work in this direction.

Fig. 5. Major coal employment centers under alternative assumptions.

In the East, the same general findings appear. However, in this instance, major employment centers that are linked economically to coal-producing areas seem to receive significant stimulus. The Williamsburg region, for example (BEA 11), receives an employment impact that far exceeds that attributable to coal mining changes, as does the Philadelphia region. However, increased out-migration is evident in several regions even as employment rises. These results are summarized in Table 2.

Table 2. Projected coal employment impacts on selected coal-producing regions for 2020

BEA No.	Name	Coal employment change	Total employment change	Total population change
11	Williamsburg	250	4,946	5,279
13	Wilkes-Barre	-937	-218	-1,475
15	Philadelphia	1,760	4,846	-8,126
50	Knoxville	6,007	5,226	2,508
51	Bristol	217	1,359	-3,520
52	Huntington	42,855	14,021	28,805
53	Lexington	13,505	5,133	6,340
55	Evansville	42,602	6,295	16,296
65	Clarksburg	17,960	5,506	7,322
66	Pittsburg	30,935	17,607	16,130
95	Billings	34,840	11,810	28,606
114	St. Louis	26,445	24,159	17,806
146	Albuquerque	13,069	3,998	7,281
149	Grand Junction	18,629	32,697	55,028
161	Las Vegas	21,512	4,573	10,488

Whether or not the absolute changes that were produced through this simulation exercise are realistic, they contain an important lesson. Because the nation operates largely as a closed socioeconomic system, one region can increase its population share or employment share only at the expense of others. Thus, from the standpoint of regional economics, it is not sufficient to assume that an economic stimulus will automatically

trigger successive rounds of economic growth; other factors, such as proximity to other regions, general migratory and development trends, and the economic composition of the region all enter into the regional development equation. It is quite easy to be overly sanguine about the development possibilities of any single region, particularly if one examines the region in isolation.

These findings, however, should be tempered by two additional considerations. First, as was seen by the rapid change in migration patterns between the 1960s and the 1970s, behavior changes can occur, and it is difficult to simulate this type of shift. Thus, the trends of the 1980s and 1990s may not wholly resemble those of the 1960s and the 1970s, and to the extent they do not, the actual pattern of development in 2020 may not resemble those of our computerized model. In this regard, we are limited by the data we observe.

The second caveat regards the distribution of activity within regions. Clearly, the advent of new coal mines may cause significant shifts in the location of towns and individual settlements. These will cause severe economic and social pressures in many instances, and no attempt is made here to minimize the importance of this issue. What is important to recognize, however, is that development of entire regions is a separate issue from development of towns and villages, and we should tread carefully as we attempt to predict a major reorganization of the spatial distribution of people and jobs for the nation as a whole.

V. POLICY IMPLICATIONS

Energy planning requires long lead times. The year 1985 is likely to mark the initial period of analysis. Beyond this it is difficult to suggest a terminal year. Effective technology planning requires assaying probable futures beyond the turn of the century, perhaps to 2020.

The tendency of many energy analysts to focus mainly on energy consumption behavior as a guide to policy appears not to be justified. When the focus turns to subnational portions of the country, the role of changing socioeconomic distributions becomes an increasingly important

portion of the analysis. At sufficiently fine levels of spatial detail, it is not unreasonable to suggest that they will become the prime determinants of energy needs. Thus, bounding the range of possible growth paths that socioeconomic activity will follow is necessary.

Despite commentary to the contrary, energy supply changes may modify regional concentrations of economic and demographic activity only marginally. The data presented above suggest that existing trends will likely continue to drive regional growth and development. It therefore appears most useful to analyze energy policy in terms of how existing trends may be influenced and modified. While it is clear that industrial development, energy and otherwise, will cause redistribution within regions, the evidence for broad regional shifts is more elusive. Nonetheless, our research indicates that very different regional responses can occur in the face of ongoing movements of people and jobs, and these movements should be taken into account.

It therefore appears that a broad understanding of regional change deriving from energy policy can only be gained by conducting analysis within the format of national growth policy. While it is possible to consider the role of the individual region in a system of regions within the NEPA format, experience indicates that this will not be the case. NEPA-type analyses tend to view socioeconomic change resulting from policy change only at the local level and then with "multiplier-type" tools which abstract from the fact that growth in one region's share of activity must come at the expense of other regions. Although the "point source" of economic activity mode of analysis is indeed likely to yield information useful for local planning, it will probably not provide the proper information for circumspect policy analysis.

Finally, our simulations indicate that certain induced employment stimuli, such as from coal mining, may replace other employment opportunities, and employment time paths with increased coal activity may not differ greatly from those without new coal activity. This is a rather controversial finding, and one that should be re-examined for both coal and the larger range of other energy-producing activities. For many of these technologies, we simply have no past experience.

REFERENCES

1. See for example, J. E. Dobson et al., "A Nationwide Assessment of Water Quality Impacts of the National Energy Plan," Vol. 7, Summary and Conclusions, Oak Ridge National Laboratory Report ORNL/TM-6098, December 1977.
2. The energy data in this section were taken from Bureau of Mines Information Circular 8704, "Historical Fuels and Energy Data, 1960-1972," and Bureau of Mines Information Circular 8739, "Fuels and Energy Data: United States by States and Census Division, 1974." The population data were taken from Bureau of the Census, *Statistical Abstract*, 1977.
3. The methodology for the ORNL projections is described in R. J. Olsen et al., *MULTIREGION: A Simulation-Forecasting Model of BEA Economic Area Population and Employment*, Oak Ridge National Laboratory Report ORNL/RUS-25, October 1977.
4. W. H. Miernyk et al., *Regional Impacts of Rising Energy Prices*, Regional Research Institute, West Virginia University, August 1977, p. 2-1.
5. S. Sacks et al., "Energy Costs and Use and Patterns of Economic Activity in the Northeastern United States," Syracuse Research Corporation, SRC TR 76-606, December 1976, p. 42.
6. Note that traditional measures of value added frequently omit energy on the grounds that it is a material input.
7. It should be added that this incentive assumes "other things are equal." If, for example, the capital intensity of this industry precluded mobility, it might be more accurate to limit this characterization to the opening of new firms.
8. See for example, D. P. Vogt, "The Structure of Regional Demands for Energy in the Manufacturing Sector," presented at the annual meeting of the Western Economics Association, Honolulu, Hawaii, June 24, 1978.
9. R. J. Olsen et al., op. cit.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

INTERNAL DISTRIBUTION

1. S. I. Auerbach	23. E. B. Peelle
2. S. E. Beall	24. H. Postma
3. D. J. Bjornstad	25. P. L. Rice
4. B. H. Bronfman	26. C. R. Richmond
5. A. A. Brooks	27. M. W. Rosenthal
6. R. S. Carlsmith	28. T. H. Row
7. W. S. Chern	29. R. M. Rush
8. J. E. Cope	30. R. L. Spore
9. R. M. Davis	31. D. N. Stuckwish
10. R. C. DeVault	32. T. Takayama
11. J. E. Dobson	33. R. I. Van Hook
12. W. Fulkerson	34. A. H. Voelker
13. H. W. Herzog	35. D. P. Vogt
14. E. A. Hirst	36. G. W. Westley
15. R. B. Honea	37. T. J. Wilbanks
16. D. G. Jacobs	38. D. J. Wilkes
17. D. L. Kaserman	39-40. Central Research Library
18. C. R. Kerley	41. Document Reference Section
19. A. S. Loeb1	42-43. Laboratory Records
20. J. B. Mankin	44. Laboratory Records - RC
21. J. B. Mills	45. ORNL Patent Office
22. D. C. Parzyck	46-127. Regional Economic Analysis Group
Economic Analysis Section
Energy Division

EXTERNAL DISTRIBUTION

128. Office of Assistant Manager, Energy Research and Development, DOE-ORO.
- 129-155. Technical Information Center, DOE-ORO.
- 156-308. Economic Analysis Section Distribution, Energy Division.