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Scientific and Technical Personnel in Energy-Related Activities: Current Situation and Future Requirements

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Hugh Folk
Robert DauffenBach
Jack Fiorito
Doug Gilmore
Wallace Hendricks
Thomas P. Milke
Ronald Seeber

Center for Advanced Computation
University of Illinois, Urbana-Champaign

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Errata

The numerator and denominator used to calculate percentage energy-related employment in 1974 are not strictly comparable. The employment requirements in the numerator correspond to estimates based on the Limited Imports scenario, while the denominator is based on the BLS' estimate of actual economic activity in 1974. These estimates were prepared to provide a rough "benchmark" for comparison with 1980 and 1985 projection. Actual levels (and mix) of economic activity in 1974, as estimated by BLS, are closely, but not strictly, comparable to the scenario values, since the scenario was not in effect. The Limited Imports scenario was used because it corresponds to actual activity more closely than the Free Imports or Synthetics scenarios.

Due to data availability constraints, the estimates on p. 204 are the best that could be made, but they should be interpreted with caution. In effect, the estimated percentage of petroleum engineers in energy-related employment, 114.2%, suggests that virtually all petroleum engineers were engaged in energy-related employment, but does not in itself constitute evidence of a shortage.

Jack Fiorito
Research Associate
Center for Advanced
Computation
October 17, 1977

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Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Many CAC members worked on this project. Robert Dauffenbach supervised the surveys and data analysis. The Current Situation Survey was led by Jack Fiorito, and the Projection Survey by Ronald Knecht. Wallace Hendricks led the pretest study effort. Alice Ray, Richard Roistacher, and John Hackmann participated in sample and questionnaire design. Response coding and editing was led by Louise Holmgren, who wrote the appendix on survey method and coding. The interviews and data coding were supervised by Louise Holmgren, Cheri McGhee, Ronald Seeber, and Michael Witte. Interview and coding staff included: Janet Balin, Betsy Banks, Ann Blanchard, Richard Brouay, Nancy Clarke, Barry Goldberg, Mike Grotto, Steve Hirsh, Catherine Kaplinski, Iva Karno, Paul Knight, Dominic Lucenta, Mary Metcalf, Sandy Milin, Terry Pasteris, Ken Slivken, and Jim Stewart.

Thomas Milke designed and supervised the coding of the data entry and analysis programs. Janet Finin assisted in the programming. Model development was led by Clark Bullard, assisted by David Pilati (who prepared the Free Imports and Technical Fix energy supply matrices), and Donna Amado as programmer. Doug Gilmore designed and coded the computer system used in the projections. He was assisted by Robert Schulman and You Bae Kim. Sandy McGhee and Hattie Price assisted in typing the final report.

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Authorship of a complex joint effort such as this is difficult to assign accurately. Jack Fiorito wrote most of Chapter 2 and was assisted on parts of it by Ron Seeber. Doug Gilmore, Thomas Milke, Robert Dauffenbach, and Wallace Hendricks wrote parts of Chapter 3. Robert Dauffenbach wrote most of Chapter 4 with the assistance of Jack Fiorito on Section 4.10. Hugh Folk wrote Chapter 1 and much of Chapter 3.

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PRINCIPAL FINDINGS: Current Situation

1. A survey was conducted of establishment in energy-related activities. Evidence of possible excess demand for specific scientific and technical personnel (STP) occupations can be found in salary changes, acceptance-to-offer ratios, and vacancy and quit rates.

a. Starting salaries for new graduates increased less rapidly than the consumer price index over the period 1972-1975. Average annual salary increases were highest for Petroleum, Mechanical, and Chemical engineers among the engineering occupations; for Physicists, Geelogists, and Chemists among the scientific occupations; and for Biological, Other, and Surveyors among the technician occupations.

b. The ratio of acceptances to offers for STP declined for all STP occupations combined. The ratio declined most for Mining, Metallurgical, Materials, and Ceramic, and Petroleum Engineers among the engineering occupations; for Agriculturists, Chemists, and Meteorologists among the scientific occupations; and for Draftsmen, Other, and Electrical/Electronic technicians among the technician occupations.

c. Quit rates and vacancy rates were highest for Nuclear, Mining, Chemical, and Industrial Engineers among the engineering occupations; Other scientists; and for Draftsmen, Chemical, and Mechanical Technicians among the technician occupations.

2. The survey results for establishments classified by industry investigated employment and utilization of scientific and technical personnel (STP) during the period 1972-1975. In 1975, compared to 1972, for all industry combined there was

a. slightly less overtime for STP
b. somewhat less job redesign to economize STP
c. considerably less reduction in hiring standards for STP
d. substantially less subcontracting for STP
e. less frequent use of temporary STP
f. less frequent borrowing of STP from other parts of the firm
g. little change in STP training costs (in constant dollars)
h. less curtailment of production or research and development owing to lack of STP

3. Some direct indicators of excess demand for (or shortage of) STP are retraining effort and recruiting effort.

a. 11 per cent of the establishments found it necessary to retrain STP from one specialty to another in 1975.

b. Recruiting activity was higher in most industries in 1975 than in 1972.

c. The number of recruiting personnel increased from 1972 to 1975, indicating increased recruiting.

d. All industries combined showed a gradual decline in the ratio of acceptances to offers, indicating increased difficulty in recruiting.

e. Vacancy rates in 1975 exceeded 6 per cent of employment (the all-industry average) in Architectural and Engineering Services, Railroads, and Iron and Steel Foundries.

f. The following industries had scores indicating greater increase in excess demand than the all-industry average on 9 or more of the 16 indicators of excess demand investigated:

Gas Utilities	Heating Equipment
Petroleum Refining	Railroads
Engines and Turbines	General Industrial Machinery
Iron and Steel Foundries	Pipelines except Natural Gas
Commercial RD	Non-commercial R&D
Construction Machinery	Oil and Gas Extraction

4. While recruiting activity increased and the ratio of acceptances to offers declined overall since 1972, there was little evidence either of economizing of STP already employment or specific occupational shortages. Salaries of new graduate STP increased less rapidly than the consumer price index. The few specific comments indicating shortages or difficulty in recruitment related to persons with highly specific experience. These findings indicate that there was no general shortage of STP experienced by energy related establishments in 1975.

PRINCIPAL FINDINGS: Future Requirements

1. An input-output model using projected final demands under three alternative oil prices and projected energy construction and energy usage patterns under three alternative scenarios was developed to project scientific and technical personnel (STP) requirements for non-government employment.

2. There was relatively little variation in STP requirements among the three scenarios.

   a. Private STP requirements were projected to increase, by 39 per cent from 1974 to 1985 under the three scenarios, from 2.3 million to 3.2 million.

   b. STP requirements were:

Scenario	1980	1985
	(number in thousands)	
Free Imports	2,798.7	3,202.0
Limited Imports	2,768.4	3,182.9
Synthetics	2,764.7	3,181.5

   c. Projections were prepared for four components of energy related demand: direct and indirect construction and direct and indirect energy production. Energy related STP requirements for 1985 for the three scenarios were as follows:

Partition	Free Imports	Limited Imports	Synthetics
	(number in thousands)		
Direct constr.	96.8	107.7	111.5
Indirect constr.	59.2	60.6	61.8
Direct energy	174.1	153.3	152.1
Indirect energy	23.9	23.4	22.7
Energy related	354.0	345.1	348.1
Private STP	3,202.1	3,183.0	3,181.5
% Energy related	11.1	10.8	10.9

   d. STP requirements were largest under the Free Imports scenario (which projected the highest energy usage). This occurs because the higher STP requirements for construction in Synthetics and Limited Imports is more than offset by the reduction in STP requirements for energy production in these scenarios.

3. Total STP occupational requirements were about the same under the three scenarios. 1974 estimated, 1985 projected under the Free Imports scenario, and percentage change 1974-1985 are presented below:

Occupation group	1974	1985	% increase
	(number in thousands)		
Engineers	1,004.5	1,400.1	39.4
Chemical	49.0	69.0	40.9
Civil	128.7	199.1	54.7
Electrical	262.9	370.5	40.9
Industrial	173.2	229.1	32.3
Mechanical	171.2	240.8	40.6
Metallurgical	16.2	20.2	24.9
Aero-astro.	44.4	49.2	10.9
Mining	4.7	6.5	39.7
Petroleum	11.8	18.9	60.0
Other	142.6	196.8	38.0
Life & phys. scientists	175.5	225.1	28.3
Chemists	107.2	132.8	23.9
Biological	19.3	27.3	41.4
Physicists & astronomers	15.0	21.0	40.4
Geologists	24.5	32.0	30.7
Agriculture	6.6	8.1	22.7
Marine	1.3	1.6	23.3
n.e.c.	1.7	2.3	39.7
Mathematicians	5.3	8.3	56.2
Statisticians	15.4	21.1	37.5
Computer spec.	268.1	398.0	48.4
Technicians	812.2	1,149.4	41.5
Agric, biology	34.0	41.3	21.4
Chemical	76.3	99.5	30.4
Electrical	140.1	197.8	41.2
Industrial	21.4	30.6	42.9
Mechanical	12.2	17.5	43.2
Mathematical	.6	.8	35.0
Surveyors	62.7	78.6	25.3
Drafters	284.0	433.0	52.3
Eng. & Sci.,n.e.c.	180.8	250.3	38.5

Chapter 1

Introduction and Summary of Findings

1.1 - Introduction

Scientists, engineers, and technicians play a central role in the high technology industries so important in advanced economies. Because electronics, chemicals, and aircraft require highly trained specialized workers most countries have long been concerned about the adequacy of supply of such workers. Now that energy supply is a prominent problem, concern is focused on the high-level personnel needed for energy production. In the United States, the National Science Foundation has a major responsibility for planning and supporting the education and training of scientists and engineers, and NSF has the specific responsibility for developing information on scientific and technical personnel.

This report presents the results of two projects performed by the Center for Advanced Computation, University of Illinois, Urbana-Champaign for the National Science Foundation, Division of Science Resources Studies. The first project is a study of the balance between supply of and demand for Scientific and Technical Personnel (STP) in energy-related activities and is reported on in Chapter 2. The

second study is a projection of STP requirements in energy-related activities for 1980 and 1985 and is reported on in Chapters 3 and 4.

The supply and demand study is based upon a survey of energy-related establishments conducted in 1976. The stuoy of projected future requirements is based on an economic projection model and additional survey information. The energy-related industries used in these surveys are discussed in the next section of this chapter. Shortages and reactions to shortage, the subjects of the supply and demand project, are discussed next. Next, projections and their relationship to energy policy are considered, and the projection model developed and the computer system in which it is implemented are examined briefly. Finally, summaries of findings of the two studies are presented.

1.1.1 - Definition of Energy Related Activities

The definition of energy-related activities used in selecting the industries to be sampled was twofold: "directly related industries" are engaged in the production of fuel or energy; "indirectly related industries" produce significant inputs to directly related industries. In an interdependent economy, of course, almost every industry requires either direct or indirect inputs from every other in-

dustry, but some industries are more closely related to energy production than others. Since the goal was to study the impact of energy policy alternatives on labor markets, those industries that are likely to be significantly affected by energy policy received particular attention. While it is true that farmers are involved in the production of commodities that form inputs to industries (such as chemicals) that are inputs to energy facilities and production, it is not true that the choice between alternative modes of energy production has a noticeable affect on the number of farmers employed.

A number of sources, such as input-output tables and energy facility bills-of-goods, were examined to identify those industries that had important inputs to energy production and facilities and for which energy business was a significant fraction of the industry's sales. Thus trucks are an important input to energy construction and production, but energy-related sales of automobiles and equipment are not a very large fraction of the total industry's sales and the automobile industry was excluded from the study.

The industries included, direct and indirect, are listed in tables 1.1.1a and 1.1.1b.

Table 1.1.1a Direct Energy Industries

SIC	Industry
131	Crude Petroleum
132	Natural Gas Liquids
291	Petroleum Refining and Related
492	Gas Production and Distribution
1094	Uranium Mining and Milling
1111	Anthracite Mining
1112	Anthracite Mining Services
1211	Bituminous Mining and Lignite
1213	Bituminous Mining Services
1381	Oil and Gas Field Drilling
1382	Oil and Gas Field Services
1389	Oil and Gas Field Services, nec
2819	Fissionable Materials Production
4011	Coal Unit-Train
4911	Electric Services
4931	Electric, Gas & Other (major electric but< 95%)
4932	Electric & Gas Services, Primarily Gas
4939	Electric and Gas Services, nec
4961	Steam Supply, Including Geothermal

Table 1.1.1b - Indirect Energy Industries

SIC	Industry
281	Industrial Chemicals
1623	Heavy Construction Contractors Except Highway and Street
1629	Heavy Construction, nec
3293	Gaskets, Packing, and Asbestos Insulation for Boilers
3317	Oil Country Tubular Goods
3433	Heating Equipment Except Electric
3443	Fabricated Structural Metal Products
3451,52	Screw Machine Products
3494	Pipe Fittings, Flanges and Valves
3511	Turbines and Steam Engines
3531	Construction Equipment
3532	Mining Equipment
3533	Oil Field Equipment
3534	Elevators and Moving Stairways
3535	Cranes and Hoists
3536	Conveyors
3561	Pumps and Compressors
3566	Power Transmission Equipment
3567	Industrial Process Furnaces and Ovens
3612	Power, Distribution, and Specialty Transformers
3613	Switchgear
3621	Motors and Generators
3623	Welding Apparatus
3811,21	Mechanical Controls and Instruments
3822	Automatic Temperature Controls
7391	Research and Development Laboratories
8911	Architectural and Engineering Services
8921,22	Nonprofit Education, Scientific, and Research Organizations
9631	Regulatory Agencies

1.1.2 - Definition of Scientific and Technical Personnel

Occupational specialists understand that a category such as "scientific and technical personnel" is not precisely defined for all purposes. While it appears obvious that a nuclear physicist or electronic engineer belongs in the category, it is not clear if others do. Should an engineer trained in electronics and engaged in the marketing of computers, or the general manager of a computer firm be included? Likewise, the line of demarcation is not clearcut at the other end of the training ladder. A worker who washes laboratory glassware is seldom considered a scientific and technical worker, but should a laboratory artificer be included?

These questions imply that every study of STP must select a definition. Ordinarily, this requires a list of occupational categories. This study follows, whenever possible, the occupational categories used by NSF. These are little different from the lists used by BLS and the Bureau of the Census. The survey instructions used NSF definitions (which were furnished in the questionnaires).

Respondents were asked to include "those who work at a level which requires knowledge of the subject at least equivalent to that acquired through completion of a 4-year college course in one of those fields, regardless of whether

they hold a college degree." Thus respondents who employ nongraduate engineers should have included those positions in the survey if the employer considers them as "real" engineers. Employers are usually somewhat more flexible than engineering societies (which usually hold to rather strict educational definitions of engineer or scientist), and define many more nongraduates as engineers or scientists than would the societies.

Social scientists, psychologists, and economists were excluded, since only a few of them are likely to be involved directly in energy development and there is great difficulty in distinguishing those persons involved as practitioners (in personnel work and financial analysis, for instance) from those involved in research and development. Among medical scientists, only those in research, production, and technical writing, and related activities were included, while practitioners were excluded.

The occupations on which data were collected in the surveys are:

Engineers	Scientists	Technicians
Chemical	Chemists	Agricultural
Civil/Sanitary	Physicists	Biological
Electrical/Electronics	Metallurgists	Chemical
Industrial	Geologists/Geophysicists	Electrical/Electronic
Materials/Metallurgical/Ceramic	Agriculturists	Industrial
Mechanical	Biologists	Mechanical
Aeronautical	Medical	Medical
Mining	Mathematicians	Mathematical
Petroleum	Statisticians	Surveyors
Geological	Computer	Draftsmen
Nuclear	Marine	Other
Other	Other	

Data were also collected on architects.

Occupational classification in the United States is not a precise or rigid practice. Occupational counts will vary with the question asked, the respondent, and the coder. In these studies, the NSF occupational definitions were specified, but respondents may not always have followed the instructions. It must be recognized that two establishments reporting employment or requirements for "electrical engineers" may have very different requirements in mind, and the jobs might not be suitable for an arbitrarily selected electrical engineer.

1.1.3 - Shortages of Scientific and Technical Personnel

One of the major objectives of this study was to determine the extent to which scientific and technical personnel

shortages had occurred in energy-related activities in recent years. There is a large literature on occupational shortages, especially shortages of scientists and engineers. The term "shortage" is rarely used in precisely the same way by any two people. In an earlier work, the taxonomy of shortages was discussed, and eight ways in which the term was sometimes used were identified.[1] "Shortage" in all of its uses suggests that there are not enough people from a particular point of view. The eight shortages are

1) salary-rise
2) dynamic
3) controlled price
4) projected supply shortfall
5) national policy goal
6) inelastic supply
7) limited pool of ability
8) misallocation.

Shortage is used in the salary-rise sense most often by economists. Demand rises more than supply and competition leads to increased wages and salaries. This study sought to determine if starting salaries of STP in energy-related establishments increased more than other occupations and industries.

A dynamic shortage consists of a cumulative growth of vacancies as a result of lagging salaries or recruiting ef-

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[1] H. Folk, The Shortage of Scientists and Engineers, Heath Lexington Books, Lexington. Massachusetts, 1970.

fort. In this study changes in job vacancies in energy related industries were estimated.

A controlled price shortage occurs when firms are unable to hire or retain sufficient workers because they are unwilling or unable to pay competitive salaries. In this study, controlled prices appeared to be irrelevant.

A projected supply shortfall occurs when projected requirements exceed projected supply. This question is to be investigated when the projections of requirements from this study are compared to projections of supply to be prepared in a future study.

The national policy goal shortage occurs when the number of STP available are insufficient to meet the many social objectives of the country. The present study of supply and requirements has a bearing on this question.

A limited pool of ability shortage is a qualitative shortage and occurs when demand increase leads to a decline in the average quality of a workforce because less qualified workers must be hired. This study attempted to ascertain the presence of this problem by examining employer recruiting and utilization behavior that leads to an appearance of economizing on scarce personnel by increasing hours, borrowing personnel, or reducing qualifications for hiring.

Inelastic supply shortage is indicated in this study by examining the relationship between recruiting effort and new hires and economizing measures.

Misallocation is a relative term. If specialized workers were no more costly than unspecialized persons, then their interchangeable use would not be economic misallocation. The use of a higher priced specialist interchangeably with a lower priced nonspecialist would be misallocation. Employers can adjust to occupational shortages of the salary-rise, dynamic, controlled price, or inelastic supply type by modifying their work assignment practices. Modification of work practices to reduce the need for an occupational specialty is often evidence of existence of one or another of these shortages. Of course, such adjustment may also simply reflect better management practices. Thus evidence of work practice adjustments is consistent with the presence of a shortage, but not necessarily evidence of such a shortage.

1.1.4 - Reactions to Shortage

This study concentrated heavily on STP adjustments. The absence, or relative insignificance of such adjustments, would be evidence of the absence of such shortages.

The kinds of adjustments expected from employers in the presence of excess demand for an occupation have been described elsewhere[2] as

1) overtime
2) redesign of jobs
3) reduction of the education, training, experience, and other personal qualification requirements
4) increases in the level of salary offers to attract more hires
5) increases in the level of salaries internally to reduce quit rates
6) intensification of recruiting effort
7) subcontracting of job or parts of jobs to outside firms
8) rental from outside firms
9) borrowing or transferring from other locations
10) borrowing from other companies
11) leaving vacancies unfilled and reducing production and/or research

All of these adjustments were explored with the respondent firms.

The questionnaires allowed employers in some instances (such as hires, quits, starting salaries, and retraining) the opportunity to identify particular occupations, but most of the adjustment questions applied to STP in general.

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[2] Folk, op. cit., p. 154.

As part of this study, a survey of a number of firms was made with respect to experience of shortages since 1972. Occupations and industries that had experienced difficulties in obtaining adequate numbers of STP were identified. Thus, industries and occupations and their recent experience can be related to expected experience.

1.1.5 - Projecting STP Requirements

The process of projecting requirements for an occupation that is both closely coupled to a given industry and has no close substitutes, such as teachers or physicians, is not trivial, but it can be readily accomplished by projecting the final demand for the industry, such as education or physicians' services, and estimating the relation of occupational requirements per unit of output. Most STP occupations, however, are not closely coupled to a single "final demand industry." Even if final demand is estimated precisely, it is still uncertain how many workers of each occupation will be required in each industry. Most industries have an economic role of intermediate industries. Much of their output enters into other industries as inputs and does not appear in final demand. Hence, STP projections require prior projections not only of final demand and the relationship of occupational requirements to output by industry, but also estimates of interindustry trade.

Because the composition of output by industry can be expected to vary with the policies adopted by the Nation, occupational requirements will be influenced by policy as well. Moreover, the attainment of policy objectives depends on adequate supplies of inputs. For instance, in the 1950's and early 1960's, both defense and space programs faced serious shortages of scientists and engineers. As a result of the inadequacy of supply for expanding demands, salaries of engineers and some scientific occupations rose relative to other occupations and delays occurred.

The undertaking of a new energy development program with highly specific and specialized STP requirements, such as solar power, might create significant shortages even if the general market for STP was in a balanced or surplus situation.[3] The study of current conditions in energy-related activities sought to identify firms in detailed energy-related industries and to find specific occupational shortages. The projection study, however, is much more general, and deals with what are considered by labor market analysts to be "detailed occupations," but which are actually very aggregated categories from the point of view of individual

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[3] ERDA has begun to commission studies of manpower requirements and availability for new technologies, such as solar power.

employers. The requirements projections are not intended to be highly detailed, and cannot be made in the detail necessary to identify highly specific categories of STP.

The intent of these studies is to provide a detailed picture of the current situation, and a somewhat broader perspective of future requirements. When supply estimates are made, and the differences between requirements and supply are calculated, the adjustment process by which the shortages or surpluses might be eliminated can be studied. It must be recognized that even the complete analysis will only give the dimensions of the problem in aggregated occupational terms. Only detailed study of an industry and its specific occupational needs can provide confidence that supply will be adequate.

Nevertheless, the attempts being made by NSF and ERDA to assess requirements and supply for STP is heartening evidence that the government is approaching manpower questions involved in energy planning with intelligent foresight.

1.1.6 - Projections and Policy

The assertion made in a forecast is that the events will or are likely to occur. Projections, frequently made in sets under alternative assumptions, are conditional forecasts. If certain preconditions hold, then the projected results are expected to hold. Most forecasts prepared by

government, or under government sponsorship, such as this one, are labeled "projections" rather than "forecasts." All projections, like forecasts, are based on assumptions.

One excellent reason for alternative projections is that preparing an occupational projection is a time-consuming and tedious operation. Social choices and political decisions take place continually, and it is usually impossible to take account of these as swiftly as they occur, so that any single projection is likely to become outdated almost as soon as it is made. When a set of alternative projections is available, one of them is likely to be closer to the realized events than others and to serve, at least in the interim, until new projections can be made. Therefore, the projections made in this study are based on alternative likely domestic energy production and use scenarios.

1.1.7 - Energy Policy

Energy policy is not settled and predictable. In recent years the United States has undergone a number of changes in energy policy. Once an exporter of energy, the United States is now a net importer. At one time or another, policies to limit imports (such as the oil quota) or to encourage free imports have been pursued. The Oil Embargo of October, 1973 and the recent rapid increases in world

petroleum price (some of which predated the embargo) led to a marked increase in debate over energy policy.

The sudden growth of interest in domestic energy production, using nuclear power, coal, and synthetics, was in part a reflection of concern for national autonomy (as reflected in President Nixon's "Project Independence") and in part a natural result of higher oil prices that made more domestic energy production economically feasible.

Domestic energy developments can be expected not only to affect energy producing industries, but also to affect those industries that supply or depend on the energy industries. So far, the results of the new recognition of energy problems have been substantial, but highly concentrated. The Alaskan oil pipeline was authorized. Petroleum exploration was stepped up. Smaller automobiles with higher miles per gallon started, at least in 1974, to replace larger cars in new car sales. Energy R & D spending has increased substantially. A number of new energy facilities have been begun or planned.

Oil imports have increased since the embargo, and one possible future policy is to continue to rely on growing imports. Threats to secure supply or increases in the price of foreign oil supplies could lead to stepped up effort at increasing domestic energy production. There are two major

approaches within a limited import policy. One policy alternative limits imports and emphasizes nuclear development. Another alternative limits imports and emphasizes synthetics, such as synthetic natural gas from coal and synthetic crude from oil shale or coal. These synthetic technologies, while technically feasible, have not been demonstrated to be economically feasible under current price structures.

The three alternative policies, free imports, limited imports and limited imports (synthetics), among others, have been specified by ERDA, and are the scenarios investigated in this study. The Bureau of Labor Statistics has prepared three final demand vectors for 1980 and 1985 representing estimated final demand by industry under three levels of oil prices. Three different energy technology submatrices, reflecting varying expected patterns of fuel use under the three oil price scenarios, are utilized. For example, under a high-priced oil scheme, one should expect relatively greater use of coal in electric power generation. This is reflected in the Limited Imports technology patterns. The BLS low-priced oil final demand vector is coupled with the Free Imports technology pattern, the medium-priced oil final demand with the Limited Imports technology, and the high-priced oil final demand with the Synthetics technology to represent reasonable combinations of final demand, energy production, and energy consumption technology.

Each policy or scenario can be expected to have economic requirements that differ from the others. Different facilities would be built under different policies.

The energy production and requirements under the three scenarios have been developed using the Brookhaven Energy Model and the Bechtel Energy Supply Model. The Bechtel Model produces estimates of the direct construction labor and the materials required to produce the facilities expected under the three scenarios. The direct material requirements have been converted to industry final demand requirements compatible with the input-output model used in this study.

1.1.8 - Projection Model

The projection study required a substantial effort in projection model development. The model developed is useful for making occupational projections of STP requirements under alternative final demand, energy technology, and energy supply assumptions. The CAC Model is closely tied to BLS projection techniques, and thus can be readily updated to utilize the newer technology coefficients and final demand patterns as BLS develops them. The magnitude of the efforts required to prepare non-energy technology coefficients and final demand vectors makes it impossible for an agency to develop these in any detail or to keep up-to-date, as chang-

ing conditions require. The close integration of the CAC model with the BLS model is a major advantage. Moreover, the CAC Model includes a highly disaggregated energy sector that is arranged in such a way that projected changes in fuel mix, energy process efficiencies, and relative prices can be readily incorporated in the model. This provides a substantial advantage over the energy sectors in the BLS model that are expressed in constant dollars, rather than energy units. The CAC Model is also closely comparable to the Brookhaven Energy Model and the Bechtel Energy Supply Model, so that fuel mixes and process efficiencies expressed in those models can be simulated in the CAC Model. In effect, the CAC Model incorporates the strength of the BLS model in projected final demand and non-energy sectors, and the energy sector projections of the Brookhaven Model, while allowing direct comparison to energy construction projections from the Bechtel Energy Supply Planning Model.

1.1.9 - Computer System

A substantial advantage of the CAC Model developed in this project is that it is implemented in a computer system that is extraordinarily quick and economical to run. Any coefficient may be changed and a new projection run in seconds and for pennies. Detailed sensitivity analysis of the results can be obtained in a reasonable time and for

modest cost. Moreover, the use of the model need not require an experienced programmer. It is implemented on a PDP11/50 at CAC, running the UNIX operating system, and is accessible by direct telephone connection or through the ARPANET. However, it should not be expected that so complex a model should be trivially easy for a non-programmer to use.

The accessibility and ease of maintenance suggests that it will be an easy instrument for further work. It is simple to change any coefficient to simulate any new economic or energy relationship; aggregation or disaggregation of the model is straightforward.

1.2 - Summary of results

1.2.1. - Current STP labor market conditions

Evidence of excess demand for specific occupations can be examined from changes in salaries of inexperienced hires, acceptance rates, and combined vacancy and quit rates.

Average annual salary increases were highest for Materials, Metallurgical, and Ceramic , Aeronautical, and Petroleum Engineers, for Statisticians, Physicists, and Geologists, and Biology, Mathematical, and Other technicians.

Acceptance ratios declined most for Mining, Metallurgical, Materials, and Ceramic, and Petroleum Engineers, Agriculturists, Chemists, and Meteorologists, and Draftsmen, Other, and Electrical/Electronic technicians.

The Quit Rates and Vacancy Rates were highest for Nuclear, Mining, Chemical, and Industrial Engineers, Other scientists, and Draftsmen and Chemical and Mechanical technicians.

If these measures of occupational shortage are equally weighted and combined, Nuclear, Mining, and Chemical Engineers, Physicists, Chemists, Agriculturists, and Geologists, and Draftsmen, Surveyors, Chemical, Mechanical, and Other technicians show the greatest evidence of excess demand or shortage.

Mining, petroleum, chemical, industrial, and "welding" engineers were occasionally cited as presenting problems. The quantitative data were consistent with, but not strongly supportive of these claims.

All industries combined showed a gradual decline in the acceptance to offer ratio from about two-thirds in 1972 to one-half in 1975. Iron and Steel Foundries, Petroleum Refining, Oil and Gas Extraction, and Coal Mining all had acceptance ratios below the all-industry mean in 1975 and also showed declining acceptance ratios over the period 1972-75.

Quit rates were substantially higher for STP in establishments in Rolling and Extruding of Non-ferrous Metals, Electric Lighting and Wiring Equipment, Metalworking Machinery, Commercial Research and Development, Motor Vehicles, and Non-commercial Scientific and Research.

Most industries showed some vacancies, but vacancies exceeded 6 per cent of employment (the all-industry average) only in Architectural and Engineering Services, Railroads, and Iron and Steel Foundries. Of the 16 indicators investigated, some firms scored consistently in the direction of relatively greater shortage or excess demand for STP. Gas Utilities, Heating Equipment, Petroleum Refining, Railroads, Engines and Turbines, General Industrial Machinery, Iron and Steel Foundries, Pipelines except Natural Gas, Commercial Research and Development, Non-commercial Scientific and Research, Construction Machinery, and Oil and Gas Extraction all indicated more than average excess demand for STP on 9 or more of the indicators.

Solid evidence of shortages or excess demand, however, was quite limited. An employer reported a problem filling a vacancy 1) for an extremely narrow specialty, perhaps one that exists only within that employer's firm; 2) for experienced STP...indicating the lack of urgency; or, 3) for female or minority candidates.

A wide range of labor market indicators was examined. Detailed occupational data were collected on salaries, quits, vacancies, hires, offers, and employment for STP in energy-related industries. Employers' reactions to possible excess demand for STP, such as retraining and job redesign, were examined. The variety of measures employed consistently show no evidence of serious shortages.

Respondents in energy-related establishments were asked about actions that would accommodate to excess demand for STP. They were to compare their usage of such actions in 1975 and in 1972, a year marked by the highest level of excess supply of STP in decades. The actions examined were:

a) overtime
b) redesigning jobs
c) reducing hiring qualifications
d) sub-contracting work
e) hiring temporary STP
f) borrowing STP from other firms
g) borrowing STP from other divisions or locations
h) training costs
i) delaying or cancelling production

All industries combined reported slightly less overtime in 1975 than in 1972, but three direct energy industries (Coal Mining, Oil and Gas extraction, and Gas Utilities) and 13 indirect energy industries (including Materials Handling Machinery, Heavy Construction, Pipes, Valves, and Fittings, and Industrial Chemicals) reported more overtime for STP in 1975 than in 1972.

All industries combined redesigned jobs somewhat less in 1975 than in 1972, but Pipelines (except Natural Gas), Petroleum Refining, and Electric Utilities among the direct industries, and 10 indirect industries (including Electronic Components, Fabricated Steel, and Engines and Turbines) reported more job redesign in 1975 than in 1972.

Reduction of hiring requirements was used by all industries combined considerably less, on the average, in 1975 than in 1972, but Pipelines (except Natural Gas), Electronic Components, and Instruments found it necessary to take this action more in 1975 than in 1972.

Subcontracting was substantially less used by all industries in 1975 than in 1972. Only Heating Equipment, Petroleum Refining, and Non-commercial Scientific and Research subcontracted more in 1975 than in 1972.

Temporary STP from outside firms were used less often in 1975 than in 1972. Only General Industrial Machinery used this option more often in 1975 than in 1972.

STP were borrowed from other parts of the firm less frequently in 1975 than in 1972. Only Basic Steel and Engines and Turbines reported interfirm borrowing more in 1975 than in 1972.

None of the surveyed industries reported borrowing STP

from other firms more in 1975 than in 1972.

Industry as a whole reported that training costs (in constant dollars) scarcely changed from 1972 to 1975. Only Gas Utilities, of the direct industries, reported an increase in real training costs, but 9 indirect Industries, including industrial Chemicals, Electronic Components, and Heavy Construction, reported increases.

Curtailment of production or research and development was substantially less necessary in 1975 than in 1972. Only Non-commercial Scientific and Research curtailed production to a greater extent in 1975 than in 1972.

Although there are no consistent patterns of excess demand for STP shown in the individual actions, some industries did consistently score below the all-industry average, but the average on the individual actions in every instance indicates that excess demand was less in 1975 than in 1972. The data indicate that relative to other energy related industries, the following faced somewhat greater excess demand:

Pipelines except natural gas
Gas Utilities
Coal Mining
Oil and Gas Extraction
General Industrial Machinery
Heating Equipment except Electric
Engines and Turbines
Railroads
Industrial Chemicals
Fabricated Structural Steel

Commercial Research and Development
Non-commercial Scientific and Research

Of those industries indicating higher excess demand in 1975 than in 1972, only 8 industries showed any indication of more excess demand in 1975 than in 1972 on 3 or more items. These included with 4 items, General Industrial Machinery, and with 3 items, Heavy Construction, Industrial Chemicals, Engines and Turbines, Electronic Components, Instruments, Commercial Research and Development, and Non-commercial Research and Development.

More direct indicators of excess demand are found in retraining effort, number of recruiting interviews, number of recruiting personnel, ratio of acceptances to job offers, quit rates, and vacancy rates.

Eleven per cent of the establishments found it necessary to retrain STP from one specialty to another in 1975. One third of the establishments in Engines and Turbines, one-fourth of those in Metalworking Machinery, and about one-fifth of those in Oil and Gas Extraction, Construction Machinery, Screw Machine Products, Petroleum Refining, Instruments, and Commercial Research and Development found it necessary to retrain STP.

Recruiting activity was quite volatile. Many industries showed greater recruitment activity in 1975 than in 1972, with the greatest annual average percentage increases

in Gas Utilities, Architectural and Engineering Services, Commercial Research and Development, Heating Equipment except Electric, and Iron and Steel Foundries. In about 16 industries there was evidence of recovery from very low or zero recruitment in 1972-74. These results indicate an increase in demand for these industries.

Recruiting personnel employed in industries shows substantial average annual increases for Pipes, Valves, and Fitting, Oil and Gas Extraction, Construction Machinery, Iron and Steel Foundries, Heating Equipment, Architectural and Engineering Services, Instruments, Electric Transmission Equipment, and General Industrial Machinery. These increases indicate a considerable increase in demand for these industries since 1972.

Several industries showed a substantial increase in use of managerial or technical staff for recruiting, with Industrial Chemicals, Railroads, Heavy Construction, Petroleum Refining, and Iron and Steel Foundries showing the greatest increases.

The energy-related industries have had few STP problems in their expansion to date as a result of inadequate demand for labor in the economy as a whole. Unemployment rates for STP in 1975 and 1976 reached their highest recorded historical levels, falling below 3 per cent only once, in March,

1975.[4] The quantitative survey data indicate that the state of the labor market (from the employer's viewpoint) in 1975 can be concisely summed up by the respondents' frequent comment: "No problem."

1.2.2 - Summary of STP Projections

STP projections for 1980 are approximately 2.8 million; and for 1985, 3.2 million. The corresponding base for 1974 is 2.3 million. There is little variance among scenarios, and the differences are in a direction that is counterintuitive. The Synthetics scenario yields the lowest projection of total 1980 STP requirements, for the sample occupations, 2.77 million; Free Imports, the highest, 2.80 million (Table 1.2.2a).

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[4] "Selected Unemployment Indicators" (table), Monthly Labor Review, Vol. 99, No. 4, (April 1976).

Table 1.2.2a

1980 and 1985 Employment Projection of Private Scientific and Technical Personnel and Energy-Related Industry Employment

(number in thousands)

	Free Imports	Limited Imports	Synthetics
1980 Import Scenario			
Total STP Employment	2,798.7	2,768.4	2,764.7
Energy-Related Industries[1]	1,051.3	1,027.4	1,030.2
Engineers	532.6	523.0	524.8
Scientists	63.6	59.1	59.5
Math Specialists	65.1	63.2	63.1
Technicians	390.0	382.1	382.8
Other Industries	1,747.4	1,741.0	1,734.5
Engineers	718.9	715.1	710.5
Scientists	139.6	139.9	140.3
Math Specialists	293.3	292.3	292.5
Technicians	595.6	593.7	591.2
1985 Import Scenario			
Total STP Employment	3,202.0	3,182.9	3,181.5
Energy-Related Industries[1]	1,239.3	1,228.0	1,230.9
Engineers	618.6	616.9	618.1
Scientists	71.3	66.7	67.5
Math Specialists	77.4	75.5	75.4
Technicians	472.0	468.9	469.9
Other Industries	1,962.7	1,954.9	1,950.6
Engineers	781.5	777.1	773.2
Scientists	153.8	154.4	155.1
Math Specialists	350.0	348.5	349.3
Technicians	677.4	674.9	673.0

1 Includes Bechtel STP requirements for Construction of Energy Facilities.

Thus only 34 thousand workers separate the high and low scenario estimates. The 1985 scenario projections are even closer; only a 21 thousand difference between Free Imports and Synthetics. Since the construction STP manpower requirements are higher for the Synthetics scenario, the lower levels of energy production associated with the higher oil price scenarios produces a disemployment effect that exceeds the higher construction manpower requirements. For 1985 the Synthetics scenario require 112 thousand STP personnel for construction of energy facilities, according to the Bechtel estimates; 97 thousand for the Free Imports scenario. Energy use is, however, 14 per cent higher under the Free Imports scenario (99.1 vs 86.9 quadrillion Btu's). The number of operations and maintenance STP personnel is substantially reduced under lower levels of energy production.

Energy-related industries are defined as those directly or indirectly involved in the production of energy and construction of energy facilities, but energy-related employment consists of workers involved in the production of energy and construction of energy facilities employed both in energy-related and other industries. Not all STP in energy-related industries are in energy-related activities, and some STP in non-energy industries are engaged in energy-related activities.

Energy-related employment projections are partitioned into four groups: direct construction, indirect construction, direct production of energy, and indirect energy production (Table 1.2.2b).

The direct construction STP requirements are provided by Bechtel. For 1980, Bechtel predicts slight variation in manpower requirements. Construction requirements for the Limited Imports scenario will utilize 83.7 thousand STP workers versus 89.3 thousand for the Synthetics scenario. No scientists or mathematical specialists are required in Bechtel's view and all of the requirements for technicians are for the single category of draftsmen. Engineers account for about 70 per cent of the STP requirements for this partition component. Civil, electrical, and mechanical engineers represent the dominant engineering categories.

For 1985, Bechtel projects substantial increases in STP requirements: 96.8 thousand for Free Imports; 111.5 thousand for Synthetics. There is also wider variation in requirements across scenarios (15 per cent vs 7 per cent for 1980). Again, engineers represent about 70 per cent of total STP requirements for this partition component.

Units of STP manpower, as well as other types of labor inputs, are indirectly embodied in the materials used for construction of energy facilities. Multiplying the

Table 1.2.2b

STP Requirements for 1980 and 1985, by Scenario, Major STP Specialty, and Energy-Related Employment as Per cent of Total STP Employment

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Free Imports --1980								
Engineers	59,600	29,315	60,308	7,918	165,207	1,086,305	1,251,512	13.2
Scientists	0	3,239	26,690	1,805	31,743	171,471	203,214	15.6
Math, computer	0	5,115	11,026	3,021	19,961	330,496	350,457	5.6
Subtotal	59,600	37,669	106,504	12,736	216,911	1,596,272	1,813,183	12.0
Technicians	24,600	20,696	46,307	7,557	99,239	806,403	905,640	10.1
	24.8	20.9	46.7	7.6	108.8			
Total	84,200	58,365	153,291	20,293	316,150	2,402,673	2,798,823	11.3
Limited Imports --1980								
Engineers	59,600	28,942	60,050	7,939	156,520	1,081,534	1,238,062	12.6
Scientists	0	3,062	22,370	1,913	27,366	171,647	199,013	13.8
Math, computer	0	5,022	10,245	2,920	18,199	377,391	355,598	5.1
Subtotal	59,600	37,046	92,665	12,782	202,093	1,590,567	1,792,660	11.3
Technicians	24,100	20,403	40,404	7,703	92,610	883,208	975,818	9.5
Total	83,700	57,449	133,069	20,485	294,703	2,473,772	2,768,475	10.6
Synthetics --1980								
Engineers	62,900	30,643	50,607	7,626	159,775	1,075,485	1,235,260	12.9
Scientists	0	3,207	22,921	1,773	27,900	171,913	199,813	14.0
Math, computer	0	5,269	10,284	2,863	18,356	337,162	356,518	5.2
Subtotal	62,900	39,319	91,812	12,202	206,031	1,584,560	1,790,591	11.5
Technicians	26,400	21,617	39,569	7,306	94,892	879,560	974,452	9.7
Total	89,300	60,736	131,381	19,508	300,923	2,464,120	2,765,043	10.9
Free Imports --1985								
Engineers	68,100	28,722	79,953	9,072	185,827	1,214,292	1,400,119	13.3
Scientists	0	3,263	20,679	2,028	33,970	191,175	225,145	15.1
Math, computer	0	5,355	13,546	3,715	22,616	404,789	427,405	5.3
Subtotal	68,100	37,328	122,178	14,815	242,413	1,810,256	2,052,669	11.8
Technicians	28,700	21,830	51,897	9,113	111,541	1,037,878	1,149,419	11.0
Total	96,800	59,150	374,075	23,920	353,954	2,848,134	3,202,088	11.1
Limited Imports --1985								
Engineers	76,300	29,533	70,330	8,060	185,829	1,209,024	1,394,853	13.3
Scientists	0	3,297	24,227	2,093	29,617	191,528	221,145	13.4
Math, computer	0	5,454	11,917	3,466	20,837	403,150	421,987	4.9
Subtotal	76,300	38,282	106,474	14,680	235,463	1,803,702	2,039,165	11.5
Technicians	31,400	22,336	46,820	9,014	109,570	1,034,236	1,143,806	9.6
Total	107,700	60,618	153,294	23,443	345,053	2,837,938	3,182,991	10.8
Synthetics --1985								
Engineers	78,600	30,122	68,671	8,663	186,856	1,205,260	1,391,316	13.4
Scientists	0	3,291	25,160	1,947	30,394	192,157	222,555	13.7
Math, computer	0	5,549	12,023	3,302	20,954	403,753	424,707	4.9
Subtotal	78,600	38,962	105,854	13,992	237,408	1,801,170	2,038,578	11.6
Technicians	32,900	22,822	46,287	8,698	110,699	1,032,217	1,142,916	9.7
Total	111,500	61,784	152,141	22,682	345,107	2,833,387	3,181,494	10.9

Leontief-inverse matrix by the vector of industry inputs of energy construction materials provides a basis for partitioning this element of indirect labor input. The materials requirements specified by Bechtel are used here.

Between 57 and 61 thousand STP are indirectly involved in construction of energy facilities. Larger STP requirements are projected for the Free Imports scenario than the Limited Imports scenario. This difference indicates the imporance of capital requirements for petroleum storage and refining under the Free Imports scenario. The Synthetics scenario, however, requires the largest inputs of STP manpower, 61 thousand; yet, this represents only about 2.3 per cent of projected total STP employment for 1980. Indirect construction requirements are large in relation to direct construction requirements. For example, the Free Imports scenarios has indirect requirements equal to 41 per cent of the total (direct and indirect) 1980 STP construction requirements. Thus, neglect of indirect requirements can lead to a substantial understatement of manpower requirements.

Projections for 1985 STP indirect construction requirements are only slightly higher than the 1980 estimates. The estimate for the Free Imports scenario is, for example, less than 1 thousand higher. Again, total STP requirements vary only slightly across scenarios; the largest difference is only 4 per cent.

STP occupations which are important to indirect construction of energy facilities include electrical, industrial, mechanical and miscellaneous engineering categories, computer specialists, electrical and electronic technicians, draftsmen, and engineering and science technicians, n.e.c. Although the distributions of requirements varies substantially across STP occupations, there appears to be less relative variation as a per cent of total requirements per occupation. This is because STP occupations which are needed in larger numbers for indirect energy facility construction are also occupations for which economy-wide requirements are high. For example, electrical engineers and chemists represent 12 and 4 per cent of the 61.8 thousand STP required for the 1985 indirect construction component of the Synthetics scenario. Yet, these requirements represent only 2.0 and 1.5 per cent of economy-wide STP requirements for each respective occupation. Thus, STP requirements for indirect construction are a small per cent of economy-wide requirements for each STP occupation even though some categories are needed in larger numbers than others.

Consequently, the differential impact of this component of requirements on the STP occupational spectrum will be small, provided that supply closely approximates demand.

Employment resulting from total energy demand comprises the third partition component. This direct-energy production component yields the largest share of total energy-related employment even though the proportion of total energy-related employment accounted for by this component varies from about one-half to one-third across scenarios.

Because the level of energy use is substantially higher under the Free Imports scenario, STP requirements are also substantially higher- - 153.3 thousand scientific and technical personnel under Free Imports versus 131.4 thousand under the Synthetics scenario. For 1985 the differential across scenarios widens by 10 thousand (174.1 versus 152.1).

Engineers represent about 45 per cent of the total STP requirements for this component for both 1980 and 1985 projections. Electrical and petroleum engineers account for about 54 per cent of engineer requirements in 1980; 50 per cent in 1985. Geologists, computer specialists, chemical and engineering and science technicians represent other important occupations for direct energy production.

Although there is some variation in STP requirements across scenarios, this variation runs counter to scenario variation in direct and indirect construction requirements. Furthermore, for 1985 in particular, the variation is requirements for direct energy production is substantially offset by variation in total construction requirements.

The 1985 variation across scenarios of 32 thousand is reduced by 41 per cent when construction variation is added. A substantial leveling of total scenario projections is the result.

Indirect employment resulting from total demand for energy is the least impressive of the partition components. STP requirements are low and variation across scenarios is small (less than one thousand workers). Requirements are highest for the Limited Imports scenario in 1980 at 20.5 thousand STP workers and lowest for Synthetics, 19.5 thousand. In addition requirements across the STP occupational spectrum are relatively flat in relation to economy-wide requirements. That is, there are no occupational "bulges" for indirect energy production. The only striking feature of this component is its comparative lack of significance. Indirect requirements for energy production are only about 12 to 13 per cent of total energy production requirements.

Summing the four partition components yields projection of total energy-related employment. These sums show the substantial leveling of employment across scenarios that results once all the contributions to energy-related employment are examined. The Free Imports scenario yields the highest value of projected STP employment: 316.2 thousand. This total is only 7 per cent higher than the Limited Imports scenarios which yields the lowest projection (294.7 thousand).

That it is higher at all is counterintuitive. This analysis has shown that the additional employment effects of increased energy facility construction are not sufficient to offset the disemployment effects associated with lower energy use with higher priced energy.

For 1980 and 1985, approximately 11 per cent of total STP requirements in the private economy will be needed in energy-related activities (Table 1.2.2b). There is only slight variation across scenarios: For 1980 the Free Imports scenario requires 11.3 per cent; Synthetics, 10.9 per cent. There is some variation among the aggregated STP groups. The percentage requirements of engineers is approximately 13 per cent for 1980 and 1985. Scientists requirements are slightly higher at 14 to 15 per cent while Math and Computer Specialists are substantially lower, 5 per cent. Technicians requirements are 10 to 11 per cent. Percentage requirements for energy activities for some individual occupations such as Petroleum Engineers, Mining Engineers, and Geologists are high. For 1985, Limited Imports scenario, the proportion of these STP categories utilized in energy-related activities is 38, 88, and 63 per cent, respectively. The proportion of Electrical Engineers is also relatively high: 17 per cent. For almost all of the

other detailed categories, however, energy-related utilization is less than 10 per cent.

For comparative purposes, estimates of energy-related employment for 1974 were prepared by the same method. The 1974 proportions of STP enegaged in energy-related activities are quite close to the proportions projected for 1980 and 1985, indicating that energy development programs will not result in an increased proportion of private STP employment being drawn into energy related work.

Chapter 2

Current STP Labor Market Conditions

2.1 - Introduction

This chapter examines the labor market experience of energy-related employers since 1972 in order to identify occupations and industries that may have experienced shortages. At best, the term "shortage" is open to many interpretations.[1] The common attributes of all of the meanings implies unusual difficulty in obtaining adequate numbers of workers of customary quality on customary terms of employment. Blank and Stigler, for instance, argue that that "shortage" is identical to a rise in price.[2] This usage, although generally accepted by many economists, hardly exhausts all such situations as are commonly described as shortages. Salary increases are examined in this study as primary evidence of the existence of a shortage. It is difficult to believe that severe difficulty in obtaining STP could exist without a rise in salaries of STP, since em-

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1 For a discussion of some of the usages of the term in STP studies, see H. Folk, The Shortage of Scientists and Engineers, Lexington: Heath Lexington Books, 1970, pp. 2-19.

2 David M. Blank and George J. Stigler, The Demand and Supply of Scientific Personnel (New York: National Bureau of Economic Research, 1957) p. 24.

ployers have been free to bid competitively for personnel.

A second usage of the term "shortage" has been examined by Arrow and Capron who argue that salaries may lag increases in demand because of administrative problems in adjusting salaries upward fast enough to fill all of the job vacancies that appear when demand for the product increases.[3] This is termed a "dynamic shortage." The best evidence for a dynamic shortage is found in increasing numbers of vacant jobs. An attempt was made in this study to collect survey data on vacancies over the period 1972-75, but it was impossible to obtain useful data except for a few occupations in 1975. Other possible sources of vacancy data, such as the Bureau of Labor Statistics and the Job Banks of the public employment service, were examined but did not provide data useful for the present purposes.

One important use of the term "shortage" relates to utilization. If employers have difficulty obtaining adequate numbers of employees of customary quality on customary terms they may be expected to economize the use of the employees they already have. Measures such as overtime, job redesign, sub-contracting, and borrowing should be utilized more extensively during periods of shortage than in a period

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3 Kenneth J. Arrow and William M. Capron, "Dynamic Shortages and Price Rises: The Engineer-Scientist Case," Quarterly Journal of Economics, May, 1959, p. 306.

of surplus or balanced supply and demand. In this study, 1972 was adopted as the base year to which later utilization indicators were compared because it was a year of widely recognized excess demand for STP. In the discussion of utilization, the term "relative shortage" is often used to compare conditions between occupations and industries. This term does not rule out the presence of a surplus in an absolute sense. Thus an industry or occupation may have experienced a change in a measure of utilization over the period 1972-75 that indicates a relative shortage in 1975 compared to 1972, even though an absolute surplus (or excess supply) of STP existed in both years. A relative shortage in 1975 suggests that the shortage was greater, or the surplus smaller, in 1975 than in 1972.

Other usages of the term "shortage" relate to hiring success. If employers in one year have a smaller proportion of job offers accepted than in the previous year, they may interpret this as a shortage. The ratio of acceptances to offers for various occupations are examined, and, for many STP occupations, the ratio declined over the period 1972-75. This is a difficult measure to interpret unambiguously, since the number of offers made depends to some extent on what the employer's expectation of acceptance might be. A decline in the acceptance-to-offer ratio is certainly consistent with the existence of a shortage, but, by itself, it may simply indicate that employers, recognizing the presence

of excess supply in the market, make offers to better quality people whom they would not ordinarily expect to be able to hire on the terms offered. In the discussion of acceptance ratios, the concept of "relative shortage" is used as it is in the discussion of utilization.

The rest of Section 2.1 discusses the occupations and indicators on which data were collected in the survey and supports the selection of 1972 as a base year for comparisons. Section 2.2 examines the specific STP occupations with respect to salaries, acceptance ratios, and quits and vacancies. Section 2.3 examines employer utilization behavior by industry. Section 2.4 examines some specific STP occupations and relates employment conditions of the occupations to the needs of specific industries. It also includes conclusions on specific occupations in which there is significant evidence of shortages.

2.1.1 - Occupations Included

Engineers	Scientists	Technicians
Chemical	Chemists	Agricultural
Civil/Sanitary	Physicists	Biological
Electrical/Electronic	Metallurgists	Chemical
Industrial	Geologists/	Electrical/
Materials/	Geophysicists	Electronic
Metallurgical/Ceramic	Agriculturists	Industrial
Mechanical	Biologists	Mechanical
Aeronautical	Medical	Mathematical
Mining	Mathematicians	Surveyors
Petroleum	Statisticians	Draftsmen
Geological	Computer	Other
Nuclear	Marine	
Other	Other	

This detailed occupational scheme is compatible with both the National Science Foundation's, and the Bureau of Labor Statistics' 470-level occupational classification system. It is the most disaggregated level which one could expect a wide spectrum of industries to find meaningful.

Respondents were asked to specify the "Other" STP for which they reported data. From this specification it was possible to isolate three additional occupational specialties:

General Engineers
Meteorologists (Scientists)
Engineering Technicians.

2.1.2 - Data Source and Type

The primary source of data for this chapter is an extensive STP survey, conducted by mail and telephone between January and June, 1976, of manpower, personnel, and industrial relations experts in industries directly and indirectly related to energy production.4 Quantitative STP data were collected on salaries, quits, vacancies, hires, offers, recruiting and other labor market indicators in recent years.

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4 Appendix A explains sample construction, Appendix B discusses the survey process, and Appendix C contains the survey materials.

Comments on recent experience were also solicited. These data are supplemented by information drawn from other sources, such as the Bureau of Labor Statistics, Frank Endicott's annual surveys of college placements, and the College Placement Council.

2.1.3 - Indicators

Salaries of inexperienced new hires should be directly related to labor market excess demand though competition. Excess demand is the difference between the demand and supply schedules at a certain price. It is positive when demand exceeds supply, and negative when supply exceeds demand. Positive excess demand in a market presents a situation that may be characterized as "tight" or "shortage" from the point of view of demanders, or employers. The ratio of acceptances to offers should be inversely related since prospective hires will receive more good offers in a market with positive excess demand. Data were collected for new inexperienced hires to avoid clouding the data by mixing offers to experienced and inexperienced hires.5 Vacancy and quit rates for STP should be directly related to the level

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5 Hansen has shown that only starting engineers registered larger increases than did all workers in a tight STP job market. W. L. Hansen, "The Shortage of Engineers," Review of Economics and Statistics, Vol. XLIII (August 1961), pp. 251-56.

of excess demand. Workers experiencing high demand for their specialty should quit more often as they are lured to better offers, creating vacancies.

College and university interviews with scientific and technical students, and the number of recruiting personnel used should be directly related to the excess demand of the job market. Lower acceptance rates and more vacancies as well as incremental need for STP should cause increases in these indicators.

Other indicators and actions employers may have taken to accommodate to excess demand in the STP labor market are also discussed. These include:

a) overtime
b) redesigning jobs
c) reducing educational, experience, or other qualifications
d) sub-contracting work
e) hiring temporary STP
f) borrowing STP from other firms
g) borrowing STP from other divisions or locations
h) training costs
i) delaying or cancelling production
j) retraining from one technical specialty to another
k) using managerial or technical staff whose duties do not normally include recruiting for recruiting purposes.

2.1.4 - General conditions

The STP labor market conditions for industries included in this study reflect the generally languorous conditions of the entire economy in 1975. The unemployment rate for the nation ranged from 7.7 to 8.4 per cent in 1975 (quarterly

BLS data), the most recent reporting period included in the survey. The unemployment rate of professional and technical workers, while less than one-half the national average, was higher in 1975 and 1976 than in 1971, its previous peak. STP employment as a whole reflects the presence of considerable excess supply of labor over the period 1972-75, and direct measures (such as starting salaries) show little evidence of shortages for engineers or scientists in general, although a few engineering occupations and several technician occupations do show signs of moderate shortages. Job vacancy data are available only for 1975, and for most occupations are not especially large in size, although there is no convenient base to which the 1975 vacancy estimates can be compared. Acceptance-to-offer ratios are consistent with increasing shortages (or decreasing surpluses) for several occupations from 1972 to 1975, but most occupations show a relatively high degree of success in recruiting. Industry indicators of utilization do not, on the whole, indicate that energy-related industries economized STP more in 1975 than in 1972.

2.1.5 - 1972 as a Reference Year

Nineteen seventy-two was selected as the reference year because it was the last full year before the onset of the Arab Oil Embargo of October 1973 and was a year of historically high unemployment for STP.

The following quotation is a typical account of STP labor market conditions in 1972:

> Unemployment among engineers, rather than shortages of a decade ago, became a major concern as the economy entered the 1970's. Cutbacks in Federal expenditures for defense and space activities and the slower pace of economic progress were its major causes. Reports of many unemployed engineers driving taxis for a living, abandoning their mortgaged homes, or living on welfare appeared in numerous professional publications and newspapers. State employment service offers across the country showed shrinking job opportunities for engineers.[6]

Part of the problem in 1972 was the fact that many 1971 science and engineering graduates were still seeking jobs. A 1972 Wall Street Journal story was captioned "Glum Grads; As Class of '72 Nears Marketplace, Class of '71 is Still Pounding Streets."[7] The Engineering Manpower Commission found only 88 per cent of 1971 graduates had commitments upon graduation compared to 96 per cent in 1969. These percentages overstate the ability of the market to employ jobseekers since among those commitments were 20 per cent planning graduate study and 14 per cent entering military service in 1971 compared to 16 per cent and 9 per cent respectively in 1969.[8]

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6 K. Naughton, "Characteristics of Jobless Engineers," Monthly Labor Review, Vol. 95, No. 10, (October 1972), p. 16.

7 "Glum Grads;...," Wall Street Journal, January 21, 1972.

8 "Engineering and Technology Graduates - 1971," New York, Engineering Manpower Commission, Engineers Joint Council, 1971.

The Engineering Manpower Commission, reported: "the effect of aerospace cutbacks was at its most severe stage [in 1971-2]". "The year 1972 marked the bottom of a three-year decline in engineering hires when its graduating class was the largest since 1950."9

The editors of Chemical Engineering Progress describe the years 1971-2 as "gloomy" for engineering employment.10 One indicator they cite is the number of pages of recruitment advertising in their journal. In 1971 and 1972 the average number of pages was four, compared to eight and one-half for 1973 and slightly higher in 1974. In August of 1972 the journal's help wanted ads were running at their lowest level in 14 years.11

The Bureau of Labor Statistics compiles occupational unemployment data for professional and technical workers as a group. Their data show that 1971 and 1972 were the years of greatest unemployment for this category since the data series began, (except for 1975 and 1976). These data are

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9 J. Houston, " Engineering Grads Find Poorer Job Prospects," Chicago Tribune, November 23, 1975.

10 "Jobless Rate Among Engineers Causing Concern," Chemical Engineering Progress, Vol. 71, No. 9, (September 1975), p. 37.

11 "Words, Words, Words," Chemical Engineering Progress, Vol. 68, No. 8, (August 1972), p. 41.

shown in table 2.1.5a and figure 2.1.5.12

The Bureau notes however, that "meaningful comparisons of occupational employment levels cannot be made between 1971-72 with prior periods nor between these years," due to questionnaire and classification changes. Almost paradoxically, they then state the effect on unemployment rates are "believed" to be "negligible."13

John Alden of the Engineering Manpower Commission called the 1971 situation "the aerospace unemployment crisis." He also complains of the government's discontinuation of the collection of data since 1970, saying that there are "no good employment data more recent than 1970."14

The National Science Foundation reports unemployment data for a less aggregated occupational category -- science and engineering labor force (Table 2.1.5b). The 1972 unemployment rate of 1.9 per cent was almost double the 1970 or 1974 rate of 1.1 per cent.15

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12 U. S. Bureau of Labor Statistics, Handbook of Labor Statistics - 1975, and Monthly Labor Review, Vol. 99, No. 9, (September 1976), pp. 74-5, for 1975-76 data.

13 U. S. Bureau of Labor Statistics, Handbook of Labor Statistics - 1975, p. 2.

14 J. Alden, "An Overview of the Situation," Chemical Engineering Progress, Vol. 71, No. 10, (October, 1975). It should be noted that the BLS, with NSF support, will resume collecting data for STP in 1977.

15 National Science Foundation, "Science Resource Studies Highlights," May 19, 1975.

Table 2.1.5a

Percentage Change in Monthly Salaries and Consumer Price Index,
Annual Unemployment Rates

	69/70	70/71	71/72*	72/73	73/74	74/75	75/76
Professional, administrative and technical support**	6.2	6.7	5.5	5.4	6.3	8.3	6.7
Chemist	5.9	5.5	5.1	3.7	7.1	10.1	6.6
Engineer	5.5	5.7	5.2	5.1	5.4	8.4	6.8
Engineering Technician	6.3	6.5	5.1	4.7	6.0	9.0	8.1
Draftsmen	4.9	5.6	7.2	6.2	6.7	8.0	7.4
Chemist I	4.9	5.6	1.6	2.0	6.2	10.7	5.8
Engineer I	5.7	4.6	2.2	2.6	6.2	8.5	7.8
Engineering Technician I	6.1	8.8	5.3	4.0	6.4	8.1	5.1
Draftsmen I	5.4	6.0	4.7	5.9	6.5	5.6	8.7
CPI		4.5	2.9	4.7	10.2	10.3	6.1

	69	70	71	72	73	74	75	76
Unemployment rate Professional and Technical	1.3	2.0	2.9	2.4	2.2	2.3	3.2	3.1

*Survey data did not represent a 12-month period. Data prorated to represent 12-month interval for non-entry level occupations. Entry level (Grade I) and CPI data are for 9 months, June '71 to March '72.

**Includes accountants, auditors, persoirel directors, attorneys, buyers, job analysts.

Source: U.S. Bureau of Labor Statistics, National Surveys of Professional, Administrative, Technical and Clerical Workers.

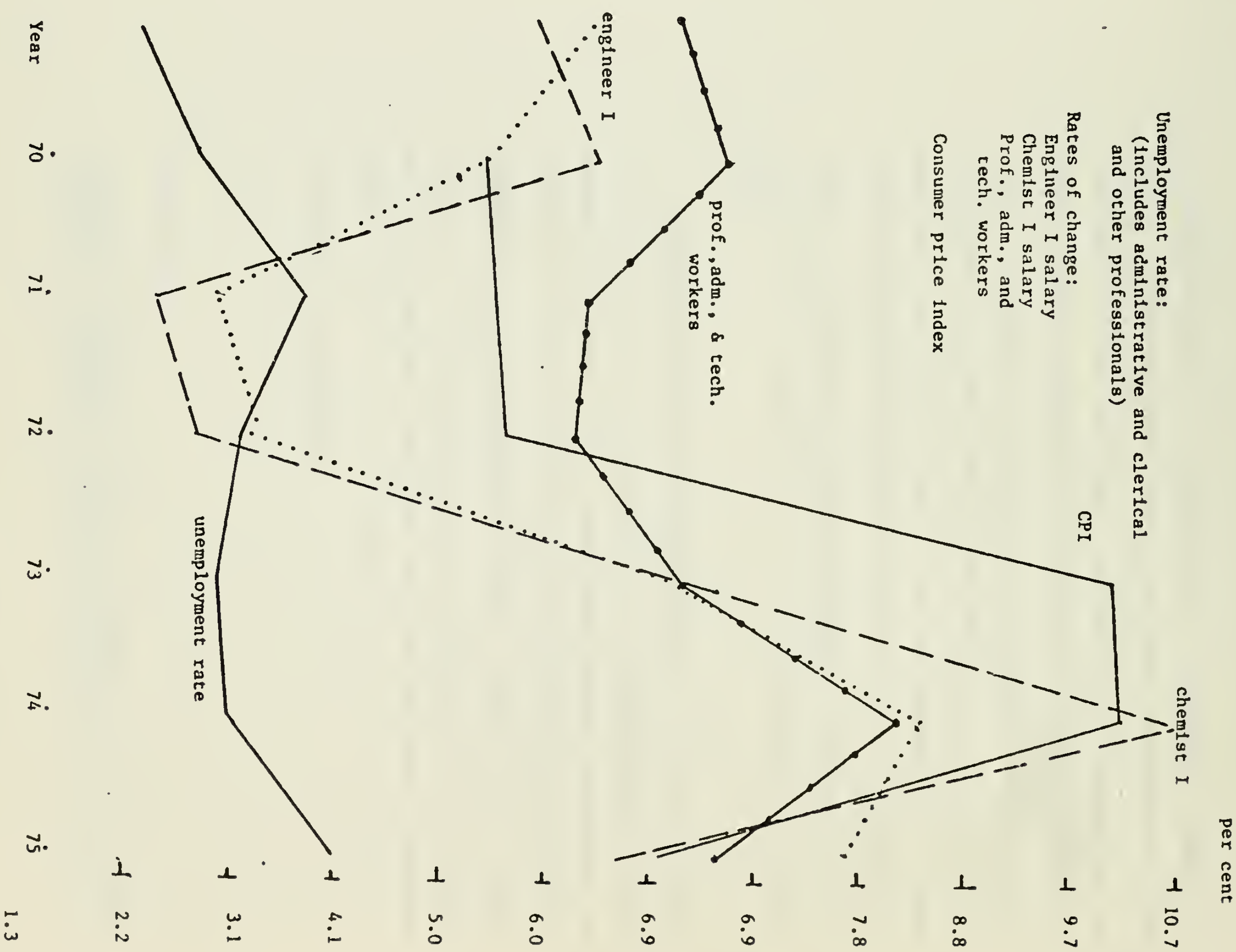

Figure 2.1.5

Source: Bureau of Labor Statistics

Table 2.1.5b

Science and Engineering Labor Force Unemployment Rates
(N.A. = not available)

	1970	1972	1973	1974
Computer specialists	N.A.	1.4%	.5%	1.0%
Engineers	N.A.	2.2	.9	1.1
Mathematical scientists	N.A.	1.8	1.0	.9
Life scientists	N.A.	1.2	.8	1.0
Physical scientists	N.A.	1.8	.7	1.3
Environmental scientists	N.A.	1.6	.9	1.1
All fields, including social scientists	1.1%	1.9	.9	1.1

Source: National Science Foundation

The Engineering Manpower Commission's salary survey of July 1972, showed that median salaries of inexperienced bachelor's degree recipients increased 1 per cent from 1970-72, compared to 5.8 per cent for the 1968-70 period.16 This increase resulted in a net loss in real terms, since inflation for the same period, 1970-72, exceeded 5.5 per cent. The previous lowest increase in the survey's twenty-year history for this category was 3.5 per cent from 1960 to 1962. Experienced engineer categories received comparable low increases compared to historical trends.

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16 J. Alden, "Professional Income of Engineers - 1972," EMC, EJC, New York, 1972.

Engineering and professional societies, alarmed at 1972's depressed labor market, called on government to lend assistance to the technical professions. "Presidents of seven leading engineering societies met with Secretary of Labor J. D. Hodgson and other high Manpower Administration officials" to discuss defense and aerospace cutbacks."17 The government was asked to assist the unemployed in finding jobs and stimulate demand for scientific and technical personnel by expanding government programs to address national needs such as productivity, mass transportation, and pollution.

Despite the lack of detailed data, 1972 (or 1971-72) was obviously the worst period for STP employment in recent history, at least until the more general recession of 1975-76. 1972 was characterized by relatively high unemployment, under-utilization, layoffs, falling real wages, fears for job security, poor job prospects for new graduates, and regional migration out of the most depressed areas. The "relative shortages" should be interpreted in this frame of reference.

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17 "Engineering Society Presidents Meet with Labor Secretary," Chemical Engineering Progress, Vol. 68, No. 2, (February 1972), p. 6.

2.2 - Occupation-specific labor market conditions for STP

2.2.1 - Introduction

This section discusses the relative labor market conditions for specific scientific, engineering, and technical occupations. Occupational conditions measured across all sample industries are examined for evidence of relative conditions.

Thirty-nine occupations were included in the survey and some data were received for nearly all of the occupations. Sample sizes were small in some occupational areas and only guarded conclusions can be drawn in those cases.

Three questions were asked to obtain data indicating labor market conditions for the specific occupations: 1) the number and magnitude of salary offers made to inexperienced new hires in the STP occupations between 1972 and 1975, and the number of those offers that were accepted; 2) the number of quits in the various occupations from 1972 to 1975; and 3) the number of vacancies in each of the occupations in the same years.

2.2.2 - Salary Offers

The first question concerned salary offers made to inexperienced new hires from 1972 to 1975. Salary offers

would be raised at a greater rate in the tighter labor markets in an attempt to attract the qualified people required. Average salary offers were calculated for each of the thirty-nine occupations (See Table 2.2.2a). As one measure of shortages, an average percentage rate of increase in salaries was calculated for all occupations over the four-year period. A high rate of increase indicates a greater shortage than a low rate of increase.

Engineers

A complete summary of the average percentage increase in salary offers is presented in Table 2.2.2b. The three highest average occupations in the engineering group are 1) Materials, Metallurgical and Ceramic; 2) Aeronautical; and 3) Petroleum. Most of the other engineering occupations are grouped in a range of +5.7 per cent to +7.4 per cent per year.

Scientists

As can be seen from Table 2.2.2b, the data for scientists vary much more than that for engineers. This variation is largely the result of sampling error arising from the small numbers of energy-related establishments that employed or hired scientists. The three occupations that have the greatest average salary increase are 1) Statisticians, 2) Physicists, and 3) Geologists.

Table 2.2.2a

Engineers-Salary-Grand Mean

Occupation	1975	1974	1973	1972
Chemical	1172	1078	1016	947
Civil/Sanitary	1072	1011	925	877
Electrical/Electronic	1112	1030	991	927
Industrial	1092	1032	963	925
Materials/Metallurgical/Ceramic	1512	**	1052	*
Mechanical	1129	1034	957	891
Aeronautical	1389	**	966	**
Mining	**	**	840	**
Petroleum	1282	1134	1009	945
Geological	*	**	*	*
Nuclear	1067	992	928	1045
General	**	*	**	**
Other, n.e.c.	1061	946	865	868

Scientists-Salary-Grand Mean

Occupation	1975	1974	1973	1972
Chemists	1105	932	902	830
Physicists	1358	1130	1065	956
Metallurgists	964	**	988	777
Geologists	1069	822	871	795
Agriculturists	1061	1002	977	903
Biologists	899	909	827	**
Medical	*	*	*	*
Mathematicians	992	986	1028	809
Statisticians	1458	**	884	*
Computer	1082	989	859	921
Marine	*	*	*	*
Meteorologist	**	**	**	**
Other, n.e.c.	610	1389	1122	**

Technicians-Salary-Grand Mean

Occupation	1975	1974	1973	1972
Agricultural	**	730	**	**
Biological	599	515	445	**
Chemical	732	641	588	585
Electrical/Electronic	816	721	652	641
Industrial	852	687	637	650
Mechanical	871	794	645	682
Medical	*	*	*	*
Mathematical	837	613	563	617
Surveyors	798	697	678	583
Draftsmen	769	672	634	604
Engineering	**	700	600	**
Other, n.e.c.	901	661	646	669

Architects-Salary-Grand Mean

Occupation	1975	1974	1973	1972
Architects	1012	939	835	840

Table 2.2.2b

Engineers-Percentage change in salary offers

Occupation	75-74	74-73	73-72	Average
Chemical	+8.7	+6.1	+7.3	+7.4
Civil/Sanitary	+6.0	+9.3	+5.5	+6.9
Electrical/Electronic	+8.0	+3.9	+6.9	+6.3
Industrial	+5.8	+7.2	+4.1	+5.7
Materials/Metallurgical/Ceramic	**	**	*	**
Mechanical	+9.2	+8.0	+7.4	+8.2
Aeronautical	**	**	**	**
Mining	**	**	**	**
Petroleum	+13.0	+12.4	+6.8	+10.7
Geological	*	*	*	*
Nuclear	+7.6	+6.9	-11.2	+1.1
General	*	*	**	**
Other, n.e.c.	+12.2	+6.9	+2.0	+7.0

Scientists-Percentage change in salary offers

Occupation	75-74	74-73	73-72	Average
Chemists	+18.6	+3.3	+8.7	+10.2
Physicists	+20.2	+6.1	+11.4	+12.6
Metallurgists	**	**	+27.2	+8.7
Geologists	+32.5	-5.6	+9.6	+12.2
Agriculturists	+5.9	+2.6	+8.2	+5.6
Biologists	-1.0	+9.9	**	+3.8
Medical	*	*	*	*
Mathematicians	+0.6	-4.1	+27.1	+7.9
Statisticians	**	**	*	**
Computer	+9.4	+15.1	-6.7	+5.9
Marine	*	*	*	*
Meteorologists	**	**	**	**
Other, n.e.c.	-56.1	+23.8	**	-14.9

Technicians-Percentage change in salary offers

Occupation	75-74	74-73	73-72	Average
Agricultural	**	**	**	**
Biological	+16.3	+15.7	**	+36.7
Chemical	+14.2	+9.0	+0.5	+7.9
Electrical/Electronic	+13.2	+10.6	+1.7	+8.5
Industrial	+24.0	+7.8	-2.0	+9.9
Mechanical	+9.7	+23.1	-5.4	+9.1
Medical	*	*	*	*
Surveyors	+14.5	+2.8	+16.3	+11.2
Draftsmen	+14.4	+6.0	+5.0	+8.5
Engineering	**	+16.7	**	+1.2
Other, n.e.c.	+36.3	+2.3	-3.4	+11.7

Architects-Percentage change in salary offers

Occupation	75-74	74-73	73-72	Average
Architects	+7.8	+12 5	-0.6	+6.6

Technicians

From Table 2.2.2b, the four highest-ranking technician occupations are 1) Biology Technicians, 2) Mathematical Technicians, 3) Other Technicians, n.e.c., and 4) Surveyors. The rest of the occupations range from +1.2 per cent to +9.9 per cent average salary increase.

By a strict application of the "salary-rise" shortage criterion, of course, all occupations showed evidence of shortages by the increase in salaries. During the 1972 to 1974, however, the purchasing power of the dollar decreased, so that real salaries, or salaries in dollars of constant purchasing power, may not have increased. The Consumer Price Index increased from 125.3 in 1972 to 161.2 in 1975 (1967 = 100), an increase of 28.7 per cent. If the starting salary of an occupation increased by more than 28.7 per cent, it may be said that the occupation experienced a salary-rise shortage during the period. Occupations in which starting salaries increased more rapidly than the CPI are:

Occupation	% Increase 1972-75
Petroleum Engineer	35.7
Chemist	33.1
Physicist	42.1
Geologist	37.0
Electrical/Electronic Technician	31.0
Mathematical Technician	35.7
Surveyor	36.9
Other Technician, nec	34.7

These salary increases, while greater than the cost of living, hardly indicate rapid or substantial increases in real earnings or real cost of labor. For real earnings to increase as little as these occupations have over a period of four years would hardly have been considered evidence of a shortage in the 1960's. Nevertheless, these findings do suggest that for these occupations there has been a small, but real salary increase over the period 1972-75.

It is customary in discussing "salary-rise" shortages to compare the salaries of the occupation under examination to the salaries of comparable occupation to determine relative salary-rise shortages. Comparable occupational groups for STP might include professional and technical workers and managers and administrators. Average weekly earnings for professional and technical workers were $192 in 1972 and $246 in 1975, in current dollars, and showed no change over the period in constant 1967 dollars at $154. Weekly earnings for managers and administrators averaged $214 in 1972 and $274 in 1975, and were unchanged at $172 in 1967 constant dollars.[18] The fortuitous lack of change in real earnings over the period 1972-75 makes it unnecessary to evalu-

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18 Bureau of Labor Statistics, Special Labor Force Report, No. 143, Usual Weekly Earnings of American Workers, 1971 and unpublished data in Bureau of the Census, Statistical Abstract of the United States, 97th Edition, December 1976, table 603, p. 377.

ate relative changes, since if occupational starting salaries increased more than the change in the CPI, the salary relative to these two occupational groups would also increase.

If year-to-year changes in starting salaries are compared to changes in the CPI, a measure of shortages for each year can be observed. For engineers, 1973 showed a number of salary-rise shortages. Chemical, Civil/Sanitary, Electrical/Electronic, Mechanical, and Petroleum Engineers all showed shortages. It is likely that other specialties, such as Mining and Geological Engineers would also have shown a shortage were data available. These salary increases represent pre-Embargo conditions, since the Embargo could have had little effect on starting salaries of most of the new hires who were employed before October 1973. In 1974, only Petroleum Engineers showed a salary-rise shortage, and in 1975, only Petroleum and Other, nec Engineers showed a shortage. Petroleum Engineers are clearly unusual in that a salary increase greater than the increase in the CPI occurred in all three years, 1973, 1974, and 1975. Petroleum Engineers are also noteworthy in that their starting salaries were higher than most engineering occupations in 1972, so that these annual increases represent getting ahead, rather than catching up.

For scientists, real salary increases, or salary-rise shortages, were observed for Chemists in 1973 and 1975, for

Physicists in 1973 and 1975, for Metallurgists in 1973, for Geologists in 1973 and 1975, for Agriculturists in 1973, for Mathematicians in 1973, for Computer Scientists in 1974, and for Other Scientists, nec in 1974.

For the technician occupations for which salary data were available, salary-rise shortages were observed for most occupations in 1974 and 1975, and for Surveyers and Draftsmen in 1973.

Additional information on starting salaries are available from other sources, and are presented for purpose of comparison. The College Placement Council, Frank Endicott, and BLS all survey engineering starting salaries (Table 2.2.2c).

The CAC sample results are reasonably close to the other surveys for each of the years examined. For all engineers, CAC and BLS did not find a real salary increase in 1975, while Endicott and CPC did, but the percentage changes are reasonably close for all surveys. CAC and Endicott found a salary rise for engineers in 1973, but CPC and BLS did not, but, once again, the percentage changes are close for the four surveys.

For scientific occupations, there is a large variance in results among surveys. It must be admitted that the CAC

Table 2.2.2c

Percentage Changes in Starting Salaries, Selected Scientific Occupations, 1972-1976

Source	1972	1973	1974	1975	1976
Engineering					
CAC	na	5.6	7.5	9.2	na
CPC*	1.5	4.3	7.2	11.6	7.3
Endicott**	1.0	5.8	6.4	10.9	5.6
BLS***	2.2	2.6	6.4	8.5	7.8
Chemists					
CAC	na	8.7	3.3	18.6	na
CPC*	-1.5	5.5	7.0	8.1	7.5
Endicott**	2.6	3.4	8.3	4.3	6.4
BLS***	1.6	2.0	6.2	10.7	5.8
Mathematicians-Statisticians					
CAC	na	0.6	-4.1	27.1	na
Endicott**	1.0	7.9	4.2	5.4	8.4
CPC (math)*	1.0	1.9	7.9	4.7	7.8
CPI	2.9	4.7	10.2	10.3	6.1

* College Placement Council
** Frank Endicott
*** Bureau of Labor Statistics for Cnemist I grade.

survey results appear to be very different from the others. This arises from the small number of scientists employed in the establishments and industries that are energy related.

It seems reasonable to attach little importance to the salary rise shortages observed in the CAC sample data because of the high variance in the results of the several surveys and small number of years in which a shortage would be found for these occupations in these other surveys.

2.2.3 - Acceptance Ratios

A second question designed to obtain data on relative shortages is the ratio of hires/offers, or average acceptance ratio. Table 2.2.3a summarizes the data for all occupations for each of the four years, 1972 to 1975. The measure used to observe relative shortages is the average decline in the acceptance rate between 1972 and 1975. If there is a shortage in an occupation, the average firm would have to make more job offers in order to be sure of attracting the number of people the firm wishes to employ in that occupation. Therefore, the greatest average percentage decline in acceptance rates would reflect the greatest relative shortage.

Table 2.2.3a

Acceptance Ratio-Engineers

Occupation	1975	1974	1973	1972
Chemical	0.434	0.379	0.452	0.561
Civil/Sanitary	0.595	0.512	0.465	0.539
Electrical/Electronic	0.559	0.648	0.763	0.809
Industrial	0.545	0.532	0.495	0.647
Materials/Metallurgical/Ceramic	0.222	0.364	0.500	*
Mechanical	0.559	0.754	0.758	0.700
Aeronautical	0.300	0.429	0.700	0.500
Mining	0.300	0.429	1.000	*
Petroleum	0.292	0.471	0.628	0.444
Geological	*	*	*	*
Nuclear	0.622	0.673	0.678	1.000
General	*	*	*	*
Other, n.e.c.	0.332	0.437	0.412	0.337

Acceptance Ratio-Scientists

Occupation	1975	1974	1973	1972
Chemists	0.659	0.556	0.728	0.914
Physicists	0.810	0.677	0.603	0.796
Metallurgists	1.000	**	0.809	1.000
Geologists/Geophysicists	0.608	0.684	0.770	0.364
Agriculturists	0.333	1.000	*	1.000
Biologists	0.429	**	1.000	*
Medical	*	*	*	*
Mathematicians	0.929	0.667	0.750	0.500
Statisticians	0.750	*	0.607	*
Computer	0.700	0.667	0.605	0.656
Marine	*	*	*	*
Meteorologists	1.000	1.000	1.000	1.000
Other, n.e.c.	0.222	0.400	1.000	1.000

Acceptance Ratio-Technicians

Occupation	1975	1974	1973	1972
Agricultural	0.824	1.000	1.000	0.714
Biological	**	**	**	1.000
Chemical	0.871	0.896	0.877	**
Electrical/Electronic	0.639	0.850	0.840	0.841
Industrial	0.701	0.734	0.719	0.536
Mechanical	0.480	0.650	0.628	0.572
Medical	*	*	*	*
Mathematical	0.412	0.515	0.829	0.417
Surveyors	0.843	**	0.636	0.778
Draftsmen	0.468	0.418	0.790	0.719
Engineering	1.000	1.000	1.000	1.000
Other, n.e.c.	0.589	0.520	0.552	1.000

Acceptance Ratio-Architects

Occupation	1975	1974	1973	1972
Architects	0.500	0.708	0.816	0.636

Engineers

The three highest ranking occupations in the engineering area are 1) Mining Engineers, 2) Metallurgical, Materials, Ceramic Engineers, and 3) Petroleum Engineers. Table 2.2.3b lists the rankings. There is wide variance from year to year, as can be seen in Petroleum Engineers. This is mainly caused by different firms reporting data for different years.

The pattern of acceptance ratios, both in level in 1975 and in changes, is consistent with shortages of Materials/Metallurgical/Ceramic, Aeronautical, Mining, and Petroleum Engineers. Less than one-third of the offers in these specialties resulted in hires in 1975, and in each case the acceptance ratio had declined from earlier years.

Scientists

The three highest ranking occupations in the scientists group are 1) Agricultural, 2) Chemists, and 3) Meteorologists. As can be seen in Table 2.2.3b, large variations are evident and some occupations have no data at all.

The only occupations with both low acceptance ratios and declines are Agriculturists and Biologists, but the data are spotty, and probably deserve little attention.

Table 2.2.3b

Engineers-Ranked Average Percent Change in Acceptance Rates

Occupation	Average	75-74	74-73	73-72
Mining	-29.1	-30.1	-57.1	*
Materials/Metallurgical/Ceramic	-22.1	-39.0	-27.2	*
Nuclear	-13.5	-7.6	-6.7	-32.2
Electrical/Electronic	-11.5	-13.7	-15.1	-5.7
Aeronautical	-9.6	-30.1	-38.7	+40.0
Petroleum	-7.2	-38.0	-25.0	+41.4
Chemical	-7.0	+14.5	-16.2	-19.4
Mechanical	-6.0	-25.9	-0.5	+8.3
Industrial	-4.5	+2.4	+7.5	-23.5
Other, n.e.c.	+1.5	-24.0	+6.1	+22.3
Civil/Sanitary	+4.2	+16.2	+10.1	-13.7
Geological	*	*	*	*
General	*	*	*	*

Scientists-Ranked Average Percent Change in Acceptance Rates

Occupation	Average	75-74	74-73	73-72
Agriculturists	-22.2	-66.7	*	*
Chemists	-8.5	+18.5	-23.6	-20.4
Metallurgists	-6.4	*	*	-19.1
Meteorologists	0.0	0.0	0.0	0.0
Computer	+2.4	+4.9	+10.2	-7.8
Physicists	+2.6	+19.6	+12.3	-24.2
Mathematicians	+26.1	+39.3	-11.1	+50.0
Geologists	+29.7	-11.1	-11.2	+111.5
Other, n.e.c.	+65.2	-44.5	-60.0	+300.0
Biologists	*	*	*	*
Medical	*	*	*	*
Statisticians	*	*	*	*
Marine	*	*	*	*

Technicians-Ranked Average Percent Change in Acceptance Ratio

Occupation	Average	75-74	74-73	73-72
Other, n.e.c.	-12.4	+13.3	-5.8	-44.8
Draftsmen	-8.4	+12.0	-47.1	+9.9
Electrical/Electronic	-7.9	-24.8	+1.2	-0.1
Surveyors	-6.1	*	*	-18.3
Mechanical	-4.3	-26.2	+3.5	+9.8
Chemical	-0.2	-2.8	+2.2	*
Engineering	0.0	0.0	0.0	0.0
Agricultural	+7.5	-17.6	0.0	+40.1
Industrial	+10.6	-4.5	+2.1	+34.1
Mathematical	+13.6	-20.0	-37.9	+98.8
Biological	*	*	*	*
Medical	*	*	*	*

Architects-Ranked Average Percent Change in Acceptance Ratio

Occupation	Average	75-74	74-73	73-72
Architects	-4.8	-29.4	-13.2	+28.3

Technicians

Among the technician occupations, the three highest ranking are 1) Other, n.e.c., 2) Draftsmen, and 3) Electrical/Electronic.

Only Draftsmen show both a low level of acceptance ratio and a noticeable decline.

2.2.4 - Quits and Vacancies

A third measure of shortage is quit rates as shown in Table 2.2.4. This question asked for the number of quits in each occupation for each of the years 1972 to 1975.

Quit rates were calculated for 1975. The quit rate equals the number of quits per firm divided by the number of employees per firm in the particular occupation. A fourth measure was vacancy rates, also included in Table 2.2.4. Vacancies were obtained for each of the years 1972 to 1975 and vacancy rates were calculated for 1975 in the same manner that quit rates were calculated. These two measures were grouped together because of the similarity of the questions, and the expected comparability of the results. In each case, a higher rate would show greater excess demand than a lower quit or vacancy rate.

Table 2.2.4

Engineers-1975: Quits' & Vacancies' Rankings

Occupation	Quits	Occupation	Vacancies
Nuclear	0.571	Nuclear	0.500
Mining	0.080	Chemical	0.177
Civil/Sanitary	0.055	Industrial	0.141
Chemical	0.052	Mechanical	0.051
Industrial	0.047	Civil/Sanitary	0.041
Electrical/Electronic	0.042	Mining	0.034
Other, n.e.c.	0.041	Other, n.e.c.	0.024
General	0.040	Materials/Metallurgical/Ceramic	0.023
Geological	0.036	Petroleum	0.022
Mechanical	0.035	Electrical/Electronic	0.021
Petroleum	0.026	Aeronautical	0.000
Aeronautical	0.020	Geological	0.000
Materials/Metallurgical/Ceramic	0.012	General	0.000

Scientists-1975: Quits' & Vacancies' Rankings

Occupation	Quits	Occupation	Vacancies
Other, n.e.c.	0.229	Other, n.e.c.	0.145
Mathematicians	0.157	Agriculturists	0.143
Biologists	0.110	Geological	0.040
Meteorologists	0.109	Computer	0.036
Physicists	0.098	Chemists	0.018
Metallurgical	0.087	Physicists	0.005
Geological	0.073	Metallurgical	0.000
Computer	0.064	Biologists	0.000
Chemists	0.049	Medical	0.000
Agriculturists	0.027	Mathematicians	0.000
Medical	0.000	Statisticians	0.000
Statisticians	0.000	Marine	0.000
Marine	0.000	Meteorologists	0.000

Technicians-1975: Quits' & Vacancies' Rankings

Occupation	Quits	Occupation	Vacancies
Chemical	0.180	Chemical	0.069
Surveyors	0.172	Draftsmen	0.045
Engineering	0.156	Mechanical	0.034
Draftsmen	0.099	Mathematical	0.033
Mechanical	0.096	Electrical/Electronic	0.032
Industrial	0.095	Surveyors	0.031
Mathematical	0.087	Other, n.e.c.	0.019
Other, n.e.c.	0.085	Agricultural	0.010
Biological	0.067	Industrial	0.007
Agricultural	0.024	Biological	0.000
Electrical/Electronic	0.009	Medical	0.000

Architects-1975: Quits' and Vacancies' Rankings

Occupation	Quits	Occupation	Vacancies
Architects	0.003	Archit :ts	0.004

Engineers

Four specific occupations were rated among the top five in each of the quit and vacancy rate measures. These were 1) Nuclear Engineers, 2) Mining Engineers, 3) Chemical Engineers, and 4) Industrial Engineers. Civil Engineers were included in the top five of quit rates, and Mechanical Engineers were in the top five of vacancy rates. This comparison has been made because it seems that there should be a high correlation between these two measures.

Scientists

The data for the scientists are not as highly correlated as for the engineers. The only occupation that is ranked highly in both quits and vacancy rates is Other, n.e.c. For quit rates, the highly ranked occupations are 1) Other, n.e.c., 2) Mathematicians, 3) Biologists, 4) Meteorologists, and 5) Physicists. For vacancy rates, the five high-ranked groups are 1) Other, n.e.c., 2) Agriculturists, 3) Geologists, 4) Computer, and 5) Chemists.

Technicians

The data for technicians are correlated to a greater extent than that for scientists. Three occupations appear in the top five of both quit and vacancy rates. They are 1)

Chemical Technicians, 2) Draftsmen, and 3) Mechanical Technicians. Surveyors and Engineering Technicians are highly ranked in quit rates. Mathematical Technicians and Electrical Technicians are highly ranked in vacancy rates.

It is impossible to place the vacancy and quit rates in perspective, since responses and data did not permit estimation of these rates in earlier years. The quit and vacancy rates for nuclear engineers are quite high by any standard, but with the very low salaries offered in this specialty, and rather high and unchanging acceptance ratios, it is impossible to take these measures seriously. Establishments that have unfilled nuclear engineering positions apparently have done very little either to raise salaries to levels comparable to other engineering specialties or to increase recruiting effort by increasing the number of offers.

It is difficult to guess what a normal or acceptable vacancy rate would be for engineers and scientists. A vacancy rate of 10 per cent or more might be thought to be a major inconvenience if the vacancies represented funded and needed positions, but since many starting engineers positions are primarily for training new engineers and little productive work is expected from such trainees, a substantial number of vacancies may create no real inconvenience. The well-known reluctance of employers to utilize, or even interview, walk-in or experienced job applicants suggests that most employers rely heavily on the June graduates as

the major source of new engineering hires, and that an unsuccessful recruiting year causes relatively little inconvenience. A succession of two or more unsuccessful years in which large numbers of new engineering positions went unfilled would be a different story.

2.2.5 - Summary Results

In Table 2.2.5, each occupation has been ranked from relative shortage to relative surplus for each of the four measures; a score of one (1) indicating a relative shortage and a score of thirteen (13) indicating a relative surplus. These rankings were summed for each of the occupations, and a total relative surplus to relative shortage table developed. There is no indication that the measures should be equally weighted. Conversely, there is no indication that one measure is more important than the others, so a simple summation has been used.

For engineers, a group of three stands out at the relative shortage end of the table. These are 1) Nuclear Engineers, 2) Mining Engineers, and 3) Chemical Engineers. The other occupations are ranked substantially below the first three occupations. Nevertheless, the inconsistency of very low salaries along with very high vacancy, quit, and acceptance rates suggests that Nuclear Engineers are really a shortage occupation. Moreover, the low acceptance rate

Table 2.2.5

Engineers-Rank

Occupation	Salary	Quit	Vacancy	Acceptance
Nuclear	11	1	1	3
Mining	7.5	2	6	1
Chemical	5	4	2	7
Materials/Metallurgical/Ceramic	1	13	8	2
Mechanical	4	10	4	8
Industrial	10	5	3	9
Aeronautical	2	12	11	5
Civil/Sanitary	7.5	3	5	13
Electrical/Electronic	9	6	10	4
Petroleum	3	11	9	6
Other, n.e.c.	6	7	7	12
General	12	8	13	10.5
Geological	13	9	12	10.5

Scientists-Rank

Occupation	Salary	Quit	Vacancy	Acceptance
Physicists	2	5	6	5
Chemists	4	9	5	2
Agriculturists	8	10	2	1
Geologists	3	7	3	8
Computer	7	8	4	4
Meteorologists	6	4	10	3
Mathematicians	5	2	10	7
Other, n.e.c.	13	1	1	9
Metallurgists	10	6	10	6
Biologists	9	3	10	11.5
Statisticians	1	12	10	11.5
Marine	11.5	12	10	11.5
Medical	11.5	12	10	11.5

Technicians-Rank

Occupation	Salary	Quit	Vacancy	Acceptance
Draftsmen	7.5	4	2	2
Surveyors	4	2	6	4
Chemical	9	1	1	6
Mechanical	6	5	3	5
Other, n.e.c.	3	8	7	1
Mathematical	2	7	4	10
Electrical/Electronic	7.5	11	5	3
Industrial	5	6	9	9
Engineering	11	3	11	7
Biological	1	9	11	11.5
Agricultural	10	10	8	8
Medical	12	12	11	11.5

and the relatively high starting salary and the salary-rise shortage in each of the years 1972-1975 indicates that there may very well be a shortage of Petroleum Engineers, even though vacancy and quit rates are not very high.

For scientists, four occupations stand out as relative shortage occupations. These are 1) Physicists, 2) Chemists, and 3) Agriculturists, and 4) Geologists. There is no large break in the total scores, as in the engineering category, and the next four occupations are not ranked far behind. Because of the relatively low numbers of persons in these occupations in the establishments surveyed, and the inconsistency between the CAC and other survey data, it is difficult to accept the conclusion that any of these occupations have actually experienced any significant shortage during the period.

In the technicians group, five occupations stand apart from the rest. They are 1) Draftsmen, 2) Surveyors, 3) Chemical, 4) Mechanical, and 5) Other, n.e.c. The substantial salary increases, high quit and vacancy rates, and relatively low acceptance rates in 1975 for these occupations indicate that there probably is a shortage in these occupations. The salary increases are particularly significant, in that they occurred during a period when most occupations were experiencing either small or no increases in real earnings.

2.3 - Conditions for STP in Energy-related Industries

2.3.1 - Introduction

This section discusses a number of measurements of labor market excess demand for all scientific and technical workers. Industry-specific rather than occupation-specific conditions are considered. Poor response in a few industries prohibits presentation of empirical results for some items to ensure confidentiality and avoid spurious conclusions.

2.3.2 - Employer actions

Several questions were asked to elicit responses concerning actions employers might take to alleviate the effects of a general STP shortage. Many types of actions are probable prior to raising salaries to attract greater supply. Problems of maintaining internal wage differentials and the aggregate ineffectiveness of salary competition call for a variety of other actions.

Each question was framed in terms of the extent (much more, more, less, much less on a 1-4 scale) which the employer used an action to alleviate possible STP shortages since the pre-energy crisis year of 1972. Thus a neutral score, 2.5, indicates that employers perceive no change in their manpower utilization behavior in 1975 versus 1972.

Caution must be exercised in interpeting a particular score. If Industry A scores lower than Industry B on a particular item (with this scoring system), one would conclude that Industry A found it necessary to increase the use of an action to a greater extent than Industry B, and therefore that labor market conditions had tightened more in the former. Since the scale is ordinal, it cannot be said that a score of 1.5 (one unit from neutral) indicates conditions had tightened twice as much as a score of 2.0 (one-half unit from neutral). Also, if a behavioral action was used extensively in 1972 and 1975, the appropriate score might be 2.5, indicating no change. Finally, respondents may tend to score high or low on any particular question, perhaps indicating an aversion to an action rather than comparative labor market conditons, so the all-industry score is presented with each question to provide a reference frame.

Typical questions concern such actions as overtime and redesigning jobs to free STP from clerical or administrative duties. Each question will be presented with the all-industry score and individual industries that scored lower. The survey question is presented so that the precise wording may be referred to. Again, a low score would indicate a tightening labor market relative to 1972.

2.3.3 - Overtime

The first question concerned overtime for STP. Overtime is likely to be an employer's first, though probably temporary, response to increased STP requirements. It is an economical way to increase STP supply when the increase in requirements is of uncertain duration or magnitude.

All industries combined reported their STP worked slightly less overtime in 1975 than 1972. Several industries reported they used this device more in 1975. In addition to the "direct" energy-supply industries (Oil and Gas Extraction and Coal Mining), several "indirect" energy-supply industries ranked high on their use of overtime, including Materials Handling Equipment, Pipes, Valves, and Fittings, Engines and Turbines, Industrial Chemicals, and Basic Steel. A complete ranking of industries scoring below the all-industry mean is provided with the precise wording of the question in Table 2.3.3.

2.3.4 - Redesigning jobs

Redesigning jobs to free STP from administrative or clerical tasks is another way to increase effective STP supply. Increased requirements for STP should cause employers to utilize their STP more effectively by releasing them from administrative and clerical tasks, assuming the people who will perform the tasks are not themselves in short supply.

Table 2.3.3

Question 8 In comparison to 1972, to what extent did your scientific and technical employees work overtime in 1975?

SIC	Industry	Score
	All Industries	2.57
3534-7	Materials Handling Machinery and Equipment	2.00
11;12	Coal and Lignite Mining	2.25
1623,9	Heavy Construction except Highway and Street	2.25
3494,8	Pipes, Valves, and Fittings	2.25
13	Oil and Gas Extraction	2.31
281,6,9	Industrial Chemicals	2.33
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	2.33
351	Engines and Turbines	2.33
7391	Commercial Research and Development Laboratories	2.33
40;471	Railroads	2.38
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	2.40
356	General Industrial Machinery and Equipment	2.41
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	2.42
332	Iron and Steel Foundries	2.50
492	Gas Utilities	2.50
8911	Architectural and Engineering Services	2.53

All industries combined reported that they redesigned jobs for this purpose slightly less than in 1972 (Table 2.3.4). Indirect energy-supply industries dominated the ranking of industries, led by Electronic Components and Accessories, Fabricated Structural Metal Products, and Engines and Turbines.

2.3.5 - Reducing qualifications

Employers may increase their effective supply of STP by reducing the formal requirements of jobs. In effect, a specification of 10 years experience or a master's degree might be a desirable but not a strictly necessary qualification for a particular position. Even a genuine prerequisite may be waived in favor of on-the-job training during a tight labor market situation.

The composite score for all industries on this item was 2.9 on a 1-4 (more to less) scale of the extent this action was necessary (Table 2.3.5). This indicates that industry as a whole found it far less necessary to reduce qualifications in 1975 than in 1972. Both indirect and direct industries scored relatively high on this item, indicating no need to reduce qualifications. Industries which reported this action was used more in 1975 than in 1972 include Electronic Components and Accessories, Pipelines except natural gas, and Engineering and Scientific Instruments.

Table 2.3.4

Question 9 In comparison to 1972, to what extent did your establishment find it necessary to redesign jobs in order to release scientific or technical staff from non-technical duties such as clerical or administrative work in 1975?

SIC	Industry	Score
	All industries	2.54
367	Electronic Components and Accessories	2.00
344	Fabricated Structural Steel Products	2.14
351	Engines and Turbines	2.17
46	Pipelines, except Natural Gas	2.17
281,6,9	Industrial Chemicals	2.33
356	General Industrial Machinery and Equipment	2.33
371	Motor Vehicles and Motor Vehicle Equipment	2.33
1623,9	Heavy Construction except Highway and Street	2.36
7391	Commercial Research and Development Laboratories	2.40
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	2.42
29	Petroleum Refining	2.42
343	Heating Equipment except Electric	2.43
491,[illegible]	Electric Utilities	2.47
11;12	Coal and Lignite Mining	2.50
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	2.50
3494,8	Pipes, Valves, and Fittings	2.50
492	Gas Utilities	2.50

Table 2.3.5

Question 10 In comparison to 1972, to what extent did your establishment reduce education, experience, training or other qualifications for scientific and technical jobs in 1975?

SIC	Industry	Score
	All industries	2.90
367	Electronic Components and Accessories	2.00
46	Pipelines, except Natural Gas	2.25
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	2.42
492	Gas Utilities	2.57
281,6,9	Industrial Chemicals	2.67
344	Fabricated Structural Steel Products	2.67
371	Motor Vehicles and Motor Vehicle Equipment	2.67
11;12	Coal and Lignite Mining	2.75
491,3	Electric Utilities	2.75
1623,9	Heavy Construction except Highway and Street	2.81
40;474	Railroads	2.88
29	Petroleum Refining	2.90

2.3.6 - Sub-contracting

Employers facing excess demand for STP might be expected to sub-contract part of their work. The net effect of this action on labor market conditions would depend on the occupational requirements of subcontractors and interindustry occupational specificity, among other factors. Unlike the three previous behavioral actions, this particular action reduces employer requirements rather than increases effective supply. The net result in alleviating a possible shortage is the same.

Most employers reported that sub-contracting was substantially less necessary in 1975 than in 1972 (Table 2.3.6). On the scale of 1-4 (more to less) the all-industry score was 2.87. Heating Equipment except electric, Petroleum Refining, and Non-commercial Scientific and Research Establishments were the only industries reporting an increased reliance on sub-contracting of work to alleviate STP shortages.

2.3.7 - Temporary STP

Employers can increase their effective STP supply by hiring temporary personnel from outside firms. Like overtime, this is at best a temporary solution, but may appear the most desirable alternative under uncertain conditions.

Table 2.3.6

Question 11 In comparison to 1972, to what extent did your establishment find it necessary to sub-contract work as a result of scientific or technical personnel shortages in 1975?

SIC	Industry	Score
	All industries	2.87
343	Heating Equipment except Electric	2.33
29	Petroleum Refining	2.40
8922	Non-commercial Scientific and Research Establishments	2.44
351	Engines and Turbines	2.50
356	General Industrial Machinery and Equipment	2.50
492	Gas Utilities	2.50
40;474	Railroads	2.63
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	2.67
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	2.70
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	2.70
46	Pipelines, except Natural Gas	2.75
344	Fabricated Structural Steel Products	2.79
7391	Commercial Research and Development Laboratories	2.80

The composite industry score on this item was 2.96, indicating that most employers hired fewer temporary STP in 1975 than in 1972 (Table 2.3.7). The only industry which resorted to this action more in 1975 was General Industrial Machinery. Industrial Chemicals, Engines and Turbines, and Non-Commercial Scientific and Research Establishments reported they used temporary help to the same extent in both years.

2.3.8 - Borrowing or transferring STP from other divisions or locations

Since many firms have more than one establishment, it is possible for a particular establishment in a particular product-line to have excess demand while other locations are operating below capacity and have excess personnel. Under these conditions intra-organizational transfers or borrowing of personnel might be undertaken to fill positions.

Industry as a whole reported that this was less necessary in 1975 than 1972 (Table 2.3.8). Basic Steel and Engines and Turbines were the only industries reporting increased reliance on borrowing or transferring STP from other locations or divisions. Non-commercial Scientific and Research Establishments and Pipelines except natural gas reported no change since 1972.

Table 2.3.7

Question 12 In comparison to 1972, to what extent did your establishment hire temporary scientific or technical personnel from outside firms in 1975?

SIC	Industry	Score
	All industries	2.96
356	General Industrial Machinery and Equipment	2.43
281,6,9	Industrial Chemicals	2.50
351	Engines and Turbines	2.50
8922	Non-commercial Scientific and Research Establishments	2.50
29	Petroleum Refining	2.60
40;474	Railroads	2.63
343	Heating Equipment except Electric	2.67
491,3	Electric Utilities	2.72
13	Oil and Gas Extraction	2.73
11;12	Coal and Lignite Mining	2.75
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	2.75
46	Pipelines, except Natural Gas	2.75
492	Gas Utilities	2.75
7391	Commercial Research and Development Laboratories	2.80
344	Fabricated Structural Steel Products	2.81
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	2.90

Table 2.3.8

Question 13 In comparison to 1972, to what extent did your establishment borrow or transfer scientists or technicians from other locations or divisions of your firm in 1975?

SIC	Industry	Score
	All industries	2.85
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	2.00
351	Engines and Turbines	2.17
46	Pipelines, except Natural Gas	2.50
8922	Non-commercial Scientific and Research Establishments	2.50
343	Heating Equipment except Electric	2.58
40;474	Railroads	2.63
29	Petroleum Refining	2.70
356	General Industrial Machinery and Equipment	2.70
11;12	Coal and Lignite Mining	2.75
281,6,9	Industrial Chemicals	2.75
492	Gas Utilities	2.75
8911	Architectural and Engineering Services	2.75
3494,8	Pipes, Valves, and Fittings	2.78
361	Electric Transmission and Distribution Equipment	2.79

2.3.9 - Borrowing STP from other firms

Another employer response to increased STP requirements could be to borrow personnel from other firms in the area which may be experiencing slack conditions. This type of action is probably most common in a contract industry, subject to wide fluctuations in activity as contracts come and go. Although this action may be rare for industry, it is potentially important since it provides a means of smoothing cyclical variations and avoiding layoffs which might cause permanent loss of personnel.

None of the surveyed industries reported more borrowing in 1975 than in 1972 (Table 2.3.9). Only Railroads and Non-commercial Scientific and Research Establishments reported no change. Industry as a whole reported using this device substantially less in 1975 with a mean score of 3.11 on the 1-4 (Much More to Much Less) scale.

2.3.10 - Training costs

Employers can counter a lack of needed technical personnel by increasing their in-house training efforts. For example, a firm could develop programs to upgrade promising technicians to engineering status, particularly when the desired specialty is not typically offered at educational institutions.

Table 2.3.9

Question 14 In comparison to 1972, to what extent did your firm borrow scientists or technicians from other firms (which might have been experiencing slack periods) in 1975?

SIC	Industry	Score
	All industries	3.11
40;474	Railroads	2.50
8922	Non-commercial Scientific and Research Establishments	2.50
344	Fabricated Structural Steel Products	2.75
46	Pipelines, except Natural Gas	2.75
29	Petroleum Refining	2.80
351	Engines and Turbines	2.83
356	General Industrial Machinery and Equipment	2.86
492	Gas Utilities	2.90
361	Electric Transmission and Distribution Equipment	2.93
11;12	Coal and Lignite Mining	3.00
371	Motor Vehicles and Motor Vehicle Equipment	3.00
332	Iron and Steel Foundries	3.00
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	2.00
343	Heating Equipment except Electric	3.08
7391	Commercial Research and Development Laboratories	3.10
13	Oil and Gas Extraction	3.11

Several industries reported an increase in training costs beyond inflation, while all industry combined reported practically no change since 1972 (Table 2.3.10). Industries which led the list of increased training costs include Industrial Chemicals, Electronic Components and Accessories, Heavy Construction except highways, and Iron and Steel Foundries.

2.3.11 - Delaying or cancelling production

As a last resort employers may find it necessary to delay or cancel production as a result of STP vacancies. The choice between hiring additional personnel and continuing or undertaking projects may be decided by abandoning those projects with the lowest expected payoff.

Non-commercial Scientific and Research Establishments was the only industry to report curtailment of production or research and development relative to 1972 (Table 2.3.11). All industries combined reported this was a substantially smaller problem in 1975 than in 1972.

2.3.12 - Summary of employer actions

It is difficult to distinguish any clear and consistent patterns of labor market tightness from the discussion and data thus far presented. Table 2.3.12a illustrates that these patterns do in fact exist. It shows that the same in-

Table 2.3.10

Question 15 In comparison to 1972, to what extent did your constant dollar training costs for scientific and technical personnel increase or decrease in 1975?

SIC	Industry	Score
	All industries	2.54
281,6,9	Industrial Chemicals	2.00
367	Electronic Components and Accessories	2.00
1623,9	Heavy Construction except Highway and Street	2.21
332	Iron and Steel Foundries	2.25
8922	Non-commercial Scientific and Research Establishments	2.27
356	General Industrial Machinery and Equipment	2.29
3534-7	Materials Handling Machinery and Equipment	2.33
492	Gas Utilities	2.36
7391	Commercial Research and Development Laboratories	2.40
8911	Architectural and Engineering Services	2.40
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	2.50
3494,8	Pipes, Valves, and Fittings	2.50
343	Heating Equipment except Electric	2.50
351	Engines and Turbines	2.50
46	Pipelines, except Natural Gas	2.50

Table 2.3.11

Question 16 In comparison to 1972, to what extent did your establishment find it necessary to delay or cancel production or research and development due to vacancies in scientific and technical positions in 1975?

SIC	Industry	Score
	All industries	2.96
8922	Non-commercial Scientific and Research Establishments	2.45
356	General Industrial Machinery and Equipment	2.57
40;474	Railroads	2.63
343	Heating Equipment except Electric	2.67
492	Gas Utilities	2.70
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	2.75
11;12	Coal and Lignite Mining	2.75
46	Pipelines, except Natural Gas	2.75
29	Petroleum Refining	2.80
344	Fabricated Structural Steel Products	2.83
351	Engines and Turbines	2.83
491,3	Electric Utilities	2.84
3494,8	Pipes, Valves, and Fittings	2.94

Table 2.3.12a

Summary of questions 8-16

SIC	Industries with 4 or more scores below all-industry score	Number of times below all-industry score
356	General Industrial Machinery and Equipment	8
46	Pipelines, except Natural Gas	8
492	Gas Utilities	8
11;12	Coal and Lignite Mining	7
29	Petroleum Refining	7
343	Heating Equipment except Electric	7
351	Engines and Turbines	7
40;474	Railroads	7
281	Industrial Chemicals	6
344	Fabricated Structural Steel Products	6
7391	Commercial Research and Development Laboratories	6
8922	Non-commercial Scientific and Research Establishments	6
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	5
1623,9	Heavy Construction except Highway and Street	5
3494,8	Pipes, Valves, and Fittings	5
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	5
491,3	Electric Utilities	5
13	Oil and Gas Extraction	4
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	4
332	Iron and Steel Foundries	4

dustries consistently score below the all-industry mean on most of the preceeding questions. However, this should not be interpreted as evidence of a general shortage of STP for these industries. Recall that most of the items yielded all-industry scores above the neutral value (2.5), indicating 1975 conditions were generally less tight than 1972 conditions.

The data support the conclusion that, relative to other industries, tighter labor market conditions exist in several direct and indirect energy-supply industries. Pipelines except natural gas, Gas Utilities, Coal Mining, and Oil and Gas Extraction evidence relatively tight labor market conditions among direct industries. General Industrial Machinery, Heating Equipment except electric, Engines and Turbines, Railroads, Industrial Chemicals, Fabricated Structural Steel Products, Commercial Research and Development Labs, and Non-commercial Scientific and Research Establishments show relatively tighter job market conditions among indirect industries.

Table 2.3.12b shows those industries which scored below the neutral (no change since 1972) value on three or more of the nine items. It is interesting that only indirect industries qualify under this admittedly arbitrary criteria. The results are not very consistent. General Industrial Machinery leads the ranking by scoring below the neutral value in only four of nine possible measures. The obvious

Table 2.3.12b

Summary of questions 8-16

SIC	Industries with 3 or more scores below neutral value	Number of times below
356	General Industrial Machinery and Equipment	4
1623,9	Heavy Construction except Highway and Street	3
281,5,9	Industrial Chemicals	3
351	Engines and Turbines	3
367	Electronic Components and Accessories	3
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	3
7391	Commercial Research and Development Laboratories	3
8922	Non-commercial Scientific and Research Establishments	3

conclusion, that these industries are experiencing tight labor market conditions, is only weakly supported by the data.

2.3.13 - Retraining STP

A tight job market would make retraining an attractive substitute for higher or more intensive recruiting for the desired specialty (if it is found outside the firm). A firm's willingness to bear retraining costs is also a function of the desired occupations specificity with respect to the firm. The retrained worker with readily transferrable skills may change firms before the employer can recapture his investment.

Very few industries reported a necessity to retrain STP from one particular occupational specialty to another, such as Civil Engineer to Mining Engineer. Only 11 percent of all firms reported that retraining was necessary, led by Engines and Turbines where 33 per cent of the establishments found it necessary to retrain from one area of specialization to another. Industries where the percentage of respondents reporting a necessity to retrain exceeded the all-industry percentage are reported in Table 2.3.13, with the exact wording of the question.

Table 2.3.13

Question 17a Has your establishment found it necessary to retrain scientific or technical personnel from one area of specialization to another? (i.e., their primary activity is not their area of degree specialty)

SIC	Industry	Found Retraining Necessary
	All industries	11%
351	Engines and Turbines	33%
354	Metalworking Machinery and Equipment	25%
13	Oil and Gas Extraction	22%
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	20%
345	Screw Machine Products, and Bolts, Nuts, Screws, Rivets, and Washers	20%
29	Petroleum Refining	17%
381,2,7	Engineering, Laboratory, Scientific & Research Inst.	17%
7391	Commercial Research and Development Laboratories	14%

2.3.14 - Interviews of college and university technical graduates

Recruiting activity appears to be the most volatile of measures employed in the survey. This is to be expected since new college graduates are the greatest source of accessions.

Gas Utilities, Architectural and Engineering Services, Commercial Research and Development Labs, and Heating Equipment except electric showed a large average annual increase. These percentage changes can be somewhat misleading as in the case of Gas Utilities which showed the largest average percentage change although the industry's interviews in 1975 were still far below the 1972 level. In addition, the establishment focus of the survey may bias the figures in favor of the industries with decentralized recruiting, given poor response in certain industries. Both the average annual percentage change and the yearly mean number of interviews per firm are presented in Table 2.3.14. Industries are ranked by the average percentage change.

2.3.15 - Personnel used for recruiting

The number of full time (equivalent) personnel used for college and university recruiting should be inversely related to the ability of the establishment to fill vacancies. Although this measure should be highly correlated with the number of interviews, it is more stable. It may also differ in that the intensity of recruiting effort may vary. Table 2.3.15 shows the average annual percentage change in full time recruiting personnel for industries registering larger than average increases.

2.3.16 - Using managerial or technical staff for recruiting

Employers can supplement their normal STP recruiting staff by "deputizing" other managerial and technical staff for recruiting purposes. Under tight job market conditions, employers can increase their recruiting effort by increasing recruiting staff. Many respondents used this method (as indicated by the all-industry score of 2.53 on a 1-4 (more to less) scale) more in 1975 than in 1972. Industries that increased their use of this device most include Industrial Chemicals, Railroads, Heavy Construction except highway and street, Petroleum Refining, and Iron and Steel Foundries. All industries with scores below the all-industry score are shown in Table 2.3.16.

Table 2.3.14

Mean number (per establishment) of college and university interviews with scientific and technical students

SIC	Industry	Average Annual Percent Change In Interviews	Mean Number of Interviews per Establishment 1975	1974	1973	1972
	All industries	21.3	34.0	29.3	21.5	21.1
492	Gas Utilities	1114.7	7.2	.2	7.8	18.8
8911	Architectural and Engineering Services	304.0	85.5	88.6	8.9	7.5
7391	Commercial Research and Development Laboratories	283.0	115.8	11.0	45.3	62.9
343	Heating Equipment except Electric	125.0	5.4	1.2	0.0	1.0
332	Iron and Steel Foundries	116.3	6.0	4.0	1.0	1.0
371	Motor Vehicles and Motor Vehicle Equipment	90.3	26.7	12.7	13.3	5.0
29	Petroleum Refining	65.0	32.0	27.6	25.3	11.8
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	48.0	16.7	8.5	0.0	0.0
13	Oil and Gas Extraction	42.3	68.0	57.2	26.5	28.8
1623,9	Heavy Construction except Highway and Street	30.7	1.5	.6	.8	1.2
351	Engines and Turbines	28.3	50.0	50.0	40.3	25.0
356	General Industrial Machinery and Equipment	17.5	3.6	.8	0.0	0.0
361	Electric Transmission and Distribution Equipment	14.7	23.0	12.4	15.6	19.6
354	Metalworking Machinery and Equipment	11.3	2.4	2.0	3.0	2.0
46	Pipelines, except Natural Gas	8.5	60.3	51.7	0.0	0.0
40;474	Railroads	7.5	172.6	157.0	143.0	139.4
8922	Non-commercial Scientific and Research Establishments	5.0	11.3	9.4	11.1	10.1
281,6,9	Industrial Chemicals	2.7	2.3	2.1	2.9	3.9

Other industries showed decreases or no change.

Table 2.3.15

Average annual percentage change in full time or equivalent recruiting personnel

SIC	Industry	Avg. Annual Percent Change
	All industries	14.9
3494,8	Pipes, Valves, and Fittings	124.6
13	Oil and Gas Extraction	74.2
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	48.3
332	Iron and Steel Foundries	44.3
343	Heating Equipment except Electric	30.7
8911	Architectural and Engineering Services	24.9
381,2,7	Engineering, Laboratory, Scientific & Research Inst.	20.0
361	Electric Transmission and Distribution Equipment	19.5
356	General Industrial Machinery and Equipment	18.7

Table 2.3.16

Question 18c - In comparison to 1972, to what extent did your establishment use managerial or technical staff whose duties do not normally include recruiting for recruiting purposes.

SIC	Industry	Score
	All industries	2.53
281,6,9	Industrial Chemicals	1.40
40;474	Railroads	1.67
1623,9	Heavy Construction except Highway and Street	2.00
29	Petroleum Refining	2.00
332	Iron and Steel Foundries	2.00
13	Oil and Gas Extraction	2.06
492	Gas Utilities	2.14
8922	Non-commercial Scientific and Research Establishments	2.17
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	2.20
371	Motor Vehicles and Motor Vehicle Equipment	2.33
46	Pipelines, except Natural Gas	2.33
343	Heating Equipment except Electric	2.40
381,2,7	Engineering, Laboratory, Scientific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	2.40
3534-7	Materials Handling Machinery and Equipment	2.50
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	2.50

2.3.17 - Acceptance ratios

An establishment's hire-to-offer ratio for inexperienced new hires is the result of a number of factors, including:

a) salary

b) job content

c) geographical location

d) applicant's perceptions of career opportunities

e) general image or reputation of firm and industry.

In addition to these factors an industry's acceptance ratio is affected by excess demand. The net result of attempts by firms to outbid each other for scarce talent should be a reduction in the ratio of acceptances to offers for each establishment as each candidate receives more offers.

The inter-industry acceptance rates presented were constructed by aggregating across all engineering occupations. Thus they reflect acceptance rates for the particular specialties employed in each industry as well as industry-specific rates. For example, if petroleum engineers are heavily concentrated in Oil and Gas Extraction, and have low ratios, the respective industry ratio should be quite low.

Coal Mining, Oil and Gas Extraction, Petroleum Refining, and Iron and Steel Foundries all show low and falling acceptance ratios. Industries which reported sufficient

data are presented in order of their 1975 acceptance ratio in Table 2.3.17.

2.3.18 - Quit rates for engineers

Industries facing excess demand for STP should be expected to show higher quit rates. Internal wage equity considerations may prevent an employer from matching other available offers. Employees will move towards these better offers.

Rolling, Drawing, and Extruding of Non-ferrous Metals, Electric Lighting and Wiring Equipment, and Miscellaneous Machinery except electrical reported quit rates for engineers substantially above those of other industries. Industries with engineering quit rates above all-industry levels are presented in Table 2.3.18. Like the preceeding acceptance ratios, these were calculated by aggregating engineering occupations.

2.3.19 - Vacancy rates for engineers

Industries with increased demand for specialties in short supply should exhibit higher vacancy rates due to 1) increased quits and 2) the creation of new positions as a normal result of expansion. Industries reporting relatively high vacancy rates in 1975 include Architectural and Engineering Services, Railroads, and Iron and Steel Foundries.

Table 2.3.17

Acceptance ratios for engineers

SIC	Industry	1975	1974	1973	1972
	All industries	.50	.59	.62	.66
343	Heating Equipment except Electric	.14	*	.25	*
332	Iron and Steel Foundries	.16	.20	.33	1.0
29	Petroleum Refining	.17	.26	.33	.58
13	Oil and Gas Extraction	.28	.42	.57	.35
11;12	Coal and Lignite Mining	.33	.50	1.0	*
8922	Non-commercial Scientific and Research Establishments	.35	.27	.26	1.0
344	Fabricated Structural Metal Products	.47	.39	.60	.50
3531-3	Construction, Mining, and Oil Field Mach'y and Equip.	.50	.67	*	*
3494,8	Pipes, Valves, and Fittings	.50	.40	.67	.67
40;474	Railroads	.52	.37	.74	.39
8911	Architectural and Engineering Services	.53	.59	.67	.70
351	Engines and Turbines	.62	.63	*	0.0
491,3	Electric Utilities	.69	.70	.70	.71
361	Electric Transmission and Distribution Equipment	.70	.74	.68	.87
281,6,9	Industrial Chemicals	.75	.83	.56	.50
356	General Industrial Machinery and Equipment	.75	.67	1.0	1.0
7391	Commercial Research and Development Laboratories	.90	.63	.75	.65
492	Gas Utilities	*	.33	.39	.48

Table 2.3.18

Quit rates for engineers in 1975

SIC	Industry	Annual quit rate in 1975
	All industries	4.3%
3356,7	Rolling, and Extruding of Non-ferrous Metals	28.6%
364	Electric Lighting and Wiring Equipment	16.1%
354	Metalworking Machinery and Equipment	11.4%
7391	Commercial Research and Development Laboratories	11.3%
371	Motor Vehicles and Motor Vehicle Equipment	10.9%
8922	Non-commercial Scientific and Research Establishments	10.2%
3534-7	Materials Handling Machinery and Equipment	9.4%
331	Blast Furnaces, Steel Works, and Rolling and Drawing Mills	7.7%
8911	Architectural and Engineering Services	6.8%
40;474	Railroads	6.1%
492	Gas Utilities	4.9%
332	Iron and Steel Foundries	4.7%
3494,8	Pipes, Valves, and Fittings	4.7%

Table 2.3.19 ranks industries with above average vacancy rates. Vacancy rates were estimated by aggregating employment and vacancies across engineering occupations and dividing vacancies by employment.

2.3.20 - Note on metal mining

The very small number of establishments and the poor response in the ferrous and non-ferrous ore mining industries prevents presentation of quantitative results for those industries. The general nature of these few responses warrants mention.

The metal mining industries report generally tighter job-market conditions for STP in 1975 than in 1972. Employers report pursuing more of the types of actions one anticipates during excess demand conditions. Quantitative data on quits, interviews, vacancies, acceptances, and salaries also ranked the metal mining industries high on the relative shortage end of the spectrum.

2.3.21 - Summary of industry-specific conditions

The survey results evidence few clear patterns of industry-specific STP shortages. Few industries consistently report tighter job-market conditions relative to 1972 and other industries in 1975. On the whole, STP labor market conditions are slack. Most employers report "no problem"

Table 2.3.19

Vacancy rates for engineers in 1975

SIC	Industry	Percent vacancies per position, 12/31/75
	All industry	6.0%
8911	Architectural and Engineering Services	16.5%
40;474	Railroads	11.1%
332	Iron and Steel Foundries	9.4%
354	Metalworking Machinery and Equipment	5.7%
29	Petroleum Refining	5.4%
8922	Non-commercial Scientific and Research Establishments	5.1%
343	Heating Equipment except Electric	5.0%
491	Electric Utilities	4.5%
281	Industrial Chemicals	3.5%
351	Engines and Turbines	3.4%
3534-7	Materials Handling Machinery and Equipment	3.1%
3494,8	Pipes, Valves, and Fittings	2.4%
356	General Industrial Machinery and Equipment	2.[illegible]%
344	Fabricated Structural Steel Products	2.2%
371	Motor Vehicles and Motor Vehicle Equipment	2.2%
492	Gas Utilities	2.0%
364	Electric Lighting and Wiring Equipment	1.6%
13	Oil and Gas Extraction	1.3%

securing needed technical employees. Employers who offered explanations attributed the current STP labor market situation to the generally bearish economy. Employers reporting difficulties filling STP positions usually mentioned experience requirements, or extremely narrow specialties such as "mechanical engineers with experience in load cells or strain gauges". Several respondents did mention difficulty in securing female and minority candidates.

Although occasional manifestations of tight job-market conditions can be found in the high-ranking industries, an instance of raiding in General Industrial Machinery perhaps, it is difficult to call these "shortage" industries. Rather, it seems appropriate to say these industries are the least affected by the general economic recession. The recession's impact has probably been partially offset by increased energy development activity in those industries.

Industries which consistently ranked above all-industry values on the excess demand indicators are (SIC codes at left):

492	Natural gas utilities	11 of 16 indicators
343	Heating equipment, except elec.	11 " " "
2911	Petroleum refining	11 " " "
40;474	Railroads	10 " " "
351	Engines and turbines	10 " " "
356	General industrial machinery	9 " " "
332	Iron and steel foundries	9 " " "
46	Pipelines except natural gas	9 " " "
7391	Commercial research and dev. labs	9 " " "
8922	Non-comm. sci. and res. estabmnts.	9 " " "
3531-3	Constr., mining, and oil field mach	9 " " "
13	Oil and gas extraction	9 " " "
11;12	Coal mining	8 " " "
3494,8	Pipes, valves, and fittings	8 " " "
381,2,7	Engineering, Laboratory, Scie·tific & Research Inst. & Assoc. Equip., Measuring and Controlling Inst., Clockwork Devices	8 " " "
344	Fabricated structural steel prods.	7 " " "
281,6,9	Industrial Chemicals	7 " " "
1623,9	Heavy Construction except Highway and Street	7 " " "

Two interesting patterns are exhibited. First, the ranking does not appear to differentiate between direct and indirect industries. This suggests that ignoring indirect effects can be grossly misleading. Present energy-supply development activities seem to be having as much of an impact on the labor market for mecnanical engineers in the pump industry as for mining engineers in the coal industry. Second, the indirect industries which top the list are those which one would expect to expand under an accelerated energy development scenario, namely Heating Equipment and General Industrial Machinery. Both of these indirect industries showed large growth requirements in Bullard and Pilati's study of capital requirements for a Project Independence scenario.[19]

Two industries which did not appear in the summary ranking merit mention. Insufficient survey response prevents comparable consideration of the metal mining industries. It should also be noted that Architectural and Engineering services report less tight labor market conditions in 1975 than in 1972, but ranked relatively high on vacancies and increase in interviews of technical graduates.

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19 C. Bullard and D. Pilati, "Direct and Indirect Requirements for a Project Independence Scenario," CAC Document No. 178, Center for Advanced Computation, September 1975.

2.4 - Summary of Labor Market Conditions for Scientific and Technical Personnel in Energy-Related Industries

Nuclear engineers

Across all industries, nuclear engineers appear in relatively short supply. It could also be said that the occupation is low in excess supply. Since they are used in only a few industries, identification of the shortage locations is straightforward. Electric Utilities, Architectural and Engineering Services, and Non-commercial Scientific and Research Establishments are the only industries in the sample reporting substantial utilization of this specialty. Only Electric Utilities reported substantial vacancies. Salaries for nuclear engineers (all salaries cited are for inexperienced new hires) were relatively low ($1067/month), exceeding only salary offers to engineers, n.e.c. Electric Utilities' salary offers in 1975 were generally lower than other industries for all engineering specialties. The following comment is typical of the power industry: "We have very low turnover. There seems to be a large number of qualified applicants for our vacancies in the engineering field. Only recruiting problem is lack of minority candidates."

Mining engineers

Mining engineers are in relatively short supply in at least two industries, Coal Mining and Non-ferrous Ores Mining. Acceptance ratios were lower than other engineering specialties, except for petroleum engineers and materials/metallurgical/ceramic engineers. Salary data from late returns ranks this specialty second behind offers to materials/metallurgical/ceramic engineers, ahead of petroleum engineers. However, the only comment from mining industries was "never had problems in securing employees....we have an over-supply of labor in this area."

Chemical engineers

Chemical engineers, unlike the two preceeding specialties, are found in most of the industries included in this study. Highest salary offers to chemical engineers were reported in Commercial Research and Development Labs ($1350/month) and Petroleum Refining ($1279/month). Chemical engineers had the lowest acceptance ratios among engineering hires in Electric Utilities, Petroleum Refining, and Non-commercial Scientific and Research Establishments. Vacancies were highest in Petroleum Refining and Architectural and Engineering Services. A firm in the industrial chemicals industry reported recruiting of chemical engineers "has been highly competitive".

Petroleum engineers

Petroleum engineers did not appear to be in short supply in the previous "all-industry" analysis. However, among engineering specialties they ranked second in acceptance ratios (30 per cent) and third in salaries ($1282/month). In Oil and Gas Extraction they ranked highest and in Petroleum Refining they ranked second in vacancy rates for engineers.

During a personal interview, a personnel officer of a southwestern gas company said that inexperienced bachelor graduates were getting offers as high as $1625 a month to start during the summer of 1975, but the market had loosened somewhat since then. Another southwestern establishment in Oil and Gas Extraction reported vacancies for petroleum engineers remaining unfilled for six months.

The Oil and Gas Extraction Industry also expressed a need for "welding engineers." This specialty was not specifically included in the occupational scheme of the survey. Several respondents complained that only a handful of higher education institutions offer the specialty.

Mechanical engineers

Several "shortage industries" report problems in securing mechanical engineers. The only instance of raiding reported was in a midwestern pump manufacturing (General In-

dustrial Machinery) firm which claimed it was being "attacked by professional recruiters". Mechanical engineers ranked high on vacancy rates in several industries. It is difficult to isolate particular industries due to the widespread employment of the occupation.

Relatively high vacancy rates among engineers were reported in Pipes, Valves, and Fittings, Heating Equipment except electric, Fabricated Structural Steel Products, General Industrial Machinery, Engines and Turbines, and Materials Handling Machinery and Equipment. One firm reports it is "Difficult to attract qualified engineers with Process Equipment experience...", while another finds it "Very difficult to find engineers qualified and interested in engineering new developments in construction equipment...". One establishment in Materials Handling Machinery and Equipment reports "Particular problems have been encountered in securing mechanical engineers experienced in material handling project area..." and a steel fabricator in the east says the local "market for experienced mechanical engineers is highly competitive. There exists considerable fluidity as to movement among companies based on salaries and workload. Good engineers were at a premium even during the recent recession."

The highest salary offers to the specialty were reported in Non-commercial Scientific and Research Establishments ($1375/month), Fabricated Structural Steel Products

($1300/month), Petroleum Refining ($1294/month), Industrial Chemicals ($1238/month), and Oil and Gas Extraction ($1215/month). Mechanical engineers had the lowest acceptance ratios among other specialties in several of the above industries.

Physicists

Only two industries, Commercial Research and Development Labs and Non-commercial Scientific and Research Establishments, reported hires of physics graduates in 1975. Only the latter reported vacancies. The acceptance ratio was very high (83 per cent) in 1975. The only other industry reporting hires since 1972 was Engines and Turbines. Other industries which reported employment of physicists in 1975 are Oil and Gas Extraction, Electric Utilities, Pipes, Valves, and Fittings, Petroleum Refining, Electrical Transmission and Distribution Equipment, Scientific and Controlling Instruments, and Rolling, Drawing and Extruding of Non-ferrous metals except aluminum and copper.

Chemists

Like chemical and mechanical engineers, chemists were employed in many of the industries in this study. They had lowest acceptance ratios among scientists in Petroleum Refining (30 per cent) and Engines and Turbines (50 per cent) in 1975. Highest 1975 salary offers were reported in Com-

mercial Research and Development Labs ($1167/month) and Non-Commercial Scientific and Research Establishments ($1259/month). Vacancies were reported in Industrial Chemicals and Non-commercial Scientific and Research Establishments.

Agriculturists

Only four industries reported employment of this specialty: Oil and Gas Extraction , Fabricated Structural Steel Products, Commercial Research and Development Labs, and Non-commercial Scientific and Research Establishments. Only the last reported figure for 1975 ($1061/month) and vacancies. The acceptance ratio for 1975 was 33 per cent.

Geologists

Employment of geologists was reported in most energy conversion and production industries, in both research industries, and Heavy Construction except highways. They had the lowest 1975 acceptance ratio among scientists in Oil and Gas Extraction (59 per cent), and ranked second in Petroleum Refining (33 per cent). Salary offers for 1975 were reported in Non-ferrous Metal Mining ($1200/month), Oil and Gas Extraction ($1075/month), and Petroleum Refining ($1050/month). Vacancies were reported for geologists only in Oil and Gas Extraction in 1975, where one respondent was

reportedly unable to fill a position for six months.

Chemical technicians

Chemical technicians are employed in most of the energy-related industries, including the indirect industries. They had the lowest acceptance ratios among technicians in Petroleum Refining (75 per cent) and Commercial Research and Development Labs (80 per cent). The highest monthly salary offers in 1975 were reported in the latter ($782/month) and Industrial Chemicals ($895/month). Chemical technicians had the highest vacancy and quit rates for technicians across all industries, but no vacancies were reported in the "shortage industries" in 1975.

Draftsmen

Draftsmen are employed in all of the industries studied and comprise the largest single specialty (by technical employment) in many industries. the lowest 1975 acceptance ratios were reported in Engines and Turbines and Materials Handling Machinery and Equipment. Salary offers in 1975 varied widely around a mean of $769/month Industries which led in 1975 monthly salary offers were Pipelines except natural gas, Metalworking Machinery and Equipment, Fabricated Structural Steel Products, Industrial Chemicals, and Screw Machine Products. Architectural and Engineering Services recorded a mean of $680/month Vacancies were reported in

Materials Handling Machinery and Equipment, Pipes, Valves, and Fittings, Fabricated Structural Steel Products, Engines and Turbines, Railroads, Gas Utilities and Architectural and Engineering Services. A metal forming establishment reported a need for "draftspersons with experience in cold heading or related field of metal forming", but "no great problem in finding these people". the highest vacancy rates were reported in Railroads (16.7 per cent), Engines and Turbines (12.7 per cent), and Gas Utilities (11.1 per cent).

Mechanical technicians

Mechanical technicians are employed in most of the energy-related industries. Monthly salaries to new hires were reported highest in Oil and Gas Extraction, Screw Machine Products, Metalworking Machinery and Equipment, and General Industrial Machinery and Equipment. Acceptance ratios for industries hiring mechanical technicians were lowest in Heating Equipment except electric (50 per cent), Engines and Turbines (63 per cent), and Oil and Gas Extraction (43 per cent). Vacancies were reported in Oil and Gas Extraction, Pipes, Valves, and Fittings, Heating Equipment except electric, and Fabricated Structural Steel Products.

Surveyors

Several energy-related industries reported employment of surveyors. Vacancies were reported in Oil and Gas Extraction and Architectural and Engineering Services. The latter industry reported the lowest acceptance ratio, 80 per cent, and an average monthly salary offer to inexperienced new hires of $703.

Chapter 3

Projection Method

3.1 Outline of the Model

One objective of this study was to develop a highly flexible and adaptable forecasting system that could be readily updated to reflect new information, data, and policies. Over the past few years CAC has developed a number of manpower and energy models and this prior work is drawn on heavily here.[1]

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[1] Some of the earlier work includes H. Folk, "Manpower Research Alternatives and Imperatives," in John R. Niland, editor, The Production of Manpower Specialists. Ithaca: New York State School of Industrial and Labor Relations, 1971, pp. 181-198; H. Folk and B. Hannon, "An Energy, Pollution, and Employment Policy Model," in Michael S. Macrakis, editor, Energy: Demand, Conservation, and Institutional Problems, Proceedings of a Conference on Energy at the Massachusetts Institute of Technology. Cambridge: MIT Press, 1973, pp. 159-173; Roger H. Bezdek, Long-Range Forecasting of Manpower Requirements, Theory and Applications, New York: Institute of Electrical and Electronic Engineers, Inc., 1974; R. Herendeen, An Energy Input-Output Matrix for the United States, 1963: User's Guide, Document No. 69, Center for Advanced Computation, University of Illinois, Urbana-Champaign, March 1973; R. Herendeen and C. Bullard, Energy Costs of Goods and Services, 1963 and 1967, Document No. 140, Center for Advanced Computation, University of Illinois, Urbana-Champaign, November 1974; R. Knecht and C. Bullard, End Uses of Energy in the U.S. Economy, 1967 Document No. 145, Center for Advanced Computation, University of Illinois, Urbana-Champaign, September 1975; C. Bullard, An Input-Output Model for Energy Demand Analysis, Document No. 146, Center for Advanced Computation, University of Illinois, Urbana-Champaign, January 1975; C. Bullard and D. Pilati, Direct

This chapter provides a comprehensive examination of the CAC projection model. As described in Chapter 1, this model yields projections for three energy scenarios. The actual manpower projections are accomplished in a multi-step procedure. The first step is to make GNP projections. These projections provide a final demand vector which is used in conjunction with an input-output (I-O) model to provide total manpower required for specific occupations in specific industries. Each of these steps is examined in detail in the following sections. The individual scenarios are described in section 3.1.1. The resulting projections are given in Chapter 4. A schematic representation of the model's subcomponents and their interaction is given in figure 3.1.

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and Indirect Requirements for a Project Independence Scenario, Document No. 178, Center for Advanced Computation, University of Illinois, Urbana-Champaign, September 1975; D. Pilati, Energy Demand Model Refinements for 1985 Supply Mix, Technical Memorandum No. 70, Center for Advanced Computation, University of Illinois, Urbana-Champaign, February, 1976; and D. Amado, C. Foster, and D. Pilati, Two Models for Energy and Labor Impact Analysis, Technical Memorandum No. 69, Center for Advanced Computation, University of Illinois, Urbana-Champaign, January, 1976.

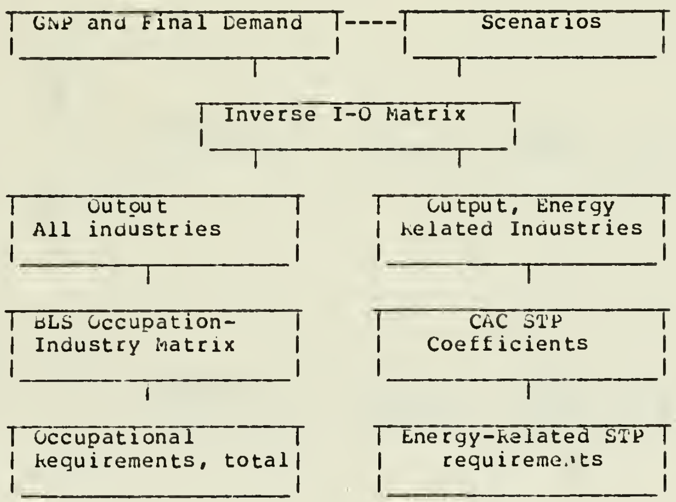

Figure 3.1

Outline of Projection System

3.1.1 - Energy Scenarios

The three scenarios studied are (1) Free Imports, (2) Limited Imports, and (3) Limited Imports - Synthetics (termed simply "Synthetics" henceforth). They are based on ERDA-48.[2] Direct construction manpower and materials re-

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[2] U.S. Energy Research and Development Administration, A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future, Report ERDA-48, vol.1, June 1975.

quirements are derived from the Bechtel Corporation's Energy Supply Planning Model.[3] Calculations were prepared that reflected the energy facility construction implied by the energy usage specified in the scenarios (Table 3.1.1). There are slight differences in the energy levels implied between ERDA and Bechtel due to the use of slightly different fuel-Btu conversion ratios, but the correspondence between the ERDA and Bechtel scenarios of the same names is close. In what follows, the Bechtel scenario estimates are used.

The Free Import scenario assumes that energy consumption in the United States increases from the 1973 level of about 73 quadrillion Btu's to 99.1 quadrillion Btu's in 1985. Domestic energy production increases, but the growth of imports of oil and gas are substantial.

The Limited Imports scenario assumes energy usage increases to 84.1 quadrillion Btu's in 1985. Domestic coal production increases substantially more than in Free Imports, and nuclear power grows substantially more. Oil imports are much lower under Limited Imports.

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[3] Carasso, et. al., The Energy Systems Group, The Energy Supply Planning Model, Bechtel Corporation, San Francisco, 1975.

Table 3.1.1

Fuel Requirements (Physical Units), 1985

	1973	Free Imports	Limited Imports	Synthetics
Electric power capacity (GWe)				
Coal	180	253	274	266
Gas	86	100	61	61
Nuclear	21	162	185	185
Oil	66	84	46	46
Other	86	171	167	175
Total	439	757	733	733
Coal (MM Tons/Y)	486	770	799	899
Petroleum (MM BPD)				
Imports	6.1	8.3	4.7	4.2
Domestic	9.1	10.4	9.8	9.5
Synthetic	0.0	0.0	0.0	0.4
Total	15.2	18.7	14.5	14.1
Gas (TCF/Y)				
Imports	.9	1.8	1.3	0.7
Domestic	22.7	24.8	23.3	23.9
Synthetic	0.0	0.0	0.0	0.5
Total	23.6	26.6	24.6	24.6
Uranium (Million Tons of 0.2% U_3O_8)	10.2	34.2	37.0	37.3
Total (quad Btu's)	73.2	99.1	84.1	86.9

The Synthetics scenario uses the same major assumptions as the Limited Imports scenario but in addition assumes a program of developing synthetic oil and gas that would produce a 930 MBPD oil equivalent in 1985 and 1835 MBPD equivalent in 1990. The 1985 output is assumed to be 300 MBPD of shale oil, 100 MBPD of coal liquids, 280 MBPD in high-Btu gas, and 250 MBPD of low and medium Btu gas from coal. While these quantities are not enormously significant in 1985, they do involve substantial investment in construction cost and employment.

The total fuel requirements in 1985 under Synthetics is 86.9 quads, slightly above the 1985 Limited Imports level.

The total twelve-year investment costs under the three alternatives are estimated by Bechtel to be (in 1973 dollars):

Free Imports	$413 billion
Limited Imports	$408 billion
Synthetics	$420 billion

There is only small variation in expenditures and in manpower and materials among the three scenarios. Synthetics, for instance, costs $12 billion more than Limited Imports but produces slightly more energy. Free Imports is $5 billion more costly than Limited Imports but produces 15 quads more energy.

3.1.2 - GNP Projections

The GNP projections used in this study are those prepared by the Bureau of Labor Statistics.[4] These projections permit the use of the detailed final demand patterns developed by BLS. The projections take specific account of three alternative energy price systems. The BLS assumes unemployment of 7.8 per cent in 1976, falling to 4.7 per cent in 1980 and 4.0 per cent in 1985. The total labor force is assumed to increase from an actual level of 89 million in 1972 to 103.3 million in 1980, and 107.7 million in 1985. Output per man hour is assumed to increase at 2.2 per cent per year from 1972 to 1980 and at 2.6 per cent per year from 1980 to 1985.

BLS estimates that constant dollar GNP will increase at 2.51 per cent per year for 1972-85. In 1958 constant dollars, this represents a 1980 GNP of $1,078 billion and a 1985 GNP of 1,284.5 billion, compared to $792.5 for 1972.

In the present study, production was placed on a domestic base by subtracting out imports. The purpose of this is

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4 R. Kutscher, "Revised BLS Projections to 1980 and 1985: An Overview," Monthly Labor Review, March 1976, pp. 3-8.

to provide domestic base total production in order to use the appropriate base for energy consumption. Total domestic production, or the sum of the final demands actually used in the analysis is given in table 3.1.2.

Table 3.1.2

Total Domestic Production

(millions of 1963 dollars)

Oil price	1980	1985
$7	$992,856	$1,175,894
9	996,803	1,179,487
11	996,308	1,180,236

3.1.3 - Final Demand Patterns

The final demand patterns used in the study are those prepared by BLS. The final demands for 1980 and 1985 were estimated for three oil price levels: high ($11), medium ($9), and low ($7). The dollar values do not represent actual prices, but are relative prices in 1973 dollars.[5] Final

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5 BLS prepared these estimates for the March 1976 version of the BLS input-output model. The $9 oil price represented the level of crude oil price then current expressed in 1973 dollars.

demands for each industry expressed in 1963 dollar amounts for 1980 and 1985 for the three oil price scenarios are included in Chapter 4.

The final demand patterns are derived by BLS from analysis of consumption and production studies. There are substantial differences in final demand associated with different oil prices. In 1980, for instance, BLS industry sector 53, other primary non-ferrous metal, shows only 76 per cent as much demand for $11 as for $7 oil, an implied elasticity of -.59. Examples of other industries with relatively high elasticities are petroleum products, air transportation, primary aluminum, and gas utilities. Some of the industries showing increases in demand in 1980 at $11 as opposed to $7 oil are automobile repair, railroad equipment, coal mining, telephone apparatus, and owner-occupied dwellings. The industries with the highest and lowest elasticities for 1980 and 1985 are presented in tables 3.1.3a, 3.1.3b, 3.1.3c, and 3.1.3d.

Table 3.1.3a

Oil Price Impact on Final Demand
1980
Rank Order of Twenty Highest Negative Change Industries

BLS Industry	$11 vs $7 Oil Final Demand Ratio	Implied Point Elasticity
53. Other primary nonferrous metal and secondary nonferrous	.7665	-.59
42. Petroleum products.	.8495	-.37
3. Forestry and fisheries.	.8847	-.28
23. Miscellaneous textile and floor coverings	.8920	-.26
125. State and local government enterprises.	.8925	-.26
97. Air transportation.	.8931	-.25
83. Motor vehicles.	.8934	-.25
46. Cleaning and toilet preparations.	.8944	-.25
36. Agricultural chemicals.	.8977	-.24
52. Primary aluminum.	.8991	-.24
87. Transportation equipment, NEL	.9024	-.23
102. Gas utilities	.9031	-.23
110. Hotels and lodging places	.9047	-.23
37. Plastic materials and synthetic rubber.	.9066	-.22
44. Plastic products.	.9069	-.22
31. Paper products.	.9087	-.22
38. Synthetic fibers.	.9147	-.20
28. Millwork and plywood and miscellaneous wood products. . .	.9217	-.18
41. Paint	.9218	-.18
11. Chemical and fertilizer mining.	.9248	-.18

Table 3.1.3b

Oil Price Impact on Final Demand
1980
Rank Order of Twenty Highest Positive Change Industries

BLS Industry	$11 vs $7 Oil Final Demand Ratio	Implied Point Elasticity
115. Automobile Repair	1.1705	.35
86. Railroad and other misc. transportation equipment	1.1276	.27
94. Local, suburban and interurban highway transportation	1.1268	.27
76. Household appliances	1.1058	.23
116. Motion pictures	1.0954	.20
56. Other nonferrous rolling and drawing	1.0863	.19
65. Construction, mining, and oil field machinery	1.0814	.18
7. Other nonferrous metal ore mining	1.0812	.18
43. Rubber products	1.0764	.17
6. Coal mining	1.0753	.16
49. Blast furnaces and basic steel products	1.0751	.16
79. Telephone and telegraph apparatus	1.0606	.13
25. Apparel	1.0576	.13
29. Household furniture	1.0573	.13
108. Owner-occupied dwellings	1.0568	.12
45. Leather, footwear, and leather products	1.0567	.12
119. Hospitals	1.0506	.11
118. Doctors, dentists, and other medical services	1.0484	.11
78. Radio and tv receiving sets	1.0483	.11
117. Other amusements	1.0480	.11

Table 3.1.3c

Oil Price Impact on Final Demand
1985
Rank Order of Twenty Highest Negative Change Industries

BLS Industry	$11 vs $7 Oil Final Demand Ratio	Implied Point Elasticity
53. Other primary nonferrous metal and secondary nonferrous	.7665	-.59
42. Petroleum products	.7811	-.55
3. Forestry and fisheries	.8713	-.31
23. Miscellaneous textile and floor coverings	.8811	-.28
125. State and local government enterprises	.8911	-.28
97. Air transportation	.8912	-.28
83. Motor vehicles	.8922	-.26
40. Cleaning and toilet preparations	.8925	-.26
36. Agricultural chemicals	.8950	-.25
52. Primary aluminum	.8957	-.25
87. Transportation equipment, NEL	.8965	-.25
102. Gas utilities	.9000	-.24
116. Hotels and lodging places	.9057	-.22
37. Plastic materials and synthetic rubber	.9059	-.22
44. Plastic products	.9075	-.22
31. Paper products	.9097	-.21
38. Synthetic fibers	.9102	-.21
28. Millwork and plywood and miscellaneous wood products	.9104	-.21
41. Paint	.9144	-.20
11. Chemical and fertilizer mining	.9144	-.20

Table 3.1.3d

Oil Price Impact on Final Demand
1985
Rank Order of Twenty Highest Positive Change Industries

BLS Industry	$11 vs $7 Oil Final Demand Ratio	Implied Point Elasticity
115. Automobile Repair	1.1699	.35
86. Railroad and other misc. transportation equipment	1.1298	.27
94. Local, suburban and interurban highway transportation	1.1287	.27
65. Construction, mining, and oil field machinery	1.1127	.24
76. Household appliances	1.1092	.23
7. Other nonferrous metal ore mining	1.1067	.23
56. Other nonferrous rolling and drawing	1.1002	.21
49. Blast furnaces and basic steel products	1.0966	.21
8. Coal mining	1.0923	.20
116. Motion pictures	1.0907	.20
43. Rubber products	1.0798	.17
16. All other new construction	1.0724	.16
79. Telephone and telegraph apparatus	1.0666	.15
25. Apparel	1.0651	.14
24. Hosiery and knit goods	1.0644	.14
108. Owner-occupied dwellings	1.0644	.14
29. Household furniture	1.0643	.14
45. Leather, footwear, and leather products	1.0643	.14
119. Hospitals	1.0572	.13
78. Radio and tv receiving sets	1.0563	.12

3.1.4- Input-Output Model

Estimates of total production by industry require interindustry analysis. Any commodity or service entering into final demand is made up of many intermediate products. Some industries, such as automobiles, have total production very close to production for final demand because little of their output is used as intermediate inputs to other industries. Other industries, such as steel, have little production for final demand because they are used predominantly as inputs to other industries. BLS, working with input-output relations developed by BEA studies, has developed projected input-output tables. Each element in an input-output matrix shows how much of the industry output in a row is necessary to produce a unit of output in a column industry. This "input-output matrix" expressed in unit terms is derived from Census of Manufactures and other data for recent years (the 1967 matrix is the most recent available). BLS has projected input-output matrices for future years, taking account of expected technological changes.

Each of the input-output coefficients, a_{ij}, represents the amount of input i required to produce a unit output of

industry product j. A fundamental assumption of input-output analysis is that input requirements are proportional to outputs. Thus the total production of output of industry i, X_i is equal to final demand for output i, Y_i, plus all of the inputs required to produce the outputs of the other industries, so

$$X_1 = Y_1 + a_{11}X_1 + a_{12}X_2 \cdot \cdot \cdot + a_{1j}X_j + \dots a_{1n}X_n$$

...

$$X_i = Y_i + a_{i1}X_1 + a_{i2}X_2 \cdot \cdot \cdot a_{ij}X_j + \dots a_{in}X_n$$

...

$$X_n = Y_n + a_{n1}X_1 + a_{n2}X_2 \cdot \cdot \cdot a_{nj}X_j + \cdot \cdot a_{nn}X_n$$

Expressing this in matrix form,

$$x = y + Ax$$

or, solving for x,

$$x = (I-A)^{-1} y$$

where x is a vector of total demand, y is the vector of final demand, A is the matrix of input-output coefficients, I is the identity matrix, and $(I-A)^{-1}$ is the inverse matrix. Thus use of the input-output matrix allows derivation of total demand from final demand in a direct way. As long as

the matrix A does not change, any change in final demand can be converted into changes in total demand by multiplication.

BLS estimates an occupation-industry matrix that shows the number of workers in each occupation in each industry for a future year such as 1985. This matrix is estimated from recent census data and supplementary analyses. It can be converted into a matrix of occupation-industry coefficients by dividing the occupational requirements in each industry by the estimated total output of that industry in the same year. The fundamental assumption made in this step is that occupational requirements are proportional to output. When this matrix of coefficients (M) is multiplied by the vector of total industry outputs, a projection of occupational requirements, or demands, is obtained. An occupational coefficient, m_{kl}, for instance, shows the number of workers in occupation k required to produce a unit output in industry l.

There are many simplifying assumptions made in the development and use of the this kind of model. First, the fundamental assumption of linearity or proportionality of inputs to outputs made in input-output analysis is not strictly correct, at least for large changes. An obvious example of this would be seen in the extraction of mineral resources. Doubling domestic coal or oil output would re-

quire a more than doubling of inputs because of the expected decline in quality or recoverability of coal or oil. Doubling automobile production, in contrast, might be accompanied by economies of scale in production, although larger capital investment would have to be made. In this model, capital inputs only enter through increases in final demand in the form of gross private domestic investment. Such large-scale changes can be expected to have disproportionate effects on input requirements and they may reflect either economies or diseconomies of scale in production. Fortunately, in a period of a few years, such large-scale changes are unusual. Over longer periods some of the problem can be dealt with by projecting changes in input coefficients.

A related problem arises for capacity utilization. If in the base year, there is excess capacity, output expansion may require less than proportionate inputs, but once capacity is reached, output cannot be expanded at all or may require more than proportionate inputs.

A second problem in input-output analysis arises from changes in input-output coefficients themselves. Coefficients are usually several years old when they are published and therefore reflect old technology. In some instances this can lead to errors in estimates of input requirements.

Many production technologies appear to be reasonably stable, so that proponents of input-output analysis usually argue that errors arising from instability or change of coefficients are not serious. BLS has attempted to project input-output coefficients to take account of expected changes in technology.

One of the major deficiencies in the input-output approach in which technical coefficients are derived from monetary transactions, as in the BLS example, arises in technological change. In the present application the principal problems arise in the production of energy and the use of energy in non-energy sectors in the economy. CAC has developed a number of input-output models in which energy flows are represented by physical units (Btu's). The use of physical units is particularly valuable when questions of changes in fuel mix (as in fuels for generation of electricity) or changes in process efficiency are considered. The basic BLS projection model has been modified by eliminating the BLS energy sectors entirely and replacing them with energy supply sectors consisting of all production technologies expected to be used in 1980 and 1985, and developing corresponding fictitious energy product industries, such as coke and other feedstocks, electric power, space heat, process heat and motive power. The energy product input coefficients to all other industries are essentially independent

of the fuels used to produce these energy products. The process efficiencies for producing the various energy products and the fuel mix are embodied in a single submatrix that can be readily adjusted to reflect different scenarios of other technological developments.

The composite model developed for this project consists of nine submatrices. Submatrix I is the energy supply matrix, consisting of inputs from energy supply industries to other energy supply industries. Submatrix II is energy supply to energy product industries, and embodies the assumed unit requirements of energy supplies (measured in Btu's) to produce a Btu of energy product. Submatrix III is energy supply to non-energy industries, and consists entirely of zeroes, since it is assumed that non-energy industries only use energy in the form of energy products. Submatrix IV is energy product industries to energy supply industries. Submatrix V is energy product to energy product industries. Submatrix VI is energy product to non-energy industries. Submatrix VII is non-energy industry to energy supply industry, and represents non-energy inputs required per Btu of energy supply. Submatrix VIII is non-energy industry to energy product industry and represents non-energy inputs to energy products. Submatrix IX is non-energy industry to non-energy industry, and represents

dollars of non-energy input required per dollar of non-energy output. This scheme and the source of the estimates is shown in figure 3.1.4.

	Output Industries		
Input Industries	Energy Supply	Energy Product	Non-Energy
Energy Supply	I. CAC	II. CAC	III. = 0
Energy Product	IV. CAC	V. CAC	VI. CAC
Non-Energy	VII. CAC	VIII. CAC	IX. BLS

Figure 3.1.4

Industry Classifications and Sources for CAC I-O Model

Another major problem in the use of the BLS model is the lack of an occupation-industry model. BLS has developed an estimated occupation-industry matrix for 1985, and this is used to develop a set of occupation-industry coefficients which when multiplied by estimated industry output provides an estimate of occupational employment in each industry. The coefficients are applied in essentially a linear and

proportional manner, so that a given increase in industrial output implies the same proportionate increase in employment in each of the occupations employed in the industry. It must be stressed that the occupational projections labeled "BLS-Data" that are included for purposes of comparison were not prepared by BLS and do not represent projections that BLS would have prepared. They are simply projections that would occur using the BLS input-output model, final demands, and occupation-industry matrix in the manner prescribed in the BLS publication, Tomorrow's Manpower Needs. It must be remembered that all of the projections in the present study are on a domestic production base, including the BLS-Data projections.

The occupation-industry coefficients developed for this study take account of the possibility of economies of scale and reflect employers' judgements of changes in occupational requirements from current levels.

3.1.4.1 - Conversion to Domestic Base

The CAC projection input-output matrices are derived from two sources. Rows and columns for the energy industries are aggregated from the CAC 372th order CAC energy ma-

trix (Amado, Foster, Pilati, 1975). Except for refined petroleum products, (BLS industry 42), the non-energy industries were taken from the BLS projection matrices, March 1976 revised version. Since refined petroleum is already accounted for in energy industry 7 in the CAC 372th order matrix, the corresponding aggregated row and column were taken from the CAC 372th order matrix instead of row and column 42 in the BLS matrix. Thus except for refined petroleum products, there is a direct correspondence between the nonenergy industries of the BLS 129th order matrix and the CAC 142th order matrix.

There are two discrepancies between the form of the CAC and BLS matrices. The first is that the energy industries are domestic based, while the BLS matrix is not. In others words, the BLS matrix assumes a fixed ratio between total output and imports for each industry. This problem is alleviated by transforming the BLS matrix into a domestic matrix. If A^{dom} is the resultant domestic base matrix and A is the original total output based matrix, then:

$$A^{dom} = AX(X^{dom})^{-1}$$

where

$$X(X^{dom})^{-1} = \text{diag}\left(\frac{x_1}{x_1^{dom}}, \frac{x_2}{x_2^{dom}}, \ldots, \frac{x_n}{x_n^{dom}}\right)$$

note that

$$\frac{x_i}{x_i^{dom}} = \frac{x_i}{x_i - m_i} = \frac{1}{I - a_{mj}}$$

where a_{mi} is the i^{th} element of the imports row of the A matrix. The total demand vector is defined to be the domestic total output vector, x^{dom} plus the imports vector m.

The other discrepancy is that the BLS matrix is in 1963 constant dollars while the CAC energy sectors are in Btu's and 1967 constant dollars. Thus before the nonenergy sectors of the BLS domestic matrix, A_{63}^{dom}, are transformed and overlayed on the energy matrix, they are inflated to 67 dollars by:

$$A_{67}^{dom} = D_{67}A^{dom}D_{67}^{-1}$$

where D_{67} is the diagonalization of the inflator vector for year 1967 in 1963 dollars. This vector was supplied by the Division of Economic Growth, Bureau of Labor Statistics.[6]

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[6] John Tschetter of the BLS Division of Economic Growth

A domestic-based matrix in 1967 dollars is calculated by combining these two steps such that,

$$x = (I - A)^{-1}f$$

$$= D_{67}^{-1}(I - A_{67}^{dom})^{-1}D_{67}(f - m) + m$$

where A is the original BLS matrix based in 1963 dollars, A_{67}^{dom} is the original BLS matrix transformed into a domestic base matrix, then inflated into 1967 dollars, f is the total final demand vector, and m is the imports vector.

3.1.4.2 - Energy Supply to Energy Product Sectors

Input-output coefficients are derived from historical data, and are usually badly out-of-date by the time they are published. It is understood that technology changes, and the BLS projects I-0 coefficients for future years. For non-energy industries, BLS projected coefficients are used exclusively, but the energy industry (coal, crude oil, refined petroleum, electric utilities, gas utilities) rows and

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was extremely helpful in furnishing the disaggregated deflators, and his assistance is gratefully acknowledged.

columns of the matrices have been modified not only in values, but conceptually as well.

Twelve energy supply industries were established:

1. Coal
2. Crude oil
3. Shale oil
4. Coal gasification
5. Solvent refined coal
6. Refined petroleum
7. Gas utilities
8. Coal combined cycle
9. Fossil electric
10. Light water reactor
11. High temperature gas reactor
12. Renewable electric

Eight energy product industries were established:

13. Coke feedstocks
14. Chemical feedstocks
15. Motive power
16. Process heat
17. Water heat
18. Space heat
19. Air conditioning
20. Electric power

All energy inputs are assumed to come from the twelve energy supply sectors, and to be converted into energy products that then form the only energy inputs to non-energy industries. All transformations in which energy supplies are converted into energy products are included in the 12 x 20 matrix. The system developed is compatible with the energy classifications in the Brookhaven National Laboratory's Reference Energy System[7]

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[7] U.S. Energy Research and Development Administration,

Two energy supply to energy product matrices are developed in this study: Free Imports and Technical Fix.[8] The Free Imports case for BNL includes 16.37 quadrillion Btu's of imported crude, and 2 quadrillion Btu of imported natural gas in 1985. The correspondence between the CAC matrices and BNL Reference Energy System scenarios are set out in detail elsewhere.[9] In the Technical Fix matrix, the Reference Energy System in ERDA-48 is used.[10] It is assumed there are no natural gas imports and 10.49 quadrillion Btu's of imported crude.

The Free Imports matrix assumes fuel mixes and process efficiencies that are compatible with increased usage of petroleum and natural gas. There is a substantial input of LWR to electric power (.279 Btu input per Btu output), some-

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op. cit.

[8] The Technical Fix matrix is used both for the Limited Imports and the Synthetics scenarios. The differences in the Limited Imports and Synthetics scenarios are a very small amount of shale oil, coal liquifaction, and coal gasification. The differences resulting from use of the Technical Fix matrix for the synthetics case are trivial in terms of CTP employment.

[9] D. Pilati, Energy Demand Model Refinements for 1985 Supply Mix, Technical Memorandum No. 70, Center for Advanced Computation, University of Illinois, Urbana-Champaign, February 1976.

[10] U.S. ERDA, op. cit., fig. B-3.

what lower than in the Technical Fix matrix (.321 Btu input per Btu output). There are continued heavy inputs of refined petroleum to fossil electric (.76 Btu input per Btu output) and of natural gas to fossil electric (.64 Btu input per Btu output). Other input patterns are rather conservative: there is no shale oil, coal gasification, solvent refined coal, coal combined cycle, or high temperature gas reactor inputs to any energy product.

In contrast, the Technical Fix matrix has much lower inputs of refined petroleum to fossil electric (46 Btu input per Btu output) and of natural gas to fossil electric (.49 Btu input per Btu output). These coefficients are quite large, however, and indicate a belief that these will continue to be important fuels in 1985 for electric power. This appears to be rather unavoidable, and is in sharp contrast to BLS's large reductions of gas inputs to electric power production. The rather special role of natural gas as fuel for gas turbine peaking power units is projected to continue. Combined with an enhanced role for gas in space heat and process heat these gas inputs to electric power account for the substantially higher demands for gas utilities in the CAC projections than are found in the BLS projections.

3.1.4.3 - Energy Products to Non-Energy Industries

The 8 x 122 submatrix of energy product to non-energy industry input output coefficients differs between the Free Imports and Limited Imports matrices. The coefficients correspond to the reduction in energy requirements per unit of output described in the Energy Policy Project's "Technical Fix" scenario.[11] The major kind of change embodied in this submatrix reflects assumed higher energy prices and heightened awareness of the need to conserve energy. It is represented by a reduction in the input coefficients from energy products to non-energy industries.

In contrast, the Free Imports submatrix reflects a return to energy input coefficients as they were in 1967, long before energy prices began their recent large increases. These submatrices are described in more detail elsewhere.[12]

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11 Energy Policy Project, A Time to Choose: America's Energy Future, Ballinger PRess, Cambridge, Mass., 1974.

12 D. Amado, C. Foster, D.A. Pilati, Two Input-Output Models for Labor Impact Analysis, Technical Memorandum No. 69, Center for Advanced Computation, University of Illinois, Urbana-Champaign, January 1975.

3.1.5 - STP Coefficients

The STP coefficients used to estimate STP employment from total output under the three combinations of final demand and input-output technologies are derived from two sources: (1) the Projection Survey of Energy-Related Employment conducted as part of this study, and (2) The BLS estimated occupation-industry matrix for 1985.

3.1.5.1 - Estimation of STP Coefficients

Occupation-industry coefficients were developed from the BLS 1985 occupation-industry matrix by dividing each of the industry occupational employment estimates by the domestic-base estimated total outputs for the various industries for the 9-dollar oil final demand and matrix.

The occupation-industry matrix approach to projecting employment involves projecting industry employment (by a technique such as input-output or regression) and then distributing projected industry employment by occupation according to the proportions observed in recent years or projected to occur. BLS estimated occupational employment by industry for 1985 and 1974. Occupation-industry coefficients were estimated for 1975 for energy-related industries that

were surveyed by using BLS 1974 estimated occupational employment in these industries and 1975 estimated total output. This is a straightforward technique that is used by the National Planning Association and Bechtel Corporation in their energy supply model. These coefficients can be expected to change in the future as a result of interoccupational substitution, improved labor productivity, and technical change. To estimate the changes, responses from employers in energy-related industries were analyzed. Respondents were asked what they expected their detailed STP requirements to be in 1980 and 1985 under three alternative assumptions about output levels. The percentage changes in requirements expected from 1975 to 1980 and to 1985 were calculated, weighting by the level of sales to derive a percentage change in the estimated occupation-industry coefficient. In many industries the coefficient estimate from the sample differed substantially from the 1975 coefficient estimated from BLS data, so that the use of the survey coefficients would have made the projection non-comparable to the base figure. To correct for possible sample bias, the 1975 coefficients estimated from BLS data were multiplied by the percentage change in the occupation-industry coefficient developed by the survey, so that the change in coefficient is estimated, rather than the coefficient itself. For each occupation in each industry there are three coefficients for 1980 and three for 1985 representing different levels of ex-

pansion of output. Once total output for 1980 or 1985 is estimated for the industry, the percentage change in output from 1975 to 1980 is estimated, and the occupational coefficient is computed by interpolation. If an industry was projected to have a 75 per cent increase in output from 1975 to 1985, for instance, the occupational coefficient was estimated by interpolation between the coefficient for that occupation and industry for a 50 per cent increase in output and a 100 per cent increase in output.

Evidence of economies of scale in use of STP were observed in some industries. The approach followed allows these expectations to be embodied in the projections.

For those industries that were not surveyed, or for which survey results were unusable, 1985 coefficients derived from the BLS occupation-industry matrix for 1985 were used. The total industry outputs were projected using medium priced oil final demand and the associated BLS input-output matrix. Thus it is assumed that the non-survey coefficients are linear and proportional.

The assumption that occupation-industry coefficients can be projected is fundamental to the analysis. This assumption is questioned by many analysts. In particular, those who believe that substantial substitution among occu-

pations is possible and will occur in the event of shortages or significant salary differentials do not accept the validity of fixed coefficients. The survey results showed substantial variance in current coefficients for firms. There was a noticeable tendency for these to be related to the size of the firm. The highest establishment coefficients were usually observed in the smallest sales class in an industry, and the lowest coefficients were usually observed in the largest sales class of establishments in an industry.

3.1.5.2 - The Variability of STP Coefficients

There is no direct method of testing the reliability of industry manpower coefficients when these coefficients are obtained at a single time. Some of the surveyed "experts" clearly indicated that they believed significant economies of scale were available in the use of STP by their answers to the survey questions about conditional manpower needs at different levels of output. These answers formed the basis for the revision of BLS-data coefficients. However, even if these experts were perfect in their judgements about the future manpower needs in their firms, the calculation of industry manpower coefficients would not be straightforward. This calculation depends crucially on assumptions about how future demand increases will be distributed across firms in the industry. For example, if industry output increases by

100 per cent, this output increase could occur through small firms increasing their outputs while large firms produce about the same. These small firms might be able to reap significant economies of scale as a result. On the other hand, this output increase could also result from an increase in the number of firms. In the former case, a significant decline in the industry manpower coefficient would be expected; in the latter case there might be little decline.

Calculated changes in manpower coefficients through time and at different output levels were based on the simplifying assumption that future output changes would occur proportionally for all firms. That is, if industry output increases by 20 per cent, then the output of small and large firms both increase by 20 per cent. Among the possible choices of distributions, this appeared to be the most reasonable.

To investigate the impact of any distribution assumption, it is necessary to analyze the variability of STP coefficients within industries. If there is little variability, the distribution question is moot. If there is substantial variability, it is important to determine whether

this variability occurs across size classes of firms (indicating economies of scale) or within size classes as well (indicating significant substitution possibilities at the same output level).

The variability of STP coefficients within industries was examined by aggregating the data for the 39 detailed occupational classifications into the classes of engineers, scientists, and technicians (architects were excluded). Coefficients for each establishment were calculated for each occupational class on a full time equivalent (FTE) per thousand dollar basis. Coefficients for each of the twenty-six BLS sectors surveyed were calculated and the distributions plotted and examined visually to note patterns in variability. Data were plotted on the basis of labor intensity per establishment versus total sales in 1975. Since occupational inventories were obtained in both the current situation and future requirements surveys, these responses were combined to increase the sample size. The ratio of the industry-wide coefficients in the requirements survey were plotted against the same data for the current survey as a check on the calculations as well as to establish that the two surveys were indeed drawn from the same sample and no significant biases exist. For all three occupational classes, the slope of the line is close to one, indicating that both surveys arrived at approximatel· the same industry

coefficients. The only significant deviations from the lines occurred in industries where the sample size was very small. In order to minimize this problem, further analysis on the establishment coefficients was conducted only on the five industries with the largest response frequencies. This group includes crude petroleum, new highway construction, petroleum refining, electric utilities and miscellaneous professional services.

Examination of the distribution of individual firm coefficients for these five industries in each of the occupational groups yielded similar results. In general there is significant variation among the coefficients. In all cases the standard deviations of the coefficients are larger than means. The greatest variation is within the establishments doing the smallest dollar volume. In each case, the highest labor intensity is found within this group. At the same time, the largest firms contain only low labor intensive establishments. This confirms the hypothesis that there are economies of scale with respect to use of scientific and technical personnel. This also suggests that the use of an industry labor coefficient for a particular job class will be accurate at different levels of output, but only so long as the sample that the coefficient was derived from approximates the sales distribution of the industry universe. If a change in output requires a significant

change in the proportion of output produced by a particular size class of establishments, a significant change in the labor intensity of the industry as a whole may result. This will be likely if the output distribution is shifted to either the extremely large or extremely small end of the distribution.

Given the larger variance among the coefficients for small size firms than large size firms and the lack of any data on capital, any attempt to quantify the relationship between output levels and labor requirements at the establishment level appears fruitless in this study. However, the correlations between the three classes of labor have been investigated. In new highway construction, electric utilities, and miscellaneous professional services these correlations were weak. In crude petroleum and petroleum refining, however, the simple correlations between the number of engineers, scientists, and technicians per dollar of output ranged from .97 to .99.

This indicates that those establishments that utilize scientific and technical personnel are likely to use all of them in rather large numbers and those which use no STP in a given classification are likely to not use any STP at all. This is probably due to the fact that research and development units are included in the industry as well as estab-

lishments that are primarily production operations. This is a definitional problem caused by the aggregated level of analysis represented by the BLS industry groups and may be a significant source of error if changes in total demand are not in proportion to the mix of R & D and production activities in the current economy.

3.1.5.3 - Implications for STP Projections

The high variability of establishment coefficients must cause serious concern for those who would use occupation-industry coefficients for projecting STP requirements. This is particularly important in projecting, because it is possible that the low coefficient firms might grow rapidly and the high coefficient firms slowly and that the industry coefficient would as a result decline. The reverse could happen as well, so that the size of the future industry occupational coefficient depends on the composition of the industry as well as its level of output. If it turns out, on further examination, that the high variance of establishment occupational coefficients cannot be explained by inappropriate aggregation of firms into industries, differences in locus of STP activities in headquarters and establishments, or other rational practices, then the rationale for occupational projections would be seriously weakened. What this means, of course, is that if the occupational employment

pattern of an employer is arbitrary or judgemental, and is not dictated by technology and product, it is impossible to predict with any confidence what future employment will be even if the level of output of the firm can be projected.

It is hoped that disaggregation of major industries into R&D and non-R&D subindustries will reduce within establishment variation in STP coefficients. During a future phase of analysis, the data will be reprocessed so that R&D and non-R&D quasi-establishments will be defined for major industries. It seems reasonable to expect that much of the variance of STP coefficients among establishments in a single industry will be associated with variance in the degree of R&D activity within the establishment. If so, then the disaggregation of the model into R&D and non-R&D constituent subindustries should reduce within-industry coefficient variance, and improve the credibility, if not the reliability, of the coefficients.

3.2 - Energy Scenarios and Technology

The three energy scenarios, Free Imports, Limited Imports, and Synthetics imply different final demand patterns and technology. In the Free Imports case, the BLS low-priced oil final demand pattern and the Free Imports tech-

nology matrix are used. This matrix reflects 1967 energy efficiency. In the Limited Imports case, the BLS medium priced oil final demand and the Technical Fix input-output matrix are used. This matrix involves substantial improvements in energy utilization technology and reflects the fuel mixes and process efficiencies implied in the ERDA scenarios. Finally, the BLS high-priced oil final demand vector and the Technical Fix matrix are used in preparing the Synthetics scenario projections.

3.3 - Energy-Related Activities

The model takes into account many of the sources of energy-induced economic change. Final demand estimates are based on three different oil prices. Input-output coefficients reflect both changing fuel mixes and process efficiencies in energy production and use. Occupation-industry coefficients reflect both employer expectations and changing levels of production. Energy construction reflects varying energy supply level and composition under the three scenarios.

The model, however, does not explicitly represent the R&D expenditure and STP requirements to attain the Technical Fix technologies in the energy consuming industries. It is

doubtful that the degree of reduction in energy consumption per unit of output implied by the Technical Fix matrix could be attained without increases in R&D activity and employment in the consuming industries, and such an increase is not necessarily included in the occupation-industry coefficients implied by the 1985 BLS estimates of occupational employment by industry.

The industries identified as energy-related in the surveys are those involved directly in energy construction and production, and those that provide important inputs to these industries. Far more industries are energy-related in some degree. In the projections of energy-related STP employment, only the employment that arises from energy construction and production is desired, and not industry totals. Total employment from the direct and indirect energy industries used in the surveys are not used as energy-related employment. Rather employment is projected by using four groups of activities:

I. Direct Energy Construction ("Direct Construction")

II. Intermediate Demand due To Energy Construction ("Indirect Construction")

III. Total Energy Demand ("Direct Energy")

IV. Intermediate Demand due to Final Demand for Energy ("Indirect Energy")

Employment in Direct Energy Construction (or "Direct Construction") is obtained from the Bechtel Energy Supply Planning Model that specifies a construction program to provide future fuel supplies.

Employment arising from materials demand, or "Indirect Construction," is derived from the material inputs specified in the Bechtel Model processed to provide a vector of final demands that is in turn multiplied by the I-O inverse matrix to produce an estimate of total production that is multiplied, in turn, by the occupation-industry coefficients.

The total energy demand (or "Direct Energy") is all employment in the energy industries, except for that generated by the materials requirements for energy construction and is the total demand for the energy industries induced by all GNP except for materials requirements for energy construction mentioned above. Multiplying the energy industries' employment coefficients by the respective total energy demand yields total employment in the energy industries arising from this modified GNP final demand vector.

Intermediate employment requirements due to final demand for energy (or "Indirect Energy") is estimated by multiplying the final demand of the energy industries by the

Leontief inverse to obtain total demand, though the total demands in the energy industries are zeroed since they have already been counted in the preceeding case. Employment is determined by multiplying the total demand vector by the occupation-industry coefficients.

Total energy-related employment is the sum of the four categories of energy-related employment for each STP occupation. This is then compared to total STP employment estimated for the entire economy to produce the percentages of total employment by STP occupation. If the employment generated in other industries due to nonenergy GNP final demand minus energy investment is added to the sum of energy related employment above, the total is equal to total employment. Thus the five classes do not overlap and the classification is complete.[13]

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[13] Clark Bullard and Doug Gilmore developed this scheme and proved its completeness.

Chapter 4

Projection of STP Requirements

4.1 - On Comparing Projections

The CAC projection technique for determining STP requirements in 1980 and 1985 has been described in Chapter 3. This chapter presents the results of these projections as well as BLS data base projections for 1980 and 1985.

The assumptions of the BLS data base projections correspond approximately to the CAC Limited Imports Scenario (henceforth CAC LIS).[1] The aggregate domestic final demand in the CAC LIS and the BLS data base projections are identical. Final demands are also identical when they are classified into the 129 sectors used in the input-output matrix.

There are two major sources of difference between the CAC and BLS data base projections:

1) Differences in manpower coefficients for individual industries and occupations, and

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[1] The BLS data base manpower coefficients are those implied by using the final demand vector and BLS employment projections. The CAC manpower coefficients were calculated using the results of the CAC forecast survey to adjust the BLS implied coefficients.

2) Differences in total demand necessary to achieve this final product mix.

Table 4.1a gives a summary of the sectors which exhibit the largest differences between the BLS data base projections and the CAC LIS scenario projections. Total aggregate demand is 1.6 per cent lower in both 1980 and 1985 under the CAC projections than the BLS data base projections. As would be expected, the sectors which account for this difference are largely "intermediate." The major discrepancies occur in petroleum products, utilities and government sectors. The differences in utilities and government in the two forecasts are in part definitional. The CAC model lumps government generation of energy into the energy sectors. Thus, total demand in the government enterprise sector should be lower in the CAC projections. This also indicates that the discrepancy between the CAC and BLS data base projections for electric utility total demand is even greater than is indicated in Table 4.1a. A significant portion of this difference is explained by the much heavier reliance on natural gas in the CAC projections. The total demand for natural gas is 20 per cent higher in 1980 and 34.6 per cent higher in 1985 than the BLS-data projections.

TABLE 4.1a: Limited Import CAC Domestic Total Demand Versus BLS Domestic Total Demand (in thousands of dollars)

	1980 Diff	%Diff (BLS base)	1985 Diff	%Diff (BLS base)
Coal mining	- 843	-18.5	- 349	- 7.4
Crude Petroleum	+ 1098	+ 7.9	+ 915	+ 5.9
Agri chem	+ 1108	+29.6	+ 1440	+34.9
Petrol. products	-10031	-26.9	-11652	-27.6
Water Transportation	+ 343	+ 6.8	+ 632	+12.8
Other Transportation	- 1254	-38.4	- 1425	-36.6
Electric Utilities	-10926	-27.5	-15364	-28.6
Gas Utilities	+ 3304	+20.0	+ 6046	+34.6
Misc. Business	- 1527	- 4.4	- 2054	- 4.8
Other Fed	- 1192	-29.9	- 1612	-34.4
State and Local	- 4083	-29.5	- 5563	-33.5
Total (all industries)	-33692	- 1.6	-39687	- 1.6

Table 4.1b provides a comparison of total demand by sector under each of the three CAC scenarios for those sectors which exhibit the largest differences. Total aggregate demand is higher under the Free Imports scenario (1.4 per cent in 1980 and 1.5 per cent in 1985) than the Limited Imports scenario; it is approximately the same under the Synthetic and Limited Imports scenarios. The impact of altering the scenario is basically the same for both 1980 and 1985. Total demands for crude petroleum, petroleum products, motor vehicles and utilities are increased substantially under the Free Imports scenario. Since total demand increases in all three major energy sectors (petroleum, electricity and natural gas), this projection indicates a much more energy-intensive technology than would exist under the Limited Imports scenario.

The effect of an increase in the price of oil (the Synthetics scenario) is in the opposite direction. The total demand for petroleum products, motor vehicles and electricity falls. However, this impact is not perfectly symmetrical to a price decrease (the Free Imports scenario). The demands for crude petroleum and natural gas either increase or at least remain the same.

TABLE 4.1b: Limited Import CAC Domestic Total Demand Versus Free Import and Synthetic Domestic Total Demand Scenarios (in thousands of dollars)

	1980 Free Import Diff	%	Synthetic Diff	%	1985 Free Import Diff	%	Synthetic Diff	%
Crude Petroleum	+ 4077	+27.1	+ 758	+5.0	4691	+28.8	+1677	+10.3
Maintenance Const.	+ 781	+ 3.2	+ 321	+1.3	+ 846	+ 3.2	+ 409	+ 1.6
Cleaning Preparations	+ 581	+ 4.9	- 559	-4.8	+ 697	+ 4.9	- 665	- 4.7
Petroleum Products	+11062	+40.6	-1416	-5.2	+15125	+49.4	- 975	- 3.2
Construction Machinery	- 307	- 3.0	+ 235	+2.3	- 511	- 4.2	+ 407	+ 3.3
Motor Vehicles	+ 4377	+ 5.6	-5194	-6.7	+ 4922	+ 5.9	-5591	- 6.7
RR & Misc Vehicles	- 309	- 7.1	+ 271	+6.2	- 357	- 6.5	+ 413	+ 7.5
Electric Utilities	+ 5253	+18.2	-2284	-7.9	+ 6539	+17.0	-3790	- 9.9
Gas Utilities	+ 3211	+16.2	+ 358	+1.8	+ 3603	+15.3	21	0.0
Total(all industries)	+29239	+ 1.4	-5283	-0.3	+37640	+ 1.5	-3675	- 0.1

In each of the sections which follow, projections are given for both BLS-base data and CAC alternative scenarios. To reiterate, these projections will differ for three reasons: different scenarios, different input-output coefficients for the same final demand scenario, and different manpower coefficients. In each case an attempt is made to present the projections so that it is possible to differentiate the basic reasons for the different projections. Thus projections are made with BLS coefficients and BLS demand patterns; CAC coefficients and CAC demand patterns; and, BLS coefficients with CAC demand patterns. The latter two projections are projected on a scenario basis.

Total STP employment, energy and construction employment, employment for materials for energy production, employment for energy production, employment for inputs to energy production, total energy-related employment, and energy-related STP employment as a percentage of total STP employment are discussed in separate sections below.

4.2 - Projections of Total Private STP Requirements

Sections 4.2 to 4.8 of this report examine the CAC scientific and technical manpower projections. Alternative concepts of energy-related employment are used. First, STP projections are presented for 1980 and 1985 by what is denoted as "energy and related industry" employment or ERI.

With this concept, STP employment in industries which are closely related to energy-producing industries, in an inter-industry transactions sense as important suppliers to the energy industries, are included with STP manpower directly employed in energy-producing industries. This concept does not measure the number of STP workers directly and indirectly related to energy production. Instead, it measures employment in those sectors of the economy which have been identified as important for energy production.

For measurement of direct and indirect STP manpower which is energy-related a partition of the input-output matrix has been developed to provide estimates of various components: (1) construction of energy facilities; (2) materials for energy facility construction; (3) total energy demand; (4) interindustry transactions to energy producing industries; and (5) balance of the economy. The sum of (1) through (4) is called energy-related employment (ERE). The manpower projections for each of these categories are presented in sections 4.3 to 4.8. Section 4.9 provides STP projections classified by major industry groups and section 4.10 presents a comparison with the findings of other studies.

Before examining the projections of economy-wide STP requirements, a brief comment on the scope of the definition

of energy activities is in order. The energy activities which are addressed are energy <u>production</u> activities, both direct and indirect. Direct requirements are generated by construction of energy facilities and operations and maintenance of those facilities. Indirect requirements are generated through supply of material inputs from non-energy producing industries to construction and operations and maintenance. Outside the scope of this definitional framework are energy conservation and environmental activities. Thus engineers and scientists working in the automotive industry to develop a more efficient carburetor are not defined to be within the scope of this study. A recent survey of scientists and technical personnel (S-280) by the U.S. Bureau of the Census used this more inclusive concept of energy activities. It is not surprising that their survey found a significant portion (14 per cent) of the STP workforce to be engaged in energy activities.

Also excluded from the projections are the STP workers directly employed by government, except for those STP working in government enterprises enaggaged in the production of energy which are treated as part of the corresponding utilities industries in the CAC model, rather than as part of government enterprises as they are in the BLS model. Only private sector STP employment is projected. Furthermore, the analysis excludes social scientists from the projections since the occupations of this group are not represented in

the sample industries in significant numbers. Thus, if the CAC projections are to be compared to other studies, it is necessary to subtract government employed STP and the social science categories of economists, psychologists and other social scientists from the other studies. Medical scientists, practitioners, and health technologists are also excluded. Science and engineering teachers are treated both by BLS and CAC in the corresponding teaching professions and are not included in the STP concept used here. The following STP categories are included in the sample domain:

A. Engineers: Chemical, Civil, Electrical, Industrial, Metallurgical, Mechanical, Aero-Astronautical, Mining, Petroleum, and Other;

B. Scientists: Chemists, Physicists and Astronomers, Geologists, Agricultural, Biological, Marine, and Life and Physical, n.e.c.;

C. Math Specialists: Mathematicians, Statisticians, and Computer Specialists (includes Programmers);

D. Technicians: Agricultural and Biological except health, Chemical, Industrial, Mechanical, Engineering and Science, n.e.c., Draftsmen and Surveyors.

Tables 4.2.1 and 4.2.2 show economy-wide projections of STP manpower for 198Ø and 1985 by import scenario. BLS data base projections are also given. The latter result from straightforward use of BLS manpower coefficients, inverse-matrix, and final demand sectors.

The tables are subdivided into energy and non-energy related sectors. Subtotals are provided for four aggregated categories of STP employment. The tables show STP projections for 198Ø of approximately 2.8 million; for 1985 3.2 million. The striking feature of the projection results is how little variance there is between scenarios. The ordering of the projections by scenarios is also counterintuitive. The Synthetics scenario yields the lowest projection of total 198Ø STP requirements, for the sample occupations, 2.77 million; Free Imports, the highest 2.8Ø million. Thus, only 34 thousand workers separates the high-low scenario estimates. The 1985 scenario projections are even closer; only a 21 thousand difference between Free Imports and Synthetics. Since the construction STP manpower requirements are higher for the Synthetics scenario, the lower levels of energy production associated with the higher oil price scenarios produces an disemployment effect that exceeds the higher construction manpower requirements. For 1985 the Synthetics scenario require 112 thousand STP personnel for construction of energy facilities, according to the Bechtel estimates; 97 thousand for the Free Imports scenario. Ener-

gy use is, however, 14 per cent higher under the Free Imports scenario (99.1 vs 86.9 quadrillion Btu's). The number of operations and maintenance STP personnel is substantially reduced under lower levels of energy production.

For 1980 scenario results are somewhat lower than those obtained with the BLS data base projections. The lowest scenario projection is only 1.4 per cent less than the projection results obtained from the BLS data base.

For 1985, CAC scenario projections yield higher levels of STP employment. But again the margin is small; less than 1 per cent. The significant difference between the BLS data base results and CAC's lies in the "mix" of employment between and within the two industry divisions. CAC coefficients yield higher intensities of engineering employment in energy and related industries. Proportional utilization of math specialists and technicians is lower whereas the scientists proportion is approximately equal to the BLS data base value. Projected scenario employment is 50 to 61 thousand (36 to 49 for 1980) lower for non-energy related industries. Thus, the CAC manpower coefficients yield greater STP intensity in energy and related industries and, within those industries, a higher intensity of engineering employment. A similar pattern of higher STP intensity for energy-related industries is found in both the 1980 and 1985 projections.

Table 4.2.1

1980 Employment Projection
of
Scientific and Technical Personnel
(In Thousands)
Energy-Related Industry Employment
(ERI)

	Import Scenario			BLS Data Base Projection[2]
	Free Imports	Limited Imports	Synthetics	
Total STP Employment	2,798.7	2,768.4	2,764.7	2,803.7
Energy-Related Industries[1]	1,051.3	1,027.4	1,030.2	1,019.8
Engineers	532.6	523.0	524.8	488.4
Scientists	63.6	59.1	59.5	62.4
Math Specialists	65.1	63.2	63.1	73.8
Technicians	390.0	382.1	382.8	395.2
Other Industries	1,747.4	1,741.0	1,734.5	1,783.9
Engineers	718.9	715.1	710.5	732.5
Scientists	139.6	139.9	140.3	141.0
Math Specialists	293.3	292.3	292.5	302.6
Technicians	595.6	593.7	591.2	607.8

1 Includes Bechtel STP requirements for Construction of Energy Facilities.

2 Includes Bechtel STP requirements from the Limited Imports Scenario.

Table 4.2.2

1985 Employment Projection
of
Scientific and Technical Personnel
(In Thousands)
Energy-Related Industry Employment
(ERI)

	Import Scenario			BLS Data Base Projection[2]
	Free Imports	Limited Imports	Synthetics	
Total STP Employment	3,202.0	3,182.9	3,181.5	3,179.8
Energy-Related Industries[1]	1,239.3	1,228.0	1,230.9	1,168.0
Engineers	618.6	616.9	618.1	541.3
Scientists	71.3	66.7	67.5	66.0
Math Specialists	77.4	75.5	75.4	84.7
Technicians	472.0	468.9	469.9	476.0
Other Industries	1,962.7	1,954.9	1,958.6	2,011.8
Engineers	781.5	777.1	773.2	799.7
Scientists	153.8	154.4	155.1	155.9
Math Specialists	350.0	348.5	349.3	362.9
Technicians	677.4	674.9	673.0	693.3

1 Includes Bechtel STP requirements for Construction of Energy Facilities.

2 Includes Bechtel STP requirements from the Limited Imports Scenario.

4.3 - Projections of Energy Construction Requirements

This discussion of direct energy construction requirements begins the presentation of the partition results. Energy-related employment projections are partitioned into four groups: direct construction, indirect construction, direct production of energy, and indirect energy production. The direct construction STP requirements are provided by Bechtel (Tables 4.3a,b, and c).

For 1980, Bechtel predicts slight variation in manpower requirements. Construction requirements for the Limited Imports scenario will utilize 83.7 thousand STP workers versus 89.3 thousand for the Synthetics scenario. No scientists or mathematical specialists are required in Bechtel's view and all of the requirements for technicians are for the single category of draftsmen. Engineers account for about 70 per cent of the STP requirements for this partition component. Civil, electrical, and mechanical engineers represent the dominant engineering categories.

For 1985, Bechtel projects substantial increases in STP requirements: 96.8 thousand for Free Imports; 111.5 thousand for Synthetics. There is also wider variation in requirements across scenarios (15 per cent vs 7 per cent for 1980). Again, engineers represent about 70 per cent of total STP requirements for this partition component.

Table 4.3a

Direct Employment, by Occupation, for Construction of a Bechtel Model -- Free Import Scenario in 1,000 Man-Years

Occupation	1980	1985
Chemical Engineers	0.8	1.1
Civil Engineers	18.2	21.6
Electrical Engineers	20.7	24.3
Mechanical Engineers	11.4	13.5
Mining Engineers	0.1	0.2
Nuclear Engineers	0.8	1.0
Geological Engineers	3.6	2.9
Petroleum Engineers	3.3	2.7
Other Engineers	0.7	0.8
Designers and Draftsmen	24.6	28.7
Supervisors, Managers, Foremen	12.7	13.9

Table 4.3b

Direct Employment, by Occupation, for Construction of a Bechtel Model -- Limited Imports in 1,000 Man-Years

Occupation	1980	1985
Chemical Engineers	0.7	1.0
Civil Engineers	18.6	25.0
Electrical Engineers	20.0	28.3
Mechanical Engineers	11.6	14.4
Mining Engineers	0.1	0.2
Nuclear Engineers	1.0	1.2
Geological Engineers	3.6	3.0
Petroleum Engineers	3.3	2.6
Other Engineers	0.7	0.6
Designers and Draftsmen	24.1	31.4
Supervisors, Managers, Foremen	12.6	13.7

Table 4.3c

Direct Employment, by Occupation, for Construction of a Bechtel Model -- Synthetics in 1,000 Man-Years

Occupation	1980	1985
Chemical Engineers	1.3	1.3
Civil Engineers	19.6	25.8
Electrical Engineers	20.8	28.9
Mechanical Engineers	12.5	15.0
Mining Engineers	0.2	0.3
Nuclear Engineers	1.0	1.2
Geological Engineers	3.4	2.8
Petroleum Engineers	3.1	2.4
Other Engineers	1.0	0.9
Designers and Draftsmen	26.4	32.9
Supervisors, Managers, Foremen	12.8	14.2

4.4 - Projections of Employment for Energy Construction Materials

Units of STP manpower, as well as other types of labor inputs, are indirectly embodied in the materials used for construction of energy facilities. Multiplying the Leontief-inverse matrix by the vector of industry inputs of energy construction materials provides a basis for partitioning this element of indirect labor input. For this projection the materials requirements specified by Bechtel were used. Tables 4.4.1 and 4.4.2 list the 1980 and 1985 projections for 29 categories of STP manpower.

Six projection values for each occupation and each projection year result from application of the three scenarios and two manpower coefficient matrices (CAC and BLS Data-Base coefficients). Table 4.4.1 shows that a sizeable number of scientific and technical personnel are indirectly involved in construction of energy facilities: 57 - 61 thousand using the CAC manpower coefficient base. Interestingly, in comparison to the Limited Imports scenario, larger STP requirements are projected under the Free Imports scenario. This testifies to the large capital requirements for petroleum storage and refining under the Free Imports scenario. The Synthetics scenario, however, requires the largest inputs of STP manpower, 61 thousand; yet, this represents only about 2.3 per cent of projected total STP employment for 1980.

Table 4.4.1

Comparative Scenario Employment Projections
Materials for Energy Facility Construction
1980

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	860	825	618	773	846	799
2 engineers, civil	1464	1210	1436	1175	1531	1235
3 engineers, electrical	6821	6262	6613	6039	6697	6315
4 engineers, industrial	7412	4733	7362	4665	7952	4913
5 engineers, metallurgical	1043	902	1026	866	1091	931
6 engineers, mechanical	5619	5432	5866	5461	6136	5691
7 engineers, aero-astronautic	634	618	634	618	652	636
8 engineers, mining	216	215	205	202	213	210
9 engineers, petroleum	231	293	190	222	193	227
10 engineers, other	4815	3795	4632	3753	5132	3952
11 chemists	2288	2077	2220	1996	2311	2076
12 physicists and astronomers	324	315	319	308	333	323
13 geologists	487	577	408	468	421	482
14 agricultural scientists	32	31	31	31	33	32
15 biological scientists	60	57	58	55	60	58
16 medical workers, exc tech	89	90	67	87	90	90
17 mathematicians	239	226	234	221	245	231
18 statisticians	4767	4614	4761	4566	4934	4723
19 computer specialists	15	13	14	12	14	12
20 marine scientists	33	32	32	31	35	34
21 life, physical scientists nec	107	109	105	106	109	111
22 agri, biolog tech exc health	1227	1250	1164	1165	1203	1263
23 chemical tech	3437	3534	3356	3422	3517	3574
24 electrical, electronic tech	800	688	791	679	829	712
25 industrial engineering tech	757	421	770	418	816	436
26 mechanical engineering tech	13	13	13	13	13	13
27 health technol and tech	561	769	533	732	552	756
28 mathematical tech	8920	8773	8869	8717	9488	9339
29 surveyors	4874	4494	4802	4381	5098	4666
Totals	58365	52366	57447	51087	60736	53722

FI: Free Imports Scenario; CAC Coefficient Base.
FI*: Free Imports Scenario; BLS Coefficient Base.
LI: Limited Imports Scenario; CAC Coefficient Base.
LI*: Limited Imports Scenario; BLS Coefficient Base.
SY: Synthetics Scenario; CAC Coefficient Base.
SY*: Synthetics Scenario; BLS Coefficient Base.

Table 4.4.2

Comparative Scenario Employment Projections
Materials for Energy Facility Construction
1985

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	866	784	853	758	861	766
2 engineers, civil	1565	1073	1561	1056	1594	1070
3 engineers, electrical	6935	6255	7285	6526	7397	6623
4 engineers, industrial	6531	4533	6758	4768	6934	4793
5 engineers, metallurgical	1107	845	1152	882	1175	898
6 engineers, mechanical	5917	5211	6036	5308	6163	5407
7 engineers, aero-astronautic	581	546	590	554	596	559
8 engineers, mining	217	221	218	222	222	226
9 engineers, petroleum	220	314	190	237	183	238
10 engineers, other	4763	3481	4886	3557	4997	3620
11 chemists	2297	1947	2322	1956	2358	1982
12 physicists and astronomers	352	322	364	331	369	337
13 geologists	476	583	426	485	422	466
14 agricultural scientists	28	26	28	27	28	27
15 biological scientists	60	54	61	54	62	55
16 medical workers, exc tech	93	90	94	90	95	91
17 mathematicians	239	227	242	230	246	234
18 statisticians	5023	4773	5118	4638	5208	4912
19 computer specialists	15	11	15	10	15	10
20 marine scientists	35	33	36	34	37	35
21 life, physical scientists nec	110	112	109	112	111	114
22 agri, biolog tech exc health	1219	1223	1200	1174	1208	1165
23 chemical tech	3599	3632	3751	3640	3810	3894
24 electrical, electronic tech	853	707	875	730	888	742
25 industrial engineering tech	691	416	711	427	720	434
26 mechanical engineering tech	13	13	14	13	14	13
27 health technol and tech	548	747	527	717	531	720
28 mathematical tech	9645	8871	9897	9100	10124	9318
29 surveyors	5152	4542	5297	4623	5416	4704
Totals	59152	51593	60618	52601	61763	53493

FI: Free Imports Scenario; CAC Coefficient base.
FI*: Free Imports Scenario; BLS Coefficient base.
LI: Limited Imports Scenario; CAC Coefficient base.
LI*: Limited Imports Scenario; BLS Coefficient base.
SY: Synthetics Scenario; CAC Coefficient base.
SY*: Synthetics Scenario; BLS Coefficient base.

It is worth noting that indirect construction requirements are large in relation to direct construction requirements. For example, CAC coefficients for the Free Imports scenario yield indirect requirements equal to 41 per cent of the total (direct and indirect) 1980 STP construction requirements. Thus, neglect of indirect requirements can lead to a substantial understatement of manpower requirements.

BLS-Data Base coefficients lead to lower projected values of indirect STP construction requirements of about 6 to 7 thousand STP per scenario. This difference is caused solely by differences in employment-per-dollar estimates. Among the individual occupations, the largest differences occur among engineering and technician categories, principally electrical, industrial and mechanical engineers, engineers, other, draftsmen, and engineering and science technicians, n.e.c.

Projections for 1985 STP indirect construction requirements are only slightly higher than the 1980 estimates. CAC coefficient base estimate for the Free Imports scenario is, for example, less than 1 thousand higher. Again, total STP requirements vary only slightly across scenarios; the largest difference is only 4 per cent. The difference in CAC versus BLS-Data coefficients widens for 1985: CAC total STP requirements are 7 to 8 thousand higher for 1985 versus 6 to 7 thousand for 1980.

STP occupations which are important to indirect construction of energy facilities include electrical, industrial, mechanical and miscellaneous engineering categories, computer specialists, electrical and electronic technicians, draftsmen, and engineering and science technicians, n.e.c. Although the distributions of requirements varies substantially across STP occupations, there appears to be less relative variation as a per cent of total requirements per occupation. This is because STP occupations which are needed in larger numbers for indirect energy facility construction are also occupations for which economy-wide requirements are high. For example, electrical engineers and chemists represent 12 and 4 per cent of 61.8 thousand STP required for the 1985 indirect construction component of the synthetic fuels scenario. Yet, these requirements represent only 2.0 and 1.5 per cent of economy-wide STP requirements for each respective occupation. Thus, per occupation, STP requirements for indirect construction are a small percentage of economy-wide requirements even though some categories are needed in larger numbers than others.

Consequently, the differential impact of this component of requirements on the STP occupational spectrum will be small, provided that supply closely approximates demand.

For the indirect construction component of ERE, it is seen that rather large numbers of scientific and technical personnel will be needed, that there is little variation in

requirements between scenarios, that CAC coefficients of manpower per-dollar-of-output yield higher projections than unmodified BLS manpower coefficients, that 1985 projections are not significantly higher than 1980 projections, and that indirect construction does not cause a disproportionate impact on STP requirements relative to total requirements, per occupation. Thus, relative demand levels between occupations are essentially unaffected by the indirect construction requirements.

4.5 - Projections of Employment for Energy Production

Employment resulting from total energy demand comprises the third partition component. This direct-energy production component yields the "lion's share" of total energy-related employment even though the proportion of total energy-related employment accounted for by this component varies from about one-half to one-third across scenarios. Tables 4.5.1 and 4.5.2 show manpower requirements by detailed STP occupation for 1980 and 1985.

Because the level of energy use is substantially higher under the Free Imports scenario, STP requirements are also substantially higher. CAC manpower coefficients yield 153.3 thousand scientific and technical personnel under Free Imports versus 131.4 thousand under the Synthetics scenario. For 1985 the differential across scenarios widens by 10 thousand (174.1 versus 152.1).

Table 4.5.1

Comparative Scenario Employment Projections
Energy Production
1980

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	6661	7530	5774	5560	5582	5376
2 engineers, civil	5343	5165	4421	4252	4210	4146
3 engineers, electrical	24494	22843	22242	19258	21179	17933
4 engineers, industrial	3659	3845	3300	3116	3254	3664
5 engineers, metallurgical	279	302	241	230	241	232
6 engineers, mechanical	7854	8536	6855	6936	6667	6768
7 engineers, aero-astronautic	13	4	11	4	10	3
8 engineers, mining	1652	2067	1469	1831	1464	1833
9 engineers, petroleum	12706	18016	10718	14115	11067	14747
10 engineers, other	5499	4309	5019	3539	4913	3444
11 chemists	5946	7150	5511	5450	5367	5366
12 physicists and astronomers	399	496	329	367	329	390
13 geologists	20010	26137	16246	20559	16933	21516
14 agricultural scientists	57	21	47	17	44	16
15 biological scientists	90	86	79	69	76	67
16 mathematicians	262	304	225	232	227	235
17 statisticians	782	790	731	650	724	631
18 computer specialists	10782	11151	9289	8902	9333	8823
19 marine scientists	152	165	126	134	122	134
20 life, physical scientists nec	44	36	32	26	30	24
21 agri, biolog tech exc health	58	63	44	46	45	50
22 chemical tech	10991	12165	9763	6965	9558	6749
23 electrical, electronic tech	5805	5638	5098	4862	4873	4662
24 industrial engineering tech	308	286	229	217	212	206
25 mechanical engineering tech	36	37	33	28	32	25
26 mathematical tech	22	5	20	4	19	4
27 surveyors	4393	4989	3712	4164	3639	4085
28 draftsmen	14452	15605	12305	12782	12024	12556
29 engineering, science tech nec	10322	13051	9200	10451	9167	10516
Totals	153292	171610	133068	136825	131361	135601

FI: Free Imports Scenario; CAC Coefficient Base.
FI*: Free Imports Scenario; BLS Coefficient Base.
LI: Limited Imports Scenario; CAC Coefficient Base.
LI*: Limited Imports Scenario; BLS Coefficient Base.
SY: Synthetics Scenario; CAC Coefficient Base.
SY*: Synthetics Scenario; BLS Coefficient Base.

Table 4.5.2

Comparative Scenario Employment Projections
Energy Production
1985

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	8198	8498	6608	5964	5354	5899
2 engineers, civil	6934	5648	5578	4619	5458	4529
3 engineers, electrical	27572	25192	25715	21401	24518	19088
4 engineers, industrial	4479	4093	3922	3300	3676	3270
5 engineers, metallurgical	321	324	277	239	279	252
6 engineers, mechanical	8906	9746	7660	7666	7325	7724
7 engineers, aero-astronautic	17	0	15	0	13	0
8 engineers, mining	2249	2557	1843	2265	1907	2295
9 engineers, petroleum	13899	20632	12332	16067	12848	17665
10 engineers, other	7376	4540	6440	3718	6101	3612
11 chemists	6908	7661	5963	5814	5530	5869
12 physicists and astronomers	579	569	453	437	435	457
13 geologists	20754	28726	17455	22292	16552	24466
14 agricultural scientists	70	0	57	0	54	0
15 biological scientists	128	93	109	74	104	73
16 mathematicians	301	329	225	242	233	256
17 statisticians	663	633	767	666	763	664
18 computer specialists	12362	12202	10905	9625	11007	9695
19 marine scientists	167	167	155	150	151	156
20 life, physical scientists nec	53	35	35	23	34	22
21 agri, biolog tech exc health	66	65	49	49	51	53
22 chemical tech	12621	13113	12239	9277	12114	9277
23 electrical, electronic tech	6461	6477	5554	5419	5747	5180
24 industrial engineering tech	432	312	314	229	287	218
25 mechanical engineering tech	37	38	34	26	34	25
26 mathematical tech	25	0	24	0	23	0
27 surveyors	5196	5866	4446	4938	4365	4821
28 draftsmen	15619	17741	13457	14469	15130	14364
29 engineering, science tech nec	11420	15244	10303	12042	10516	12565
Totals	174076	151121	153293	151320	152140	152915

FI: Free Imports Scenario; CAC Coefficient Base.
FI*: Free Imports Scenario; BLS Coefficient Base.
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SY*: Synthetics Scenario; BLS Coefficient Base.

BLS coefficients yield substantially higher projections, particularly for the Free Imports scenario. For 1980, there is an 18 thousand STP worker differential; for 1985, 17 thousand. The principal difference lies in projections of petroleum engineers and geologists. For 1985, CAC coefficients yield 7 and 8 thousand fewer of these STP workers, respectively. Respondents to the CAC survey of energy establishments simply predicted lower rates of utilization of petroleum engineers and geologists at the higher levels of energy production associated with the Free Imports scenario. Non-linearity of per-dollar-of-output manpower coefficients was particularly acute for these two occupations.

Engineers represent about 45 per cent of the total STP requirements for this component for both 1980 and 1985 projections. Electrical and petroleum engineers account for about 54 per cent of engineer requirements in 1980; 50 per cent, in 1985. Geologists, computer specialists, chemical and engineering and science technicians represent other important occupations for direct energy production.

Although there is some variation in STP requirements across scenarios, this variation runs counter to scenario variation in direct and indirect construction requirements. Furthermore, for 1985 in particular, the variation is requirements for direct energy production is substantially

offset by total construction requirements variation.

The 1985 variation across scenarios of 32 thousand is cut by 41 per cent when construction variation is added. A substantial leveling of total scenario projections is the result.

4.6 - Projections of Employment for Inputs to Energy Production

Indirect employment resulting from total demand for energy is the least colorful of the partition components. Tables 4.6.1 and 4.6.2 present these results for 1980 and 1985. STP requirements are low, variation across scenarios is small (less than one thousand workers), and the CAC coefficients results are essentially equivalent to the BLS values. Requirements are highest for the Limited Imports scenario in 1980 at 20.5 thousand STP workers and lowest for Synthetics, 19.5 thousand. In addition requirements across the STP occupational spectrum are relatively flat in relation to economy-wide requirements. That is, there are no occupational "bulges" for indirect energy production. The only striking feature of this component is its comparative lack of significance. Indirect requirements for energy production are only about 12 to 13 per cent of total energy production requirements.

Table 4.6.1

Comparative Scenario Employment Projections
Inputs for Energy Production
1980

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	999	984	1083	1068	991	976
2 engineers, civil	844	851	838	843	810	816
3 engineers, electrical	1751	1717	1726	1690	1665	1629
4 engineers, industrial	1558	1228	1542	1217	1497	1173
5 engineers, metallurgical	121	113	122	113	120	110
6 engineers, mechanical	1284	1273	1287	1274	1241	1229
7 engineers, aero-astronautic	84	83	82	81	80	79
8 engineers, mining	60	54	62	56	58	53
9 engineers, petroleum	31	19	30	19	29	18
10 engineers, other	1178	1090	1167	1075	1135	1044
11 chemists	1432	1416	1533	1517	1414	1398
12 physicists and astronomers	148	147	149	149	141	140
13 geologists	82	85	82	85	79	82
14 agricultural scientists	42	42	45	45	42	41
15 biological scientists	74	73	78	76	72	71
16 mathematicians	60	60	58	59	56	56
17 statisticians	119	110	117	109	111	104
18 computer specialists	2842	2914	2755	2826	2636	2706
19 marine scientists	5	6	5	5	5	5
20 life, physical scientists nec	22	22	21	21	20	20
21 agri, biolog tech exc health	101	101	103	103	97	97
22 chemical tech	1664	1665	1821	1822	1659	1660
23 electrical, electronic tech	1052	1003	1028	979	984	940
24 industrial engineering tech	166	159	170	163	162	155
25 mechanical engineering tech	87	67	89	67	88	66
26 mathematical tech	4	5	4	5	4	5
27 surveyors	490	666	480	651	467	635
28 draftsmen	2447	2486	2426	2462	2362	2399
29 engineering, science tech nec	1546	1541	1561	1554	1483	1473
Totals	20293	19980	20464	20137	19506	19183

FI: Free Imports Scenario; CAC Coefficient Base.
FI*: Free Imports Scenario; BLS Coefficient Base.
LI: Limited Imports Scenario; CAC Coefficient Base.
LI*: Limited Imports Scenario; BLS Coefficient Base.
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SY*: Synthetics Scenario; BLS Coefficient Base.

Table 4.6.2

Comparative Scenario Employment Projections
Inputs for Energy Production
1985

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	1178	1142	1246	1211	1141	1105
2 engineers, civil	1025	926	997	900	979	884
3 engineers, electrical	2058	1957	1969	1868	1937	1836
4 engineers, industrial	1575	1345	1517	1291	1503	1271
5 engineers, metallurgical	137	117	135	115	135	115
6 engineers, mechanical	1537	1438	1497	1399	1473	1375
7 engineers, aero-astronautic	94	90	89	86	69	85
8 engineers, mining	69	71	71	73	67	69
9 engineers, petroleum	22	22	21	21	20	21
10 engineers, other	1377	1167	1326	1118	1319	1110
11 chemists	1594	1560	1664	1630	1537	1502
12 physicists and astronomers	177	171	172	167	165	159
13 geologists	102	102	101	101	98	98
14 agricultural scientists	42	41	43	43	40	40
15 biological scientists	82	78	83	79	78	74
16 mathematicians	77	77	72	72	71	70
17 statisticians	139	123	132	116	127	113
18 computer specialists	3499	3557	3262	3317	3184	3242
19 marine scientists	6	6	6	6	6	6
20 life, physical scientists nec	25	25	24	23	23	22
21 agri, biolog tech exc health	116	116	116	115	110	109
22 chemical tech	1983	1983	2124	2124	1923	1923
23 electrical, electronic tech	1275	1179	1200	1109	1173	1066
24 industrial engineering tech	197	187	196	186	191	181
25 mechanical engineering tech	93	75	92	73	93	73
26 mathematical tech	5	6	5	6	5	6
27 surveyors	571	770	545	736	541	734
28 draftsmen	2996	2795	2900	2704	2689	2693
29 engineering, science tech nec	1877	1814	1836	1774	1765	1704
Totals	23928	22939	23443	22464	22660	21705

FI: Free Imports Scenario; CAC Coefficient Base.
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4.7 - Total Private Energy-Related Employment

Summing the four partition components yields projection of total private energy-related employment. Tables 4.7.1 and 4.7.2 present these results. These tables illustrate the substantial leveling of employment across scenarios that results once all the contributions to energy-related employment are examined. The Free Imports scenario yields the highest value of projected STP employment: 316.2 thousand. This total is only seven per cent higher than the Limited Imports scenarios which yields the lowest projection (294.7 thousand).

That it is higher at all is counterintuitive. This analysis has shown that the additional employment effects of increased energy facility construction are not sufficient to offset the disemployment effects associated with lower energy use with higher priced energy.

Table 4.7.1

Comparative Scenario Employment Projections
Energy-Related Employment
1980

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	9340	10139	8375	8101	8720	8453
2 engineers, civil	25851	25445	25295	24870	26150	25798
3 engineers, electrical	53766	51523	50581	46987	50540	46678
4 engineers, industrial	12829	9605	12224	8998	12702	9149
5 engineers, metallurgical	1444	1316	1369	1230	1452	1274
6 engineers, mechanical	26357	25641	25547	25211	26564	26188
7 engineers, aero-astronautic	731	705	727	703	742	718
8 engineers, mining	2028	2436	1835	2189	1935	2296
9 engineers, petroleum	16268	21629	14238	17656	14390	18093
10 engineers, other	16593	14294	16317	13666	16500	13839
11 chemists	9667	10642	9265	8964	9112	8839
12 physicists and astronomers	871	958	797	844	803	854
13 geologists	20578	26799	16737	21112	17432	22082
14 agricultural scientists	131	94	123	92	118	89
15 biological scientists	224	216	214	200	206	195
16 mathematicians	411	454	371	378	373	381
17 statisticians	1140	1127	1083	979	1050	966
18 computer specialists	18410	18679	16745	16236	16903	16252
19 marine scientists	173	184	145	151	142	152
20 life, physical scientists nec	99	90	65	79	85	79
21 agri, biolog tech exc health	266	273	252	258	251	257
22 chemical tech	13881	15060	12748	11973	12419	11612
23 electrical, electronic tech	10294	10374	9483	9263	9375	9176
24 industrial engineering tech	1274	1133	1169	1059	1204	1074
25 mechanical engineering tech	880	525	692	511	936	527
26 mathematical tech	39	23	37	22	36	22
27 surveyors	5444	6423	4725	5567	4656	5477
28 draftsmen	50419	51464	47699	48061	50273	50694
29 engineering, science tech nec	16742	19086	15563	16365	15740	16595
Totals	316151	327556	294660	291749	300923	297605

FI: Free Imports Scenario; CAC Coefficient Base.
FI*: Free Imports Scenario; BLS Coefficient Base.
LI: Limited Imports Scenario; CAC Coefficient Base.
LI*: Limited Imports Scenario; BLS Coefficient Base.
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SY*: Synthetics Scenario; BLS Coefficient Base.

Table 4.7.2

Comparative Scenario Employment Projections
Energy-Related Employment
1985

	FI	FI*	LI	LI*	SY	SY*
1 engineers, chemical	11342	11524	9707	8953	9656	9069
2 engineers, civil	31124	29245	33136	31575	33823	32283
3 engineers, electrical	60865	57764	63270	58096	62752	56967
4 engineers, industrial	12585	9972	12197	9300	12312	9335
5 engineers, metallurgical	1566	1287	1564	1235	1589	1265
6 engineers, mechanical	29861	29895	29534	26974	29961	29506
7 engineers, aero-astronautic	692	635	694	639	698	643
8 engineers, mining	2735	3049	2331	2760	2495	2889
9 engineers, petroleum	16840	23868	15143	18926	15452.	20264
10 engineers, other	18217	13888	17452	13194	17317	13242
11 chemists	10798	11368	9950	9400	9725	9373
12 physicists and astronomers	1109	1063	989	934	969	953
13 geologists	21332	29411	17982	22678	19972	25052
14 agricultural scientists	140	68	126	70	122	67
15 biological scientists	270	224	253	207	243	202
16 mathematicians	471	496	391	404	398	417
17 statisticians	1241	1182	1161	1032	1157	1011
18 computer specialists	20904	20531	19285	17780	19398	17649
19 marine scientists	209	204	176	166	172	172
20 life, physical scientists nec	113	93	95	81	94	80
21 agri, biolog tech exc health	292	293	274	276	272	275
22 chemical tech	15823	16319	15562	12575	15244	12384
23 electrical, electronic tech	11355	11289	10905	10368	10730	10160
24 industrial engineering tech	1482	1206	1386	1145	1365	1140
25 mechanical engineering tech	821	529	837	525	847	532
26 mathematical tech	44	19	42	19	41	19
27 surveyors	6316	7385	5518	6391	5457	6276
28 craftsmen	56961	58108	57653	57693	59043	59275
29 engineering, science tech nec	18449	21600	17437	18489	17697	18913
Totals	353956	362454	345053	334085	348103	339613

FI: Free Imports Scenario; CAC Coefficient Base.
FI*: Free Imports Scenario; BLS Coefficient Base.
LI: Limited Imports Scenario; CAC Coefficient Base.
LI*: Limited Imports Scenario; BLS Coefficient Base.
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SY*: Synthetics Scenario; BLS Coefficient Base.

4.8 - Private Energy-Related STP Employment as Percentage of Total Private STP Employment

For 1980 and 1985, 11 per cent of total private STP requirements will be in energy-related activities. There is little variation across scenarios: For 1980 Free Imports requires 11.3 per cent; Synthetics, 10.9 per cent. There is some variation among STP groups. About 13 per cent of engineers are in energy-related activities in 1980 and 1985. Requirements for scientists are slightly higher at 14 to 15 per cent, while Math and Computer Specialists are substantially lower at 5 per cent. Technicians requirements are 10 to 11 per cent. Percentage requirements for energy activities for some individual occupations are high. In 1985, for Limited Imports, Petroleum Engineers, Mining Engineers, and Geologists utilized in energy-related activities are 38, 88, and 63 per cent respectively. The proportion of Electrical Engineers in energy-related activities is also relatively high: 17 per cent. For almost all of the other detailed categories, however, energy-related utilization is less than 10 per cent.

Tables 4.8.1 through 4.8.6 summarize the scenario projection results of energy-related employment for the four major subdivisions of STP employment, showing, for each scenario, projected employment and percentage distribution by partition component.

Table 4.8.1

Free Imports Projections--1980

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Engineers	59,600	29,315	68,360	7,910	165,207	1,086,305	1,251,512	13.2
	36.1	17.7	41.4	4.8	100.0			
Scientists	0	3,239	26,698	1,805	31,743	171,471	203,214	15.6
	0.0	10.2	84.1	5.7	100.0			
Math and Computer Specialists	0	5,115	11,826	3,021	19,961	338,496	358,457	5.6
	0.0	25.6	59.3	15.1	100.0			
Subtotal	59,600	37,669	106,984	12,736	216,911	1,596,272	1,813,183	12.0
Technicians	24,600	20,696	46,387	7,557	99,239	886,401	985,640	10.1
	24.8	20.9	46.7	7.6	100.0			
Total	84,200	58,365	153,291	20,293	316,150	2,482,673	2,798,623	11.3

Table 4.8.2

Limited Imports Projections--1980

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Engineers	59,600	28,942	60,050	7,939	156,528	1,081,534	1,238,062	12.6
	38.1	18.5	38.4	5.1	100.0			
Scientists	0	3,082	22,370	1,913	27,366	171,647	199,013	13.8
	0.0	11.3	81.7	7.0	100.0			
Math and Computer Specialists	0	5,022	10,245	2,930	18,199	377,391	355,590	5.1
	0.0	27.6	56.3	16.1	100.0			
Subtotal	59,600	37,046	92,665	12,782	202,093	1,590,567	1,792,660	11.3
Technicians	24,100	20,403	40,404	7,703	92,610	883,200	975,810	9.5
	26.0	22.0	43.6	8.3	100.0			
Total	63,700	57,419	133,069	20,485	294,703	2,473,772	2,768,475	10.6

Table 4.8.3

Synthetics Scenario Projections--1980

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Engineers	62,900	30,643	58,607	7,626	159,775	1,075,485	1,235,260	12.9
	39.4	19.2	36.7	4.8	100.0			
Scientists	0	3,207	22,921	1,773	27,900	171,913	199,813	14.0
	0.0	11.5	82.1	6.4	100.0			
Math and Computer Specialists	0	5,269	10,284	2,803	18,356	337,162	356,518	5.2
	0.0	28.7	56.0	15.3	100.0			
Subtotal	62,900	39,119	91,812	12,202	206,031	1,584,560	1,790,591	11.5
Technicians	26,400	21,617	39,569	7,306	94,892	879,560	974,452	9.7
	27.8	22.8	41.7	7.7	100.0			
Total	89,300	60,736	131,381	19,508	300,923	2,464,120	2,765,043	10.9

Table 4.8.4

Free Imports Projections--1985

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Engineers	68,100	28,702	79,953	9,072	185,827	1,214,292	1,400,119	13.3
	36.6	15.4	43.0	4.9	100.0			
Scientists	0	3,263	28,679	2,028	33,970	191,175	225,145	15.1
	0.0	9.6	84.4	5.0	100.0			
Math and Computer Specialists	0	5,355	13,546	3,715	22,616	404,789	427,405	5.3
	0.0	23.7	59.9	16.4	100.0			
Subtotal	68,100	37,320	122,178	14,815	242,413	1,810,256	2,052,669	11.8
Technicians	28,700	21,830	51,897	9,113	111,541	1,037,878	1,149,419	11.0
	25.7	19.6	46.5	8.2	100.0			
Total	96,800	59,150	174,075	23,928	353,954	2,848,134	3,202,088	11.1

Table 4.6.5

Limited Imports Projections--1985

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Engineers	76,300	29,531	70,330	8,868	185,029	1,209,024	1,394,053	13.3
	41.2	16.0	38.0	4.8	100.0			
Scientists	0	3,297	24,227	2,093	29,617	191,528	221,145	13.4
	0.0	11.1	81.8	7.1	100.0			
Math and Computer Specialists	0	5,454	11,917	3,466	20,837	403,150	423,987	4.9
	0.0	26.2	57.2	16.6	100.0			
Subtotal	76,300	38,282	106,474	14,600	235,483	1,803,702	2,039,185	11.5
Technicians	31,400	22,336	46,820	9,014	109,570	1,034,236	1,143,606	9.6
	28.7	20.4	42.7	8.2	100.0			
Total	107,700	60,618	153,294	23,443	345,053	2,837,938	3,182,991	10.8

Table 4.8.6

Synthetics Scenario Projections--1985

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Energy Related Employment	Non-Energy Related Employment	Total Employment	Percent Energy Related
Engineers	78,600	30,122	68,671	8,663	186,056	1,205,260	1,391,316	13.4
	42.2	16.2	36.9	4.7	100.0			
Scientists	0	3,291	25,160	1,947	30,398	192,157	222,555	13.7
	0.0	10.8	82.8	6.4	100.0			
Math and Computer Specialists	0	5,549	12,023	3,382	20,954	403,753	424,707	4.9
	0.0	26.5	57.4	16.1	100.0			
Subtotal	78,600	38,962	105,854	13,992	237,408	1,801,170	2,038,578	11.6
Technicians	32,900	22,822	46,287	8,690	110,699	1,032,217	1,142,916	9.7
	29.7	20.6	41.8	7.9	100.0			
Total	111,500	61,784	152,141	22,682	348,107	2,833,387	3,181,494	10.9

For comparative purposes, estimates of energy-related employment in 1974 using similar techniques to the projections were prepared. Direct construction employment estimates were those of the first year of the Bechtel Limited Imports scenario. Indirect construction employment was estimated using the corresponding bill-of-materials as input to an estimated input-output matrix. Direct energy production employment was derived from the BLS 1974 occupational employment estimates, and indirect energy production employment was estimated from the input-output table and the estimated level of 1974 output of the energy production industries.

The results are shown in Table 4.8.7 for STP occupations. The proportions are quite close to those of 1985, indicating that energy development programs will not result in an increased share of private STP employment being drawn into energy related work. In 1974, for instance, 13.2 per cent of engineers, 14.6 per cent of scientists, 6.0 per cent of math and computer scientists, and 9.9 per cent of technicians were employed in energy related activities. The similarity of proportions indicates that projected growth of energy-related and other STP employment will proceed at about the same rates.

Table 4.8.7

Private Energy-Related Employment of STP by Occupation
and as Per Cent of Total Private STP Employment, 1974

	Direct Construction	Indirect Construction	Direct Energy	Indirect Energy	Total ERE	Total Private STP	ERE as % of Private STP
1 engineers, chemical	600	335	6194	706	7836	49000	16.0
2 engineers, civil	15400	580	4401	1506	21687	126700	17.0
3 engineers, electrical	17800	3315	21410	3026	45550	262900	17.3
4 engineers, industrial	0	2517	3269	2060	7845	173200	4.5
5 engineers, metallurgical	0	389	235	165	790	16200	4.9
6 engineers, mechanical	8800	2967	6716	1904	20387	171200	11.9
7 engineers, aero-astronautic	0	461	11	193	665	44400	1.5
8 engineers, mining	100	49	1536	50	1735	4700	36.9
9 engineers, petroleum	3100	57	10270	43	13470	11600	114.2
10 engineers, other	4500	2253	3872	2040	12665	142600	8.9
11 chemists	0	857	5781	1319	7957	107200	7.4
12 physicists and astronomers	0	165	333	207	706	15000	4.7
13 geologists	0	118	16125	121	16364	24500	66.8
14 agricultural scientists	0	17	49	52	118	6600	1.8
15 biological scientists	0	30	75	104	210	19300	1.1
16 mathematicians	0	45	229	69	363	5300	6.8
17 statisticians	0	113	710	209	1032	15400	6.7
18 computer specialists	0	2147	8817	4996	15961	266100	6.0
19 marine scientists	0	8	123	12	143	1300	11.0
20 life, physical scientists nec	0	16	38	33	87	1700	5.1
21 agri, biolog tech exc health	0	54	47	162	263	34000	0.8
22 chemical tech	0	457	10336	1061	11854	76300	15.5
23 electrical, electronic tech	0	1608	4968	1581	8377	140100	6.0
24 industrial engineering tech	0	312	260	202	774	21400	3.6
25 mechanical engineering tech	0	98	35	99	332	12200	2.7
26 mathematical tech	0	8	14	8	30	600	5.0
27 surveyors	0	269	3731	1044	5043	62700	8.0
28 draftsmen	20400	4210	12013	4138	40761	284000	14.4
29 engineering, science tech nec	0	1989	8839	2056	12883	180800	7.1
Totals	70700	25745	130456	29187	256088	2281200	11.2

4.9 - Detailed Occupation and Industry Projections

This section examines scenario differentials in projections by detailed occupation and industry. For each scenario and for each of the 29 STP occupations that comprise the sample base, differentials in CAC/BLS coefficient projections are presented and analyzed. Also, percentage changes in employment for 1980 and 1985 relative to 1974 employment levels are presented. Industry projections for the private economy are presented on a 20-order industry breakdown that includes five aggregate categories: total, manufacturing, non-manufacturing, durables and non-durables. For purposes of comparability with other employment projections for the U. S. economy, social scientists have been added into the industrial projections. Thus total industry projections of STP employment are approximately 240,000 larger for 1985. Percentage changes for total employment by detailed industry relative to 1974 are also presented for the industry projections. Tables 4.9.1 through 4.9.6 present the detailed STP occupational projections for the three scenarios and two projection periods.

Table 4.9.1

Detailed STP Occupational Projections
Free Imports Scenario--1980

	construct.	unsampled indust.	BLS sampled indust.	CAC sampled indust.	CAC-BLS diff.	CAC-BLS percent diff.	CAC total	1974-80 percent change
1 engineers, chemical	600	43470	14348	15267	939	6.5	59557	21.6
2 engineers, civil	18200	62362	71216	80329	9113	12.8	160891	25.0
3 engineers, electrical	20700	201654	93367	101629	8262	8.8	323982	23.2
4 engineers, industrial	0	137549	51076	88936	37859	74.1	226484	30.8
5 engineers, metallurgical	0	8480	8597	9995	1397	16.3	18475	14.1
6 engineers, mechanical	11400	124650	75239	76649	1410	1.9	212698	24.2
7 engineers, aero-astronautic	0	47242	1831	2081	250	13.6	49322	11.2
8 engineers, mining	100	2686	3150	3239	69	2.8	6025	29.1
9 engineers, petroleum	3300	637	19419	15113	-4305	-22.2	19250	63.3
10 engineers, other	5100	89998	67266	79730	12464	18.5	174828	22.6
11 chemists	0	93606	26817	27742	925	3.4	121548	13.4
12 physicists and astronomers	0	11101	6552	6546	-6	-0.1	17647	16.0
13 geologists	0	4786	31328	24833	-6495	-20.7	29619	20.9
14 agricultural scientists	0	6918	374	488	114	30.6	7406	12.4
15 biological scientists	0	21235	1977	2334	357	18.0	23569	22.3
16 mathematicians	0	5012	1613	1792	-21	-1.2	6803	28.5
17 statisticians	0	14493	4114	4042	-73	-1.8	18535	20.6
18 computer specialists	0	273830	66296	59290	-7006	-10.6	333120	24.2
19 marine scientists	0	312	1143	1103	-40	-3.5	1414	6.4
20 life, physical scientists nec	0	1431	554	579	25	4.5	2010	19.5
21 agri, biolog tech exc health	0	35556	1694	2005	312	18.4	37561	10.3
22 chemical tech	0	72937	17040	16100	-940	-5.5	69037	16.7
23 electrical, electronic tech	0	122798	40481	46427	5945	14.7	169225	20.8
24 industrial engineering tech	0	19592	6248	7341	1093	17.5	26932	25.9
25 mechanical engineering tech	0	9649	4315	6914	2599	60.2	16563	35.2
26 mathematical tech	0	547	150	106	-42	-26.2	654	17.4
27 surveyors	0	18040	60895	46512	-14383	-23.6	64552	2.9
28 draftsmen	24600	157113	185719	181794	-3925	-2.1	363506	28.0
29 engineering, science tech nec	0	159394	59128	58215	-913	-1.5	217609	20.4
Totals	84200	1747476	922146	967149	45001	4.9	2798825	22.7

Table 4.9.2

Detailed STP Occupational Projections
Limited Imports Scenario--1980

	construct.	unsampled indust.	BLS sampled indust.	CAC sampled indust.	CAC-BLS diff.	CAC-BLS percent diff.	CAC total	1974-80 percent change
1 engineers, chemical	700	43225	12319	14340	2020	16.4	58265	19.0
2 engineers, civil	16600	61936	70412	79764	9352	13.3	160301	24.6
3 engineers, electrical	20000	201385	89040	98911	9871	11.1	320296	21.8
4 engineers, industrial	0	136971	49965	87799	37834	75.7	224770	29.8
5 engineers, metallurgical	0	8398	8472	9892	1420	16.6	18290	13.0
6 engineers, mechanical	11600	123229	73308	75424	2116	2.9	210253	22.8
7 engineers, aero-astronautic	0	46599	1820	2065	245	13.4	48664	9.7
8 engineers, mining	100	2711	2903	3016	113	3.9	5827	24.8
9 engineers, petroleum	3300	834	15442	13024	-2418	-15.7	17157	45.6
10 engineers, other	5300	89794	66165	79144	12979	19.6	174238	22.2
11 chemists	0	93761	25017	27183	2166	8.7	120944	12.6
12 physicists and astronomers	0	11095	6431	6463	32	0.5	17558	17.4
13 geologists	0	4798	25651	21008	-4643	-16.1	25806	5.3
14 agricultural scientists	0	6983	372	482	110	29.6	7465	13.3
15 biological scientists	0	21530	1963	2326	363	18.5	23856	23.8
16 mathematicians	0	4962	1738	1755	17	1.0	6737	27.3
17 statisticians	0	14467	3968	3977	9	0.2	18444	20.0
18 computer specialists	0	272895	63728	57513	-6215	-9.8	330407	23.2
19 marine scientists	0	312	1114	1076	-35	-3.2	1390	4.6
20 life, physical scientists nec	0	1429	543	565	22	4.1	1994	18.5
21 agri, biolog tech exc health	0	36036	1692	1997	305	18.1	38033	11.7
22 chemical tech	0	72468	13616	14959	1143	8.3	67427	14.6
23 electrical, electronic tech	0	122641	39094	44955	5861	15.0	167595	19.6
24 industrial engineering tech	0	19531	6134	7193	1059	17.3	26724	24.9
25 mechanical engineering tech	0	9472	4278	7002	2724	63.7	16474	34.5
26 mathematical tech	0	546	149	105	-43	-29.0	651	16.9
27 surveyors	0	17903	59943	45795	-14148	-23.6	63696	1.6
28 draftsmen	24100	156167	162042	176944	-3096	-1.7	359211	26.5
29 engineering, science tech nec	0	158869	56378	57087	708	1.3	215976	19.5
Totals	63700	1740985	863696	943766	59669	6.8	2768450	21.4

Table 4.9.3

Detailed STP Occupational Projections
Limited Imports/Synthetics Scenario--1980

	construct.	unsampled indust.	BLS sampled indust.	CAC sampled indust.	CAC-BLS diff.	CAC-BLS percent diff.	CAC total	1974-80 percent change
1 engineers, chemical	1300	42651	12115	14164	2049	16.9	58315	19.1
2 engineers, civil	19600	61114	70616	80091	9475	13.4	160805	25.0
3 engineers, electrical	20800	201252	87458	97699	10241	11.7	319751	21.6
4 engineers, industrial	0	136433	49626	87442	37816	76.2	223875	29.3
5 engineers, metallurgical	0	8278	8391	9921	1530	18.2	16199	12.4
6 engineers, mechanical	12500	121572	72926	75131	2204	3.0	209202	22.2
7 engineers, aero-astronautic	0	45929	1816	2059	243	13.4	47988	8.1
8 engineers, mining	200	2631	2905	3001	96	3.3	5832	25.0
9 engineers, petroleum	3100	829	16076	13354	-2722	-16.9	17262	46.6
10 engineers, other	5400	69604	65925	79004	13080	19.8	174008	22.0
11 chemists	0	93724	24801	26887	2087	8.4	120611	12.5
12 physicists and astronomers	0	11114	6437	6459	23	0.4	17574	17.5
13 geologists	0	4722	26620	21710	-4910	-16.4	26432	7.9
14 agricultural scientists	0	7042	373	483	110	29.6	7525	14.3
15 biological scientists	0	21958	1964	2326	363	16.5	24285	26.0
16 mathematicians	0	4966	1739	1757	17	1.0	6725	27.0
17 statisticians	0	14460	3947	3970	23	0.6	18450	20.0
18 computer specialists	0	273006	63505	57338	-6167	-9.7	330344	23.2
19 marine scientists	0	310	1116	1078	-39	-3.5	1388	4.4
20 life, physical scientists nec	0	1432	543	565	22	4.0	1997	18.7
21 agri, biolog tech exc health	0	36616	1704	2001	297	17.4	38617	13.5
22 chemical tech	0	71863	13582	14858	1277	9.4	66722	13.6
23 electrical, electronic tech	0	122678	38714	44133	5419	14.0	166811	19.0
24 industrial engineering tech	0	19451	6070	7102	1032	17.0	[illegible]	24.1
25 mechanical engineering tech	0	9266	4234	7072	2839	67.1	16338	33.4
26 mathematical tech	0	546	148	104	-44	-29.6	650	16.7
27 surveyors	0	17552	59888	45716	-14171	-23.7	63268	0.9
28 draftsmen	26400	155106	181633	178661	-2972	-1.6	360167	26.8
29 engineering, science tech nec	0	158147	56349	57179	830	1.5	215326	19.1
Totals	89300	1734475	881220	941267	60047	6.8	2765042	21.2

Table 4.9.4

Detailed STP Occupational Projections
Free Imports Scenario--1985

	construct.	unsampled indust.	BLS sampled indust.	CAC sampled indust.	CAC-BLS diff.	CAC-BLS percent diff.	CAC total	1974-85 percent change
1 engineers, chemical	1100	47646	15916	20264	4348	27.3	69011	40.9
2 engineers, civil	21600	70661	76027	106833	30806	40.5	199095	54.7
3 engineers, electrical	24300	226116	101138	120117	18979	18.8	370533	40.9
4 engineers, industrial	0	146060	53917	83014	29098	54.0	229074	32.3
5 engineers, metallurgical	0	8817	8581	11398	2817	32.8	20215	24.9
6 engineers, mechanical	13500	135128	81449	92182	10733	13.2	240811	40.6
7 engineers, aero-astronautic	0	46670	1734	2529	795	45.9	49199	10.9
8 engineers, mining	200	3055	3831	3264	-566	-14.8	6519	39.7
9 engineers, petroleum	2700	949	22457	15211	-7245	-32.3	18661	60.0
10 engineers, other	4700	96417	69772	95686	25914	37.1	196803	38.0
11 chemists	0	100989	28158	31807	3650	13.0	132796	23.9
12 physicists and astronomers	0	13200	6664	7793	1129	16.9	20993	40.4
13 geologists	0	5582	34235	26447	-7788	-22.7	32029	36.7
14 agricultural scientists	0	7500	327	582	254	77.7	8081	22.7
15 biological scientists	0	24507	1708	2751	1043	61.0	27258	41.4
16 mathematicians	0	6257	1831	2014	183	10.0	8271	56.2
17 statisticians	0	16482	4577	4652	75	1.6	21134	37.5
18 computer specialists	0	327245	75916	70753	-5163	-6.8	397998	48.4
19 marine scientists	0	339	1199	1300	101	8.4	1639	23.3
20 life, physical scientists nec	0	1732	522	617	95	18.3	2349	39.7
21 agri, biolog tech exc health	0	38837	1728	2481	753	43.6	41318	21.4
22 chemical tech	0	80383	18402	19094	693	3.8	99477	30.4
23 electrical, electronic tech	0	141836	44669	55983	11314	25.3	197819	41.2
24 industrial engineering tech	0	21941	7049	8635	1587	22.5	30576	42.9
25 mechanical engineering tech	0	10262	4683	7279	2596	55.4	17541	43.2
26 mathematical tech	0	623	185	129	-56	-30.1	752	35.0
27 surveyors	0	21233	70903	57363	-13540	-19.1	78597	25.3
28 draftsmen	26700	178962	203656	225338	21682	10.6	433000	52.4
29 engineering, science tech nec	0	183298	67063	67042	-21	-0.0	250340	38.5
Totals	96800	1962729	1008296	1142561	134265	13.3	3202090	40.4

Table 4.9.5

Detailed STP Occupational Projections
Limited Imports Scenario--1985

	construct.	unsampled indust.	BLS sampled indust.	CAC sampled indust.	CAC-BLS diff.	CAC-BLS percent diff.	CAC total	1974-85 percent change
1 engineers, chemical	1000	47354	13342	18682	5340	40.0	67036	36.9
2 engineers, civil	25000	70215	75128	106076	30948	41.2	201292	56.4
3 engineers, electrical	28300	225693	96825	118181	21356	22.1	372174	41.6
4 engineers, industrial	0	145435	52828	82243	29415	55.7	227678	31.5
5 engineers, metallurgical	0	8728	8466	11332	2867	33.9	20060	23.9
6 engineers, mechanical	14400	133454	79281	90580	11299	14.3	238434	39.3
7 engineers, aero-astronautic	0	46095	1724	2510	786	45.6	48605	9.5
8 engineers, mining	200	3067	3526	2847	-680	-19.3	6113	31.0
9 engineers, petroleum	2600	942	17608	13610	-3999	-22.7	17152	45.5
10 engineers, other	4800	96128	68633	94578	25945	37.8	195507	37.1
11 chemists	0	101036	26025	30770	4745	18.2	131806	23.0
12 physicists and astronomers	0	13201	6522	7653	1131	17.3	20854	39.4
13 geologists	0	5578	27696	23099	-4597	-16.6	28677	17.0
14 agricultural scientists	0	7589	330	574	244	74.1	8163	23.9
15 biological scientists	0	24930	1691	2734	1043	61.7	27663	43.5
16 mathematicians	0	6216	1740	1938	198	11.4	8154	54.0
17 statisticians	0	16478	4425	4557	132	3.0	21034	36.8
18 computer specialists	0	325792	73003	69007	-3996	-5.5	394799	47.2
19 marine scientists	0	339	1164	1270	107	9.2	1610	21.1
20 life, physical scientists nec	0	1729	510	600	90	17.7	2329	38.5
21 agri, biolog tech exc health	0	39436	1724	2478	754	43.8	41914	23.1
22 chemical tech	0	79853	14532	18874	4341	29.9	98727	29.4
23 electrical, electronic tech	0	141549	43351	54698	11347	26.2	196247	40.0
24 industrial engineering tech	0	21874	6930	8439	1509	21.8	30312	41.7
25 mechanical engineering tech	0	10079	4643	7277	2634	56.7	17356	41.7
26 mathematical tech	0	.2	184	127	-56	-30.6	750	34.5
27 surveyors	0	21048	69746	57363	-12383	-17.8	78411	25.0
28 draftsmen	31400	177826	199526	222529	23003	11.5	431755	52.0
29 engineering, science tech nec	0	182644	63641	65736	1895	3.0	248380	37.4
Totals	167700	1954931	964945	1120363	155418	16.1	3182993	39.5

Table 4.9.6

Detailed STP Occupational Projections
Limited Imports/Synthetics Scenario--1985

	construct.	unsampled indust.	BLS sampled indust.	CAC sampled indust.	CAC-BLS diff.	CAC-BLS percent diff.	CAC total	1974-85 percent change
1 engineers, chemical	1300	46910	13239	18456	5217	39.4	66665	36.1
2 engineers, civil	25800	69517	75337	106580	31243	41.5	201697	56.9
3 engineers, electrical	28900	225934	94859	117130	22271	23.5	371964	41.5
4 engineers, industrial	0	145130	52502	82111	29610	56.4	227241	31.2
5 engineers, metallurgical	0	8607	8395	11241	2646	33.9	19848	22.6
6 engineers, mechanical	15000	131751	78904	90194	11290	14.3	236945	38.4
7 engineers, aero-astronautic	• 0	45356	1723	2504	782	45.4	47660	7.9
8 engineers, mining	300	2966	3558	2913	-646	-18.1	6179	32.4
9 engineers, petroleum	2400	938	19145	14120	-5026	-26.3	17458	48.1
10 engineers, other	4900	96097	68395	94258	25862	37.8	195255	36.9
11 chemists	0	101098	25973	30478	4505	17.3	131577	22.8
12 physicists and astronomers	0	13254	6548	7638	1091	16.7	20893	39.7
13 geologists	0	5499	29881	24206	-5675	-19.0	29705	21.2
14 agricultural scientists	0	7666	332	575	243	73.3	8241	25.1
15 biological scientists	0	25459	1694	2735	1041	61.4	26194	46.3
16 mathematicians	0	6209	1753	1947	193	11.0	8156	54.1
17 statisticians	0	16535	4402	4556	154	3.5	21091	37.2
18 computer specialists	0	326514	72958	68945	-4012	-5.5	395460	47.5
19 marine scientists	0	338	1173	1270	97	6.3	1608	21.0
20 life, physical scientists nec	0	1738	510	599	69	17.5	2337	38.9
21 agri, biolog tech exc health	0	40063	1738	2492	754	43.4	42555	25.0
22 chemical tech	0	79138	14533	18656	4323	29.7	97994	28.4
23 electrical, electronic tech	0	141876	42982	53959	10976	25.5	195835	39.7
24 industrial engineering tech	0	21796	6861	8307	1446	21.1	30105	40.7
25 mechanical engineering tech	0	9884	4597	7205	2609	56.6	17089	39.5
26 mathematical tech	0	623	184	126	-56	-31.3	749	34.5
27 surveyors	0	20713	69720	57695	-11625	-17.0	78608	25.3
28 draftsmen	32900	176960	199133	222269	23136	11.6	432129	52.1
29 engineering, science tech nec	0	181987	64133	65863	1730	2.7	247850	37.1
Totals	111500	1950561	965166	1119426	154267	16.0	3181487	39.5

A number of general observations on these projection results can be made. There is a wide divergence between projections based on CAC and BLS coefficients. Within scenarios, CAC coefficients generally yield higher projection values. There are exceptions, however: Mining engineers, petroleum engineers, geologists, and surveyors projections are considerably lower when CAC output-per-dollar manpower coefficients are applied to the same total demand vectors. Percentage differences can be misleading. At times, for a given occupation the absolute differences are small for the sample industries that comprise the energy-related sample base relative to total employment in non-energy-related industries, yet the percentage difference is large. This is the case with aeronautical engineers, for example. In the 1985 Free Imports scenario (Table 4.9.4) there is a 46 per cent difference in the CAC/BLS projection for energy-related industries. Yet, employment in energy-related industries accounts for less than 4 per cent of total aeronautical engineers employment. At times, the occupation is small in absolute terms as in the case with mathematical technicians. Thus a large percentage difference is of little significance. For the previously mentioned four occupations--mining engineers, petroleum engineers, geologists and surveyors--however, sizeable proportions of total employment are energy-related. Thus the lower CAC projections take on added significance.

Between scenarios there is general agreement in the CAC/BLS coefficient projections, especially for the Limited Imports and Synthetics scenarios. Nevertheless, the varying industry output levels associated with each scenario coupled with the non-linearity of the CAC coefficients produces some variation between scenarios. For example, the chemical engineers percentage differential is 27 per cent for the 1985 Free Imports scenario and 40 per cent for the 1985 Limited Imports scenario. Percentage differentials also vary considerably for mining engineers, petroleum engineers, geologists, surveyors and chemical technicians.

Percentage growth relative to 1974 is high for most of the STP occupations. The percentage change for the engineering categories combined is 39 per cent (3.0 per cent annual rate); 28 per cent for scientists (2.2 per cent annual rate); and 42 per cent for technicians (3.2 per cent annual rate). Despite the lower projection for petroleum engineers relative to the BLS coefficient value, the CAC projection implies a 59 per cent change in employment for this STP category based on 1985 free imports scenario.

There is, however, substantial variation in percentage growths across scenarios for highly energy-related STP occupations: The percentage change for petroleum engineers drops to 46 per cent under the Limited Imports scenario for 1985. Substantial variance is also recorded for chemists (27 to 40 per cent), mining engineers (40 to 31) and geologists (31 to 17) between the Free Imports and Limited Imports scenarios, 1985.

Tables 4.9.7 through 4.9.12 present the detailed industry projections. Each table references a given scenario and projection year and consists of four parts: A) direct energy employment (construction and total demand for energy); B) indirect energy employment (construction materials and interindustry transaction to energy producing establishments); C) non-energy employment; and D) total employment. In addition to total employment, Part D of each table presents implied percentage growths.

For direct energy there is a general decrease in employment between the Free Imports and Limited Imports scenarios. In manufacturing this decrease is attributed solely to the petroleum products industry. In non-manufacturing the general decrease in direct energy employment is compensated, although not completely, by the higher value of construction employment. For indirect energy, a slightly lower manufacturing total employment (attributed primarily to durable goods) for the Free Imports scenario is compensated by a slightly lower Limited Imports total in non-manufacturing yielding only minor projection differentials. For 1985 non-energy projections the Free Imports projection is 10 thousand higher than the Limited Imports projection. This differential is attributed almost entirely to the durable goods sector. Within this sector the princi-

Table 4.9.7A

Direct Energy STP Employment Projections
Free Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	127981	32248	160229	81768	241997
2	manufacturing	10400	6516	16916	13434	30350
3	nondurables	10400	6516	16916	13434	30350
4	textiles	0	0	0	0	0
5	paper	0	0	0	0	0
6	chemicals	0	0	0	0	0
7	petroleum	10400	6516	16916	13434	30350
8	other nondurables	0	0	0	0	0
9	durables	0	0	0	0	0
10	primary metals	0	0	0	0	0
11	mach. except electric	0	0	0	0	0
12	electrical mach.	0	0	0	0	0
13	transportation	0	0	0	0	0
14	instruments	0	0	0	0	0
15	other durables	0	0	0	0	0
16	non-manufacturing	117581	25732	143313	68333	211646
17	mining	1551	417	1968	981	2949
18	petroleum extraction	18374	21382	39756	17146	56902
19	other mining	0	0	0	0	0
20	construction	59600	0	59600	24600	84200
21	communications	0	0	0	0	0
22	elec. and gas utilities	38056	3933	41990	25606	67595
23	research and dev.	0	0	0	0	0
24	eng. and arch. services	0	0	0	0	0
25	other non-manufacturing	0	0	0	0	0

Table 4.9.7B

Indirect Energy STP Employment Projections
Free Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	37226	8261	45487	35882	81369
2	manufacturing	28961	5156	34116	24592	58708
3	nondurables	4961	2248	7229	5727	12957
4	textiles	33	10	43	67	110
5	paper	169	55	225	280	505
6	chemicals	1849	1675	3524	3231	6756
7	petroleum	117	73	191	151	342
8	other nondurables	2812	434	3246	1997	5244
9	durables	23979	2988	26867	18864	45752
10	primary metals	2982	1125	4107	3123	7230
11	mach. except electric	8470	551	9021	5747	14769
12	electrical mach.	6262	472	6734	4303	11037
13	transportation	853	56	910	421	1330
14	instruments	1466	255	1721	1471	3192
15	other durables	3945	448	4394	3800	8194
16	non-manufacturing	8266	3105	11370	11290	22660
17	mining	289	252	541	229	770
18	petroleum extraction	264	307	572	246	818
19	other mining	62	31	94	70	163
20	construction	255	2	257	167	424
21	communications	737	40	777	612	1388
22	elec. and gas utilities	4[illegible]	47	497	304	800
23	research and dev.	39	79	118	55	173
24	eng. and arch. services	2980	274	3255	3274	6528
25	other non-manufacturing	3190	2071	5261	6334	11595

Table 4.9.7C

Non-Energy STP Employment Projections
Free Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1086306	338174	1424480	1201111	2625591
2	manufacturing	665736	134829	800565	632179	1432743
3	nondurables	123706	71555	195260	193699	388959
4	textiles	9487	2381	11868	16925	28793
5	paper	9994	3335	13330	16959	30289
6	chemicals	46210	47176	93387	85270	178657
7	petroleum	0	0	0	0	0
8	other nondurables	58014	18662	76676	74545	151221
9	durables	542030	63274	605304	438479	1043764
10	primary metals	31492	11546	43038	32600	75636
11	mach. except electric	136540	12396	148937	124622	273558
12	electrical mach.	157949	12447	170396	126496	296894
13	transportation	122987	9806	132793	64029	196822
14	instruments	30729	7674	38403	33851	72254
15	other durables	62332	9205	71537	56879	128416
16	non-manufacturing	420571	203345	623916	568932	1192848
17	mining	2357	2256	4614	1922	6536
18	petroleum extraction	0	0	0	0	0
19	other mining	1375	696	2071	1542	3613
20	construction	86546	3095	89641	68319	157960
21	communications	48247	2724	50971	33442	84413
22	elec. and gas utilities	0	0	0	0	0
23	research and dev.	11900	24360	36260	17070	53330
24	eng. and arch. services	133655	12307	145962	146806	292768
25	other non-manufacturing	136490	157905	294396	299831	594227

Table 4.9.7D

Total STP Employment Projections
Free Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1251514	378663	1630196	1316760	2946956
		25	19	23	22	23
2	manufacturing	705096	146501	851597	670204	1521802
		20	10	16	19	19
3	nondurables	139087	80318	219405	212861	432266
		10	6	8	16	12
4	textiles	9520	2391	11911	16992	28903
		7	9	7	17	13
5	paper	10164	3390	13554	17239	30794
		7	6	5	17	11
6	chemicals	48060	48851	96911	88502	185413
		16	8	12	17	14
7	petroleum	10517	6589	17107	13586	30692
		9	6	6	4	6
8	other nondurables	60826	19096	79923	76542	156465
		6	0	5	16	10
9	durables	566009	66162	632192	457344	1089535
		23	16	22	21	22
10	primary metals	34474	12671	47145	35923	83068
		29	19	26	29	27
11	mach. except electric	145011	12947	157958	130369	288327
		45	28	43	29	36
12	electrical mach.	164211	12919	177131	130801	307931
		11	9	11	16	13
13	transportation	123840	9862	133702	64450	198152
		12	13	12	15	13
14	instruments	32195	8129	40324	35122	75446
		7	19	9	20	14
15	other durables	66277	9654	75931	60679	136610
		45	9	39	20	30
16	non-manufacturing	546417	232182	778599	648555	1427154
		26	22	25	21	23
17	mining	4196	2927	7123	3132	10255
		2	-4	-0	5	1
18	petroleum extraction	18638	21689	40327	17393	57720
		26	25	26	30	27
19	other mining	1436	727	2165	1611	3776
		1	-3	-0	1	0
20	construction	146401	3097	149499	93086	242584
		62	6	66	58	71
21	communications	48984	2764	51748	34054	85801
		13	6	12	16	14
22	elec. and gas utilities	38506	3980	42486	25909	66395
		21	12	20	20	20
23	research and dev.	11938	24439	36377	17126	53503
		-1	4	2	-1	1
24	eng. and arch. services	136635	12582	149217	150080	299297
		18	9	17	6	12
25	other non-manufacturing	139680	159977	299657	306165	605822
		25	34	30	30	30

Table 4.9.8A

Direct Energy S&E Employment Projections
Limited Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	119650	26887	146537	73792	220329
2	manufacturing	8769	5360	14129	12051	26180
3	nondurables	8769	5360	14129	12051	26180
4	textiles	0	0	0	0	0
5	paper	0	0	0	0	0
6	chemicals	0	0	0	0	0
7	petroleum	8769	5360	14129	12051	26180
8	other nondurables	0	0	0	0	0
9	durables	0	0	0	0	0
10	primary metals	0	0	0	0	0
11	mach. except electric	0	0	0	0	0
12	electrical mach.	0	0	0	0	0
13	transportation	0	0	0	0	0
14	instruments	0	0	0	0	0
15	other durables	0	0	0	0	0
16	non-manufacturing	110881	21527	132407	61741	194149
17	mining	1541	402	1944	971	2915
18	petroleum extraction	15335	17660	32994	13520	46514
19	other mining	0	0	0	0	0
20	construction	59600	0	59600	24100	83700
21	communications	0	0	0	0	0
22	elec. and gas utilities	34405	3465	37870	23150	61020
23	research and dev.	0	0	0	0	0
24	eng. and arch. services	0	0	0	0	0
25	other non-manufacturing	0	0	0	0	0

Table 4.9.8B

Indirect Energy S&E Employment Projections
Limited Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	36876	8136	45014	35540	80554
2	manufacturing	28999	5199	34199	24712	58910
3	nondurables	5054	2331	7385	5870	13255
4	textiles	33	10	44	67	111
5	paper	167	55	222	277	499
6	chemicals	1962	1780	3742	3421	7163
7	petroleum	93	57	149	127	276
8	other nondurables	2799	430	3229	1977	5206
9	durables	23946	2868	26814	18842	45656
10	primary metals	2910	1096	4005	3052	7057
11	mach. except electric	8639	559	9198	5881	15079
12	electrical mach.	6104	458	6561	4186	10747
13	transportation	860	57	916	424	1340
14	instruments	1388	241	1628	1393	3021
15	other durables	4046	458	4504	3907	8411
16	non-manufacturing	7879	2937	10815	10829	21644
17	mining	279	246	525	222	747
18	petroleum extraction	203	233	436	179	615
19	other mining	64	33	97	72	169
20	construction	254	2	256	166	422
21	communications	719	39	758	592	1349
22	elec. and gas utilities	316	34	349	216	565
23	research and dev.	38	78	116	54	170
24	eng. and arch. services	2913	269	3182	3206	6388
25	other non-manufacturing	3093	2003	5096	6123	11219

Table 4.9.8C

Non-Energy STP Employment Projections
Limited Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1081532	338428	1419961	1196863	2616824
2	manufacturing	661653	134135	795788	629067	1424855
3	nondurables	123503	71318	194821	193329	388150
4	textiles	9557	2389	11946	17014	28960
5	paper	9878	3293	13171	16741	29912
6	chemicals	45718	46790	92508	84460	176968
7	petroleum	0	0	0	0	0
8	other nondurables	58350	18846	77196	75115	152311
9	durables	538150	62817	600967	435738	1036705
10	primary metals	31323	11486	42809	32654	75463
11	mach. except electric	136340	12370	148710	124714	273424
12	electrical mach.	157945	12419	170365	125929	296294
13	transportation	120122	9527	129649	62400	192049
14	instruments	30764	7868	38632	33700	72331
15	other durables	61656	9146	70802	56343	127145
16	non-manufacturing	419879	204294	624173	567796	1191969
17	mining	2407	2306	4713	1963	6675
18	petroleum extraction	0	0	0	0	0
19	other mining	1367	692	2058	1532	3591
20	construction	87092	3122	90214	68464	158678
21	communications	48156	2720	50876	33305	84180
22	elec. and gas utilities	0	0	0	0	0
23	research and dev.	11947	24455	36401	17116	53517
24	eng. and arch. services	132766	12253	145019	146077	291096
25	other non-manufacturing	136145	158747	294892	299340	594231

Table 4.9.8D

Total STP Employment Projections
Limited Imports Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1238060	373451	1611511	1306196	2917707
		23	18	22	21	21
2	manufacturing	699422	144694	844116	665830	1509946
		19	9	17	19	18
3	nondurables	137326	79009	216336	211249	427585
		8	4	7	15	11
4	textiles	9591	2399	11989	17081	29070
		8	10	8	17	13
5	paper	10045	3348	13392	17018	30410
		5	-1	4	16	10
6	chemicals	47680	48570	96250	87880	184131
		15	8	11	16	13
7	petroleum	8862	5417	14279	12178	26457
		-8	-13	-10	-7	-9
8	other nondurables	61149	19276	80425	77092	157517
		7	1	5	17	11
9	durables	562095	65685	627780	454581	1082361
		22	15	21	20	21
10	primary metals	34232	12582	46814	35705	82519
		28	19	25	28	26
11	mach. except electric	144980	12929	157908	130595	288503
		45	28	43	29	37
12	electrical mach.	164049	12877	176926	130114	307041
		11	9	11	15	12
13	transportation	120981	9584	130565	62824	193369
		9	9	9	12	10
14	instruments	32152	8108	40260	35093	75353
		7	19	9	19	14
15	other durables	65702	9605	75306	60250	135556
		44	8	38	20	29
16	non-manufacturing	538639	228757	767396	640366	1407762
		24	21	23	19	21
17	mining	4227	2954	7181	3156	10337
		3	-3	1	6	2
18	petroleum extraction	15537	17893	33430	13699	47129
		5	3	4	2	4
19	other mining	1431	724	2155	1604	3760
		1	-3	-1	0	-0
20	construction	146946	3124	150070	92730	242800
		83	9	80	57	71
21	communications	48875	2759	51633	33896	85530
		13	5	12	17	14
22	elec. and gas utilities	34721	3498	38219	23366	61585
		9	-1	8	8	8
23	research and dev.	11985	24532	36517	17170	53688
		-1	4	3	-1	2
24	eng. and arch. services	135680	12522	148202	149282	297484
		17	9	16	8	12
25	other non-manufacturing	139237	160751	299988	305462	605450
		25	35	30	30	30

Table 4.9.9A

Direct Energy STP Employment Projections
Limited Imports/Synthetics Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	121508	27342	148849	75302	224151
2	manufacturing	8473	5165	13638	11718	25357
3	nondurables	8473	5165	13638	11718	25357
4	textiles	0	0	0	0	0
5	paper	0	0	0	0	0
6	chemicals	0	0	0	0	0
7	petroleum	6473	5165	13638	11718	25357
8	other nondurables	0	0	0	0	0
9	durables	0	0	0	0	0
10	primary metals	0	0	0	0	0
11	mach. except electric	0	0	0	0	0
12	electrical mach.	0	0	0	0	0
13	transportation	0	0	0	0	0
14	instruments	0	0	0	0	0
15	other durables	0	0	0	0	0
16	non-manufacturing	113035	22176	135211	63583	198794
17	mining	1527	390	1916	959	2875
18	petroleum extraction	15876	16457	34332	14075	48407
19	other mining	0	0	0	0	0
20	construction	62900	0	62900	26400	89300
21	communications	0	0	0	0	0
22	elec. and gas utilities	32732	3330	36062	22150	58212
23	research and dev.	0	0	0	0	0
24	eng. and arch. services	0	0	0	0	0
25	other non-manufacturing	0	0	0	0	0

Table 4.9.9B

Indirect Energy STP Employment Projections
Limited Imports/Synthetics Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	38267	8160	46427	36493	82920
2	manufacturing	30363	5218	35581	25655	61236
3	nondurables	4931	2215	7146	5652	12798
4	textiles	33	10	43	66	109
5	paper	165	54	219	273	492
6	chemicals	1836	1664	3501	3207	6707
7	petroleum	94	57	151	130	282
8	other nondurables	2803	429	3232	1976	5208
9	durables	25432	3003	28435	20003	48437
10	primary metals	3009	1126	4135	3140	7275
11	mach. except electric	9165	582	9747	6169	15916
12	electrical mach.	6299	473	6772	4313	11086
13	transportation	892	59	951	441	1392
14	instruments	1501	257	1757	1503	3260
15	other durables	4566	506	5072	4436	9508
16	non-manufacturing	7904	2942	10846	10638	21685
17	mining	286	251	538	227	765
18	petroleum extraction	204	237	441	161	621
19	other mining	63	32	95	71	166
20	construction	243	2	245	159	405
21	communications	712	39	751	580	1331
22	elec. and gas utilities	342	36	378	233	611
23	research and dev.	38	77	115	54	169
24	eng. and arch. services	2941	272	3213	3238	6450
25	other non-manufacturing	3075	1996	5071	6095	11166

Table 4.9.9C

Non-Energy STP Employment Projections
Limited Imports/Synthetics Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1075484	339312	1414797	1193001	2607798
2	manufacturing	655821	133331	789152	625284	1414436
3	nondurables	123325	71244	194569	193203	387772
4	textiles	9644	2391	12035	17098	29132
5	paper	9759	3249	13008	16510	29518
6	chemicals	45289	46545	91835	83829	175664
7	petroleum	0	0	0	0	0
8	other nondurables	58633	19059	77692	75767	153458
9	durables	532497	62087	594584	432080	1026664
10	primary metals	30774	11222	41997	31975	73972
11	mach. except electric	135697	12361	148058	124927	272985
12	electrical mach.	157458	12377	169835	125039	294874
13	transportation	116938	9208	126146	60564	186709
14	instruments	30682	7861	38543	33639	72182
15	other durables	60948	9057	70006	55936	125942
16	non-manufacturing	419663	205981	625644	567718	1193362
17	mining	2295	2199	4494	1872	6366
18	petroleum extraction	0	0	0	0	0
19	other mining	1351	684	2035	1515	3550
20	construction	87177	3118	90295	68158	158453
21	communications	48235	2725	50959	33326	84285
22	elec. and gas utilities	0	0	0	0	0
23	research and dev.	11973	24508	36482	17142	53623
24	eng. and arch. services	132407	12229	144636	145767	298404
25	other non-manufacturing	136224	160519	296743	299938	596681

Table 4.9.9b

Total STP Employment Projections
Limited Imports/Synthetics Scenario--1980

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1235259	374814	1610073	1304796	2914869
		23	18	22	21	21
2	manufacturing	694657	143714	838372	662657	1501028
		18	8	16	18	17
3	nondurables	136728	78625	215353	210574	425927
		8	4	6	14	10
4	textiles	9677	2401	12078	17164	29242
		9	10	9	18	14
5	paper	9924	3303	13226	16783	30010
		4	-2	2	14	9
6	chemicals	47126	48210	95335	87036	182371
		13	7	10	15	12
7	petroleum	8567	5223	13790	11848	25638
		-11	-16	-13	-10	-12
8	other nondurables	61435	19488	80924	77742	158666
		7	2	6	18	11
9	durables	557929	65090	623019	452083	1075102
		21	14	20	20	20
10	primary metals	33783	12349	46132	35115	81247
		26	16	23	26	25
11	mach. except electric	144862	12943	157805	131097	288902
		45	28	43	30	37
12	electrical mach.	163757	12850	176607	129353	305960
		11	9	10	14	12
13	transportation	117830	9267	127097	61004	188101
		6	6	6	9	7
14	instruments	32183	8118	40300	35142	75442
		7	19	9	20	14
15	other durables	65515	9563	75078	60372	135450
		44	8	38	20	29
16	non-manufacturing	540602	231100	771701	642139	1413841
		25	22	24	20	22
17	mining	4108	2840	6948	3058	10006
		0	-6	-3	3	-1
18	petroleum extraction	16079	18694	34773	14255	49028
		9	8	8	6	8
19	other mining	1415	716	2130	1586	3716
		-0	-4	-2	-1	-1
20	construction	150320	3120	153440	94718	248158
		87	9	84	60	74
21	communications	48947	2763	51710	33906	85616
		13	6	12	17	14
22	elec. and gas utilities	33074	3366	36440	22383	58822
		4	-5	3	4	3
23	research and dev.	12011	24585	36597	17196	53792
		-1	5	3	-1	2
24	eng. and arch. services	135348	12501	147849	149005	296854
		16	8	16	8	12
25	other non-manufacturing	139299	162515	301814	306033	607848
		25	37	31	30	30

Table 4.9.10A

Direct Energy STP Employment Projections
Free Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	148053	34555	182608	92979	275588
2	manufacturing	12519	7433	19953	15620	35573
3	nondurables	12519	7433	19953	15620	35573
4	textiles	0	0	0	0	0
5	paper	0	0	0	0	0
6	chemicals	0	0	0	0	0
7	petroleum	12519	7433	19953	15620	35573
8	other nondurables	0	0	0	0	0
9	durables	0	0	0	0	0
10	primary metals	0	0	0	0	0
11	mach. except electric	0	0	0	0	0
12	electrical mach.	0	0	0	0	0
13	transportation	0	0	0	0	0
14	instruments	0	0	0	0	0
15	other durables	0	0	0	0	0
16	non-manufacturing	135534	27122	162656	77359	240015
17	mining	2074	498	2572	1168	3740
18	petroleum extraction	20164	21949	42114	18527	60641
19	other mining	0	0	0	0	0
20	construction	68100	0	68100	28700	96800
21	communications	0	0	0	0	0
22	elec. and gas utilities	45195	4675	49870	28964	78834
23	research and dev.	0	0	0	0	0
24	eng. and arch. services	0	0	0	0	0
25	other non-manufacturing	0	0	0	0	0

Table 4.9.10B

Indirect Energy STP Employment Projections
Free Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	37774	8798	46571	39467	86039
2	manufacturing	26382	5349	33731	26316	60047
3	nondurables	4772	2287	7059	6124	13183
4	textiles	35	11	46	77	123
5	paper	177	56	233	317	550
6	chemicals	2006	1746	3753	3640	7393
7	petroleum	120	71	191	150	341
8	other nondurables	2433	403	2836	1940	4776
9	durables	23609	3062	26671	20192	46864
10	primary metals	3181	1129	4309	3169	7478
11	mach. except electric	6759	563	7322	5497	12820
12	electrical mach.	6543	524	7067	4623	11690
13	transportation	825	56	880	420	1300
14	instruments	1572	301	1873	1732	3605
15	other durables	4730	490	5220	4752	9972
16	non-manufacturing	9392	3449	12841	13151	25992
17	mining	309	248	558	247	804
18	petroleum extraction	273	297	571	251	822
19	other mining	65	32	97	73	170
20	construction	329	3	331	224	555
21	communications	796	41	837	706	1543
22	elec. and gas utilities	450	48	497	290	788
23	research and dev.	42	86	127	62	189
24	eng. and arch. services	3380	284	3664	3690	7353
25	other non-manufacturing	3748	2410	6158	7609	13767

Table 4.9.10C

Non-Energy STP Employment Projections
Free Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1214492	385676	1600168	1414972	3015141
2	manufacturing	697888	141741	839629	710127	1549756
3	nondurables	129419	72127	201546	212015	413561
4	textiles	9862	2535	12397	18845	31242
5	paper	10617	3394	14011	19422	33433
6	chemicals	49213	47636	96848	91273	188121
7	petroleum	0	0	0	0	0
8	other nondurables	59727	18562	78289	82476	160765
9	durables	568469	69614	638083	498112	1136195
10	primary metals	35551	12319	47870	35549	83418
11	mach. except electric	133140	14744	147885	146305	294189
12	electrical mach.	175317	14170	189486	145226	334713
13	transportation	121442	9814	131256	64660	195916
14	instruments	32836	8953	41789	38965	80754
15	other durables	70183	9614	79797	67408	147205
16	non-manufacturing	516405	244135	760540	704845	1465385
17	mining	2606	2313	4919	2169	7088
18	petroleum extraction	0	0	0	0	0
19	other mining	1456	714	2171	1628	3798
20	construction	112940	3806	116746	89272	206018
21	communications	53991	2904	56895	38752	95647
22	elec. and gas utilities	0	0	0	0	0
23	research and dev.	12940	26724	39663	19221	58884
24	eng. and arch. services	169749	14263	184012	185312	369324
25	other non-manufacturing	162723	193411	356134	368492	724626

Table 4.9.10D

Total STP Employment Projections
Free Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1400119	429228	1829348	1547419	3376767
		39	35	38	43	41
2	manufacturing	738789	154523	893312	752064	1645376
		26	16	24	34	28
3	nondurables	146711	81847	228556	233760	462317
		16	8	13	27	19
4	textiles	9897	2546	12444	18922	31365
		11	17	12	30	22
5	paper	10794	3450	14244	19739	33983
		13	2	10	34	23
6	chemicals	51219	49382	100601	94912	195513
		23	10	16	25	20
7	petroleum	12639	7504	20144	15770	35914
		31	20	27	20	24
8	other nondurables	62160	18965	81125	84416	165542
		8	-1	6	28	16
9	durables	592078	72676	664754	518304	1183058
		28	28	28	37	32
10	primary metals	38731	13446	52179	38717	90896
		45	27	40	39	39
11	mach. except electric	139899	15368	155267	151742	307009
		40	52	41	50	45
12	electrical mach.	181860	14693	196553	149849	346402
		23	24	23	32	27
13	transportation	122267	9870	132137	65080	197216
		10	13	11	16	12
14	instruments	34408	9254	43662	40696	84358
		14	36	18	39	27
15	other durables	74913	10103	85016	72160	157176
		64	14	56	43	50
16	non-manufacturing	661330	274705	936036	795355	1731391
		53	45	50	48	49
17	mining	4990	3058	8048	3584	11632
		22	1	13	20	15
18	petroleum extraction	20438	22247	42684	18778	61462
		38	28	33	40	35
19	other mining	1521	746	2268	1700	3968
		7	-0	5	6	5
20	construction	181368	3809	185177	118196	303373
		126	33	123	100	113
21	communications	54787	2946	57733	39458	97190
		26	13	25	36	30
22	elec. and gas utilities	45645	4723	50367	29254	79622
		43	33	42	36	40
23	research and dev.	12961	26829	39791	19282	59073
		7	14	12	12	12
24	eng. and arch. services	173128	14547	187675	189002	376677
		49	26	47	36	41
25	other non-manufacturing	166472	195821	362292	376101	738393
		49	65	57	60	58

Table 4.9.11A

Direct Energy SIP Employment Projections
Limited Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	146629	28909	175539	89125	264663
2	manufacturing	9703	5498	15201	13237	28439
3	nondurables	9703	5498	15201	13237	28439
4	textiles	0	0	0	0	0
5	paper	0	0	0	0	0
6	chemicals	0	0	0	0	0
7	petroleum	9703	5498	15201	13237	28439
8	other nondurables	0	0	0	0	0
9	durables	0	0	0	0	0
10	primary metals	0	0	0	0	0
11	mach. except electric	0	0	0	0	0
12	electrical mach.	0	0	0	0	0
13	transportation	0	0	0	0	0
14	instruments	0	0	0	0	0
15	other durables	0	0	0	0	0
16	non-manufacturing	136927	23411	160337	75887	236225
17	mining	1965	477	2441	1130	3571
18	petroleum extraction	17390	18804	36194	16091	52285
19	other mining	0	0	0	0	0
20	construction	76300	0	76300	31400	107700
21	communications	0	0	0	0	0
22	elec. and gas utilities	41272	4130	45402	27267	72668
23	research and dev.	0	0	0	0	0
24	eng. and arch. services	0	0	0	0	0
25	other non-manufacturing	0	0	0	0	0

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Table 4.9.11B

Indirect Energy SIP Employment Projections
Limited Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	38399	8796	47195	19776	66971
2	manufacturing	29463	5528	34991	27238	62229
3	nondurables	4849	2357	7206	6275	13481
4	textiles	36	11	48	79	126
5	paper	174	55	229	313	541
6	chemicals	2118	1841	3959	3833	7793
7	petroleum	88	50	139	121	259
8	other nondurables	2432	400	2831	1930	4761
9	durables	24615	3171	27786	20963	48748
10	primary metals	3270	1157	4427	3249	7676
11	mach. except electric	6861	576	7437	5578	13015
12	electrical mach.	7128	569	7698	4980	12677
13	transportation	833	56	889	424	1313
14	instruments	1614	306	1920	1776	3696
15	other durables	4909	506	5415	4956	10371
16	non-manufacturing	8936	3268	12204	12537	24741
17	mining	319	260	579	256	835
18	petroleum extraction	220	238	457	203	660
19	other mining	68	33	101	76	177
20	construction	324	3	327	221	548
21	communications	769	40	809	668	1477
22	elec. and gas utilities	334	36	369	224	593
23	research and dev.	41	84	125	61	186
24	eng. and arch. services	3277	275	3553	3581	7134
25	other non-manufacturing	3585	2299	5884	7247	13131

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Table 4.9.11C

Non-Energy STP Employment Projections
Limited Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1209023	306437	1595461	1409751	3005211
2	manufacturing	693394	140954	834348	705940	1540288
3	nondurables	129303	71902	201205	211635	412841
4	textiles	9948	2542	12491	18948	31438
5	paper	10466	3342	13807	19115	32923
6	chemicals	48677	47233	95910	90327	186237
7	petroleum	0	0	0	0	0
8	other nondurables	60212	10705	70997	83245	162242
9	durables	564091	69052	633143	494305	1127447
10	primary metals	35358	12197	47555	35232	82787
11	mach. except electric	132905	14724	147629	145993	293622
12	electrical mach.	175067	14133	109201	144455	333656
13	transportation	110602	9536	120138	63016	191154
14	instruments	32796	8941	41737	38940	80677
15	other durables	69363	9519	78882	66669	145551
16	non-manufacturing	515629	245484	761113	703811	1464924
17	mining	2618	2323	4941	2179	7120
18	petroleum extraction	0	0	0	0	0
19	other mining	1446	709	2156	1616	3772
20	construction	114040	3846	117886	90405	208291
21	communications	53865	2899	56764	38566	95330
22	elec. and gas utilities	0	0	0	0	0
23	research and dev.	12971	26804	39776	19265	59040
24	eng. and arch. services	168674	14174	182848	184302	367150
25	other non-manufacturing	162014	194728	356742	367477	724219

Table 4.9.11D

Total STP Employment Projections
Limited Imports Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1394652	424143	1818194	1538651	3356845
		39	34	38	42	40
2	manufacturing	732560	151986	884540	746415	1630956
		24	14	23	33	27
3	nondurables	143854	79758	223612	231148	454760
		13	5	10	26	18
4	textiles	9985	2553	12538	19026	31565
		12	17	13	31	23
5	paper	10640	3397	14036	19428	33464
		12	0	9	32	21
6	chemicals	50795	49075	99870	94161	194030
		22	9	15	24	20
7	petroleum	9791	5549	15340	13358	28698
		1	-11	-3	2	-1
8	other nondurables	62644	19185	81828	85175	167003
		9	0	7	29	17
9	durables	588706	72222	660928	515267	1176196
		28	27	27	36	31
10	primary metals	38628	13354	51982	38480	90463
		44	26	39	38	39
11	mach. except electric	139766	15300	155066	151571	306637
		39	52	41	50	45
12	electrical mach.	182196	14703	196899	149435	346333
		23	24	23	32	27
13	transportation	119436	9592	129028	63440	192468
		8	10	8	13	10
14	instruments	34409	9247	43657	40716	84372
		14	36	18	39	27
15	other durables	74271	10026	84297	71626	155923
		63	13	55	42	49
16	non-manufacturing	661492	272162	933654	792236	1725890
		53	44	50	48	49
17	mining	4901	3060	7961	3566	11527
		[illegible]	1	12	20	14
18	petroleum extraction	17609	19042	36651	16294	52945
		19	10	14	22	16
19	other mining	1514	743	2257	1692	3949
		7	-1	4	6	5
20	construction	190665	3848	194513	122027	316540
		137	34	134	107	123
21	communications	54634	2939	57573	39234	96007
		26	12	25	36	29
22	elec. and gas utilities	41606	4165	45771	27491	73262
		31	17	29	28	29
23	research and dev.	13012	26089	39901	19325	59226
		8	14	12	12	12
24	eng. and arch. services	171951	14449	186400	187883	374284
		48	25	46	36	41
25	other non-manufacturing	165599	197027	362626	374724	737351
		48	66	57	59	58

Table 4.9.12A

Direct Energy STP Employment Projections
Limited Imports/Synthetics Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	147270	29790	177060	90194	267254
2	manufacturing	9472	5353	14825	12984	27809
3	nondurables	9472	5353	14625	12984	27809
4	textiles	0	0	0	0	0
5	paper	0	0	0	0	0
6	chemicals	0	0	0	0	0
7	petroleum	9472	5353	14625	12984	27809
8	other nondurables	0	0	0	0	0
9	durables	0	0	0	0	0
10	primary metals	0	0	0	0	0
11	mach. except electric	0	0	0	0	0
12	electrical mach.	0	0	0	0	0
13	transportation	0	0	0	0	0
14	instruments	0	0	0	0	0
15	other durables	0	0	0	0	0
16	non-manufacturing	137799	24437	162235	77210	239445
17	mining	1675	459	2334	1097	3431
18	petroleum extraction	18538	20091	38629	17112	55741
19	other mining	0	0	0	0	0
20	construction	78600	0	78600	32900	111500
21	communications	0	0	0	0	0
22	elec. and gas utilities	38786	3887	42673	26101	68774
23	research and dev.	0	0	0	0	0
24	eng. and arch. services	0	0	0	0	0
25	other non-manufacturing	0	0	0	0	0

Table 4.9.12B

Indirect Energy STP Employment Projections
Limited Imports/Synthetics Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	38764	8686	47472	39901	87374
2	manufacturing	29909	5446	35355	27439	62795
3	nondurables	4680	2210	6890	5964	12854
4	textiles	35	11	46	76	122
5	paper	169	53	222	304	526
6	chemicals	1958	1698	3656	3543	7200
7	petroleum	88	50	137	120	257
8	other nondurables	2430	398	2828	1921	4749
9	durables	25230	3236	28465	21475	49940
10	primary metals	3353	1174	4527	3309	7637
11	mach. except electric	7015	589	7603	5687	13291
12	electrical mach.	7229	578	7806	5046	12852
13	transportation	641	57	898	428	1326
14	instruments	1655	312	1967	1620	3788
15	other durables	5137	526	5663	5184	10848
16	non-manufacturing	8875	3242	12117	12462	24579
17	mining	318	260	578	256	835
18	petroleum extraction	212	230	442	196	637
19	other mining	65	32	97	73	170
20	construction	308	2	311	210	521
21	communications	750	39	789	648	1437
22	elec. and gas utilities	351	37	387	238	626
23	research and dev.	40	83	122	59	162
24	eng. and arch. services	3295	277	3572	3600	7172
25	other non-manufacturing	3535	2283	5818	7181	12999

Table 4.9.12C

Non-Energy STP Employment Projections
Limited Imports/Synthetics Scenario--1985

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1205258	388216	1593474	1408278	3001752
2	manufacturing	688862	140212	829074	702671	1531745
3	nondurables	129025	71758	200783	211293	412076
4	textiles	10010	2531	12540	18961	31501
5	paper	10330	3293	13624	18831	32455
6	chemicals	48149	46933	95082	69498	164579
7	petroleum	0	0	0	0	0
8	other nondurables	60536	19001	79537	84004	163541
9	durables	559837	68454	628291	491378	1119669
10	primary metals	34960	11929	46889	34628	81517
11	mach. except electric	132660	14762	147422	146286	293708
12	electrical mach.	175369	14146	189515	144154	333669
13	transportation	115279	9213	124493	61124	185617
14	instruments	32842	8965	41806	19017	60824
15	other durables	68727	9439	78166	66168	144334
16	non-manufacturing	516396	248004	764400	705607	1470007
17	mining	2491	2210	4702	2074	6775
18	petroleum extraction	0	0	0	0	0
19	other mining	1424	698	2122	1591	3713
20	construction	114408	3844	118252	90770	209023
21	communications	53989	2906	56895	38619	95514
22	elec. and gas utilities	0	0	0	0	0
23	research and dev.	13004	26887	39891	19310	59201
24	eng. and arch. services	168563	14165	182728	184194	366922
25	other non-manufacturing	162516	197294	359810	369049	728859

Table 4.9.12D

Total STP Employment Projections
Limited Imports/Synthetics Scenario--1965

		engineers	scientists	engineers and scientists	technicians	total
1	all industries	1391312	426694	1818007	1538373	3356380
		39	35	38	42	40
2	manufacturing	728243	151011	879254	743094	1622349
		24	14	22	32	28
3	nondurables	143177	79321	222498	230241	452739
		13	4	10	25	17
4	textiles	10045	2542	12588	19037	31824
		13	18	14	31	23
5	paper	10500	3347	13848	19135	32981
		10	-1	7	30	19
6	chemicals	50107	48631	98738	93041	191779
		21	8	14	23	18
7	petroleum	9559	5403	14962	13104	28066
		-1	-13	-6	-0	-3
8	other nondurables	62966	19399	82365	65924	148289
		10	2	8	30	18
9	durables	585067	71690	656757	512853	1169609
		27	28	27	36	30
10	primary metals	38314	13103	51417	37938	89354
		43	23	38	36	37
11	mach. except electric	139675	15351	155025	151974	306999
		39	52	41	51	45
12	electrical mach.	182597	14724	197321	149199	346521
		23	25	23	32	27
13	transportation	116121	9270	125391	61552	188942
		5	6	5	10	7
14	instruments	34497	9277	43774	40838	84612
		14	36	18	39	28
15	other durables	73864	9986	83829	71353	155182
		62	12	54	42	48
16	non-manufacturing	663069	275683	938752	795279	1734031
		55	45	51	48	50
17	mining	4684	2930	7614	3427	11041
		14	-3	7	15	9
18	petroleum extraction	[illegible]	20320	39070	17308	56378
		27	17	22	29	24
19	other mining	1489	730	2219	1664	3884
		5	-2	2	4	3
20	construction	193317	3846	197163	123881	321044
		141	34	137	110	128
21	communications	54739	2945	57684	39266	96951
		26	13	25	36	29
22	elec. and gas utilities	39137	3923	43060	26339	69400
		23	11	22	22	22
23	research and dev.	13044	26970	40013	19369	59382
		8	15	13	12	12
24	eng. and arch. services	171858	14442	186300	187795	374095
		48	25	46	36	41
25	other non-manufacturing	166051	199577	365628	376230	741858
		49	68	58	60	59

pal actors are transportation equipment and other durable goods.

The percentage change in total industry employment is only one percentage point higher for the Free Imports scenario in 1985--41 per cent versus 40 per cent for the Limited Imports scenario. This small difference in total employments masks substantial intraindustry changes across scenarios. Petroleum products, for example, drops from a 24 per cent change under Free Imports to a minus 1 per cent change under limited imports in 1985; petroleum extraction, from 35 per cent to 16 per cent; electric and gas utilities, from 40 per cent to 29 per cent. Construction employment, on the other hand, rises subtantially under all scenarios: 113 to 126 per cent.

To summarize, the above analysis shows that almost all of the variance across scenarios in CAC/BLS projection differentials and in percentage growth in total employment by occupation and industry can be attributed to a few occupations and industries, each of which is closely tied to energy production. Furthermore, this analysis of detailed occupation and industry shows that the near equality of employment projections across scenarios masks substantial intra-occupational and intra-industry differentials. One important direct energy industry, however, is consistently high: Construction. With respect to this component of STP worker demand, it should be noted that these high levels of energy

facility construction employment are expected to remain high throughout the decade of the 1980's and into the 1990's. Bechtel projections are based on a long-range program of energy facility construction, not a one-shot build-up of energy production capacity.

4.10 - Comparison with Other Studies

4.10.1 - Introduction

This section compares projections prepared with CAC's STP coefficients and I/O model to results from other studies of occupational employment. It should be noted that references to "BLS projections" in Section 4.10.2 are to projections prepared by BLS. Previous sections have referred to "BLS-data" or "BLS data base" projections. These were projections prepared by CAC using BLS data.

No two of the studies discussed are completely comparable. Differences result from definitions, assumptions, and methods as well as data. In each case the major sources of discrepancies are identified to facilitate comparison, but also to suggest the limits of comparability.

4.10.2 - Bureau of Labor Statistics Projections

BLS published two different sets of occupational employment projections in late 1976.[2] The first of these

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[2] U.S. Bureau of Labor Statistics, <u>Occupational</u>

(presented in <u>Bulletin 1918</u>), prepared for use in conjunction with BLS's Occupational Outlock program, uses 241 occupational categories. The second uses BLS's industry-occupation matrix, with more than 400 occupations (November 1976 <u>Monthly Labor Review</u>). In addition to differences in occupational aggregation, the projections differ in occupational definitions within common occupational titles. Both sets of projections are for the total economy, that is, private and non-private sectors. The projections use essentially the same methodology, briefly:[3]

1. Future labor force is derived from Bureau of the Census population projections, using "expected" labor force participation rates for major demographic groups.

2. After subtracting unemployed persons from the above (by assuming future unemployment rates), employed persons are multiplied by a projection of output per worker. These output/worker estimates are based on trends in productivity and weekly hours of work. This determines GNP.

3. GNP is classified by consumer expenditure category (final demand pattern).

<u>Projections and Training Data</u> (Bulletin 1918), Division of Occupational Outlook, 1976 and Max L. Carey, "Revised Occupational Projections to 1985," <u>Monthly Labor Review</u>, Division of Occupational Outlook, November, 1976.

[3] <u>BLS Bulletin 1918</u>, Appendix A, pp. 66-67. See also Bulletins 1809 and 1831, March, 1976 and the November, 1976 issue of the <u>Monthly Labor Review</u> for detail.

4. The final demand pattern is multiplied by the BLS's Leontief inverse to obtain total output by industry.

5. Estimates of future output per man-hour, based on studies of productivity and technological trends for each industry, are used to derive industry employment.

6. The industry employment projections are compared with projections from regression models. Where there are inconsistencies between the two, they "adjust the projections accordingly".

7. Final employment projections are applied to the projected patterns of occupational structure for each industry using "an industry-occupation matrix". Employment is then aggregated by 400 occupational categories.

Differences between the two sets of projections are substantial. The Bulletin projections include some teachers allocated to their specialties, while the Monthly Labor Review projections classify them as teachers. This appears to be the main reason for differences.

Since the Monthly Labor Review projections utilize the industry-occupation matrix which CAC used to obtain STP coefficients for non-surveyed industries, CAC results are compared to the Monthly Labor Review projections. Projections for the CAC Limited Import scenario employ the same final demand pattern as the BLS "basic scenario for recovery from the 1974-75 recession". BLS also prepared projections for two alternative scenarios corresponding to 1) an "alternate policy" and 2) a "slower recovery version". Occupational projections are reported to be "virtually the same, regardless of the scenario" and only results for the basic version have been published.

Differences between BLS's basic version projections and CAC's Limited Imports scenario arise from three sources. First, although identical final demand patterns are used, different I/O models result in different total outputs for industries. Second, the BLS has employed a number of internal studies of particular industries, using regression analysis, to project 1985 employment/output relations. CAC's 1985 employment output relations are determined by surveys of employers for the energy-related sectors of the model. Third, the BLS projections include the non-private economy, so base year (1974) employment estimates differ since the CAC projections are for the private economy only--government is excluded. In order to improve the comparability of coverage, the BLS government sector has been estimated by CAC by subtracting the BLS data base Limited Imports employment projections from the BLS Monthly Labor Review estimates and this difference, representing government employment, has been added, occupation by occupation, to the CAC Limited Imports estimates to develop a CAC projection of total private and government STP employment. It should be remembered that the CAC projections related to the private economy but included STP in government energy enterprises, and that science and engineers teachers are excluded

from the STP definition in both the CAC and BLS projections. It should be recognized that this projection is the sum of the CAC Limited Imports projections and a projection of government employment estimated by CAC using BLS data. CAC did not prepare projections of government STP employment and the estimates of total STP employment are at best approximate.

Table 4.10.2.1 shows base year employment, projected 1985 requirements, and growth in requirements for STP under the CAC Limited Imports Scenario and the BLS "basic version" scenario.

Table 4.10.2.1

CAC and BLS Projections for Identical Final Demand Patterns, 1985

(number in thousands)

	1974 BLS		CAC Limited Imports			BLS	% Difference
	Private	Total	1985 Private	1985 Government	1985 Total	1985 Total	CAC over BLS
Engineers	1004	1168	1393	189.3	1582	1460	8.4
Chemical	49	50	67	0.3	67	62	8.1
Civil	129	167	201	54.7	256	225	13.8
Electrical	263	287	372	23.2	395	374	5.6
Industrial	173	193	228	25.7	253	224	12.9
Mechanical	171	183	238	6.9	245	234	4.7
Aero-astronautic	44	51	49	9.2	58	57	1.8
Other	176	237	238	69.3	308	284	8.5
Life and Physical Scientists	176	229	230	54.7	285	282	1.1
Chemists	107	121	132	17.9	150	145	3.4
Biological	19	32	28	14.4	42	41	2.4
Physicists & Astronomers	15	22	21	9.3	30	29	3.4
Geologists	24	27	29	3.7	32	37	-13.5
n.e.c.	10	26	20	10.4	31	30	3.3
Mathematicians	5	np	8	np	np	np	np
Statisticians	15	23	21	9.1	30	30	0.0
Computer Specialists	268	308	395	77.2	472	476	-0.8
Technicians	812	915	1144	156.7	1310	1277	2.6
Agriculture, Biology, except health	34	42	42	7.8	50	49	2.0
Chemical	76	83	99	9.6	108	104	3.8
Surveyors	63	73	78	25.2	104	116	-10.4
Drafters	284	298	432	14.8	446	423	5.4
Engineer & science, n.e.c.	355	420	493	109.3	602	585	2.9

np = not projected

For all of the engineering specialties for which estimates are available, the CAC projection is higher than the BLS projections, although the differences are greater than 10 per cent only for Civil and Industrial Engineers. For scientists, the projections are quite close, except for Geologists for whom CAC projects about 14 per cent lower requirements than BLS. The projections for technicians are reasonably close, except that CAC projects requirements that are about 10 per cent lower than those projected by BLS for Surveyors.

4.10.3 - National Planning Association Study

The NPA study projected manpower requirements through 1990 for a number of activities in energy-related industries.[4] In terms of composition, the scenario reflects a "business as usual" government policy. Imports of crude oil rise to slightly more than one-half of oil use during the projection period, 1977-1990. No solar, geothermal, coal, or synthetics development is included although demonstration coal synthetics plants begin to come on-line by 1985. Shale oil is projected to supply almost 2 per cent of oil produc-

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[4] I. Gutmanis et al., Study of Manpower Requirements by Occupation for Alternative Technologies in the Energy-Related Industries, U. S. 1970-1990, National Planning Association, Washington, D. C., August 1974.

tion by 1985.

The manpower requirements projections are given for this scenario's "direct" impact only. The projections should be considered a "maximum" case, since no allowance is made for productivity increases. That is, manpower coefficients for each activity are fixed for the projection period.[5]

The scope closely corresponds to the present study's concept of "direct" industries. The NPA study included construction, operations, and maintenance of oil, gas, coal, nuclear, synthetic fuels, shale oil, related transportation, and conversion facilities. Manpower coefficients expressing man-years of a given occupation required to produce a unit (usually Btu's, but units varied by industry) of output with current technology were estimated.

Projected requirements were obtained by multiplying the manpower coefficients by the physical units for each activity in each industry. Activity levels were determined by an FEA-specified scenario dated August 2, 1974. The scenario is termed "low case". That is, the projected energy consumption is considered low at 95 and 112 quadrillion Btu's for 1980 and 1985 respectively. This labelling reflects the

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[5] NPA, op. cit., p. 70.

changing perception of high and low energy use over time. For example, the high energy use scenario (Free Imports) projects use of 99 quadrillion Btu's by 1985.

The difference in scenarios makes comparison rather meaningless. The bulk of energy facilities needed through 1990 are scheduled to be on line by 1980 in the NPA scenario. Thus the level of construction activity in 1980 or 1985 is not comparable to that in any of the CAC scenarios.

Table 4.10.3.1 shows the results for engineers in 1985 for the CAC Free Imports scenario and the NPA scenario. Non-comparability between the studies should be kept in mind in evaluating these results.

Table 4.10.3.1

1985 Free Import Scenario and NPA Scenario

	CAC Construction Indirect	Direct Construction CAC	Direct Construction NPA	Direct Facility O & M CAC	Direct Facility O & M NPA*	CAC O & M Indirect
Engineers						
Chemical	866	1100	249	8198	12515	999
Civil	1565	21600	2180	6934	6328	844
Electrical	6935	24300	672	27572	22536	1751
Industrial	6531	0	53	4479	3505	1558
Metallurgical	1107	0	58	321	1051	121
Mechanical	5917	13500	542	8906	12727	1284
Aeronautical	581	0	np	17	np	84
Mining	217	200	14	2249	1544	60
Petroleum	220	2700	32	13899	9627	31
Other	4763	4700	1292	7378	10511	1178
Nuclear	np	np	38	np	5291	np
Sales	np	np	0	np	3269	np

np: not projected
* less transportation

4.10.4 - NSF/Department of Commerce Study

The CAC energy-related employment projections are not comparable to the current energy-related employment figures obtained by the 1975 Department of Commerce Survey of Scientific and Technical Personnel (form s-280). The purpose of the Commerce survey is to determine the number of STP in each occupation "engaged in all activities relating to the exploration, discovery, extraction, refining, conversion, transportation, transmission, distribution, storage and utilization of (certain) energy sources."

Although almost exactly the same occupational scheme and definitions are used, the purposes, and thus results, are quite different. The CAC projections determine future requirements for STP in activities that are significantly related to the production of energy.

Thus the Commerce survey should include portions of STP across all industries and in any given industry. A Chemical Engineer developing a better automobile ignition battery in the automobile parts industry falls within the Commerce survey scope, as would any scientific or technical employee developing a night-setback thermostat, or improved efficiency air conditioners in the appropriate industries. These types of personnel are not included in the CAC's concept of energy-related. Their activities may not be significant inputs to the production of energy, directly or indirectly.

CAC's projections of energy-related STP will reflect those requirements generated by the construction and operation of energy conversion and related facilities, directly and indirectly. The CAC energy-related requirements will include personnel in industries such as Primary Steel, where the employee's output is not identified by the Commerce study's concept as energy-related, but whose output becomes a significant input to energy production.

Appendix A: Sample Construction

I. Identification of a Universe of Energy-Related Industry Sectors for a Study of Scientific and Technical Manpower Requirements in Energy-Related Industries.

The final universe of industry sectors used in this study is shown in table 1. This list includes all industry sectors that are likely to be substantially affected by a Project Independence or similar scenario. Several methods were used in the determination of this final list. Certain procedures which are described below were used to verify or amplify results. The use of several different approaches to the identification of energy-related industries insured greater objectivity. Throughout this identification process, the knowledge and experience of the primary researchers and others with expertise in energy-related fields was utilized. In all cases the object was to be over-inclusive rather than under-inclusive in the selection of industry sectors for the universe.

TABLE 1

UNIVERSE

SIC	Description
1011	Iron Ores
1021	Copper Ores
1051	Bauxite & Other Aluminum Ores
1081	Metal Mining Services
1094	Uranium-Radium-Vanadium Ores
1111	Anthracite
1211	Bituminous Coal & Lignite
1213	Bituminous Coal & Lignite Mining Services
1311	Crude Petroleum and Natural Gas
1321	Natural Gas Liquids
1381	Drilling Oil and Gas Wells
1382	Oil and Gas Field Exploration Services
1389	Oil & Gas Field Services, N.E.C.
1623	Water, Sewer, Pipeline, Communication and Power Line Construction
1629	Heavy Construction, N.E.C.
281x	Industrial Inorganic Chemicals
2911	Petroleum Refining
3292	Asbestos Products
3293	Gaskets, Packing, and Sealing Devices
3312	Blast Furnaces, Steel Works & Rolling Mills, Primary Iron and Steel
3315	Steel Wire Drawing and Steel Nails & Spikes
3317	Steel Pipe & Tubes
3321	Gray Iron Foundries
3324,3325	Steel Foundries
3331	Primary Smelting and Refining of Copper
3334	Primary Production of Aluminum
3351	Rolling, Drawing, and Extruding of Copper
3353	Aluminum Sheet, Plate, and Foil
3354	Aluminum Extruded Products
3355	Aluminum Rolling & Drawing, N.E.C.
3357	Drawing & Insulating of Nonferrous Wire
3433	Heating Equipment, except Electric and Warm Air Furnaces
3443	Fabricated Plate Products (Boiler Shops)
345x	Screw Machine Products, and Bolts, Nuts, Screws Rivets, and Washers
3494,3498	Pipe, Valves and Fittings
3511	Steam, Gas, and Hydraulic Turbines and Turbine Generator Set Units
3519	Internal Combustion Engines, N.E.C.
3531	Construction Machinery and Equipment

TABLE 1 (cont'd)

3532	Mining Machinery and Equipment, Except Oil Field Machinery and Equipment
3533	Oil Field Machinery and Equipment
3534	Elevators & Moving Stairways
3535	Conveyors and Conveying Equipment
3536	Hoists, Industrial Cranes & Monorail Systems
354x	Metalworking Machinery and Equipment
3561	Pumps and Pumping Equipment
3562	Ball and Roller Bearings
3563	Air and Gas Compressors
3566	Speed Changers, Industrial High Speed Drives, and Gears
3567	Industrial Process Furnaces & Ovens
3568	Mechanical Power Transmission Equip., N.E.C.
3612	Power, Distribution & Specialty Transformers
3613	Switch Gear and Switchboard Apparatus
3621	Motors and Generators
3623	Welding Apparatus, Electric
3811	Engineering, Lab, Scientific, and Research Instruments and Associated Equipment
3822	Automatic Controls for Regulating Residential and Commercial Environments and Appliances
3823	Industrial Instruments for Measurement, Display and Control of Process Variables; and Related Products
3824	Totalizing Fluid Meters and Counting Devices
3829	Measuring and Controlling Devices, N.E.C.
4612	Crude Petroleum Pipelines
4613	Refined Petroleum Pipelines
4922	Natural Gas Transmission
4923	Natural Gas Transmission and Distribution
4924	Natural Gas Distribution
4925	Mixed, Manufactured or Liquefied Petroleum Gas Production and/or Distribution
4931	Electric & Other Services Combined
4932	Gas and Other Services Combined
4939	Combination Utilities, N.E.C.
7391	Research and Development Labs
8911	Engineering, Architectural and Surveying Services
8922	Noncommercial Educational, Scientific, and Research Organizations
9631	Regulation and Administration of Communication, Electric, Gas, and Other Utilities

The research began with broad industry sectors. If these sectors were to be used in forecasting scientific and technical manpower requirements, serious errors could result from the level of aggregation since scientific and technical manpower intensity might vary greatly among a broad industry's sub-sectors. Consequently, broad industry sectors were disaggregated to the level required for the study.

Since industry-specific data was required and most firms span industries, the desired unit of focus was the establishment rather than the firm. To the extent possible, the industry sectors in the final universe correspond to 4-digit SIC codes which describe establishments at the required level. The use of the 4-digit codes provides a common denominator between the CAC model and other models.

To facilitate a detailed explanation, the research methods will be divided into sections, as follows:

A. Formulation of a list of primary energy-related industries.

B. Input coefficients inspection, using a 367-sector input- output model of the U.S. economy [1].

C. Analysis of construction requirements for a Project Independence scenario, based on Bullard and Pilati's 18 broad "high-growth" sectors (out of a total 90-sector economy) [2].

D. Analysis of operations requirements for proposed

energy facilities, based on the Stanford Research Institute's report [4].

Following are the explanations of procedures:

A. Primary Energy-Related Industries

This list (see Table 2) includes the broad categories that would definitely be affected by a Project Independence (PI) scenario. It was necessary to extend this list to include all industries that would be affected both directly and indirectly by a PI scenario. An input-output model of the U.S. economy was used in the identification process. The selection procedure is described in the next section.

B. Input Coefficients Inspection

An input-output model is constructed by dividing the economy into sectors, which are put in matrix format. The horizontal rows of figures show how the output of each sector of the economy is distributed among the others. The vertical columns show how each sector obtains from the others its needed inputs of goods and services.

Input-output coefficients are usually listed as dollar amounts. Detailed input-output models also include input coefficients that show the fraction of dollar input entering the column industry from the row industry. These ratios can be used to calculate secondary demand on the output of the industries that supply, for example, the suppliers of the

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TABLE 2

PRIMARY ENERGY RELATED INDUSTRIES

	Energy-Related Industries	SIC	
1.	Electric Power Generation	491	
		493	partial
2.	Petroleum and Natural Gas Extraction	13	
3.	Petroleum Refining	291	
4.	Pipelines, except Natural Gas	461	
5.	Petroleum (Crude) Pipelines	4612	
6.	Petroleum (Refined) Pipelines	4613	
7.	Natural Gas Production, Transmission, and Distribution	1311	partial
		4922	
		4923	
		4924	
		4925	
8.	Coal Mining	12	
9.	Coal Transportation, Railroad	4011	
10.	Nuclear Fuel Production	1094	
		2819	partial
11.	Steam Engines; Steam, Gas, and Hydraulic Turbine Generator Set Units	3511	
12.	Power, Distribution and Speciality Transformers	3612	
13.	Fabricated Plate Works	3443	partial
14.	Energy-Related Construction	16	partial
15.	Architectural and Engineering Professional Services	8911	
16.	Pipes, Valves, and Fittings	3494	
		3498	
17.	Pumps and Compressors	3561	
		3563	
18.	Motors and Generators	3621	

machine tools industry, and so on through successive outputs and inputs. Thus, given an industry sector, input coefficients can be used to trace the effects of final demand for the products of that industry on every other sector of the economy.

It was decided to analyze the list of primary energy-related industry sectors by the inspection of the input coefficients of those sectors, using the 367-sector input-output tables from <u>Input-Output Structure of the U.S. Economy: 1967</u> [1]. A modified input-output table was constructed with the primary sectors listed horizontally across the top, and industries listed vertically which had input coefficients of .01 or greater for any of the horizontally listed sectors. This matrix was used as one criterion for determining which of the input industries themselves should be included in the universe. By taking into account the size of the input coefficients and the number of appearances of coefficients along a row, a judgment was made about the importance of the input industries. After this process was completed, the analysis was repeated by placing these input industries horizontally across the top of a new matrix. In other words, some of the original input industries became output industries whose inputs were then analyzed as described above.

Such a manual input-output analysis is not as scientifically precise as Bullard and Pilati's input-output analysis

(explained in section C). Input coefficients are traced back only one or two steps, and only relatively large input sectors are taken into consideration; therefore, little is revealed about more subtle indirect effects on the economy. However, since this analysis is based on a 367-sector model of the economy, it provides greater detail than Bullard and Pilati's analysis which is based on a 90-sector model. This type of analysis uncovered several industries which otherwise might not have been included in the universe, and was used throughout the research to amplify results obtained through other methods.

C. Analysis of Construction Requirements for a Project Independence Scenario

The analysis of materials requirements for construction was based on the research of Professors Bullard and Pilati [2]. Their research evaluated direct <u>and indirect</u> requirements for a Project Independence scenario through the use of a linear model of the U.S. economic system. They used the direct materials requirements and the energy facilities' construction schedule that were generated by the Bechtel Energy Supply Planning Model [3] for a 20-sector economy.

In order for the Bechtel data to be compatible with the I/O model used by Bullard and Pilati, the Bechtel requirements were transformed into 90-sector requirements in units of 1967 producers' prices (except the five energy producing

sectors which are given in Btu's). (For an explanation of this transformation, see the Appendix to the Bullard and Pilati report, section C.)

The results of this input-output analysis are given in Table 3 (Bullard and Pilati 1975, Table 2). This table shows the average annual percent increase in sector output for the 18 sectors (out of a total 90 sectors) that supply a significant fraction of their output to the proposed construction scenario. (These sectors will be referred to in this Appendix as "high-growth" sectors.) As is noted, sectors are included whose 1976-1985 average required output exceeds the sector's 1972 gross output by five percent. This was one criterion used in the selection of broad industry sectors for the universe.

The importance of evaluating total requirements as opposed to direct requirements is illustrated by the fact that less than half the total material inputs were required directly at the construction site. This evaluation of total requirements by industry "permits a full accounting of (say) engineers required indirectly to design purchased components of energy facilities, in addition to those needed directly to design the facility itself." [2]

TABLE 3

TOTAL MATERIAL REQUIREMENTS FROM SEVERAL SECTORS* OF THE ECONOMY

Bureau of Economic Analysis Industry Sector	Percent Required Directly at Construction Site	1976-1985 Average Annual Requirements (millions of 1974 dollars)		Average Annual Percent Increase in Sector Output
Iron and ferroalloy ores mining	0	235	(21.6)**	1.1
Nonferrous metal ores mining	0	248	(13.0)	.7
Lumber and wood products except containers	36	1068	(7.3)	.3
Asphalt felts and coating	37	35	(5.1)	.5
Stone and clay products	38	1042	(8.79	.6
Primary iron and steel manufacturing	22	5504	(19.1)	1.6
Primary nonferrous metals manufacturing	26	4571	(20.3)	1.2
Heating, plumbing and fabricated metal products	48	6867	(49.0)	3.6
Screw machine products, bolts, nuts, etc., and metal stampings	0	344	(5.2)	.3
Other fabricated metal products	32	1274	(9.)	.6
Engines and turbines	46	3514	(70.1)	3.4
Construction, mining, oil field machinery equipment	46	3637	(53.9)	2.8
Materials handling machinery and equipment	37	265	(9.8)	.4
General industrial machinery and equipment	34	1511	(19.9)	1.8
Machine shop products	0	228	(6.8)	.4
Electric transmission and distribution equipment and electrical industrial apparatus	44	4533	(44.4)	2.2
Professional, scientific and controlling instruments, and supplies	44	1304	(19.3)	1.1
Railroads and related services	32	993	(8.0)	.4

* Included are sectors whose 1976-1985 average required outputs exceed the sector's 1972 gross output by five percent.

** Equivalent percent of 1972 gross domestic output.

The 18 sectors selected from Bullard and Pilati [2] were disaggregated to more specific levels through the use of Bechtel's list of "Typical Construction Materials and Equipment" [3]. The major headings on this list (wood, petroleum refinery products, stone and clay, etc.) were matched to a similar "high-growth" sector. Next, the appropriate 4-digit SIC codes were assigned to the individual product categories on the Bechtel list. The results are shown in Table 4. The relative importance of these product categories was determined by taking into account the following:

1. Average annual percent increase in sector output (see Table 3)
2. SIC industry descriptions
3. Information from scientists and engineers experienced in energy-related fields.
4. Input coefficients analysis of product categories being considered for inclusion in the universe

For example, it was decided that "wood", which had a relatively low average annual percent increase in output, should not be included in the final universe. Therefore none of the industries described under the SIC major group "Paper Products" were expected to be significant. In some instances, while checking the SIC descriptions of product categories on

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TABLE 4

I/O	Avg. Annual Increase in Output (%)	Products	SIC
20.00	.3	WOOD	2411,2491
		Pilings	2439,2452
			2491
		Structural wood	2499
31.00	.5	PETROL. REFINERY	
		Paving compounds	2951
		Bulk hydrocarbons	2911
36.00	.6	STONE AND CLAY	
		Cement	3297,3241
		Brick	3251,3271
		Tile	3251
		Porcelain insulation	3264
		Concrete block	3271
		Stone and gravel	3295
		Asbestos	3292
		Ready-mix	3273
37.00	1.6	PRIMARY IRON AND STEEL	
		Iron & steel plate & sheet	3312
		Iron & steel bars, ingots rails	3312
		Unfabricated iron & steel pipe	3317,3312
		Oil country tubular goods	3317,3312
		Iron & steel castings (unfab.)	3312
		Iron & steel forgings (unfab.)	3312
		Bulk alloy steel	3312,3324
			3325
38.00	1.2	PRIMARY NONFERROUS METALS	
		Bulk copper, aluminum, lead, zinc	3331,3332, 3334,3333
		Rolled, drawn & extruded n/f metals, unfab. (plate, sheet, strip, bar, tubing)	3351,3353 3354,3355 3356
		N/f wire and cable	3351,3353 3354,3355 3356
		N/f castings, unfab.	3361,3362 3369
		N/f forgings	3463
		N/f pipe, unfab.	3356
		Welding rods	3356

TABLE 4 (cont'd)

40.00	3.6	FABRICATED STRUCTURAL PRODUCTS	
		Structural iron & steel	
		(for buildings & support)	3441
		Agricultural metal work	
		(fences and railings)	3446
		Sheet metal other than HVAC	3444
		Rebar	3449
42.00	.6	OTHER FABRICATED PRODUCTS	
		Pipe fittings and flanges	3494,3079
		Valves	3494,3079
			3069
		EQUIPMENT	
40.00, 52.00	3.6	HVAC EQUIPMENT	
40.07		Ductwork, including: supports stiffener, registers, grille, dampers	3292,343x
52.03		HVAC heating and cooling units	3443,3567
			3293
43.01	3.4	TURBINES	
		Steam turbines	3511
		Gas turbines	3511
		Complete turbine-generator set units	3511
45.00	2.8	CONST., MINING, & OIL FIELD EQUIP.	
45.01		Mobile cranes	3531,3536
45.01		Excavating	3531
45.01		Paving	3531
47.01,47.02		Metalworking	3541,3542
47.04		Welding (gas)	3549
53.06		Welding (electric)	3623
45.02		Draglines	3531,3532
45.02		Rock drills	3532
45.02		Ore crushers	3532
45.02		Flotation machinery	3532
45.03		Rock bits	3533
45.03		Derrick	3533
45.03		Drill rigs	3533

TABLE 4 (cont'd)

45.00	.4	MATERIALS HANDLING	
		Industrial cranes	
		(permanent, plant)	3536
		Conveyers	3535
49.00	1.8	GENERAL INDUSTRY	
		Pumps and compressors	3561,3563
		Blowers and fans	3564
		Industrial process furnaces and ovens	3567
51.00, 62.00	1.1	INSTRUMENTATION & CONTROLS	
51.00		Process computers	3573,3574
62.00		Mechanical controls & instruments	3811,3823
			3824,3829
62.00		Automatic temperature controls	3822
62.00		Process instrumentation	3811,3823
62.00		Process controls	3811,3823
53.00,55.00	2.2	ELECTRICAL EQUIPMENT	
53.01		Electric line instrumentation	
		(voltmeter, ammeters, etc.)	3825
53.02		Transformers	3612
53.03,53.05		Switchgear and other elec. line controls	3613
53.04		Motors and motor control (elec.)	3621,3622
53.04		Generators (other than T-G sets)	3621
53.06		Electric fixtures (welding)	3623
40.06	3.6	FABRICATED PLATE PRODUCTS	
		High pressure power boiler	3443
		Heat exchangers	3443
		Condensers	3443,3621,
			3629
		Tanks	3443
		Pressure vessels	3443
		Large pipe fabricated from plate	3443

the Bechtel list, related products not listed by Bechtel were uncovered that were expected to cause substantial growth in their respective industries. For example, from the SIC industry descriptions under "Stone, Clay and Glass" (major group 32), a product category (not listed on Bechtel's "Typical Construction Materials") was found that was suspected to be important - "Steam and Other Packing and Pipe and Boiler Coverings" (SIC code 3293). Further investigation led to the inclusion of this sector in the universe.

The above examples illustrate that the decision to include a sector in the universe depended on a combination of criteria.

D. Analysis of Operations Requirements for Proposed Energy Facilities

As discussed in section C, the Bechtel data that Bullard and Pilati used in their input-output analysis referred to construction requirements only. In addition, it was necessary to analyze the effect on the economy of the operation of proposed energy facilities. This analysis was expected to yield many of the same industry sectors (for inclusion in the universe) obtained from earlier analyses. However, an additional analysis of operations requirements was essential to insure that no important industry sectors would be left out.

For this additional analysis, data was used from the Stanford Research Institute report commissioned by Bechtel [4], which evaluated annual manpower, materials, equipment, and utility requirements for the normal operation and maintenance of each of 67 prototype facilities (as described in the Bechtel report). A typical facility might be a mine, a pipeline, a coal-fired power plant, or some similar energy development, transportation, or conversion facility. Specifically, the SRI materials and equipment requirements lists were used for the analysis. This data (in dollar amounts) was used along with Bechtel's schedule of facilities on-line in each year 1973-1985, to produce a matrix of operating requirements for each year.

To generate this matrix, it was necessary to consolidate the SRI lists (for each prototype facility that had an on-line schedule in Bechtel) into a 12-sector product list (see Table 5), by summing across facilities for each product. The individual products (sub-sectors) in the 12-sector list were made compatible with BEA 4-digit codes. Products cited often and in relatively large amounts in the SRI lists were used as sub-sectors under one of the 12 sectors. Products cited only occasionally and in small amounts in the SRI lists, were grouped together in a "miscellaneous" or "all" category in each sector. The level of aggregation of each sector varied according to the importance of the sector. For example, sector 1, wood, was grouped together in

TABLE 5

12-SECTOR LIST

I. Wood (20,21) - All

II. Paper and Allied Products (24-26) - All

III. Chemicals (27-32)
- A. Industrial chemicals
- B. Paints and coatings
- C. Explosives
- D. Tires
- E. Insulation
- F. Fuels (oil, gas, diesel)
- G. Pavings
- H. Misc.

IV. Stone, Glass and Clay (35,36)
- A. Concrete and brick
- B. Cement
- C. Insulation
- D. Refractories
- E. Misc.

V. Non-ferrous Metals
- A. Copper wire
- B. Aluminum castings
- C. Welding rods
- D. Misc.

VI. Metal Products (39-42)
- A. Fabricated structural steel and iron
- B. Concrete reinforcing bars
- C. Pipes, valves, and pipe fittings
- D. Plating
- E. Nuts and bolts
- F. Fabricated plate products
  1. heat exchangers
  2. boilers
  3. condensers
- G. Misc. (tools)

VII. Misc. Materials - All

VIII. Non-Electric Machines (43-50, 52)
- A. Heating equipment and air conditioning
- B. Compressors and pumps
- C. Turbines and engines (groups)
- D. Tools
- E. Boiler parts
- F. Construction machinery
- G. Mining equipment
- H. Oil field equipment (crusher)
- I. Materials handling (hoists, cranes, conveyors, trucks)
- J. Engines (internal combustion)
- K. Misc. (groups of parts, metalworking machinery)

TABLE 5 (cont'd)

IX. Electric Equipment (53-58)
- A. Transformers
- B. Motors and generators
- C. Engines
- D. Welding
- E. Mining
- F. Engine and motor parts (lumped batches of parts)
- G. Industrial control
- H. Telecommunications
- I. Switch gear
- J. Misc.

X. Transportation Equipment (59-61)
- A. Trucks
- B. Air craft and boats
- C. Spare parts for vehicles
- D. Misc.

XI. Instruments and Controls (62,63)
- A. Controls
- B. Instruments
- C. Metering
- D. Gauges
- E. Process computers
- F. Misc.

XII. Misc. Equipment (64) - All

an "all" category because wood products were cited only occasionally in the SRI lists; whereas sector 6, metal products, was disaggregated into seven product categories.

An annual operating requirements matrix was generated for each prototype facility. Multiplying each of these matrices by the number of facilities that would be on-line in a given year, and summing across the different prototype facilities, yielded a matrix of total dollar requirements by product and sector for the year.

Total requirements by year and average requirements (sum of matrices for each year/number of years) were compared with 1972 data on the value of U.S. shipments of selected products (U.S. Census of Manufacturers) to determine which industries' outputs would need to grow significantly. (Average required outputs for operating requirements were calculated as a percentage of the sector's 1972 shipments.) The industries that required a substantial percentage increase in output (and that had not been definitely included in the universe as a result of other analyses) were analyzed by input coefficients inspection as described in section 2. Industrial chemicals (SIC 281) was added to the final universe as a result of this analysis, since expected additional requirements appeared to constitute a significant portion of its current output. The importance of other industries already included in the universe was amplified by the analysis of operating requirements.

II. Procedures for Establishment Selection

The desired sample size was 20-50 establishments for each sector (4-digit SIC code) included in the universe. Following are the references used to obtain the samples:

1. Fortune's Plant and Product Directory of the Nation's 1000 Largest Corporations (Fortune, 1966).
2. Million Dollar Directory, 1975 (Dun and Bradstreet, Inc.).
3. Middle Market Directory, 1975 (Dun and Bradstreet, Inc.).
4. Standard and Poor's Register of Corporations, Directors and Executives, 1975.
5. Moody's Industrial Manual, 1975.
6. 30,000 Leading U.S. Corporations (News Front, 1973).
7. Directory of Manufacturers, 1974 Buying Directory (Coal Age, July, 1974).
8. 1976 USA Oil Industry Directory (Oil and Gas Journal).
9. "Consultants to the Power Industry" (Power Engineering, May, 1975). "New Generating Plants" (Power Engineering, May, 1975).
10. Report to the Congress - How the Federal Government Participates in Activities Affecting the Energy Resources of the United States (Comptroller General of the United States, 1973).
11. United States Government Manual 1975/1976 (Office of the Federal Register, National Archives and Records Service, General Services Administration).

12. Research Centers Directory (5th ed. Archie M. Palmer, ed. Detroit: Gale Research Co.).

13. Dun's Marketing Index, (Marketing Services Division, Dun and Bradstreet, Inc.).

To note which sectors each directory was used for, the sectors in the final universe will be divided into six groups, A-F, described below.

A. Commercial Sectors Included in *Fortune's Plant and Product Directory of the Nation's 1000 Largest Corporations*

This directory lists, by SIC codes, each plant or facility (location and products produced) associated with a specific firm. It was a primary source for commercial manufacturing establishments because its level of aggregation coincides with the establishment focus of the study. Following are some examples of industry sectors whose establishment samples were obtained from Fortune's directory:

SIC 3541	Machine Tools, Metal Cutting Type
SIC 3623	Welding Apparatus
SIC 3621	Motors and Generators
SIC 3443	Fabricated Plate Products

Whenever possible, Fortune's directory was a first source. If fewer than 20 establishments were listed for a particular SIC code, other references were used to supplement the list. If more than 50 establishments were listed, similar facilities or plants belonging to the same firm were eliminated from the sample.

B. Commercial Sectors not Included in *Fortune's* Directory

In addition to serving as supplements to *Fortune's* listings, directories 2-6 were used for commercial sectors not included in *Fortune's* directory. These directories list a corporation under all the appropriate SIC codes, but they do not list individual plants and their addresses; instead a corporate headquarters address is given. Dun and Bradstreet's *Million Dollar Directory* was the preferred source; the other four directories were used primarily to supplement and check other listings. Following are some examples of industry sectors whose establishment samples were obtained from the above directories:

SIC 1382	Oil and Gas Field Exploration Services
SIC 4925	Mixed, MFG, or Liquid Gas Products
SIC 4922	Natural Gas Transmission
SIC 3811	Engineering Lab and Scientific Research Instruments and Associated Equipment
SIC 132	Natural Gas Liquids

C. Industry Sectors for Which More Comprehensive Direc-

tories Were Available

Reference 7 was used to supplement _Fortune's_ listings of suppliers to the coal industry, such as SIC code 3532, Mining Machinery and Equipment.

Establishments for SIC code 291, Petroleum Refining, were taken primarily from reference 8, which was also used to supplement listings from Dun and Bradstreet for SIC code 7391, Research and Development Labs (private industry).

"Consultants to the Power Industry" was used to obtain listings for SIC codes 1623 and 1629 (Construction Industry Sectors), and to supplement Dun and Bradstreet's listings for SIC code 8911, Engineering, Architectural and Surveying Services. To supplement listings for SIC codes 4931, 4932, and 4939 (utilities), the article on "New Generating Plants" was used.

D. Government Agencies and Activities Relating to Energy (1 Sector)

References 10 and 11 were used to obtain a sample for SIC code Regulatory Agencies and Government Activities Relating to Energy. The _Report to the Congress_ lists all the related agencies and the _United States Government Manual_ gives current addresses.

E. Non-profit Research and Development Institutions (1 Sector)

A sample of Non-profit Research and Development Institutions (SIC code 8922) was obtained from reference 12. Palmer's directory lists institutions specifically designated as independent, non-profit research organizations with their own boards of control. Organizations that are an integral unit of an educational or governmental institution are not included. The sample is comprised of institutions that are engaged in energy-related research with staff sizes of more than 12 people.

F. Source for Supplemental Listings

3000 additional establishment listings were obtained from Dun's Marketing Index to supplement listings for sectors which were under-represented. The distribution of establishments by SIC codes in the DMI listing was representative of DMI's universe of specified (by CAC) SIC codes. The listing excluded establishments with less than 30 employees. It was not possible to specify _within_ SIC groups the number of establishment listings desired or minimum total employment. Since the universe of industry sectors used in this study is based on representation _within_ SIC groups, many of the establishment listings obtained from DMI were removed from the final sample.

References

1. U.S. Dept. of Commerce. 1974. Input-Output Structure of the U.S. Economy: 1967
2. Bullard, C. and Pilati, D. 1975. Direct and Indirect Requirements for a Project Independence Scenario
3. Carasso et al. The Energy Systems Group, Bechtel Corp., San Francisco, Calif. The Energy Supply Planning Model
4. Stanford Research Institute. 1975. Manpower, Materials, Equipment and Utilities Required to Operate and Maintain Energy Facilities

Appendix B: Survey Administration

A. Removals from Original Sample

A total of approximately 5664 establishment listings were collected for the original sample. These were obtained as described in Appendix A. About 1494 of these listings (almost all from the 3000 obtained from DMI) were removed because the establishments' respective SIC Codes were over-represented (more than 100 establishments) in the sample. Removals consisted mostly of small construction or consulting establishments (SIC Codes 8911 or 1623,9). These were over-represented even though the DMI listing excluded establisnments with less than 30 employees. Theoretically the distribution in the listing was representative of DMI's universe of specified (by CAC) SIC Codes. However, we were not interested in universe representation per se as much as representation within SIC groups. The 4100 remaining listings were randomly assigned to one of the two survey subsamples.

B. Confirmation of Need for Intensive Effort

It became clear very early in the project that due to the length and complexity of the survey instruments and the contemporary attitude towards voluntary surveys in the business community, obtaining the desired 10-20 responses per

major SIC group would require an intensive effort. In addition, the small number of firms in certain industrial groups such as "turbines and generators" or "reactor vessels" mandated a survey at the intensive rather than extensive margin.

Before pre-test results were obtained, it was hoped that the Current Situation Survey might be administered using a "blind" mailing [1], since the data requested was primarily of an historical nature, i.e. -- an "expert" would not be required to copy data from the establishment's records onto the survey instrument. However, only one of the nine pre-test instruments was returned completed, so the need for an intensive approach was confirmed.

The forecasting survey fared slightly better. Nine establishments were contacted , and the appropriate "house expert" in manpower forecasting was solicited for participation. In many instances the caller was referred to another location where a new "expert" was sought to report for his (or her) respective location. [2] Forecasting surveys with cover letters were addressed to the "experts" who agreed to

----

[1] Addressed to personnel depts. rather than individuals

[2] In both surveys the establishment focus was sought, see Appendix C.

participate after the study was explained to them. Three of the nine pre-test participants completed and returned the survey.

At this point, and on the NSF's recommendation, it was decided that, for both surveys, each establishment in the sample would have to be contacted by telephone prior to the initial mailing of the survey.

C. Procedures for Initial Calls

The interviewer began by explaining the nature of the study and survey in an effort to contact the appropriate person, or expert. Experts were expected to be found among engineering and research executives, manpower planners, and professional recruiters. Interviewers were required to call the most appropriate person at each establishment (using snowball techniques), rather than allow a secretary or other subordinate to accept the survey on behalf of his superior.

After explaining the survey to the house expert, the interviewer attempted to obtain some degree of commitment prior to mailing. (It would not have been worth postage to mail the lengthy instruments to resistant contacts.) "House experts" at 465 of the 4100 establishments refused to participate in the study at the initial contact. The most common reasons given for resistance at this point fell into five

approximately equal-sized classes:

1.) Not applicable -- not energy-related
2.) Not applicable -- no scientific or technical personnel
3.) Too busy
4.) Against company policy
5.) Too many other requests for information

Many contacts presumed that they were not energy-related if they did not directly produce energy, or consume large quantities. Interviewers attempted to explain the input-output concept to this type of respondent with some degree of success. Some contacts were impressed with the thoroughness of a study using this concept while others simply shifted their grounds for refusal. A few sample establishments were, in fact, not substantially energy-related by the I/O concept, but were in an SIC group which was substantially energy-related. In these cases, interviewers attempted to obtain participation on representational grounds.

Many contacts attempted to evade participation because their establishments had little or no STP. Every effort was made to convince these contacts that it was as important for our sample to be representative as it was to obtain data from STP intensive establisnments. Some success was obtained with this approach. Interviewers' bargaining power

was augmented since they could promise these contacts that the survey would take little of their time.

Interviewers attempted to convince contacts that purported to be "too busy" to review the instrument, and complete as much of it as possible. In all cases, contacts were cautioned that the instrument would appear much longer than it was in fact, since probably only a few of the 39 possible occupational categories would apply to a particular establishment.

Confidentiality was emphasized to contacts that declined on grounds of "company policy". Interviewers reported little headway against this type of resistance, particularly with establishments that were divisions or subdivisions of very large corporations.

Ultimately, over 3000 prospective participants were identified, requiring in excess of 12,000 phone calls for initial contacts alone. Approximately 1260 establishments from the final sample were not sent a survey. They are classified as follows:

1.) Refused at initial contact call	465
2.) No phone listing, out of business, or no answer	300
3.) Subsumed under divisional or corporate report	68
4.) Duplicate listing	78
5.) Contacted but not sent survey for other reasons	226
6.) Other, records show no contact made	129

D. Contact-Mailing Phase

Prospective participants in the two studies (approximately evenly divided between the forecast and current situation surveys) were mailed the respective instrument (including definitions), a post-paid return envelope, a postcard for requesting summary results, and a personalized cover letter. (See Appendix C)

The cover letters were continuously modified throughout the three and one-half month contact-mailing phase. Experience mounted as to the nature of refusals and certain items were appropriately emphasized and de-emphasized. The essence of the letter remained unchanged, containing statements concerning:

1.) Authority of the study
2.) Nature of the respective study and/or model
3.) Assurance of confidentiality
4.) Benefits to the respondent
5.) Brief description of the respective instrument
6.) An invitation to call respective survey directors collect about any ambiguities or questions.
7.) Reference to initial agreement to participate

and signature of phone interviewer

A large number of participants (over 800) [3] indicated by mail, telephone, or in follow-up that they did not wish to participate after receipt of the respective instrument.

Several major types of refusals can be identified. Approximate distribution of these is as follows:

1.) Proprietary data or "against company policy"	10%
2.) Not applicable -- "not energy-related"	15%
3.) Not applicable -- "no STP"	15%
4.) Not applicable -- other or unspecific reason	15%
5.) Too much work and/or too complex	25%
6.) Data not available at this level	10%
7.) No specific reason	10%

The length and complexity of the instruments probably accounts for a greater proportion of refusals (and outstanding surveys which are not officially refusals) than the above distribution would indicate; i.e., willingness rather than ability seemed to be the major obstacle to response.

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[3] This does not include the substantial number (893) of participants who had not indicated refusal and had not been contacted in follow-up.

The forecast survey consisted of a potential 1737 questions and the current situation survey consisted of a potential 1417 questions plus two areas for comments. Both surveys included over three and one-half single-spaced pages of instructions and standard NSF definitions. The University of Illinois' Survey Research Laboratory was consulted and the instruments were designed as simply as possible, given the information required, to accommodate many different types of industry establishments. However, many respondents filled out the instruments incorrectly.

Many reported occupations specifically excluded in the definitions or gave incremental or conditional forecasts in the forecast survey. In the current situation survey, many respondents reported hires of experienced personnel or generally gave information containing significant internal inconsistencies. For example, there were many cases where vacancies for 1975 plus current employment by degree or experience level were not equal to current requirements. These inconsistencies were not always attributable to "margin of error".

E. Follow-Up Procedure

It was obvious at an early date that intensive follow-up was required. Interviewers attempted to contact participants with outstanding surveys approximately five weeks

after the initial contact, allowing respondents sufficient time to review the instrument. Interviewers were instructed to verify the receipt of the questionnaire, answer any questions, and (for the third time) convince the respondent that the study was applicable and that the instrument was much less difficult to complete than it appeared.

Due to time constraints interviewers were limited to two calls in their attempt to follow-up outstanding surveys. With this constraint they were able to contact approximately 1000 participants (50% of outstanding surveys) over the course of the follow-up procedure. Responses to follow-up calls were approximately distributed as follows:

1.) Refusal for reason of applicability, burden, other	40%
2.) Agreed to at least partially complete instrument	40%
3.) "Did not receive"	15%
4.) "Already returned"	5%

The number of participants who claimed not to have received or had already returned the instruments could not be reconciled with a physical count of remaining survey materials or meticulously kept computer records of individual establishment status in the sample. The University Survey Research Laboratory, having had similar experience, advised that these were probably disguised refusals. A second mailing was made to these establishments. Of those that agreed

to complete the survey during follow-up, it is estimated that approximately 20 to 30% of these in fact returned a useful response.

By the end of the follow-up procedure it was apparent that there would be a significant number of confirmed non-respondents in addition to those participants who could not be contacted in the follow-up procedure. A much shortened version (2 pages plus instructions and NSF definitions) of both survey instruments was devised to avoid non-respondent bias.

The current situation short form solicits industry identifying information, current STP requirements, and subjective assessment of the STP labor market. Analysis of the preliminary results indicate no important deviation from longer version quantitative results.

The forecasting short form solicits industry identification, current STP requirements and forecasts under each scenario for the total rather than four separate activities. Few non-respondents have offered forecasts on this form, and there is presently no resultant evidence to suggest whether or not the forecasts from the longer forms are representative.

Six hundred and eighty-three completed long forms (about evenly split between the two surveys) were on hand as

of the cutoff date for the sample. Most of these required clarification or lacked essential information which was obtained in telephone interviews prior to their addition to the data-base.

F. Editing Procedure

The next task was editing the returned questionnaires to prepare them to be added to the computerized data base via an interactive data entry program. The editing process usually involved contacting the respondent by phone to obtain essential information or clarify ambiguous responses. All editors received detailed editing instructions and a consistency checklist to aid them in the editing process. All returns received from various establishments within a given corporation were handled by one editor. This helped to clarify responses peculiar to that firm and to prevent the possibility of overlapping reporting.

Each question in both surveys was given a priority rating. Editors were instructed to call the respondent if any high priority questions were unanswered or required clarification, or if there were substantial inconsistencies in reporting. For example, there were many instances in which the respondent indicated "not available" or "confidential" as an answer to the question on sales volume (a high-priority question). Editors were often able to obtain a

sales volume figure by assuring the respondent over the phone that the information would remain confidential. In the case of a company division or plant not involved directly in sales, the editor would try to contact someone at a regional sales office or corporate headquarters who might have the information. This approach was also sometimes successful. If the information was, in fact, "unavailable", a researcher attempted to obtain information from the University library.

There were also many instances of inconsistent reporting. For example, some current situation surveys were returned in which the number of inexperienced new hires (Item III.22.) did not correspond to experience figures given in Item V.28. (with number of quits, IV.23., taken into consideration). In many of these cases, the editors discovered that the respondent had listed <u>all</u> new hires, not only inexperienced new hires. Appropriate corrections were made.

Editors were instructed to phrase questions carefully so as not to lead the respondents. The amount of clarification possible depended on the respondent. If a respondent seemed unsure of an answer, or simply wanted to get off the phone as quickly as possible, missing data codes were used. The final disposition of the sample is shown in table 1. The status of those who were contacted and agreed to participate is shown in table 2.

Table 1

FINAL DISPOSITION OF THE SAMPLE

1.)	Contacted and mailed long form of either survey	3060
2.)	Refused participation at initial contact	435
3.)	No phone listing or out of business	300
4.)	Subsumed under other reporting unit	68
5.)	Duplicate listings	78
6.)	Additional establishment listings available to complete sample if necessary	1494
7.)	Other	226
	Approximate Effective Sample (1+2+4+7)	3796

Table 2

FINAL STATUS OF SAMPLE

1.)	In process	0
2.)	Unconfirmed non-response	393
3.)	Followed-up (respondent agreed to complete, unreturned)	466
4.)	Refused to complete after follow-up or respondent initiated return	649
5.)	Completed and returned	683
6.)	Additional establishment listings available to complete sample	1494
7.)	Short form completed	170

OMB No. 99-S75017

Survey No.__________

Center for Advanced Computation
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801

National Science Foundation

STUDY OF SCIENTIFIC AND TECHNICAL MANPOWER IN ENERGY-RELATED INDUSTRIES

The establishment location for which data are requested is shown in the address label below. For purposes of this study an establishment usually is a single physical location, engaged in one predominant activity. If you are unable to report data on this basis please indicate the unit(s) for which data is reported.

Corrections: (If label does not represent reporting units;) ____________________

Confidentiality

When we receive your response we will transfer the data (except for item VIII) to a computer file which will not be identified with your firm. Surveys will then be destroyed. The results will be used only when combined with those of many other firms.

SURVEY OF SCIENTIFIC AND TECHNICAL MANPOWER

Instructions: Please scan the Reporting Instructions at the end of this questionnaire and then begin here, referring back to the definitions as necessary.

Item I. General Information

1. What is the primary product of this establishment? (*by dollar sales volume or operating revenue*) __________

2. Please list your next most important items by sales volume or operating revenues:
   a. __________
   b. __________
   c. __________

3. a. What percentage of your scientific and technical personnel are based at foreign locations? __________% (If "0", skip to Question 4)
   b. Of these foreign-based scientific and technical personnel, what percentage are U.S. citizens? ______%

4. What was the total sales volume for your establishment? (*Answer either "a" or "b" and "c"*)
   a. From Jan. 1, 1975 to December 31, 1975, it was $__________
   b. For fiscal year __________ to __________, it was $ __________
   c. At what percentage of capacity did your company operate in 1975? (*See definitions for capacity*) __________%

5. a. What were your company funded (own account) research and development expenditures for 1975 or other period which you reported sales volume for in question 4? (*See definitions for "research and development".*)
   $ __________
   b. What were your government or other non-company (grants, contracts, etc.) expenditures for research and development in 1975 or other period reported in question 4?
   $ __________

6. What was the total employment for this establishment? (*Answer either "a" or "b"*)
   a. December 31, 1975 __________; December, 31, 1974 __________;
   b. __________, 1975 __________; __________, 1974 __________

7. For each of the supervisory groups listed below, please estimate how many in each group in your establishment are scientists, engineers, technicians and non-technical staff.

	Scientists	Engineers	Technicians	Non-technicial
Foremen				
Managers				
Supervisors				
Other Supervisory				

Item II. Labor Market Experience Since 1972

Please circle one answer code number unless otherwise instructed.

	Much More	More	Less	Much Less
8. In comparison to 1972, to what extent did your scientific and technical employees work overtime in 1975?	1	2	3	4
9. In comparison to 1972, to what extent did your establishment find it necessary to redesign jobs in order to release scientific or technical staff from non-technical duties such as clerical or administrative work in 1975?	1	2	3	4
10. In comparison to 1972, to what extent did your establishment reduce education, experience, training or other qualifications for scientific and technical jobs in 1975?	1	2	3	4
11. In comparison to 1972, to what extent did your establishment find it necessary to sub-contract work as a result of scientific or technical personnel shortages in 1975?	1	2	3	4
12. In comparison to 1972, to what extent did your establishment hire temporary scientific or technical personnel from outside firms in 1975?	1	2	3	4
13. In comparison to 1972, to what extent did your establishment borrow or transfer scientists or technicians from other locations or divisions of your firm in 1975?	1	2	3	4
14. In comparison to 1972, to what extent did your establishment borrow scientists or technicians from other firms (which might have been experiencing slack periods) in 1975?	1	2	3	4
15. In comparison to 1972, to what extent did your constant dollar training costs for scientific and technical personnel increase or decrease in 1975?	1	2	3	4
16. In comparison to 1972, to what extent did your establishment find it necessary to delay or cancel production or research and development due to vacancies in scientific and technical positions in 1975?	1	2	3	4

17. a. Has your establishment found it necessary to retrain scientific or technical personnel from one area of specialization to another? (*i.e., their primary activity is not their area of degree specialty.*)

Yes 1
No 2
(If "No", skip to Question 18)

	Much More	More	Less	Much Less
b. In comparison to 1972, to what extent was retraining necessary in 1975?	1	2	3	4

c. For which occupations has this been necessary?

Occupation after retraining	Occupation before retraining
1) ____________	____________
2) ____________	____________
3) ____________	____________

18. **Recruiting:**

a. What is the total number of college and university interviews with scientific and technical students your firm has conducted for recruiting purposes during . . . (*If none, please indicate "0"*).

1975? __________; 1974? __________;
1973? __________; 1972? __________.

b. What was the number of full time (or *equivalent*) personnel your establishment used for recruitment purposes during . . . .

1975? __________; 1974? __________;
1973? __________; 1972? __________.

c. In comparison to 1972, to what extent did your establishment use managerial or technical staff whose duties do not normally include recruiting for recruiting purposes? (*Circle one number*).

Much More	More	Less	Much Less
1	2	3	4

19. a. Does your establishment develop forecasts for future requirements of scientific and technical personnel?

Yes . . . . . . 1 No 2
(*If No, skip to Question 20*)

b. Is this forecast done in terms of specialized occupations such as "Chemical Engineer", "Civil Engineer", etc. as opposed to "Engineer"?

Yes . . . . . . 1 No 2

c. For what years have you made these forecasts?

19_____ 19_____ 19_____ 19_____ 19_____

d. Please describe your establishment's forecasting method and the accuracy of it:

____
____
____
____
____
____
____
____
____
____

Item III. Salary Offers and Acceptances for Inexperienced New Hires by Occupation

For each of the occupations listed . . .	20. What was your average monthly Salary offer to inexperienced new hires in:				21. What was the total number of job offers made to inexperienced new hires in:				22. What was the total number of inexperienced new hires in:			
	1975?	1974?	1973?	1972?	1975?	1974?	1973?	1972?	1975?	1974?	1973?	1972?
(100) Total Engineers												
(101) Chemical												
(102) Civil/Sanitary												
(103) Electrical/Electronic												
(104) Industrial												
(105) Materials/Metallurgical/ Ceramic												
(106) Mechanical												
(107) Aeronautical												
(108) Mining												
(109) Petroleum												
(110) Geological												
(111) Nuclear												
(190) Other *(specify)* 1. ______												
2. ______												
(200) Total Scientists												
(201) Chemists												
(202) Physicists												
(203) Metallurgists												
(204) Geologists/Geophysicists												
(205) Agriculturists												
(206) Biologists												
(207) Medical												
(208) Mathematicians												
(209) Statisticians												
(210) Computer												
(211) Marine												
(290) Other *(specify)* 1. ______												
2. ______												
(300) Total Technicians												
(301) Agricultural												
(302) Biologists												
(303) Chemical												
(304) Electrical/Electronic												
(305) Industrial												
(306) Mechanical												
(307) Medical												
(308) Mathematical												
(309) Surveyors												
(310) Draftsmen												
(390) Other *(specify)* 1. ______												
2. ______												
(400) Total Architects												

Item IV. Number of Quits and Vacancies by Occupation

Occupations	23. For each of the occupations listed, what was the number of quits in:				24. For each of the occupations listed, what was the number of unfilled vacancies this establishment had on Dec. 31:			
	1975?	1974?	1973?	1972?	1975?	1974?	1973?	1972?
(100) Total Engineers								
(101) Chemical								
(102) Civil/Sanitary								
(103) Electrical/Electronic								
(104) Industrial								
(105) Materials/Metallurgical/ Ceramic								
(106) Mechanical								
(107) Aeronautical								
(108) Mining								
(109) Petroleum								
(110) Geological								
(111) Nuclear								
(190) Other *(specify)* 1. ______								
(2. ______								
(200) Total Scientists								
(201) Chemists								
(202) Physicists								
(203) Metallurgists								
(204) Geologists/Geophysicists								
(205) Agriculturists								
(206) Biologists								
(207) Medical								
(208) Mathematicians								
(209) Statisticians								
(210) Computer								
(211) Marine								
(290) Other *(specify)* 1. ______								
2. ______								
(300) Total Technicians								
(301) Agricultural								
(302) Biologists								
(303) Chemical								
(304) Electrical/Electronic								
(305) Industrial								
(306) Mechanical								
(307) Medical								
(308) Mathematical								
(309) Surveyors								
(310) Draftsmen								
(390) Other *(specify)* 1. ______								
2. ______								
(400) Total Architects								

25. What was the total number of quits for all employees, including non-technical in. . .
1975? ______ 1974? ______ 1973? ______ 1972? ______

26. What was the total number of unfilled vacancies for all occupations including non-technical jobs on Dec. 31:

Item V. No. of Scientific and Technical Personnel by Highest Degree Attained and Years of Experience on December 31, 1975	27. How many employees in each of the occupations listed below have . . .				28. How many employees in each of the occupations listed below have . . .			
	less than a bachelors degree?	a bachelors degree only?	a masters degree but not a Ph. D.?	a Ph. D.?	less than 1 year's experience	1–5 years experience only?	6-10 years experience only?	11 or more years experiance?
(100) Total Engineers								
(101) Chemical								
(102) Civil/Sanitary								
(103) Electrical/Electronic								
(104) Industrial								
(105) Materials/Metallurgical/ Ceramic								
(106) Mechanical								
(107) Aeronautical								
(108) Mining								
(109) Petroleum								
(110) Geological								
(111) Nuclear								
(190) Other *(specify)* 1. ______								
2 ______								
(200) Total Scientists								
(201) Chemists								
(202) Physicists								
(203) Metallurgists								
(204) Geologists/Geophysicists								
(205) Agriculturists								
(206) Biologists								
(207) Medical								
(208) Mathematicians								
(209) Statisticians								
(210) Computer								
(211) Marine								
(230) Other *(specify)* 1. ______								
2. ______								
(300) Total Technicians								
(301) Agricultural								
(302) Biologists								
(303) Chemical								
(304) Electrical/Electronic								
(305) Industrial								
(306) Mechanical								
(307) Medical								
(308) Mathematical								
(309) Surveyors								
(310) Draftsmen								
(390) Other *(specify)* 1. ______								
2. ______								
(400) Total Architects								

Item VI. Current Scientific and Technical Requirements *(employment plus vacancies)* **By Occupation and Primary Activity**

For each of the activities listed across, please indicate your manpower requirements *(employment plus vacancies)* for the specific occupations shown as of December 31, 1975. Make your estimates in man-years.

	29. How many of your employees *(and vacancies)* are involved in: FORCE-ACCOUNT CONSTRUCTION ?	30. How many of your employees *(and vacancies)* are involved in: RESEARCH AND DEVELOPMENT?	31. How many of your employees *(and vacancies)* are involved in: OPERATIONS AND MAINTENANCE? *or contract construction for construction establishments?*	32. How many of your employees *(and vacancies)* are involved in: OTHER *(specify)* ? ______
(100) **Total Engineers**				
(101) Chemical				
(102) Civil/Sanitary				
(103) Electrical/Electronic				
(104) Industrial				
(105) Materials/Metalurgical/ Ceramic				
(106) Mechanical				
(107) Aeronautical				
(108) Mining				
(109) Petroleum				
(110) Geological				
(111) Nuclear				
(190) Other *(specify)* 1. ______				
2. ______				
(200) Total Scientists				
(201) Chemists				
(202) Physicists				
(203) Metallurgists				
(204) Geologists/Geophysicists				
(205) Agriculturists				
(206) Biologists				
(207) Medical				
(208) Mathematicians				
(209) Statisticians				
(210) Computer				
(211) Marine				
(290) Other *(specify)* 1. ______				
2. ______				
(300) Total Technicians				
(301) Agricultural				
(302) Biologists				
(303) Chemical				
(304) Electrical/Electronic				
(305) Industrial				
(306) Mechanical				
(307) Medical				
(308) Mathematical				
(309) Surveyors				
(310) Draftsmen				
(390) Other *(specify)* 1. ______				
2 ______				
(400) Total Architects				

Item VII. Comments

____

(If more space is needed, feel free to use a separate sheet of paper.)

Item VIII. Contact Person

Please complete the following information so that we may clarify the information you have given us (if necessary).

Name: ____________________

Title: ____________________

Address: ____________________

Telephone: ____________________

Date: ____________________

1. GENERAL INSTRUCTIONS

The establishment location for which data are requested is shown in the address label. For purposes of this survey, an establishment usually is a single physical location, engaged in one predominant activity.

Because the establishments in this survey are selected on a sample basis to represent all sizes of establishments in many manufacturing and nonmanufacturing industries, multiunit companies may receive more than one questionnaire. It is important that you complete the questionnaire only for the establishment designated.

Items I and VIII should be completed and the form returned, even if you do not employ any scientific and technical personnel. Providing this information is essential to the estimating procedure and will avoid unnecessary correspondence.

All employment figures should be reported for the pay period which includes December 31, 1975.

2. DEFINITION OF TERMS

A. General

Employees in the specialized occupations, reported in items III, IV, V and VI should be counted on a "*Working As*" basis, as of the date of the report (Dec. 31, 1975) regardless of their field of degree or whether they hold a college degree. For example, an employee trained as an engineer but working as a mathematician as of the date of the report should be reported as a mathematician. Similarly, an employee trained as a biological technician but working as a medical technician should be reported as a medical technician. When actual data are not available, please make an estimate.

B. Scientists and engineers

For the scientific or engineering occupations, *include* those who work at a level which requires knowledge of the subject at least equivalent to that acquired through completion of a 4-year college course with a major in one of those fields, regardless of whether they hold a college degree. *Include* all scientists and engineers in research and development, production, management, technical services, sales, or other positions which require the use of the indicated level of knowledge. *Exclude* persons trained as scientists or engineers but currently employed in positions not requiring the use of such knowledge.

Engineers

Count as engineers all persons actually engaged in chemical, civil, electrical, industrial, mechanical, materials/metallurgical, mining, petroleum, or any other type of engineering. *Include* architectural engineers; *exclude* architects.

Physical and life scientists

Count as scientists all chemists, physicists, metallurgists, geologists/geophysicists, agricultural scientists, biological scientists, medical scientists, and other physical and life scientists who are actually engaged in scientific work. *Exclude* psychologists, economists and other social scientists. Definitions for medical, agricultural, and biological scientists follow.

Medical scientists — are only those physicians, dentists, public health specialists, pharmacists, and members of other scientific professions who are concerned with the understanding of human diseases and improvement of human health, and spend the greatest proportion of their time in clinical investigation or other research, production, technical writing, and related activities. *Exclude* from this category all practitioners — that is, those medical scientists who spend the greatest portion of their time providing care to patients, dispensing drugs or services, or in diagnosis, etc. Persons working as pathologists, microbiologists, pharmacologists, etc., should be excluded from the figures for the medical scientists and included in the figures for biological scientists.

Agricultural scientists — are all persons who are primarily concerned with the understanding and improvement of agricultural productivity, such as those working in agronomy, animal husbandry, forestry, horticulture, range management, soil culture, and veterinary science. *Exclude* veterinarians who spend the greatest portion of their time providing care to animals since they are primarily practitioners and not within the scope of this survey.

Biological scientists — are all persons who spend the greatest portion of their time in scientific work dealing with life processes other than those classified in the agricultural and medical science. *Include* pathologists, microbiologists, pharmacologists, bacteriologists, toxicologists, botanists, zoologists, etc.

Mathematical scientists

Count as mathematical scientists all persons who are primarily concerned with the development of mathematical theory or the application of established mathematical laws and principles to specific problems and situations. *Include* actuaries only if they specialize in mathematical techniques; *exclude* accountants.

Mathematicians — are only those persons who spend the greatest portion of their time in mathematical research or in the development or application of mathematical techniques in science, management, and other fields, and/or solving or obtaining solutions to problems in various fields by mathematical techniques.

Statisticians — are all persons, other than those reported as mathematicians, who meet the general requirements for "Mathematical scientists" and who are primarily engaged in the recurrent application of statistical techniques. For purposes of this survey, statistical techniques include the design of surveys or experiments as well as the collection, organization, interpretation, or analysis of numerical data. *Exclude* statisticians who are engaged solely in the development of mathematical theory associated with the general application of statistical techniques — these persons should be reported as mathematicians. Also, *exclude* persons engaged in quality control, time or motion study applications, inventory control, computer programming, testing, etc., who utilize statistical techniques merely as an occasional tool in connection with the performance of other primary duties.

Computer scientists

Count as computer scientists all persons working as computer systems analysts, systems engineers, computer specialists, data processing systems project planners, software specialists, etc. *Include* computer programmers only if their positions meet the foregoing requirements. Other computer programmers should be included in the category "other technicians" (See definition for draftsmen and technicians).

C. Draftsmen and technicians

Count in this occupational grouping all persons actually engaged in technical work at a level which requires knowledge of engineering, mathematical, and physical or life sciences, comparable to that acquired either through study at technical institutes, junior colleges, or through equivalent on-the-job training or experience. Some typical job titles are draftsmen, surveyor, laboratory assistant, physical science aide, and electronic technician. All persons in positions which require the indicated level of knowledge should be counted, regardless of job title or department in which employed. Computer programmers who meet the above definition of technicians and surveyors should be reported as "other technicians". *Exclude* those persons whose positions require knowledge or training consistent with the foregoing definitions of engineers, mathematicians, or scientists, and report them in the appropriate occupational category on the questionnaire. Also, *exclude* all craftsmen such as machinists, electricians, and specialized personnel such as airline pilots, navigators, flight engineers, and ships' officers. Separate definitions of electrical and electronic technicians; other engineering and physical science technicians; and biological, agricultural, and medical technicians follow:

Electrical and Electronic technicians — are all persons with a background in electrical or electronic theory, physical science, and

mathematics which enables them to perform jobs above the routine operating or maintenance levels. Normally, such employees are engaged in construction, repairing, testing, installing, modifying, operating, or even designing a variety of production or experimental types of complex electrical or electronic equipment.

Biological, agricultural, and medical technicians — are all persons with a background in agricultural, biological, or other life science which enables them to perform jobs above the routine level in both laboratory and operations activities. *Exclude* medical and dental technicians who spend the greatest portion of their time providing care or services to patients.

Other engineering and science technicians — are all persons who assist engineers and scientists in both laboratory and production types of activities. Normally, these technicians work under the direct supervision of an engineer or scientist and assist him in those functions usually described as routine at the professional level. Where possible, count these personnel as chemical, mechanical, industrial, or mathematical technicians.

3. RESEARCH & DEVELOPMENT FUNCTIONS

Include in this function those individuals who spend the greatest proportion of their time performing, managing, or administering basic and applied research and in the design and development of prototypes, processes, studies, surveys, and related activities. If the primary objective of an activity is to make further improvements on the products, processes, or studies, then the work is research-development. If, on the other hand, the product or process is substantially operational and the primary objective is to develop markets, do preproduction planning, or get the production process going smoothly, then the work is no longer research-development. For purposes of this survey, research and development *includes* the activities described below whether assigned to separate research and development organizational units of the establishment, or carried on by laboratories and technical groups not part of a separate research and development unit per se.

(a) *Pursuit of planned research for new knowledge, whether or not the research has reference to a specific application.*

(b) *Application of existing knowledge to problems involved in the creation of a new product, process, study, or survey, including work required to evaluate possible uses.*

(c) *Application of existing knowledge to problems involved in the improvement of a present product, process, survey, or study.*

Development activities include — the design and operation of pilot plants or semi-works plants so long as the principal purposes are to obtain experience and to compile engineering and other data to be used in evaluating hypotheses, writing product formulas, or establishing finished product specifications; engineering activity required to advance the design of a product or a process to the point where it meets specific functional and economic requirements and can be turned over to manufacturing units; and design, construction, and testing of preproduction prototypes and models and "engineering follow-through" in the early production phase.

The development of designs for special manufacturing equipment and tools is included but tool making and tool tryout are not included. The preparation of reports, drawings, formulas, specifications, standard practice instructions or operating manuals, and other media for transmitting to operating units information obtained from the above activities is included. However, the production of detailed construction drawings or manufacturing blueprints is not included. The question, *"When does development end and production begin?"* is often asked. If the primary objective is to make further improvements on the product or process, then the work comes within the definition of research and development. If, on the other hand, the product or process is substantially "set", and the primary objective is to develop markets or to do preproduction planning, or to get the production process going smoothly, then the work is no longer research and development.

Research and development excludes — routine collection of information or statistics (i.e., performing market surveys to determine product acceptance); collating amount of overtime worked in different organizational units; market development (including the sale of either old or new products to obtain acceptance of them in new outlets); quality and quantity control tests and analyses; trouble shooting in connection with breakdowns in full scale production; technical plant sanitation control; work required for minor adaptations of a specific product to meet the requirements of a specific customer; engineering and other technical service furnished in accordance with agreement to licensees outside the company, and furnished by the research and development organization to manufacturing divisions to enable them to operate in accordance with previously determined formulas, practice instructions, or finished product specifications; aid furnished to develop advertising programs to promote or demonstrate new products or processes including the development of material furnished for trial or demonstration; experimental work performed at the request of the patent division to provide information needed during the prosecution of a patent litigation, and technical writing.

4. OPERATIONS AND MAINTENANCE

Include the day-to-day functions of this establishment. In general, this category should include all personnel not counted in Research and Development or Force Construction.

5. CONSTRUCTION

Force construction is construction undertaken by the establishment on its own behalf and does not include construction performed under contract for others. *Include* plant additions or renovations performed by your personnel. *Exclude* plant additions or renovations contracted out, but include your personnel assigned to contract supervision.

Contract construction Is construction under contract for others. If your establishment's principal line of business is contract construction most personnel should be counted under the activity heading "Operations and Maintenance." In any case, construction performed by your personnel on your own behalf should be counted as Force Construction.

6. CAPACITY

Capacity or capacity output is the maximum physical output that can be produced during a given time period with existing plant and equipment.

OMB No. 99-S75017

Survey No.__________

Center for Advanced Computation
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801

National Science Foundation

STUDY OF SCIENTIFIC AND TECHNICAL MANPOWER REQUIREMENTS IN ENERGY-RELATED INDUSTRIES

The establishment location for which data are requested is shown in the address label below. For purposes of this study an establishment usually is a single physical location, engaged in one predominant activity. If you are unable to report data on this basis please indicate the unit(s) for which data is reported.

Corrections: (If label does not represent reporting units:) ______________________

____

____

Confidentiality

When we receive your response we will transfer the data (except for item V) to a computer file which will not be identified with your firm. Surveys will then be destroyed. The results will be used only when combined with those of many other firms.

SURVEY OF SCIENTIFIC AND TECHNICAL MANPOWER REQUIREMENTS

Instructions: Please scan the Reporting Instructions at the end of this questionnaire and then begin here, referring back to the definitions as necessary.

Item I. General Information

1. What is the primary product of this establishment? (*by dollar sales volume or operating revenue*) ____________

2. Please list your next most important items by sales volume or operating revenues:
   a. ____________
   b. ____________
   c. ____________

3. a. What percentage of your scientific and technical personnel are based at foreign locations? ________% (If "0", skip to Question 4)
   b. Of these foreign-based scientific and technical personnel, what percentage are U.S. citizens? ______%

4. What was the total sales volume for your establishment? (*Answer either "a" or "b" and "c"*)
   a. From Jan. 1, 1975 to December 31, 1975, it was $____________
   b. For fiscal year __________ to __________, it was $ ____________
   c. At what percentage of capacity did your company operate in 1975? (See *definitions for capacity*) __________%

5. a. What were your company funded (own account) research and development expenditures for 1975 or other period which you reported sales volume for in question 4? (*See definitions for "research and development".*)
   $ ____________
   b. What were your government or other non-company (grants, contracts, etc.) expenditures for research and development in 1975 or other period reported in question 4?
   $ ____________

6. What was the total employment for this establishment? (*Answer either "a" or "b"*)
   a. December 31, 1975 ____________; December, 31, 1974 ____________;
   b. __________, 1975 ____________; __________, 1974 ____________

7. For each of the supervisory groups listed below, please estimate how many in each group in your establishment are scientists, engineers, technicians and non-technical staff.

	Scientists	Engineers	Technicians	Non-technical
Foremen				
Managers				
Supervisors				
Other Supervisory				

Item II. Current Scientific and Technical Requirements *(employment plus vacancies)* **By Occupation and Primary Activity**

For each of the activities listed across, please indicate your manpower requirements *(employment plus vacancies)* for the specific occupations shown as of December 31, 1975. Make your estimates in man-years.

		8. How many of your employees *(and vacancies)* are involved in: FORCE-ACCOUNT CONSTRUCTION?	9. How many of your employees *(and vacancies)* are involved in: RESEARCH AND DEVELOPMENT?	10. How many of your employees *(and vacancies)* are involved in: OPERATIONS AND MAINTENANCE? *or contract construction for construction establishments?*	11. How many of your employees *(and vacancies)* are involved in: OTHER *(specify)*? ________
(100)	Total Engineers				
(101)	Chemical				
(102)	Civil/Sanitary				
(103)	Electrical/Electronic				
(104)	Industrial				
(105)	Materials/Metalurgical/Ceramic				
(106)	Mechanical				
(107)	Aeronautical				
(108)	Mining				
(109)	Petroleum				
(110)	Geological				
(111)	Nuclear				
(190)	Other *(specify)* 1. ________				
	2 ________				
(200)	Total Scientists				
(201)	Chemists				
(202)	Physicists				
(203)	Metallurgists				
(204)	Geologists/Geophysicists				
(205)	Agriculturists				
(206)	Biologists				
(207)	Medical				
(208)	Mathematicians				
(209)	Statisticians				
(210)	Computer				
(211)	Marine				
(290)	Other *(specify)* 1. ________				
	2 ________				
(300)	Total Technicians				
(301)	Agricultural				
(302)	Biologists				
(303)	Chemical				
(304)	Electrical Electronic				
(305)	Industrial				
(306)	Mechanical				
(307)	Medical				
(308)	Mathematical				
(309)	Surveyors				
(310)	Draftsmen				
(390)	Other *(specify)* 1 ________				
	2 ________				
(400)	Total Architects				

Item III. Forecasts of Expected Manpower Requirements

Instructions: In the four tables which follow estimate for each of three future years (1977, 1980 and 1985) the total scientific and technical manpower requirements for your establishment under the conditions listed for each year.

The conditions for 1977 are:

1. *No change in physical output from 1976;*
2. *10% increase in output; and*
3. *20% increase in output.*

For 1980 the conditions are:

1. *No change in physical output from 1976;*
2. *25% increase in output; and*
3. *50% increase in output.*

For 1985 the conditions are:

1. *No change in physical output from 1976;*
2. *50% increase in output; and*
3. *100% increase in output.*

If you think that a given increase in output is not possible for your establishment, please say so in the column provided for response on that level of increase.

Any purchases of services or construction from other firms can be ignored here since those purchases would result in increased employment for other firms, not for your firm.

In making these forecasts, take into account the effects of changes in technology, the mix of activities at your establishment, productivity of scientific and technical manpower, etc. Please make your estimates in man-years (one full-time equivalent for one year).

If you are unable to forecast your future manpower requirements by activity (such as "Force-Account Construction", "Operations and Maintenance (*or contract construction for construction establishments*)", or "Research and Development"), please use the forecasting form labeled "Other" to estimate your *total* manpower requirements. Indicate on the "Other" form that your estimates are for *total* requirements for all activities. An example of a filled-out form is provided on the next page.

EXAMPLE MANPOWER FORECAST

RESEARCH AND DEVELOPMENT Make all estimates in man-years		12. For Research and Development what would your total manpower requirements be by occupation in 1977 if physical output increased by			13. For Research and Development what would your total manpower requirements be by occupation in 1980 if physical output increased by			14. For Research and Development what would your total manpower requirements be by occupation in 1985 if physical output increased by		
		0%	10%	20%?	0%	25%?	50%?	0%?	50%?	100%?
(100)	Total Engineers									
(101)	Chemical	2	2.5	3	2	4	4	2	3	3
(102)	Civil/Sanitary									
(103)	Electrical/Electronic	2	2.5	3.5	2	4	6	2	5	7
(104)	Industrial	1	2	3.5	1	2.5	5	1	2.5	3
(105)	Materials/Metallurgical/Ceramic		1	1		1	1		1	1
(106)	Mechanical									
(107)	Aeronautical									
(108)	Mining	9	11	13	9	13.5	18	9	14.5	19
(109)	Petroleum									
(110)	Geological									
(111)	Nuclear									
(190)	Other (specify) 1. Biological	1	1	1	1	1	2	1	1	2
	2.									
(200)	Total Scientists	1	1	1	1	2	2	1	2	2
(201)	Chemists									
(202)	Physicists									
(203)	Metallurgists	1	1	1	1	2	2	1	2	2
(204)	Geologists/Geophysicists									
(205)	Agriculturists									
(206)	Biologists									
(207)	Medical									
(208)	Mathematicians									
(209)	Statisticians									
(210)	Computer									
(211)	Marine									
(290)	Other (specify) 1.									
	2.									
(300)	Total Technicians	22	23	24	19	26	33	19	26	33
(301)	Agricultural									
(302)	Biologists									
(303)	Chemical	19	20	20	15	20	25	15	20	25
(304)	Electrical/Electronic									
(305)	Industrial									
(306)	Mechanical									
(307)	Medical									
(308)	Mathematical	3	3	4	4	6	8	4	6	8
(309)	Surveyors									
(310)	Draftsmen									
(390)	Other (specify) 1.									
	2.									
(400)	Total Architects									

Notice that in the sample forecast above the respondent forecast requirements only for those occupations he reasonably expects to employ under the various assumptions. In effect, the blanks imply zero entries.

In some instances, a given level of output may require more manpower in 1985 than 1980 since expected technological changes may require more technical manpower.

In the case of Materials Engineers, the respondent does not expect a need for this occupation unless output increases.

In some cases, a given level of output may require less manpower in 1985 than 1980 since growth would be less rapid for the 1985 case.

RESEARCH AND DEVELOPMENT Make all estimates in man-years.		12. For Research and Development what would your total manpower requirements be by occupation in 1977 if physical output increased by:			13. For Research and Development what would your total manpower requirements be by occupation in 1980 if physical output increased by:			14. For Research and Development what would your total manpower requirements be by occupation in 1985 if physical output increased by:		
		0% ?	10% ?	20%?	0% ?	25%?	50%?	0%?	50%?	100%?
(100)	Total Engineers									
(101)	Chemical									
(102)	Civil/Sanitary									
(103)	Electrical/Electronic									
(104)	Industrial									
(105)	Materials/Metallurgical/Ceramic									
(106)	Mechanical									
(107)	Aeronautical									
(108)	Mining									
(109)	Petroleum									
(110)	Geological									
(111)	Nuclear									
(190)	Other (specify) 1.									
	2.									
(200)	Total Scientists									
(201)	Chemists									
(202)	Physicists									
(203)	Metallurgists									
(204)	Geologists/Geophysicists									
(205)	Agriculturists									
(206)	Biologists									
(207)	Medical									
(208)	Mathematicians									
(209)	Statisticians									
(210)	Computer									
(211)	Marine									
(290)	Other (specify) 1.									
	2.									
(300)	Total Technicians									
(301)	Agricultural									
(302)	Biologists									
(303)	Chemical									
(304)	Electrical/Electronic									
(305)	Industrial									
(306)	Mechanical									
(307)	Medical									
(308)	Mathematical									
(309)	Surveyors									
(310)	Draftsmen									
(390)	Other (specify) 1.									
	2.									
(400)	Total Architects									

FORCE-ACCOUNT CONSTRUCTION

(see point #5 in "Reporting Instructions")

Make all estimates in man-years.

		15. For Force-Account Construction what would your total manpower requirements by occupations be in 1977 if physical output increased by:			16. For Force-Account Construction what would your total manpower requirements by occupation be in 1980 if physical output increased by:			17. For Force-Account Construction] what would your total manpower requirements by occupation be in 1985 if physical outout increased by:		
		0%?	10%?	20%?	0%?	25%?	50%?	0%?	50%?	100%?
(100)	Total Engineers									
(101)	Chemical									
(102)	Civil/Sanitary									
(103)	Electrical/Electronic									
(104)	Industrial									
(105)	Materials/Metallurgical/Ceramic									
(106)	Mechanical									
(107)	Aeronautical									
(108)	Mining									
(109)	Petroleum									
(110)	Geological									
(111)	Nuclear									
(190)	Other *(specify)* 1. ________									
	2. ________									
(200)	Total Scientists									
(201)	Chemists									
(202)	Physicists									
(203)	Metallurgists									
(204)	Geologists/Geophysicists									
(205)	Agriculturists									
(206)	Biologists									
(207)	Medical									
(208)	Mathematicians									
(209)	Statisticians									
(210)	Computer									
(211)	Marine									
(290)	Other *(specify)* 1. ________									
	2. ________									
(300)	Total Technicians									
(301)	Agricultural									
(302)	Biologists									
(303)	Chemical									
(304)	Electrical/Electronic									
(305)	Industrial									
(306)	Mechanical									
(307)	Medical									
(308)	Mathematical									
(309)	Surveyors									
(310)	Draftsmen									
(390)	Other *(specify)* 1. ________									
	2. ________									
(400)	Total Architects									

OPERATIONS AND MAINTENANCE

(or contract construction for construction establishments)

Make all estimates in man-years.

		18. For Operations and Maintenance what would your total manpower requirements by occupation be in 1977 if physical output increased by:			19. For Operations and Maintenance what would your total manpower requirements by occupation be in 1980 if physical output increased by:			20. For Operations and Maintenance what would your total manpower requirements by occupation be in 1985 if physical output increased by:		
		0%?	10%?	20%?	0%?	25%?	50%?	0%?	50%?	100%?
(100)	Total Engineers									
(101)	Chemical									
(102)	Civil/Sanitary									
(103)	Electrical/Electronic									
(104)	Industrial									
(105)	Materials/Metallurgical/Ceramic									
(106)	Mechanical									
(107)	Aeronautical									
(108)	Mining									
(109)	Petroleum									
(110)	Geological									
(111)	Nuclear									
(190)	Other *(specify)* 1. ________									
	2. ________									
(200)	Total Scientists									
(201)	Chemists									
(202)	Physicists									
(203)	Metallurgists									
(204)	Geologists/Geophysicists									
(205)	Agriculturists									
(206)	Biologists									
(207)	Medical									
(208)	Mathematicians									
(209)	Statisticians									
(210)	Computer									
(211)	Marine									
(290)	Other *(specify)* 1. ________									
	2. ________									
(300)	Total Technicians									
(301)	Agricultural									
(302)	Biologists									
(303)	Chemical									
(304)	Electrical/Electronic									
(305)	Industrial									
(306)	Mechanical									
(307)	Medical									
(308)	Mathematical									
(309)	Surveyors									
(310)	Draftsmen									
(390)	Other *(specify)* 1. ________									
	2. ________									
(400)	Total Architects									

OTHER *(specify)* ________ Make all estimates in man-years.		21. For ____ what would your total manpower requirements by occupation be in 1977 if physical output increased by:			22. For ____ what would your total manpower requirements by occupation be in 1980 if physical output increased by:			23. For ____ what would your total manpower requirements by occupation be in 1985 if physical output increased by:		
		0%?	10%?	20%?	0% ?	25%?	50%?	0%?	50%?	100%?
(100)	Total Engineers									
(101)	Chemical									
(102)	Civil/Sanitary									
(103)	Electrical/Electronic									
(104)	Industrial									
(105)	Materials/Metallurgical/Ceramic									
(106)	Mechanical									
(107)	Aeronautical									
(108)	Mining									
(109)	Petroleum									
(110)	Geological									
(111)	Nuclear									
(190)	Other *(specify)* 1. ____									
	2. ____									
(200)	Total Scientists									
(201)	Chemists									
(202)	Physicists									
(203)	Metallurgists									
(204)	Geologists/Geophysicists									
(205)	Agriculturists									
(206)	Biologists									
(207)	Medical									
(208)	Mathematicians									
(209)	Statisticians									
(210)	Computer									
(211)	Marine									
(290)	Other *(specify)* 1. ____									
	2 ____									
(300)	Total Technicians									
(301)	Agricultural									
(302)	Biologists									
(303)	Chemical									
(304)	Electrical Electronic									
(305)	Industrial									
(306)	Mechanical									
(307)	Medical									
(308)	Mathematical									
(309)	Surveyors									
(310)	Draftsmen									
(390)	Other *(specify)* 1. ____									
	2. ____									
(400)	Total Architects									

Item IV. Factors Influencing Your Estimates

24. How important were each of the following factors in influencing your predictions in the tables on the preceeding pages? Please circle the number which corresponds to the level of importance to you of each factor. Feel free to rate additional factors on the lines provided.

Factor	Not Important	Slightly Important	Somewhat Important	Very Important
Scale of operation	1	2	3	4
Volume of output	1	2	3	4
Productivity	1	2	3	4
Technology	1	2	3	4
Changes in manpower use	1	2	3	4
Data from departments	1	2	3	4
Others (specify)	1	2	3	4
____	1	2	3	4
____	1	2	3	4
____	1	2	3	4

25. Please read the definition of "*Capacity*" in point #6 of the Reporting Instructions. Under this definition, what was your percentage of capacity utilization as of December 31, 1975?

____

Item V. Contact Person

Please complete the following information so that we may clarify the information you have given us (*if necessary*).

Name: ____

Title: ____

Address: ____

____

Telephone: ____

Date: ____

1. GENERAL INSTRUCTIONS

The establishment location for which data are requested is shown in the address label. For purposes of this survey, an establishment usually is a single physical location, engaged in one predominant activity.

Because the establishments in this survey are selected on a sample basis to represent all sizes of establishments in many manufacturing and nonmanufacturing industries, multiunit companies may receive more than one questionnaire. It is important that you complete the questionnaire only for the establishment designated.

Items I and V should be completed and the form returned, even if you do not employ any scientific and technical personnel. Providing this information is essential to the estimating procedure and will avoid unnecessary correspondence.

All employment figures should be reported for the pay period which includes December 31, 1975.

2. DEFINITION OF TERMS

A. General

Employees in the specialized occupations, reported in items II and III should be counted on a "*Working As*" basis, as of the date of the report (Dec. 31, 1975) regardless of their field of degree or whether they hold a college degree. For example, an employee trained as an engineer but working as a mathematician as of the date of the report should be reported as a mathematician. Similarly, an employee trained as a biological technician but working as a medical technician should be reported as a medical technician. When actual data are not available, please make an estimate.

B. Scientists and engineers

For the scientific or engineering occupations, *include* those who work at a level which requires knowledge of the subject at least equivalent to that acquired through completion of a 4-year college course with a major in one of those fields, regardless of whether they hold a college degree. *Include* all scientists and engineers in research and development, production, management, technical services, sales, or other positions which require the use of the indicated level of knowledge. *Exclude* persons trained as scientists or engineers but currently employed in positions not requiring the use of such knowledge.

Engineers

Count as engineers all persons actually engaged in chemical, civil, electrical, industrial, mechanical, materials/metallurgical, mining, petroleum, or any other type of engineering. *Include* architectural engineers; *exclude* architects.

Physical and life scientists

Count as scientists all chemists, physicists, metallurgists, geologists/geophysicists, agricultural scientists, biological scientists, medical scientists, and other physical and life scientists who are actually engaged in scientific work. *Exclude* psychologists, economists and other social scientists. Definitions for medical, agricultural, and biological scientists follow.

Medical scientists — are only those physicians, dentists, public health specialists, pharmacists, and members of other scientific professions who are concerned with the understanding of human diseases and improvement of human health, and spend the greatest portion of their time in clinical investigation or other research, production, technical writing, and related activities. *Exclude* from this category all practitioners — that is, those medical scientists who spend the greatest portion of their time providing care to patients, dispensing drugs or services, or in diagnosis, etc. Persons working as pathologists, microbiologists, pharmacologists, etc., should be excluded from the figures for the medical scientists and included in the figures for biological scientists.

Agricultural scientists — are all persons who are primarily concerned with the understanding and improvement of agricultural productivity, such as those working in agronomy, animal husbandry, forestry, horticulture, range management, soil culture, and veterinary science. *Exclude* veterinarians who spend the greatest portion of their time providing care to animals since they are primarily practitioners and not within the scope of this survey.

Biological scientists — are all persons who spend the greatest portion of their time in scientific work dealing with life processes other than those classified in the agricultural and medical science. *Include* pathologists, microbiologists, pharmacologists, bacteriologists, toxicologists, botanists, zoologists, etc.

Mathematical scientists

Count as mathematical scientists all persons who are primarily concerned with the development of mathematical theory or the application of established mathematical laws and principles to specific problems and situations. *Include* actuaries only if they specialize in mathematical techniques; *exclude* accountants.

Mathematicians — are only those persons who spend the greatest portion of their time in mathematical research or in the development or application of mathematical techniques in science, management, and other fields, and/or solving or obtaining solutions to problems in various fields by mathematical techniques.

Statisticians — are all persons, other than those reported as mathematicians, who meet the general requirements for "Mathematical scientists" and who are primarily engaged in the recurrent application of statistical techniques. For purposes of this survey, statistical techniques include the design of surveys or experiments as well as the collection, organization, interpretation, or analysis of numerical data. *Exclude* statisticians who are engaged solely in the development of mathematical theory associated with the general application of statistical techniques — these persons should be reported as mathematicians. Also, *exclude* persons engaged in quality control, time or motion study applications, inventory control, computer programming, testing, etc., who utilize statistical techniques merely as an occasional tool in connection with the performance of other primary duties.

Computer scientists

Count as computer scientists all persons working as computer systems analysts, systems engineers, computer specialists, data processing systems project planners, software specialists, etc. *Include* computer programmers only if their positions meet the foregoing requirements. Other computer programmers should be included in the category "other technicians" (See definition for draftsmen and technicians).

C. Draftsmen and technicians

Count in this occupational grouping all persons actually engaged in technical work at a level which requires knowledge of engineering, mathematical, and physical or life sciences, comparable to that acquired either through study at technical institutes, junior colleges, or through equivalent on-the-job training or experience. Some typical job titles are draftsmen, surveyor, laboratory assistant, physical science aide, and electronic technician. All persons in positions which require the indicated level of knowledge should be counted, regardless of job title or department in which employed. Computer programmers who meet the above definition of technicians and surveyors should be reported as "other technicians". *Exclude* those persons whose positions require knowledge or training consistent with the foregoing definitions of engineers, mathematicians, or scientists, and report them in the appropriate occupational category on the questionnaire. Also, *exclude* all craftsmen such as machinists, electricians, and specialized personnel such as airline pilots, navigators, flight engineers, and ships' officers. Separate definitions of electrical and electronic technicians; other engineering and physical science technicians; and biological, agricultural, and medical technicians follow:

Electrical and Electronic technicians — are all persons with a background in electrical or electronic theory, physical science, and

mathematics which enables them to perform jobs above the routine operating or maintenance levels. Normally, such employees are engaged in construction, repairing, testing, installing, modifying, operating, or even designing a variety of production or experimental types of complex electrical or electronic equipment.

Biological, agricultural, and medical technicians — are all persons with a background in agricultural, biological, or other life science which enables them to perform jobs above the routine level in both laboratory and operations activities. *Exclude* medical and dental technicians who spend the greatest portion of their time providing care or services to patients.

Other engineering and science technicians — are all persons who assist engineers and scientists in both laboratory and production types of activities. Normally, these technicians work under the direct supervision of an engineer or scientist and assist him in those functions usually described as routine at the professional level. Where possible, count these personnel as chemical, mechanical, industrial, or mathematical technicians.

3. RESEARCH & DEVELOPMENT FUNCTIONS

Include in this function those individuals who spend the greatest proportion of their time performing, managing, or administering basic and applied research and in the design and development of prototypes, processes, studies, surveys, and related activities. If the primary objective of an activity is to make further improvements on the products, processes, or studies, then the work is research-development. If, on the other hand, the product or process is substantially operational and the primary objective is to develop markets, do preproduction planning, or get the production process going smoothly, then the work is no longer research-development. For purposes of this survey, research and development *includes* the activities described below whether assigned to separate research and development organizational units of the establishment, or carried on by laboratories and technical groups not part of a separate research and development unit per se.

(a) *Pursuit of planned research for new knowledge, whether or not the research has reference to a specific application.*

(b) *Application of existing knowledge to problems involved in the creation of a new product, process, study, or survey, including work required to evaluate possible uses.*

(c) *Application of existing knowledge to problems involved in the improvement of a present product, process, survey, or study.*

Development activities include — the design and operation of pilot plants or semi-works plants so long as the principal purposes are to obtain experience and to compile engineering and other data to be used in evaluating hypotheses, writing product formulas, or establishing finished product specifications; engineering activity required to advance the design of a product or a process to the point where it meets specific functional and economic requirements and can be turned over to manufacturing units; and design, construction, and testing of preproduction prototypes and models and "engineering follow-through" in the early production phase.

The development of designs for special manufacturing equipment and tools is included but tool making and tool tryout are not included. The preparation of reports, drawings, formulas, specifications, standard practice instructions or operating manuals, and other media for transmitting to operating units information obtained from the above activities is included. However, the production of detailed construction drawings or manufacturing blueprints is not included. The question, *"When does development end and production begin?"* is often asked. If the primary objective is to make further improvements on the product or process, then the work comes within the definition of research and development. If, on the other hand, the product or process is substantially "set", and the primary objective is to develop markets or to do preproduction planning, or to get the production process going smoothly, then the work is no longer research and development.

Research and development excludes — routine collection of information or statistics (i.e., performing market surveys to determine product acceptance); collating amount of overtime worked in different organizational units; market development (including the sale of either old or new products to obtain acceptance of them in new outlets); quality and quantity control tests and analyses; trouble shooting in connection with breakdowns in full scale production; technical plant sanitation control; work required for minor adaptations of a specific product to meet the requirements of a specific customer; engineering and other technical service furnished in accordance with agreement to licensees outside the company, and furnished by the research and development organization to manufacturing divisions to enable them to operate in accordance with previously determined formulas, practice instructions, or finished product specifications; aid furnished to develop advertising programs to promote or demonstrate new products or processes including the development of material furnished for trial or demonstration; experimental work performed at the request of the patent division to provide information needed during the prosecution of a patent litigation, and technical writing.

4. OPERATIONS AND MAINTENANCE

Include the day-to-day functions of this establishment. In general, this category should include all personnel not counted in Research and Development or Force Construction.

5. CONSTRUCTION

Force construction is construction undertaken by the establishment on its own behalf and does not include construction performed under contract for others. *Include* plant additions or renovations performed by your personnel. *Exclude* plant additions or renovations contracted out, but include your personnel assigned to contract supervision.

Contract construction is construction under contract for others. If your establishment's principal line of business is contract construction most personnel should be counted under the activity heading "Operations and Maintenance." In any case, construction performed by your personnel on your own behalf should be counted as Force Construction.

6. CAPACITY

Capacity or capacity output is the maximum physical output that can be produced during a given time period with existing plant and equipment.