DOCUMENT RESUME

ED 151 142 SE 022 859

TITLE	Reviews of Data on Science Resources, No. 29. Current and Future Utilization of Scientific and Technical Personnel in Energy-Related Activities.
INSTITUTION	National Science Foundation, Washington, D.C. Div. of Science Resources Studies.
REPORT NO	NSF-77-315
PUB DATE	Jun 77
NOTE	8p.; Not available in hard copy due to marginal legibility of original document
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 038-000-00328-3; No price quoted)
EDRS PRICE	MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	*Career Education; *Energy; *Engineers; Manpower Development; *Manpower Needs; Personnel; Professional Personnel; Science Education; Scientific Manpower; *Scientists
IDENTIFIERS	National Science Foundation

ABSTRACT

This National Science Foundation (NSF) bulletin summarizes the NSF program of energy manpower studies that assessed the impact of past energy developments and future options for scientific and technical manpower. This document summarizes the utilization of scientific personnel in energy-related activities in private industry in 1975 and shortages of technical personnel for energy-related activities in private industry. Also, projected needs for science and engineering personnel in energy-related activities are summarized. Graphs and charts are used to illustrate the discussions. Highlights of the report include: (1) Numbers of baccalaureate degrees in mining, chemical, and petroleum engineering have increased in response to job market demand; (2) Projected requirements for scientists and engineers for 1985 in energy production are approximately 220,000; and (3) The energy production sector will not, according to projections, make greater proportionate demands on the supply of manpower as time passes. (MR)

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Reviews OF DATA ON SCIENCE RESOURCES

NATIONAL SCIENCE FOUNDATION, WASHINGTON, D C NSF 77-315 No 29, June 1977

Current and Future Utilization of Scientific and Technical Personnel in Energy-Related Activities

Introduction

Current interest in scientific and technical personnel for energy-related activities arises from national recognition of the need to decrease reliance on imported energy supplies. This need was brought forcibly to the forefront with the Arab oil embargo of October 1973

The Project Independence report[1] foresaw substantial domestic energy development and some concern has been expressed that the necessary research and development, contruction, and operation of such a program might possibly strain available scientific and technical personnel resources

Consequently, the National Science Foundation undertook a program of energy manpower studies to assess the impact of past energy developments and future options on scientific and technical manpower

Impact Highlights

- Since 1972 there has been a trend in tightening of the job market for personnel in energy-related activities In early 1977 there was evidence of significant shortages of mining, chemical, and petroleum engineers However, since 1975 the numbers of baccalaureate degrees in these fields have grown substantially, indicating that students are responding to the increased opportunities for employment

- For any one of three assumed energy-use scenarios for 1985, projected requirements for scientists and engineers in energy production are approximately identical, 220,000 This is because decreases in employment stemming from an assumed lesser use of traditional energy sources are counterbalanced by requirements for research and development in new technologies and the construction and operation of new domestic energy components

- Regardless of the scenarios selected, projections indicate that an annual 3-percent growth rate in employment of scientists and engineers is likely to be needed to meet the requirements of the economy Compared to the base year 1974, the proportion of scientists and engineers involved in energy production, 13 percent, would not change significantly Thus, the energy production sector will not make greater proportionate demands on the supply of manpower as time passes

Descriptive Highlights

- In 1975, 16 percent of all scientists and engineers and 15 percent of the technicians in private industry were employed in energy-related activities, 11 percent of all R&D scientists and engineers were engaged in energy-related work

[1] Federal Energy Administration *Project Independence Blueprint Final Task Force Reports Labor Report* (Washington DC 20402 Supt of Documents U S Government Printing Office November 1974)

(Prepared in the Manpower Utilization Studies Group, Division of Science Resources Studies)

- The largest activity in terms of employment was energy distribution and storage, accounting for 25 percent of the 186,000 scientists and engineers in energy-related activities in private industry
- By type of energy in which scientists and engineers were involved, electric power was the largest (37 percent of energy-related employment) followed by petroleum (31 percent)
- Engineers comprised 82 percent of the total scientists and engineers in energy-related activities in private industry

Utilization of Scientific Personnel in Energy-Related Activities in Private Industry, 1975

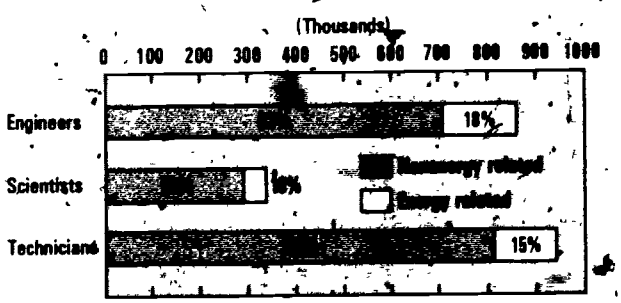
In March 1975 a sample survey of establishments in the private industry sector provided information on the utilization of 1,200,000 scientists and engineers and about 1 million science and engineering technicians. About 70 percent of total scientists and engineers in the United States are employed in private industry

The data show that of the 850,000 engineers in private industry, 18 percent were employed in energy-related activities, as well as 10 percent of the 330,000 scientists, and 15 percent of the technicians (chart 1)

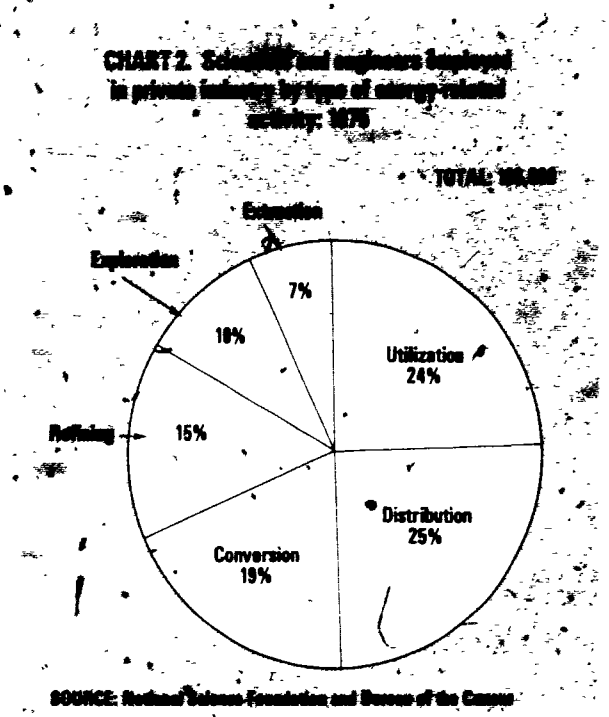
Of all energy-related activities, distribution and utilization were the two largest. Utilization is defined as those activities specifically directed at conservation, improved efficiency or improved environmental conditions in energy end-use (chart 2).

With regard to energy-related research and development, 20 percent of the scientists and engineers in

CHART 1. Total scientists, engineers, and technicians employed in private industry in energy-related and nonenergy-related activities: 1975



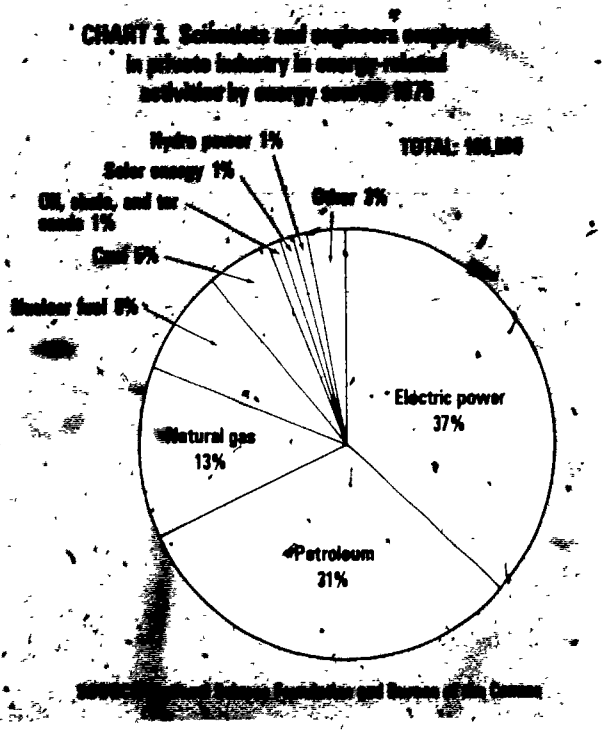
SOURCE National Science Foundation and Bureau of the Census



SOURCE: National Science Foundation and Bureau of the Census

energy-related activities were employed in research and development. These personnel comprised 11 percent of all R&D scientists and engineers in the private industry sector.

Most scientists and engineers are involved with the traditional forms of energy. Thus, two out of every three were concerned with either electric power or



some aspect of petroleum. Only 2 percent were engaged in work on solar energy, and oil shale or tar sands (chart 3).

The energy field is relatively engineering intensive. Thus, of those scientists and engineers in energy, 82 percent were engineers. The largest engineering specialties are mechanical and electrical. As one would expect, physical scientists made up the bulk of the scientist group (chart 4).[2]

Shortages of Technical Personnel for Energy-Related Activities in Private Industry

In order to assess the job-market situation for personnel in energy-related activities, several indicators were examined.

It is difficult to obtain and interpret direct evidence of shortages. Consequently, a 1975 survey of employers involved in energy-related activities, conducted for NSF by the University of Illinois,[3] focused on expected objective behavior by firms if the firms had difficulties in obtaining adequate numbers of scientific and technical personnel.

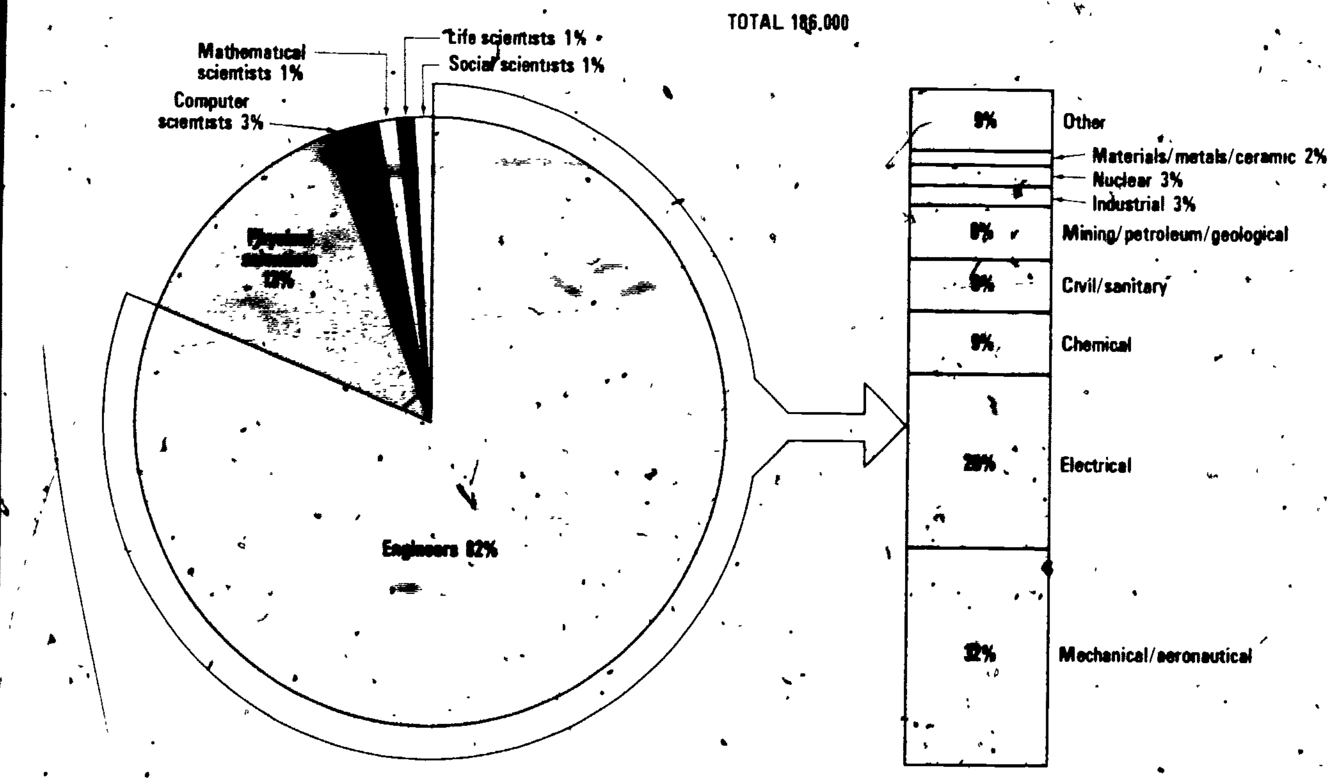
A wide range of labor-market indicators was examined for the period 1972 through 1975. Detailed occupational data were collected on salaries, quits, vacancies, hires, offers, and employment in energy-related industries. This study concluded that the variety of measures employed consistently showed no evidence of any serious shortages of scientists and engineers in late 1975.

However, while no critical shortages were noted, there was an apparent trend in the tightening of the job market for some specialties, specifically petroleum, mining, metallurgical and materials, chemical, and nuclear engineers.

[2] [illegible] National Science Foundation [illegible] Employment of Scientists and Engineers [illegible] 1975 [illegible] NSF 77-[illegible] Washington, D.C. 20550, May 25, 1977 [illegible] will be published shortly.

[3] [illegible] Scientific and Technical Personnel in Energy [illegible] Requirements [illegible] University of Illinois [illegible] 24, 1977 [illegible]

CHART 4. Scientists and engineers employed in private industry in energy-related activities by occupation: 1975



SOURCE National Science Foundation

To update this information, and to determine if employers view the supply demand situation as serious, 30 of the largest employers of energy-related science and engineering personnel, representing the major energy production industries, were interviewed during March 1977.[4] On an occupation by occupation basis, the following emerged.

1) Throughout the coal industry there is a need for, but a serious shortage of, new recipients of bachelor's and master's degrees in mining engineering.

2) The market is also very tight for chemical engineers at the bachelor's and master's level, a serious shortage exists at the Ph D level.

3) There is a serious shortage of petroleum engineers at all degree levels.

Available data for starting wage offers to college graduates reinforce these conclusions, with petroleum and mining, and chemical, engineers receiving the highest current salary offers among all disciplines.[5]

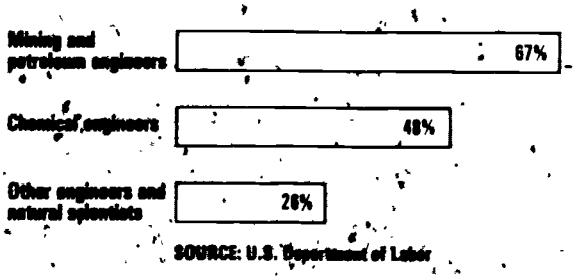
A final piece of evidence regarding shortages relates to the immigration of scientists and engineers. Regulations require such entrants to have a job offer that the Department of Labor has certified as being unfillable by a domestically available qualified person.

In 1975 and 1976 a total of 9,100 natural scientists and engineers applied for entry to the United States for the purpose of accepting a job offer in their field. A relatively high proportion of immigrant applicants in the short-supply occupations in energy-related activities were granted worker certification. On the other hand, only 26 percent of the applicants in the other engineering and natural science specialties were granted worker certification (chart 5).

This was a nonstatistically valid sample interviewed by Division of Science Resources Studies, NSF staff.

College Placement Council, *Study of Beginning Salary Offers Special Interim Report Covering Period 9/1/76 to 1/17/77* (Bethlehem, Pa., 1977).

CHART 5. Percent of immigrant scientists and engineers approved for admittance to the United States by occupation: 1975 and 1976



SOURCE: U.S. Department of Labor

In summary, based on the available job-market indicators and employers' judgment as to the situation, energy-related industries seem to have serious difficulties in obtaining mining engineers below the Ph D level, petroleum engineers at all degree levels, and chemical engineers at the Ph.D. level with the particular skills required by those industries.

Comparing 1975 with 1978 projected bachelor's degrees provides a rough indication of whether students have responded to the increased demand of the market in these fields (chart 6). Total engineering bachelor's in 1978 are projected to be 25 percent higher than in 1975. On the other hand, for the short-supply fields, petroleum engineering degrees are 167 percent greater; mining 100 percent greater, and chemical 68 percent greater. Therefore, the market appears to be responding to the tightness in the case of petroleum, mining, and chemical engineering.

Projecting Requirements for Scientists and Engineers in Energy-Related Activities

In order to assess the long-range requirements for scientists and engineers in energy-related activities, NSF supported a study which has developed a forecasting system. The work drew on, refined, and integrated a number of manpower and energy models developed in recent years. The system was designed by the Center for Advanced Computation at the University of Illinois.[6]

The first projections of 1985 scientist and engineer requirements from this system incorporate the latest alternate energy scenarios specified by ERDA.[7] The three energy scenarios examined are called *Free Imports*, *Limited Imports*, and *Limited Imports Synthetics*. They imply different final demand and technology patterns.

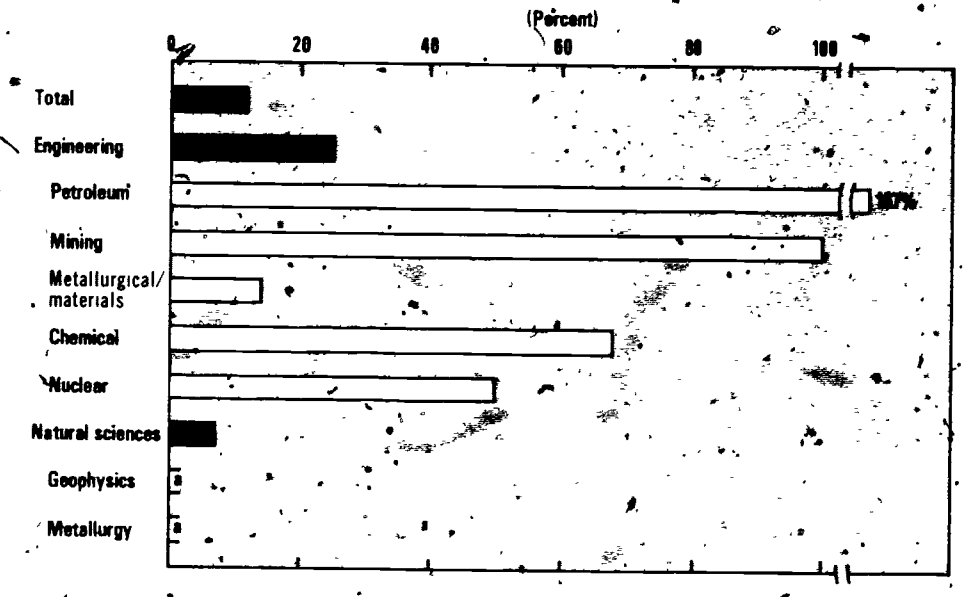
Free Imports assumes that energy consumption in the United States increases from 1973 by about 36 percent in 1985. Domestic energy production increases, but the growth of imports of oil and gas are substantial. This scenario assumes a real price increase of oil between 1973 and 1985 of about 100 percent, and assumes current energy efficiency levels.

Limited Imports assumes that energy usage increases by 15 percent and a price increase of about 150

Ibid., *op. cit.*

Energy Research and Development Administration, *A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future*, Vol. I: The Plan (ERDA 48-0) (Washington, D.C. 20402: Superintendent of Documents, U.S. Government Printing Office, June 1975).

CHART 6. Increase of 1978 baccalaureate degrees in the natural sciences and engineering compared with those for 1975 by selected field



[a]No change.
SOURCE: National Science Foundation and National Center for Education Statistics

percent. Domestic coal production increases substantially more than in *Free Imports*, nuclear power grows substantially more, and oil imports are much lower.

Limited Imports Synthetics uses the same major assumptions as the *Limited Imports* one except that oil prices increase by about 200 percent, and energy use by 19 percent. In addition, it assumes a program of developing synthetic oil and gas which involves substantial investment in construction costs. The two *Limited Imports* scenarios assume substantial improvement in energy utilization technology and process efficiencies over current levels.

The overall national level and pattern of outputs of goods and services used were derived by the Bureau of Labor Statistics from analyses of consumption and production studies. The Bureau model has as its major assumptions a drop in unemployment from nearly 8 percent in 1976 to 4 percent by 1985, a 3.8-percent annual growth in gross national product (GNP), and a peacetime economy. In the *Limited Imports* cases for 1985, total GNP is assumed to be 1.5 percent lower than in the *Free Imports* case, and there are substantial differences in output patterns associated with the different scenarios. The University of Illinois researchers developed projected manpower to output coefficients for the energy industry sectors from a direct industry survey. Subsequent application of these coefficients applied to the projected outputs, derived by input-output analysis,[8] produced estimates of energy-related scientists and engineers.

The findings of the study show that the range of requirements in private industry for all scientists and engineers and those in energy-related activities under the three scenarios is very small. For *Free Imports*, projected requirements for private industry total employment is 1,650,000 natural scientists and engineers, about the same as for the *Limited Imports* cases. The same proportion of the projected scientists and engineers will be employed in energy production under the three scenarios—13 percent.

While the lack of significant differences between scenarios may seem surprising, several important and related factors must be kept in mind. The scenarios that incorporate development of new domestic capabilities also assume a reduction in imports with the net effect being a lower level of energy use. The diminished use of energy reduces not only the total demand for scientists and engineers because of lower economic activity, but also those involved in energy. Thus, the additional manpower requirements to construct and operate nuclear power plants, expand coal use and synthetics use and to do research on new

[8] The input-output matrix consists of nonenergy coefficients projected by the Bureau of Labor Statistics and energy industry coefficients developed by the Center for Advanced Computation.

technologies are just about sufficient to offset manpower reductions from the declines in nonnuclear electric power production, in petroleum extraction and refining, in natural gas production, and other economic cutbacks resulting from reduced energy use.

Regardless of which of the three scenarios is assumed, the projections indicate a likelihood for an annual 3-percent growth rate in employment of scientists and engineers to meet the requirements of the economy between 1974 and 1985 (table 1). Compared to the base year 1974, the proportion of scientists and engineers involved in energy production under the assumed scenarios does not change significantly—about 13 percent of total private employment. Thus, the production of energy will not make greater proportionate demands on the supply of manpower as time passes.[9]

[9] Whether or not the future supply of scientists and engineers in particular energy related specialties will be equal to, in excess of, or short of requirements under the scenarios studied would depend on the future supply of scientists and engineers, interoccupational mobility, and other factors relating to the dynamics of the job market for scientists and engineers. These factors will be analyzed in a forthcoming NSF-supported study by the University of Illinois.

TABLE 1—TOTAL ESTIMATED SCIENTISTS AND ENGINEERS IN PRIVATE INDUSTRY BY ENERGY INVOLVEMENT, 1974 AND PROJECTED 1985 FOR A FREE IMPORTS SCENARIO

[Numbers in thousands]

Occupation group	Total employment			Energy-related employment		
	1974	1985	Percent increase	1974	1985	Percent increase
Total natural scientists and engineers	1 200	1 650	38	160	220	39
Scientists	200	250	30	30	40	37
Engineers	1 000	1 400	39	130	180	40

NOTE: Absolute numbers are rounded. Percent increases are based on unrounded data.

SOURCE: Center for Advanced Computation, University of Illinois.

In considering these projections, it must be realized that the numbers of scientists and engineers in 1985 forecast in these scenarios are not predictions but are meant to show what might occur under the many assumptions discussed. The eventual GNP, energy technology, fuel prices and energy program adopted by the country may vary substantially from the assumptions embodied in these projections.

Technical Notes

The data for 1975 private industry employment were derived from a sample survey representing all establishments of the industry sector. The 1975 data are not strictly comparable to the 1974 energy-manpower data shown as the base year for the 1985 projections since the 1974 data are derived from a model which relates estimated manpower relationships to energy outputs. The 1975 data in addition to the production activities include as energy-related any personnel involved in conservation, environmental concerns, or improved utilization in energy end-use; however, the 1974 estimates and 1985 projections do not include persons in the latter activities. In addition, the 1974 estimates relate only to industries involved in the production of energy and some of the major suppliers to those industries,[a] while the 1975 data represent all industries. The relative standard error of the estimate for the 186,000 energy-related scientists and engineers in 1975 is 4 percent. Considerably more detail on industry of employment, R&D employment, employment by energy source and type of energy-related activity with comparable data for technicians can be found in the reports referenced in footnotes 2 and 3. Information as to the reliability of the estimates, sampling procedures, and methodologies can also be found in these reports. A limited number of these reports will be available from the Division of Science Resources Studies, National Science Foundation, Washington, D.C. 20550.

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[a] Direct energy industries included in the 1974 data by Standard Industrial Classification are: SIC 131 Crude Petroleum; SIC 132 Natural Gas Liquids; SIC 291 Petroleum Refining and Related; SIC 492 Gas Production and Distribution; SIC 1094 Uranium Mining and Milling; SIC 1111 Anthracite Mining; SIC 1112 Anthracite Mining Services; SIC 1211 Bituminous Mining and Lignite; SIC 1213 Bituminous Mining Services; SIC 1381 Oil and Gas Field Drilling; SIC 1382 Oil and Gas Field Services; SIC 1389 Oil and Gas Field Services n.e.c.; SIC 2819 [illegible] Materials Production; SIC 4011 [illegible] Iron; SIC 4911 Electric Services; SIC 4931 Electric, Gas & Other [illegible] Less than 95 percent; SIC 4932 Electric & Gas Services, Primary Gas; SIC [illegible] Gas [illegible]; SIC 4961 Steam Supply [illegible]

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