Manpower for the Coal Mining Industry: an Assessment of Adequacy through the Year 2000

Final Technical Report
Volume I: Executive Summary

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Abstract

This report presents a summary of the analytical approach taken and the conclusions reached in an assessment of the supply and demand for manpower in the coal mining industry through the year 2000. A hybrid system dynamics/econometric model of the coal mining industry was developed which incorporates relationships between technological change, labor productivity, production costs, wages, graduation rates, and other key variables in estimating imbalances between labor supply and demand.

Study results indicate that while the supply of production workers is expected to be sufficient under most future demand scenarios, periodic shortages of experienced workers, especially in the Northern Great Plains, can be expected. Other study findings are that the supply of mining engineers will be sufficient under all but the highest coal demand scenario; a shortage of faculty will affect the supply of mining engineers in the near term; and the employment of mining technicians is expected to exhibit the largest increase in any labor category studied.

This volume of the report is an Executive Summary which provides a brief description of the study and gives its major conclusions and recommendations. An accompanying volume (Vol. II) provides a detailed description of the analytical basis for the study, the sources of data used, and a discussion of the conclusions reached.

Preface

In this report, the work carried out in assessing the supply of and demand for manpower in the coal mining industry in the United States through the year 2000 is described. The report is in two volumes: an Executive Summary (Vol. I) and a description of the technical approach taken (Vol. II). This work was carried out over a 15 month period for the Office of Coal Mining in the U.S. Department of Energy. The objectives of this study were:

- to project manpower supply and demand for a variety of future coal production scenarios and to identify future imbalances by producing region, mining technology, and skill category
- to estimate the sensitivity of manpower supply and demand to changes in major influencing factors; e.g., labor productivity, wages and salaries, coal production, technology mix, capital costs
- to assess the adequacy of existing Federal educational support programs for manpower training in the coal mining industry and the impacts of future support on manpower supply

With these objectives in mind, it is apparent that in order to understand the nature of the major influences on manpower supply and demand, it is necessary to identify and quantify many of the relationships which characterize the coal mining industry in the United States.

The analytical approach chosen to do this involves the development of a hybrid system dynamics/econometric model which simulates, on a regional and annual basis, the supply of and demand for coal mining manpower. For any desired coal production and price schedule (given on a national or regional basis), the model provides estimates of the implications of that schedule in terms of manpower requirements and manpower supply.

As a result of this work, a tool has been developed that can be used to answer a wide variety of questions involving the coal mining industry in general and coal mining manpower in particular. For example, questions involving the impacts on manpower of such factors as production costs, Federal policies, the market penetration of new technologies, labor productivity, and total coal demand can be answered using the model which has been developed in this study.

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Executive Summary

1. Project Summary

The supply of and demand for manpower in the coal mining industry has been estimated on a regional basis for the time period 1980-2000. The objectives of the work carried out and summarized in this report are:

- to project manpower supply and demand for a variety of future coal production scenarios and to identify future imbalances by producing region, mining technology, and skill category
- to estimate the sensitivity of manpower supply and demand to changes in major influencing factors, e.g., labor productivity, wages and salaries, coal production, technology mix, capital costs
- to assess the adequacy of existing Federal educational support programs for manpower training in the coal mining industry and the impacts of future support on manpower supply/demand balances

Several studies have been conducted which address various aspects of the manpower supply/demand outlook in the coal mining industry. In none of these, however, has the entire work force been considered in sufficient detail to permit comparison of the labor supply by educational or experience category with labor demand by function or job category. Also, these studies have not considered the impacts of changes in coal mining technology on future manpower needs. Without such considerations, it has been difficult to assess the likelihood of future shortages of specific types of manpower.

To address the objectives identified above, the approach selected in this study consisted of the following elements:

- an assessment of expected changes in coal production technologies given technology costs and market constraints
- extensive gathering of published and unpublished data from producers, industry organizations (including unions), government agencies, and universities. This was supplemented by visits to and interviews with selected producers and university spokesmen
- development of technology-specific cost and labor data for nineteen representative coal mines
- use of these data in a comprehensive system dynamics/econometric model of the coal mining industry which quantifies the numerous relations which exist between major variables such as labor supply, demand, productivity, wages and salaries, coal production, prices, etc.

The model developed is comprised of three primary sectors—labor demand, labor supply and wage determination—within which numerous submodels interact. Labor demands by job category are derived based on system dynamics relationships involving technology costs, labor productivity, the ability of operators to attract financing, technology constraints, capacity construction and retirement rates, and the allocation of new investments by profitability criteria. The major exogenous inputs to the labor demand sector are coal demand levels, freight-on-board (F.O.B.) selling prices, capital, labor and related input requirements for 19 model coal mines representing six distinct deep and surface mining technologies.

The labor supply and wage determination sectors are developed primarily through multiple regression analysis. Key relationships in the labor supply sector involve estimating the relative impact of factors such as wages, job opportunities, and general economic conditions on graduation rates for engineers, scientists and technicians. The forecasting of graduation rates based on various market conditions is essential to estimating the future supply of professional and technical labor that is anticipated both with and without Federal funding programs. The impact of these factors on the number of entrants into the coal mining work force of new hourly production workers was estimated.

The wage determination sector estimates market wages for each labor supply category based on lagged supply/demand imbalances. Wage levels for labor supply categories then affect coal production costs (and in turn, labor demand) based on the types of labor employed within the industry work force. The major exogenous inputs to the labor supply and wage determination sectors are real GNP, unemployment rates, inflation rates, mining engineer demands by non-coal industries and Federal educational support levels.

Beginning with initial year (1960) values for each variable, differential equations (which comprise the various submodels within the three model sectors) are solved simultaneously. Annual values for each variable are then solved iteratively and are thus influenced by the previous year's solution set. In this manner, the model attempts to simulate the continuous or dynamic behavior of the interrelated elements within the overall system.

Because abundant empirical data were not always available, many relationships within the model (e.g., the impact of Federal funding, company hiring preferences, etc.) were developed from assumptions based on extensive interviews with coal company, union, government, and university officials. The largest number of interviews were conducted to address the need for and the impact of Federal funding on professional and technical school enrollments.

For this purpose, a telephone survey was conducted among the following: (a) universities with programs in mining and mineral engineering, (b) other universities not having such programs but receiving funds under the State Mining and Mineral Resources and Research Institute program (SMMRRI), and (c) community college/vocational schools offering two-year degrees and related coursework in mining technology. The results of these surveys, apart from those inputs used in the model, are discussed in some detail in Appendix B of Volume II.

2. Study Results

The study results obtained were based on three levels of coal demand through 1990 which were developed by other DOE contractors in previous studies. These estimates were then extrapolated by MITRE to the year 2000. Among the exogenous inputs not pertaining specifically to the coal industry, real Gross National Product (GNP) was found to be the most significant in terms of exhibiting a strong influence on the demand for engineering and scientific manpower nationwide, as well as on unemployment rates. Table I presents the exogenous coal demands and real GNP levels used in this study.

It should be noted that the three demand levels forecasted assumed a continuation of the same hiring practices and industry concentration of producers as occurs at present. This does not necessarily imply that the medium coal demand, or Base Case, in Table I is the most probable future in terms of employment outlook, but rather, that it provides a basis upon which assumed changes in industry and other economic conditions can be measured.

In addition to the three coal demand cases, nine sensitivity analyses were conducted to account for those uncertainties most likely to affect future labor supply/demand imbalances. A description of these analyses is presented in Table II. It should be noted that all three initial coal demand cases forecast sufficient professional manpower supplies in general, and a surplus of mining engineers in particular. Thus, most of the analyses were structured to define sets of market conditions which may result in future labor shortages which might require alleviation via Federal funding programs.

The range of probable employment futures developed from the set of model outputs (from the three initial cases and nine sensitivity analyses) was assessed in light of expected industry trends and conditions as expressed in numerous interviews with knowledgeable officials. Table III presents MITRE's estimates of high, most probable, and low employment futures in terms of manpower supply categories through 2000.

The most probable employment future was considered the one forecasted in Sensitivity Analysis #3. In selecting this analysis as representing the most probable employment future, two assumptions were made:

- The most likely coal production case is the Base Case in which 1.1 and 2.2 billion tons per year are expected to be produced by 1985 and 2000, respectively.
- Offsite employment will almost double as a percentage of total coal industry employment reaching about 10 percent by 1990. This is based on some continuation of probable conditions, including: a greater concentration of large companies and conglomerates controlling production; a shift to larger, predominantly area surface mines which are more productive and which require more planning and design work relative to full-time onsite personnel; and some increases in regulatory requirements which occupy more corporate or division office personnel in terms of permit applications, monitoring and related paperwork.

In terms of the work force composition by education and experience level, the category which shows the greatest variance among the employment futures is that of inexperienced workers.*

The number of such workers fluctuates considerably based on overall industry growth rates. At 12 percent of total employment by 2000 in the High Employment Future, this is double their percentage

*Inexperienced workers as a supply category include all workers employed in coal mining less than one year except personnel with degrees related to their job function (i.e., mining engineers, other engineers, scientists and mining technicians), or clerical and general office personnel (i.e., administrative). Experienced workers exclude the same personnel categories as do inexperienced workers, and simply are comprised of all other workers employed for at least one year.

Table I
Exogenous Coal Demands and Real GNP Assumed in High, Medium, and Low Coal Demand Cases

		1978 (actual)	1985	1990	2000
Low Case	Coal Demand*	653.8	990.1	1114.4	1673.5
	Real GNP**	1860.6	2257.7	2594.5	3327.7
Medium (Base) Case	Coal Demand	653.8	1116.3	1521.0	2284.0
	Real GNP	1860.6	2414.3	2828.6	3626.8
High Case	Coal Demand	653.8	1188.2	1856.5	2787.8
	Real GNP	1860.6	2622.2	3132.4	4017.6

*Coal Demand in 10^6 Tons/year
**Real GNP in \$1976 x 10^6

Table II
Description of Sensitivity Analyses

Analysis Number	Coal Demand Case Assumed	Assumptions Changed	Impacts
1	Base	Assumes productivity (measured as real gross output per employee in non-coal mining industries) remains constant at 1977 levels, rather than increasing through 1990 as in Bureau of Labor Statistics projections.	Increase in mining engineers demanded by non-coal mining industries, based on relationship to total work force. Impact on supply/demand balance and wages of mining engineers and, by association, supervisors and technical support staff.
2	Base	Assume high future demand specifically for mining engineers in metal and non-metal mining industries, based on 1977 American Mining Congress (AMC) survey. For new positions above replacements, assume 200 per year to 1985, and 250 per year through 2000.	Same as for Analysis #1.
3	Base	Gradual increase in off-site personnel as percent of total coal industry employment from 5.5% at present (kept constant in three initial cases) to 10.0% by 1990. Based on assumed trend toward industry concentration by large producers and oil/mining company subsidiaries, with tendency for greater off-site staffing and performance of regulatory work in-house.	Increase in demand for all types of engineers and scientists applicable to mining as well as administrative/office workers.
4	Base	Combines assumptions made in Analyses #2 and #3.	Magnifies the increased labor demands and potential imbalances cited in Analyses #2 and #3.
5	Base	Same as assumptions made in Analysis #4, but includes Federally funded scholarships at level assumed to encourage 60 additional B.S. degree mining engineer graduates per year beginning in 1983.	Same as Analysis #4 except Federal funding reduces potential supply/demand imbalance of mining engineers.
6	Base	Assumes stricter environmental, health and safety regulations affecting labor and capital requirements in coal industry. After 1980 for all deep mines, labor demand increases ranging from 2.5% more supervisors to 10% more technical support staff, while all capital, fuel and non-labor operating costs assumed to increase by 5% (with all capital and labor increases double the above for surface mines).	Increases on-site labor and capital costs which influences technology mix and surface-deep production split. Reduces profit margin on marginal mine types and accelerates shift toward higher profit mines.
7	High	Combines assumptions made in Analyses #2 (high mining engineer demand in metal and non-metal mining), #3 (increase in off-site coal industry employment) and #6 (increased labor and capital requirements in all mine types) with those of High Coal Production Case.	Provides greatest potential for professional manpower shortages, especially mining engineers, with accelerated shifts toward higher profit mines.
8	High	Same as assumptions made in Analysis #7, but includes Federally funded scholarships at a level assumed to encourage 110 additional B.S. degree mining engineer graduates per year beginning in 1983.	Same as Analysis #7 except Federal funding reduces potential supply/demand imbalance of mining engineers.
9	Base	Same as assumptions made in Analysis #3 and including a gradual 10% lower selling price for coal produced by technologies which characterize midwest and western coal regions. This reflects an assumption of lower F.O.B. selling prices for coal from these regions as a result of higher transportation costs.	Shifts the production of coal from the predominantly western surface technologies to the eastern deep and surface technologies.

in the Low Employment Future, reflecting the underlying difference between the two futures in terms of coal production growth.

It was also found that mining technicians are the fastest growing component of the coal industry work force. Employment of mining technicians is forecasted to grow at rates of almost 15 percent per year in any case, unless the coal industry itself grows at a rate slower than that of the Low Coal Production Case.

Table III
*Forecasted Work Force Composition**

	Low Employment Future (Low Case)			Most Probable Employment Future (Analysis #3)			High Employment Future (Analysis #8)		
Labor Category	1980	1990	2000	1980	1990	2000	1980	1990	2000
Mining Engineers	1,480 (0.6)	1,450 (0.6)	1,220 (0.4)	1,510 (0.6)	2,250 (0.7)	1,990 (0.4)	1,510 (0.6)	2,150 (0.6)	2,130 (0.4)
Other Engineers	1,070 (0.5)	1,210 (0.5)	1,200 (0.4)	1,090 (0.5)	1,870 (0.6)	2,040 (0.4)	1,090 (0.5)	1,990 (0.6)	2,260 (0.4)
Scientists	510 (0.2)	590 (0.2)	760 (0.3)	520 (0.2)	910 (0.3)	1,310 (0.3)	520 (0.2)	990 (0.3)	1,580 (0.3)
Experienced Workers	184,930 (79.2)	188,200 (76.6)	240,850 (79.5)	184,930 (78.7)	240,340 (72.1)	351,610 (75.0)	184,930 (78.7)	247,090 (69.2)	412,840 (74.8)
Inexperienced Workers	32,800 (14.0)	31,780 (13.0)	18,080 (6.0)	33,810 (14.4)	58,930 (17.7)	55,300 (11.8)	33,810 (14.4)	73,960 (20.7)	66,810 (12.1)
Mining Technicians	2,120 (0.9)	9,170 (3.7)	21,340 (7.0)	2,120 (0.9)	9,160 (2.7)	24,580 (5.2)	2,120 (0.9)	9,650 (2.7)	26,850 (4.9)
Administrative	10,820 (4.6)	13,280 (5.4)	19,470 (6.4)	10,990 (4.7)	19,630 (5.9)	32,270 (6.9)	10,990 (4.7)	20,890 (5.9)	38,970 (7.1)
Total Employment	233,730	245,680	302,920	234,970	333,090	469,100	234,970	356,720	551,440

*Figures in parentheses are percentages of totals for each year.

3. Study Conclusions

A number of more specific conclusions have been drawn from our assessment of the various model outputs and from the numerous interviews conducted during the course of this study. These conclusions are presented below.

(1) Area Surface Mining to Dominate Coal Production by 2000

The combination of large and small area mines located in the midwestern and western regions of the nation is expected to dominate coal production by 2000. These surface mines, in the most probable case (Analysis #3 in Table II), will produce about 55 percent of the nation's total tonnage by 1990 and over 75 percent by 2000. Total employment in these mines will, however, account for 26 percent of the total on-site employment in 1990 and 52 percent in 2000. The high productivity, favorable mining conditions, and relative profitability of these mines contribute significantly to their rapid growth rates. Deep mining production, in the most probable case, exhibits a slow growth in production from a little under 300 million tons per year in 1980 to 400 million tons per year in 1990. The relatively slower growth rate of deep mining results in a continuing decline in its percentage share of national coal production.

(2) Labor Productivity in Deep and Surface Mining to Increase Moderately in the 1980s.

The labor productivity in both deep and surface mining is expected to increase moderately in the 1980s regaining some but not all of the productivity losses experienced in the 1970s. Deep mining labor productivity is expected to increase from a low of 8.3 tons/man-day in 1978 to a high of 12 tons/man-day in 1990. Similarly, surface mining labor productivity is expected to increase from a low of 26.4 tons/man-day in 1976 to 34 tons/man-day by 1990. The gains in productivity during the 1980s are primarily due, in deep mining, to an increase in the percentage of production from continuous mining operations and a gradual decline in conventional mining production. In surface mining, the gains in productivity are attributable to a shift in surface production from the less productive, thin seam eastern contour mines to the larger, thick seam western and midwestern area mines. Both underground and surface mining productivity were forecasted to decline slightly during the 1990s. The shift toward more mechanized, highly productive mines in each sector achieves saturation levels (e.g., such mines account for over 90 percent of production in surface and deep mining) resulting in little additional productivity growth. At the same time, rising real coal prices still attract some number of marginal (i.e., high per ton cost) mines into operation, slightly outweighing productivity increases from other factors over this period.

(3) Periodic Shortages of Experienced Hourly Production Workers

The high turnover rate among hourly production workers having less than one year's experience (35-40 percent), when combined with fluctuating regional

growth rates in coal production, is expected to result in the continued employment of large numbers of inexperienced miners (i.e., around 60,000 in 1990 in the Median Demand, or Base Case). This employment is necessary in order to fill the gap between the demand for and the supply of experienced production workers. It is not until the early 1990s that the number of inexperienced miners is forecasted to fall and remain below 20 percent of the hourly production work force in most cases.

(4) Labor Shortages Most Likely in the Northern Great Plains and Midwest Region.

For all future coal demands considered, the fastest growth rates for labor demand by the coal mining industry are in the Northern Great Plains and Midwest regions. The demand for labor in 1975 as a percentage of the available male labor force was 6.2 percent in the Northern Great Plains and 5.5 percent in the Midwest. By 1990 the demand for labor as a percentage of the available male labor force is projected to increase to 35.2 percent in the Northern Great Plains and 15.9 percent in the Midwest. The projections of the regional male labor force are based on state level U.S. Bureau of Census projections which assume a continuation of 1970-75 interstate migration patterns. Clearly, if labor demand increases as projected in the Northern Great Plains and Midwest and migration patterns are not altered significantly, labor supply will be a major constraint to rapid coal development in these areas.

(5) Relative Predominance of Mining Engineering Within Coal Industry Facing Modest Decline

The percentage of all engineers in the coal industry who are mining engineers (currently about 60 percent) will continue a modest decline, approaching 50 percent of all engineers or about 2,000 mining engineers by the year 2000. This appears to be due to a trend toward continued growth of surface relative to underground mining which has enhanced the willingness of some producers to substitute other professionals, such as civil engineers, for mining engineers, especially for positions in production supervision.

(6) Mining Engineer Shortages Unlikely by the Mid-1980s

The likelihood of mining engineer shortages affecting the coal mining industry any time after the mid-1980s appears to be rather small under most combinations of probable economic and energy demand conditions. Only in cases which combine at least two out of the following five conditions do persistent shortages of mining engineers, in the absence of Federal funding, occur:

(a) very high demand for mining engineers in non-coal mining industries (i.e., 250 new positions per year from 1985 to 2000)
(b) doubling of offsite employment (with greatest concentration of professionals) as percentage of total coal industry employment to 10 percent by 1990
(c) increased onsite personnel requirements due to regulatory changes, resulting in 20 percent greater technical support staff and 10 percent greater total employment after 1980
(d) major increase in eastern coal production reaching 0.6 billion tons per year by 2000, including almost a fourfold increase in eastern surface production (based on higher transportation costs facing midwestern and western coal producers)
(e) high coal production scenario reaching 2.8 billion tons per year by 2000

(7) Current B.S. Degree Graduation Levels Sufficient Under Most Probable Future Conditions

The current level of B.S. degree mining engineering graduates from both accredited and non-accredited curricula (about 630 in 1979), if maintained throughout the 1980s, would result in a surplus under all but the most optimistic demand assumptions as described above. As there is very little demand specifically for advanced degree engineers of any type in the coal industry, the projected yearly graduation rate of between 500 and 600 B.S. degree mining engineers resulting from market forces alone (i.e., in the absence of scholarship funding) is capable of meeting coal mining engineering demand in almost all cases.

(8) Potential Shortage of Mining Engineers Can Be Alleviated Via Scholarship Funding

Under conditions where the greatest potential for future shortages of mining engineers exists (Analyses #2, 4 & 7), Federal scholarship funding at the same constant dollar level as at the present, if directed toward mining engineers, is expected to eliminate these shortages usually by the late 1980s (Analyses #5 & 8). This is based on a continuation of historical trends in which 25 to 50 percent of undergraduate students who receive most of their educational expenses under scholarships are attracted to mining engineering instead of to other disciplines by such funding. In the highest future manpower demand case (Sensitivity Analysis #8), sufficient students are attracted so that about 100 additional B.S. degree mining engineers graduate from 1984 onward. This would eliminate the manpower shortage projected in this case by the early 1990s.

(9) Professional Manpower Availability Facing the Coal Industry for Other Engineers and Scientists Appears Adequate Through 2000

The coal industry currently accounts for about 0.1 percent of the nation's employment of non-mining engineers and scientists with degrees applicable to mining.* By 2000, these percentages are expected to increase slightly in the most probable future to about

*Civil, mechanical, industrial, and electrical engineers, and scientists with degrees in chemistry, ecology, biology, agronomy, forestry, wildlife and range management.

0.17 and 0.28 percent of national employment respectively among these engineering and science disciplines. Even in those cases where the nation's demand for non-mining engineers and scientists is greatest (Analyses #7 & 8), coal industry employment within those national totals accounts for only 0.19 and 0.30 percent, respectively. Thus, apart from a major national shortage of professionals in these disciplines, it appears unlikely that the coal industry will be faced with an insufficient professional labor supply. This conclusion is further supported by the long established tradition within industry (and recognized by the National Science Foundation in its demographic studies) that many workers performing as engineers and scientists, especially those engaged in non-academic or non-certifiable work such as that of production, often learn their skills on the job under the tutelage of degreed personnel.

(10) Shortage of Mining and Mineral Engineering Faculty

A major near-term problem affecting the supply of mining engineering graduates is the difficulty of mining schools in attracting sufficient faculty. The level of full time equivalent faculty engaged in research has declined dramatically since the 1973-74 academic year. The remaining faculty resources available for teaching has resulted in effective student/faculty ratios of between 30 and 40 to 1 in most schools. The Engineers Council For Professional Development (ECPD) has defined 20 to 1 as a desirable maximum ratio of teaching faculty to undergraduate students. Thus, a need exists for attracting more faculty to reduce undesirable teaching loads, as well as to perform more research related to the improvement of mining technologies and labor productivity.

(11) Impact of Relative Salaries in Creating Faculty Shortage

Faculty salaries relative to those which can be earned by bachelor degree engineers in the coal industry have been the cause of a major labor market distortion. Increasing industry personnel demands and salaries have resulted in more students enrolling in programs such as mining engineering, and in turn, in a requirement for more faculty. However, the number of faculty are limited by salaries that are low relative to those paid by industry. The highest faculty salaries for full professors are about $30,000 to $35,000 ($24,000 to $28,000 in 1976 dollars). These salaries are often exceeded by those paid to industry supervisors who possess only a bachelor's degree. Thus, the ability of schools to retain existing faculty, much less to train new M.S.'s and Ph.D.'s, becomes even more limited.

(12) Potential for Inter-School Competition for Scarce Faculty

If additional State Mining and Mineral Resources and Research Institutes are established without raising faculty salaries, competition is likely to take place among universities for existing faculty. Although inter-school competition may marginally increase faculty salaries, all schools face the same constraint of maintaining relative salary equivalence among faculty of like rank across disciplines.

(13) Distribution of Engineers and Scientists in Salaried Work Force

Among coal industry positions grouped as salaried or non-hourly personnel,* on the average, engineers now comprise about five percent and scientists about one percent of this industry segment. Although the number of engineers as a group initially grows faster than does that of scientists, after the mid-1980s, the size of the former group grows more slowly. This slower growth is attributable mainly to the maturation of non-conventional deep mine technologies (i.e., continuous and longwall) and to the decline of eastern surface mining, which requires more engineers among non-hourly personnel than do technologies which characterize the midwest and west. However, the absolute growth of engineers and scientists employed in the coal industry and in related consulting companies is dependent largely on the growth of environmental, health, and safety regulations.

(14) Demand for Mining Technicians

The demand for qualified mining technicians, preferably having two-year associate degrees, will grow quite rapidly as long as the coal industry itself is expanding. This demand exists primarily for skilled production workers (e.g., electricians, heavy equipment operators, welders, and various types of mechanics, especially for diesel equipment in surface mines), and, to a lesser degree, for those in technical support positions (e.g., health and safety personnel, reclamation technicians, etc.). In the most probable employment future as identified in this study, the number of such technicians is expected to increase from less than one percent of total coal industry personnel in 1980, i.e., about 2,000 technicians, to over five percent or about 25,000 technicians by the year 2000.

(15) Support for Mining Technology Programs

Coal companies have been particularly active in establishing and supporting mining technology programs, especially two-year degree programs usually offered through community colleges. Both industry and college officials have confirmed the overall success of such programs, many of which provide on-the-job work experience and rapid placement following graduation. However, the performance of graduates, both in school and on the job, varies greatly. Notably, according to all faculty and coal company personnel questioned on this subject, CETA-funded students consistently have had higher-than-average dropout rates during enrollment and

*Defined to include all non-production and office personnel, on- and off-site, plus production supervisors and technical support staff (e.g., safety inspectors) involved directly in production.

higher-than-average quit rates shortly after employment.

(16) Potential Competition Between Two-Year and Four-Year Degree Graduates

A key area of potential job competition between four-year B.S. degreed engineers and two-year A.S. degreed mining technicians is that of production or first-line supervision (i.e., section foremen in deep mines, pit foremen in surface mines). Company interest in hiring more B.S. degreed engineers for supervisory and other state-certified positions stems in part from the waiver by most states of two out of the three years' experience requirement for certified positions. This interest in hiring B.S. degreed engineers is mitigated by a tradition of promoting from within the production work force, and, according to most coal producers interviewed, a general reluctance of B.S. degreed persons to spend much time directly in production. Moreover, several states now waive one year of experience for two-year mining technology graduates at approved schools. To the extent that two-year degreed technicians are willing to work their way up and remain in the production work force, many of them may obtain jobs that otherwise might be offered to B.S. degreed engineers.

4. Recommendations

As a result of both the modeling effort and the discussions with university personnel and coal producers carried out in this study, a number of recommendations are given below. These recommendations are directed toward the Federal government in terms of implementing its manpower and training programs, and to the academic community regarding appropriate program emphasis in light of present and future industry needs.

(1) Enhance Federal Support to Existing State Mining and Mineral Resources and Research Institutes (SMMRRI) but Reconsider the Establishment of New Institutes in Light of Long Term Enrollment Needs

Support should be enhanced to mining and mineral engineering programs, through increased institutional funds and continuation of the SMMRRI research/scholarship funds authorized under the Surface Mining Control and Reclamation Act of 1977. This is important both to expand faculty and thus to ease teaching loads, and also to allow research to be performed on improving labor productivity and technology innovation. It is felt in the industry and university communities alike that more research in these areas is needed to lend greater balance to the current emphasis on environmental, health and safety research. Opportunities for faculty development through creative research should not be looked upon as merely a buffer during periods of low enrollment; rather, such opportunities are essential for professionals to remain current in their fields, and to perform the types of basic research necessary for later technological breakthroughs which private industry is often reluctant to fund.

Nevertheless, given the forecasted demand for new mining engineers through 2000, it is unlikely that enrollment capacity greater than that occurring at present will be required over this period. Therefore, it is necessary to reconsider the need for establishing any new SMMRRI's. The addition of new mining schools in a few years will not be able to alleviate the temporarily high enrollment problem which suffers mainly from a lack of available faculty. Instead, additional mining schools will enhance the likelihood of inter-school competition for limited faculty and future undergraduate enrollments which are forecasted to decline up to 50 percent by the early 1990s.

(2) Place More Emphasis on Surface Mining Skills

Major fluctuations in past enrollments in mining and mineral engineering over the last 30 years may be repeated by the mid- to late 1980s if current high production growth forecasts for coal and other mining industries do not come to pass. To minimize this possibility, schools should consider placing greater emphasis on surface mining skills (more in demand for the coal, copper, and other mining industries) relative to deep mining techniques, perhaps through some modification of curricula.

(3) Provide Realistic Expectations to Students about Probable Job Assignments

Students in mining and other engineering disciplines should be made aware that most coal and other mining companies offer initial assignment as production supervisor trainees. Moreover, production supervision is the job function most in demand by industry, and advancement to engineering and management positions occurs only as expansion and retirements permit. Nevertheless, both schools and coal producers should stress that the relative compensation of production supervisors vis a vis front office positions does reflect the high demand and overall regard within industry for those involved directly in the production process.

(4) Continue Support Through Existing Programs for Assistance to Community Colleges and Vocational Schools

Community colleges and vocational/technical schools offering coursework related to mining technology, including two-year and even four-year curricula, presently receive funding through a number of Federal programs. These include: Mine Safety and Health Administration (MSHA) funds for miner health and safety training, and HEW/Office of Education (OE) funds, both to state boards of vocational education and to state prime sponsors, under the Comprehensive Employment and Training Act (CETA). Although Federal funding levels comprise a small fraction of state expenditures (less than 10 percent of all vocational training funds spent), and although the successful use of these funds may

vary, there is no need at present for massive Federal aid specifically geared toward mining technology, regardless of the rapidly growing demand for technicians. This recommendation is based on the cooperative relationship exhibited between many state agencies and coal companies in structuring practical programs most appropriate to industry needs. Although additional support through existing programs may be useful and certainly welcomed by the states and coal producers alike, it appears that coal producers have demonstrated a willingness to support such schools, in terms of financing, developing suitable curricula, and providing on-the-job training through work-study type arrangements. Since mandatory training with respect to health and safety is already ensured under MSHA regulations, any additional assistance to train skilled miners should permit the same type of state and company discretion to meet indigenous needs as is presently the case.

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