Volume 76 | Issue 3 Article 5

April 1974

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Last year, the United States' total energy consumption from all sources was 75 quadrillion BTUs.[1] This was more than twice the quantity of energy we consumed in 1950, just twenty-three years ago. It was ten per cent more than we consumed three years ago, and five per cent more than we consumed in 1972. That is quite a quantum increase for a year. In standard units of measure, last year we consumed about 550 million tons of coal, 6.3 billion barrels of petroleum, 23 trillion cubic feet of gas, and nuclear and hydro power equivalent to about 360 billion kilowatt hours. Perhaps through the use of an illustration I can give you a better picture of what the world's oil production means. A river, one hundred feet wide and six feet deep, flowing at four miles per hour, represents the quantity of oil that was produced last year throughout the world, and that river was following around the clock, seven days a week.

CHART 1

Trends in United States' Energy Consumption

Year	Population (millions)	Per Capita Consumption (million BTU)	Total Energy Consumption (quadrillion BTU)
1950	152	225	34
1960	180	250	45
1970	204	337	68
1975	215	412	89
1985	237	563	133
2000	266	720	192

Chart 1, which depicts recent and predicted energy trends, shows the alarming rate at which energy consumption has been rising. We expect this rate to continue and almost double by 1985. By the year 2000, we might require 192 quadrillion BTUs of energy, almost six times the amount we needed in 1950. However, I think it is pertinent to mention that conservation will be necessary for the

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[1]The BTU, or British Thermal Unit, is a standard measure of energy output and represents the quantity of heat required to raise the temperature of one avoirdupois pound of water one degree Fahrenheit at or near its maximum density.

short term period, mainly because of the fifteen per cent shortfall between the supply and demand.

This shortfall that we expect to have, at least until 1980, has many reasons behind it, and they are complex and varied. For the purpose of this analysis, we can simply say that it is because demand exceeds supply. This is so not because we do not have enough energy resources as a nation, but because we have utterly failed to develop them adequately.

Unlike many of the other countries that are experiencing energy shortages, the United States has an extremely large energy resource base. Although many reports contend that we have only an eleven year supply of oil and a twelve year supply of gas, there is ample geological evidence to support the conclusion that this country has tremendous resources in areas underlain by rocks favorable to the occurrence of oil and gas. We also have enormous resources locked in the oil shale in the Western States—vast quantities of fissionable material and billions of tons of coal. Thus, a large potential store of resources remains to be explored and developed.

CHART 2

Energy Resources
Total Recoverable Reserves—Estimated

Values are expressed in quintillion BTUs (10^{18} BTU)

SOURCE	ESTIMATED U.S. RESERVE
Petroleum	0.5 to 14
Natural Gas	0.5 to 2
Coal	10 to 30
Shale Oil	7 to 80
Uranium	0.6 to 16 (1% use) 40 to 1100 (70% use)

Chart 2, which shows the estimated recoverable quantities of each of our energy resources, again indicates that the coal resources of the United States are vast. Deposits have been identified by mapping and exploration that, according to recent estimates, contain nearly 1,600 billion tons of coal. Further, there are additional deposits in nearby areas, though not mapped or explored, that may contain equally large deposits. However, the total coal resources are relatively unimportant when compared to the coal reserves—the amount that can be recovered at the present time at prices competitive with other fuels.

CHART 3

Fossil Fuel Reserves

Commodity	Measured	Indicated	Possible	Current Consumption
Coal Tons x 10^9	200	200	1,200	0.60
Petroleum Bbl x 10^9	36	75	600	6
Shale Oil Bbl x 10^9	80	540	2000	0
Natural Gas Cu. ft. x 10^{12}	270	170	435	23

Chart 3 shows the size of coal reserves in the United States as compared with other fossil fuels. Although it is not indicated on this chart, because the quantities are not in standard units, we estimate that the demonstrated coal reserves constitute about fifty percent of the total measured and indicated quantities for all fossil fuels. The current estimates are that the United States has about 400 billion tons of coal in-place that can be produced under present technology and price. However, I think it is safe to assume that only about fifty per cent of this reserve can be recovered because of man-made and natural production barriers. But we still have 200 billion tons of recoverable coal, the equivalent of about 350 years supply at the 1973 consumption rate. This consumption rate is going to increase, of course, but the amount of recoverable coal will also increase as developing technology and increasing prices move additional coal deposits from the subeconomic to the economic recoverable category. In-place reserves of coal in the area where we are most vitally concerned today—the Appalachian area—are estimated at 138 billion tons, about 69 billion tons in recoverable reserves. Nine-tenths of the total is bituminous and one-tenth is anthracite. West Virginia has nearly half of that 69 billion tons of reserves; Pennsylvania approximately a fourth; Ohio, about twelve per cent; eastern Kentucky about eight per cent; with the remaining five per cent scattered among Alabama, Maryland, Tennessee and Virginia.

Looking at the background of Appalachian coal, the Bureau of Mines' records show that approximately 41 billion tons of coal was produced in the United States between 1890 and 1972. Nearly seventy per cent of that 41 billion tons came from the Appalachian area. Even though production patterns have changed recently, Appalachia still accounts for nearly two-thirds of the total United States' coal production. Preliminary data for 1973 shows that Appalachian coal production amounted to about 425 million tons, fourteen per cent of the nation's total energy output. Most of this coal was shipped to electric utilities for thermal power generation. Also, Appalachia supplied ninety per cent of the premium quality bituminous coals required for the production of metallurgical coke, nine per cent of the coal shipped to other industrial plants, and virtually all of the 56 million tons exported.

Although the Appalachian region has historically dominated the domestic coal market, the market is changing. Low sulfur coal (less than one percent sulfur), which is in growing demand in the United States, is in ample supply. However, seventy percent of the nation's low sulfur reserves are located in the Western States. Western coals are lower in quality than the Eastern coals and have remained relatively undeveloped because they are of a lower calorific value and are in areas distant from most markets. Owing to environmental considerations, there has been some recent development of the Western coals, but the Appalachian region still accounted for an estimated eighty percent of the low sulfur coals produced in the United States in 1973.

I think most of us are concerned not so much with what we are doing now or what we have done in the past but with what we are going to do in the years immediately ahead. In order to explore this, we have to look at the near term past. In 1969, the Federal Coal Mine Health and Safety Act became law. While all the developments growing out of this legislation cannot be assessed, we do feel that implementation of the standards under this law helps to reduce substantially the number and rate of fatalities in our nation's coal mines. In 1970, for example, there were 260 such fatalities at the rate of one per million man hours of work time. Last year there were only 132 mine fatalities. I should not say "only" because that is still a serious figure, as is the loss of a single man, but the rate of occurrence was only .45 fatalities per million man hours.

We believe that the 1969 law has also been a factor in the decline in underground mine productivity from 13.75 tons per man day in 1970 to 11.75 tons per man day in 1973. Mine operators cite a number of reasons for this, among them the increased employment of nonproduction workers, whereby people are diverted from production to achieve compliance with the health and safety requirements. I want to emphasize that I am just stating *some* of the suspected effects that the legislation appears to have had on productivity. An additional effect ascribed by industry to this legislation has been the closing of many small, marginal mines that could not afford to meet the safety and health requirements. We recently completed a study in the Bureau of Mines covering 1970 through 1972. In that time, there were 1,585 deep mine closings and only 609 deep mine openings. Interestingly though, neither employment nor production suffered; employment stayed about the same, and overall production increased about twenty percent.

Productivity declines have resulted in substantial production cost increases in underground mines. We cannot determine what the full impact of health and safety regulations might be on future mining costs, but the cost of underground mining is going to increase because of the imposition and implementation of new health and safety regulations.

The coal industry has another major area of concern—the environment. The air quality standards under the Clean Air Act Amendments of 1970 are scheduled for implementation by the states in about a year. These standards are definitely going to disqualify for use large quantities of Appalachian coals now being produced. The sulfur content of these coals cannot be reduced sufficiently, and commercial processes for removing sulfur from stack gases of thermal power plants have not yet been perfected. The Appalachian region has significant reserves of low sulfur coals, but their commercial development has not kept pace with that of the higher sulfur coals because of higher production costs. If we are going to achieve any significant expansion of facilities for producing Appalachian low sulfur coals, even under ideal conditions, we cannot achieve it in less than five years.

The next problem of the coal industry I would like to consider is federal strip mine legislation, which is now being considered by the Congress and which can be expected to have a very substantial impact. One significant feature of the pending legislation is the provision requiring restoration of surface mined coal land to its original contour. The proposed bills provide essentially for backfilling, compaction, and grading to restore the land's approximate original contour. The product of years, centuries, and millenniums of erosion and other natural processes might not have been the best contour, but it was the contour that was there, and it is the contour to which the land must be restored if the proposed federal legislation is enacted. There is a lot of discussion on this subject because many of the operators feel, and perhaps rightly so, that even a better surface can be obtained through proper terracing and landscaping.

Another of the critical problems facing the coal industry is a shortage of manpower. Although the industry has been able in recent years to attract additional miners, many of them in the lower age groups, these new workers require substantial training, especially in safe and healthful work practices. In addition, difficulties have been experienced with absenteeism and wildcat strikes, which are going to have to be overcome if coal is to fulfill its projected future role. This particular problem is of great concern to the Appalachian area because the underground mines that predominate here are more labor-intensive than the strip mine operations.

Secondary problems confronting the industry include transportation and raising sufficient capital. Escalating costs and stiffer competition for investment capital, compounded by all the uncertainties previously mentioned, make attracting capital more difficult. The transportation problem, though self-evident, is not easily solved. The coal must be taken to market, and the principal way of doing that is by rail. Coal cannot be stored at the mines because the mines do not have the facilities. If the rail cars are not there, the mines will close. The major railroads, as we all know from reading the daily papers, are in serious financial difficulty and I question whether they are going to be able to supply the additional capacity for transporting coal unless they get some outside assistance.

Looking briefly at the short and long term potential, I think from the figures seen here it is apparent that we are going to have to look inescapably to coal for the near term future. Coal has to rise to meet the need. For the reasons I have cited and others, production capacity today stands at virtually the same level as it was a decade ago. We have reached the point where most of the deficits in our energy supply can be filled only by coal, at least for the next ten years or so. Consequently, coal production must be expanded. Since the industry is concentrated in the Appalachian area, we have to look to this region for the bulk of the incremental supply. Our surveys show that the major markets for Appalachian coal in the near term future, that is, the next decade or so, are going to be essentially the same as those at present—electric power generation, coke production, and exports. All the markets, except those for domestic coke production, are expected to increase substantially. Although there must be some re-evaluation because of the current energy situation, some of our recent studies conclude that energy resource input in the electric utility sector in 1985 will be more than double the 1972 input. Sixty percent of this has to be supplied by coal. This is equivalent to a coal demand of 613 million tons for power generation alone in 1985, or nearly twice the amount that was consumed for that purpose in 1973.

We cannot estimate Appalachia's share of this market because the bulk of the Appalachian coal currently going to electric utilities has a sulfur content in excess of limitations imposed or proposed by most of the air quality standards. However, there may be some relaxation of these standards, and, in this event, Appalachian states probably could maintain their present levels of supply to utilities and add quantities commensurate with the percentages of utility coal they supplied in the past. It also appears that a number of Eastern utility plants that formerly burned coal but that are now fueled with low sulfur fuel oil will reconvert to coal because of the present fuel oil shortage. If all plants that could convert back to coal would do so an incremental annual demand increase of 86 to 87 million tons of coal would result. However, we cannot expect that additional demand until the plants are reconverted, and that will take at least eighteen or twenty months. All these plants that could reconvert are in the East, and, of course, Appalachian coal would be the fuel for them.

Generally, Western States have the bulk of the nation's low-sulfur fuel reserves, and any stringent enforcement of the Air Quality Control Regulations will rule out the use of most of the Eastern coals, with a subsequent movement to Western coal development. But there is an aspect of this situation that is not popularly recognized, and I think we ought to touch upon it. The Air Quality Control Regulations are based on sulfur dioxide emissions per million BTUs of energy input. Because of their relatively low BTU value, a large part of the Western "low sulfur" reserves cannot meet established or proposed air quality standards. The recent regulations applicable to all new major fuel burning plants constructed or modified after August, 1971, limit sulfur dioxide emissions to 1.2 pounds of sulfur dioxide per million BTUs of input. When we convert that to sulfur content it means that coal containing one percent sulfur has to have a calorific value of about 16,600 BTUs per pound. However, the calorific value of most of the coal in Appalachia will average roughly twelve thousand BTUs per pound. At this value, the maximum allowable sulfur content for such coal is only .72 percent. Coals that have a calorific value of fourteen thousand BTUs can have a sulfur content as high as .84 percent. The Western low-sulfur coals probably average only nine thousand BTUs per pound. Thus, in order to comply with air quality standards, sulfur content of Western coal is going to be limited to an average of .54 percent, which may throw a lot of that coal out of the picture.

The Appalachian region has the bulk of the nation's premium coking coals and is going to be called upon in the future to provide these coals for the production of coke, which is used to reduce iron ore in steelmaking. But the quantities of coking coal, as I mentioned before, are not expected to increase materially, primarily because continuing improvements in iron extraction technology should result in decreasing coke requirements per ton of steel production. However, there will be a continuing demand for United States coking coals in foreign markets. Our coking coal exports have been forecasted to double by 1980 and to reach 138 million tons by 1985. The bulk of these exported coals are low in sulfur and many of them could be used as utility fuel in lieu of low sulfur fuel oil. But, when you think about using them domestically, they command premium prices and their use by utilities would usually require some technological changes in power generating equipment. Also of significance is the fact that these exports earn credits to our international balance of trade of about a billion dollars a year, which is important in restraining somewhat the shrinking dollar.

The long term potential for coal lies, of course, in the development of economic processes to convert coal into gas and liquid fuels. The extent to which the Appalachian area will share in this potential market we cannot estimate at this time because economic gasification and liquifaction processes depend upon the availability of large blocks of coal and substantial water supplies. These requisites are met primarily in the Western states, but there may be suitable areas not yet identified in the East.

CHART 4
OUTLOOK

Immediate future to 1980
Conservation
No additional imports
Increased coal use
Tertiary recovery

The next decade
Increased efficiency
Coal gas and liquids
Shale oil
Nuclear

The long term
Breeder reactor
Solar
Fusion

Chart 4 sets out our future energy expectations. Energy is definitely in short supply, and it appears that we can meet our basic requirements only by conservation. Despite some reports to the contrary, we probably will not receive sufficient oil imports to take care of more than a part of our growing demand for energy. The only short term answer is increased development of our coal reserves.