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VOLUME 2

ENERGY AND MATERIALS: A SHORTAGE OF RESOURCES OR COMMITMENT?

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LETTERS OF TRANSMITTAL

NOVEMBER 28, 1980.

To the Members of the Joint Economic Committee:

Transmitted herewith is a staff study, printed separately, and technical papers which together form Volume 2 of the Special Study on Economic Change (SSEC).

Volume 2 is entitled "Energy and Materials: A Shortage of Resources or Commitment?" and is one of 10 areas on different aspects of the economy published by the SSEC. The SSEC was initiated in 1978 under the direction of the former Chairman of the Joint Economic Committee, Representative Richard Bolling, then Vice Chairman Senator Hubert H. Humphrey, and the former Ranking Minority Member, Senator Jacob K. Javits. It is intended to identify major changes in the economy and to analyze their implications for policymakers. The successful completion of this Study will, I believe, help provide an economic agenda for the United States for the decade of the 1980's.

The views expressed in the technical papers are exclusively those of the authors and do not necessarily represent the views of the Joint Economic Committee or of individual members. The staff study was approved by the Chairman's Special Study Review Committee formed by the Chairman, Representative Bolling, Ranking Minority Member Representative Clarence J. Brown, and Senator Javits.

Sincerely,

LLOYD BENTSEN,
Chairman, Joint Economic Committee.

NOVEMBER 24, 1980.

Hon. LLOYD BENTSEN,
Chairman, Joint Economic Committee,
Congress of the United States,
Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith is a staff study printed separately, and technical papers entitled "Energy and Materials: A Shortage of Resources or Commitment?" which constitue Volume 2 of the Special Study on Economic Change (SSEC).

The SSEC was initiated under the leadership of former Chairman of the Joint Economic Committee, Representative Richard Bolling, Vice Chairman Senator Hubert H. Humphrey, and former Ranking Minority Member, Senator Jacob K. Javits. The Study is divided into 10 substantive areas, which together chart major changes in the economy and analyze their implications for policymakers. Volume 2 comprises an economic analysis of the relationship between energy and economic growth, together with supply and demand scenarios for the coming decade.

The events of the past 7 years have demonstrated dramatically the extent of this country's dependence upon secure sources of energy for stable economic growth. Energy finds its way into virtually every economic activity. An energy policy which insures adequate levels of supply, encompasses realistic estimates of energy demand, and encourages conservation of energy resources is, therefore, critical to maintaining a strong economy in this country. This study describes the critical link between energy supply and economic growth and provides a sobering account of the likely course of energy supply and demand over the next decade.

It should be understood that the views expressed in the technical papers are exclusively those of the authors and do not necessarily represent the views of the Joint Economic Committee or of individual members. The staff study was approved by the Chairman's Special Study Review Committee formed by the Chairman, Representative Bolling, Ranking Minority Member Representative Clarence J. Brown, and Senator Javits.

Sincerely,

JOHN M. ALBERTINE,
Executive Director, Joint Economic Committee.

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U.S. ENERGY DEMAND IN THE NEXT 15 YEARS: A SKEPTICAL EVALUATION OF PROGNOSIS

By Oscar Gass*

CONTENTS

I. Summary and Conclusions

Uncertainty and Precaution

Great uncertainty envelops any reasoned judgment of the probable growth in the demand of the United States for Energy in the fifteen years from 1976–77 to 1991–92. Consequently, a thoughtful public policy, which attempts to restrain demand, will aim also to provide a supply that will prove adequate even if energy demand should rise above median expectations.

In our attempt to gain an image of future U.S. energy demand, we proceed on the basis of public and private developments now ongoing in the American economy. We have not taken into account comprehensive rationing, or a major war, or revolutionary supply discoveries. However we *have* deliberately given consideration to the preferred need of providing energy for a better level of economic improvement than has characterized the U.S. economy of recent years. In 1973–78 the American economy achieved *no* net increases in income per member of an expanded labor force. We have not focused our consideration of the next 15 years exclusively on the energy demand consequences of so poor a performance. A public energy policy that is rationally precautionary will look to provide the supply that will be needed if the U.S. economy functions much better than it has in the average of the past five years.

*Consulting economist, Washington, D.C.

Demand: "Minimal," "Modest," and "Good"

In our judgment, the minimal growth in U.S. demand for energy would arise from the unlikely combination of a "Poor" general economic growth with an "Excellent" success in reducing the energy required per unit of real gross product. ("Poor" might yield a doubling of income per member of the labor force in 35 years or longer; "Excellent" would reduce energy demand per unit of real product by 20 percent.) In that unlikely event, we calculate the growth in U.S. demand for energy may be as low as 34 percent. The total would rise from over 75 quadrillion btu in 1976–77 to over 100 quadrillion btu in 1991–92. This would be an average annual growth in energy demand of about 2.0 percent—half the annual rate of 1960–73.

We suggest equal consideration to the alternative that the general economic growth of the United States will be not "Poor" but what we name "Modest"—coinciding with the experience of 1960–73—while the national success in reducing the requirement of energy per unit of real gross product may be not "Excellent" but only "Good." ("Modest" might yield a doubling of income per member of the labor force in 28 years or longer; "Good" would reduce energy demand per unit of real product by 10 percent.) In this case, we calculate the growth in energy demand at 62 percent, to over 121 quadrillion btu in 1991–92. The implied annual growth in energy demand would be about 3.3 percent—over four-fifths of the rate in 1960–73.

A more happy general economic experience—though quite out of accord with the depressed economic expectation of Americans in 1978—would be a general economic growth which we would name "Good" coinciding with the "Excellent" 20 percent level of energy economizing per unit of real product. ("Good" might yield a doubling of real income per member of the labor force in 23 years or longer.) In this case, we calculate the growth in energy demand at nearly 55 percent, to just over 116 quadrillion btu. The implied annual growth in energy demand would be about 3.0 percent—three-quarters of the 1960–73 rate.

It is however no part of our judgment to suggest that the range of rational uncertainty is exhausted by these three illustrations.

Reducing Intensities and Expanding Supplies

There are industrialized countries (Canada, the Netherlands) that greatly exceed the United States in intensity of use of energy. One other (the United Kingdom) stands very close to the United States. These are however among the nations that today enjoy very different energy supply circumstances from those of the United States. Some (the Netherlands, Norway) are already net exporters of energy, which they sell at high prices. Others (the United Kingdom certainly, Canada possibly) have the choice of becoming net exporters in the 1980's. In international issues of energy development and price, these countries are now *de facto* collaborators—as well as jostling competitors—with the OPEC cartel. Though the U.S. may envy or condemn their international policies of restrained development and enhanced price, the

U.S. cannot emulate them. The American economy recently (1977) imported over a quarter of its energy consumption, in fossil fuels alone, at a landed cost of $47 billion. With inattention to economizing use and current distressingly laggard expansion of domestic supply, this quarter could rise swiftly toward three-tenths. Already in 1977, the U.S. paid over one-fourth of the total gross value ($175.5 billion) of all its exports of goods and services for its fossil fuel imports alone.

On the consumption side, the countries the United States would gain from emulating are those like the German Federal Republic (which reports an energy consumption about 20 percent below the American, per unit of gross product) or Sweden (about 14 percent below the U.S.). American consumption of total primary energy in 1976–77 was roughly 58 million btu, or the heat equivalent of 10 barrels of crude oil, per $1,000 of 1972-priced Gross Domestic Product (GDP). A not entirely visionary target would be to reduce this energy requirement gradually, by perhaps 20 percent, as industry, transportation, commerce and housing are reshaped, during the next 15 years or so. Then, by the early 1990's perhaps, the U.S. would be consuming the equivalent of 8 barrels of crude oil per constant-priced $1,000 of gross product, instead of the present 10 barrels.

However, the problem of meeting U.S. energy requirements, for the next fifteen years, is not to be conceived as primarily one of restraining demand. Even in a poorly growing or modestly growing economy, the greater contribution must come from expanded supply.

Grounds for Energy Economizing

Economizing in the national use of energy has three valid motivations.

First: The prices Americans now pay for their imported energy supplies are very high. The United States now exports some fossil fuel ($4.2 billion worth in 1977) and imports a great deal more ($47.0 billion in 1977). The 1977 American imports of $47.0 billion supplied rather over one-quarter (about 26.0 percent) of the national energy consumption. This $47.0 billion is *without* the further cost of domestic transportation, refining most of the import, converting a part into electricity, and distributing the final products to their ultimate users. This predominantly unfinished 26 percent of our national energy supply of 1977 cost over 2½ percent of the entire national GDP of $1,870 billion. In an economy in which such prices per unit of heat value prevailed generally, finished energy would cost greatly more than 10 percent of an enormously price-swollen Gross Domestic Product. Obviously, insofar as such huge energy costs can be avoided, without incurring other greater costs and burdens, the reduction is of great importance. The rise in the cost of energy has made rational other combinations of labor, materials, and capital than were best when energy was cheap.

Second: Restraining U.S. demand for energy may have a significant effect in slowing further energy price advances. The prices the U.S. now pays for its more expensive energy supplies, and particularly for its imports, do not reflect the costs of producers who are selling in competitive markets. (Nevertheless the propaganda in support of this price scale has fixed upon it the encomium of being the "world market" price level.) Petroleum in particular is now the "swing" element in international energy supply—the element of which production and delivery is comparatively quickly expansible. Petroleum comes in to satisfy demand where other energy supplies are short. Petroleum exporting governments, partly members of OPEC and partly going along with OPEC, join in restraining the development of oil fields, restricting the production of oils, and maintaining export prices, in accordance with their broadly shared conceptions of long-term exporters' interests. Exporters (and also domestic suppliers) of other energy materials, notably natural gas and coal, try to secure a price as near as possible to the price of imported oils—adjusted for the higher cost of transporting gas and coal and for the more limited uses of these other energy materials, particularly as transportation fuels. These producers also draw around themselves the handsome cloak of the "world market" price. In mid-1978, the major oil exporting countries were sustaining oil prices by keeping "shut-in" something between one-fifth and one-quarter of their immediate crude oil capacity. In the first half of 1978, the entire OPEC group held its crude oil production to a daily level 12 percent less than it had produced already in the third quarter of 1973, on the immediate eve of the Oil Price Revolution. Some members of the petroleum exporters' collusion do, from time to time, shade prices to expand their sales. Obviously, in so far as the U.S.—and other importing countries—restrain the demand for energy, the importers become somewhat less easily vulnerable targets for the collusive price extortion of exporters. Equally obviously, this importers' defense of restraining demand can be offset in so far as major exporters are willing to cutrail their export sales.

Third: Energy supplies—and particularly petroleum—may be withheld (or threatened to be withheld) collusively not only to raise prices but also for politico-military reasons. A core group of petroleum exporters may collaborate, as some Arab nations did in 1973–74, to withhold supplies in an effort to support their political or military objectives. In so far as this withholding is of short duration, it can be partly offset by importers' accumulations of emergency stockpiles. However, long-term political and military independence is certainly enhanced, in some degree, by reducing dependence on the core countries' petroleum exports. Reducing energy demand is therefore one path—though perhaps not a major one—toward enhancing the political and military security of energy importers. In the long run, both expanding alternative supplies and politico-military counter-action are perhaps more important.

Targets and Uncertainties in U.S. Energy Demand

We would attribute great value to achieving a clear, validated image of what quantity of energy the United States will require in a future that is 5, 10, and 15 years ahead. To arrive at such an image, however, we would need to know two things: (1) How much economizing the U.S. will achieve in the physical quantity of energy required per $1,000 of constant-priced GDP; and (2) how much GDP will grow, in the real aggregate, during these 15 years. Our experience with sophisticated studies of these questions is that, with regard to question (1), they have made errors of estimate up to 100 percent, in forecasting the most probable or median change in U.S. energy consumption for periods of 10 and 15 years forward. With respect to question (2), the national experience includes growth variations of 100 percent (from under 2½ percent to about 5 percent per year) sustained for long periods. Since we do not attribute to ourselves a foresight of which there is no precedent, we must state unequivocally that whatever we suggest regarding future U.S. energy requirements is subject to wide error. Only a society which has access to great elasticity of energy supply, without punishing increases in costs, an elasticity quite absent in the United States for the past decade, is safe against highly damaging consequences from such uncertainties regarding demand and supply as now beset the American economy.

Regarding energy demand targets and uncertinties, we stress four general findings.

First: Neither the long national history nor the recent experience record points a straight arrow toward the U.S. energy future.—Our long history shows unforeseen ups and downs, of which we give some account below. Recently, in the average of the years 1976 and 1977, the United States consumed rather more than 75 quadrillion British Thermal Units (btu) of energy per year. This amounted to a little more than 58 million btu of energy per $1,000 of GDP, measured in the constant prices of 1972. As the average grade of crude oil is evauated at about 5.8 million btu per barrel of 42 U.S. gallons, we may also say that, in 1976–77, the U.S. consumed the heat equivalent of about 10 barrels of crude oil for every $1,000 of 1972-priced GDP. (Alternatively 58 million btu and 10 barrels of crude oil, per $1,000 of 1972-priced GDP, may then be said to measure the energy "intensity" of the U.S. economy in 1976–77.) The 1972 constant prices are convenient for long-term comparisons. However we must also not forget that the average cost of $1,000 of 1972 GDP in 1976–77 was about $1,372 and the average cost of 10 barrels of imported crude oil, landed in the U.S., in those two years, was about $140. The imported crude therefore cost the U.S. over $2.40 per million btu. Had a year's 75 quadrillion btu been purchased all at such a price, the total would have cost over $180 billion—for unprocessed energy material.

The 1976–77 consumption level of 58 million btu reflected a distinctly lower energy intensity than prevailed in the early 1970's. However this 58 million btu was only about 2½ percent lower than in the strongly expanding and relatively price-stable years 1962–68. Neither the revolution in energy prices from 1972 nor public efforts to reduce energy consumption have yet had a great effect in the United States, except in the "Industrial" sector, as distinguished from the entire society. The sharp intensity contraction of 1977 seems to have been prematurely heralded as a definitive break with the past. When real GDP rose by about 4.0 percent in the first half of 1978 (in relation to the same period of 1977), energy consumption rose by 3.4 percent. Consequently, a sustained and confidently measurable declining intensity of U.S. energy demand is not yet demonstrated. The quantified consequences of the now ongoing public efforts to reduce energy intensity have yet to be measured.

Second: The U.S. cannot simply take a model from the conduct of other industrialized nations.—Though some may be attracted to the posture of repentant sinners, it is not true that the United States is the most lavish of the nations in its use of energy, or the least concerned with measures of conservation, or the most acceptant of dependence on oil imports. According to the measures of the International Energy Agency (IEA), in 1976 already the United States ranked intermediate, among non-Communist industrialized societies, between countries like the Netherlands and Canada, who consumed 12 percent to 24 percent more energy per thousand dollars of GDP, and countries like Italy and Germany who consumed 15 percent to 20 percent less.

It is also not true that the Government of the U.S. is other than intermediate in the program it proposes for reducing energy consumption in the next years. For 1985, the "National Energy Program," as advanced by the Executive Branch and accordingly communicated to the IEA, sought a reduction of about 9¼ percent from the actual level of 1976 in U.S. energy consumption per unit of GDP. The United Kingdom and Norway presented programs of reducing by about 13 percent and 15 percent during the same period. On the other hand, countries like Japan and Italy seek little reduction (4½ percent) or a slight increase (2½ percent): their concerns are primarily to diversify their energy sources and so increase their security of supply.

Most clearly, in comparison with other industrialized countries, the United States does not forecast a unique rate of dependence on imported oil. In 1978 submissions to the IEA, the U.S. (dependent on net imports of oil for 19.1 percent of its total primary energy in 1976, according to IEA calculations) forecast a 1990 oil import dependence of 26.0 percent. After taking into account their conservation programs, for 1990 Japan forecast an oil import dependence of 55.5 percent of its total primary energy needs, Italy of 51.6 percent, and Germany of 41.5 percent.

Third: There is no sense in a policy that would reduce Gross Domestic Product so as to reduce the national consumption of energy.—It is not to be denied that the U.S. has now become an economy in which adding $1,000 of output (in current prices) to GDP may also add substantially more than $100 in total final expenditures on energy. (Imported crude oil at the June 1978 price of $14.54 per barrel undoubtedly yielded a higher total addition.) Still, there would remain the difference—something well below $900—of additional goods and services, apart from the energy cost and direct energy use benefit. These gains are not lightly to be thrown away.

There is no reasoned ground for believing that a more prosperous economy—therefore presently consuming relatively more energy—

will fail to provide more for the energy needs of the distant future than will a poor economy. The poor one will consume less energy but will also be less able to support energy exploration, research, development, and investment. In the middle range of the next 15 years, U.S. domestic energy supply growth seems likely to be basically dependent on the nation's success in expanding production of coal and of fission nuclear power: Both will require the investment resources of a thriving economy. If the U.S. is fortunate, this added supply of coal and nuclear power (largely supplanting gas and oil as boiler fuels), will be supplemented by important additional domestic supplies of oil and gas. This oil and gas must come, first, from new findings both in frontier provinces and at great depths, and, second, from achieving economical higher rates of recovery from presently known oil fields: These things will be performed better in an economy of rapidly growing markets than amid relative stagnation. Beyond these things lie more economical technologies for recovery from shales, heavy oils, and tar sands. Geothermal, solar, wind, and wave power are also capable of making some contribution. And, more speculatively, and still further in time, there may possibly come so unparalleled an of possible outcomes of GDP growth is very wide. Eliminating the achievement as would be the mastery of fusion power generation by techniques not requiring prohibitive capital costs. In all these things, and in quite other realms of value, the Nation will be able to provide better for the future if it produces more in the present.

Unfortunately, neither our knowledge of the past nor any reasoning on the future can give us justified confidence that we know how successfully the American economy will grow in the next 15 years. With such limited foresight as we can attain of the growth in the national labor force, its employment, and its productivity, the range extremes of success and failure, we put a "Poor" growth in GDP at an average of 3.5 percent per annum (which probably means, at best, doubling real income per member of the labor force in 35 years). We call "Modest" a GDP growth of 4.0 percent; that was the rate of 1960–73. We name "Good" a GDP growth of 4.5 percent. In the lowest of these three cases, GDP would grow, from 1976–77 to 1991–92 by 67.5 percent. In the median case it would grow by 80 percent, and in the highest by 93.5 percent.

Obviously, unless the U.S. economy remains quite stagnant, or falls into a recession like that of 1974–75, American energy requirements must grow massively in the next 15 years—even after any reasonably forseeable reduction in energy intensity per $1,000 of GDP. If the energy problem is "the moral equivalent of war," primary concentration on conservation—without great emphasis on expanding energy supply—is the moral and intellectual equivalent of defeatism.

Fourth: A target of achieving, during the next 15 years or so, a 20 percent reduction in U.S. energy requirements, per $1,000 of 1972-priced GDP, is neither entirely visionary nor readily attainable.— If that target were achieved, the U.S. would be consuming about 46.4 million btu per $1,000 of 1972-priced GDP instead of the 58 million btu of 1976–77, or the heat equivalent of 8 barrels of crude oil instead of 10 barrels.

However, nothing remotely approaching a 20 percent conservation target is now in process of being achieved in the largest major division of the energy economy. This largest branch is now conventionally labelled the "Residential/Commercial" sector. It comprehends all households, all commerce, and all services except transportation. This sector consumed 37.1 percent of all U.S. usage of energy in 1977. Its share is steadily rising. We expect it to reach 40 percent in a few years. In the first half of 1978, its usage increased by 5.2 percent. In this largest sector, we anticipate least reduction in energy intensity. Housing economizing through insulation is being offset by more numerous, more separate, larger, and second homes. The increased energy efficiency of appliances is offset by their increased number. Commerce and services are absorbing five-sixths of the entire national increase in employment. Despite the higher prices of residential and commercial fuels and electricity, nothing now ongoing in this sector would suggest a reduction in energy intensity even remotely approaching 20 percent in a period of 15 years.

The opposite judgment is surely the valid one regarding the sector which the Department of Energy has denominated "Industry." This is the entire commodity-producing branch of the economy. It is a sector of business cost calculations, including all manufacturing, agriculture, mining, and construction. This sector's share of national energy consumption now shrinks steadily. In 1977 it still accounted for 36.7 percent. Soon this share will be down to 35 percent, and thereafter—unless the whole structure of the Nation's economy is transformed—we expect this share to fall further, from year to year. In the first half of 1978, the quantity of energy consumed by "Industry" was still about 2.9 percent lower than the average for 1973. Yet manufacturing output was 9.5 percent higher than in 1973; farm output (comparing '77 with '73) was 8.0 percent higher; mining output was 6.2 percent higher; only construction was still 6.7 percent lower. In rough weighting, we estimate that this sector reduced its energy consumption per unit of output by about 10 percent, in the past five years. There is good reason to anticipate that this sector will reduce its energy intensity by a further amount of more than 20 percent in the next 15 years—and especially if its output grows greatly. Reduction in intensity is a continuously ongoing process, as equipment is renovated or replaced.

The sector of Transportation is also one from which much may be hoped in reduced energy intensity, though with less continuity and certainty than in Industry. Its consumption is now settling in the range of 25 percent of the national total. Transportation is, however, a specially precious energy sector, because 96 percent of its consumption consists unavoidably of oils. Moreover Transportation is the sector in which Government has committed its severest regulatory authority, by mandating severely fuel-efficient cars. Price has been brought into play, so that the highest quality premium gasolines now approach 80 cents per gallon. Yet energy consumption, which declined nearly 3 percent in Industry during 1973–78, has risen about 11 percent in Transportation during the same years. In the first half of

1978. Transportation use of energy rose by 3.2 percent while an expanding Industrial sector claimed only a 1.6-percent rise. Popular anticipations of high reductions in transportation fuel have perhaps given too little consideration to the fact that nearly half of transportation energy is used for other than passenger cars. Pipelines, ships, railroads, airplanes, trucks, and even buses are relatively efficient users of fuel, subject to slow improvement.

Moreover even the passenger car of the near future is also unhappily a somewhat unpredictable fuel user: its annual mileage is highly uncertain. Endowed by government regulation with a car having heavy fixed costs for fuel-efficient engines of low pollution, the driver will again find himself with incremental consumption of gasoline *cheap* per mile, in contrast to his high annual costs of depreciation, insurance, financing, garaging, and maintenance. Given the increasing dispersal of the population, and the increasing mode of long-distance travel, mileage per passenger car might rise sharply. Therefore it may come about that—having rejected rationing—the American community may conclude that it can secure decisively lower energy intensity in transportation only through major further inflation of the prices of passenger car fuels (probably through heavier excises). Can regular unleaded gasoline at $1.00 a gallon be far away?

II. Light From a Past Century of American Energy Consumption?

For the two years 1976 and 1977, the present official U.S. calculation of American consumption of energy averages 75,181 trillion btu.[1] Let us say approximately 75 quadrillion btu; otherwise we shall be trapping ourselves in a specious precision. In heat equivalent, this total amounts to about 35.5 million barrels of crude oil per day.

Actually about 47.9 percent of the total consumed was derived from refined petroleum products, about 26.6 percent from dry natural gas, some 18.5 percent from coal, and the significant remainder from hydro and nuclear power.

The Gross Domestic Product (GDP) of the American economy was officially calculated to average $1,777.8 billion for 1976–77 in the current prices of those two years, or $1,294.8 billion in the held-constant 1972 prices which preceded the Oil Price Revolution and the subsequent rapid general price inflation.[2] For ready comparability with other years, where real GDP quantities are involved, we shall usually employ the 1972 constant price basis. Then we may calculate that in 1976–77, the U.S. consumed 58.06 million btu of energy per thousand dollars of 1972-priced GDP.

To avoid a misleading precision, we shall in fact say that our 1976–77 base is 58 million btu per $1.000 of 1972-priced GDP, and we shall equate this quantity with the thermal equivalent of 10 barrels of crude oil. These figures are all approximate. They omit wood, and consequently surely err modestly on the low side.

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[1] Energy estimates from 1972 onward taken from Monthly Energy Review, U.S. Department of Energy.

[2] GDP estimate from Survey of Current Business, U.S. Department of Commerce, September 1978, p. 9. Earlier years back to 1929 in special Survey issue of January 1976.

By what path did the U.S. arrive at its 1976–77 consumption in the range of 75 quadrillion btu? Does our experience of the course of this consumption—and of past predictions of how that course would run—lend credibility to present forecasts of American energy demand 10 or 15 years from now?

In gross outline, United States energy experience has hitherto included only three dominant fuels—first wood, then coal, and then the hydrocarbon oils and gases.[3] In 1860 wood accounted for about 84 percent and in 1880 still 57 percent of all American fuel use. By 1920 coal dominated with nearly 73 percent. In 1960 more than 71 percent of all U.S. energy consumption consisted of the closely related hydrocarbons—oils and natural gases. The hydrocarbons remain dominant today. They supplied 74.5 percent of all U.S. energy consumption in 1976–77. And, so far as we can now foresee, these same hydrocarbons will have to supply the major portion of American energy demand also in the next 15 years, though increased supplies of nuclear power and of coal could significantly diminish the hydrocarbon share.

With respect to the total quantity of energy that may be needed for a satisfactory growth in the national product, the diversity of historic American energy experience should install caution in the thoughtful energy forecaster.[4]

First: From 1860 to 1900, while real Gross National Product expanded at an annual average rate in the general range of 4 percent, our national consumption of energy rose at an annual rate of only about 2.8 percent.

Second: From 1900 to 1920, reversing the earlier relationship, while GNP rose at an annual rate averaging just over 3.3 percent, energy consumption rose at a rate of about 4.1 percent. True, in the period 1900 to 1920 the American economy developed greatly in industries that were heavy energy users: steel, coal-burning railroads, inefficient electricity production, inefficient autos, etc. Equally true, this new industry emphasis was not foreseen.

Third: Still more unforeseen, in the next two decades, energy consumption decelerated enormously, to a cumulative growth of little over 0.8 percent per annum. These were undoubtedly years of great improvement in energy efficiency, especially in electricity production, in machine installations, in automobiles, etc. They were also the years in which oil and gas reversed the growth of coal use. However, and perhaps most important, these years included perhaps the greatest depression in American history. Even after the European war-induced lift of 1939–40, in the year 1940 GNP stood only by a compounded 2.5 percent per annum higher than two decades earlier. Per capita product had risen since 1920 by only 1.4 percent per year.

Fourth: However, and then thought to be unequivocally indicative of a continuing trend of decline in energy required per unit of real GNP, in the relatively prosperous years from 1940 through 1955, the decline in energy intensity *was* sustained. While GNP rose by 4.4 percent per annum, energy usage rose by a rate of less than 3.3 percent.

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[3] See Table 1 annexed, for some further details on energy demand from 1860 to 1955.

[4] For a wide perspective on the growth of the national product, see Simon Kuznets "Notes on the Pattern of U.S. Economic Growth." in his Economic Growth and Structure, W. W. Norton, 1965, pp. 304–27. For long-term series on GNP, see Long-Term Economic Growth 1860–1965, U.S. Department of Commerce, 1966, p. 166ff.

Therefore a sustained pattern of lower energy demand, already striking in the dominantly poor economic climate of 1920–40, appeared to receive reconfirmation in a period of more satisfactory economic growth.

This energy use experience may be summarized, for the first 55 years of the twentieth century, as follows:

RISE AND DECLINE IN THE INTENSITY OF U.S. ENERGY DEMAND, 1900–55

	1900	1920	1930	1940	1945	1950	1955
GNP (real)	100	192	249	317	474	491	598
Energy use (Btu)	100	223	247	263	341	366	425
Energy use per unit of GNP	100	116	99	83	72	75	71

After rising and falling, in 1930 U.S. energy input per constant-priced quantity of GNP had been about the same as in 1900. However, in the subsequent 25 years through 1955, the required intensity of energy input had fallen by roughly 28 percent. Was it not then reasonable to conclude—after a careful review of ongoing processes in the various sectors of the U.S. economy—that this trend of relative decline in energy demand would probably continue, at least for a further decade or two? Alas for such reasoning.

III. The Experience of Sophisticated U.S. Energy Forecasting in 1957–62

We cite, from the vast literature of energy futurology, only two forecasts of the relation between future U.S. national product and corresponding U.S. energy consumption. One forecast was apparently completed a little more than two decades ago, the other a little less. The first, which we shall call S–N, looked forward 20 years, from 1955 to 1975.[5] The second, which we shall call L–F–F, cast its eyes 40 years forward, from 1960 to 2000.[6] We have chosen these two examples of long-term energy demand forecasting not at all because of any thought that they are worse than others. On the contrary, in our judgment, they are among the cream of the crop—among the best informed, best reasoned, and most systematic. They stand head-and-shoulders above similar forecasts which flood learned journals, trade publications, and corporate statements.

S–N is a major pioneering work. Its comprehensive data end generally in 1955, but it includes scattered records that run as late as 1957, and the book was printed in 1960. After an exhaustive review of uses and requirements (occupying 774 closely printed pages), S–N came to conclusions which we summarize below. We follow the authors in measuring energy use against GNP, though we ourselves prefer GDP where only domestic consumption of energy comes under consideration. We also deliberately do not project these conclusions

[5] "Energy in the American Economy, 1850–1975," by Sam H. Schurr and Bruce C. Netschert, 1960, The Johns Hopkins Press.

[6] "Resources In America's Future . . . 1960–2000," by Hans H. Landsberg, Leonard L. Fischman, and Joseph L. Fisher, 1963. The Johns Hopkins Press.

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to 1975, terminating them in 1973, because it would be unfair to impose upon the authors the burden of forseeing the Oil Price Revolution which began in the fourth quarter of 1973 and was followed in 1974–75 by the deepest economic recession in U.S. experience since the 1930's. Their forecasts and the related actual outcomes may then be summarized as follows:

1. Energy consumption of 1955, as utilized by S–N (mineral fuels and hydropower only).	39,723 trillion Btu.
2. GNP of 1955, as in S–N, but converted to 1972 prices.	$654.8 billion.
3. Energy consumed in 1955 per billion dollars of GNP.	60.66 trillion Btu.
4. S–N forecast of annual GNP growth rate____	4 percent.
5. S–N forecast of annual growth in energy consumption.	3.2 percent.
6. GNP of 1973 which would have resulted from S–N growth rate.	$1.326.5 billion.
7. Energy use of 1973 resulting from S–N growth rates.	70,028 trillion Btu.
8. Energy use of 1973, per billion dollars of GNP, from S–N rates.	52.79 trillion Btu.
9. Actual 1973 GNP, in the same constant 1972 prices.	$1,235 billion.
10. Actual 1973 energy consumption____________	74,586 trillion Btu.
11. Actual energy consumption per billion dollars of GNP.	60.39 trillion Btu.

As is apparent from the above tabulation, the entire S–N energy forecasting venture was a vast futility. Its central assumption was a continuing decline in energy demand per unit of real GNP. This central assumption proved unsound. While the forecast saw the energy intensity of a billion dollars of real GNP falling from 60.66 trillion btu to 52.79 trillion, the actual decline was recorded only to 60.39 trillion btu. Indeed it makes more sense to say that there was no measurable decline: the reported decline of 0.27 trillion btu in eighteen years is well within the margin of error of such reporting. The entire study would have been almost perfectly sound—through 1973—had it concluded that the energy requirements of a real billion dollars of GNP would be the same in its projected U.S. future as in 1955.

Moreover the results of the S–N demand forecasts cannot be extenuated on any ground that S–N assumed that demand would be lower because domestic energy supply would be constraining lower and prices higher. On the contrary, the study overestimated the ease of expanding domestic supply even more than it underestimated demand. Thus S–N concludes (p. 4), in a passage it singles out for emphasis:

> Viewed strictly from the point of view of its natural resource position and with due allowance for technological advance, the United States in 1975 or thereabouts could satisfy its demands for all energy, and for each of the energy materials of which the total is composed, from domestic sources of supply at no significant increases in costs, except for those which might be brought about by a rise in the general price level.

This supply error was at its maximum in the case of oils. S–N concluded (p. 10) that U.S. crude oil "producible" in 1975 would be "on the order of 6 billion barrels," i.e. 16,438,000 barrels per day. Domestic production of crude in 1975—despite the oil price revolution—was actually only 8,375,000 barrels per day.

In general, U.S. demand for energy proved distinctly *higher* than S–N forecast though domestic supply of energy as a whole (and of each of its major forms—oil, gas, and coal) turned out substantially *lower*.

L–F–F is an even more compendious study than S–N (1,017 double columned pages!). Not limited to energy alone, it nevertheless reconsiders energy demands and supplies from many facets. Yet its forecasts are subject to the same generic dubieties as are those of S–N.

Signed for publication in 1962, the base data of L–F–F end in 1960, It puts the 1960 energy demand a little higher than do others, because it includes exports of coal and oil (page 858). Therefore it writes 45,350 trillion btu for 1960 energy demand where the U.S. official sources show 44,525 trillion btu. (See the Annexed Table 2.) This difference is of no importance. What is important can be indicated most readily after translating the original study's 1960 GNP dollars into the 1972 dollars we have utilized above. (This is then an adaptation of pages 292 and 858 of L–F–F.)

L–F–F– FORECAST OF GNP AND ENERGY DEMAND, 1960–2000

	1960	1970	1980	1990	2000
GNP, in 1972 (billions of dollars)	732	1,086	1,543	2,199	3,203
Energy use (trillion Btu's)	45,350	60,190	79,190	101,910	135,160
Energy use, per billion dollars of GNP (trillion Btu's)	62.0	55.4	51.3	46.3	42.2

The GNP forecast of L–F–F implied a 4 percent per annum advance from 1960 to 1970, and it was very close to the actual outcome of $1,075 billion—a deviation of barely 1⅔ percent after 10 cumulative years! However its forecast energy rise was only 32.7 percent, while the actual rise was 50.7 percent (on the official figures) to a total of 67,121 trillion btu. Instead of btu per billion dollars falling during the decade by over 10 percent, btu consumed per real billion dollars actually *rose* by over 3 percent. The light shed by this forecast is therefore severely questionable. That question cannot be silenced should the Oil Price Revolution of 1973 and the deep recession of 1974–75 contribute to making the 1980 forecast energy total come nearer to actuality than the 1970 one did. A forecast is not validated by influences of which it took no account.

Supply or cost considerations are not forecast by L–F–F– to greatly constrain U.S. energy demand up through the year 2000 (pages 381–421). However, for the period beyond 1975, the *possibility* of such constraints is taken somewhat more seriously by L–F–F than does S–N in assessing its earlier period. Coal, in L–F–F as in S–N, is found available "at current prices" (page 414) far beyond the year 2000. Domestic crude oils are also judged clearly available at prices advancing no more than the general price level through 1975; after 1975 and through 2000, should the advance of oil technology alone not prove sufficient for oil price stability, cheaper oil imports and competition from coal would ". . . circumscribe rather narrowly the level to which the price of crude might rise" (page 399). Only in natural gas is there a forecast of possible domestic peaking of supply (page 405ff.) and that at about 22.5 trillion cubic feet and between 1970 and 1980.[7]

[7] This was remarkably prescient. Production peaked at 22.6 trillion cubic feet of wet gas in 1973.

However, taken all together, it cannot be said that the supply and price outlook for energy were forecast by L–F–F as placing any serious new level of restraint on energy demand even up to the year 2000.

IV. A Closer Look at U.S. Energy Demand in the Years 1960–73

The paths both of energy demand and of GDP for the years 1960–73 deserve close examination. To these two we have added the related path of manufacturing output. (For details, see the Annexed Table 2.) For the composite 13-year period, before the Oil Price Revolution, energy demand and GDP show the same compound annual 4.0 percent growth. Manufacturing output grows much faster—at a compound rate of 5.4 percent per year. (The United States is *not* a "post-industrial" society!)

In comparison with Energy Demand, the path of GDP is more volatile, and Manufacturing Output is more volatile still. Energy Demand (like consumers' spending) never actually declines in any year of the thirteen, while both GDP and Manufacturing Output do show minus signs in the bad recession year 1970. On the other hand, neither Energy Demand nor GDP rise by significantly over 6 percent in any year, while Manufacturing Output advances distinctly more than 6 percent in 6 years out of the 13.

All of the more prosperous years in both GDP and Manufacturing (1962, 1966, 1968, 1972, and 1973) are also years of above average Energy consumption. Moreover the poorest years for GDP and Manufacturing (1961, 1967, 1970, and 1971) show poorest growth for Energy too. However, the coincidence is not perfect. In 1964 consumption of Energy lags, and in 1969 Energy leads. Single years—particularly affected by weather or some other special circumstances—are poor guides to any continuing conclusion.

We do not represent the years 1960–73 as ones of glittering prosperity. For the whole 13, per capita GDP growth was 2.8 percent per year. (At this rate, real income per capita would double in 25 years.) In our observation, the American public—however arbitrarily—regarded a 2.8 percent annual increase in income as toward the lower end of reasonable expectation.

More, in these 13 years (as also more recently), the Labor Force grew more rapidly than the U.S. population as a whole. Per member of the Labor Force, GDP rose by only 2.2 percent per annum. (See Table 4 annexed.) At such a rate, a doubling of his real income, for a representative member of the Labor Force, would require 32 years. American aspirations are higher.

It should be clearly held in mind that 1960–72 was a period of *relative* decline in American energy prices, though—at the wholesale level—1969–72, taken alone, already began to reverse the decline. (For details, see the Annexed Table 5.) The great leap in energy prices came, however, only with the onset of the Oil Price Revolution, in the fourth quarter of 1973.

While the index of Wholesale Prices (as constructed by the Bureau of Labor Statistics) is not so composed as to yield an exact measure of industrial energy costs, this index does provide a rough indication. The component of this wholesale index named "Fuel and related products and power" rose in price by only 23 percent in the years 1960–

72, while the price of total "Gross Business Product" rose by 38 percent. Each of the major fuels for industry (including electricity) shows the same pervasive lesser price advance during 1960–72, except coal which rose sharply in price after 1965. However, when coal prices jumped (and indeed roughly doubled), the consumption of coal stagnated while industrial use of oil and gas increased sharply.

Similarly, the indices of Personal Consumption Expenditures show, for 1960–72, the same lesser advance in what we may call "retail" energy prices than in the prices of other areas of personal consumption. While the total price index of Personal Consumption rose by 39 percent, the consumer index for "gasoline and oil" rose by only 18 percent, for "electricity and gas" by 22 percent, and for "fuel oil and coal" by 31 percent.

We repeat: these are not exactly comparable measures. Yet they do indicate that, *relative to other prices*, energy was becoming cheaper to American users in the period 1960–72. American users of energy therefore had only a limited incentive to save by using less energy, and this incentive was indeed minimal wherever such saving involved substitution of other goods and services of which the prices were rising faster than the prices of oil, gas, or electricity.

In the light of this price experience and the later history of the 1970's, it may be useful to recall the message of perhaps the most authoritative American government document, dealing with essential U.S. energy requirements, issued at the beginning of the 1970's. This was the report of the Cabinet Task Force (including six Cabinet members, with Secretary George P. Schultz as Chairman). Its title was "The Oil Import Question," and its thrust was to meet U.S. energy demands as economically as possible in the context of safeguarding the national security. The report was issued in February 1970, when "energy crisis" had already become a commonplace expression.

The key recommendation of this report, as endorsed by the majority of the Task Force, was to take steps to *reduce* the price of crude oil produced in the United States. The report found its key reference point in a then price of $3.30 per barrel for 30 degree gravity crude at the South Louisiana wellhead (page 41). It recommended reducing this price to "about $2.00 per barrel." (As this $2.00 was in constant 1970 values, it would mean—by coincidence—again about $3.30 per barrel at the GDP price level of the second quarter of 1978.) Imports were to be made freer and lower ocean transport costs to be enlisted to the end that "about $2.00 per barrel" (in constant 1970 prices) would be "the price that would prevail at the South Louisiana wellhead in 1980" (page 19).

The Task Force consisted of judicious, well-informed men. It had an able staff. They saw the reasonable satisfaction of U.S. energy demands in a policy of lower prices and freer importation.

V. The U.S. Energy Demand Record Since the Oil Price Revolution

The conclusions to be drawn from American experience with energy demand since the Oil Price Revolution came to its climax, in 1973–74, are not transparent, nor are they unqualifiedly encouraging.

Taking the four years 1973–77 together, U.S. consumption of energy did rise at only the very restrained compound annual rate of less than one-half of a percent. (For details, see the Annexed Table 3.) Even so however, the average intensity of consumption of energy in 1974–77, at 58.8 trillion btu per billion dollars of constant-priced GDP, was not so low as the average for the seven years 1962–68. (For details, see Table 7.) Moreover, in the earlier seven years, real GDP rose at a compound annual rate of 4.8 percent, while in 1974–77 the growth averaged only 1.9 percent. Further, in the earlier seven-year period, GDP prices rose at the comparatively moderate rate of 2.6 percent per year, in the later period at a disturbing 7.5 percent per year.

The years 1974 and 1975 were characterized by the sharpest U.S. economic recession since the 1930's. During 1974–77, the calculated "Labor Force Time Lost" moved up from 6.1 percent to 9.1 percent, then down to 8.3 percent and 7.6 percent.[8] A rough estimate of unemployment that included "discouraged workers" not looking for a job because they believed no job to be found might average in the general range of 10 percent for the whole four years. It is possible therefore to take a grim view of the social price paid for the modest energy economizing achieved in 1974–77. Moreover, such evidence as is now in hand, does not suggest that 1978 will reflect a significantly lower intensity of energy use, per billion dollars of real GDP, than did 1977.

If an increase in the relative price of energy has a quick impact toward reducing energy consumption, such an impact has certainly had a chance to operate since 1972. From average 1972 to the second quarter of 1978, in a period of slightly less than six years, each of the more general indices of prices (those for GDP, for Personal Consumption Expenditures, and for Gross Business Product) has risen about 50 percent. During the same period, energy prices show a rise variously from about 2 to 20 times as great, with those materials near domestic gas wells or free import prices rising most. (See the Annexed Table 6.) The wellhead price of natural gas averaged 18.6¢ per thousand cubic feet in 1972. This average had more than quadrupled by 1977, and—for new gas—it will be 11 times as high in the winter of 1978–79. The U.S. landed price of imported crude oil has more than quadrupled, to a present (June 1978) price in the range of $14.54 per barrel, or about $2.51 per million btu.[9] [At this level of prices, the national consumption of energy in 1978—unrefined, undistributed, and unconverted to electricity—would have a cost approaching $200 billion!] Despite a variety of price controls over gas and oil, the average price of *domestically* produced mineral fuels has tripled since 1972. The composite wholesale price of fuel and power, as purchased by large users, has risen from 100 to about 270, with natural gas rising most and electric power more than doubling. Energy purchased at retail has gone up from 100 to about 200, with the fuel oil and coal used by households rising from 100 to over 250.

In a substantial measure, energy price pressures and supply uncertainties were motors of the general price inflation, of the poor national economic performance, and of the dubieties that have come to weight pervasively in the public mind during the years since the Oil Price Revolution.

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[8] Bureau of Labor Statistics, as reproduced in Economic Indicators, August 1978, p. 12.
[9] Monthly Energy Review, October 1978, p. 58.

Since 1972, exports of oil by the 13 OPEC cartel members have risen in volume by only about 14 percent, from some 25.5 million barrels per day to a 1977 level of some 29.1 million barrels per day. However the foreign exchange revenues from oil accruing to these 13 cartel members have multiplied nearly 9 times, from $14.4 billion in 1972 to $128.4 billion in 1977. Peak OPEC *production* of oil was actually reached in the third quarter of 1973, just before the Oil Price Revolution. Then it attained 32.5 million barrels per day; in the first half of 1978, OPEC production was only 88.0 percent of this 1973 peak.[10]

The impact of the Oil Price Revolution may be divided into four strands. *First:* It transferred over $100 billion of annual income from oil importers to oil exporters. *Second:* It created pressures towards a roughly corresponding rise in the prices of energy materials other than oil. *Third:* It exposed enterprises to the competitive uncertainties of exploring the substitution of other energy materials for the now more expensive and uncertain oil supplies. *Fourth:* It pushed nations formerly unconcernedly dependent on oil imports towards designing policies to minimize the effective pressure of the worldwide collusion of oil exporting nations in OPEC and out of it.

These elements of pressure were certainly important in the matrix which dropped the real GDP of the United States by 6⅝ percent from the fourth quarter of 1973 to the first quarter of 1975. From then, the decline was reversed so that GDP recovered to a level above the 1973 peak in the first quarter of 1976. Accompanying the economic decline, national energy consumption dropped by 2.50 percent in 1974 and a further 2.86 percent in 1975. (For details, see especially Tables 3, 4, and 7.) Then however, as GDP rose by 5.58 percent in 1976 (and manufacturing output jumped more than 11 percent), energy consumption rose by 5.33 percent. In 1977, a new era may have seemed to be dawning: GDP rose by 4.83 percent and energy consumption by only 2.08 percent. However, up to now, the record of 1978 does not confirm a new era. Energy consumption has been rising, in the first half of this year, just behind GDP. When GDP has risen by 3.95 percent, energy consumption has risen by 3.42 percent.

Moreover, if we examine U.S. energy consumption in 1973–77 by end use, only productive Industry (including construction, agriculture, etc., as well as manufacturing), characterized by high cost-consciousness, seems to be consistently and strongly economizing of energy.[11] Industrial use of energy was reduced, from 1973 to 1977, by about 4.4 percent, in spite of an increase in manufacturing output by about 7.3 percent: The saving was about 1,274 trillion btu for a year's usage. But residential and commercial usage rose about 6.1 percent—an increase of 1,384 trillion btu. And transportation, including private auto transportation, has increased its energy usage by 5.4 percent—an increase of 1,025 trillion btu. It is also to be noted that these changes are all measured from 1973, a year in which energy consumed per billion dollars of real GDP was somewhat higher (see Table 7) than in 12 other of the 19 years included in the 1955–73 record. Considering the economic price paid, the 1973–77 record of energy economizing was, at best, indifferent. And 1978 is not significantly better.

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[10] Export earnings estimates by Shell International, summarized by E. Stanley Tucker, in Petroleum Economist, London, July 1978, pp. 285–6. For OPEC production 1973–78, see same journal, October 1978, p. 445.

[11] Monthly Energy Review, October 1978, pp. 4–10.

The price level for crude oil, established by the OPEC cartel, was once regarded as an intolerable abuse. It was then stigmatized as reflecting, in extreme cases, perhaps 30 or 40 times the related f.a.s. costs. Today however this is the recognized "world market" level. Respected opinion is almost unbroken in its emphasis that a "real" price in the range of $14.50 per barrel is a *given:* It is the unavoidable price for the "swing" product in energy supply. For this oil product—accepted as a cartelized unit offering—there is no ready replacement substitute. Not only the members of OPEC but also the United Kingdom, Norway, Mexico, China, as well as the great international oil companies, now cleave to this price—and plan calmly that it will rise further. The International Energy Agency, created as an instrument of defense against OPEC extortion and embargo, scolds those countries which are laggard in equating their own domestic energy prices to this OPEC level—as this level now stands and presumably as it may further rise.[12]

The architects of "models" of the U.S. energy economy are necessarily explorers (and usually partisans) of the impacts of steeply higher energy prices, respectfully regarded as true mirrors of "real costs." Higher prices are counted upon as motors of the "elasticity of substitution" (of other materials, labor, and capital in place of energy. But, alas, we do not know what the U.S. "elasticity of substitution" is for energy—this year, or 5, 10, or 15 years forward. The architects of such models prefer to let their projections run forward for 40 or 50 years and on wide-ranging alternative assumptions concerning the underlying causal relationships.[13] Perhaps this preference is not unaffected by the consideration that, 40 or 50 years hence, a forbearing posterity will have forgotten what we modeled or forecast in 1978.

VI. Energy Intensities of U.S. and of Other Developed Economies

International comparisons of intensity of energy utilization are difficult to express quantitatively, and the import of such quantity differences is hard to establish. It is hard to find price denominators through which the size of the various national products can be fairly compared. Even among industrial countries alone, there are great differences in the makeup of housing, the layout and scope of commercial services, the needs of transportation, and the commodity composition of industrial production.

A house in Chicago has very different heating and cooling requirements from a house in London or San Francisco. And the relatively spacious separate house of the United States has very different energy requirements from the tiny residence that characterizes contemporary Japan. (We may say that the former mode of housing is more "energy intensive" than the latter; we should not say that the latter is "more efficient.") Where living and working are dispersed, consumer energy requirements are higher than where they are concentrated; yet the consumer may consider himself fortunate to have avoided the blessing

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[12] Energy Policies and Programmes of IEA Countries: 1977 Review, Paris, OECD, 1978. For examples of sponsorship of "world market" prices, see p. 31 and p. 173.

[13] Some of the most interesting of these models are contained in Modelling energy-economy interactions, ed. by C. J. Hitch, Washintgon, 1977.

of the mass transportation which carries the accolade of being less "energy intensive." And where production materials and components are moved across a great continental land mass (as in the U.S.A. and the U.S.S.R.), a specific product may involve more ton-miles than in the industrial concentration that comprehends the Netherlands, Belgium, northern France, and the northern Rhineland.

Also, where energy has been relatively abundant, electro-chemical and electrometallurgical industries have tended to be located, and where their power was cheap these industries used it abundantly rather than making large investments to conserve it. (Therefore, if we find French production of aluminum ingot to be less energy intensive than the aluminum output along the great hydropower installations of the U.S. and Canada, we may say that the French producers were less energy intensive; in economizing total costs per ton, they were not necessarily more efficient.) Petrochemical industries have moved toward natural gas wells and toward oil refineries that supply refinery gases and liquid fractions difficult to transport. (We shall not call the Netherlands "inefficient" because it has one of these great refining and chemical concentrations; however we shall say it is heavy with energy intensive industries.)

Perhaps the most sophisticated study of these questions, in our acquaintance, is the volume entitled "How Industrial Societies Use Energy: A Comparative Analysis," by Joel Darmstadter, Joy Dunkerley, and Jack Alterman.[14] The authors provide a detailed and persuasive analysis, for the period they cover, of why United States' energy use is more intensive than that of all but one of the other nations they chose to cover. (These are Canada, France, West Germany, Italy, the Netherlands, the United Kingdom, Sweden, and Japan.) Only Canada comes out more energy intensive than the U.S. Taken sector by sector, where Canada is highest, the U.S. is usually second. Passenger transport—primarily using gasoline—is shown to be the largest factor of difference. (In freight transport, the U.S. is shown to be far *less* intensive than other industrial countries, because of the heavy share of pipeline, waterborne, and rail traffic in the American economy.) After passenger cars, the high energy intensity of U.S. industry weighs in as the second factor; moreover, industry would be the first intensifier but for the fact that the U.S. ranks seventh among these ten countries in the share that industry contributes to GDP. After passenger cars and industry, the separate single family and high heating houses of the U.S. make a weak third but easily identifiable factor in the total U.S. high intensity complex. The proliferation of commercial services may be a fourth, but that is harder to measure. The authors conclude: "There is then a pervasive tendency, reflected in all of the main consuming centers, for U.S. consumption [of energy] relative to GDP to be higher than that of other countries." (p. 25) And, with particular respect to industry, the authors suggest: ". . . the findings . . . constitute at least a strong presumption that U.S. industrial managers concerned with energy utilization might profitably explore the nature of foreign practices and results." (p. 192)

But, alas, though published in 1977, the dates of reference of these analyses are 1970 and 1972. The most sophisticated analysis (Part III, on "Input-Output and Final-demand") relates to 1970. Unfortu-

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[14] Published for Resources for the Future, by the Johns Hopkins Univ. Press, 1977.

nately, 1970 happens also to be the year of the last 23 (1955–77 inclusive) in which U.S. energy intensity was highest (62.7 million btu per $1,000 of 1972 priced GDP); 1972 was also high (61.5 million btu). The authors write from the other side of the Oil Price Revolution. The partial obsolescence of their analysis, for our present condition, is suggested by their statement (p. 11) that the requirements of costs other than energy "... may swamp energy costs by a factor of 25 to 1." Looking from the present forward, and from the perspective of the economy as a whole, the illustrative weight for energy would be better doubled or, in extreme cases, tripled.

Fortunately, in early 1978, the International Energy Agency made a summary review and appraisal of the energy policies and programs of each of the IEA member countries. (It should be recollected that IEA was organized to concert policies of the major oil importers after the 1973–74 experience of OPEC extortion and embargo.) After an April 1978 policy review meeting in Tokyo, the Governing Board of IEA decided to publish this appraisal, though recognizing that it is a compound in which facts expectations, and aspirations are mixed in uncertain proportions. Unfortunately, also—as it has chosen to emhasize its independence of both "North" and "South"—France has not joined the IEA and has therefore not been covered, though France is among the foremost in economizing energy.

Central to this IEA compound is the projection (page 25) that, for the entire IEA membership, the total requirement of "Primary Energy," per unit of real GDP, would be reduced in such a ratio that if 1976 is expressed as 144, then 1985 would be 136 and 1990 would be 132. Otherwise restated, per unit of real GDP, the energy required, for all IEA together, based on 100 in 1976, would be 96.44 in 1985 and 91.67 in 1990. It is not a heroic reduction.

Moreover the IEA group projected that its total GDP would rise at an average rate of 4.3 percent per annum in 1976–85 and 4.0 percent in 1976–90. Nine years growth of 100 at 4.3 percent yields a total of 146.07, and 14 years growth of 100 at 4.0 percent yields a total of 173.17. Compounding with the declining rates of energy needed per unit of GDP, we derive, for the entire IEA family, an energy requirement of 100 in 1976, then 141 in 1985, and 159 in 1990. Total energy demand is therefore projected to rise by 59 percent in the fourteen years 1976–1990.

The result of this IEA exercise has no inherent implausibility, though it is also no more plausible—no more a basis for firm reliance—than the estimates of 15 and 20 years ago (as reviewed in Section III above) or the estimates of 1970 made by the U.S. Cabinet Task Force (of which brief mention is made in Section IV above).

The IEA averages are not specific for the U.S. alone. Yet their meaning may perhaps be clarified by applying them directly to the U.S. base. Then, as the United States required about 58.9 million btu per thousand dollars of 1972 priced GDP in 1976, the U.S. would need about 55.6 million btu per thousand dollars in 1985 and 54.0 million in 1990. Moreover, the GDP of the U.S., having been $1,264.3 billion in 1976 (in constant 1972 prices) would rise to $1,847 billion in 1985 and $2,189 billion in 1990. The U.S.A. having consumed some 74.4 quadrillion btu of energy in 1976, would require about 103 quadrillion btu in 1985 and about 118 quadrillion btu in 1990.

Again, for the U.S., the above calculation yields a result of no inherent implausibility. However, he would be a very bold, inexperienced venturer who would assign this estimate, for 1990, a probable error of so little as 20 percent. The cumulative error in the estimate of the growth of GDP may itself be fully this wide, where a 14-year interval is involved—of which only the second is now elapsing.

The IEA also assembled a variety of projections on the individual energy intensities of its members, per $1,000 of constant 1970 dollar priced GDP. These serve to indicate that the United States—while, in aggregate, consuming in 1976 more than half of the IEA energy consumption total—is not at all, in respect to energy intensity per unit of GDP, in a league quite by itself. There are both higher intensity consumers than the U.S. and near equals. Some aspire to sharp future reduction; some do not. A selection of these facts is contained in the following table:

ACTUAL AND PROJECTED CONSUMPTION OF ENERGY, PER $1,000 OF 1970 PRICED GDP, FOR 10 INDUSTRIALIZED MEMBERS OF IEA, WITH ENERGY EXPRESSED IN EQUIVALENT METRIC TONS OF OIL PRODUCTS

	1976	1980	1985	1990	Reference (page)
1. Canada	1.87	1.80	1.71	1.64	74
2. Netherlands	1.68	1.70	1.60	1.50	131
3. United Kingdom	1.52	1.41	1.32	1.24	166
4. United States	1.51	1.41	[1] 1.41–1.37	1.37	174
5. Belgium	1.42	1.37	1.34	1.31	66
6. Norway	1.41	1.24	1.20	1.12	145
7. Japan	1.336	1.317	1.276	1.262	120
8. Sweden	1.32	1.19	1.16	1.09	154
9. Italy	1.24	1.27	1.27	1.25	110
10. Germany	1.20	1.23	1.11	1.04	91

[1] Indicated achievable "with national energy program."

Source: See text footnote 12.

Canada and the Netherlands have a higher intensity of energy use than the U.S., and they expect to continue above the U.S. For Canada, this relationship is explicable, on the demand side, by use practices like those of the U.S. plus a severe climate and long distances; on the supply side, it is rendered feasible for Canada by large hydro resources—already supplying one-quarter of all energy and moving toward 30 percent by 1990 (10 times the U.S. hydro share). For the Netherlands, the natural gas of Groningen is decisive. Its annual thermal yield—more than half exported—is equal to the total energy requirements of the country. Dutch natural gas production contributes perhaps 6 percent of total GDP and 12 percent of the entire revenue of the central government. Fortunate also in an advantageous petroleum refining location, the Netherlands enjoy great fuel and feedstock advantages. Consequently, in the near future (to 1980), the Dutch do not even pretend to reduce the intensity of their energy use; later projections also do not bind tightly.

The United Kingdom now consumes approximately the same quantity of energy, per unit of GDP, as does the U.S. Despite more austere U.K. projections, the future paths of the two countries may not be greatly dissimilar. In 1980 the U.K. expects to become an oil exporter. She will also be producing more gas, coal, and nuclear power. Indeed, between 1976 and 1985, the energy production of the U.K. is scheduled to more than double, making the country a net energy exporter. It is too early to be confident of severe British energy economizing.

Belgium and Japan, having neither the great continental land transport distances of the U.S. nor (especially in Japan) housing of remotely American size to heat and cool, have 1976 energy intensities, per unit of GDP, respectively 6 percent and 12 percent below the U.S. The Belgian authorities project a 1990 intensity about 8 percent below 1976 and Japan 6 percent below 1976. Italy, being poorer, projects *no* reduction in energy intensity but instead a tiny increase. In none of these countries is there planning for energy austerity. Belgium is distinct in its high intended reliance on nuclear power. The distinction of the Japanese program is the high continued reliance on imported oil. Already for 1980, the Japanese import of oil is projected to be about 6,400,000 barrels per day and in 1990 more than 8,000,000 barrels per day. In volume of projected oil imports, Japan is the only IEA country that bears comparison with the U.S.A. And Japanese public authorities are prepared to increase this dependence, greatly above the quantities indicated above, if diverse origins (China, Mexico, etc.) can be found. So, for example, her Minister of International Trade and Industry stated, in October 1978, that Japan's need for oil imports (which had provided a consumption of 5,345,000 barrels per day in 1977) would increase by 2,800,000 barrels per day by 1985 [15]—thus providing a total for 1985 greater than Japan had communicated to the IEA for 1990.

Norway, Sweden, and Germany stand out as industrialized members of IEA which already have moderate or low intensities of energy use and profess seriously to reduce these intensities further and greatly (by 15 percent to 20 percent) during the next years. Germany alone claims a first pause (through 1980) but from a strikingly modest intensity level. Norway's program—if accomplished—will be the most remarkable of all. From 1960 to 1973, Norway's energy use grew by about 6.2 percent per annum. Now, for 1976 to 1990, this growth is to be reduced to about 2.9 percent per annum. There is no pressure of energy shortage. Norway derived about three-fifths of its total energy consumption in 1976 from hydropower and plans to derive half of its consumption still in 1990 from hydropower. Already a net energy exporter, Norway expects to be a large net exporter of oil and gas, in a range equivalent to roughly 1,100,000 barrels per day of oil. in the period 1980 through 1985. In spite of this energy abundance, Norway projects a steadily lower energy intensity, falling by about one-fifth per unit of real GDP from 1976 to 1990. Moreover public policy enunciates a firm resolve *to go very slowly* with North Sea exploration and development. No other IEA member combines so great an abundance of self-supply with such planned severe restraint in energy production and use.

VII. Reducing Energy Consumption by Reducing Income

The most certain way to minimize the market demand for energy is to be poor. Produce little, consume little. Walk; do not ride. Do not travel. Turn the lights out. For protection against the winter cold, wrap in a heavy blanket. Against the summer heat, seek shade. Minimize producing metals—especially the electrometallurgicals. In general, avoid electricity: about 65 percent of the thermal input is lost in

[15] The Japan Economic Journal, Tokyo, issue of Oct. 10, 1978, p. 7.

converting fuels into electric current and perhaps 3 percent more is lost in delivery.

More formally, we may distinguish three ways to restrain (or halt) the growth of total national energy demand:

(1) Reduce, or even reverse, the growth of Gross Domestic Product. (Reversal is no novelty; it happened in 1974–75.)

(2) Produce an unreduced growth but alter the *composition* of the total product so that it will be made up of goods and services requiring less energy than the former composition.

(3) Change neither the rate of growth of GDP nor its basic composition but find methods of producing that will require less energy input—and presumably more input of capital or labor or non-energy materials—than the former methods of production.

Strictly speaking, perhaps only the third of these should be called "energy conservation"; however, loose usage confounds the three.

Our present subject is the first—reduction in the growth of the Gross Domestic Product.

In our judgment, to reduce the GDP for the sake of reducing the demand for energy is to adopt the wisdom that would burn down the house to prevent its occupants from bumping against the furniture. Yet, to the extent of our acquaintance, it is upon reduction in the growth of GDP that presently dominant informed opinion *does* count predominantly for being able to "live with" energy demand in the next 15 years.

We cite, as representative of such opinion, a document of which the principal authors are John H. Lichtblau and Helmut J. Frank, entitled "The Outlook for World Oil . . . with Emphasis on the Period to 1990." [16] We choose this document, as an illustration, because it is a thoughtful, indeed impressive, study—far more weighty than the generality of energy publications. Writing in May 1978, the authors say: ". . . we believe strongly that the average economic growth rate in the period 1976–90 will be significantly below that of the 1960–76 period." (page 1–4) Wrongly, in our judgment, they describe the economic achievement of 1960–73, as "soaring." (In those "soaring" years, U.S. real GDP rose by 4.0 percent per annum and the labor force by 1.8 percent, yielding a growth rate at which income per member of the labor force would double in 32 years—hardly what Americans regard as high flying.) They call a GDP growth rate for 1980–90 of 3.5 percent per annum "High" and a rate of 3.0 percent "Moderate." Very carefully, they list, from other authors (page 2–6), a large array of "Economic Growth Assumptions." Then they conclude that: ". . . lower estimates of economic growth are more likely to be on target than the more optimistic projections . . ." (page 2–8). And they add, with a confidence we do not share, ". . . at least in the economically developed nations, . . . the slow economic growth rates (by pre–1974 standards) will be accepted." (page 2–9) On the contrary, we suspect that they will be rejected. And, if advanced economies function so poorly that they are able to supply only such small real income growth, these economies will usually be required to maintain the appearance of supplying more by paying in the false income growth of inflation.

We take the views of Lichtblau and Frank, as cited above, therefore,

[16] Prepared by the Petroleum Industry Research Foundation. Published by the Electric Power Research Institute. Palo Alto. Calif., May 1978.

not as reflecting some natural necessity but rather as a fair reflection of governing opinion in mid-1978. As such, they are close to the views of major energy companies. Exxon, for example, in April 1978, states [17] that "Economic growth is projected to be slower in the future than in the past" (page 7), and it puts this growth of real GNP for 1980–90 at 3.4 percent per annum for the U. S. Shell, publishing in July 1978,[18] is rather more pessimistic. First stating that "The domestic economic growth, as measured by Gross National Product, will be slower than that experienced during the post-World War II period" (page 3), it then estimates U.S. growth in GNP at 3.1 percent per annum in 1980–90.

We do not assert that the above estimates are wrong. We do however assert that there is no necessity for their being right—or even nearly so. The quality of functioning of the U.S. economy in the next 5 or 10 or 15 years is not yet determined. The range of uncertainty in the future growth of American GDP is therefore much greater than these estimates suggest.

The growth of the U.S. national product will derive from the growth in the American labor force, its sustained employment, and the growth in productivity per worker. On none of these developments do we have ground for assurance.

In the 15 years 1963–78, the labor force of the U.S. grew at a compound annual rate of 2.1 percent. In the five years 1973–78 alone, the growth has been at a rate of about 2.4 percent. Despite the change in the U.S. age composition, we find no basis for confidence that the labor force will grow at a greatly lesser rate in the 15-year period 1976–77 to 1991–92 than it has in the past 15 years. Our reasons are the following, listed in the order of their weight:

(1) There is continuing expansion in the participation of women in the labor force. In 1950 some 24 percent of wives were in the labor force, in 1977 about 46 percent. Females from the 1946–50 birth group have an indicated labor force participation over 55 percent. The 1950–54 group is responsibly estimated at over 60 percent.

(2) The immediate next years will show a one-time accretion from the legal extension of the compulsory retirement age minimum from 65 years to 70 years.

(3) Immigration is increasing, especially from Latin America.

(4) Our beginning point in 1976–77 had a large quotient of "discouraged" abstainers from the labor force.

For these reasons, we estimate the average annual addition to the labor force of the U.S. in 1976–77 to 1991–92 at between 1.5 percent and 2.5 percent.

Productivity gain is even more uncertain. The course of decline in manhour output in the private sector, from 3.3 percent per annum gain in 1947–67 to 2.0 percent in 1967–73 and to 1.2 percent in 1973–77, is well known. However we do not find this trajectory a firm basis for permanent discouragement. In 1978, productivity has been rising—in the third quarter, by a reported 3.7 percent. If output grows, and new plant and equipment are put in place, productivity will probably grow too. Yet, here too, we do not see any rational basis for assurance.

[17] World Energy Outlook, April 1978.
[18] The National Energy Outlook 1980–1990, July 1978.

For 15 years forward, the achievement might be as bad as 1.5 percent per annum or as good as 3.5 percent. We do not know.

Combining these uncertainties in labor force growth and in productivity, we achieve the following totals for GDP growth.

A JUDGMENT ON GROWTH IN REAL VOLUME OF GDP IN THE UNITED STATES DURING 15 YEARS, 1976-77 TO 1991-92

Rate of growth per year (percent)	Qualitative judgment on economic performance	Cumulative growth in 15 yr (percent)
3.0	Very poor	55.8
3.5	Poor	67.5
4.0	Modest: experienced 1960-73 by United States	80.0
4.5	Good	93.5
5.0	Very good	107.9
5.5	Excellent	123.2

These ranges are indeed very wide. However the uncertainty in our knowledge is no narrower.

In the above table, what we have called "Very Good" comes very close to the composite experience of the industrialized countries in 1960-73.[19] What we have called "Excellent" is well below the 6.3 percent per annum gain, in 1960-73, of the composite of all OECD countries, excluding the United States.[20]

VIII. Conservation Feasibilities in American Energy Demand

The following table reflects, in barest skeleton outline, our judgment of what *may* prove feasible, in American energy conservation, during the next 15 years.

A JUDGMENT ON FEASIBLE U.S. INTENSITIES OF ENERGY CONSUMPTION PER $1,000 OF GDP, IN CONSTANT 1972 PRICES

Amount, in rounded millions of Btu's	Qualitative judgment on achievement	Amount, in equivalent barrels of crude oil	Plausible date
58.0	Actual	10.0	1976-77
55.1	Moderate	9.5	1981-82
52.2	Good	9.0	1986-87
49.3	Very good	8.5	1991-92
46.4	Excellent	8.0	1990's

We wish immediately to clarify what we mean by saying that these intensities "*may* prove feasible." We have stated above that we proceed "always" on the basis of processes "now ongoing" in the U.S. economy. Here we do not so proceed. Only in the commodity-producing sector denominated "Industry" do we see such a level of conservation now ongoing. In the "Residential/Commercial" sector, we believe that additional restraining measures will be needed to achieve the "1990's" target. And we suspect that the "Transportation" sector may also lag.

Obviously the qualitative judgments, which we have expressed so flatly, can only be generally indicative. What is only "Very Good" when dated 1991-92 would be "Excellent" to a level beyond belief if it were achieved in 1981-82. And we would not qualify any of these

[19] World Bank, Annual Report 1978, p. 119.
[20] OECD, Economic Outlook, July 1975, p. 13.

conservation levels as marking an "Excellent" accomplishment if it went along with sustained general economic contraction comparable to that of 1974–75. Perhaps the above table would best be taken as merely conveying the general judgment that it would be a notable adjustment if the American economy were to reduce its energy intensity by 20 percent, even if that adjustment were to require somewhat more than fifteen years.

It should be observed that the targets suggested in the table above are more severe than those deduced (in Section VI) by applying general IEA conservation goals specifically to the U.S. The IEA averages would indicate 55.6 million btu per $1,000 of GDP for the U.S. in 1985 and 54.0 million btu in 1990. This comparison does however not take into account the fact that the U.S. starting base is higher than the IEA average.

The intensity reductions indicated as "feasible" in our above table are also not to be identified with the more modest ones set, for Western Europe, by the Council of the European Economic Community at its Bremen meeting of July 1978. The Council there proposed the objective of ". . . cutting to 0.8:1.0 the ratio between *the rate of increase* for energy consumption and that for gross domestic product."[21] [Emphasis added] The Council's formulation therefore runs in terms only of the growth increment and not—as ours does—the entire GDP content. At a growth rate of 4 percent for GDP, the Council's proposal would bring about a 20 percent reduction in total energy intensity only after 30 years.

In our judgments above, we have not reckoned with an average for 15 years repeating such extremely poor economic growth as occurred in 1973–78. Nor have we reckoned with a repetition of such catastrophic energy price developments. Therefore we repeat our emphasis on the great factor of uncertainty, particularly for a country so dependent on a cartel (and on cartel collaborators) as the U.S. has become.

In our judgment, the weightiest obstacle to achieving an average conservation of 20 percent. from the 1976–77 base, in the next 15 years, is the increased weight, in total U.S. energy consumption, of what the Department of Energy names the "Residential/Commercial" sector. This sector includes all homes, all commerce, and all services except transportation. The facts of its increasing dominance are summarized in the following table:

U.S. ENERGY CONSUMPTION BY MAJOR ECONOMIC SECTOR

[In trillion Btu's and percentage shares]

	Residential/commercial		Industrial		Transportation		Total	
	Btu's	Percent	Btu's	Percent	Btu's	Percent	Btu's	Percent
1973	26,540	35.6	29,170	39.1	18,877	25.3	74,587	100.0
1976	27,260	36.6	27,854	37.4	19,295	25.9	74,409	100.0
1977	28,161	37.1	27,871	36.7	19,901	26.2	75,934	100.0
6 mo 1977	14,932	39.1	13,390	35.1	9,832	25.8	38,154	100.0
6 mo 1978	15,712	39.8	13,601	34.5	10,145	25.7	39,458	100.0

Source: Monthly Energy Review, Oct. 1978, p. 5.

[21] Petroleum Economist, November 1978, p. 459.

In 1973–77, the increase in energy demand in the Residential/Commercial sector alone accounted for *more* than the total national increase in the use of energy. And again in 1978, this sector is the only one that is increasing its share. In the first six months of 1978, national energy consumption rose by 3.42 percent. However Residential/Commercial consumption rose by 5.22 percent. Transportation by 3.18 percent and Industry by only 1.58 percent. The Residential/Commercial sector is moving toward accounting for two-fifths of total national energy consumption.

The Residential/Commercial sector dominates electricity use, and electricity has been the form of energy for which demand has risen most rapidly. The dominance of Residential/Commercial uses of electricity is indicated by the following table:

ENERGY CONSUMPTION IN ELECTRICITY BY MAJOR CONSUMING SECTORS

[In gross trillions of Btu's and percentage share]

	Residential/ commercial		Industrial		Transportation		Total	
	Btu's	Percent	Btu's	Percent	Btu's	Percent	Btu's	Percent
1977	13,336	58.9	9,071	40.1	0.219	1.0	22,626	100.0
6 mo 1978	6,800	59.0	4,611	40.0	0.112	1.0	11,523	100.0

Source: Monthly Energy Review, Oct. 1978, pp. 8–10.

At present electricity requires about 30 percent of all energy consumption in the U. S. We expect a further growth to 35 percent, and—on present trends—the share of the Residential/Commercial sector will continue to expand. The electric utility industry has expressed the view that, even in a slowly expanding economy, its net generation in the contiguous U. S. mainland will have to expand about 5.4 percent per year, during 1977–87.[22] This rate seems too high. In 1975–76 utility electricity production did rise by 6.3 percent and in 1976–77 by 4.3 percent; however, it seems to have risen only by 3.2 percent in the first 9 months of 1978. Over all, steeply rising higher electricity prices have had an effect. In residential use, consumption rises more rapidly because of the high rate of household formation, the high rate of new residential construction (particularly of separated, single-family structures), and the increased use of electrical appliances: these things push residential electricity consumption up even when other sectors lag. They operate strongly to offset any reductions in usage from better house insulation and more efficiency in electrical appliances.

In the commercial area (including all services except transportation), it is the endless proliferation of establishments and employments that expands energy consumption. From average 1973 to September 1978, total civilian employment (seasonally adjusted) rose by 10,460,000 persons. Of this total, agriculture contributed a reduction of 40,000, transportation and utilities a gain of 200,000, and industry (manufacturing, construction, and mining) a gain of 550,000. The entire difference—about 9¾ million persons—was added to employment in the trade and service occupations included in the energy

[22] Eighth Annual Review . . . of the North American Bulk Power Systems, August 1978, issued by National Electric Reliability Council. See specially pp. 4, 9, and 38.

sector of "Commerce." These commercial facilities are now increasingly dispersed in separated "drive-in" facilities, in suburban market centers, in separated banking and real estate offices, and in lighted, heated, and air-conditioned shopping malls. American labor force participation of the non-institutional population over age 16 will, we estimate, reach the unprecedented annual average of 63.6 percent in 1978, and it will continue to increase. These people are increasingly employed in "Commerce." This is the American wave of the present and the near future.

Also for the Transportation sector, the increased dispersal of the American pattern of living and working gives us pause in accepting very low estimates of the probable increased demand for energy in the next 15 years. The Energy Information Administration utilizes a "model" which forecasts a "Medium" growth of 1.4 percent per annum in 1975–85 and of 1.8 percent of 1985–90.[23] We doubt the probability of so low a growth. In the 1975–76 recovery, Transportation use of energy rose by 5.1 percent, in 1976–77 by a further 3.1 percent, and in the first half of 1978 by 3.2 percent more. In these two and one-half years, the gain in Transportation use of energy is already nearly two-thirds of the Energy Information Administration's "Medium" forecast for the entire decade.

It is entirely understandable that conservation efforts are highly concentrated on the transportation sector. Some 96 percent of all energy used in transportation is petroleum, and Transportation accounts for more than half (51.7 percent in 1977) of all the nation's petroleum use. However, only slightly over half of all Transportation energy is used in private passenger vehicles. The remainder is used in trucks, airplanes, ships, pipelines, railroads, etc. These are already relatively efficient fuel users. Their mileage may expand proportionately—or even more than proportionately—with GDP growth. Their fuel economizing will improve, but slowly.

The drive to conserve petroleum, and to minimize its importation, has found its strongest expression in the legal requirement of more fuel-efficient passenger cars. Also consumers have been pressed toward conserving by higher gasoline prices. From September 1973 to September 1978, the retail price of major-brand gasoline (as reported by the *Oil and Gas Journal*) has risen by about 75 percent, to 66.63¢ per gallon. The next years may well bring the price for regular up to $1.00. (Premium unleaded already sells near 80¢.) Yet even these higher prices and the beginnings of more fuel-efficient cars have not "killed" the demand for gasoline. In May–August 1978 motor gasoline demand stood 5½ percent higher than in the same four months of 1977.

Even the higher gasoline price—and especially combined with the lower gasoline-consuming car—is no sure basis for proportionate energy economizing. The U. S. is moving toward a passenger car with high fixed capital costs and relatively low incremental mileage costs. The Energy Information Administration calculates that, in 1972, the average passenger car was driven 10,180 miles per year. At an efficient 25 miles per gallon, this mileage would require just under 408 gallons per year. At a dollar a gallon, gasoline would cost $408 per year. This $408 would probably be less than 40 percent of the annual depreciation of such a car. It would almost certainly be less

[23] Energy Information Administration, Annual Report to Congress . . . 1977, published April 1978, vol. II, pp. 112–113.

than 20 percent of the total annual cost of owning the car (including depreciation, insurance, maintenance, financing, garaging, licensing, etc.) The gasoline-efficient car of the future may correspondingly be expected to have a high mileage. This factor makes for an uncertain *net* conservation change. Probably the fuel-efficient passenger car alone does not assure a 20 percent decrease in energy intensity for the entire Transportation sector even by 1990.

We again emphasize the factor of dispersal. The American population is moving from the congested Northeast to the spacious West and South, Pacific Coast, and Florida. Factories are abandoning old industrial concentrations. Mass transportation becomes an outdated fancy. (Washington D.C.'s "Metro" may be the last of its kind.) The city center has less resident population. Even the greater Metropolitan District becomes less populous; people move out to the rural counties. Long-distance travel becomes more frequent. All these things sustain the demand for Transportation—of people, of materials and components, and of finished commodities.

Industry—or rather the commodity producing group—has been the great sector for reducing energy intensity in the past five years. We expect it to continue this preeminence, though perhaps not by the same wide margin, in the next 15 years. The industry sector consists of cost-conscious, profit-maximizing firms. Whether in manufacturing, construction, mining, or agriculture, their effort to reduce costs is an ongoing daily concern. Savings—small or great—accumulate continuously as they modify, renovate, or replace their processes and equipment.

Since 1973, total energy consumption by Industry—alone of all major sectors—has not risen but fallen. Industry's consumption was 29.169 trillion btu in 1973 and only 27.895 trillion btu in 1977. In the first six months of 1978, Industry's total usage came to 13,601 trillion btu, or 1.58 percent over the same period of 1977. If we annualize the 1978 rise, we may say that consumption in 1978 was running at an annual rate of about 28.335 trillion btu. This is still about 3 percent under 1973. Meanwhile the output of the four Industry subsectors has developed as follows.

OUTPUT OF THE VARIOUS "INDUSTRY" SUBSECTORS

	Manufacturing	Construction	Mining	Farming
1973	129.8	134.8	114.7	112
1976	129.5	109.9	114.2	117
1977	137.1	121.3	117.8	121
First half 1977	135.0	118.4	118.5	(1)
First half 1978	142.1	125.8	121.8	(1)
Percent growth, 1973 to first half 1978 [2]	+9.5	−6.7	+6.2	+8.0

[1] Not meaningful.
[2] Farming growth index 1973–77.

Sources: Manufacturing and Mining, Federal Reserve indexes, 1967=100. "Farming," USDA index "Farm Output," 1967=100. "Construction" from GDP series in constant 1972 dollars.

While we have not been in a position to weight each of these sectors currently by its value added, it seems that the 3 percent decline in energy use in 1973–78, together with the advances in output for three out of four of the subsectors (where manufacturing has at least five times the weight of construction), suggests a minimal 10 percent reduction in the energy consumed per unit of Industry output. It should be further noted that in the single year 1977–78, while energy consumption in the entire Industry sector rose by only 1.58 percent, output in manufacturing rose by 5.26 percent, in construction by 6.25 percent, and in mining by 2.78 percent. Obviously the commodity-producing Industry sector is reducing its energy intensity at a rate quite unparalleled in the other major sectors of the national economy.

As one example of how this lower energy intensity is achieved, though undoubtedly an unusually brilliant one, we call attention to the accomplishment of the Continental Oil Company.[24] The firm has described, in considerable detail, its energy saving changes made from 1972–73 to 1977. These savings amounted, for the year 1977, to 21 trillion btu, or 3½ million barrels of fuel oil, with annual value of almost $32 million. In several major instances, the expenditure for conservation is specified to have been recovered in a single year. In refining, the energy saved by 1977 was 19.6 percent. And, most encouraging, such savings are conceived as a continuing process. The company reports: "When the projects underway and those presently budgeted are completed, Continental expects to reduce energy use an additional 6 to 7 percent in its refineries." This is an outstanding case, but it is also part of a general process now taking place throughout Industry. If this condition were not so, the idea of reducing U.S. energy intensity by 20 percent, even in a period longer than 15 years, would be, to our minds, only an idle wish-fancy.

Lest however we suggest a consensus that does not exist, we call attention to a prognosis that sees the Industry future quite differently.[25] The Energy Information Administration of the Department of Energy communicated to the Congress, under the date of April 1978, the results of its "model" forecasts of the U.S. energy future. This shows a "Medium" annual growth of Industry consumption of 4.3 percent from 1975 to 1985 and of 3.6 percent from 1985 to 1990. If we express 1975 as 100, the year 1985 is then 152.35, and 1990 comes to 181.82. Applying this factor to the gross energy use of 26,110 trillion btu which the Department of Energy reports for Industry in 1975, yields a gross total requirement of some 47.5 quadrillion btu in 1990.

Such a huge rate of increase in energy consumption by Industry seems to us not at all "in the works." And, if we thought it were indeed in process, we would be compelled to forego anything approaching the possible reduction in national energy consumption we have suggested.

We do not assert that we are right and the Energy Information Administration wrong. We assert that "models" can apparently be poor guides, and the future is very uncertain.

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[24] Oil and Gas Journal, Sept. 25, 1978, pp. 89–95.
[25] Energy Information Administration, op. cit., vol. II, pp. 106–108.

TABLE 1.—CONSUMPTION OF ALL ENERGY AND OF MAJOR ENERGY SOURCES, 1860–1955

[In trillions of Btu]

	All energy	Coals	Oils and gases	Fuel wood	Hydropower
1860	3,160	516	3	2,641	
1880	5,001	2,054	96	2,851	
1900	9,587	6,841	481	2,015	250
1920	21,378	15,504	1,547	1,610	539
1930	23,708	13,639	3,489	1,455	785
1940	25,235	12,535	10,425	1,358	917
1945	32,700	15,972	13,981	1,261	1,486
1950	35,136	12,913	19,458	1,164	1,601
1955	40,796	11,703	26,529	1,067	1,497

Sources: "Relative Rate of Growth of Mineral Fuels and Waterpower," in Petroleum Statement Annual, U.S. Department of Interior, issued Nov. 19, 1962, pp. 25–29 and Energy in the American Economy, by Sam H. Schurr and Bruce C. Netschert, Johns Hopkins University Press, 1960, pp. 495–499.

TABLE 2.—U.S. CONSUMPTION OF ENERGY, GROSS DOMESTIC PRODUCT, AND MANUFACTURING OUTPUT, 1960–73, BEFORE THE OIL PRICE REVOLUTION

	Energy consumed (trillion Btu)	Year-to-year consumption growth (percent)	Gross domestic product (1972 dollars in billions)	Year-to-year change in GDP (percent)	Manufacturing output (1967 = 100)	Year-to-year change in manufacturing (percent)
1960	44,525		733.6		65.4	
1961	45,280	+1.70	751.2	+2.40	65.6	+3
1962	47,384	+4.65	794.3	+5.74	71.5	+9
1963	49,271	+3.98	825.8	+3.97	75.8	+6
1964	51,206	+3.93	868.7	+5.19	81.0	+7
1965	53,313	+4.12	919.9	+5.89	89.7	+11
1966	56,381	+5.76	975.6	+6.06	97.9	+9
1967	58,234	+3.29	1,001.9	+2.70	100.0	+2
1968	61,722	+5.99	1,045.7	+4.37	106.4	+6
1969	64,947	+5.23	1,073.1	+2.62	111.0	+4
1970	67,121	+3.35	1,069.8	−0.31	106.4	−4
1971	68,326	+1.80	1,100.3	+2.85	108.2	+2
1972	71,610	+4.81	1,164.1	+5.80	118.9	+10
1973	74,586	+4.16	1,227.4	+5.44	129.8	+9
Total growth 1960–73	30,061	+67.52	493.8	+67.31	64.4	+98.5
Compounded yearly growth 1960–73		+4.0		+4.0		+5.4

Sources: For energy consumption through 1971, Annual Report to Congress 1977, by Energy Information Administration, published May 1978, vol. III, p. 5. For energy consumption from 1972, Monthly Energy Review, U.S. Department of Energy, October 1978, p. 4. These series omit firewood. For GDP and Manufacturing Output, Economic Report of the President, January 1978, pps. 269 and 302. "Manufacturing Output" is preferred to "Industrial Production" because the latter's 2 additional components of "mining" and "utilities" are substantially duplicative of a large part of energy.

TABLE 3.—U.S. CONSUMPTION OF ENERGY, GROSS DOMESTIC PRODUCT, AND MANUFACTURING OUTPUT SINCE THE OIL PRICE REVOLUTION

	Energy consumed (trillion Btu)	Year-to-year consumption growth (percent)	Gross domestic product (1972 dollars in billions)	Year-to-year change in GDP (percent)	Manufacturing output (1967 = 100)	Year-to-year change in manufacturing (percent)
1973	74,586		1,227.4		129.8	
1974	72,725	−2.50	1,211.0	−1.34	129.4	−0.3
1975	70,646	−2.86	1,197.5	−1.12	116.3	−10.1
1976	74,409	+5.33	1,264.3	+5.58	129.5	+11.3
1977	75,953	+2.08	1,325.3	+4.83	137.1	+5.9
Total growth 1973–77	1,367	+1.83	97.9	+7.3	7.3	+5.6
1st 6 mo 1977	38,154		1,308.6		135.2	
1st 6 mo 1978	39,458	+3.42	1,360.3	+3.95	142.1	+5.1

Sources: Survey of Current Business, July 1978, p. 15 and September 1978, p. 9. Federal Reserve Bulletin, October 1978 and August 1977, p. A46. Monthly Energy Review, October 1978, p. 4.

TABLE 4.—GROWTH OF POPULATION, LABOR FORCE, AND GROSS DOMESTIC PRODUCT, 1960–73 AND 1973–77 AND IN FURTHER TIME AT SAME RATES

	Population (thousands)	Labor force (thousands)	Gross domestic product (1972 dollars in billions)
1960 numbers	180,671	72,292	$733.6
1973 numbers	210,410	91,040	1,227.4
1977 numbers	216,817	99,534	1,325.3
1960–73 cumulative growth (percent)	16.46	25.93	67.31
1973–77 cumulative growth (percent)	3.05	9.33	7.98
1960–73 growth percent per year	1.2	1.8	4.0
1973–77 growth percent per year	0.75	2.3	1.9
Product per capita 1960			$4,060
Product per capita 1973			5,833
Product per capita 1977			6,113
Product per member labor force 1960			10,148
Product per member labor force 1973			13,482
Product per member labor force 1977			13,315
Approximate doubling period at 1960–73 rates:			
Per capita of population (years)			25
Per member of labor force (years)			32
Approximate doubling period at 1973–77 rates:			
Per capita of population (years)			60
Per member of labor force			(1)

1 Never, declining.

Sources: Economic Report of the President, as cited above, corrected for 1977 GDP reestimate by Survey of Current Business, July 1978, p. 15.

TABLE 5.—COMPARATIVE RISE IN PRICES OF GDP AND OF ENERGY SOURCES, 1960–73

[1972=100]

	1960	1963	1966	1969	1972	1973
Indexes for GDP and some major components' prices:						
GDP	68.6	71.6	76.8	86.8	100	105.8
Gross business	72.3	74.6	79.2	88.5	100	105.6
Personal consumption	71.7	74.7	79.3	88.5	100	105.5
Indexes for energy prices:						
Wholesale:						
Fuel and related products and power	81.0	81.2	82.5	85.1	100	113.2
Coal	49.3	48.4	49.2	58.1	100	112.5
Electricity	83.3	83.4	82.0	83.7	100	106.4
Gas	76.4	80.5	84.8	81.8	100	111.0
Petroleum products	87.7	87.3	89.4	91.5	100	118.2
Retail:						
Gasoline and oil	84.5	84.5	89.5	97.0	100	109.4
Fuel oil and coal	76.2	81.0	83.0	90.3	100	114.8
Electricity and gas	82.3	82.8	82.8	85.6	100	104.9

Sources: For GDP and components, the deflators in the Survey of Current Business, January 1976, pt. II, pp. 92–93 and 100–103. For wholesale and retail prices, the indexes prepared by the Bureau of Labor Statistics and published in successive issues of the Handbook of Labor Statistics.

TABLE 6.—COMPARATIVE RISE IN PRICES OF GDP AND OF ENERGY SOURCES, 1972–78

(1972=100 in all cases)

	1973	1974	1975	1976	1977	1978 2d quarter
Indexes for GDP and some major components' prices:						
GDP	105.7	115.6	126.8	133.3	141.1	150.4
Gross business	105.5	115.8	127.2	133.3	140.8	150.1
Personal consumption	105.5	116.9	126.5	133.1	140.7	149.3
Indexes for energy supplies prices:						
Wholesale:						
Fuel and related products and power	113.2	175.6	206.7	224.0	254.8	269.8
Coal	112.5	171.5	199.1	190.3	200.9	222.5
Gas	111.0	142.2	189.9	251.4	339.9	375.6
Petroleum products	118.2	205.1	236.5	254.0	283.1	288.9
Electric power	106.4	134.2	159.2	170.9	191.7	208.5
Retail:						
Gasoline and oil	109.1	147.8	157.6	164.9	174.4	178.4
Fuel oil and coal	114.8	182.3	197.5	211.7	239.4	252.1
Electricity and gas	104.7	122.1	140.6	154.2	169.5	184.2
Domestically produced mineral fuels, near point of production:						
Composite	113.7	207.4	234.0	259.2	295.9	
Crude oil	114.7	199.0	223.1	240.2	251.0	
Natural gas	116.7	163.9	242.2	314.4	424.4	
Bituminous coal	111.3	205.6	256.4	263.6	288.7	

Sources: For GDP and the wholesale and retail energy prices, Survey of Current Business, September 1978, p. 6 and p. S9 and corresponding tables in earlier issues. For the prices of domestically produced mineral fuels, our indexes derived from the Energy Information Administration's Annual Report to Congress: 1977, issued May 1978, p. 19.

TABLE 7.—ENERGY CONSUMED PER BILLION DOLLARS OF CONSTANT PRICED GDP, 1955–78

	Energy consumed (Btu, trillions)	GDP (billions, in constant 1972 prices)	Energy consumed per $1,000 GDP (Btu, millions)
1955	39,666	$652.2	60.8
1956	41,662	666.1	62.5
1957	41,675	678.0	61.5
1958	41,650	676.5	61.6
1959	43,100	717.3	60.1
1960	44,525	733.6	60.7
1961	45,280	751.2	60.3
1962	47,384	794.3	59.7
1963	49,271	825.8	59.7
1964	51,206	868.7	58.9
1965	53,313	919.9	58.0
1966	56,381	975.6	57.8
1967	58,234	1,001.9	58.1
1968	61,722	1,045.7	59.0
1969	64,947	1,073.1	60.5
1970	67,121	1,069.8	62.7
1971	68,326	1,100.3	62.1
1972	71,610	1,164.1	61.5
1973	74,588	1,225.7	60.9
1974	72,728	1,211.0	60.1
1975	70,648	1,197.5	59.0
1976	74,409	1,264.3	58.9
1977	75,953	1,325.3	57.3
1978 (estimate)	78,500	1,375.0	57.0

Sources: For energy, Annual Report to Congress: 1977, by Energy Information Administration, issued May 1978, vol. III, p. 5, through 1971. Later years from Monthly Energy Review, issued by Energy Information Administration, October 1978, p. 4. Estimate for 1978 is a rough projection by author based on 6 months information. For GDP, Survey of Current Business, January 1976, pt. II, pp. 6–7 for years through 1972 and issue of July 1977, p. 20, and September 1978, p. 9, for later years.

REAL ENERGY PRICES AND FUTURE ECONOMIC GROWTH

By Michael J. Deutch*

CONTENTS

SUMMARY

1. *Previous inquiries.*—Various authors estimate the macroeconomic impacts of the sixfold rise in energy prices (1972–76) to have caused: A reduction of 3.2 percent in real GNP; a drop of 8.8 percent in consumption of energy, resulting in a fall of 4 percent in the ratio of energy consumed per constant GNP dollar, and a reduction of $103 billion in the level of capital stock, as gross investment dropped to $165 billion in 1976. The employment decline, due to energy prices, was estimated at 500,000 only.

The continued escalation of energy prices in 1977–79 accelerated inflation, slowing down further capital spending in real terms and labor productivity. Our competitiveness in world markets, our balance of payments, and our ability to fund a number of urgent national priorities are now in doubt.

2. *Pitfalls in energy forecasting.*—The assumptions, levels of aggregation and the choice of issues usually reflect each forecaster's particular concern in the interface of energy and economic growth. The disparity of assumptions made on price/demand elasticity; on the feasibility of shifting users from one scarce fuel to another; and on the true cost (in capital and time) to develop sources of new or synthetic fuels is so wide as to be supportive of quite divergent policies.

The economic models of 1976/77 have been invalidated by events and outlook. An inquiry into the energy interface of economic change must now attempt a crisper definition of the factors bearing on the changing outlook for the economy from 1979 through 1985.

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3. *International disparity.*—Our per capita energy demand cannot be reduced to the levels of other Organization for Economic Corporation and Development (OECD) nations, solely through conservation, because:

Each country has sui generis climatic, transportation and occupational patterns, as well as resources and fiscal policies which bear on energy needs and usage, and differences in "standard of living." The assumption that the Nation can do with much less energy until new technology makes it independent of OPEC, discounts the risk that excessively restrictive conservation measures will cause severe economic disruption and personal hardship, and might defer the search for valid, long-term solutions.

Higher energy prices and taxes only partly explain lower per capita energy consumption in other industrialized countries: Conservation practices; the necessity to earn foreign exchange to pay for oil imports; and geography, the density of transportation and market radius, may provide additional constraint to energy use abroad.

4. *Energy prices* are likely to increase much more rapidly than the rate of inflation over the next five years: The confusion and turmoil in Iran, or other unforeseen events in the Persian Gulf or along trade routes to U.S. ports, may also increase uncertainty in supply, causing a scramble among OECD members for more crude. If and when synthetic fuels and alternate sources of energy become available, their real prices may be 2 or 3 times higher than those prevailing in July 1978.

Our ability to adjust to such costly energy inputs needs further study. In short, new threats of a worldwide economic slowdown (with international trade and monetary affairs in disarray) and a cloudy geopolitical outlook point to ever higher energy prices and uncertainty of supply.

5. *The long range outlook for our economy is bleak.*—In the wake of higher energy prices and renewed efforts to deflate the economy, the boom of 1972 and 1973 gave way to the recession of 1974 and 1975 (the most severe downturn of the postwar period, which resulted in a 13.2-percent drop of investment in real terms). The recovery of 1976/78 is now ended. Some of its salient features ran counter to prior cyclical experiences: The recovery of capital spending was very weak. The growth of productivity (defined as output per hour worked for the nonfarm business sector) has lagged behind its rate of growth in the previous recovery:

The rate of return for the economy as a whole, corrected for inflation, has been drifting steadily downward relative to levels in the past, thus reducing investment in needed energy facilities.

There is, as always, uncertainty over the depth and duration of the present recession, and no certainty that energy prices will not be raised to a level that may abort economic recovery in 1980/81.

6. *Energy and economy in 1979–80.*—Business confidence is declining, even as consumer spending or borrowing and the cost of living are rising. Institutional investors are deterred from financing long leadtime projects because of uncertainty over regulatory policies, the declining dollar, increasing costs of financing and construction, and the

apprehension that uncertainties of supply may spread to critical material. So much uncertainty implies that housing and other programs to "save the cities" will be limited; even defense spending is constrained, despite the cloudy international outlook. The equivalent of an Apollo Project to develop exotic energy sources, or improved health care or Basic Sciences then may seem less likely.

7. We fear that the most significant U.S. economic reversals since the Great Depression will be seen by future students of Government to have been the slowdown in economic growth and the era of stagflation brought about, originally, by the establishment of the OPEC cartel. Few analysts will dispute the fact that our energy predicament has been compounded by structural difficulties in industry and government that retard perception of the causes, and formulation of policies to counteract unfavorable effects of economic change.

INTRODUCTION

The purpose of this paper is to analyze and assess the macroeconomic impacts on the U.S. economy of relative increases in real energy prices since the start of the oil embargo in late 1973, and to identify the nature and the magnitude of these impacts on:

(1) The GNP.
(2) Economic growth.
(3) Price levels.
(4) Unemployment.
(5) Productivity.
(6) The changes in energy usage, inputs and requirements brought about by the increases in prices.
(7) Lasting changes in: capital flows; and prospects for economic growth.
(8) Possibility of economic dislocation due to episodic interruption in energy supply from abroad.

Previous Studies

A number of econometricians examined the impact of higher energy prices on the U.S. economy from 1972 [1]–76 concluding that:

Real GNP in 1976 was reduced by 3.2 percent by the increase in energy prices.

Total energy consumption in 1976 was reduced by 8.8 percent by the increase in energy prices, resulting in a sizable fall in the energy-GNP ratio.

The level of capital stock in 1976 was reduced by $103.0 billion, in constant dollars of 1972, by the increase in energy prices. This can be compared with 1976 gross investment of $165 billion in constant dollars.

Despite the reduction in GNP growth, *employment* in 1976 declined *by only 500,000* jobs as a result of higher energy prices. As a consequence, productivity declined substantially over the period 1972–76.

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[1] The year 1972 is the last year of the "old" regime of energy prices. It provides the starting point for our paper, as well as a convenient benchmark for "real" or constant dollar prices.

In our view, the dramatic impact of higher energy prices on the U.S. economy over the period 1972–76 was far greater than the figures above: It brought about a slowdown in economic growth, a further decline in capital formation and spending, a substantial increase in employment, and a decline in growth, productivity, and export competitiveness (all of which came to cut us deeper with the further increases of energy prices in 1978–79).

Discussion of Elasticity

An understanding of the ways energy prices have affected the U.S. economy requires a comprehensive analysis of changes in the composition of total spending; of the impact of a reduction of energy and energy-intensive inputs into the productive sectors of the economy; and, finally, of the *cumulative* impacts and interactions of these changes on investment, industrial capability, and on employment and labor productivity. The projections from 1978 through 1985 were based on elasticity factors (for demand and substitution) which were empirical and tentative. These have now been invalidated by intervening events and perceptions.

Future inquiries into the energy interface of economic change must be less empirical, and based on a crisper definition of the factors that change the outlook for energy and the economy from 1979 through 1985. A macroeconomic study that does not attempt to disaggregate various segments of the energy program and the main sectors of the economy is obviously less meaningful than an inquiry into specific fuel supply economics.

Energy policy formulation requires the careful analysis of many interacting factors that determine the demand and supply of energy, and its mix, as well as objective scrutiny of the feasibility and cost of various supply strategies. The institutional rigidities, the regulatory uncertainty, the sectoral and regional problems and, last but not least, the degree of adaptability of industry to unforeseen and sudden change are critical to policy trade-offs that go beyond macroeconomic modeling.

The present view of demand and substitution elasticity among distinguished macroeconomists can be summarized as follows:

> Energy availability is not particularly important in determining the *rate* of economic growth, *but energy prices are* important in determining energy *demand.*
>
> In the short run energy prices and economic growth play an important part in determining energy demand, *but the speed of demand adjustment* to the new energy prices may be slow. The combined effects of price adjustments and lower economic growth may eventually bring energy demand below previously expected levels.
>
> If all energy prices do not move together, the demand for individual fuels may show variations and sensitivity to changes which have little impact on total energy demand. Eventually, when prices stabilize and the price adjustments have been completed, the growth rate in the demand for energy *will be determined by the growth rate of the economy.*

1. The Effects of Energy Prices on GNP

The effects of energy prices on the Gross National Product depend on the level and cost of oil imports and the growth of energy supply from both domestic and import sources. As the costs of imports of crude and refined products inflate the trade deficit and the domestic price level, the growth of GNP in real terms is reduced. The extent of the slowdown in economic growth depends on the level of energy demand in the economy, and the degree to which higher prices reduce productivity and export competitiveness on the world markets. It is here that the coefficients of elasticity used in the Nation's energy and GNP forecasts come into play:

The performance of the U.S. and world economy is a stronger determinant of future energy demand than energy prices.—While the long-term relationship between economic growth and energy consumption is not clear, there is definitely a link between the two phenomena. (An Exxon study suggested in 1978 that a 0.5-percent change in free world GNP growth rates—upward or downward—could increase or reduce energy demand by 13 million barrels per day oil equivalent between 1978 and 1990. Studies by others imply that a slowdown of 1 percent in the GNP of the United States may reduce energy demand by 0.8 or 7.6 percent.)[2]

Demand elasticities, *or the changes over time of the volume of energy needed to produce an additional unit of GNP.*—Variations in the energy/GNP ratio have been significant in the United States during the past quarter of a century, but the long term trend (1920–78) has been one of less energy consumed per additional unit of GNP. This happened under declining real prices for energy, and it would not be unreasonable to assume that this trend will continue in the future. We should recognize that expectations of energy conservation differ widely from country to country, and that the energy/GNP relationship is subject to further adjustment especially if and when energy prices in real terms increase sharply again.

The Price Elasticity multiplier, or the degree of demand elasticity under a scenario of rising prices is a coefficient in hot dispute: The difference, however, between a free world *energy multiplier* (energy growth rates divided by economic growth rates) of 0.9 or 1.0, for example, an additional free world demand of almost 13 million barrels per day (bbl/d) of oil equivalent between 1976 and 1990.

Since macroeconomic projections based on aggregated energy models are often quite subjective and do not take into account the properties (convenience of environmental disincentives inherent to various forms of energy) appendix I includes tables 1–4 correlating annual variations of various energy uses with GNP in constant dollars.

Our view that various forms of energy (i.e. oil, refined products, coal and others) each have a distinct bearing on our energy predicament, and also market price and economic fluctuations of their own, is illustrated in appendix II (a set of charts "Energy Facts 1978").

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[2] Most recent forecasts by IMF, BIR, OECD and others released for publication in September 1979 predict a much deeper downslide in the world economy. It would be erroneous to find consolation in the thesis that perhaps a protracted and deep recession will sharply reduce oil demand.

Appendix III summarizes our current data base on the historical behavior of supply and demand for oil, gas, coal and refined products in U.S. markets, at various stages of OPEC pricing, as well as the most important energy time series that impact on economic trends of concern to the Joint Economic Committee (JEC). The vast array of data illustrates the diversity and complexity of energy flows into the economy, should the Committee wish to address the pervasive effects of price escalation and possible disruption.

2. The Impact of Energy Prices on Economic Growth

In the Short Run, 1979–84

(*a*) In 1979 OPEC served notice that the price of Arabian Light crude oil would be raised from $12.70 per barrel to $14.54 per barrel by October 1, 1979, causing U.S. consumers to pay an average of $14.00 per barrel in 1979, versus $12.70 in 1978, or an average price increase of 10 percent. OPEC also coupled this announcement with a built-in 5 percent price "interim" increase for 1980, *before consideration of any ultimate price increase* in 1980. That OPEC decision followed much talk and expert forecasting of "oil glut and OPEC price freeze"; it was, in fact, announced just as supplies became much tighter than they have been over the past few years. But it is now past history, since prices have been increased again, and by the publication of this paper, may stand, de facto, at $27–32 per barrel, FOB Persian Gulf.

(*b*) Our hopes of lasting improvement in the economy are now superceded by the stark reality of further inflationary pressures, and possibly a period of persistent economic stagnation and unemployment.

U.S. refining and marketing profits (which generally account for 10–25 percent of a large integrated oil company's earnings), could be squeezed further, leaving even less incentive for industry to invest in additional U.S. refinery capacity—a capacity which is now insufficient to process our demand for crude. (We are now importing not only crude oil, but also refined products, and will continue to do so, at high cost.)

The profitability on Alaskan North Slope and of U.S. stripper oil, which accounts for 30 percent of U.S. crude oil production, should improve; but, the transportation of this oil to the lower 49 states will still take time and add still higher capital costs.

The value of North Sea crudes and other non-OPEC crude oils (i.e., Egypt, Indonesia, Australia, etc.), should increase to follow OPEC prices even though there will be some psychological relief from European Common Market (ECM) apprehension over U.S. importation of an increasing percentage of available world crude.

OPEC plans to increase the price of lighter crude oils (similar to North Sea crudes) by an amount that exceeds the average price increase and plans to increase the price of heavier crudes (similar to North Slope crude) by an amount that is less than the average increase. This reflects OPEC's intent to market more of its heavier crudes.

(*c*) While the leading economic indicators advanced through October 1978, our own analysis, in the first draft of this paper (Nov. 1978), assumed the onset of serious economic weakness to occur by mid-1979. We fear, as in the past, sharp increases in prices for OPEC oil, and for natural gas (non-OPEC and OPEC)—occurring at the same time that declining dollar exchange rates abroad and rising costs of living at home bring about cyclical strains in consumer liquidity and a contraction in spending prompted by: (*i*) the decline in *real* take-home pay; (*ii*) the diminishing access to credit as rates of interest go higher; and (*iii*) increased concern over further increase in unemployment which now appears warranted by reduced outlays for plant, equipment, housing, and transportation).

Consumer retrenchment (as rates of interest keep rising to unprecedented levels) is likely to accelerate recessionary trends. Should the defense and attempts to stabilize the dollar be pursued up to the point where it becomes imperative to increase outlays for national security (for emergencies of high priority programs) our economy may face a protracted period of stagflation, rather than vigorous recovery from a third recession in one decade.

In the Long Term, 1985–2000

As we reach the era of high technology (it is hoped, still as the preeminent scientific power in the world) we look to new synthetic fuels or renewable energy sources to reduce our dependence on increasingly costly energy from abroad—improving also our currency. Still, a number of technical and economic assessments of new energy sources (e.g., solar, oil from shale, synthetic fuels from coal and others) fear limited opportunity for their commercialization except at prices considerably higher than current prices for OPEC oil (in constant dollars). Successive stages of the National Energy Plan may require much more time, and real prices two or three times the current levels if and when they are implemented by industry.[3] However overdue and imperative our applied research on, and commercialization of, new energy sources may be, there is room for further study of the effect on our economy of oil prices that may go as high, in the near future, as $35–40 (in 1975 dollars).

Will this abort or prevent economic recovery from the recession now under way? The general economic reasoning goes as follows:

> At any given level of output, higher energy prices drive down the demand for energy. While in the short run impact of changes in energy prices is rather modest, in the long run elasticity of demand for primary energy sources—crude petroleum, natural gas, and coal—is in the order of magnitude of 0.3 to 0.4 so that a ten percent increase in the price of energy causes a decrease in energy demand of only three or four percent.
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> Different authors and different interests assume widely ranging coefficients of elasticity, thus leading to a wide disparity of supply/demand projections. The Congressional Reference Service has

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[3] See attached estimate by DOD's shale oil task force of probable cost of alternative fuel options for DOD's mobility requirements after 1980. Most of these are twice the price projected for imported crude oil, app. IV.

done signal work in illustrating the wide margin of error that might result from erroneous choice of elasticity ratios in E/GNP).[4]

Similarly, at any given level of output higher energy prices influence the demand for capital, labor and nonenergy intermediate goods (i.e., "materials, semifinished manufactured goods, and services"). Recent empirical research has shown that an increase in energy prices has a positive impact on the demand for labor, so that energy and labor are "substitutes." Since higher energy prices also have a positive impact on the demand for materials, energy and materials are also said to be substitutes.

However, higher energy prices have a negative impact on the demand for capital, so that energy and capital are considered to "complement" each other.

Thus, the impact of higher energy prices is to drive down the demand for energy and capital and to drive up the demand for labor and materials at any given level of output.

In practical terms of economic growth and employment, macroeconomic discussion on the various coefficients of elasticity or substitution pertains to the following issues of our National Energy Policy:

In 7 years after the first warning[5] of a "growing energy gap that might presave an energy crisis," (and 5 years after the embargo) our efforts to increase substantially energy supplies from non-OPEC sources, or to stockpile fuel at points of use have been disappointing, giving an even greater urgency to conservation and substitution. In these areas too we have not, as yet, made a great dent on our oil imports.

If deep cuts of energy consumption could have been achieved without serious economic consequences, and if capital and trained labor needed to achieve our conservation goals had been made available in 1974–75, the objectives of our National Energy Policy might have been achievable.

The events in Iran, along with the ever present danger of other geopolitical upheavals in the Persian Gulf—including transit "choke points"—imply that the most optimistic set of assumptions on Energy/GNP correlations would not reduce our oil imports (and their effects on the economy) below the threshold of alarm.

Inflationary pressures, dislocation of essential supplies and episodical interruptions affect different industries and services in different ways. Comprehensive analytical studies of the principal sectors of our economy by Bureau of Labor Statistics (BLS) show that the 16 most energy intensive industries of 1972 still have a quite similar individual ranking in 1978, and are not expected to vary much in 1980. Unfortunately, many of these industries also rank high in terms of employment per $1 billion of GNP, and in export earnings. Until we

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[4] Cf. U.S. Congress Committee Print 95–43, Subcommittee on Energy and Power, "U.S. Energy Demand and Supply, 1976–1985," p. 19, fig. 1: A reduction of 27.3 percent in energy consumption would reduce the GNP by 4.5 percent if the elasticity of demand substitution is 0.1 (but only by 0.3 percent if the elasticity is 0.7).

[5] Cf. presentations by J. Akins, M. Deutch and Gen. Lincoln to NSC and EOP in 1971, 1972 and 1973, and the original work of Senator H. Jackson on the Government Oversight Committee.

reach the point, in the mid-1980's, when the new era of high technology will boost our GNP and our balance of payments, our employment and exports remain heavily dependent on aluminum, automobiles, metals and minerals, containers, polymer chemicals, plastics, paper, etc. Denial or cutback of energy supplies to these industries in 1980–82 would cause severe damage to our economy.

3. Price Levels and Employment

Although the OPEC embargo did not, by itself, cause the last recession, it triggered a chain reaction magnifying the impact of the worldwide energy gap on the economic and structural deficiencies in our econmy, at a time when the world monetary and trade systems showed signs of disarray.

> One direct effect of higher oil prices was to raise the cost of living of essentials (i.e., gasoline, heating, food and some other items at the bottom of the United Nations International Labor Organization (ILO) "cost of living basket") thus causing: A reduction of savings and capital formation; an increase in cost of living and final purchases of goods and services; and substantial reductions in energy input to manufacturing and service industries. The resulting increase in the number of households with two wage earners will increase further with higher costs of living.
>
> Higher energy prices led to a reduction in investment levels and to a slowing in the rate of growth of capital stock and productive capacity. But, labor demand increased as the economic adjustment shifted final spending toward labor-intensive services and substituted labor for energy as a production input— thereby offsetting, to a large extent, the adverse employment impacts of the reduced level of economic activity resulting from higher energy prices.

While the reduction in employment resulting from higher energy prices following the embargo was estimated to be 0.06 percent (or a loss of 500,000 jobs in 1976),[6] secondary effects also had a pervasive and retarding influence on recent economic developments: In the economic recovery of 1976–78, employment expanded much more rapidly, and unemployment declined to a greater extent, for awhile. However, investment and productivity picked up more slowly than one would have anticipated from what had happened in past cyclical upturns.

> Both of these developments are due, at least in part, to structural shifts (that came about in the process of adjustment to lower energy use) being superimposed on normal cyclical patterns of recovery from recession: The slow rate of investment in new plant and equipment is due both to inflation and much higher rates of interest. The slow advance in productivity, compared to other recoveries, may also be traced to the greater intensity of labor use per unit of output with energy savings or cutbacks.

The extent to which inflation and higher interest rates *have increased the cost of industrial construction, modernization and retrofitting* in the energy, refining, chemical and processing industries, is not fully appreciated. The construction cost of energy facilities and

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[6] We are considering here only the official estimated increase in unemployment that is due to the *primary*, macroeconomic, effect attributed to increased oil prices. The indirect, cumulative effects on employment are discussed below.

specialized equipment that require careful engineering design and experienced labor more than doubled in the last two years. Interest rates more than doubled during construction, driving capital costs to levels judged too prohibitive. Capital costs included new long lead-time energy projects and modification of existing processing plants to make them less energy intensive.[7] Instead of capital investment, makeshift labor is used for patchwork.

4. Productivity and Competitiveness

What happens on the supply side of the *labor market* as workers face greater demands for their services?

> In the short run, wages will rise and employment will increase. Higher wages and enhanced prospects for employment have accelerated the growth of the labor force. Rapid growth of the labor force has contributed to the persistence of high levels of unemployment in the face of rapidly expanding employment opportunities.

The supply of *capital* is fixed in the short run, so that reduced demand for capital depresses its rate of return without increasing its supply. In the last recovery (1975–77), rates of return deteriorated steadily relative to levels at corresponding stages of earlier recoveries.

> For any given level of output a fall in the rate of return results in a fall in the level of capital formation and a rise in consumption. In 1976/77, recovery of investment spending was disappointingly sluggish, while a boom in consumer spending led the recovery. It is now slowing down as a result of high interest rates and other factors. In short, the tendencies in the U.S. economy that have set the current recovery apart from previous historical experience are likely to continue.

Historically, gains in U.S. productivity can be attributed about equally to increases in the capital intensity of production through substitution of capital for labor and to increases in the level of technology.

> A reduction in the level of capital formation (at any level of output) will result in a slowdown in the rate of substitution of capital for labor over time. When there will be no tendency to substitute labor for capital, the rate of productivity growth unavoidably slows down.

Since the rate of economic growth is the sum of the rate of growth in productivity and the rate of growth in hours worked, the outlook for the U.S. economy over the next decade is for much reduced rates of economic growth. This reduction in real growth rates, originally attributed to the fourfold increase in world petroleum prices that followed the 1973 oil embargo and the transfer of much financial and political power to OPEC, has been accelerated and compounded by inflation and lower savings.

> In the short run, higher energy prices may result in relatively rapid growth of personal disposable income through rising wages and rapid growth in employment.

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[7] Cost of design, equipment and labor used in the construction of new energy facilities, or the retrofitting or conversion of old facilities to alternate fuels have increased much more than the cost of living or materials prices. This is not fully realized by the public, and the figures have not as yet been fully revealed in the energy debate. They should be.

The longrun outlook is for disappointing gains in real personal disposable income and for an end to the boom in consumer spending that has fueled the current recovery.

There are recent indications that other geopolitical trends also becloud the supply outlook for a number of minerals and metals critical to segments of our economy that provide steady and sizable employment in the manufacture of capital goods, in construction, in transportation and in housing. Economic change in the materials cycle affects our economy in sectors or regions that are often the same as those where our energy predicament is at its worse. Even the institutional weaknesses in the materials cycle are different—higher prices and uncertainty in supply of both energy *and* materials could compound the damage of each in a period of stagflation.

5. Changes in Energy Usage and Inputs

(*a*) There is much uncertainty about the likely levels of future energy demand, in spite of a plethora of energy demand forecasts. Several estimates of total primary energy consumption and imports are included in table 1 [8] merely to show how deeply policy views are influenced by the long term projections postulated in each forecast.

While there has been some convergence in the most recent estimates of demand, the estimates on the supply side vary greatly according to their sources, and in some cases seem to be "hinged" on advocacy of specific choices of policy or technology. Thus, important differences remain in estimates of oil and gas imports for 1985 regarding origin, quantity, costs, size of possible shortfall and economic impact.

TABLE 1.—SELECTED FORECASTS: TOTAL PRIMARY ENERGY DEMAND AND IMPORTS

[In quadrillion Btus]

Study	1985		1990		2000	
	Demand	Imports	Demand	Imports	Demand	Imports
Project Independence, 1974	102.9–109.1	6.6–24.8				
FEA National Energy Outlook, 1976	90.7–105.6	11.8–25.2	114.0–121.7	11.6–41.4		
A time to choose:						
Historical growth	116.1				186.7	
Technical fix	91.3				124.0	
Zero energy growth	88.1				100.0	
USDI, Energy Through the Year 2000:						
1972 forecast	116.6				191.9	
1975 forecast	103.5				163.4	
Shell:						
1976 forecast	96.2	24.0	110.0	22.0		
1978 forecast	90.4	22.6	101.2	22.6		
Exxon, 1977	93.0	27.0	108.0	26.0		
National Energy Plan, 1977	97.0	23.0				
CIA, 1977	98.6	26.8				
CONAES MGR, 1977:						
DESOM			112.0–114.0			
ETA			103.1–104.8			
NORDHAUS			80.5–96.2			
SRI			108.9			
CRS, 1977	91.2–98.4	19.7–38.9	104.5–113.4	20.5–45.2		
MOPPS, 1978	94.6	15.3			117.3	12.5
EIA, 1978	91.2–96.9	21.4–22.9	100.7–109.4	24.1–29.7		

[8] A more detailed list will be found in the forthcoming study of the Senate Committee on Energy and Natural Resources.

(*b*) These demand forecasts were prepared at different times and for different purposes. The variations in assumptions, levels of aggregation, and methodologies are determined by the explicit or implicit issues underlying each analysis, or on the issues to be addressed. In the specific problem before us (the impact of rising energy prices on domestic employment and growth), the results and range of recent demand sensitivity tests [9] demonstrate the substantial uncertainties in energy forecasts (except for macroeconomic aggregates)—the elasticity of energy demand is a key but *uncertain* parameter. Consideration of the potential shifts in the demand for energy forms, such as from oil to coal, indicates even greater uncertainties, particularly where conversion from one fuel to another will take place through legislation or supply constraints.

(*c*) As the Special Study reviews the most essential sectors of the economy, in a definite time frame, it may well find that the effects of increases in energy prices from 1973 to 1977 will be surpassed in the event of disruption of supply or episodic incidents due to sudden and unforeseen political or monetary change, or strains in power networks. Thus, it may be advisable to disaggregate this paper, seeking more detailed data.

(*d*) The relationship between energy consumption and economic output or purchasing power will also change in the marketplace as the relative prices of other labor materials or financial charges change (for better or for worse).

Conservation.—Energy inputs and *patterns of consumption* will change if the structure of our economy is altered, or if the Department of Energy (DOE) Conservation Program is successful.

> Conservation can indeed be encouraged without jeopardy to economic performance (perhaps more cost effectiveness) by relying on incentive rather than penalty, and interfering as little as possible with the economic harmony of the system.
>
> The first steps to conservation are "housekeeping" practices like insulation and improved maintenance. Beyond these, there is a whole spectrum of energy saving opportunities which cover a range of investment from replacement of process equipment to rearranging parts of the manufacturing process. Unfortunately, all of these require a substantial amount of investment, in capital *and* time, for outlays that are particularly sensitive to inflation.

Reliability of supply.—In addition to the economic impact of changes in energy usage, increasing attention is warranted by the seriousness of *episodic dislocations to employment and essential services* that have occurred in cases of sudden interruption or curtailment of energy supply. It is likely that they may recur more frequently not only because of uncertainty or shortfall in supply, but through insufficient reserve margins of network safety, strikes or sabotage.

> While in the past, episodic interruptions or blackouts lasted but a few days or weeks—a duration that does not cause a significant dip in the Nation's GNP or employment figures, the effect of power outages or fuel shortages on business and transportation has been quite severe in places. When such episodes are short, the

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[9] Energy Modelling Forum. Center of Policy Studies, University of Chicago, Nov. 2, 1978.

economic system adjusts and repairs the damage, particularly if some emergency reserve or stockpiling is in position at the point of use, as was hoped for in the past.[10] The Bureau of Labor Statistics' study of the effects of the 1977 coal strike illustrates this well.

However, should episodic interruptions occur more frequently, their effect on local peace and order might be quite severe. If such interruptions are not of short duration, they may cause lasting damage to essential public services, as well as production and employment. Whether the disruptions are due to domestic tensions, or to international events, they may have compounded effects on the economy.

A look at the tanker routes that carry our imported fuels does reveal a number of troubling "choke points" which may cause severe delays to essential U.S. imports even in areas where the U.S. is not involved in conflict resolution.

Spot prices and CIF cost of oil and points of use is quite sensitive to the possibility of supply interruptions, or international unrest. If an actual oil deficit appears likely in 1980, the Rotterdam value of an average barrel of product might go much higher than $40 per barrel (in 1978 dollars). Presently, the most likely scenario for the flow and price of OPEC crude oil is as follows:

> If Iranian exports go down to 2–2.5 million barrels per day and Saudi Arabia cuts back its production to 8.5 million, without other OPEC producers raising theirs from 14.8 (in 1978) to more than 17 million barrels in 1980, we may face a deficit of 1.5 million barrels per day, causing prices in 1980 to rise 15–20 percent from the present level.

The impact of these oil price movements—past and future—on our balance of payment is linear. But it is the *secondary*, or indirect economic consequences which should be of concern. These consequences causing concern would be those that compound the direct loss of production, exports and taxation attributable to escalating energy costs. Of additional concern would be the "cascade" effect of cutbacks or interruption of energy supply to most essential facets on the national and local level.

6. Capital Flows and Future Economic Growth

The sense of urgency in the development of comprehensive energy policies is now clearly justified by the resolve of OPEC to tie the prices of its oil to "constant" dollars, Special Drawing Rights, or other units of account in which an increasing proportion of the foreign reserves of oil exporting nations are now kept. Past assumptions that OPEC will not know how and where to "recycle" or reinvest its funds and will thus be moderate in its pricing policy have now been disproved.

Thus, in the short run, we are now facing a scenario of rising OPEC prices up to 1985—or until such time as spectacular discoveries of oil occur outside of OPEC, or sufficiently large production of synfuels is available. Our economy is further handicapped by the weakness of the U.S. dollar compounded by international tensions and economic distabilization due in great part to increasing capital flows to OPEC. Continuously rising energy prices also increase inflationary pressures

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[10] A recent announcement by DOE now states that refiners expect to have 240 million barrels in hand by October 31st.

to which the domestic economy does not seem able to adjust. Deflationary measures and credit controls, even if they are implemented gradually, are also likely to slow down further the financing—and the cost—of urgent energy facilities indispensable in the long run.

Sudden changes in energy prices can have severe economic impacts: most analysts agree that the large, unexpected increases in oil prices were the major forces leading to the economic recession of 1973–75, causing an annual reduction of 3–5 percent in the GNP at the time.

In the longer run, we find that the gradual erosion of productivity and higher costs will continue to reduce the export competitiveness of our industry. This is perhaps the most alarming instance of economic change resulting from higher energy price, and is likely to be felt at least until such time as the advent of the decades of high technology brings us, hopefully, into a new era of prosperity.

The repercussions of this on our economy and quality of life in the next decade have not been fully perceived:

> Prospects for substantial expansion of expenditures in our transportation, housing and educational infrastructure are growing more remote with the passage of time. Programs to "save the cities" will be severely limited.
>
> Even defense spending may be constrained, despite the reappearance of a missile gap, the destabilization in Africa and the Middle East, etc.
>
> Costly programs (for example, to develop exotic energy sources or federally financed national health care plan) are less and less likely.
>
> Business confidence will be seen to be declining, and the ability of the American labor force to continue to perform according to the work ethic will be seriously questioned.
>
> Environmental regulations, occupational safety, the declining dollar—and other explanatory factors will be invoked to excuse indecision.

Government agencies (usually preoccupied with pressing problems of the day) may not be able to cope with the interdisciplinary linkage and assessment now needed for planning under emergency conditions of resource scarcity. Verification and critique of facts and figures, models and simulation will bring the energy planner to grips with the costs and benefits and policy trade-offs now so urgently needed in the implementation of a national energy policy. Until this is done, the most significant economic reversal since the Great Depression of the 1930's will be seen to be the slowdown in economic growth brought about by the establishment of the OPEC cartel.

7. Conclusions

(*a*) A critical review of the most recent energy supply and demand projections, and of the economic and financial forecasts of the Organization for Economic Cooperation and Development (OECD), European Common Market (ECM). International Energy Agency (IEA), Bank of International Standards (BIS), and International Monetary Fund (IMF)—each based on assumptions that perceive well the interdependence in the world economy in the light of their own charter and responsibility now predict for the U.S. in 1980–85:

A growth rate of 2 percent in real terms.
A rise of CPI between 9 and 10 percent.

And for all of OECD:

A growth rate of 3½ percent in real GNP.
An increase in productivity of only 2½ percent.
Unemployment remaining at 5 percent in 1980.
A price deflator of 8 to 9 percent.
And a balance of payment (BOP) deficit or shift of resources increased by $40 billion.

(*b*) These projections are somewhat "hinged" on each international agency's view of the energy outlook for the 1980's: Generally, most of them assume that by limiting economic growth to 2½ to 2¾ percent, the industrialized nations can avoid a supply deficit that would cause "surges" to $40–$50 per barrel in real oil prices, but that an economic growth of 4–4½ percent will cause a shortfall of at least 10 million barrels per day in 1985. This the Free World is not well prepared to withstand.

(*c*) Even if economic growth is limited to 3½ percent (for OECD as a whole) a shortfall of 10 million barrels may well be the bottom line in 1985. That the U.S. economy is not prepared to withstand the consequences of such a shortfall is also beyond doubt. But this point may be out of the purview of the Special Study, and certainly of this paper.

(*d*) The U.S. economy, at the end of September 1979, is faced with an economic outlook quite different from the econometric predictions and the assumptions on elasticity of energy demand used in the preparation of "Blueprints for Independence" and subsequent National Energy Plans. We are now facing:

A Balance of Payment cost of energy in the order of magnitude of $70–$80 billion (each $5 jump in OPEC pricing adds $16 billion to our bill for imported oil and products).
A cost of living now growing at the rate of 10–11 percent.
The prospect for unemployment level of 6–8 percent.
A drop in productivity of 3.3 percent.
A further erosion of the dollar; and interest rates that are unlikely to go much below 8–9 percent (by 1985).

The policy option to deliberately limit growth and to reduce a nation's standard of living would obviously reduce drastically our requirements of imported oil. Whether this is a viable option for the United States, or whether the structural changes (and institutional rigidities in the economic system are unable to cope even with the present effects of our energy predicament) is for the reader to decide.

Appendix I. U.S. Energy Demand and Gross National Product

TABLE 1.—U.S. GROSS NATIONAL PRODUCT AND PRIMARY ENERGY DEMAND, 1960–77

	GNP (trillion 1972 dollars)	Energy use (quadrillion Btu)
1960	0.74	44.6
1961	.76	45.3
1962	.80	47.4
1963	.83	49.3
1964	.87	51.2
1965	.93	53.3
1966	.98	56.4
1967	1.01	58.3
1968	1.05	61.7
1969	1.08	65.0
1970	1.08	67.1
1971	1.11	68.3
1972	1.17	71.6
1973	1.24	74.8
1974	1.22	73.0
1975	1.20	70.9
1976	1.27	74.6
1977	1.33	76.2

TABLE 2.—U.S. ENERGY CONSUMED BY INDUSTRIAL AND TRANSPORTATION SECTORS, 1960–77

[In quadrillion Btus]

	Industrial	Transportation
1960	14.6	10.8
1961	14.6	11.0
1962	15.2	11.4
1963	15.9	12.0
1964	16.7	12.3
1965	17.2	12.7
1966	18.0	13.3
1967	18.2	14.0
1968	19.4	15.2
1969	20.1	15.8
1970	20.2	16.5
1971	19.3	17.1
1972	19.8	18.1
1973	21.3	18.7
1974	20.6	18.1
1975	18.2	18.1
1976	19.2	19.1
1977	18.8	19.7
1978	18.7	20.6

TABLE 3.—U. S. ENERGY CONSUMED IN RESIDENTIAL, COMMERCIAL, AND ELECTRICITY GENERATION SECTORS, 1960–77

[In quadrillion Btus]

	Residential and commercial	Electricity generation
1960	10.2	8.3
1961	10.4	8.5
1962	10.9	9.1
1963	11.0	9.7
1964	11.1	10.4
1965	11.8	11.1
1966	12.4	12.1
1967	13.0	12.7
1968	13.1	13.9
1969	13.6	15.3
1970	14.0	16.2
1971	14.5	17.2
1972	14.9	18.5
1973	14.9	19.7
1974	14.2	19.9
1975	14.1	20.2
1976	14.7	21.5
1977	14.8	22.6

TABLE 4.—U.S. ENERGY CONSUMED PER CAPITA AND PER GNP DOLLAR, 1960–77

	Energy use	
	Per capita (million Btu)	Per GNP dollar (thousand Btu)
1960	247.8	60.5
1961	247.5	60.0
1962	255.5	59.3
1963	261.5	59.3
1964	267.9	58.6
1965	275.5	57.6
1966	288.3	57.5
1967	295.2	57.9
1968	309.4	58.7
1969	322.7	60.3
1970	329.2	62.4
1971	331.2	61.7
1972	343.9	61.1
1973	356.4	60.6
1974	345.3	59.9
1975	332.7	59.0
1976	347.5	58.7
1977	352.3	57.2

Appendix II. Energy Facts, 1978

[1] The figures for 1979 will include a comparison of capital cost escalation for energy facilities with indexes for other classes of machinery and construction.

PHYSICAL RELATIONSHIPS

Size Designations and Abbreviations

Amount	Abbreviation	Prefix	Exponents
1 Thousand	M, K, or Th.	Kilo-	1×10^3
1 Million	MM* or Mil.	Mega-	1×10^6
1 Billion	B, G, or Bil.	Giga-	1×10^9
1 Trillion	T	Tera-	1×10^{12}
1 Quadrillion	Q, P, or Quad.	Peta-	1×10^{15}

Examples: Mcf = Thousand cubic feet = 1×10^3 cu. ft.
Tcf = Trillion cubic feet = 1×10^{12} cu. ft.
2MWe = 2 Megawatts = 2 Million watts = 2×10^6 watts.

* Some sources use M to designate millions.

Approximate Conversion Factors For Crude Oil

To Convert: From \ Into	Met. Tons	Sh. Tons	Kl.*	Bbls	Cubic Ft.	Gals.
	Multiply By:					
Metric Tons	1	1.10	1.17	7.33	41.2	308
Short Tons	0.907	1	1.06	6.65	37.3	279
Kiloliters(Kl.)*	0.858	0.946	1	6.29	35.3	264
Barrels	0.136	0.150	0.159	1	5.61	42
Cubic Feet	0.024	0.027	0.028	0.178	1	7.48
Thousand Gallons	3.25	3.58	3.79	23.8	133.7	1,000

*1 Kiloliter = 1 cubic meter

Rule of Thumb Conversion

1 Metric Ton = 7 bbls = 300 gals. = 40 cu. ft.

Approximate Conversion Factors For Fossil Fuels

To Convert:	Crude Oil		Coal	Natural Gas
From \ Into	Met. Ton	Barrel	Sh. Ton	Mcf
	Multiply By:			
Metric Ton of Oil	1	7.33	1.71	41.0
Barrel of Oil	0.136	1	0.233	5.60
Short Ton of Coal	0.585	4.29	1	24.0
MMcf of Gas	24.4	179	41.6	1,000

PHYSICAL RELATIONSHIPS

Definitions and Approximate Conversions for Barrels Per Day

	Multiply by:
Metric tons per year to B/D	0.02
B/D to metric tons per year	50

B/D = Barrels per Calendar Day (365 per year)
B/CD = Barrels per Calendar Day (365 per year)
B/SD = Barrels per Stream Day (About 330 per year)

Heat Content

	Units	Million Btu: U.S. Avg., 1978	Million Btu: Range Of Estimates Used By International Sources
Bituminous Coal:			
Production	Sh. Ton	22.9	24.0-28.0
Consumption	Sh. Ton	22.6	24.0-28.0
Anthracite	Sh. Ton	22.5	24.0-28.0
Oil: Crude	Barrel	5.8	5.4- 5.8
NGL	Barrel	3.9	4.0
Distillate	Barrel	5.8	5.4- 5.8
Resid	Barrel	6.3	5.9- 6.3
Natural Gas: Wet	Mcf	1.1	1.0- 1.1
Dry	Mcf	1.0	1.0
Liquefied	Sh. Ton	47.2	44.6-47.2

Miscellaneous Heat Value Factors

1 Btu = Heat required to raise 1 lb. of water 1^{o} F.
1 calorie = Heat required to raise 1 gram of water 1^{o} C.
1 Btu = 252 calories = 0.252 Kilocalorie (Kcal).
1 Therm = 100,000 Btu.
1 Langley = 1 calorie/sq. cm. = 3.69 Btu/sq. ft.

10,000 Btu = Approximate fossil fuel energy input required to produce 1 kilowatt hour.
3,412 Btu = Energy output of 1 kilowatt hour of electricity.
6,600 Btu = Approximate conversion loss in producing 1 kilowatt hour of electricity from fossil fuels.

1 million metric tons of oil produces an electricity output of about 4 billion kwh in a modern power station.

PRODUCTION AND RESERVES OF FUELS

	Country	Crude Oil: Proved Reserves, Jan. 1, 1979: Bil. Bbls.	% of Total	1978 Production: Bil. Bbls.	Mil. B/D	% of Total	Reserves/ Prod.-- Years Supply
*	Saudi Arabia	169	26.4%	3.03	8.3	13.8%	56
	USSR	71	11.1	4.17	11.4	19.0	17
*	Kuwait	69	10.8	0.77	2.1	3.5	90
*	Iran	59	9.2	1.90	5.2	8.6	31
*	Iraq	32	5.0	0.96	2.6	4.4	33
*	UAE	31	4.9	0.67	1.8	3.0	47
	US	28	4.3	3.18	8.7	14.4	9
*	Libya	24	3.8	0.72	2.0	3.3	34
	China	20	3.1	0.70	1.9	3.2	29
*	Nigeria	18	2.8	0.70	1.9	3.2	26
*	Venezuela	18	2.8	0.79	2.2	3.6	23
	Mexico	16	2.5	0.41	1.1	1.9	39
	UK	16	2.5	0.39	1.1	1.8	41
*	Indonesia	10	1.6	0.60	1.6	2.7	17
*	Algeria	6	1.0	0.45	1.2	2.0	14
	Canada	6	0.9	0.48	1.3	2.2	12
	Norway	6	0.9	0.13	0.4	0.6	45
	Other: Non-OPEC	33	5.2	1.66	4.5	7.5	20
*	OPEC	7	1.1	0.33	0.9	1.5	22
	:ld	641	100.0%	22.02	60.3	100.0%	29
	emo: OPEC	445	69.4	10.91	29.9	49.5	41

Country	Bituminous Coal And Lignite: Recoverable Reserves: Bil. Tons	% of Total	1978 Production: Mil. Tons	% of Total	Reserves/ Prod.-- Years Supply
US	213	32.0%	654	17.4%	326
USSR	151	22.7	774	20.6	195
China	88	13.2	634	16.9	139
W. Germany	44	6.6	221	5.9	199
E. Germany	28	4.2	279	7.4	100
Australia	27	4.1	124	3.3	218
Poland	25	3.8	257	6.9	97
Other	89	13.3	807	21.5	110
World	665	100.0%	3,751	100.0%	177

PRODUCTION AND RESERVES OF FUELS

	Natural Gas					
	Proved Reserves, Jan 1, 1979		1978 Gross Production			
Country	Tcf	% of Total	Tcf	% of Total	Amount Reinjected Or Wasted -- Tcf	Reserves/ Prod.-- Years Supply
USSR	971	40.5%	13.9	22.1%	0.7	70
* Iran	378	15.8	1.7	2.7	1.0	228
US	200	8.3	20.6	32.9	1.0	10
* Algeria	105	4.4	1.2	1.9	0.7	88
* Saudi Arabia	74	3.1	1.6	2.6	1.4	46
Canada	66	2.8	3.6	5.7	0.4	18
Mexico	61	2.5	1.0	1.7	0.1	58
Netherlands	59	2.5	3.2	5.1	-	18
* Venezuela	42	1.8	1.3	2.1	0.8	32
* Nigeria	40	1.7	0.7	1.1	0.7	58
* Kuwait	40	1.7	0.4	0.6	0.2	103
* Indonesia	38	1.6	0.6	1.0	0.2	63
* UAE	31	1.3	0.6	1.0	0.5	50
Australia	30	1.3	0.2	0.4	-	125
* Iraq	28	1.2	0.4	0.6	0.3	70
China	25	1.0	2.0	3.3	0.3	12
UK	25	1.0	1.5	2.4	0.1	17
* Libya	25	1.0	0.7	1.1	0.5	37
Other: Non-OPEC	146	6.1	7.2	11.4	1.6	20
* OPEC	15	0.6	0.2	0.4	0.2	62
World	2,399	100.0%	62.6	100.0%	10.7	38
* Memo: OPEC	816	34.0	9.4	15.0	6.5	87

	Uranium (Thousand Short Tons, U_3O_8)				
	Recoverable Reserves At $30/Lb.		1978 Production		
Country	Amount	%	Amount	%	Reserves/ Prod.-- Years Supply
US	690	32.9%	18.5	40.0%	37
S. Africa	400	19.0	10.4	22.4	39
Australia	380	18.1	0.7	1.5	567
Canada	220	10.5	8.8	19.1	25
Niger	210	10.0	2.9	6.2	73
Other	200	9.5	5.0	10.8	40
Free World	2,100	100.0%	46.2	100.0%	45

U.S. COAL DATA

Resources and Production

Type of Coal	Identified Resources	Reserve Base Total	Reserve Base Strippable	Recoverable Reserves	1978 Production (Mil. Tons)
	- - - - - - - -	(Billion Tons)	- - - - - - - -		
Bituminous:					
Eastern	257.7	105.1	14.7	52.5	354
Midwestern	273.5	104.5	23.3	52.3	127
Western	154.8	23.3	2.6	11.6	24
Subtotal	686.0	232.8	40.6	116.4	505
Subbituminous	424.1	165.5	67.9	82.7	115
Lignite	449.5	28.2	28.2	14.1	34
Total	1,559.6	426.5	136.6	213.3	654

Coal Resource Terminology

IDENTIFIED RESOURCES	Discovered deposits, currently or potentially economic, to a depth of 3,000 feet.
RESERVE BASE	The portion of the identified resources confirmed, at least in part, by physical sampling.
RECOVERABLE RESERVES	The portion of the reserve base which can be legally and economically recovered at the present time. For U.S. coal it is assumed to be equal to 50% of the reserve base.

Average Quality As Received

Type of Coal	Btu Per Lb.	Mean Sulfur Content: % by Weight	Mean Sulfur Content: Sulfur Index*	Mean Sulfur Content: Lbs. SO_2 Per Million Btu	% Ash
Bituminous	12,526	2.2%	293	3.5	9.3%
Eastern	13,252	1.6	201	2.5	9.0
Midwestern	11,909	3.1	434	5.3	10.0
Western	12,018	0.6	83	1.0	7.7
Subbituminous	9,629	0.4	69	0.9	5.3
Lignite	7,247	0.5	115	1.5	7.3

* A sulfur index = 100 corresponds to emissions of 1.2 lbs. SO_2 per million Btu -- the legal limit for plants built after August 17th, 1971. In addition to the 1.2 lbs. limit, plants built after September 17th, 1978, must remove -- e.g. scrub -- at least 70% of the contained sulfur.

U.S. OIL AND GAS RESOURCES, JAN. 1, 1975

	Reserves: Demonstrated: Proved	Reserves: Demonstrated: Indicated	Reserves: Inferred	Reserves: Total	Memo: Undiscovered Recoverable Resources	Total
Crude Oil -- Billion Barrels						
Lower 48 Onshore	21.1	4.3	14.3	39.7	44	84
Alaska Onshore	9.9	-	6.1	16.1	12	28
Total Onshore	31.0	4.3	20.4	55.8	56	112
Lower 48 Offshore	3.1	0.3	2.6	6.0	11	17
Alaska Offshore	0.2	-	0.1	0.3	15	15
Total Offshore	3.2	0.3	2.7	6.2	26	32
Total Oil	34.2	4.6	23.1	62.0	82	144
Natural Gas -- Trillion Cubic Feet						
Lower 48 Onshore	169	NA	119	289	345	634
Alaska Onshore	32	NA	15	46	32	78
Total Onshore	201	NA	134	335	377	712
Lower 48 Offshore	36	NA	67	103	63	166
Alaska Offshore	-	NA	-	-	44	44
Total Offshore	36	NA	68	103	107	210
Total Gas	237	NA	202	439	484	923
Natural Gas Liquids -- Billion Barrels						
Total NGL	6	NA	6	12	16	28

U.S. DRILLING PERFORMANCE

Years	Oil Wells: Avg. Depth (Ft)	Oil Wells: Avg. Cost/Foot ($)	Gas Wells: Avg. Depth (Ft)	Gas Wells: Avg. Cost/Foot ($)	Dry Holes: Avg. Depth (Ft)	Dry Holes: Avg. Cost/Foot ($)
1960	3,946	$13.21	5,526	$18.57	4,168	$10.56
1965	4,059	13.94	5,552	18.35	4,739	11.21
1970	4,496	19.29	6,007	26.75	5,320	15.21
1971	4,260	18.41	6,013	27.70	5,418	16.02
1972	4,501	20.77	5,679	27.78	5,493	17.28
1973	4,602	22.54	5,654	27.46	5,504	19.22
1974	3,960	27.82	5,546	34.11	5,297	26.76
1975	4,059	34.15	5,667	46.23	5,234	33.86
1976	4,044	37.35	5,432	49.78	5,152	36.94
1977	4,130	41.16	5,446	57.57	5,292	43.49
1978	4,081	NA	5,373	NA	5,203	NA

PETROLEUM CHARACTERISTICS

Product	°API*	Bbls. Per Met.Ton	Thous. Btu Per Gal.	Comments
Gases -- Light natural gas liquids, top of the barrel				
LPG	125°	11.4	95.5	Very volatile -- mainly propane -- bottled gas
Naphthas -- Very light oils -- may be used as petrochemical feedstocks				
Raw Naphtha	80	9.4	110	Primarily feedstocks
Motor Gasoline	60	8.5	125	Made chiefly by cracking heavier products
Naphtha Jet Fuel	56	8.3	127	Used primarily in military aircraft
Distillates -- Light fuel oils and kerosine -- clean oils -- low sulfur, free flowing				
Kerosine Jet Fuel	42	7.7	135	Small amount used at electric utilities
Gas Oil	36	7.5	138	Similar products -- light fuels used for residential/commercial heating, transportation and some industrial uses
Diesel Fuel	35	7.4	141	
No. 2	32	7.3	141	
No. 4	22	6.8	147	Blend of No. 2 and 6, sometimes considered a residual fuel
Residual -- Bottom of the barrel -- black or dirty oils -- sulfur concentrates in No. 6 -- may require preheating				
No. 5	20	6.7	148	Heavy blend of No. 2 and No. 6
No. 6	12	6.4	150	Bunker C; viscous sludge

Memo: In 1978, petroleum products consumed in the United States contained an average 5.526 million Btu per barrel. Because of the large proportion of resid among imports, imported products averaged 5.908 million Btu per barrel.

* API gravity is a method of expressing weight per unit volume of petroleum product. Unlike specific gravity, the higher the API gravity number, the lighter is the product. Water is heavier than petroleum and is rated at 10° API.

Note: The characteristics noted in this table are typical, but may vary depending on source, because the products are mixtures rather than compounds.

PETROLEUM REFINING

Refinery Capacity and Throughput

Country	Average 1978 Capacity Mil. B/CD	Average 1978 Capacity % of Total	1978 Throughput (Mil. B/CD)	Average Capacity Utilization (%)
W. Europe	20.7	26.7%	13.5	65.2%
US	17.2	22.1	14.8	86.0
Communist Countries	13.7	17.6	12.9	94.3
Latin America	8.5	11.0	6.0	70.3
Japan	5.4	7.0	4.3	79.8
Middle East	3.4	4.4	2.5	74.9
Other	8.7	11.3	6.8	78.2
World	77.6	100.0	60.8	78.4

Approximate Refining Yields Per Barrel of Input

Country	Gasoline	Distillates	Resid	Other
US	44%	29%	12%	15%
W. Europe	16	35	30	19
Caribbean	16	27	42	15
Japan	12	19	47	22
Middle East	11	29	38	22

1978 U.S. Petroleum Balance

		Million B/D	% of Total Products
Domestic Crude		8.7	45.7%
+ Imported Crude		6.1	31.9
= Crude Runs to Stills		14.7	77.4
+ Other Supplies, Including NGL		0.7	3.8
+ Processing Gain		0.5	2.6
= Total Refinery Output		16.0	83.9
+ Product Imports			
Resid	1.3		
Other	0.7	2.0	10.5
+ Other, Including NGL from Plants		1.1	5.7
= Total Products Available		19.0	100.0
- Product Exports		0.2	1.1
= Domestic Availability		18.8	98.9
Gasoline		7.5	39.2
Distillate		3.4	17.9
Resid		3.0	15.9
Other		4.9	25.9
Total		18.8	98.9

WORLD PRIMARY ENERGY CONSUMPTION, 1978
(Million Barrels Per Day Of Oil Equivalent)

Country	Total	Fossil Fuels Total	Oil	Coal	Gas	Hydro & Nuclear
US	38.2	35.1	17.8	7.1	10.1	3.1
W. Europe	24.9	21.9	14.4	4.0	3.6	3.0
Japan	7.3	6.7	5.3	1.1	0.3	0.6
Other	22.9	19.9	12.3	4.4	3.2	3.0
Free World	93.3	83.6	49.8	16.6	17.2	9.7
Communist World	41.0	39.6	12.0	19.8	7.7	1.5
World	134.3	123.2	61.8	36.4	24.9	11.2

1978 Energy Consumption

Per $ of GNP (Thousand Btu)		Per Capita (Million Btu)	
US	32.7	US	315.9
India	31.7	Canada	275.8
Canada	31.4	Germany	167.1
UK	26.2	Sweden	165.4
Venezuela	26.0	Netherlands	148.0
Italy	21.5	UK	144.8
Pakistan	20.3	France	121.3
Iran	19.5	Japan	106.3
Turkey	18.8	Italy	89.7
Spain	17.4	Venezuela	83.0
Germany	16.0	Spain	66.8
Netherlands	15.8	Iran	50.2
Sweden	15.7	Turkey	22.0
France	13.7	India	4.9
Japan	12.5	Pakistan	4.8

Efficiency of Fossil Fuels For Electricity Generation in the United States

	Btu Consumed Per kwh Generated	Efficiency -- Btu Generated Per Btu Consumed
Coal	10,275	33.2%
Gas	10,705	31.9
Oil	10,825	31.5

U.S. Energy Consumption By Fuel and Sector, 1978

	Total	Electric Utilities	Transportation	Industrial	Residential/ Commercial
	(Quadrillion Btu)				
Oil	38.0	3.9	20.0	6.8	7.2
Gas	19.8	3.3	0.5	8.3	7.7
Coal	14.2	10.4	-	3.6	0.3
Total Fossil	72.0	17.6	20.6	18.7	15.2
Hydro	3.2	3.2	-	-	-
Nuclear	3.0	3.0	-	-	-
Total	78.0	23.7	20.6	18.7	15.2
Electricity Distributed	-	(6.8)	-	2.7	4.1
Total	78.2	16.9	20.6	21.4	19.2

ENERGY SELF SUFFICIENCY AND TRADE

Energy Self Sufficiency, 1978

Country	Domestic Production As % Of Consumption: Total Energy	Oil
Netherlands	132%	4%
USSR	128	140
UK	84	57*
US	78	54
W. Europe	46	12
W. Germany	45	3
France	20	1
Italy	14	1
Japan	8	-

* The UK is expected to become 100% self-sufficient in oil during 1979.

International Oil Trade, 1978
(Million Barrels Per Day)

Exports From \ Imports To	Western Europe	US	Japan	Other	World
Middle East	8.7	2.3	4.0	4.7	19.7
Latin America	0.3	2.2	-	0.8	3.4
North Africa	1.8	1.3	-	0.3	3.4
West Africa	0.8	1.0	-	0.4	2.1
USSR	1.4	-	0.1	0.5	2.0
Southeast Asia	-	0.6	1.1	0.1	1.8
Other	0.1	0.8	0.1	0.4	1.4
World	13.1	8.2	5.3	7.2	33.9

AVERAGE U.S. ENERGY PRICES

Years	Coal at Minemouth ($/Ton)	Oil at Wellhead ($/Bbl)	Gas at Wellhead (¢/Mcf)	Per Million Btu: Coal (¢ Per Million Btu)	Per Million Btu: Oil (¢ Per Million Btu)	Per Million Btu: Gas (¢ Per Million Btu)
1960	$ 4.69	$ 2.88	14.0¢	18.3¢	49.7¢	12.6¢
1965	4.44	2.86	15.6	17.5	49.3	14.2
1970	6.26	3.18	17.1	25.5	54.8	15.5
1971	7.07	3.39	18.2	29.2	58.4	16.5
1972	7.66	3.39	18.6	31.9	58.4	16.9
1973	8.53	3.89	21.6	35.5	67.1	19.8
1974	15.75	6.87	30.4	66.4	118.5	27.7
1975	19.23	7.67	44.5	82.9	132.2	40.6
1976	19.43	8.18	58.0	83.9	141.2	52.8
1977	19.82	8.57	79.0	86.6	147.8	71.9
1978	22.40	9.00	91.9	97.8	155.2	83.7

Approximate Interfuel Comparisons and Netbacks

If The Price Of Resid Delivered To Chicago is:	These Prices Would Be Equivalent On a Btu Basis: Oil — Netback To Wellhead, Okla.	Low-Sulfur Coal (a): Dlv'd. To Chicago	Low-Sulfur Coal (a): Netback To Mine, Colorado	Natural Gas (b): Dlv'd. To Chicago	Natural Gas (b): Netback To Wellhead, Gulf
(Per Barrel)	(Per Barrel)	(Per Short Ton)	(Per Short Ton)	(Per Mcf)	(Per Mcf)
$ 10	$ 9.75	$ 33.33	$ 15.83	$ 1.63	$ 1.18
12	11.75	40.00	22.50	1.95	1.50
14	13.75	46.67	29.17	2.28	1.83
16	15.75	53.33	35.83	2.60	2.15
18	17.75	60.00	42.50	2.92	2.47
20	19.75	66.67	49.17	3.24	2.79
22	21.75	73.33	55.83	3.57	3.12
24	23.75	80.00	62.50	3.89	3.44

(a) Coal and natural gas prices are assumed here to equate to residual fuel oil delivered to a utility in Chicago. Actual coal prices are likely to be lower than those shown; actual natural gas prices -- in the absence of controls -- are likely to be higher than those shown.

(b) Assumes no controls and no premium for gas.

MISCELLANEOUS COST ESTIMATES

Approximate Desulfurization Costs For Coal And Resid

	Sulfur Content		Cost To Yield Fuel With a Sulfur Index = 100	
	% By Weight	Sulfur Index(a)	Per Physical Unit	Per Million Btu
Midwestern Coal	3% -5%	450-750	\$11-\$22	60¢-100¢
Appalachian Coal	2 -3	250-400	10- 22	40 - 90
Lignite	0.4-1	100-300	0- 10	0 - 75
Middle East Resid	3	425	1- 2	15 - 30
Western Coal	0.3-1	50-200	0- 7	0 - 40
Appalachian Coal	0.5-1	70-150	0- 10	0 - 40

(a) Sulfur Index of 100 indicates exact compliance with the legal limit on SO_2 emissions for plants built after August 17th, 1971, as follows:

Coal - 1.2 lbs. SO_2 per million Btu -- approximately 0.7% sulfur by weight. In addition, boilers begun after September 17th, 1978, must remove -- e.g. scrub -- at least 70% of the contained sulfur.

Resid- 0.8 lb. SO_2 per million Btu -- approximately 0.7% sulfur by weight.

Estimated U.S. Average Capital Costs, 1979

	Cost Per:		
Item	Unit of Production Per Year	Unit of Production Per Day	Million Btu Per Day
Oil Well	\$23.30-\$32.88/Bbl	\$8,500-\$12,000/Bbl	\$1,475-\$2,075
Gas Well	2.75- 4.10/Mcf	1,000- 1,500/Mcf	1,000- 1,500
Refinery	7.40/Bbl	2,700/Bbl	475
Coal Mine			
Underground-East	\$40-\$50/Ton	\$14,600-\$18,250/Ton	\$610-\$760
Strip-			
Eastern	25- 30	9,125- 10,950	380- 460
Midwestern	20- 25	7,300- 9,125	330- 410
Western (Subbit.)	7- 12	2,550- 4,375	150- 260

Approximate Development and Primary Production Costs -- Petroleum, 1979

Area	Cost Per Barrel
Persian Gulf	7¢-$1.50
N. Africa	35 - 1.75
Indonesia	50 - 1.75
Venezuela	$1.00 - 2.00
W. Africa	1.00 - 2.00
U.S.	1.75 - 3.50
North Sea	2.50 - 5.00

1979 Tanker Rates

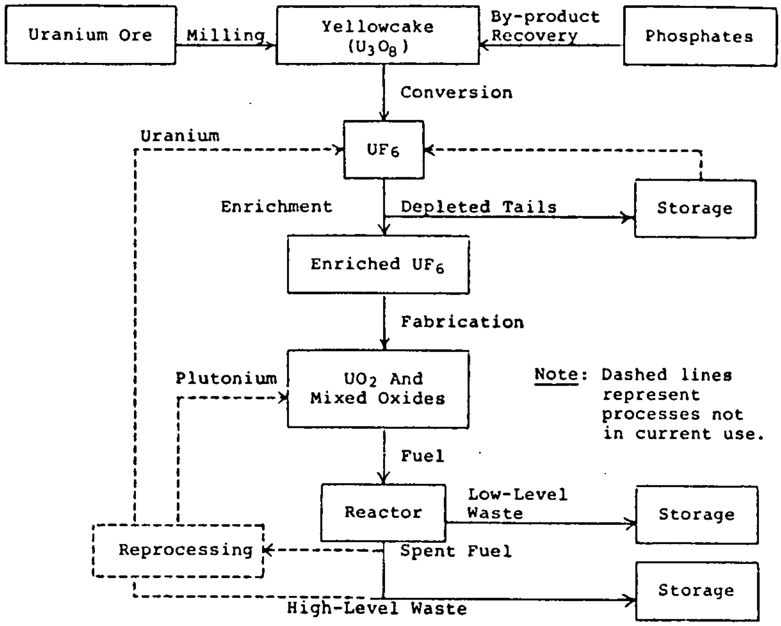
To	From	Percent of Worldscale (WS) 25%	50%	75%	100%
		- - - -($ Per Barrel) - - -			
New York	Venezuela	$0.13	$0.25	$0.38	$0.50
	Libya	0.24	0.47	0.71	0.94
	Persian Gulf	0.58	1.15	1.73	2.31
Rotterdam	Libya	$0.16	$0.33	$0.49	$0.66
	Venezuela	0.25	0.50	0.76	1.01
	Persian Gulf	0.59	1.19	1.78	2.38
Yokohama	Indonesia	$0.19	$0.38	$0.56	$0.75
	Persian Gulf	0.35	0.70	1.04	1.39

Note: 1979 rates are averaging about WS 50% for large tankers.

Approximate Current Transportation Costs

Fuel	Method	Cost Per 100 Miles Per: Physical Unit	Million Btu
Coal	Rail	80¢-$1.90/Ton	3.3¢-7.9¢
	Slurry Pipeline	$1.00/Ton	4¢
	Barge	40¢-$1.00/Ton	1.7¢-4.2¢
Oil	Barge	6¢/Bbl	1.0¢
	Pipeline	2¢- 4¢/Bbl	0.3¢-0.7¢
	Tanker	1¢ -2¢/Bbl	0.2¢-0.3¢
Gas	Pipeline	3¢/Mcf	3¢

NUCLEAR FUEL CYCLE



Conversion Factors For Uranium

To Convert: From Pounds Of: / Into Pounds Of:

From Pounds Of:	Contained Uranium: Natural	Contained Uranium: Enriched	Yellowcake Equivalent
	Multiply By:		
Uranium			
Natural (0.71% U_{235})	1	0.156	1.179
Enriched (3.2% U_{235})	6.413	1	7.562
Yellowcake (Unenriched U_3O_8)	0.848	0.132	1
UF_6			
Unenriched	0.676	0.105	0.797
Enriched	4.336	0.676	5.114
UO_2 (Enriched)	5.653	0.882	6.666

Note: Assumes 0.25% depleted tails assay

Appendix III. Pattern of Weekly Supply, Demand for Various Forms of Energy and Price Indicators for Petroleum Products and Coal

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION

Year	Persian Gulf price (per barrel): Average cost to companies of all crude oil [1]	Persian Gulf price (per barrel): Estimated selling price [2]	Tanker rates—AFRA [3]: Ras Tanura to New York [4]: Percent of worldscale	Tanker rates—AFRA [3]: Ras Tanura to New York [4]: Dollars per barrel	Tanker rates—AFRA [3]: Ras Tanura to Rotterdam [4]: Percent of worldscale	Tanker rates—AFRA [3]: Ras Tanura to Rotterdam [4]: Dollars per barrel	U.S. prices (per barrel): Average value at wellhead of domestic crude oil: Lower tier [5]	U.S. prices (per barrel): Average value at wellhead of domestic crude oil: Upper tier [5]	U.S. prices (per barrel): Average value at wellhead of domestic crude oil: Stripper crude [6]	U.S. prices (per barrel): Average value at wellhead of domestic crude oil: Average [7]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1960	$0.98	$1.53	105.5	$1.11	105.5	$0.92	(8)	(8)	(8)	$2.89
1961	.94	1.45	100.6	1.06	100.6	.89	(8)	(8)	(8)	2.80
1962	.94	1.42	96.9	1.03	96.9	.86	(8)	(8)	(8)	2.9
1963	.94	1.40	91.5	.98	91.5	.82	(8)	(8)	(8)	2.89
1964	.98	1.33	75.9	.83	75.9	.70	(8)	(8)	(8)	2.88
1965	.99	1.33	71.6	.79	71.6	.66	(8)	(8)	(8)	2.86
1966	.99	1.33	69.4	.77	69.4	.65	(8)	(8)	(8)	2.88
1967	.99	1.33	87.2	.97	87.2	.90	(8)	(8)	(8)	2.92
1968	1.00	1.30	87.8	1.00	84.3	.90	(8)	(8)	(8)	2.94
1969	1.01	1.28	71.5	.86	69.8	.74	(8)	(8)	(8)	3.09
1970	1.07	1.26	90.2	1.10	78.9	.93	(8)	(8)	(8)	3.18
1971	1.38	1.66	99.8	1.25	86.0	1.04	(8)	(8)	(8)	3.39
1972	1.54	1.84	80.3	1.09	69.3	.92	(8)	(8)	(8)	3.39
1973	2.18	2.91	116.8	1.58	104.9	1.37	(8)	(8)	(8)	3.89
1974	9.63	10.90	91.7	1.30	75.9	1.05	$5.03	$10.13	$10.13	6.87
1975	10.51	10.72	62.3	1.24	56.8	1.11	5.03	12.03	12.04	7.67
1976	11.28	11.51	56.7	1.23	50.1	1.07	5.13	11.69	12.22	8.18
1977	12.15	12.40	54.8	1.20	47.8	1.05	5.19	11.22	13.58	8.57
1978	12.45	12.70	55.3	1.29	45.2	1.06	5.46	12.15	13.95	9.00

See footnote at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	Persian Gulf price (per barrel)		Tanker rates—AFRA [3]				U.S. prices (per barrel)			
			Ras Tanura to New York [4]		Ras Tanura to Rotterdam [4]		Average value at wellhead of domestic crude oil			
	Average cost to companies of all crude oil [1]	Estimated selling price [2]	Percent of worldscale	Dollars per barrel	Percent of worldscale	Dollars per barrel	Lower tier [5]	Upper tier [5]	Stripper crude [6]	Average [7]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Months:										
July 1977	12.45	12.70	53.5	1.17	47.5	1.05	5.16	11.00	13.31	[9] 8.48
August 1977	12.45	12.70	53.4	1.17	46.8	1.03	5.18	10.93	13.95	8.62
September 1977	12.45	12.70	53.1	1.16	47.2	1.04	5.20	11.20	14.01	8.63
October 1977	12.45	12.70	52.9	1.16	47.6	1.05	5.23	11.42	14.01	8.72
November 1977	12.45	12.70	52.7	1.16	47.4	1.04	5.24	11.63	13.98	8.72
December 1977	12.45	12.70	[10] 54.0	1.18	[10] 46.8	1.03	5.25	11.76	13.98	8.77
January 1978	12.45	12.70	52.1	1.21	44.3	1.04	5.28	11.78	13.89	8.68
February 1978	12.45	12.70	52.5	1.22	45.2	1.06	5.29	11.81	13.90	8.84
March 1978	12.45	12.70	51.3	1.19	44.5	1.04	5.34	11.87	13.97	8.80
April 1978	12.45	12.70	51.3	1.19	44.5	1.04	5.35	11.94	13.95	8.82
May 1978	12.45	12.70	51.1	1.19	44.6	1.04	5.38	11.98	13.93	8.81
June 1978	12.45	12.70	53.0	1.23	44.3	1.04	5.46	12.08	13.95	9.05
July 1978	12.45	12.70	52.3	1.22	44.4	1.04	5.46	12.16	13.95	8.97
August 1978	12.45	12.70	52.0	1.21	44.4	1.04	5.50	12.22	13.93	9.05
September 1978	12.45	12.70	55.1	1.28	45.1	1.06	5.55	12.35	13.96	9.15
October 1978	12.45	12.70	56.2	1.31	45.8	1.07	5.60	12.42	13.97	9.17
November 1978	12.45	12.70	64.2	1.49	47.0	1.10	5.65	12.53	13.94	9.20
December 1978	12.45	12.70	[10] 72.0	1.68	[10] 48.1	1.13	5.68	12.59	14.08	9.47

January 1979	[11] 13.07	[11] 13.34	69.2	1.60	47.3	1.13	5.75	12.66	14.55	9.46
February 1979	[11] 13.07	[11] 13.34	66.5	1.54	46.8	1.11	5.76	12.78	14.88	9.69
March 1979	[11] 13.07	[11] 13.34	70.9	1.64	47.2	1.12	5.82	12.84	14.88	9.83
April 1979	14.25	14.55	76.6	1.77	49.1	1.17	5.85	12.94	16.71	10.33
May 1979	14.25	14.55	75.2	1.74	50.3	1.20	5.91	13.02	17.53	10.71
June 1979	17.70	18.00	76.1	1.76	52.0	1.24	6.07	13.14	20.24	11.74
July 1979	17.70	18.00	83.8	1.94	54.1	1.29	5.94	13.24	23.25	12.73
August 1979	17.70	18.00					5.98	13.33	24.00	13.09
Week ended:										
Aug. 3	17.70	18.00	([12])	([12])	([12])	([12])	5.96	13.28	23.57	12.88
Aug. 10	17.70	18.00	([12])	([12])	([12])	([12])	5.98	13.33	24.00	13.09
Aug. 17	17.70	18.00	([12])	([12])	([12])	([12])	5.98	13.33	24.00	13.09
Aug. 24	17.70	18.00	([12])	([12])	([12])	([12])	5.98	13.33	24.00	13.09
Aug. 31	17.70	18.00	([12])	([12])	([12])	([12])	5.98	13.33	24.00	13.09
Sept. 7	17.70	18.00	([12])	([12])	([12])	([12])	6.02	13.33	24.00	13.21
Sept. 14	17.70	18.00	([12])	([12])	([12])	([12])	6.02	13.43	24.00	13.21
Same week year ago	12.45	12.70	([12])	([12])	([12])	([12])	5.55	12.35	13.96	9.15
Percent increase (December) from year ago	[13] 42.2	[13] 41.7	[14] 31.5	[15] 59.0	[14] 9.7	[15] 24	[13] 8.7	[13] 8.7	[13] 71.9	[13] 44.4
Year to date:										
1978	$12.45	12.70	[16] 51.9	$1.21	[16] 44.5	$1.04	$5.39	$12.00	$13.94	$8.89
1979	15.26	15.55	[16] 74.1	1.71	[16] 49.6	1.18	5.89	13.02	18.61	11.09
Percent increase (December) from year ago	22.6	22.4	[17] 22.2	41.3	[17] 5.1	13.5	9.3	8.7	33.5	24.7

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	U.S. prices (per barrel)—continued: CIF value of all imported crude oil [18]	U.S. prices (per barrel)—continued: Average value of domestic and imported crude oil [19]	U.S. prices (per barrel)—continued: Estimated refining margin	U.S. prices (per barrel)—continued: Value of average barrel of product [20]	Rotterdam price, value of average barrel of product [21]	Inflation Consumer price (1967=100) Index	No. 2 fuel oil (cents per gallon) U.S. production prices (wholesale prices): National average [22]	No. 2 fuel oil (cents per gallon) U.S. production prices (wholesale prices): New York City [23]
	(11)	(12)	(13)-(14)-(12)	(14)	(15)	(16)	(17)	(18)
1960	$2.88	$2.88	$0.96	$3.84	[24]	88.7	8.8	9.5
1961	2.89	2.89	.98	3.87	$2.45	89.6	9.1	10.4
1962	2.84	2.89	.95	3.84	2.54	90.6	9.1	9.7
1963	2.81	2.88	.91	3.79	2.49	91.7	9.2	9.7
1964	2.71	2.85	.86	3.71	2.13	92.9	8.6	9.2
1965	2.67	2.83	1.00	3.83	2.02	94.5	9.0	9.5
1966	2.67	2.85	.99	3.84	2.12	97.2	9.1	9.9
1967	2.85	2.91	1.01	3.92	2.65	100.0	9.7	10.7
1968	2.90	2.93	.91	3.84	2.53	104.2	9.8	10.9
1969	2.80	3.05	.84	3.89	2.04	109.8	10.1	10.8
1970	2.96	3.15	1.13	4.28	2.83	116.3	10.4	11.1
1971	3.17	3.35	1.24	4.59	3.13	121.3	10.8	11.8
1972	3.22	3.35	1.22	4.57	2.98	125.3	10.6	11.7
1973	4.08	3.94	1.31	5.25	8.38	133.1	12.6	13.5
1974	12.17	8.45	1.41	9.86	12.04	147.7	22.6	24.2
1975	12.47	9.79	1.56	11.35	11.69	161.2	26.1	27.2
1976	13.39	10.31	2.10	12.41	12.69	170.5	30.4	29.9
1977	14.24	11.16	2.79	13.95	13.70	181.5	34.4	36.2
1978	14.32	11.29	2.87	14.16	15.03	195.4	35.7	37.6
Months:								
July 1977	14.28	11.08	2.96	14.04	13.75	182.6	34.8	36.5
August 1977	14.26	11.23	2.82	14.05	13.63	183.3	34.8	36.6
September 1977	14.37	11.23	2.87	14.10	13.52	184.0	34.8	36.6
October 1977	14.36	11.14	2.93	14.07	13.64	184.5	34.9	36.5
November 1977	14.45	11.28	2.76	14.04	13.72	185.4	35.2	37.0
December 1977	14.49	11.22	2.69	13.91	13.94	186.1	35.3	37.0

January 1978	14.52	11.15	2.59	13.74	13.75	187.2	35.4	37.3
February 1978	14.36	11.41	2.22	13.63	13.83	188.4	35.2	37.2
March 1978	14.28	11.03	2.46	13.50	14.14	189.8	35.1	37.0
April 1978	14.34	11.16	2.51	13.67	14.38	191.5	35.2	37.0
May 1978	14.23	10.93	3.02	13.95	14.10	193.3	35.2	37.0
June 1978	14.23	11.26	2.89	14.15	13.99	195.3	35.2	37.0
July 1978	14.22	11.20	3.02	14.22	14.20	196.7	35.2	37.0
August 1978	14.28	11.38	2.93	14.31	14.61	197.8	35.1	37.0
September 1978	14.24	11.42	2.90	14.32	15.02	199.3	35.4	37.3
October 1978	14.31	11.36	3.09	14.45	16.04	200.9	36.0	38.1
November 1978	14.35	11.49	3.29	14.78	18.34	202.0	36.8	38.9
December 1978	14.48	11.71	3.52	15.23	17.63	202.9	37.8	40.1
January 1979	14.67	11.85	3.65	15.50	20.53	204.7	38.8	40.7
February 1979	14.96	12.03	3.81	15.84	29.27	207.1	39.9	41.2
March 1979	15.51	12.29	4.35	16.64	26.31	209.1	41.6	42.1
April 1979	16.01	12.92	4.87	17.79	27.63	211.5	44.5	45.4
May 1979	17.31	13.62	5.21	18.83	32.93	214.1	47.3	48.2
June 1979	18.47	14.71	5.27	19.98	36.75	216.6	52.8	51.6
July 1979	20.26	16.00	5.27	21.27	35.89	218.9	57.1	54.5
August 1979				22.80	33.04		61.7	57.7
Week ended:								
Aug. 3	(12)	(12)	(12)	21.94	33.56	(12)	59.6	55.0
Aug. 10	(12)	(12)	(12)	22.46	33.19	(12)	61.5	55.7
Aug. 17	(12)	(12)	(12)	22.60	32.39	(12)	61.7	57.5
Aug. 24	(12)	(12)	(12)	23.42	33.10	(12)	62.5	58.9
Aug. 31	(12)	(12)	(12)	23.58	33.28	(12)	63.3	60.1
Sept. 7	(12)	(12)	(12)	24.21	33.68	(12)	64.8	61.6
Sept. 14	(12)	(12)	(12)	24.42	33.16	(12)	66.2	62.5
Same week year ago	(12)	(12)	(12)	14.30	14.86	(12)	35.4	37.0
Percent increase (December) from year ago	[15] 42.5	[15] 42.9	[15] 74.5	[13] 70.8	[13] 123.1	[15] 11.3	[15] 87.0	[13] 68.9
Year to date:								
1978	$13.31	$11.16	$2.68	$13.92	$14.17	191.7	[25] 35.1	[25] 37.1
1979	16.72	13.35	4.64	19.02	30.53	211.7	[25] 49.3	[25] 48.5
Percent increase (December) from year ago	16.8	19.6	73.1	36.6	115.5	10.4	40.5	30.7

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	U.S. product prices—Continued Wholesale prices: Residual (No. 6) fuel oil (per barrel): National average[22] (19)	New York City[26] (20)	New Orleans[23] (21)	Los Angeles[23] (22)	Gasoline (cents per gallon)[27]: Leaded: Regular (23)	Leaded: Premium (24)	Unleaded (25)	Retail price of gasoline at the pump (cents per gallon)[28]: Leaded: Regular (26)	Leaded: Premium (27)	Unleaded (28)
1960	$2.05	$2.89	$2.22	$2.09	11.6	(29)	(29)	31.1	(29)	(29)
1961	2.04	3.02	2.33	2.10	11.6	(29)	(29)	30.8	(29)	(29)
1962	2.01	3.10	2.33	2.19	11.5	(29)	(29)	30.6	(29)	(29)
1963	1.94	3.10	2.33	2.02	11.4	(29)	(29)	30.4	(29)	(29)
1964	1.89	3.10	2.33	1.79	11.3	(29)	(29)	30.4	(29)	(29)
1965	2.02	3.10	2.33	2.05	11.5	(29)	(29)	31.2	(29)	(29)
1966	1.99	3.10	2.33	2.05	11.6	(29)	(29)	32.1	(29)	(29)
1967	1.90	2.81	2.33	1.88	11.8	14.2	(29)	33.3	(29)	(29)
1968	1.81	2.53	2.33	1.75	11.6	14.0	(29)	33.7	(29)	(29)
1969	1.76	2.46	2.33	1.53	11.8	[30] 14.1	(29)	34.8	(29)	(29)
1970	2.58	3.26	2.58	2.23	12.3	[30] 14.3	(29)	35.7	(29)	(29)
1971	3.26	4.23	3.49	3.63	12.7	[30] 14.7	(29)	36.4	(29)	(29)
1972	3.19	4.08	3.23	3.60	12.7	[30] 14.7	(29)	36.1	(29)	(29)
1973	3.55	5.18	3.79	3.50	14.7	[30] 16.9	(29)	38.8	(29)	(29)
1974	8.58	14.04	10.13	6.58	25.5	[30] 28.6	(29)	52.8	56.5	54.6
1975	9.25	13.07	10.65	7.53	30.3	[30] 32.8	[30] 31.5	56.2	60.9	59.8
1976	9.10	12.96	9.81	8.11	33.8	[30] 36.3	[30] 35.1	58.7	63.8	62.5
1977	10.87	15.13	10.73	10.67	37.0	[30] 39.5	[30] 39.0	62.6	68.1	66.4
1978	9.66	14.29	10.30	8.88	39.2	[30] 42.4	[30] 41.9	63.9	69.4	68.4
Months:										
July 1977	10.35	15.09	9.96	11.25	38.0	[30] 40.4	[30] 39.8	63.4	68.9	67.3
August 1977	10.58	14.80	10.38	11.25	37.8	[30] 40.3	[30] 40.0	63.4	68.9	67.0
September 1977	10.87	14.80	10.87	11.25	37.6	[30] 40.2	[30] 39.9	63.3	68.9	67.0
October 1977	10.87	14.80	11.30	10.83	37.4	[30] 40.0	[30] 39.5	63.2	68.9	67.0

November 1977	10.68	14.80	11.58	10.25	37.4	[10] 40.2	[10] 39.7	63.1	68.9	67.0
December 1977	10.25	14.13	10.50	10.25	37.3	[10] 40.1	[10] 39.7	63.3	69.1	67.2
January 1978	9.85	13.95	10.13	10.18	37.0	[10] 39.9	[10] 39.4	61.7	67.7	65.8
February 1978	9.59	13.82	10.13	8.60	37.0	[10] 39.8	[10] 39.3	61.6	67.7	65.7
March 1978	9.33	13.90	10.13	7.32	36.8	[10] 39.6	[10] 39.6	61.7	68.0	65.8
April 1978	9.42	14.25	10.13	7.39	37.4	[20] 40.2	[10] 39.6	61.9	68.3	66.1
May 1978	9.59	14.25	11.22	7.90	38.5	[10] 41.2	[10] 40.8	62.5	69.0	66.9
June 1978	9.75	13.97	11.38	8.81	39.2	[10] 42.4	[10] 41.8	63.4	70.0	67.8
July 1978	9.46	13.62	10.42	9.25	40.0	[10] 43.3	[10] 42.6	64.6	71.1	68.8
August 1978	9.29	13.70	9.43	9.13	40.6	[10] 44.1	[10] 43.4	65.4	72.0	69.8
September 1978	9.32	14.00	9.43	9.00	40.6	[10] 44.1	[10] 43.3	65.8	72.4	70.2
October 1978	9.67	14.64	9.90	9.29	40.4	[10] 44.0	[10] 43.3	65.9	72.5	70.2
November 1978	10.09	15.46	10.63	9.76	41.1	[10] 44.8	[10] 44.0	66.7	73.3	71.1
December 1978	10.57	15.89	10.63	9.90	42.1	[10] 45.7	[10] 45.1	67.5	73.9	71.7
January 1979	10.67	16.34	10.63	9.90	42.9	[10] 46.5	[10] 45.8	68.4	74.8	72.4
February 1979	10.83	17.32	10.63	9.90	43.8	[10] 47.5	[10] 47.0	70.0	76.6	74.2
March 1979	11.78	18.91	11.76	12.33	45.6	[10] 49.3	[10] 48.6	73.2	79.7	77.6
April 1979	12.61	20.06	12.15	14.33	48.7	[10] 52.6	[10] 51.8	77.2	83.9	81.7
May 1979	13.38	20.65	14.28	15.23	51.4	[10] 55.6	[10] 54.8	81.4	87.9	85.9
June 1979	13.90	21.64	14.73	16.38	53.9	[10] 58.1	[10] 58.1	87.8	93.6	91.9
July 1979	14.31	22.56	15.02	16.94	57.8	[10] 61.5	[10] 61.3	93.1	98.8	97.0
August 1979	15.37	23.92	16.61	18.21	61.7	[10] 65.6	[10] 65.5	96.8	102.6	100.8
Week ended:										
Aug. 3	14.91	23.65	16.03	17.57	59.1	[10] 62.7	[10] 62.9	(12)	(12)	(12)
Aug. 10	14.90	23.65	16.03	18.00	60.9	[10] 64.9	[10] 64.6	(12)	(12)	(12)
Aug. 17	15.13	23.73	16.03	18.06	61.2	[10] 65.2	[10] 64.9	(12)	(12)	(12)
Aug. 24	15.96	24.20	16.60	18.40	63.5	[40] 67.2	[10] 67.3	(12)	(12)	(12)
Aug. 31	15.96	24.20	18.03	18.40	64.0	[10] 68.1	[10] 67.8	(12)	(12)	(12)
Sept. 7	15.98	24.20	18.03	18.44	66.3	[10] 70.8	[10] 70.3	(12)	(12)	(12)
Sept. 14	15.97	24.20	18.03	18.50	66.8	70.9	70.5	(12)	(12)	(12)
Same week year ago	9.34	14.08	9.43	9.00	40.4	44.0	43.2	(12)	(12)	(12)
Percent increase (December) from year ago	[13] 71	[13] 71.9	[13] 91.2	[13] 105.6	[13] 65.3	[13] 61.1	[13] 63.2	[15] 48	[15] 42.5	[15] 44.4
Year to date:										
1978	$9.52	$13.93	$10.32	$8.63	[25] 38.5	[25] 41.5	[25] 41.0	[25] 62.9	[25] 69.2	[25] 67.1
1979	13.10	20.42	13.52	14.43	[25] 51.8	[25] 55.8	[25] 55.3	[25] 81.1	[25] 87.4	[25] 85.3
Percent increase (December) from year ago	37.6	46.6	31.0	67.2	34.5	34.5	34.9	28.9	26.3	27.1

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	World production of crude oil (million barrels per day)										
		Non-OPEC [31]			OPEC [32]						
	Total	Total	Non-Communist	Communist	Total	Saudi Arabia	Iran	Venezuela	Iraq	Kuwait	Other [33]
	(29)=(30)+(33)	(30)=(31)+(32)	(31)	(32)	(33)=(34)+(35)(36)+(37)(38)+(39)	(34)	(35)	(36)	(37)	(38)	(39)
1960	21.0	12.3	9.0	3.3	8.7	1.3	1.1	2.8	1.0	1.7	0.8
1961	22.4	13.1	9.3	3.7	9.3	1.5	1.2	2.9	1.0	1.7	1.0
1962	24.3	13.8	9.7	4.2	10.5	1.6	1.3	3.2	1.0	2.0	1.4
1963	26.1	14.6	10.0	4.6	11.5	1.8	1.5	3.2	1.2	2.1	1.8
1964	28.2	15.2	10.2	5.0	13.0	1.9	1.7	3.4	1.3	2.3	2.4
1965	30.3	16.0	10.6	5.4	14.3	2.2	1.9	3.5	1.3	2.4	3.1
1966	32.9	17.2	11.3	5.9	15.8	2.5	2.1	3.4	1.4	2.4	3.8
1967	35.4	18.5	12.2	6.4	16.8	2.8	2.6	3.5	1.2	2.5	4.2
1968	38.7	19.8	13.1	6.8	18.8	3.0	2.8	3.6	1.5	2.6	5.2
1969	41.7	20.8	13.6	7.2	20.9	3.2	3.4	3.6	1.5	2.8	6.4
1970	45.8	22.4	14.5	7.9	23.4	3.8	3.8	3.7	1.6	3.0	7.5
1971	48.4	23.1	14.6	8.5	25.3	4.8	4.6	3.5	1.7	3.2	7.6
1972	50.8	23.8	14.9	8.9	27.1	6.0	5.0	3.2	1.5	3.3	8.1
1973	55.8	24.8	14.9	9.9	31.0	7.6	5.9	3.4	2.0	3.0	9.1
1974	56.3	25.5	14.6	10.9	30.7	8.5	6.0	3.0	2.0	2.5	8.8
1975	53.5	26.2	14.4	11.9	27.3	7.1	5.4	2.3	2.2	2.1	8.1
1976	57.8	27.1	14.5	12.6	30.7	8.6	5.9	2.3	2.4	2.1	9.4
1977	60.0	28.6	15.5	13.1	31.4	9.2	5.7	2.2	2.5	2.0	9.8
1978	60.2	30.3	16.7	13.6	29.9	8.3	5.2	2.2	2.6	2.1	9.5
Months:											
July 1977	58.8	28.3	15.2	13.1	30.5	9.8	4.7	2.2	2.5	1.6	9.6
August 1977	59.1	28.8	15.7	13.2	30.3	8.6	5.7	2.3	2.2	1.8	9.8
September 1977	60.2	28.8	15.6	13.2	31.5	8.7	6.0	2.4	2.6	2.3	9.5

October 1977	59.9	29.2	15.8	13.4	30.8	8.7	5.5	2.3	2.6	1.9	9.7
November 1977	61.3	29.5	16.2	13.4	31.7	8.9	6.1	2.1	2.6	2.3	9.6
December 1977	62.5	29.7	16.3	13.4	32.8	9.6	6.4	2.0	2.6	2.7	9.5
January 1978	57.0	29.4	16.0	13.4	27.6	7.8	5.3	1.7	2.1	1.7	9.0
February 1978	58.3	29.5	16.1	13.4	28.8	8.4	5.5	1.6	2.5	1.7	9.0
March 1978	59.0	30.0	16.6	13.4	29.0	7.7	5.6	2.1	2.5	2.1	9.0
April 1978	59.4	29.9	16.3	13.5	29.5	8.0	5.6	2.2	2.5	2.0	9.2
May 1978	58.9	30.2	16.7	13.5	28.7	7.3	5.7	2.3	2.4	1.8	9.2
June 1978	59.8	30.6	17.1	13.6	29.2	7.5	5.6	2.3	2.4	1.9	9.4
July 1978	59.7	30.3	16.7	13.6	29.4	7.4	5.8	2.3	2.4	2.0	9.5
August 1978	60.4	30.5	16.9	13.6	29.9	7.1	5.8	2.2	2.6	2.4	9.8
September 1978	62.5	30.4	16.8	13.6	32.0	8.4	6.1	2.3	2.9	2.6	9.8
October 1978	62.9	30.9	17.1	13.8	32.0	9.3	5.5	2.3	3.0	2.1	9.8
November 1978	62.9	31.2	17.3	13.9	31.7	10.3	3.5	2.3	3.1	2.7	9.9
December 1978	61.7	31.2	17.3	13.8	30.6	10.4	2.4	2.3	3.1	2.2	10.2
January 1979	59.6	31.1	17.2	13.9	28.5	9.8	0.4	2.3	3.1	2.6	10.3
February 1979	60.3	31.3	17.4	13.9	29.0	9.8	0.7	2.3	3.3	2.6	10.3
March 1979	61.7	31.3	17.3	13.9	30.4	9.8	2.4	2.4	3.3	2.6	10.0
April 1979	62.2	31.5	17.4	14.1	30.7	8.8	3.6	2.4	3.3	2.5	10.0
May 1979	62.3	31.2	17.5	13.6	31.1	8.8	4.1	2.4	3.3	2.6	[30] 9.9
June 1979	62.6	31.6	17.7	13.9	[30] 30.9	8.8	3.9	2.3	3.5	2.6	9.9
July 1979					31.7	9.8	3.8	2.3	3.5	2.5	9.9
August 1979											
Week ended:											
Aug. 3	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 10	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 17	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 24	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 31	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Sept. 7	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Sept. 14	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Same week year ago	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Percent increase (Dec.) from year ago	[15] 4.6	[15] 3.3	[15] 3.8	[15] 2.6	[15] 8.1	[15] 31.5	[15] (34.5)	[15] 1.8	[15] 45.8	[15] 26.8	[15] 3.9
Year to date:											
1978	58.7	29.9	16.5	13.5	28.9	7.7	5.6	2.1	2.4	1.9	9.2
1979	61.4	31.3	17.4	13.9	30.3	9.4	2.7	2.3	3.3	2.6	10.1
percent increase (Dec.) from year ago	4.6	4.7	5.9	3.2	5.0	21.1	(51.5)	12.2	38.8	35.8	9.0

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	U.S. petroleum supply/demand balance									
		Supply [35]								
	Average number of active rotary rigs [34]	Domestic production (million barrels per day)			Imports (million barrels per day)			Processing gain [36] (million barrels per day)	Total supply (million barrels per day)	Memo: Total imports as percent of total supply
		Crude oil	Natural gas liquids	Total	Crude oil	Products	Total			
	(40)	(41)	(42)	(43)=(41)+(42)	(44)	(45)	(46)=(44)+(45)	(47)	(48)=(43)+(46)+(47)	(49)=(46)÷(48)
1960	1,748	7.0	0.9	8.0	1.0	0.8	1.8	0.1	9.9	18.3
1961	1,761	7.2	1.0	8.2	1.0	.9	1.9	.2	10.3	18.7
1962	1,641	7.3	1.0	8.4	1.1	1.0	2.1	.2	10.6	19.6
1963	1,499	7.5	1.1	8.6	1.1	1.0	2.1	.2	11.0	19.4
1964	1,501	7.6	1.2	8.8	1.2	1.1	2.3	.2	11.2	20.1
1965	1,388	7.8	1.2	9.0	1.2	1.2	2.5	.2	11.7	21.1
1966	1,272	8.3	1.3	9.6	1.2	1.3	2.6	.2	12.4	20.8
1967	1,134	8.8	1.4	10.2	1.1	1.4	2.5	.3	13.0	19.4
1968	1,169	9.1	1.5	10.6	1.3	1.5	2.8	.3	13.8	20.6
1969	1,194	9.2	1.6	10.8	1.4	1.8	3.2	.3	14.3	22.1
1970	1,028	9.6	1.7	11.3	1.3	2.1	3.4	.4	15.1	22.7
1971	976	9.5	1.7	11.2	1.7	2.2	3.9	.4	15.5	25.4
1972	1,107	9.4	1.7	11.2	2.2	2.5	4.7	.4	16.3	29.1
1973	1,194	9.2	1.7	10.9	3.2	3.0	6.3	.5	17.7	35.4
1974	1,472	8.8	1.7	10.5	3.5	2.6	6.1	.5	17.1	35.8
1975	1,660	8.4	1.6	10.0	4.1	2.0	6.1	.5	16.5	36.7
1976	1,658	8.1	1.6	9.7	5.3	2.0	7.3	.5	17.5	41.7
1977	2,002	8.2	1.6	9.9	6.6	2.2	8.8	.5	19.2	45.9
1978	2,259	8.7	1.6	10.3	6.2	2.0	8.2	.5	19.0	43.3
Months:										
July 1977	2,023	8.1	1.6	9.7	7.1	2.0	9.1	.5	19.4	47.0
August 1977	2,066	8.3	1.6	9.9	6.4	2.2	8.6	.6	19.1	45.0

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September 1977	2,084	8.5	1.6	10.1	6.4	2.1	8.6	.5	19.1	44.8
October 1977	2,101	8.6	1.6	10.2	6.5	1.9	8.4	.6	19.2	43.9
November 1977	2,113	8.6	1.6	10.2	6.3	1.8	8.1	.6	18.9	43.0
December 1977	2,141	8.5	1.6	10.1	6.3	2.2	8.5	.6	19.2	44.3
January 1978	2,128	8.3	1.6	9.9	6.1	2.1	8.2	.5	18.5	44.0
February 1978	2,135	8.4	1.6	9.9	5.7	2.3	8.0	.5	18.4	43.5
March 1978	2,158	8.8	1.6	10.4	6.1	2.3	8.4	.5	19.3	43.6
April 1978	2,198	8.7	1.6	10.3	5.4	2.1	7.5	.5	18.3	41.1
May 1978	2,249	8.8	1.5	10.3	5.6	1.8	7.3	.4	18.1	40.6
June 1978	2,286	8.8	1.6	10.4	6.4	1.6	8.0	.5	18.9	42.4
July 1978	2,307	8.7	1.6	10.3	6.2	1.9	8.1	.4	18.8	43.2
August 1978	2,324	8.8	1.6	10.3	6.3	1.9	8.2	.5	19.0	43.0
September 1978	2,332	8.8	1.5	10.3	6.9	2.0	8.9	.5	19.8	45.1
October 1978	2,346	8.8	1.5	10.4	6.5	1.7	8.2	.6	19.1	42.9
November 1978	2,356	8.7	1.6	10.3	6.6	2.0	8.6	.6	19.5	44.2
December 1978	2,286	8.7	1.6	10.2	7.0	2.2	9.2	.5	19.9	46.1
January 1979	2,199	8.5	1.7	10.2	6.8	2.2	9.0	.4	19.6	45.7
February 1979	2,064	8.5	1.7	10.2	6.4	2.1	8.5	.5	19.2	44.3
March 1979	1,971	8.6	1.7	10.3	6.3	2.4	8.7	.5	19.5	44.6
April 1979	1,943	8.5	1.5	10.0	6.0	1.9	8.0	.5	18.5	43.0
May 1979	1,960	8.5	1.6	10.0	6.0	1.9	7.8	.5	18.4	42.8
June 1979	1,999	8.4	1.6	10.0	6.4	1.6	8.0	.5	18.5	43.3
July 1979	2,094	8.5	1.6	10.1	6.5	1.8	8.3	.5	18.8	44.0
August 1979	2,222	8.5	1.7	10.3	6.7	1.9	8.7	.5	19.4	44.6
Week ended:										
Aug. 3	2,145	8.5	1.6	10.1	6.2	2.3	8.5	.5	19.1	44.3
Aug. 10	2,187	8.5	1.7	10 2	6.5	1.9	8.4	.5	19.1	43.8
Aug. 17	2,208	8.5	1.7	10.2	6.6	2.0	8.6	.5	19.3	44.4
Aug. 24	2,236	8.6	1.7	10.3	7.0	1.7	8.8	.5	19.5	44.8
Aug. 31	2,256	8.6	1.7	10.3	7.0	2.1	9.1	.5	19.8	45.7
Sept. 7	2,245	8.6	1.7	10.3	6.7	1.6	8.3	.5	19.1	43.6
Sept. 14	2,288	-----	-----	-----	-----	-----	-----	-----	-----	-----
Same week year ago	2,325	8.8	1.5	10.3	6.9	2.0	8.9	.5	19.8	45.1
Percent increase (decrease) from year ago	[13] (1.6)	[13] (2.3)	[13] 11.8	[13] (.2)	[13] (3.0)	[13] (18.9)	[13] (6.5)	[13] (10.9)	[13] (3.4)	[17] (1.5)
Year to date:										
1978	2,229	8.7	1.6	10.2	6.0	2.0	8.0	.5	18.7	[16] 42.7
1979	2,070	8.5	1.6	10.1	6.4	2.0	8.4	.5	19.0	[16] 44.0
Percent increase (decrease) from year ago	(7.1)	(2.0)	4.7	(1.0)	6.9	(1.1)	4.9	3.4	1.6	[17] 1.3

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	U.S. petroleum supply/demand balance—Continued									
	Supply[35]—Continued					Domestic demand[35] (million barrels per day)				
			Memo: Refining				Major products			
	Exports (million barrels per day)	Domestic supply (million barrels per day)	Refinery capacity[39] (million barrels per day)	Crude runs[40] (million barrels per day)	Capacity utilization (percent)	All products[41]	Gasoline	Jet fuel and kerosine	Distillate	Resid
	(50)	(51)= (48)−(50)	(52)	(53)= (41)+(44) + adjustments	(54)= (53)+(52)	(55)	(56)	(57)	(58)	(59)
1960	0.2	9.7	9.6	8.1	84.2	9.8	4.1	0.6	1.9	1.5
1961	.2	10.1	9.7	8.2	84.2	10.0	4.2	.7	1.9	1.5
1962	.2	10.4	9.8	8.4	85.7	10.4	4.3	.8	2.0	1.5
1963	.2	10.8	9.9	8.7	87.4	10.8	4.5	.8	2.0	1.5
1964	.2	11.0	10.1	8.8	87.1	11.0	4.5	.8	2.1	1.5
1965	.2	11.5	10.2	9.0	89.0	11.5	4.7	.9	2.1	1.6
1966	.2	12.2	10.3	9.4	91.8	12.1	4.9	.9	2.2	1.7
1967	.3	12.7	10.8	9.8	90.0	12.6	5.0	1.1	2.2	1.8
1968	.2	13.5	11.4	10.3	90.6	13.4	5.3	1.2	2.4	1.8
1969	.2	14.1	11.7	10.6	90.6	14.1	5.6	1.3	2.5	2.0
1970	.3	14.8	12.3	10.9	88.6	14.7	5.8	1.2	2.5	2.2
1971	.2	15.2	12.8	11.2	87.2	15.2	6.1	1.3	2.7	2.3
1972	.2	16.1	13.3	11.7	88.4	16.4	6.4	1.3	2.9	2.5
1973	.2	17.4	13.9	12.4	89.6	17.3	6.7	1.3	3.1	2.8
1974	.2	16.8	14.6	12.1	83.0	16.7	6.6	1.2	2.9	2.6
1975	.2	16.3	15.0	12.4	82.7	16.3	6.7	1.2	2.9	2.5
1976	.2	17.3	15.6	13.4	86.0	17.5	7.0	1.2	3.1	2.8
1977	.2	19.0	16.7	14.6	87.4	18.4	7.2	1.2	3.3	3.1
1978	.4	18.6	17.1	14.7	85.9	18.8	7.5	1.2	3.4	3.0
Months:										
July 1977	.3	19.1	16.7	14.9	89.0	17.6	7.5	1.2	2.6	2.8
August 1977	.2	18.8	16.8	14.6	87.4	18.0	7.5	1.2	2.6	3.0

September 1977	.3	18.8	16.8	14.9	89.1	17.7	7.4	1.2	2.7	2.9
October 1977	.3	18.9	16.8	14.7	87.1	17.8	7.2	1.2	3.0	2.7
November 1977	.2	18.7	16.9	14.6	86.7	18.4	7.2	1.2	3.4	2.8
December 1977	.3	18.9	17.0	14.7	86.7	20.1	7.4	1.4	4.2	3.4
January 1978	.3	18.3	17.0	14.1	82.9	19.7	6.7	1.3	4.4	3.5
February 1978	.2	18.2	17.0	14.0	81.9	20.9	6.9	1.4	4.8	4.0
March 1978	.3	19.1	17.0	14.1	83.0	19.6	7.3	1.3	4.1	3.5
April	.3	18.0	17.1	13.9	81.2	17.7	7.2	1.1	3.1	3.0
May 1978	.3	17.8	17.1	15.0	87.5	18.1	7.8	1.1	3.0	2.7
June 1978	.4	18.5	17.2	14.7	85.6	18.3	8.0	1.1	2.8	2.6
July 1978	.3	18.5	17.1	14.9	87.0	17.6	7.6	1.1	2.5	2.8
August 1978	.4	18.6	17.1	15.2	88.8	18.6	7.9	1.2	2.8	2.9
September 1978	.5	19.3	17.1	15.1	88.1	17.9	7.4	1.3	2.7	2.7
October 1978	.5	18.7	17.2	15.0	87.1	18.4	7.5	1.2	3.1	2.6
November 1978	.4	19.1	17.3	15.3	88.7	19.2	7.5	1.3	3.6	2.8
December 1978	.5	19.5	17.4	15.4	88.7	19.9	7.5	1.3	4.1	3.1
January 1979	.4	19.2	17.4	14.7	84.0	20.6	6.9	1.4	4.5	3.5
February 1979	.5	18.7	17.5	14.1	80.8	21.2	7.3	1.5	4.8	3.6
March 1979	.6	18.9	17.5	14.1	80.2	19.2	7.3	1.2	3.6	3.2
April 1979	.4	18.1	17.5	14.4	81.9	17.6	7.2	1.1	3.1	2.9
May 1979	.5	18.0	17.5	14.3	81.9	17.0	7.0	1.2	2.9	2.7
June 1979	.5	18.1	17.5	14.7	84.1	17.1	7.1	1.2	2.7	2.7
July 1979	.4	18.5	17.7	15.1	85.2	17.0	7.1	1.2	2.7	2.5
August 1979	.5	18.9	17.8	14.9	83.4	17.5	7.2	1.3	2.7	2.6
Week ended:										
Aug. 3	.4	18.7	17.8	14.9	83.7	18.1	7.0	1.3	3.0	2.8
Aug. 10	.5	18.6	17.8	14.9	83.7	18.2	7.5	1.4	2.8	2.7
Aug. 17	.5	18.8	17.8	15.0	84.1	17.1	7.3	1.3	2.5	2.6
Aug. 24	.6	18.9	17.8	14.8	83.1	17.2	7.0	1.4	2.6	2.4
Aug. 31	.6	19.2	17.8	14.8	[20] 82.9	17.3	7.1	1.1	[20] 2.8	2.8
Sept. 7	.6	18.5	17.8	14.8	82.8	17.6	7.1	1.4	2.8	2.4
Sept. 14										
Same week year ago	.5	19.3	17.1	15.4	89.8	17.9	7.8	1.1	2.5	3.0
Percent increase (December) from year ago	[13] 26.6	[13] (4.1)	[13] 4.1	[13] (4.0)	[27] (7.0)	[13] (1.6)	[13] (8.3)	[13] 25.3	[13] 10.9	[13] (20.7)
Year to date:										
1978	.3	18.4	17.1	14.5	[16] 84.9	18.8	7.4	1.2	3.4	3.1
1979	.5	18.5	17.6	14.5	[16] 82.7	18.3	7.1	1.3	3.4	2.9
Percent increase (December) from year ago	47.3	.8	2.8	.1	[17] (2.2)	(2.3)	(4.1)	5.1	(1.8)	(5.5)

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	U.S. petroleum supply/demand balance—Continued (end of period stocks [35] million barrels)							U.S. production of fossil fuels		
			Major products							
	Total	Crude oil	Gasoline	Jet fuel and kerosine	Distillate	Resid	Unfinished oils	Natural gas [42] (trillion cubic feet)	Crude petroleum (million barrels per day)	Bituminous coal [43] (million tons)
	(60)	(61)	(62)	(63)	(64)	(65)	(66)	(67)	(68)=(41)	(69)
1960	785	240	162	38	138	45	62	12.8	7.0	416
1961	825	245	167	41	152	45	79	13.3	7.2	403
1962	834	252	184	42	144	50	82	13.9	7.3	422
1963	836	237	187	43	157	48	82	14.7	7.5	459
1964	839	230	194	46	156	40	87	15.5	7.6	487
1965	836	220	183	43	155	56	89	16.0	7.8	512
1966	[44] 881	238	194	44	[44] 158	[44] 64	89	17.2	8.3	534
1967	944	249	208	48	160	66	90	18.2	8.8	553
1968	1,000	272	212	48	173	65	93	19.3	9.1	545
1969	980	265	217	55	172	58	98	20.7	9.2	561
1970	1,018	276	214	55	195	54	99	21.9	9.6	603
1971	1,044	260	224	52	191	60	101	22.5	9.5	552
1972	959	246	217	45	154	55	95	22.5	9.4	595
1973	1,008	242	213	50	196	53	99	22.6	9.2	592
1974	[44] 1,074	265	222	45	[44] 200	[44] 60	106	21.6	8.8	603
1975	1,133	271	238	46	209	74	106	20.1	8.4	648
1976	1,112	[45] 303	234	45	186	72	110	20.0	8.1	679
1977	1,312	348	261	53	250	90	113	20.0	8.2	691
1978	1,278	377	241	48	216	90	109	19.6	8.7	654
Months:										
July 1977	1,239	335	261	53	205	78	111	[46] 19.7	8.1	[46] 584
August 1977	1,269	339	260	54	230	79	108	[46] 19.4	8.3	[46] 680
September 1977	1,304	334	259	55	253	88	111	[46] 19.4	8.5	[46] 846
October 1977	1,336	343	258	55	267	96	113	[46] 19.2	8.6	[46] 797
November 1977	1,346	350	262	56	271	95	111	[46] 19.5	8.6	[46] 839

December 1977	1,312	348	261	53	250	90	113	[46] 20.3	8.5	[46] 365
January 1978	1,267	351	275	49	213	81	109	[46] 20.5	8.3	[46] 272
February 1978	1,191	350	274	45	166	65	113	21.1	8.4	[46] 307
March 1978	1,168	364	262	44	138	62	115	[46] 20.2	8.8	[46] 456
April 1978	1,174	365	252	47	136	66	115	[46] 19.9	8.7	[46] 724
May 1978	1,178	355	236	52	145	72	114	[46] 19.2	8.8	[46] 810
June 1978	1,185	363	222	52	158	72	112	[46] 19.4	8.8	[46] 798
July 1978	1,222	368	219	54	181	75	111	[46] 19.6	8.7	[46] 632
August 1978	1,221	358	212	52	200	74	110	[46] 19.1	8.8	[46] 758
September 1978	1,263	368	219	51	221	81	106	[46] 18.7	8.8	[46] 703
October 1978	1,281	378	216	49	233	83	113	[46] 18.9	8.8	[46] 823
November 1978	1,292	382	223	48	233	89	113	[46] 19.2	8.7	[46] 842
December 1978	1,278	377	241	48	216	90	109	[46] 19.8	8.7	[46] 702
January 1979	[44] 1,227	376	259	43	176	82	108	[46] 20.2	8.5	[46] 665
February 1979	1,150	381	254	40	127	68	105	[46] 21.1	8.5	[46] 699
March 1979	1,146	400	242	43	113	72	104	[46] 20.6	8.6	[46] 771
April 1979	1,161	401	233	47	115	78	106	[46] 19.6	8.5	[46] 770
May 1979	1,190	402	231	51	124	85	108	[46] 19.4	8.5	[46] 833
June 1979	1,223	409	233	51	141	82	109	[46] 19.5	8.4	[46] 801
July 1979	1,257	400	238	50	167	85	116	----	8.5	[46] 642
August 1979	1,294	402	235	50	196	88	116	----	8.5	[46] 849
Week ended:										
Aug. 3	1,258	399	237	51	168	85	115	(12)	8.5	[46] 783
Aug. 10	1,260	397	234	50	173	86	116	(12)	8.5	[46] 793
Aug. 17	1,269	396	233	50	181	87	118	(12)	8.5	[46] 830
Aug. 24	1,281	399	235	49	188	88	116	(12)	8.6	[46] 845
Aug. 31	1,294	402	235	50	195	88	116	(12)	8.6	[46] 850
Sept. 7	1,297	399	233	49	201	90	117	(12)	8.6	[46] 746
Sept. 14	----	----	----	----	----	----	----	(12)	----	----
Same week year ago	1,228	356	212	53	205	72	110	(12)	8.8	[46] 702
Percent increase (December) from year ago	[13] 5.6	[13] 12.1	[13] 9.9	[13] (7.6)	[13] (2.2)	[13] 24.5	[13] 5.8	[15] .2	[13] (2.3)	[13] 6.2
Year to date:										
1978	(38)	(38)	(38)	(38)	(38)	(38)	(38)	20.0	8.7	600
1979	(38)	(38)	(38)	(38)	(38)	(38)	(38)	20.0	8.5	752
Percent increase (December) from year ago	(38)	(38)	(38)	(38)	(38)	(38)	(38)	.1	(2.0)	25.3

See footnotes at end of table.

WEEKLY PETROLEUM PRICE INDICATORS AND U.S. ENERGY PRODUCTION—Continued

Year	U.S. generation of electricity from nonfossil fuel sources[47] (billion kilowatt-hours)			Total U.S. energy consumption[49] (quadrillion Btu)	Total U.S. energy production[50] (quadrillion Btu)							
						Fossil fuels				Electricity from nonfossil fuel sources[54]		
	Total	Hydro[48]	Nuclear		Total	Total	Petroleum liquids[51]	Natural gas, dry[52]	All coal[53]	Total	Hydro[48]	Nuclear
	(70)=(71)+(72)	(71)	(72)	(73)	(74)=(75)+(79)	(75)=(76)+(77)+(78)	(76)	(77)	(78)	(79)=(80)+(81)	(80)	(81)
1960	146	146	1	44.1	41.8	40.2	16.4	12.7	11.1	1.6	1.6	----------
1961	154	152	2	44.7	42.3	40.6	16.8	13.1	10.7	1.7	1.6	----------
1962	171	168	2	46.8	43.9	42.0	17.1	13.7	11.2	1.8	1.8	----------
1963	169	166	3	48.6	46.2	44.3	17.7	14.5	12.2	1.8	1.8	----------
1964	180	177	3	50.8	48.0	46.1	18.0	15.3	12.8	1.9	1.9	----------
1965	198	194	4	53.0	49.7	47.6	18.4	15.8	13.4	2.1	2.1	----------
1966	200	195	6	55.7	52.5	50.4	19.6	17.0	13.8	2.1	2.1	0.1
1967	229	222	8	57.9	55.4	53.0	20.8	17.9	14.2	2.4	2.4	.1
1968	235	223	13	61.3	57.1	54.6	21.6	19.1	13.9	2.5	2.4	.1
1969	264	250	14	64.5	59.4	56.6	22.0	20.4	14.2	2.8	2.6	.2
1970	270	248	22	66.8	62.5	59.6	22.9	21.7	15.0	2.9	2.6	.2
1971	305	267	38	68.3	62.0	58.4	22.6	22.3	13.6	3.5	3.1	.4
1972	329	275	54	71.6	62.8	59.3	22.6	22.2	14.5	3.5	2.9	.6
1973	358	274	83	74.6	62.4	58.6	22.1	22.2	14.4	3.8	2.9	.9
1974	418	304	114	72.8	61.2	56.7	21.0	21.2	14.5	4.5	3.2	1.3
1975	476	303	173	70.7	60.1	54.9	20.1	19.6	15.2	5.1	3.2	1.9
1976	479	288	191	74.5	60.1	54.9	19.6	19.5	15.9	5.2	3.1	2.1
1977	475	225	251	76.5	60.4	55.3	19.8	19.6	16.0	5.1	2.4	2.7
1978	560	284	276	78.2	61.0	55.0	20.7	19.2	15.1	6.0	3.0	3.0
Months (annualized):												
July 1977	459	202	257	71.5	57.1	52.2	19.5	19.3	13.5	4.9	2.2	2.8
August 1977	468	201	268	72.7	59.6	54.5	19.9	18.9	15.7	5.0	2.2	2.9
September 1977	443	204	239	72.5	63.5	58.7	20.2	19.0	19.5	4.8	2.2	2.6
October 1977	431	207	224	72.5	62.3	57.6	20.5	18.7	18.4	4.6	2.2	2.4
November 1977	489	252	237	77.7	64.2	59.0	20.5	19.1	19.4	5.3	2.7	2.6
December 1977	552	272	280	86.4	54.6	48.7	20.3	19.9	8.5	5.9	2.9	3.0
January 1978	604	299	304	89.6	52.8	46.4	19.9	20.1	6.3	6.5	3.2	3.3
February 1978	580	296	285	90.4	54.0	47.8	20.0	20.7	7.1	6.2	3.2	3.1
March 1978	557	293	264	80.3	57.3	51.3	20.9	19.8	10.6	6.0	3.1	2.8
April 1978	524	310	214	73.1	62.6	57.0	20.8	19.5	16.7	5.6	3.3	2.3
May 1978	581	341	240	72.6	64.5	58.3	20.8	18.8	18.7	6.2	3.6	2.6
June 1978	578	308	270	72.9	64.6	58.4	21.0	19.0	18.4	6.2	3.3	2.9
July 1978	585	291	294	72.8	60.9	54.6	20.8	19.2	14.6	6.3	3.1	3.2
August 1978	566	265	301	74.4	63.1	57.1	20.8	18.7	17.5	6.1	2.8	3.2
September 1978	531	262	270	72.3	61.1	55.4	20.8	18.3	16.3	5.7	2.8	2.9
October 1978	503	232	271	74.1	63.8	58.4	20.9	18.5	19.0	5.4	2.5	2.9

November 1978	549	246	303	79.8	64.9	59.0	20.8	18.8	19.5	5.9	2.6	3.3
December 1978	563	264	299	86.4	62.2	56.2	20.6	19.4	16.2	6.1	2.8	3.2
January 1979	627	299	327	93.2	[10] 62.3	[10] 55.6	20.4	19.8	[10] 15.4	6.7	3.2	3.5
February 1979	619	282	338	[10] 94.2	[10] 63.8	[10] 57.2	[10] 20.4	20.6	[10] 16.1	6.6	3.0	3.6
March 1979	[10] 596	310	287	[10] 82.2	[10] 65.1	[10] 58.6	[10] 20.7	[10] 20.1	[10] 17.8	6.4	3.3	3.1
April 1979	537	313	224	74.9	63.4	57.7	20.8	19.2	17.8	5.8	3.3	2.4
May 1979	523	346	177	72.8	64.5	58.9	20.7	19.0	19.2	5.6	3.7	1.9
June 1979	504	308	195									
July 1979												
August 1979												
Week ended:												
Aug. 3	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 10	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 17	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 24	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Aug. 31	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Sept. 7	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Sept. 14	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Same week year ago	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)
Percent increase (December) from year ago	[15] (12.9)		[15] (27.6)	[15] 0.2	[15] (0.1)	[15] 0.9	[15] (0.8)	[15] 1.0	[15] 2.8	[15] (9.9)	[15] 2.0	[15] (26.4)
Year to date:												
1978	571	308	263	81.1	58.3	52.2	20.5	19.8	12.0	6.1	3.3	2.8
1979	567	310	257	83.3	63.8	57.6	20.6	19.7	17.3	6.2	3.3	2.9
Percent increase (December) from year ago	(0.6)	0.7	(2.1)	2.7	9.5	10.3	0.6	(0.2)	44.4	2.0	1.0	3.2

[1] Prior to 1973, this is the tax-paid cost—including lifting cost, royalty, and taxes, but no profit—of 34° Arabian light crude oil. During this period, equity, or company-owned oil made up 100 percent of production. In 1973, the Saudi government acquired a 25 percent share of production, which was increased to 60 percent as of Jan. 1, 1974, and 100 percent as of Jan. 1, 1976—although negotiations on the final terms of transfer are not yet complete. Thereafter, the cost shown is a weighted average of the tax-paid cost of equity oil and the cost to the companies to buy back government-owned oil, based on production costs and tax rates as reported by Energy Economics Research, Ltd.

[2] Prior to 1974, the price is as published by the Petroleum Industry Research Foundation (Pirinc). The 1974 price is estimated by Business Economics based on conversations with Pirinc. Beginning in 1975, the official government sales price has set the market price.

[3] AFRA is short for average freight rate assessment and is an average of all tanker fixtures—both spot and contract—during a month. It is published by the London Tanker Brokers Panel. Prior to October 1969 AFRA was stated as a percentage of "Intascale" (IS). For the sake of continuity with subsequent data based on "Worldscale" (WS), the earlier data have been expressed as a percent of Worldscale. Both WS and IS are nominal rates for a hypothetical standard vessel traveling between different port combinations. The base rate changes from year to year—with significant changes in 1975 and 1976 because of sharply higher bunkering costs.

[4] Calculated using AFRA for the largest class vessel capable of using both ports. Tanker rates before June 1967 are via the Suez Canal, and include an 89 cent per long ton (11.9 cent per barrel) toll. Rates after June 1967 are via the Cape of Good Hope. Cost per long ton has been converted to cost per barrel assuming 34° gravity—the gravity of Arabian light crude oil.

[5] As reported by the FEA prior to Oct. 1, 1977, and the Department of Energy (DOE) subsequently. Data are for the Lower 48 only, and do not include Alaskan North Slope crude.

[6] As reported by the FEA and DOE. Stripper crude was decontrolled in September 1976. Prior to that time it was priced with upper tier oil.

[7] Annual data through 1973 are as published by the Bureau of Mines. Beginning in 1974 all data are as published by DOE (FEA before Oct. 1, 1977).

[8] Not applicable before September 1973.

[9] Beginning July 1977, the average value at wellhead of domestic crude oil includes Alaska North Slope crude oil at the wellhead, and a small amount of oil, not subject to price controls, produced on the naval petroleum reserves at Elk Hills and Teapot Dome.

[10] The London Tanker Brokers published the December 1974, 1975, 1976, 1977, and 1978 AFRA based on the next year's worldscale rates. For consistency, Business Economics has recalculated the December percentages and annual averages.

[11] Because of the crisis in Iran, the Government of Saudi Arabia notified Aramco that the official sales price for crude oil liftings above the 8,500,000 barrel per day ceiling would be equal to the then scheduled fourth quarter price—e.g., $14.55 per barrel for Arabian light rather than $13.34. Because Aramco produces several different grades of crude oil in varying proportions from day to day, it is impossible to report the actual price and average cost to the companies on a current basis. For this reason the official first quarter base price is being shown. Over all Aramco production, however, the incremental price is in the range of 18 cents to 19 cents per barrel, putting the selling price of Arabian light at about $13.52 per barrel, or 6.5 percent above the $12.70 price in effect during July 1977–December 1978.

[12] Data available on a monthly basis only.

[13] Percent change from year ago week.

[14] Percentage points. Percent change from year ago month.

[15] Percent change from year ago month.
[16] Percent.
[17] Percentage points.
[18] Prior to January 1974, the Census Bureau published value of imports on an f.o.b. basis. Estimates of freight and handling charges have been added to obtain CIF values. Starting in January 1974, CIF values are reported by the Census Bureau. In addition to the value shown, import license fees were charged on a percentage of imports beginning in 1973. Currently the license fee is 21 cents per barrel, but it applies to only 65 percent of imports. A supplemental fee of $1 per barrel was implemented by President Ford on Feb. 1, 1975, and increased to $2 per barrel on June 1, 1975. The supplemental fee was removed on Dec. 22, 1975.
[19] The average of the value of domestic crude oil weighted by its production and the value of imported crude oil weighted by its volume. The effect of the supplemental import fee imposed by President Ford is included for the period February-December 1975.
[20] The average wholesale price in eight U.S. market areas of gasoline, kerosine, light fuel, and heavy fuel as reported by the IPAA, based on data published in Platt's Oilgram.
[21] The average bulk price f.o.b. Rotterdam of regular gasoline, gas oil, and residual fuel, as reported by Platt's and weighted by the Western European refinery slate. Allowance has been made for other products and for refinery fuel and loss. Data for 1961–70 were published by M. A. Adelman as the "Rotterdam composite."
[22] The average wholesale price in eight U.S. market areas, as reported by the IPAA, based on data published in Platt's Oilgram.
[23] As published in Platt's Oilgram.
[24] Data for this series are not available for 1960.
[25] Cents.
[26] As published in Platt's Oilgram for low-sulfur residual fuel.
[27] The average wholesale price—excluding taxes—in eight U.S. market areas based on data published in Platt's Oilgram. The prices for regular leaded gasoline are reported by the IPAA. Business Economics has calculated the prices for unleaded and premium leaded using the IPAA methodology.
[28] The national average retail pump price—including taxes—at full service retail outlets. Prior to 1974 data are as published in Platt's Oilgram, During 1974–78 data are as published by the Department of Energy based on its own surveys and those of the Lundberg Survey, Inc. Beginning in 1979, data are from the Lundberg Survey, as published by Platt's.
[29] Not previously published.
[30] Revised.
[31] Annual data are published by the Department of Energy (formerly the Bureau of Mines). Monthly data are taken from a variety of sources including the DOE, the Petroleum Economist, and the Oil and Gas Journal. All monthly data are adjusted to a DOE basis.
[32] Annual data through 1973 are published by the Bureau of Mines. Beginning in 1974, annual data are official OPEC statistics. Monthly data are published by Petroluem Intelligence Weekly.
[33] Nigeria, the United Arab Emirates, Libya (each about 2,000,000 barrels per day), Indonesia (about 1,600,000 barrels per day), Algeria (about 1,200,000 barrels per day), Qatar (500,000 barrels per day), Gabon, and Ecuador (each about 200,000 barrels per day).
[34] Published by the Hughes Tool Co.
[35] Annual and monthly data are published by the Department of Energy (formerly the Bureau of Mines). Weekly data are published by API.
[36] Processing gain is the increase in volume that occurs during refining. It is not accompanied by an increase in weight or heat value (Btu).
[37] Percentage points. Percent change from year ago week.
[38] Not applicable.
[39] Annual data are averages. Monthly and weekly data are for operable capacity at the beginning of the month.
[40] Crude runs differ from the total of crude oil production (col. 41) and crude oil imports (col. 44) because of stock changes, losses, and use of unrefined crude oil directly.
[41] Differs from domestic supply because of changes in stocks, losses, and other minor adjustments.
[42] Marketed production of natural gas as published by the Department of Energy (prior to Oct. 1, 1977, the Bureau of Mines). Marketed production of natural gas excludes gas used for repressuring and gas vented or flared. Natural gas production data are on a "wet" basis—that is they include natural gas liquids which are removed at gas processing plants to give dry gas. Natural gas liquids production is shown in col. 42.
[43] Published by the Department of Energy (formerly the Bureau of Mines)—includes bituminous, subbituminous, and lignite coal, but excludes anthracite.
[44] Data for stocks of distillate and residual fuel oil, and hence all stocks, in 1966 and subsequently are not wholly comparable to earlier data because of a change in reporting by the Bureau of Mines a second reporting change was made in December 1974, and a thirc—affecting NGL stocks—in. January 1979.
[45] The Bureau of Mines revised its reporting of crude oil stocks beginning Jan. 1, 1977. The data shown are unofficial Bureau of Mines revisions of the 1976 data to the 1977 basis.
[46] Annualized.
[47] Electricity generation data are published by the Department of Energy (formerly the Federal Power Commission).
[48] Includes both utility and industrial hydroelectricity plus electricity generated from geothermal sources, wood and waste, etc.
[49] As published by the Department of Energy. Gross energy consumption—which includes conversion losses in electricity generation and in synthetic fuel production—is built up from domestic production plus net imports less the increase in stocks.
[50] As published by the Department of Energy.
[51] Includes crude oil and natural gas liquids (NGL). Crude oil contains 5,800,000 Btu per barrel, and NGL contains approximately 4,000,000 Btu per barrel—the exact amount depends on the composition of the NGL.
[52] Marketed production of wet natural gas less the natural gas liquids removed at processing plants. Dry natural gas contains 1,021 Btu per cubic foot.
[53] Includes bituminous, subbituminous, lignite, and anthracite coals. The weighted average heat value has been declining as western subbituminous coal and lignite have gained in importance The latest average heat value (for 1977–79) is 22, 900,000 Btu per ton.
[54] Includes conversion losses. Hydropower is conventionally valued at the average heat rate for base-load fossil plants—currently 10,435 Btu per kilowatt-hour. Nuclear is currently valued at 10,769 Btu per kilowatt-hour, and geothermal, which in the spreadsheet is included with hydro, is valued at 21,611 Btu per kilowatt-hour.

Note: Totals and percentages have been calculated from unrounded data.

Sources: Petroleum Intelligence Weekly, Petroleum Press Service/Petroleum Economist, Indepependent Petroleum Association of America, M. A. Adelman, World Petroleum Market, Association of Ship Brokers and Agents, International Petroleum Annual, Hughes Tool Company, Department of Energy, Platt's, Bureau of Mines, FEA, Census Bureau, Oil and Gas Journal, API, FPC, and OPEC.

COAL SUPPLY/DEMAND INDICATORS

[Million short tons except where noted]

Years	Coal production [1] (1)	Coal disappearance [1]: Total (2)=(3)+(7)	Domestic consumption: Total (3)=(4)+(5)+(6)	Domestic consumption: Utilities (4)	Domestic consumption: Coke ovens (5)	Domestic consumption: Other (6)	Exports (7)
1960	416	417	380	174	81.0	125.6	36.5
1961	403	409	374	180	73.9	120.9	35.0
1962	422	426	388	191	74.3	122.7	38.4
1963	459	456	409	209	77.3	122.5	38.4
1964	487	479	431	223	88.8	119.3	48.0
1965	512	509	459	243	94.8	121.7	50.2
1966	534	535	486	264	95.9	126.2	49.3
1967	553	530	480	272	92.3	116.4	49.5
1968	545	549	499	295	90.8	113.3	50.6
1969	561	563	507	308	92.9	105.9	56.2
1970	603	587	516	319	96.0	100.7	70.9
1971	552	551	495	326	82.8	85.8	56.6
1972	595	573	517	349	87.3	80.9	56.0
1973	592	609	556	387	93.6	75.5	52.9
1974	603	613	553	390	89.7	72.9	59.9
1975	648	622	556	403	83.3	69.8	65.7
1976	679	658	599	447	84.3	67.4	59.4
1977	691	674	620	476	77.4	67.4	53.6
1978	654	658	618	480	71.1	66.8	39.8
Months (annualized):							
July 1977	582	722	661	527	78.6	54.9	60.7
August 1977	678	695	645	518	72.6	54.6	50.4
September 1977	842	677	616	487	71.6	57.6	61.3
October 1977	794	649	591	450	74.6	66.4	57.3
November 1977	836	672	617	470	73.4	74.3	54.6
December 1977	364	680	634	485	71.5	77.7	46.0
January 1978	272	651	641	502	63.6	75.5	10.2
February 1978	307	607	600	466	54.2	79.8	7.2
March 1978	456	519	516	399	46.9	69.5	3.8
April 1978	724	585	553	420	66.9	66.4	31.6
May 1978	810	626	574	437	75.4	61.5	51.9
June 1978	798	696	631	494	77.6	59.0	65.7
July 1978	632	694	653	518	76.9	57.3	41.6
August 1978	758	716	674	541	75.8	56.8	42.0
September 1978	703	697	656	518	77.8	60.5	40.6
October 1978	823	673	615	468	78.7	68.5	57.8
November 1978	842	707	635	483	79.0	73.4	72.1
December 1978	702	719	667	513	79.2	74.5	51.7
January 1979	665	749	707	554	75.7	77.8	41.5
February 1979	699	731	696	545	75.8	75.3	35.1
March 1979	771	688	634	491	78.7	64.0	54.1
April 1979	770	676	612	473	78.2	61.6	63.6
May 1979	833	694	622	488	77.2	57.3	71.7
June 1979	801						71.7
July 1979	642						
August 1979	849						
Week ended:							
Aug. 4	783	(2)	(2)	(2)	(2)	(2)	(2)
Aug. 11	793	(2)	(2)	(2)	(2)	(2)	(2)
Aug. 18	830	(2)	(2)	(2)	(2)	(2)	(2)
Aug. 25	845	(2)	(2)	(2)	(2)	(2)	(2)
Sept. 1	850	(2)	(2)	(2)	(2)	(2)	(2)
Sept. 8	746	(2)	(2)	(2)	(2)	(2)	(2)
Sept. 15		(2)	(2)	(2)	(2)	(2)	(2)
Same week year ago	702	(2)	(2)	(2)	(2)	(2)	(2)
Percent increase (December) from year ago	6.2	10.8	8.4	11.6	2.3	(6.9)	9.2
Year to date:							
1978	600	598	576	445	61.5	70.4	28.5
1979	752	707	653	509	77.2	67.0	56.5
Percent increase (December) from year ago	24.8	18.3	13.3	14.5	25.5	(4.8)	98.0

See footnotes at end of table.

COAL SUPPLY/DEMAND INDICATORS—Continued

[Million short tons except where noted]

Years	Ending coal stocks [3]					
	Total		Utilities		Coke ovens	
	Quantity	Days supply (days)	Quantity	Days supply (days)	Quantity	Days supply (days)
	(8)	(9)	(10)	(11)	(12)	(13)
1960	73	66	51.7	94	11.0	47
1961	71	59	50.1	90	10.4	44
1962	70	59	50.4	85	8.3	45
1963	70	54	50.6	75	8.0	39
1964	75	56	53.9	78	10.1	40
1965	74	56	54.5	74	10.5	45
1966	74	51	53.9	67	9.2	37
1967	93	66	71.0	89	10.9	42
1968	86	58	65.5	72	9.5	45
1969	80	53	61.9	66	9.0	35
1970	92	60	72.4	76	8.9	34
1971	90	68	78.1	79	7.2	37
1972	115	75	100.0	93	9.0	37
1973	102	63	87.3	79	6.9	27
1974	96	62	83.5	74	6.0	31
1975	127	77	110.8	92	8.7	40
1976	134	74	117.5	88	9.8	44
1977	152	88	133.3	100	12.7	65
1978	142	78	128.4	91	8.2	38
Months (annualized):						
July 1977	137	76	123.4	85	9.8	46
August 1977	137	77	123.8	87	9.0	46
September 1977	145	86	130.4	97	10.4	54
October 1977	159	98	139.7	113	12.8	63
November 1977	173	102	149.7	116	15.5	78
December 1977	152	88	133.3	100	12.7	65
January 1978	118	67	105.3	76	8.1	47
February 1978	93	57	84.7	66	5.1	35
March 1978	84	59	77.2	70	3.8	29
April 1978	97	64	88.1	76	5.6	31
May 1978	111	71	100.8	84	7.1	35
June 1978	122	70	110.9	82	8.2	39
July 1978	120	67	109.9	77	6.6	32
August 1978	123	66	112.4	76	6.3	30
September 1978	126	70	115.3	81	6.2	30
October 1978	144	85	121.9	95	7.3	34
November 1978	143	82	129.5	98	8.5	40
December 1978	142	78	128.4	91	8.2	38
January 1979	132	68	120.1	80	7.4	36
February 1979	125	66	114.3	76	6.6	32
March 1979	130	75	118.4	88	7.4	34
April 1979	138	82	124.7	96	8.3	47
May 1979	147	86	133.8	100	8.9	42
June 1979						
July 1979						
August 1979						
Week ended:						
Aug. 4	(2)	(2)	(2)	(2)	(2)	(2)
Aug. 11	(2)	(2)	(2)	(2)	(2)	(2)
Aug. 18	(2)	(2)	(2)	(2)	(2)	(2)
Aug. 25	(2)	(2)	(2)	(2)	(2)	(2)
Sept. 1	(2)	(2)	(2)	(2)	(2)	(2)
Sept. 8	(2)	(2)	(2)	(2)	(2)	(2)
Sept. 15	(2)	(2)	(2)	(2)	(2)	(2)
Same week year ago	(2)	(2)	(2)	(2)	(2)	(2)
Percent increase (December) from year ago	32.6	21.1	32.8	19.0	24.2	20.0
Year to date:						
1978	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA
Percent increase (December) from year ago	NA	NA	NA	NA	NA	NA

See footnotes at end of table.

COAL SUPPLY/DEMAND INDICATORS—Continued

[Million short tons except where noted]

Year	Metallurgical coal demand indicators					
					Ending coke stocks [5]	
	Production of raw steel [4]	Production of pig iron [1]	Pig iron production/coal carbonized	Coke consumption [5]	Quantity	Days supply (days)
	(14)	(15)	(16)=(15)÷(5)	(17)	(18)	(19)
1960	99.3	67.3	(6)	56.9	4.7	30
1961	98.0	65.3	(6)	52.1	4.0	28
1962	98.3	66.3	(6)	51.8	3.9	28
1963	109.3	72.4	(6)	55.0	2.9	19
1964	127.1	86.2	(6)	62.6	2.0	12
1965	131.5	88.9	(6)	65.4	2.7	15
1966	134.1	92.2	(6)	66.0	3.1	17
1967	127.2	87.6	(6)	61.6	5.5	32
1968	131.4	89.3	(6)	62.4	6.0	35
1969	141.2	95.5	(6)	66.2	3.1	17
1970	131.5	91.8	(6)	63.2	4.1	24
1971	120.4	81.7	(6)	56.7	3.5	23
1972	133.2	89.4	(6)	60.0	2.9	18
1973	150.8	101.2	(6)	65.8	1.2	7
1974	145.7	95.9	(6)	64.1	.9	5
1975	116.6	79.9	(6)	53.7	5.0	34
1976	127.9	86.9	(6)	56.8	6.5	42
1977	124.7	81.3	(6)	54.1	6.4	43
1978	136.7	87.7	(6)	56.6	3.5	22
Months (annualized):						
July 1977	121.5	82.5	1.049	55.3	6.5	43
August 1977	122.4	79.6	1.097	53.7	6.3	43
September 1977	122.3	79.4	1.109	53.5	6.2	42
October 1977	122.9	77.6	1.041	48.5	6.6	49
November 1977	118.6	74.3	1.012	52.1	6.5	46
December 1977	118.1	75.6	1.058	52.3	6.4	45
January 1978	121.3	75.2	.997	49.4	5.9	44
February 1978	125.7	77.8	1.437	46.0	5.2	41
March 1978	130.5	81.2	1.729	54.7	3.5	23
April 1978	140.3	87.5	1.307	55.0	3.2	21
May 1978	145.1	93.4	1.239	65.9	3.0	17
June 1978	144.3	94.3	1.215	[7] 58.1	[7] 3.0	[7] 19
July 1978	134.1	89.9	1.169	60.6	2.8	17
August 1978	136.0	88.5	1.168	56.7	3.0	19
September 1978	139.5	89.9	1.157	58.0	3.0	19
October 1978	142.5	91.9	1.169	58.9	3.1	19
November 1978	141.8	91.6	1.160	58.2	3.3	20
December 1978	139.1	90.3	1.140	57.0	3.5	22
January 1979	130.8	83.2	1.099	54.0	3.5	24
February 1979	137.8	86.5	1.141	54.4	3.4	23
March 1979	148.1	93.6	1.190	57.9	3.3	21
April 1979	148.4	94.0	1.202	54.1	3.4	23
May 1979	150.6	97.5	1.263	[7] 59.3	[7] 3.4	[7] 21
June 1979	148.8	97.7	----------	59.7	3.2	20
July 1979	139.2	91.8	----------	----------	----------	----------
August 1979	----------	----------	----------	----------	----------	----------
Week ended:						
Aug. 4	137.0	(2)	(2)	(2)	(2)	(2)
Aug. 11	134.2	(2)	(2)	(2)	(2)	(2)
Aug. 18	133.6	(2)	(2)	(2)	(2)	(2)
Aug. 25	132.8	(2)	(2)	(2)	(2)	(2)
Sept. 1	134.6	(2)	(2)	(2)	(2)	(2)
Sept. 8	128.5	(2)	(2)	(2)	(2)	(2)
Sept. 15	126.8	(2)	(2)	(2)	(2)	(2)
Same week year ago	137.7	(2)	(2)	(2)	(2)	(2)
Percent increase (December) from year ago	(7.9)	2.1	(6)	2.8	7.7	5.3
Year to date:						
1978	134.4	85.7	(6)	55.0	NA	NA
1978	140.8	92.0	(6)	56.6	NA	NA
Percent increase (December) from year ago	4.7	7.4	(6)	3.0	NA	NA

[1] As reported by the Department of Energy (DOE), formerly the Bureau of Mines.
[2] Data available on a monthly basis only.
[3] Industrial stocks and retail dealer inventories. Total stocks and stocks at coke ovens are reported by the Department of Energy (DOE), formerly the Bureau of Mines. Utility stocks are reported by the Federal Energy Regulatory Commission (FERC), formerly the Federal Power Commission.
[4] Production of ingots and steel for castings as reported by the American Iron and Steel Institute.
[5] Includes both oven and behive coke, as reported by the Department of Energy (DOE), formerly the Bureau of Mines.
[6] This is a short-term indicator designed to anticipate changes in the demand level for metallurgical coal before the more traditional indicator—days supply for coke stocks (shown in col. 19). Because of technological advances—e.g., a long-term declining rate of coke used per ton of pig iron produced—it is not applicable for comparisons of annual data.
[7] Revised.

Sources: U.S. Bureau of Mines, Federal Power Commission, American Iron and Steel Institute, Department of Energy, Federal Energy Regulatory Commission.

Appendix IV. Production of Aviation Fuel To Be Obtained by Refining Shale Oil

[From early 1978 testimony based on 1977 figures]

SUMMARY OF DOE PROJECTIONS ON COST OF JET FUEL FROM SHALE

Source and location	Economically recoverable (10⁹ Bbl)	Time to 500,000 bbl/d	Jet fuel cost (barrel)	Environmental	Institutional	Technical
Petroleum:						
(a) Conventional:						
World	547.8		$18.19			
United States	29.5 (5.4 percent).					
(b) Tertiary recovery: United States.	52	1983	33.50	Minor [1]	Moderate [2]	Minor.[1]
Alternative liquid fuels:						
(a) Oil shale:						
World	Undetermined	1989	23.00	Major [3]	Major [3]	Do.[1]
United States	80 to 200					
(b) Tar sands/heavy oil:						
World	Undetermined	1989	23.00	Moderate [2]	Major [3]	Do.[1]
United States	2.5 to 5.5					
(c) Coal (liquefaction):						
World	2,406	2000	33.00	Major [3]	Major [3]	Major.[3]
United States	657 (27.3 percent).					
(d) Hydrogen: Worldwide	Unlimited	1995	22.00	Minor [1]	Undetermined	Do.[3]
(e) Biomass:						
World	Undetermined	1995	25.00	do.[1]	Moderate [2]	Do.[3]
United States	0.8 per year					

[1] Probably easily overcome.
[2] Some uncertainty; needs attention.
[3] Will prevent success of program unless solved; will require significant effort to overcome.

Source: DOE/AF/testimony and briefing, also DFSC price lists 1978.

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

April 8, 1980

The Honorable Lloyd Bentsen
Chairman, Joint Economic Committee
Congress of the United States

Dear Mr. Chairman:

On October 31, 1979, we sent to the Congress the enclosed report entitled "The U.S. Mining and Mineral-Processing Industry: An Analysis of Trends and Implications" (ID-80-04). In the report we analyzed the decline of several U.S. mineral activities and the resulting increase in reliance on imported minerals.

We are pleased that the Joint Economic Committee recognizes the critical importance of the issues this report raises and would like to include it in the Committee's Special Study on Economic Change. We are always happy to be of assistance to the Committee and we believe the report deserves the additional exposure it will receive as part of the Special Study on Economic Change report.

Sincerely yours,

Comptroller General
of the United States

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

The U.S. Mining And Mineral-Processing Industry: An Analysis Of Trends And Implications

The report analyzes the decline of several U.S. mineral activities and the resulting increase in reliance on imported minerals. The trends have contributed to (1) increased concern about possible supply interruptions, (2) lost jobs and job opportunities in the mineral industry, and (3) pressure on the U.S. balance of trade.

The causes for the decline are complex, but the report discusses several U.S. Government policies which, in order to achieve other objectives, have contributed to the decline, including access to public lands, environmental requirements, antitrust regulations, and health and safety requirements. Conversely, some foreign governments' policies tend to enhance and encourage their mining and minerals industries.

The report shows the need for better understanding of the cumulative effects of Federal policies on the industry. It suggests that the Congress should give serious consideration to establishing a mechanism to better identify national interest concerns in the industry and to identify and resolve conflicts between goals in the minerals area and those associated with the environment and other national interests.

UNITED STATES GENERAL ACCOUNTING OFFICE

ID-80-04
OCTOBER 31, 1979

COMPTROLLER GENERAL'S
TO THE CONGRESS

THE U.S. MINING AND MINERAL-PROCESSING INDUSTRY: AN ANALYSIS OF TRENDS AND IMPLICATIONS

D I G E S T

Although the United States is rich in minerals, the future of several segments of its mining and mineral-processing industry is dim, and U.S. manufacturers are relying more and more on imported mineral products.

The causes for this decline are complex. One factor is the cumulative effect of U.S. Government actions which, although in response to legitimate public concerns, have tended to discourage investment in domestic mineral projects. By contrast, many foreign governments encourage development of their minerals production.

GAO analyzed many of the trends in the U.S. mineral industry, concentrating on zinc, ferroalloys, copper, and aluminum, and found that:

--The closing of several zinc-processing facilities has reduced domestic capacity by almost 50 percent and imports of zinc metal have increased 89 percent. (See p. 5.)

--Imports of chromium and manganese ores for use in making ferroalloys have declined while imports of ferroalloys have increased substantially. (See p. 7.)

--Despite forecasts of annual growth in copper demand, no major new smelter or refinery capacity is likely before 1985; meanwhile imports of refined copper over the last 10 years have risen from 6 percent to over 19 percent of U.S. consumption. (See p. 8.)

Tear Sheet. Upon removal, the report cover date should be noted hereon.

--Although demand for aluminum is forecast to grow at about 7 percent annually through 1985, U.S. aluminum production capacity is only growing at 1.4 percent annually and imports of aluminum are expected to double by the year 2000. (See p. 9.)

GAO's analysis concentrated on U.S. and foreign government actions that influence these trends, particularly economic access to minerals, development and financing costs, labor costs, and energy availability and price. Because of limitations on available data, GAO did not attempt to quantify the extent to which these actions have contributed to the shift of mineral processing overseas or the extent to which changes in U.S. policies could reverse these trends. However, these actions are increasingly affecting market forces in the industry. For example, the U.S. Government:

--Limits the use of Federal lands for mineral exploration; some countries are actively encouraging and sponsoring exploration. (See p. 19.)

--Imposes strict environmental requirements which add significant costs to the development of domestic mineral projects; some countries are either more lenient in their enforcement or provide assistance to defray costs. (See p. 26.)

--Restricts the use of joint ventures to pool resources and share risks; some countries not only encourage joint ventures but often participate in the financing of projects through direct grants, loans, and loan guarantees. (See p. 34.)

--Adds to the cost of labor by imposing worker health and safety requirements; some countries are more lenient in their enforcement, use different techniques to protect workers, or provide assistance to defray costs. (See p. 38.)

In addition, the absence of a clear U.S. Government energy policy and the restrictions which delay or halt construction of power-generating facilities have created much uncertainty as to the future price and availability of energy supplies needed for the mineral industry.

The decline of the industry has resulted in (1) increased concern about U.S. vulnerability to supply interruptions, (2) lost jobs and job opportunities in the mineral industry, and (3) pressure on the U.S. balance of trade. (See ch. 5.)

The Congress enacted the Mining and Minerals Policy Act of 1970, thereby reaffirming its interest in an economically sound domestic mining and mineral processing industry. That general policy expression was prompted in part by growing concern over the degree to which the Nation was becoming dependent on foreign mineral supplies to satisfy domestic needs. Subsequently, the Congress enacted much more specific legislation pertaining to other national priorities and social goals, such as energy, the environment, and land conservation and use. Implementation of programs for achieving these national goals has tended to aggravate the circumstances which prompted adoption of the 1970 Mining and Minerals Policy Act.

Without a definitive policy for guidance, Government agencies responsible for developing and implementing national policies have little or no basis for making difficult tradeoffs between conflicting mandates. In addition, no criteria or organizational basis exists for considering other alternatives to mitigate trends or events harmful to the domestic mineral industry.

Congressional committees should focus on developing a mechanism for objectively considering the consequences of Government

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actions and for resolving conflicts between policies to assure that the overall national interest is served.

AGENCY COMMENTS

The Department of the Interior agreed that:

--There is a definite trend toward increased imports of processed versus raw materials and this trend is likely to continue in the future.

--Changes in U.S. Government policies over the last 10 years have increased the cost of mining and processing minerals in the United States.

--Some improvements may be appropriate in considering the consequences of Government actions and for resolving conflicts between policies to assure that the overall national interest is served.

However, it did express some concern with the lack of quantified evidence and the apparent reliance on interviews with industry officials and that the report indicated that the Department of the Interior is solely responsible for implementing the Mining and Minerals Policy Act of 1970. (See app. II.)

GAO agrees that the quantification of the impact of each factor on the trends in the mineral industry would be useful; however, doing so was beyond the scope of this report and was not necessary to conclude that the Government should become more aware of the effect of its actions on the mineral industry. GAO did interview corporate officials and reviewed corporate record and reports, but its conclusions were also based on corroborations from academicians, investment analysts, banking officials, U.S. Government officials (including those of regulatory agencies), and officials of foreign governments and corporations.

Although GAO agrees that any agency which deals with the mineral industry has responsibility for carrying out the 1970 Mining and Minerals Policy Act, the act does give Interior prime responsibility for its implementation. However, Interior, as well as other agencies whose actions have adversely affected the mineral industry, has largely ignored the act.

Contents

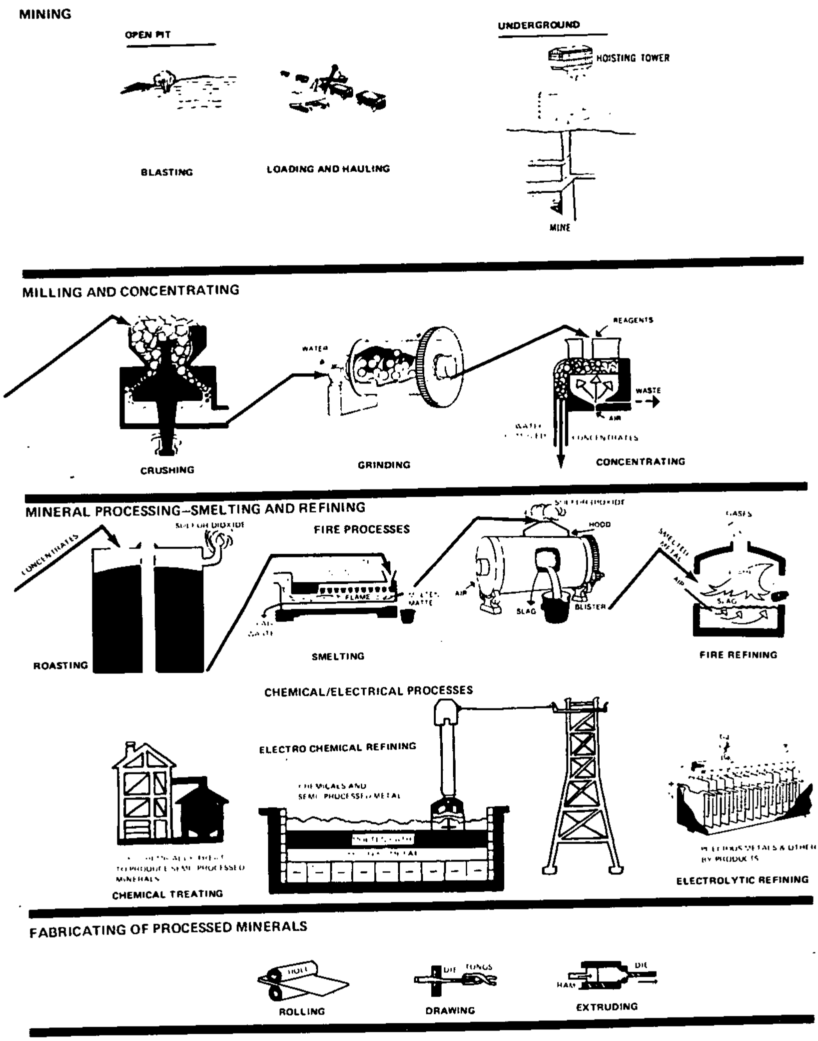
ABBREVIATIONS

BPA	Bonneville Power Administration
EPA	Environmental Protection Agency
FPA	Federal Preparedness Agency
GAO	General Accounting Office
OSHA	Occupational Safety and Health Administration
PASNY	Power Authority of the State of New York
TVA	Tennessee Valley Authority

GLOSSARY

alloy	A substance having metallic properties and composed of two or more chemical elements, at least one of which is a metal.
concentrate	Ore that has been treated to increase the percentage of valuable metal(s) within it.
concentrating	Mechanical and chemical treatment of ores to remove waste materials.
ferrous metal	A metal with iron as its major constituent.
nonferrous metals	Metals other than iron and its alloys in steel; usually applied to nonprecious metals such as copper, lead, and zinc.
ore	A natural mineral or mineral aggregate containing metals in such quantity, grade, and chemical combination as to make extraction profitable.
milling	The grinding or crushing of ore: it may include removal of valueless or harmful constituents and preparation for market.
primary metal	Metal extracted from ores, natural brines, or ocean water; also called virgin metal.
refining of metals	Operations performed after crude metals have been extracted from their ores to produce the metal in higher levels of purity.
reserve	An identified mineral commodity which can be economically and legally extracted.
resource	A concentration of naturally occurring material in such a form that economic extraction is potentially feasible.
secondary metal	Metal recovered from scrap by remelting and refining.
smelting	A reduction process, conducted in a furnace, in which metal is separated by fusion from those impurities with which it may be chemically combined or physically mixed, such as in ores or concentrates.

TYPES OF MINERAL ACTIVITY 1/



1/ THE ACTUAL ACTIVITIES USED VARY FROM METAL TO METAL AND ORE TYPE TO ORE TYPE.

FOR A GENERAL OVERVIEW OF THE PROCESSING STEPS GENERALLY USED FOR THE FOUR METALS DISCUSSED IN THIS REPORT ZINC, FERROALLOYS, ALUMINUM AND COPPER–SEE APPENDIX I

CHAPTER 1

INTRODUCTION

Assured access to mineral 1/ resources at prices established in competitive markets is important to the economic health of the United States. The question of resource availability and the extent to which the United States should rely on foreign mineral sources is complicated by national goals or policies which often operate at cross purposes. Also, to a large extent, traditional economic factors, such as remoteness of projects, ore grade, facilities and equipment needed, and access to capital, influence trends in the domestic and international mineral industries.

Compared with most nations, the United States is rich in mineral resources. 2/ Domestic smelters and refineries, using foreign ores and concentrates to supplement domestic mine production, have provided U.S. manufacturers with the majority of their mineral needs.

In recent years, however, several U.S. Government actions have reduced the profitability of domestic mineral projects, making investment in such projects less attractive than they otherwise would have been. These actions and the efforts of some foreign governments to encourage development of their minerals production have contributed to the failure of investment in domestic mineral production to keep pace with growth in U.S. demand. And, U.S. manufacturers are having to rely more and more on foreign processed minerals to meet their needs.

Some people contend that this trend is good because the United States can save its resources for future generations. This argument assumes that (1) mineral resources are approaching exhaustion and (2) the difference between the cost of extracting minerals and the price received for them is increasing fast enough to make delaying the earnings more profitable. However, these conditions have not been

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1/Unless otherwise specified, the term mineral as used in this report refers to nonfuel minerals and excludes coal, oil, uranium, etc.

2/Essentially, mineral richness is a function of land area. As would be expected of a geographically large country, the United States ranks first in reserves of copper, cadmium, lead, molybdenum, and silver and ranks high in many others.

historically true. The National Commission on Supplies and Shortages' 1976 report, "Government and the Nation's Resources," stated that:

> "The geologic, economic, and demographic evidence indicates that no physical lack of resources will seriously strain our economic growth for the next quarter century and probably for generations thereafter. Judging by past trends, the estimates of most reserves will increase; for the few cases in which crustal exhaustion is remotely likely, there will be sufficient warning for adjustments."

Another study 1/ of 14 depletable commodities, including aluminum, bauxite, copper, iron ore, and zinc, covering 1900 to 1975 showed that forced resource holdbacks beyond those in response to market forces would not have been economically beneficial to any generation. The study also showed that technological advancement can render unexploited natural resources valueless for future generations.

The Congress enacted the Mining and Minerals Policy Act of 1970 to declare that it is the continuing policy of the Federal Government in the national interest to encourage private enterprise to (1) develop an economically sound and stable domestic mining and mineral-processing industry, (2) develop domestic mineral reources to meet industrial, security and environmental needs, and (3) undertake research into mining, minerals, and metallurgy. The Department of the Interior through its Bureau of Mines and U.S. Geological Survey, the two organizations most involved with nonfuel minerals, is primarily responsible for implementing the act, which provided no new authority or funding.

As expressed in the House Committee on Interior and Insular Affairs report, the Congress expected that, because of the act, questions would be answered regarding: (1) the permissible degree of dependence on foreign supplies, (2) the need for stockpiling minerals for emergency situations, and (3) the impact of Government actions concerning taxation, manpower, health and safety, and environmental quality on the ability of the U.S. private sector to supply domestic needs.

The Congress subsequently enacted much more specific legislation pertaining to other national priorities and

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1/G.Anders, W.P. Gramm, S.C. Maurice. Does Resource Conservation Pay? International Institute for Economic Research, (Los Angeles: July 1978).

social goals, such as energy, the environment, and land conservation and use. Implementation of the latter legislation has largely ignored the Mining and Mineral Policy Act of 1970 and attempts to balance conflicting national goals or to determine other alternatives have been ineffective. During this time, the U.S. mining and mineral-processing industry has continued to decline and the United States has become more dependent on imported mineral products.

SCOPE OF REVIEW

We analyzed four metal industries--zinc, ferroalloys, copper, and aluminum--that reflect many of the problems and trends generic to the domestic mineral industry. The steel industry was excluded because we are currently evaluating national steel policies.

Our analysis concentrated on trends in production and on Government policy factors influencing these trends. Because of limitations in available data, we did not attempt to quantify the extent to which these actions have contributed to the shift of minerals-processing overseas or the extent to which changes in U.S. policies could reverse these trends.

Our analysis highlights (1) the problems faced by U.S. mineral operations in remaining competitive as a result of U.S. and foreign government actions and (2) the need for the Government to establish a mechanism for objectively considering tradeoffs and alternatives when resolving conflicts between national policies to assure resolutions which are in the overall best interest of the United States. We did not attempt to analyze the tradeoffs which must be made between Government actions.

In this review, we considered the mining and mineral-processing industry to include mineral exploration and identification; mining; crushing, grinding, screening, and separating; and concentrate smelting and metal refining to obtain a desired purity and/or mix of metals. Fabrication (the further processing of the smelted or refined metal) was not included.

We met with various U.S. Government and corporate officials and other interested persons and reviewed congressional hearings, reports, testimony, current legislative material, trade publications, and media articles and analyses. We also visited Mexico, Chile, Argentina, the Philippines, Australia, Sweden, Ireland, West Germany, Spain, and Norway to talk to foreign government, trade association, and corporate officials. Information concerning local mining and mineral-processing was provided by the U.S. Embassies in seven other countries.

CHAPTER 2

MINERAL IMPORT TRENDS: INCREASING RELIANCE ON FOREIGN PROCESSED MINERALS

The increasing reliance of U.S. manufacturers on foreign processed minerals varies from metal industry to metal industry, as does the degree to which the minerals have been processed. Imports of processed minerals are replacing domestic metal production, which uses both domestic and imported ores and concentrates. As a result, processed minerals (as opposed to ores and concentrates) represent an increasing proportion of mineral imports.

This trend is often believed to be the result of developing countries' insistence on sharing in the value added to raw minerals by having the processing done in the country where the ore was mined; however, developed countries--both those which are resource rich and those which process imported ore--continue to supply the vast majority of U.S. needs. Plans for further expansions and/or new developments indicate that developing nations will be playing a more significant role in providing processed minerals to world markets.

RELIANCE ON MINERAL IMPORTS VARIES FROM METAL TO METAL

U.S. reliance on mineral imports is increasing each year. However, a closer look at individual metals shows that the degree of reliance and the impact on the U.S. producers differ considerably. For example, several zinc-processing facilities have closed since 1969, reducing domestic zinc production. During this same period, domestic production of ferrochromium and ferromanganese alloys has been reduced as the facilities were converted to produce other alloys. In both industries, these reductions in domestic production have resulted in significant increases in U.S. reliance on foreign processed minerals, which represent over 50 percent of current U.S. consumption.

The reduction in domestic copper production has not been as pronounced. Few copper facilities have actually closed but reduction in production levels have been quite extensive, and imports of copper now represent almost 20 percent of U.S. copper consumption.

U.S. aluminum production continues at peak levels. However, little expansion of domestic aluminum production facilities is being planned to meet projected increases in U.S. consumption. Instead, these increases are going to be met by expansions of aluminum production facilities in other countries. Net imports now represent about 10 percent of U.S. aluminum consumption.

Trends for these four metals are discussed in the following sections; their causes and implications are discussed in subsequent chapters.

Zinc

Zinc stands fourth among metals in annual world consumption, and the United States consumes about one-fifth of the annual world zinc production . The construction and transportation industries account for about two-thirds of U.S. zinc metal consumption. Zinc is also a major alloying ingredient in brass and a chemical compound in rubber and paints.

U.S. industrial demand for zinc has been relatively stable for the last decade; however, the Bureau of Mines forecasts an annual 2-percent growth in demand through the turn of the century, although inroads could be made by alternate materials (aluminum and plastics). The Bureau also suggests further increased demand resulting from more extensive use of zinc for corrosion protection of steel. U.S. production capacity, however, has generally declined. Despite the startup of a new zinc plant in 1978, the closing of eight plants 1/ in the last decade, as shown below, reduced domestic capacity by almost 50 percent.

Company	Plant location	Year closed
Eagle Picher	Henryetta, Oklahoma	1969
Anaconda	Anaconda, Montana	1969
Mathiessen & Hegeler	Meadowbrook, West Virgina	1971
New Jersey Zinc	Depue, Illinois	1971
American Zinc	Dumas, Texas	1971
Anaconda	Great Falls, Montana	1972
Amax	Blackwell, Oklahoma	1973
Asarco	Amarillo, Texas	1975

As the following diagram shows, the production lost through these closings has, for the most part, been replaced by increased imports of zinc metal. Over the past decade, overall zinc imports have been relatively constant; however,

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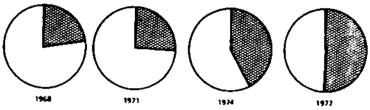
1/Two other plants were also closed during this period; however, they were modernized and have since reopened.

zinc metal imports (shaded) have increased significantly as a percentage of U.S. consumption. Zinc ore and concentrate imports (used by plants to supplement domestic mine production) have dropped 77 percent while zinc imported in metal form increased 89 percent.

ZINC METAL IMPORTS AS A PERCENT OF U S CONSUMPTION 1968 1977



Only about half the zinc needed is currently supplied from domestic mines although identified domestic reserves could provide up to 60 percent of domestic needs through the year 2000, and reasonable probability exists that new domestic areas of zinc-bearing minerals can be located that would improve the degree of self-sufficiency.

Ferroalloys

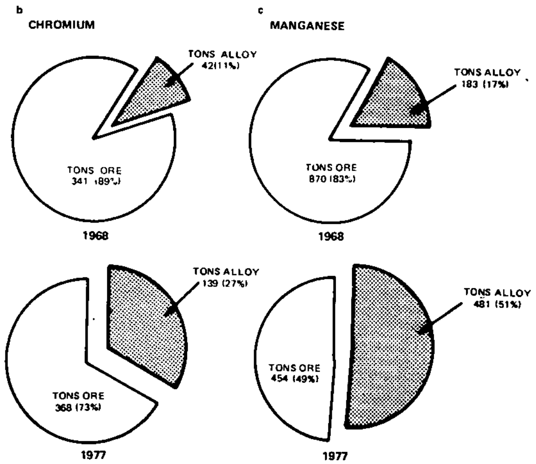
Ferroalloys, primarily mixtures of iron and some other metal, impart distinctive qualities, such as hardness or corrosion resistance, to steel, cast iron, and aluminum, or serve important functions during the production of the three metals. The principal ferroalloys are those which use chromium, manganese, and silicon.

Because of its direct relationship to the iron and steel industry, ferroalloy demand is subject to the cyclical fluctuations historically experienced by that industry. Within this context, demand for ferroalloys has been relatively stable during the last decade; however, the Bureau of Mines forecasts that through 1985 demand will increase at an annual rate of about 3.4 percent for primary chromium, 1.6 percent for manganese, and 3 percent for silicon alloys and metals, reflecting current and expected changes in iron and steel production technology.

Although U.S. demand overall has been relatively steady and is expected to grow, domestic production levels for some ferroalloys are being reduced while others are increasing. Chromium and manganese alloy furnaces in some facilities have been switched to silicon production and, in a few cases, plants are closing. Silicon capacity, on the other hand, has increased due to the switch in product mix and, in a few instances, new silicon facilities have opened.

The result of these changes can also be seen in ferroalloy imports. The United States has been almost 100-percent dependent on foreign sources for chromium and manganese ores and concentrates to supply domestic ferroalloy processors. Recently, as the diagram below shows, imports of chromium and manganese ore have been replaced by imports of ferroalloy metals.

COMPARISON OF THE IMPORT COMPONENTS OF U.S.
CHROMIUM AND MANGANESE SUPPLY 1968 AND 1977 (note a)



a/ PERCENTAGES BASED ON METAL CONTENT OF ORE AND FERROALLOY IMPORTS.

b/ CHROMIUM ORE IMPORTS ARE ALSO USED FOR CHEMICAL AND REFRACTORY PURPOSES. DEMAND FOR THESE USES RANGED FROM 21 TO 47 PERCENT OF ORE IMPORTS DURING THE PERIOD 1970-1977. THEREFORE, THE ORE/ALLOY SHIFT DEPICTED ABOVE WOULD BE EVEN GREATER IF THIS WERE TAKEN INTO ACCOUNT.

c/ MANGANESE ORE IMPORTS ARE ALSO USED FOR CHEMICAL AND BATTERY PURPOSES. DEMAND FOR THESE USES RANGED FROM 6 TO 14 PERCENT OF ORE IMPORTS DURING THE PERIOD 1970-1977. THEREFORE, THE ORE/ALLOY SHIFT DEPICTED ABOVE WOULD BE EVEN GREATER IF THIS WERE TAKEN INTO ACCOUNT.

SOURCE: BUREAU OF MINES

Copper

Copper has been one of the more important metals in the advance of civilization. Its heat and electrical conductive properties make it an essential part of the world's power and telecommunications industries. Electrical applications account for over half of U.S. copper consumption.

The United States used over one-fifth of the 1977 world copper supply and is expected to continue as a major consumer of copper. U.S. industrial demand for a little over 2 million tons annually has been relatively stable, except for 1975, when a worldwide recession severely reduced demand. The Bureau of Mines has forecast an annual growth in U.S. demand of 3.5 percent between 1975 and 2000.

While there may be some increase in mine production, no major new U.S. smelter or refinery capacity is likely to come onstream before 1985. In fact, in 1977 the International Trade Commission reported that only 65.5 percent of refinery capacity was being used. (Optimal capacity use is approximately 90 percent.)

More specifically, Atlantic Richfield Company reported that its Anaconda subsidiary closed down some copper operations and curtailed others (one of its three refineries was shut down). Amax, Inc., reported that its Twin Buttes Mine sulfide ore concentrator (which provides smelter feedstock) operated at only 60 percent of capacity during 1976 and until October 1, 1977, and then was reduced to 40 percent of capacity.

Despite increases in prices in early 1979, many domestic copper production facilities continued to operate at less than optimal capacity. While domestic production was being curtailed, imports grew significantly. Except for 1975, total imports of refined copper have been increasing.

Year	Imports	Domestic consumption	Imports as percent of consumption
	(000 short tons)		
1969	131	2,142	6.1
1970	132	2,043	6.5
1971	164	2,020	8.1
1972	192	2,239	8.6
1973	206	2,437	8.5
1974	314	2,194	14.3
1975	147	1,535	9.6
1976	382	1,992	19.1
1977	391	2,185	17.9
1978	457	2,392	19.1

Aluminum

Aluminum's high strength-to-weight ratio accounts for its prominent role in the U.S. economy. In 1977, U.S. industrial demand represented 33 percent of total world primary aluminum consumption. The Bureau of Mines forecasts an annual growth in demand of 7 percent through 1985, partly because of the transportation industry, which is trying to reduce vehicle weight and increase fuel economy.

Despite this demand, the aluminum industry has shown little overall growth in domestic production capacity; a growth of only 1.4 percent annually through 1983 is forecast because of various problems which have discouraged new investment. Thus net aluminum metal imports, which accounted for only 10 percent of U.S. consumption in 1978, are expected to increase to 15 percent by 1985 and 20 percent by 2000.

TRENDS IN THE SOURCES FOR U.S. MINERAL IMPORTS

Increased advancement of the mineral industries in developing countries is a logical outcome of their insistence that they share in the value added to their raw minerals by having the processing done within their own borders. By doing this, they hope to expand their economic base, improve their standards of living, provide employment, and generate foreign exchange with which to purchase goods they cannot produce themselves.

Because of these positive benefits to developing countries, a perception often exists that the loss of U.S. mineral producing capacity should not be viewed with concern. However, our analysis shows that the developing countries are shipping increased tonnages of processed minerals to the United States, but that most increases in U.S. mineral imports, except for copper, continue to come from other developed industrialized countries.

Canada is the principal supplier of nonfuel minerals to the United States, and in 1975 accounted for one-third the value of all crude mineral ores, concentrates, and scrap and for a slightly higher share of semiprocessed mineral imports. Because of its close proximity and abundance of mineral resources, it is easy to see why Canada is one of the principal sources for 23 of 36 minerals listed by the Bureau of Mines for which the United States depends on imports to some degree. Two other developed countries---Australia and South Africa--are among the principal sources for 6 and 9 of these minerals, respectively. These three countries are the primary sources for 23 of 36 major minerals. (See table 1.)

Table 1

Major Foreign Sources of Selected Metals and Minerals 1974-77

Metals and minerals	Major foreign sources (note a)
Aluminum:	
Metal	Canada
Alumina	Australia, Jamaica, Surinam
Bauxite	Jamaica, Guinea, Surinam
Antimony	South Africa, Mexico, Bolivia, Canada
Asbestos	Canada, South Africa
Barite	Peru, Ireland, Mexico
Cadmium	Canada, Mexico, Australia, Belgium-Luxembourg
Cement	Canada, Norway, Bahamas, Mexico
Chromium:	
Ferrochromium	South Africa, Rhodesia, Japan
Chromite	South Africa, Russia, Philippines
Cobalt	Zaire, Belgium-Luxembourg, Zambia, Finland
Columbium	Brazil, Thailand, Canada
Copper	Canada, Chile, Peru, Zambia
Fluorspar	Mexico, Spain, South Africa, Canada
Gold	Canada, Switzerland, Russia
Gypsum	Canada, Mexico, Jamaica, Dominican Republic
Iron and Steel products	Japan, Europe, Canada
Iron ore	Canada, Venezuela, Brazil, Liberia
Lead	Canada, Mexico, Peru, Australia
Manganese:	
Ferromanganese	France, South Africa, Japan
Ore	Gabon, Brazil, Australia, South Africa
Mercury	Algeria, Canada, Spain, Mexico
Mica (sheet)	India, Brazil, Malagasy Republic
Nickel	Canada, Norway, New Caledonia, Dominican Republic
Platinum group metals	South Africa, Russia, United Kingdom
Potash	Canada, Israel, West Germany
Salt	Canada, Bahamas, Mexico
Selenium	Canada, Japan, Yugoslavia, Mexico
Silver	Canada, Mexico, Peru, United Kingdom
Strontium	Mexico, Spain
Tantalum	Thailand, Canada, Malaysia, Brazil
Tin	Malaysia, Bolivia, Thailand, Indonesia
Titanium (ilmenite)	Canada, Australia
Tungsten	Canada, Bolivia, Peru, Thailand
Vanadium	South Africa, Chile, Russia
Zinc	Canada, Mexico, Australia, Belgium-Luxembourg

a/Listed in descending order of amount supplied

Source: Bureau of Mines

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Although developed countries' dominance as suppliers of minerals to the United States will probably continue, many developing countries are expanding their mining and mineral-processing industries and increasing their role as mineral exporters to the United States. The relative importance of these countries now and in the future will vary from metal to metal, as we found in our study of zinc, copper, aluminum, and ferroalloys.

Zinc metal imports have continued to come mainly from developed countries, especially Canada, as shown in table 2. Although import tonnage from developing countries almost doubled between 1971 and 1977, these countries' relative contribution to total U.S. zinc imports has changed very little. In the future, however, a greater share of new smelter capacity seems to be planned for developing countries, which could result in increased imports of zinc from them.

Table 2

Zinc Metal Imports

Developed countries	1971		1974		1977	
	000 short tons	Percent	000 short tons	Percent	000 short tons	Percent
Australia	38.6	12.1	38.9	7.2	29.3	5.1
Belgium	9.4	2.9	30.4	5.6	43.0	7.5
Canada	150.9	47.2	270.2	50.1	239.6	41.5
Finland	31.7	9.9	10.6	2.0	32.7	5.7
Japan	8.7	2.7	52.7	9.8	14.4	2.5
West Germany	3.7	1.1	8.3	1.5	41.6	7.2
Others	28.3	9.0	28.7	5.2	81.3	14.0
	271.2	84.9	439.7	81.5	481.7	83.5
Developing countries						
Mexico	10.1	3.2	23.5	4.3	30.0	5.2
Peru	23.9	7.5	31.1	5.8	18.9	3.3
Zaire	8.9	2.8	17.8	3.3	35.7	6.2
Others	.3	.1	5.6	1.1	-	-
	43.2	13.5	78.0	14.5	84.6	14.7
Planned economy countries						
Poland	2.6	.8	9.2	1.7	3.9	.7
Yugoslavia	.1	-	12.3	2.3	3.6	.6
Others	1.2	.4	.2	-	1.1	.2
	4.0	1.2	21.8	4.0	8.6	1.5
Unidentified	1.2	.4	-	-	1.9	.3
Total a/	319.6	100.0	539.5	100.0	576.7	100.0

a/Figures may not add to totals due to independent rounding of individual country data.

For refined copper, imports from developing countries have increased in both tonnage and relative contribution to total U.S. copper imports. As table 3 shows, refined copper imports from developing countries now exceeds the volume imported from developed countries. Canada continues to be the major import source, but imports from developing countries are likely to continue increasing because major copper smelter/refinery expansions are planned for such developing countries as Mexico, Zaire, Peru, Iran, the Republic of Korea, Panama, and the Philippines. In addition, plant expansions are planned for the centrally planned economy countries of Poland, Yugoslavia, and the People's Republic of China.

Table 3

Refined Copper Imports

	1968 (note a)		1971		1974		1977	
	000 short tons	Percent	000 short tons	Percent	000 short tons	Percent	000 short tons	Percent
Developed countries								
Belgium	57.9	14.5	.5	.3	8.0	2.6	14.1	3.6
Canada	135.1	33.8	123.0	75.0	118.4	37.8	101.2	25.9
Japan	-	-	-	-	73.1	23.3	-	-
Netherlands	3.7	.9	1.6	1.0	3.2	1.0	10.4	2.7
West Germany	55.3	13.8	4.4	2.7	7.2	2.3	10.4	2.7
United Kingdom	22.6	5.6	5.5	3.4	6.6	2.1	.4	.1
Others	8.6	2.2	2.7	1.6	1.2	.4	16.7	4.2
	283.2	70.8	137.7	84.0	217.7	69.4	153.2	39.2
Developing countries								
Chile	42.9	10.7	11.0	6.7	66.5	21.2	87.6	22.4
Mexico	1.1	.3	1.0	.6	.9	.3	6.3	1.6
Peru	18.5	4.6	3.5	2.1	6.9	2.2	49.0	12.5
Zambia	22.9	5.7	6.7	4.1	2.8	.9	77.9	19.9
	85.4	21.3	22.2	13.5	77.2	24.6	220.7	56.5
Planned economy countries								
Poland	-	-	.4	.2	2.2	.7	-	-
Yugoslavia	9.7	2.4	3.6	2.2	14.8	4.7	16.8	4.3
Others	-	-	-	-	1.1	.4	-	-
	9.7	2.4	4.0	2.4	18.1	5.8	16.8	4.3
Unidentified	21.9	5.5	-	-	.5	.2	-	-
Total	400.2	100.0	164.0	100.0	313.6	100.0	390.8	100.0

a/Imports were unusually high in 1968 due to a labor strike which closed more than 90 percent of the domestic industry plants. The strike started in July 1967, and full operation did not resume in most plants until April 1968.

Reliance on developed countries for aluminum also is decreasing. Several developing countries, such as Brazil, Venezuela, and Guinea, have good aluminum-producing potential because of the availability of low-cost energy and government support for development. Meanwhile, the expansion of aluminum production in developed countries will probably occur primarily in Canada and Australia.

Table 4

Aluminum Metal and Crude Alloy Imports

Developed countries	1970		1972		1974		1977	
	000 short tons	Percent	000 short tons	Percent	000 short tons	Percent	000 short tons	Percent
Canada	327.0	93.4	508.2	76.9	408.3	80.3	500.2	74.6
France	-	-	17.2	2.6	2.7	.5	5.8	.9
Japan	.5	.1	.2	-	10.2	2.0	-	-
Norway	20.0	5.7	63.9	9.7	14.4	2.8	12.5	1.9
United Kindgom	.4	.1	24.5	3.7	3.1	.6	10.4	1.6
Others	.1	-	.2	-	3.6	.7	7.0	1.0
	348.0	99.4	614.3	92.9	442.3	87.0	535.9	80.0
Developing countries								
Bahrain	-	-	-	-	-	-	9.3	1.4
Ghana	-	-	40.6	6.1	56.7	11.1	105.6	15.8
Mexico	-	-	5.0	.8	.2	-	-	-
Surinam	-	-	-	-	7.6	1.5	13.7	2.0
Others	-	-	-	-	-	-	5.6	.8
	-	-	45.6	6.9	64.4	12.7	134.2	20.0
Planned economy countries								
Poland	1.7	.5	.5	.1	-	-	-	-
Yugoslavia	-	-	-	-	1.2	.2	.1	-
Others	-	-	-	-	.5	.1	-	-
	1.7	.5	.5	.1	1.7	.3	.1	-
Unidentified	.4	.1	.6	.1	.2	-	-	-
Total	350.1	100.0	661.0	100.0	508.6	100.0	670.2	100.0

For ferroalloys, developed countries continue to dominate U.S. imports, despite the fact that South Africa is the only developed country with significant ore reserves of both chromium and manganese. While this reliance is likely to continue, production capacity is being expanded in developing countries; Brazil is expanding alloy production capacity for manganese and chromium alloy, and Mexico and India are expanding their ferromanganese capacities.

Table 5

Ferromanganese Imports, including Silicomanganese

Developed countries	1968 a 000 short tons	1968 Percent	1971 a 000 short tons	1971 Percent	1974 a 000 short tons	1974 Percent	1977 a 000 short tons	1977 Percent
France	39.3	22.1	71.6	34.2	164.9	44.3	112.2	23.6
Japan	0.7	0.4	2.3	1.1	34.2	9.2	41.2	8.7
Norway	13.1	7.4	27.4	13.1	23.4	6.3	29.7	6.3
Portugal	-	-	-	-	0.4	0.1	30.1	6.3
South Africa	33.2	18.7	70.9	33.9	101.8	27.3	119.0	25.1
West Germany	29.8	16.8	1.3	0.6	2.2	0.6	18.4	3.9
Others	33.6	18.9	7.4	3.5	26.6	7.1	37.6	7.9
	149.7	84.3	181.0	86.5	353.6	94.9	388.2	81.8
Developing countries								
Brazil	-	-	-	-	3.0	0.8	40.8	8.6
India	13.0	7.3	24.5	11.7	11.2	3.0	4.2	0.9
Mexico	1.0	0.6	1.7	0.8	-	-	25.4	5.3
Others	8.9	5.0	-	-	1.0	0.3	4.3	0.9
	23.0	12.9	26.2	12.5	15.2	4.1	74.7	15.7
Planned economy countries	-							
Yugoslavia	4.9	2.8	2.1	1.0	3.7	1.0	11.5	2.4
Total (note b)	177.6	100.0	209.2	100.0	372.6	100.0	474.4	100.0

a/Maganese content.

b/Figures may not add to totals due to independent rounding of individual country data.

Table 6

Ferrochromium Imports

Developed countries	1968 [a] 000 short tons	1968 Percent	1972 [a] 000 short tons	1972 Percent	1974 [a] 000 short tons	1974 Percent	1977 [a] 000 short tons	1977 Percent
Japan	1.5	.4	11.9	13.2	5.6	5.4	5.3	3.9
South Africa	17.4	42.4	31.5	34.9	37.4	36.4	61.0	45.4
Sweden	5.5	13.4	7.9	8.8	5.1	5.0	5.6	4.2
West Germany	6.5	15.9	3.6	4.0	4.5	4.4	2.5	1.9
Others	7.0	17.1	13.4	14.8	4.4	4.3	4.7	3.5
	37.9	92.4	68.3	75.7	57.0	55.4	79.1	58.9
Developing countries								
Brazil	-	-	2.5	2.8	6.1	5.9	6.1	4.5
Rhodesia (note b)	-	-	10.7	11.7	23.5	22.9	33.7	25.1
Turkey	2.4	5.9	4.7	5.2	1.9	1.8	-	-
Others	-	-	-	-	0.1	.1	-	-
	2.4	5.9	17.9	19.8	31.6	30.7	39.8	29.7
Planned economy countries								
Yugoslavia	0.8	2.0	4.0	4.4	14.2	13.8	15.3	11.4
Total (note c)	41.0	100.0	90.2	100.0	102.8	100.0	134.2	100.0

a/Chromium content.

b/The apparent shift to reliance on developing countries for ferrochromium is explained by increased imports from Rhodesia in anticipation of U.S. compliance with the U.N. sanctions against Rhodesia, which precluded purchases of Rhodesian chromium.

c/Figures may not add to totals due to independent rounding of individual country data.

CONCLUSIONS

Although the degree of reliance varies among minerals, the general trend is toward increased reliance on imports. More importantly, these imports are increasingly coming into the United States in the form of processed minerals--that is, metal rather than ores or concentrates.

While these trends currently cause concern, of more concern is the probability of increasing U.S. reliance on mineral imports in the futures. As discussed in chapters 3 and 4, many of the factors contributing to these trends are continuing and in some cases seem to be intensifying. As a result, most replacement and expansion of mineral-processing capacity for the four metals reviewed is planned for locations outside the United States.

CHAPTER 3

FACTORS INFLUENCING THE IDENTIFICATION AND DEVELOPMENT OF DOMESTIC MINERAL PROJECTS

The increasing reliance of U.S. manufacturers on foreign processed minerals stems from the fact that investment for expanding and modernizing domestic mineral production capacity has not kept pace with growth in demand. This is happening because investment in domestic mineral projects has become less attractive, due in part to several Government actions which adversely affect their current and/or expected profitability.

With demand for mineral products growing and some existing operations playing out or becoming obsolete, continued investment in the development of mineral-producing operations is needed. A 1977 World Bank study estimated that $12.7 billion (based on constant 1975 U.S. dollars) must be invested in copper mines and smelters simply to maintain current levels of world copper production through the mid-1980s.

Mineral projects are very expensive. A $100-million project is not uncommon, and some projects cost more than $1 billion. Consequently, few companies can afford to finance such projects from cash generated through operations, and outside investors, usually commercial lending institutions, are sought to provide the needed capital.

When deciding on investment options, investors assess a project's expected development costs, operating costs, and expected revenues. Making such an assessment in the mineral industry is difficult because of the generally long payback period, cyclical nature of mineral prices, and general uncertainty about many of the costs involved.

Prospective investors also consider how projects' production costs compare with those of competitors. Projects with relatively high costs will cross the line between profit and loss earlier than will those of competitors as prices fall or costs rise; therefore, such projects will be less able to sustain operations during periods of low prices. Conversely, those projects that have relatively low costs (including fixed charges, such as interest on debt), are less sensitive to downward price fluctuations and are less risky ventures.

Because prices are basically established through the interaction of supply and demand and not upon an individual producer's costs, 1/ expected gross revenues would vary little between projects of similar capacity. Therefore, costs and the risks associated with them are the primary distinguishing factors in investment decisions. For that reason, we have focused on these aspects of the investment decisions.

Although investment decisions are very complex and are based upon many considerations, we focused on five that are significantly influenced by government actions:

--Economic access to minerals.

--Development and financing costs.

--Opportunity to pool resources.

--Labor costs.

--Energy availability and price.

This chapter discusses the first three areas. Chapter 4 discusses labor costs and energy availability and price considerations as well as several other U.S. and foreign government actions that affect revenues and costs and ultimately influence investment decisions.

To place the factors in perspective, we briefly discuss their importance to the investment decision and some traditional economic considerations. Measuring the effects of individual factors on investment decisions was beyond the scope of this review, however we do show the directions of influence (positive or negative) that U.S. and foreign governments are having in these areas. Similarly, reducing the adverse effect of any one government action would not neccessarily alter the trends discussed earlier and our discussion should not be interpreted as implying this. We do believe, however, that, taken together, government actions have and are influencing the trends.

1/Conversely, because there is little to differentiate one producer's metal from another's, prices paid by users at one point in time are essentially the same whether the metal is produced in the United States or abroad.

We recognize that tradeoffs must be made and that balancing the benefits of developing domestic mineral supplies versus achieving other national goals is a complex problem that cannot be easily resolved.

ECONOMIC ACCESS TO MINERALS HINDERED BY GOVERNMENTS' ACTIONS

One of the most critical factors in deciding whether to invest in developing or expanding mineral-processing facilities is the ability to locate and obtain adequate supplies of ores, concentrates, and unrefined metal at competitive prices. However, minerals are widely dispersed throughout the earth's crust and major mineral ore deposits are extremely rare.

The United States has vast amounts of many minerals needed in its economy but only small quantities or none at all of others. It has sufficient supplies of copper and silicon, although higher grades of copper ore are available in some other countries. Only about half the zinc needed is currently supplied from domestic mines, although U.S. reserves are large. Again, some foreign reserves are of higher grade.

U.S. processors are almost totally dependent on foreign sources for ores and concentrates of bauxite used in producing aluminum and chromium and manganese used in producing ferroalloys.

Consequently, the domestic mineral-processing industry relies on a mix of domestic and foreign sources for its processing requirements. And, events outside the United States as well as within can effect the availability of raw materials. For example, expansions of zinc-processing capacity in Canada in the early 1970s reduced the amount of zinc concentrate available for import by the Anaconda Company's Montana zinc smelter and was a factor in the Company's decision to close the smelter in 1972. This closure eliminated 162,000 tons of domestic zinc metal production capacity and resulted in increased zinc metal imports.

Effects of government actions

Although the natural distribution and quality of mineral deposits plays the major role in the availability of minerals, government actions can also greatly limit their availability. In the United States, restrictions on the use of Federal land hinder exploration and development of domestic mineral resources. Also, the imposition of embargoes or other measures can affect the ability of U.S. companies to import minerals at competitive prices.

Restrictions on Federal land use

The identification and development of new domestic mineral deposits is the important first step in assuring that U.S. mineral processors can continue to obtain minerals at competitive prices. The long leadtime from exploration to development dictates that the United States be concerned today if future production reductions are to be avoided. However, trends in exploration activity may be inadequate to provide for future consumption.

According to the Bureau of Mines, there is no evidence that land restrictions have affected domestic mineral production as yet because current production is using mineral reserves identified years ago. Therefore, as apparent as the trends in mineral production are, the influence of this factor is yet to be felt.

Currently, the Federal Government controls more than 760 million acres (about half of it in Alaska), or about one-third of the land in the United States. While access to these lands was once unrestricted, according to the Department of the Interior Task Force on Availability of Federally-owned Mineral Lands, about 42 percent of these lands have been completely withdrawn from mineral activity, another 16 percent is severely restricted, and 10 percent more is moderately restricted. These restrictions can seriously jeopardize or delay mineral exploration and development. For example, it has been estimated that Arizona contains 65 percent of U.S. copper reserves, but 70 percent of Arizona's land area is federally controlled.

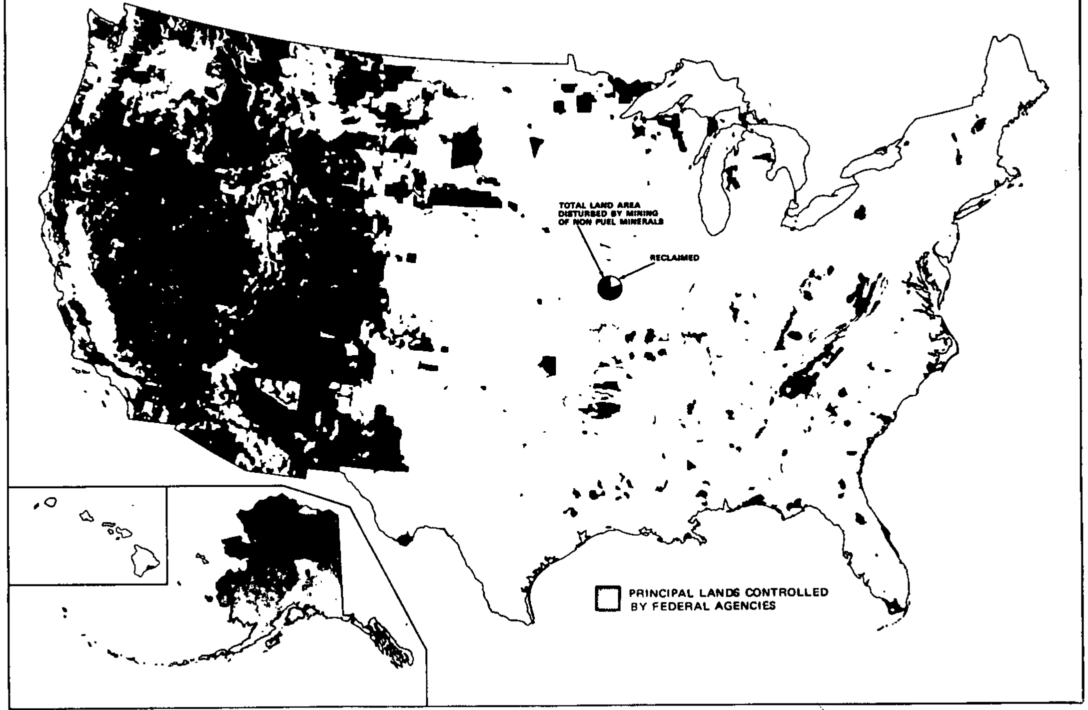
The methods used in exploration require large land masses to be covered to find the few small areas with potential mineral deposits. The probabilities are relatively strong that, when deposits are identified they will be on Federal lands, so access to some federally controlled lands are important to have meaningful exploration in the United States. According to the Task Force, because of the lack of a comprehensive withdrawal inventory and the inadequate mineral information compiled concerning Federal lands, the overall mineral capabilities of the Federal lands cannot be adequately determined. The Task Force also found that the level of mineral information entered into the decisionmaking process is frequently inadequate and little use is made of quantified economic analyses to compare costs and benefits.

In the 95th Congress, a bill that would withdraw approximately 100 million acres of Alaskan wilderness from mineral exploration was passed in the House but was opposed in the Senate and died without being resolved. However, through executive branch action in December 1978, about 100 million acres of Alaskan land was withdrawn from exploration as recommended in a Department of the Interior environmental impact statement.

Assessing the economic benefits to the Nation from development of Alaska's mineral potential was beyond the scope of our work. Accurate assessments of the mineral potential of these lands is very complex. However, one analysis of the mineral potential of Alaskan Federal lands was conducted by SRI International. According to this March 1978 study, "Impact of the Withdrawal of Alaskan Federal Lands:"

> "* * * in the absence of extensive legislative or regulatory impediments to the development of mineral resources, a mining industry could develop by the 1990's that would:
>
> > "Provide the nation with substantial quantities of nonfuel minerals, including gold, silver, copper, nickel, lead, zinc, molybdenum and asbestos, valued at between $900 million and $1 billion annually (in 1977 dollars).
> >
> > "Provide the nation with 20,000 to 40,000 additional jobs, representing about 0.5 percent of current unemployment.
> >
> > "Reduce the nation's balance of payments deficit by between $700 million and $1 billion annually (in 1977 dollars).
>
> "The above results are based on an analysis of seven specific mineral deposits considered commercially attractive * * *."
>
> * * * * *
>
> "All of the deposits are affected to some extent by proposed withdrawals of Alaskan lands, either because they fall within or close to lands proposed for withdrawal, or because access to the deposit is curtailed by the proposed withdrawals, or both. While more detailed study would be needed to fully determine the

PRINCIPAL LANDS CONTROLLED BY FEDERAL AGENCIES



OVER 760 MILLION ACRES OR ABOUT ONE-THIRD OF THE LAND IN THE UNITED STATES IS CONTROLLED BY THE FEDERAL GOVERNMENT. IN COMPARISON THE AMOUNT OF LAND AREA DISTURBED BY THE MINING OF NON FUEL MINERALS FROM 1930 THROUGH 1971 REPRESENTS ONLY 2.3 MILLION ACRES.

impact of the proposed withdrawals, it seems questionable whether any of the seven deposits could be developed if the more extensive proposals for withdrawal were enacted into law. Of perhaps even greater significance for the long term, the proposed withdrawals would likely have a severe effect on the possibilities for additional discoveries of rich deposits, such as the ones studied, because much of the area graded favorable or highly favorable by the Bureau of Mines for metallic minerals is included in the proposed withdrawals * * *."

* * * * *

"The land area disturbed by mining would be small; with proper reclamation procedures, the effects would be temporary. The total land area that would be disturbed by the seven mines analyzed in arriving at the above economic values, including all roads and other infrastructure would be about 25 square miles * * * that compares with about 586,000 square miles in all of Alaska and about 180,000 square miles proposed in various bills * * * for inclusion in parks, wildlife refuges, wild and scenic rivers, and wilderness areas."

In Montana another mineral development is being threatened by Federal land withdrawal. The Department of Agriculture's Forest Service is currently considering designating about 8,000 acres of land in Montana's Stillwater complex as a wilderness area under its RARE II program. According to the company considering development, this land contains commercially promising deposits of platinum and palladium. These are critically important industrial metals for which the United States depends heavily on the Soviet Union and the Republic of South Africa. Imports of these metals in 1977 adversely affected the U.S. balance of trade by about $275 million. Should the Forest Service decide to withdraw this land, the United States will lose the opportunity to develop domestic access to these important metals.

Because of such land withdrawals and the uncertainty over access to Federal lands in the future, several mineral exploration efforts are either being disbanded or shifted to areas outside the United States. For example, St. Joe Minerals Company has redirected much of its exploration from Alaska to Canada's Yukon Territory because, Company officials stated, it has similar land formations and the potential mineral development of Alaska but is more open to exploration.

Even when authority to explore Federal lands for minerals is granted, operating conditions must be followed which industry officials believe are overly restrictive and impede exploration and development. The conditions imposed include

--restrictions on the types of equipment that can be used, i.e., size limitations on helicopters;

--parameters for construction of roads and drill sites; and

--provisions for restoration.

Mineral exploration and development has also been hampered by administrative delays. To process lease applications for exploration and development on Federal lands, coordination is needed between Interior's U.S. Geological Survey and Bureau of Land Management and Agriculture's Forest Service. A Forest Service official estimated, based upon actual examples, that the minimum processing time for approval of a prospecting lease was 17 months and for a mineral lease and mining plan 3 years. For example, in August 1976, a U.S. firm applied for two hard-rock Federal prospecting permits covering tracts in Idaho. It took about 24 months of processing time for the permits to reach the Secretary of the Interior's office, where they were presented for signature by July 1978. As of April 1979, the applicant had not been advised of the final disposition of these permits.

In contrast to U.S. restrictions, several countries, in line with their own national priorities, successfully encourage exploration and mine development through government programs. For example:

--The Republic of South Africa funds and actively participates in exploration for certain minerals in areas selected for development.

--Ontario, Canada, funds one-third of approved exploration in selected areas.

--Argentina provides financial support and risk-sharing programs to assist in identifying and developing resources.

--The Republic of Korea directly funds a substantial mineral exploration program in support of its metal-processing industry.

--The Philippines and Spain provide development loans and loan guarantees to private companies to finance exploration and development of mineral deposits.

--Brazil has programs to finance or subsidize up to 80 percent of exploration costs.

Additionally, a number of countries, such as Japan, the Republic of Korea, France, and the Federal Republic of Germany, provide substantial incentives and subsidies to their minerals industries for exploration in foreign countries, usually with the understanding that their own processing industries will be assured access to the ores and concentrates from any deposits found.

Embargoes and other measures

Government actions can hinder the ability of the U.S. mineral industry to import raw materials.

The U.S. Government has imposed embargoes on imports from specific countries. A current example of this is the U.S. embargo on products from Rhodesia, including chromium ore. During 1966-71 and since 1977, U.S. ferrochrome alloy producers have not been permitted to obtain chromium ore from Rhodesia. This could have posed a serious problem to the ferroalloy industry but, fortunately, by the time the embargo was reimposed in 1977, new steelmaking technology permitted use of lower grade chromium ore from South Africa, the Soviet Union, Brazil, and Finland.

Foreign government actions have also limited the ability of U.S. firms to import raw materials at competitive prices.

Ontario, Canada, discourages exports of unprocessed minerals by requiring that all minerals produced in Ontario be processed in Canada. Firms must periodically apply for exemptions from this statutory provision in order to export ores or concentrates. Ontario also provides an economic incentive, called a "processing allowance," which reduces a company's tax liability as minerals are further processed in Canada.

The Mexican Government has imposed export levies on minerals. These have the practical effect of making the prices charged for exported Mexican ores higher than those paid by users in Mexico.

Conclusions

Relatively secure sources of ores, concentrates, and unrefined metals must be available at competitive prices if the domestic mineral industry is to be maintained or expanded. However, U.S. actions to preserve the environment hinder the exploration and development of domestic mineral resources and embargoes add to the problems of importing ores for processing in the United States. In contrast, some foreign governments tend to have less restrictions on exploration and development of mineral resources, and, in some cases, actively support such efforts. They also frequently provide incentives for the increased processing of minerals within their borders, which can further limit the availability of ores and concentrates to U.S. mineral processors.

DEVELOPMENT COSTS AND ACCESS TO CAPITAL ARE INFLUENCED BY GOVERNMENT ACTIONS

The cost of developing a mineral project is very large, and raising sufficient capital is very complex. In 1976 the Southern Peru Corporation began operating its copper mine and processing complex at Cuajone, Peru, at a cost of about $730 million. Over 50 financial institutions participated through direct loans in the complex financing arrangements that began in 1969. Supplier credits for the purchase of equipment and machinery and loans arranged through copper purchasers also helped finance the project.

The costs of developing mineral projects can vary significantly depending on many traditional economic factors, including their remoteness, facilities and equipment needed, and material and labor costs for construction. However, government actions are influencing these costs more and more; and to the extent that these actions increase costs, create uncertainty about future costs, or hinder capital formation, they discourage investment in mineral projects within a country's borders.

Mineral deposits are often found in relatively isolated areas, necessitating substantial investment for the roads, harbors, utilities, housing, and health and education facilities needed to support the project and its employees. For the most part, the United States has well-developed transportation and communication systems and supporting industries (for equipment and parts) and is a ready market for mineral products, giving many domestic mineral projects a relative cost advantage over projects in many other countries. However, some U.S. projects require considerable investment in infrastructure. For example, at Bagdad, Arizona, a domestic copper producer provides the housing, hospital, school, and shopping facilities for about 3,500 employees and dependents; a recent addition of 354 employee homes cost about $10.6 million.

The type and extent of facilities and equipment needed to develop projects also vary. Whether a mine is open pit or the more expensive underground type depends upon the nature of the rock formation and the closeness of the mineral deposit to the surface. Also, the quality of the ore, in terms of percent of desirable minerals and impurities, affects the processing methods and related facilities and equipment needed.

U.S. Government actions to protect the environment increase cost and uncertainty

One of the most significant ways the U.S. Government influences mineral development costs is through mandated environmental protection requirements. For instance, a study performed under contract for the Department of Commerce estimates that if compliance with Federal air and water pollution control standards and land-use requirements are fully enforced, it will cost the U.S. copper industry over $1.4 billion (1974 dollars) in capital expenditures during 1978-87. (Operating costs during this period are estimated to be an additional $1 billion.)

The regulatory issue is by no means simple. The desirability of protecting the environment is indisputable; however, the mineral industry and various U.S. Government regulatory agencies disagree considerably about the strictness and timing of the rules. Frequently disputed are the status of various control technologies, environment and health exposure thresholds, the cost to and ability of the industry to comply with regulations, and the value of anticipated benefits.

The Federal environmental regulations concerning sulfur dioxide emissions illustrate the complexity of these issues and the extent to which they increase the cost of projects in the United States. The Clean Air Act of 1970 requires the U.S. Environmental Protection Agency (EPA) to establish air quality standards for sulfur dioxide.

In a 1970 report to the Congress, entitled "The Cost of Clean Air," the Secretary of Health, Education, and Welfare

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asserted that 98.8 percent 1/ of sulfur dioxide emissions could be feasibly removed from copper, zinc, and lead plants (49 percent removal was average at the time) and that this could be accomplished at all primary nonferrous metallurgical plants in 100 selected areas over a 5-year period for a probable capital cost of $67.6 million.

However, domestic copper producers spent an estimated $695 million from 1974 to 1978 for sulfur dioxide emission controls. According to a report by Arthur D. Little, Inc., for EPA in 1978, producers could have to spend as much as an additional $953.5 million through 1987 (1974 dollars). 2/

The magnitude of these costs is such that EPA, as of January 1979, believes the anticipated future expenditures for sulfur dioxide control may prove to be beyond the means of a large portion of the smelting industry. Industry observers believe that, while 4 of the 16 primary copper smelters may be able to achieve a 90-percent sulfur dioxide removal rate, most smelters will continue to have difficulty. Our October 1978 report, "16 Air and Water Pollution Issues Facing the Nation" (CED-78-148-A/B/C) discusses the problems in implementing EPA's sulfur dioxide standard.

Other Federal environmental regulations are evolving with similar effects in much of the domestic mining and mineral-processing industry. For example, EPA has proposed new air quality standards for lead. A study for the Lead Industries Association by Charles River Associates, Inc., showed that meeting these standards will require substantial capital expenditures and could force the closure of as much as 80 percent of U.S. lead smelting and refining capacity, with a resulting increase in imports of a metal for which the United States is essentially self-sufficient. One Missouri lead smelter estimates its cost of compliance with this standard at more than $50 million.

1/EPA subsequently determined that capture of about 90 percent of the sulfur present in the ores/concentrates entering copper smelters would achieve national air quality goals.

2/The report assumes that three smelters will close in 1983 for a variety of reasons, no new capacity will come onstream, and only small additions to electrowinning capacity can be expected during 1983-87; this estimate assumes that the same smelters will close rather than incur compliance costs.

Compliance expenditures influence the competitiveness of domestic metals producers. This is particularly important during periods of weak metal prices, such as in 1977 when prices for copper fell as low as 51.9 cents a pound. Various industry and Government authorities estimate that environmental regulations have added an average of 10 to 15 cents a pound to the cost of producing refined copper. This can make the difference between profits and losses for U.S. copper producers.

Shifts in mineral sector investment due to regulatory constraints could benefit countries whose approaches to regulations are more flexible or willingness to support the additional costs may give projects cost advantages. For example, several countries, including Australia, the Philippines, Brazil, Venezuela, Sweden, West Germany, and Ireland give high priorities to the costs and practical consequences of environmental standards in determining the extent to which they will be enforced. Norway, Sweden, and West Germany also provide financial support for new equipment needed by firms, including equipment needed for environmental protection.

Because of the relatively high costs of emission control standards for the mineral industry in the United States, the industry and others have expressed concern that the development of new mineral processing may shift to other countries. The Arthur D. Little report prepared for EPA stated that "there appears to be emerging the perception that * * * the end of environmental regulations in the United States is nowhere in sight. Hence, new investment is likely to be exported abroad * * *." An official of a major U.S. primary aluminum company, in a paper presented to the American Mining Congress in 1977, commented that the probable consequence of standards and their implementation for aluminum producers will be that "most of the capacity growth needed to serve historical demand levels will have to take place off shore."

Representatives of several major commercial banks commented that in recent years banks have increasingly attempted to assess "regulatory risks" in considering mineral project proposals and that as perceptions of such risks grow, access to loan capital diminishes. One bank representative indicated that any loan made to finance a new domestic copper smelter would be loaded with protective conditions which would give a borrower difficulty but which would be necessary to protect the bank against "regulatory risks," specifically emissions regulation compliance problems.

A senior economist for Arthur D. Little, Inc., in remarks to a panel on corporate responsibilities and opportunities in June 1978, indicated that during the next decade the United States may have to make a basic policy tradeoff between environmental regulation and increasing dependence on foreign supplies of key nonfuel resources.

In addition to the administrative delays in gaining access to land, obtaining various Federal and State government approvals and permits to develop a mineral project in the United States can be lengthy. This puts domestic projects at a distinct disadvantage by adding to the uncertainty of the ultimate cost by delaying development while construction costs escalate.

Approval to develop a domestic mineral project usually requires

--preparation and approval of environmental impact statements and air, water quality, and solid waste disposal plans;

--preparation of a Cultural Resource Survey Report by a State historical preservation officer;

--negotiation of water rights; and

--a variety of State and local clearances.

Other countries sometimes have similar requirements, but the time required to obtain clearances is usually shorter and the escalation of project costs is minimized. For example, a steel mill in Japan, which has very strict environmental standards, could take 2 years from planning through construction and cost about $600 per annual ton of capacity. A similar project in the United States could take about 4 years and cost about $1,000 per annual ton of capacity. The time delay and related inflation were cited as one of the main reasons for the difference in costs.

Such delays and related increases in costs may result in new investment in mineral projects being made in other countries. For example, ALUMAX, Inc., has been planning to develop a 187,300-ton-capacity primary aluminum facility costing $184 million in Oregon. However, the project has been delayed since 1973 awaiting submission of an environmental impact statement by the Bonneville Power Authority, which would provide electricity for the facility. The statement has still not been finalized (the draft is 3,100 pages long and cost $5 million). Meanwhile, the cost of the project has escalated over 200 percent, to $400 million. An executive of ALUMAX stated that situations like this will probably force new primary aluminum projects out of the United States, thus increasing aluminum imports.

Financing of mineral projects becoming more difficult

Because of the large amounts of capital needed to finance the development of mineral projects, firms in recent years have been unable to fund projects with cash generated through operations. Instead, new projects or major expansions must be financed through a variety of other sources, such as commercial bank loans, government grants and subsidies, international financial institution loans, or sale of equity in the projects.

The ability to generate funds from these sources, however, can be constrained by the relative financial standing of the company developing the project. In recent years, the poor financial condition of many domestic mining and mineral-processing firms has hindered their abilities to obtain capital for mineral projects.

The Arthur D. Little report, in describing the financial performance of the nonferrous metals industry for the 6-year period ended in 1974, stated that "* * * the picture has been one of modest growth in sales, low return on invested capital, eroding profit margins, and higher debt * * *."

From financial data provided by Merrill Lynch Pierce Fenner & Smith, Inc., for domestic and foreign operations of eight U.S. minerals firms, we examined trends in returns on invested capital and the amount of debt and preferred stock compared with equity from 1966 to 1977. The average return on investment had declined dramatically from 1973 to 1977. Prior to that, it had fluctuated from year to year with no clear trend. (See table 7.)

Also, during the 12-year period, the companies increased their reliance on borrowed funds as sources of capital. Thus, for every $10 of equity in 1966, these firms had slightly less than $1 of debt; by 1977 they had over $5 of debt for every $10 of equity.

Table 7

U.S.-Based Mineral Industry Financial Trends

Year	Average return on invested capital (note a)	Average percent of debt and preferred stock to total equity
1966	16.6	9.4
1967	12.5	9.7
1968	14.2	12.4
1969	18.5	17.9
1970	18.0	22.9
1971	10.6	30.2
1972	10.9	34.4
1973	14.8	38.1
1974	16.9	32.0
1975	8.9	40.5
1976	7.3	48.1
1977	3.9	53.8

a/Return on investment computed after taxes; invested capital is equity and long-term debt with no credit for deferred taxes.

Banking representatives stated that when debt and preferred stock exceeds 23 percent of total equity or when debt exceeds 30 percent of total capitalization in a high-risk cyclical industry, such as mining and mineral-processing, there is a cause for concern and at least some of these firms are at their debt limit. Because of these problems, many firms do not have access to additional capital to expand or modernize their facilities or to undertake new projects.

Banking and investment industry representatives also expressed concern about the mineral industry's poor earnings record. They commented that firms in this industry should have an after-tax return on invested capital at least equal to that of U.S. manufacturing in general (about 15 percent).

Of 41 industrial groups analyzed by Citibank in 1978, the nonferrous metals group finished 40th in terms of net income (after taxes) as a percent of return on net worth in both 1976 and 1977. In both years, 1,745 firms in these 41 industrial groups averaged 15 percent on net worth. In contrast, the nonferrous metals group achieved only 8.5 percent in 1976 and 7.8 percent in 1977 (only 4 others of the 41 groups achieved less than a 10 percent return in 1977--one of which was iron and steel).

While the financial condition of U.S. mineral firms is hindering their ability to accumulate capital for domestic projects, foreign governments are often subsidizing or sharing the risks of projects within their borders as a way of stimulating development perceived to be in their national interest. One increasingly common technique is for governments to guarantee loans for projects. For example:

--Guyana guaranteed repayment to three banks for a $50-million loan to finance the development of bauxite/alumina facilities.

--The Government of Qatar guaranteed repayment to 25 banks for a $100-million loan to finance development of steel production facilities.

--New Zealand guaranteed repayment to a consortium of banks for a $100-million loan to finance mining activities.

--The Philippines guaranteed the loan for a recently completed copper mine which would not have been financed without the guarantee.

Foreign governments also have provided direct subsidies to finance new developments. For example, the Government of Ireland provided direct subsidies totaling more than $33 million for an aluminum company to construct and equip alumina production facilities. In 1974, the Canadian Government contributed $7.7 million in direct cash grants to the firm sponsoring a $63-million ferrosilicon production facility. Canada also recently contributed $18 million in cash grants and easy term loans as part of its participation with two European companies in a joint venture to develop a zinc mine.

Some governments have formed national development banks to foster growth in the minerals sector as part of economic development plans. The Development Bank of the Philippines has been effective in Philippine mining ventures through (1) loan guarantees to third parties, (2) direct funding of loans, and (3) direct investment in the project if necessary to get it started. Brazil's National Development Bank has aggressively loaned funds for steel and nonferrous metals projects as part of a national effort to reduce imports of these commodities. During 1976-79, the Bank estimated its participation in nonferrous metals projects at $111 million and in the steel industry at $518 million.

The Australian Resources Development Bank Limited was formed in 1967 by the country's major commercial banks with the support of the national government. The Bank's primary objective is to provide medium to long-term loans (5 to 12 years) for natural resource development projects. These loan periods are longer than those generally allowed by commercial banks and improve a project's financial viability. The Bank has loaned over $1 billion for natural resource development projects, including iron ore, nickel, tin, bauxite/alumina, zinc, copper, and mineral sands ventures in Australia during 1967-77.

Funds are also available for overseas projects through such international financial institutions as the International Bank for Reconstruction and Development (World Bank), the United Nation's Revolving Fund for Natural Resources Exploration, and regional development banks (i.e. the Asian Development Bank) and through international financing agencies of the United States, such as the U.S. Export-Import Bank and the Agency for International Development. In addition, the Overseas Private Investment Corporation, a Federal agency, is available to insure foreign projects against certain political risks.

These financing sources can play an important role in providing funds for projects in other countries that commercial banks will not support or for which specific governments cannot provide sufficient loans or loan guarantees. For example, the Government of Botswana provided $80 million to finance infrastructure facilities for the Selebi-Pikwe nickel-copper project with funds obtained through loans from the World Bank, Canadian International Development Agency, and the U.S. Agency for International Development.

Because of the availability of these project support techniques, access to capital for projects outside the United States is often greater and interest rates lower than they otherwise would have been. While this accomplishes one of the program objectives of increasing the supply of minerals to U.S. mineral processors, it can also put the U.S. mining and mineral-processing industry at a significant disadvantage in developing new domestic mineral projects.

Conclusions

The natural and traditional economic advantages and disadvantages of specific mineral projects greatly influence which projects are developed. However, more and more, U.S. Government actions have increased development costs and have influenced the availability of capital outside the United States, which has tended to make investments in domestic projects less attractive than they otherwise would be.

U.S. ANTITRUST LAWS MAY BE HAMPERING OPPORTUNITIES FOR POOLING RESOURCES

Companies engaged in capital intensive activities like mining and mineral processing often see the legal pooling of money, skills, property, equipment, and/or knowledge by two or more parties for some specific business purpose as a highly desirable way to share costs and risks.

However, officials of the U.S. mining and metals industry stated that U.S. antitrust policy discourages domestic firms from initiating joint ventures with each other and discourages foreign firms from forming joint ventures with U.S. companies because:

--U.S. antitrust laws are based on definitions of monopoly and competition that do not recognize the role of foreign competition in the domestic market.

--U.S. antitrust laws are nonspecific, and companies often spend considerable time evaluating proposed joint arrangements only to find that after initiation they are subject to Government surveillance and investigation.

--The extent of the applicability of U.S. antitrust laws to international activities of American multinational corporations is unclear and confusing.

--The Justice Department is antagonistic toward the Webb-Pomerene Act, a major antitrust exemption available to certain U.S. exporters.

Justice Department officials generally contend that the businessmen's assertions that they are discouraged from entering into joint ventures by fear of antitrust investigations goes to their state of mind and is impossible to verify or refute. The Department believes that the large number of joint ventures currently being operated by Americans and the lack of prosecutions of joint ventures in the last two decades tend to refute any concrete assertion about the inhibiting effect of the antitrust laws.

State Department officials, on the other hand, believe industry officials are truly fearful of antitrust investigations. They told us that in several instances industry officials have refused to participate with the Government in international mineral discussions because of antitrust concerns.

One specific example cited by State Department officials was the International Lead-Zinc Study Group.

Industry contends laws are outmoded

U.S. antitrust laws are intended to foster competition and to protect the American public from collusive business practices. However, some industry officials contend that these laws originated in an era when foreign producers held insignificant shares of domestic markets and definitions of monopoly and relative competitiveness were based almost entirely on production in the United States. They say that, while foreign competition has increased, the laws have not been updated to recognize its effect on the domestic market.

In contrast, antitrust legislation enacted by a number of other countries after World War II recognizes that their economies, for the most part, are no longer closed. In these countries, maintaining competition between domestic firms has become less important than maintaining competition between domestic and foreign industries. As a result, antitrust exemptions in these countries are more liberal than those of the United States. For example, Japan and the European Economic Community permit domestic companies to combine into commodity group cartels in order to improve production and marketing efficiencies and to encourage small, relatively inefficient firms to combine into one large-scale operation. Most of the major metallurgical plants built in Japan and Western Europe in recent years were built as joint ventures under this concept.

A Justice Department official disagreed that U.S. antitrust laws are somewhat outmoded due to their lack of recognition of the effect of foreign competition on U.S. markets. He said that, in fact, one of the earliest antitrust laws, the Wilson Tariff Act of 1894 (actually a tariff law with antitrust provisions), recognized the existence of foreign competition in the United States in its aim to halt abuses in U.S. import trade.

Concern about the lack of specificity

The major U.S. antitrust statutes--the Sherman Act (1890), the Clayton Act (1914), and the Federal Trade Commission Act (1914)--do not provide checklists of specific legal and illegal practices, but instead set forth principles of business behavior. Even though judicial precedents have helped to define the principles more clearly, firms considering a joint project must invest considerable time and resources in assessing whether the partnership might be susceptible to Government investigation.

According to domestic mineral industry officials, the perceived threat of investigation has inhibited a number of firms from considering joint ventures.

For instance, in the early 1970s, when U.S. copper smelters were pressed into producing sulfuric acid from waste gases as the most practical means of conplying with the Clean Air Act, some companies in the Southwest considered the possibility of a joint disposal effort. Because of their distance from the main sulfuric acid marker (the industrial Midwest) and because of the high cost of producing sulfuric acid, the companies believed that a joint venture would ease some of the difficulties involved in disposal of the acid. However, they decided that even though they could make a strong case for the legality of the venture, it would still be viewed with great suspicion by the Justice Department and lead to increased surveillance of the copper industry. In contrast,
Canadian copper producers formed just such a joint venture for selling sulfuric acid in the United States and, as a result, will have a lower disposal cost than they would have had otherwise.

A Justice Department official said that such concerns as financing or feasibility are usually more important then fear of antitrust investigation to firms considering joint ventures and that instances of antitrust concern being cited as a major deterrent were exceptions, not the rule. He also said that, under Justice's Business Review Procedure, companies voluntarily submit all relevant information about the venture to Justice attorneys, who then issue letters of enforecement intention. Industry officials said that the procedure is often less than facilitating, due to the 6-week delay in ascertaining opinions, and that the letters of intention do not preclude Justice from later investigating a venture's participants.

Overseas application appears uncertain and confusing

Mineral industry officials said that susceptibility to U.S. antitrust investigations not only makes domestic firms wary of joint ventures with each other but also makes foreign firms apprehensive about participating in joint ventures with U.S. firms. At any point during the investigation of a joint undertaking involving U.S. firms, the records of all concerned parties, including foreign firms, can be subpoenaed, even when the operation is outside the United States.

The Justice Department's Antitrust Guide for International Operations states that, in general, U.S. antitrust laws are applicable to American business transactions overseas when the transactions have, or will have, substantial effects on U.S. commerce. However, it also states that the extent of antitrust extraterritorial application is uncertain and cites the activities of U.S. multinationals and the fact that purely domestic decisions cannot always be readily generalized to the international context as factors contributing to the uncertainty.

Webb-Pomerene antitrust exemption

The Webb-Pomerene Act is a special antitrust exemption which permits the formation of collective export associations of U.S. producers of "good, wares, or merchandise" so that they may compete more effectively in overseas markers against foreign cartels. The Justice Department is admittedly hostile towards the act because, according to one Justice official, it does not require parties to demonstrate that conditions warrant formation of an association and all that companies have to do to qualify is register with the Federal Trade Commission. He said that the Justice Department has been pressing for revocation of the act for a number of years.

Another official denied that there was any concerted effort to investigate Webb-Pomerene groups. However, in view of admitted Department hostility toward the act, many domestic mineral industry officials stated that companies combining as Webb-Pomerene associations make themselves very susceptible to Government investigation.

Conclusions

The debate about the effect of U.S. antitrust laws and Justice Department enforecement on domestic industry's ability to pool resources is not new nor is the solution to the problem easy.

Pooling resources and sharing risks through joint ventures can make investiment in mineral projects more attractive. Certainly, not all cooperative ventures would be in the national interest; however, Justice's efforts to foster competition and to protect the American public from collusive business practices through the enforecement of U.S. antitrust laws discourages domestic firms from taking full advantage of the benefits of joint ventures.

CHAPTER 4

FACTORS INFLUENCING THE OPERATING COSTS AND REVENUES OF DOMESTIC MINERAL PROJECTS

In addition to the factors discussed in chapter 3, several others can influence the operating costs and revenues of projects. These factors include labor costs, energy availability and price; and a variety other U.S. and foreign Government actions.

DOMESTIC LABOR COSTS INCREASED BY U.S. HEALTH AND SAFETY STANDARDS

The cost of labor, including wages, fringe benefits, and health and safety measures, can account for as much as one-third of total production costs in some mineral projects. Because labor costs vary from country to country, they can often influence the location of investments in new or expanded facilities. Several mining officials in other countries cited the significant differences in labor costs as a reason for the expansion of foreign mines at a time when U.S. mines were closing.

Net effect of wage and productivity differences is unclear

Differences in wage rates and labor productivity among countries affect the competitiveness of individual projects, but their net influence is unclear. Certainly U.S. wages are higher than those of most countries; for example, the average wage in the South Korean primary nonferrous metal industry is $300 a month, 1/ compared with $1,489 for U.S. workers. The hourly wage, including fringe benefits at one major Philippine mining company is 86 cents, while at a major U.S. copper mine the basic hourly wage is $8.06. Local daily workers at a copper mine in Iran receive about $12 a day in wages and food.

Comparisons of labor productivity are more difficult because of such elements as the use of outside contractors instead of company employees, differences in product mix, and a general lack of comparable data.

1/It should be noted that productivity and other bonuses could increase basic wage levels in South Korea by 50 to 100 percent.

Some observers believe that U.S. workers are relatively more productive than their foreign counterparts. An official of a major Canadian metals company estimated Canadian productivity at 30 percent less than that of the United States, while Canadian wage levels tended to be a bit higher.

Others point to some of the more modern foreign operations and contend there is little difference in productivity.

Although a scientific assessment was not made, it appears that U.S. wages and productivity are relatively high but other countries are catching up in both categories. As shown below, the difference between productivity of U.S. iron and steel workers and workers in three other nations was much higher in 1964 than in 1976.

Relative Levels of Output Per Hour
Iron and Steel Industry (note a)

Country	1964	1976
United States	100	100
Japan	46	106
France	48	61
West Germany	53	81

a/Based on U.S. = 100 for each year

Source: U.S. Bureau of Labor Statistics

U.S. health and safety standards
affect competitiveness of domestic projects

Although it is not clearto what extent differences in wage and worker productivity affect investment, domestic mineral operations clearly are incurring higher costs due to health and safety standards set by the U.S. Occupational Safety and Health Administration (OSHA). As in the case of EPA regulations, weighing the benefits of these standards versus their cost is not simple. Considerable uncertainty surrounds the medical need for the stringent requirements of some standards and the financial and technical ability of the mineral industry to meet them. The implementation of new production processes to achieve compliance with OSHA standards has, in some industries, led to increased productivity and lower production costs. For the mineral industry, however, OSHA standards have generally imposed substantial costs and threatened the continued operation of some domestic facilities which may not be able either to achieve compliance or to remain competitive with foreign producers that do not have to meet such standards.

For example, in 1978 OSHA established a maximum standard of 10 micrograms of arsenic per cubic meter of air averaged over an 8-hour period in the workplace atmosphere. Several copper processing companies disputed the standard as being unnecessarily stringent, costly, and not technically feasible.

--One company estimated the cost of compliance at almost $80 million in capital costs at three of its smelters and more than $11 million in added annual operating costs.

--Another company stated that the arsenic standard was so strict that current engineering controls could at best achieve only a 50-percent confidence level of compliance; it estimated capital costs would be $35 million and increased annual operating costs over $10 million. Furthermore, should rotational work practices be required to meet the standards, the company would have to double its work force at a cost of $41 million a year, resulting in a 75-percent increase in the cost of smelter operations.

--A third copper company was pessimistic that processing equipment could be designed capable of achieving such low exposure levels and believed that, after spending a lot of money, the company would still not be in compliance.

--A copper smelter in Washington State, which employs 750 workers and is the only U.S. producer of arsenic, may have to close because of inability to meet the arsenic standard.

Another OSHA standard established a maximum exposure of 50 micrograms of lead per cubic meter of air averaged over an 8-hour period. A consultant's study prepared in 1977 for the Lead Industries Association found that an earlier proposed standard of 100 micrograms would cost the domestic lead industry about $416 million in capital costs and about $112 million in annual operating costs, or about $6,600 per exposed employee. The study concluded that enforcement of the standard could result in closing domestic primary lead refinery facilities, lead mines, battery plants, and secondary refineries. An OSHA analysis of the lead standard reached the same conclusion and estimated that it would add capital costs of $452.3 million and annual operating costs of $74.6 million to the domestic lead industry, and lead to a 10 to 14 percent decline in worker productivity at primary and secondary lead facilities.

A proposed OSHA standard would require that employees not be exposed for more than 8 hours to a concentration of 2 parts sulfur dioxide per million parts of air (2 ppm) or more than 15 minutes to 10 ppm. The standard also contains requirements for employee exposure measurements, methods of compliance, personal protection clothing and equipment, training, medical surveillance, and recordkeeping. The standard would apply in all workplaces where sulfur dioxide is used as a raw material or is emitted as an unwanted by-product from a chemical process or fuel combustion.

OSHA has estimated that compliance with its proposed sulfur dioxide standard by the copper, lead, and zinc smelting and refining industries would require capital costs of over $43 million and annual costs of almost $19 million.

Foreign standards

Measuring the differences between worker health and safety standards of the United States and other countries is difficult because the strictness and methods of enforcement vary from country to country. However, a significant difference in the approach to such standards does seem apparent from our observations. U.S. worker health and safety standards are enforced at all locations generally without regard to circumstances, and, although OSHA allows some variances, its latitude in permitting these variances is limited. In contrast, other countries apply their standards case by case, obtaining the level of compliance feasible for each particular facility, and seemingly giving priority to the continued operation of the facility.

OSHA also prefers engineering controls (design of processing machinery and facilities to contain emissions) for achieving compliance, while less expensive control methods, such as protective clothing, respirators, and work practices, are acceptable in some foreign countries. For example, Swedish health and safety standards are generally strict; however, a copper smelter in Ronnskar that processes copper ore with a high arsenic content, similar to a smelter in the United States, has been permitted to use protective clothing and respirators to protect its workers from arsenic exposure and has been given considerable time in which to comply with Sweden's arsenic emission standards. In 1975 the Swedish Government also authorized a $13 million grant to the firm for processing equipment that would reduce arsenic emissions.

In the Philippines, Australia, Chile, Mexico, and Spain, enforcement of worker health and safety standards does not appear to be as strict as in the United States; such needs priority and companies are often allowed great latitude in enforcing the standards. A copper smelter in Chile, for example, uses a process that occasionally emits large concentrations of sulfur dioxide gas into some work areas; a more efficient and energy-saving process is being developed which will also reduce and facilitate treatment of these emissions, but efforts directed specifically at reducing sulfur dioxide emissions will not be made until this process is implemented.

Conclusion

Balancing the benefits of health and safety standards and their costs to the mineral processing industry or identifying other alternatives for handling these costs is a complex problem.

Efforts to assure the health and safety of workers in the United States, while helping to improve some worker conditions, are adding significant costs to the processing of minerals. These added costs are contributing to the problems that domestic mineral facilities face in competing with foreign processors. As a result, investment in domestic mineral projects is less attractive.

GOVERNMENT ACTIONS RESTRICT ENERGY AVAILABILITY AND INCREASE ENERGY COSTS

The transformation of ores into metal requires large quantities of energy. An investor, before investing in a mineral processing facility, must be assured of the availability of energy for at least long enough to recover the cost of building the facility. Certainly the cost of energy can also be a factor if it makes the project unprofitable, but this is a secondary consideration to energy availability.

Of the metals we surveyed, aluminum production is the most energy intensive and the most affected by energy considerations. Production of alumina from bauxite or of primary aluminum metal from alumina is especially vulnerable to a loss of electric power. A sudden loss for about 30 minutes would require several months to return to maximum production after power is restored. Consequently, aluminum producers look for reliable sources of electricty when deciding where to build a facility.

In the United States, a large portion of aluminum metal smelter capacity is linked with public power sources that had offered low cost, dependable power during and after World War II, when the major portion of present capacity was installed.

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Two Federal power authorities, the Tennessee Valley Authority (TVA) and the Bonneville Power Administration (BPA), supply about 46 percent of the aluminum industry's electricity requirements. The Power Authority of the State of New York (PASNY) supplies another 7 percent. Thus, Government agencies supply over half of the domestic aluminum industry's electric power needs.

U.S. generating capacity is insufficient to meet growing energy demands

TVA, BPA, AND PASNY all started as predominantly hydropower systems. PASNY and BPA are meeting demand for electricity by diversifying into thermal plants. TVA has become predominantly a coal-based system. To continue to meet the energy needs of the aluminum industry and the increasing population, however, will require even more expansion; but for many utilities, licensing delays, inability to meet pollution control standards, and lack of capital have forced cancellation or delay of many expansion projects.

In the Pacific Northwest, BPA provides about 31 percent of U.S. domestic primary aluminum capacity. A provision of the Bonneville Project Act, known as the preference clause, requires that BPA give publicly owned utilities and Federal agencies first call on BPA energy. Demand for electricity is now approaching BPA's generating capacity. To meet growing demand, BPA planned construction of several thermal energy plants to be completed by the mid-1980s; however, construction has been delayed. Faced with possible power capacity shortage as demand continues to expand in the 1980s, BPA has notified the aluminum producers that their power supply contracts will not be renewed when they expire during the 1983-88 period. As a result, those producers are faced with an uncertain supply and some production capacity may close.

Our August 10, 1978, report to the Congress, "Region at the Crossroads--the Pacific Northwest Searches for New Sources of Electric Energy" (EMD 78-76), detailed the difficulties that increased demand is placing on BPA and the problems BPA has in increasing its capacity.

Increased demand for electrical power in other parts of the country is also causing concern. The future availability of power for industrial expansion will depend upon construction of new thermal plants. The growth in Government regulatory reviews and permits required to build new thermal electricity plants, however, has significantly increased the time required to bring new capacity onstream. For example, in 1968 one major electric utility system was able to build a new coal-fired power plant in about 4 years at a capital cost of about $200 per kilowatt of capacity. The same operator is currently building another coal-fired plant that will take 8 to 10 years to complete at an estimated capital cost of $560 per kilowatt of capacity.

According to representatives of the utility industry and the Department of Energy, increasing regulatory delays and related capital costs have reduced construction of new and replacement power plants.

As a result of uncertainty about electric power availability, only one major planned addition to domestic aluminum production is going forward and others have been canceled or postponed. For example, an 82,000-ton-per-year expansion of an aluminum smelter in Maryland was stopped because of possible electricity supply shortages forecast for the mid-1980s. Construction of the needed electricity generating facilities was delayed because of problems in obtaining Government permits and in complying with EPA regulations.

TVA is having similar problems in expanding its facilities. Our November 29, 1978, report to the Congress, "Electric Energy Options Hold Great Promise for the Tennessee Valley Authority" (EMD 78-91), cited several problems that TVA was having in complying with EPA standards.

Foreign governments attempt to minimize uncertainty about energy availability

Industry officials believe the uncertainties regarding electric power availability in the United States will hinder future expansion of mineral processing capacity and will encourage expansion overseas where power availability will be more assured by host governments. Some countries have a natural advantage over the United States in providing energy because they have underutilized energy resources; others are giving high priorities to securing energy for industrial expansion. For example:

--Chile, although it does not have abundant energy resources, has taken steps to assure the minerals industry of long-term energy availability.

--The Republic of South Africa provides long-term energy supply commitments to industrial customers.

--Australia, South Korea, Norway, and Sweden negotiate special energy rates of fixed (often long-term) duration.

These approaches reduce the uncertainty regarding energy availability that is important to an investment decision. This is in apparent contrast to the climate of increased uncertainty in the United States.

Energy costs are increasing

The Government has historically aided development of the mineral industry by making energy available at attractive rates; however, the tightening availability of energy coupled with Government actions, such as the recent regulations for coal mine reclamation, are expected to significantly increase energy costs. According to the Department of the Interior, uncertainty about future energy costs increases is affecting mineral investment decisions.

Conclusion

Government restrictions which delay or halt the construction of power-generating facilities are limiting the availability of energy in the United States and actions which are increasing energy costs are further discouraging the expansion and development of the domestic mineral industry.

OTHER GOVERNMENT ACTIONS INFLUENCE REVENUE AND COST

U.S. and foreign Government actions also are affecting the costs of producing mineral products or the prices received for them.

Tax laws seem to favor foreign mineral projects

The structure and stability of a nation's tax system affects the relationship between the costs and the revenues of mineral projects and, thereby, the investment decision. In addition to generating revenue, tax structures have historically been used to stimulate industry. Although no comprehensive comparisons of the effect of various countries' tax systems on the mineral industry have been made recently, analyses made in 1970 and 1975 show that the U.S. tax structure does not provide as good an investment climate as that of most other countries.

A Presidential task force on business taxation 1/ reported in 1970 that U.S. tax laws cause American industry to recover capital outlays much slower than do industries in most foreign countries. A 1975 study by the public accounting firm of Coopers & Lybrand for the American Mining Congress, analyzed the tax structure of Belgium, Canada, France, Japan, the Netherlands, Switzerland, the United Kingdom, and West Germany and measured the burden of the U.S. structure relative to those countries. According to the analysis, involving hypothetical mining ventures with varying capital expenditures, revenues, and operating costs in a number of capital-importing countries, the United States ranked eighth for average return on equity and seventh on investment.

The limitation of this analysis is that it (1) compared investments among only eight other developed countries and (2) did not compare the tax implications for a domestic project with similar projects in developing countries. The absence of these additional comparisons is significant because many developing countries (and some developed countries not considered in the study) seem to have systems which provide more encouragement for development of mineral projects than does the United States.

We looked at tax incentives offered by several foreign countries, realizing that specific incentives may not be representative of a country's overall tax structure and, therefore, such comparisons could be misleading. However, we believe that the extra incentives offered to industry by other countries generally indicate the extra encouragement they offer to industry.

For example, in the United States, companies are allowed accelerated depreciation that enables assets used in mining and beneficiation to be depreciated on a diminishing-value basis over 8 years 2/. (The minimum depreciation period for manufacturers of primary ferrous and nonferrous metals is 14.5 and 11 years, respectively.) The companies also may deduct 20 percent of the cost of qualifying property (subject to dollar limitation) as additional first year depreciation. Net

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1/"Business Taxation," the report of the President's Task Force on Business Taxation, Sept. 1970.

2/This is the lower limit of IRS' Class Life Asset Depreciation Range System of computing the reasonable depreciation allowance for all eligible property (IRS publication 534, 1979 ed.). Under the system, useful life is generally shorter than under normal methods of depreciation.

operating losses may be carried back 3 years and forward 5 years. In contrast:

--In Ireland, mining firms may claim at any time depreciation up to 100 percent of the cost of fixed plant and machinery. In the underdeveloped areas, a 20-percent investment allowance is available for new plant and machinery in addition to 100-percent depreciation (total 120 percent). Unlimited loss carryforward and a one-year loss carryback is also permitted.

--In Australia,mining firms enjoy an accelerated depreciation allowance that enables capital expenditures on the mine to be deducted on a diminishing-value basis over 5 years. They may also take a 20-percent investment allowance for new plant and equipment costs. Net operating loss carryovers may be carried forward 7 years, but not carried back.

--In South Africa, mining firms may deduct 100 percent of mining capital expenditures as incurred. While there is no loss carryback, there is no limit on loss carryforward.

--In Canada, mining firms may deduct up to 100 percent of the costs of depreciable assets acquired for new mines or major expansions of existing mines in any one year, limited to the amount of income before depreciation. Net operating losses may be carried back one year and carried forward 5 years.

Also, similar to the U.S. system which allows an investment tax credit equal to 10 percent of the cost of eligible property, some countries allow companies to set aside a portion of their profits as tax-free income to be used for new investment. For instance:

--Swedish companies are allowed to set aside 40 percent of their profits from any one year as tax-free income. These funds may be used later, under certain conditions, for new investments.

--Norwegian firms may set aside and exempt from taxable income up to 25 percent of their profits for investment in certain developing areas of Norway. Companies must reduce the depreciable amount of of assets purchased with these reserves, but the reduction may be as little as 55 percent of the the reserves used.

--Spanish companies may place up to 50 percent of their undistributed earnings in a tax-free investment reserve which may be used to acquire fixed assets.

Some countries also offer other exemptions or reductions in the amount of taxes paid by companies located there.

--Ireland offers a tax exemption on all export profits until 1990.

--The Philippines allows certain enterprises a diminishing tax exemption over a 15-year period from all national taxes except income taxes.

--The Republic of Korea allows foreign enterprises exemptions or reductions for up to 8 years for income and corporation taxes, property and acquisition taxes, and taxes on dividends.

Uncertainty about future tax laws can also detract from the investment climate. An official of the zinc industry stated that frequent changes and calls to overhaul U.S. tax laws creates a climate of uncertainty that affects long-term planning. For instance, the percentage depletion allowance has come under frequent attack as a subsidy to mineral enterprises which deprives the Federal Government of large amounts of revenue. Largely on the basis of such arguments, the Tax Reform Act of 1969 reduced percentage depletion rates for a number of minerals.

As a way to attract desired investment, some countries are guaranteeing tax rates for a period of years.

--Chile allows foreign-owned companies to pay either the prevailing tax rate, which might fluctuate, or a rate guaranteed to remain the same for 10 years.

--Peru negotiates reduced tax rates during a project's investment recovery period.

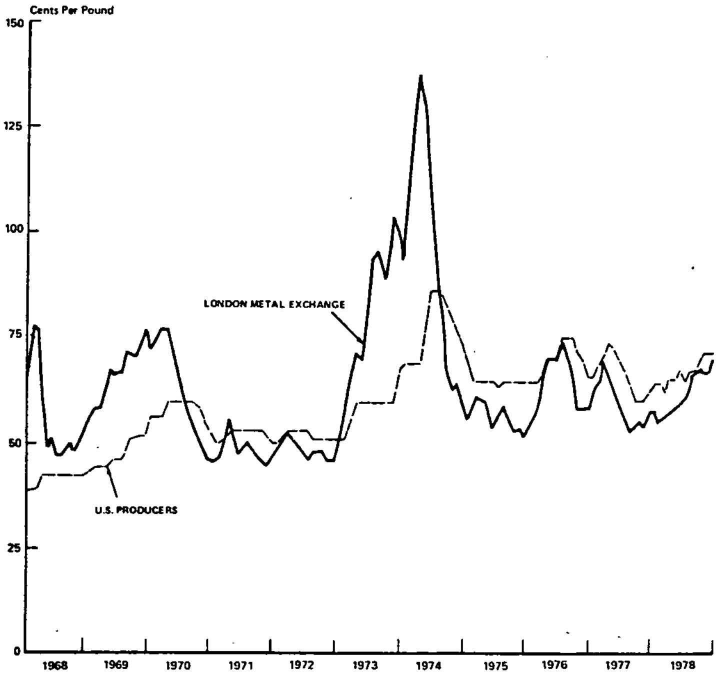
--The state governments of Australia (which have primary authority over mineral development) negotiate the terms for new ventures, including the tax rate, which may be less than the statutory rate.

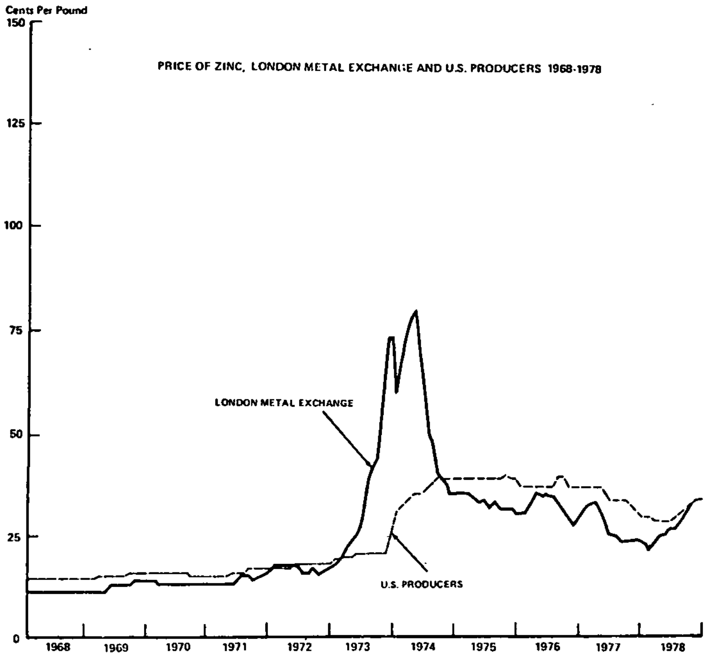
Foreign governments have allowed firms to recover a higher percentage of capital outlays in the early years of new projects. This is particularly important since the earlier the tax benefits, the sooner cash is freed for such purposes as further capital investment. Moreover, especially during periods of high inflation, the early recovery of capital outlays minimizes the effects of inflation on depreciation allowances.

Government actions influence U.S. metal prices

As noted earlier, the minerals industry is a cyclical industry that frequently encounters short run imbalances between supply and demand, causing sharp fluctuations in metal prices as well as in company profits. For example, as shown below, during 1968-78 domestic and world market prices for copper and zinc fluctuated dramatically. On the London Metal Exchange, annual average copper prices varied between 48 and 93 cents per pound, and zinc prices varied between 12 and 56 cents per pound.

PRICE OF COPPER, LONDON METAL EXCHANGE AND U.S. PRODUCERS 1968-1978





Although these fluctuations often show the effects of day-to-day events, such as strikes, calamities, wars, price controls, threats of stockpile releases, and actual stockpile sales, the effect of any specific event is difficult to measure. Two of these factors--price controls and stockpile manipulations--are particularly important to our discussion because they represent Government actions which have an affect on revenues from U.S. metal sales and, therefore, influence profitability.

Price controls

Because metal prices fluctuate, the high profits made during periods of high prices offset the low profits or losses incurred when prices are low. However, while controls help consumers in the short run, the establishment of price controls during periods of rising prices can interfere with this normal business process.

For example, in August 1971, when price controls for zinc were set at 17 cents a pound, the price on the London

Metal Exchange was 15 cents. Domestic zinc prices rose to 21 cents until the price controls were removed in December 1973. However, during the same time period, the price of zinc on the London Metal Exchange jumped to over 73 cents a pound. A report by the Lead-Zinc Producers Committee concluded that the price controls prevented domestic zinc producers from having the same advantage of higher prices as foreign producers, thus damaging the profitability and financial strength of the domestic producers.

The 1971 price controls also made it difficult to compete for foreign concentrates needed to supplement domestic mine output. As the price of zinc increased in world markets, the price of foreign concentrates also rose; but, since the price of metal produced in the United States was fixed, it was not economical to import concentrates.

The copper industry was also significantly affected by 10 months of price controls imposed in June 1973 which set copper prices at about 60 cents a pound until early December when prices were increased to between 68 and 69 cents. London Metal Exchange copper prices, which were about 51 cents a pound at the start of 1973, increased to over 99 cents by November. The 68 to 69-cent restriction on domestic producer prices continued until the end of April 1974, when price controls were lifted. London Metal Exchange prices shot from 92.1 cents a pound in January to $1.375 for April, with an all time high daily quotation of $1.52 on April 1.

The copper price controls may have also prevented the U.S. producers from taking advantage of the high prices on the world market.

A major U.S. metal-producing corporation said that during a period of strong demand, price controls slice the top off earnings but do nothing to shorten the duration or magnitude of depressed markets--a bad scenario for a cyclical industry.

More recently, the implementation of the President's voluntary wage and price guidelines may have had a negative impact on the ability of U.S. steel producers to secure adequate supplies of molybdenum. The guidelines, which do not cover exports, have resulted in a two-tier price structure, under which exports are priced higher than molybdenum sold domestically. Prior to the price controls, molybdenum was already in short supply and U.S. producers were being forced to allocate supplies to their customers. The American Iron and Steel Institute believes the two-tier price structure (while in compliance with the President's guidelines) may also have the effect of encouraging greater exports of molybdenum thus, aggravating an already serious domestic shortage.

Stockpile manipulation

The Government has used the national strategic stockpile, both indirectly and directly, to keep domestic metal prices down during periods of rising world prices.

The national stockpile consists principally of mineral commodities deemed to be strategic and critical for meeting defense and essential civilian requirements in any possible future war. However, large fluctuations in stockpile objectives over the past three decades have affected domestic mineral prices and expectations about future prices and have added uncertainty to the domestic mineral industry.

An industry official, speaking on behalf of the American Mining Congress before a congressional committee, 1/ said that "In the view of most mining people the strategic stockpile program has had a disruptive influence on commodity markets."

Threatened disposals, actual liquidations, and the continuing existence of excess stockpile mineral inventories have all had an affect on keeping domestic prices down and inhibiting additional investment.

The First Annual Report (March 1972) of the Secretary of the Interior released under the Mining and Minerals Policy Act of 1970 noted that development of domestic resources was not keeping pace with demand. One of the problems identified was that actual and threatened stockpile disposals were hanging over the domestic mineral markets and posing a concern for domestic producers. The report cited various tonnages of metals in the stockpile which were in excess of stockpile objectives and concluded that, despite the orderly disposal of these excesses, their existence and the possibility of sale tended to discourage the domestic industry's exploration and development of new mineral projects.

The Arthur D. Little January 1978 report on copper for EPA noted that:

1/Hearings before the Subcommittee on Materials Availability of the Joint Committee on Defense Production, "Purpose and Organization of Econmic Stockpiling," June 8 and 9, 1976.

"In the 1950's, when the stockpile was being purchased, the increased demand, along with the demand resulting from the Korean War, caused producers to greatly overexpand their capacity, which was later to prove quite costly to them in the late 1950's when, with a severe drop in demand, they were faced with sizable idle capacity. When prices rose in late 1959, sales from the stock pile were used to keep the price down. In 1965, when copper producers proposed raising their price by two cents per pound at the same time that the LME [London Metal Exchange] price was rising fast, President Johnson reacted by threatening to have 200,000 tons of copper sold from the United States strategic stockpile and forced producers to rescind their price increase. Later, the United States stockpile undoubtedly prevented copper prices from increasing beyond the high levels attained during the Vietnam War. Finally, following the unprecedented surge in copper prices (as well as in the prices of other nonfuel primary producers) in 1973, President Nixon ordered the complete disposal of the national stockpile to stabilize copper prices. Copper from the stockpile was then sold at a price considerably above the producers' price, at a time when the producers' price was fixed by government price controls."

Tariffs

U.S. tariffs on some metals are less than those of other countries, so foreign producers can often make greater profits by selling their metal in the United States rather than other markets. Zinc and ferroalloy industry officials, in particular, believe that the large increases in imports have been caused, in part, by low tariffs on these commodities.

According to industry officials, the United States, with no quota on metal imports and a tariff of only 0.7 cent a pound (about 1.8 percent of the April 1979 price), is the only major market relatively open to zinc metal imports. The European Economic Community, many of whose countries export zinc metal to the United States, has a tariff of 3.5 percent on the value of zinc imports.

Ferroalloy industry officials also believe that low tariffs have encouraged imports. In a submission nominating certain ferroalloys of chromium, manganese, and silicon to be exceptions from a tariff reduction, the executive director of the Ferroalloys Association stated that:

"The current disparity in duties between the United States and the other consuming countries (Japan and the EEC [European Economic Community]) and the extension of GSP [Generalized Systems of Preferences] to the developing countries have made the United States the most attractive market for ferroalloy exporting countries (including both developing and developed countries)".

One reason for the difference in tariff effectiveness is that U.S. tariffs on many metals are based upon weight (i.e., X cents a pound) while foreign tariffs are based on a percentage of the value. Because of this difference in tariff structure, inflation has reduced the relative effectiveness of U.S. tariffs. For example, the U.S. tariff on high-carbon ferrochromium has been 0.625 cent per pound of chromium since 1963. In 1967, this charge amounted to 5.3 percent of the value of a pound of alloy; by 1972 it equaled 4.9 percent; and in 1976, 1.9 percent. During the same period, tariffs of Japan and the European Economic Community were 8 percent of the value.

Other market interventions

In the United States, the production levels of mining and mineral processing firms are determined generally by market conditions, especially world metal prices, and by company policy.

In some countries, government participation may keep production levels up even if prices and demand are low (thus subsidizing world consumers). For example, in Bolivia, Peru, Zaire, and Zambia, where mineral production is an important factor in providing employment and foreign exchange, the governments intervene in some cases to continue mineral production even when normal market conditions indicate production should be reduced. These governments, through their state-controlled mineral sector enterprises, represent "new players" in the international minerals market, "playing" according to non-marketplace rules.

In other countries, production levels are not necessarily controlled by the government directly but subsidies keep production continuing even though market conditions are unfavorable.

One unique approach is the copper fund used in Norway in an attempt to maintain employment and give the more efficient producers some relief during periods of low prices. The fund is anticipated to spend some $37.8 million over a 2-year period (about $15,000 per miner). Copper producers pay into the fund when prices go above a certain ceiling price and are paid from the fund when prices fall below a certain floor price. Norway also subsidizes interest payments for the financing of ores, minerals and metals inventories during periods of weak demand.

In 1977 the Australian Government, in conjunction with state authorities, agreed to provide about $8 million in cash grants to cover the operating losses of the Mt. Lyell copper mine to prevent its closure and subsequent employment losses. The State of Tasmania also agreed not to force compliance with water pollution control measures that would require the expenditure of about $50 million and would likely close the mine.

In 1974 the Japanese Government agreed to a request by the Intergovernmental Council of Copper Exporting Countries 1/ to withhold copper from the world market. Council members contended that Japanese copper exports were contributing to the sharp fall in copper prices on the London Metal Exchange. Thus metal supplies were withheld at a time of diminishing demand.

CONCLUSIONS

The trend toward increasing reliance by U.S. manufacturers on foreign-processed minerals results primarily from the failure of investment in expanding or modernizing domestic mineral projects to keep pace with U.S. consumption. Although the problems faced by the domestic industry can be related to traditional economic factors that affect relative profitability, U.S. and foreign government actions are becoming more and more important in mineral investment decisions and are accelerating the trend toward increased reliance on foreignprocessed minerals.

The adverse effects of U.S. Government actions on the mineral industry often result from efforts to minimize or prevent inherently undesirable aspects of the industry. Foreign governments, on the other hand, are either more lenient in

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1/An organization of governments that works for worldwide copper price stabilization and market development. Members are Zambia, Chile, Peru, Zaire, and Indonesia; associate members are Australia, Mauritania, Papua-New Guinea, and Yugoslavia. Members provide about 60 percent of the Western world refined copper.

dealing with these problems, providing support to solve the problem without jeopardizing the mineral industry, or are actively assisting development of mineral projects in pursuit of their own social and economic priorities.

CHAPTER 5

IMPLICATIONS OF THE INCREASING RELIANCE ON FOREIGN MINERALS

The decline of the U.S. mining and mineral-processing industry has contributed to the loss of jobs and job opportunities in the industry, adversely affected the U.S. balance of trade, and increased concerns about vulnerability to mineral supply disruptions.

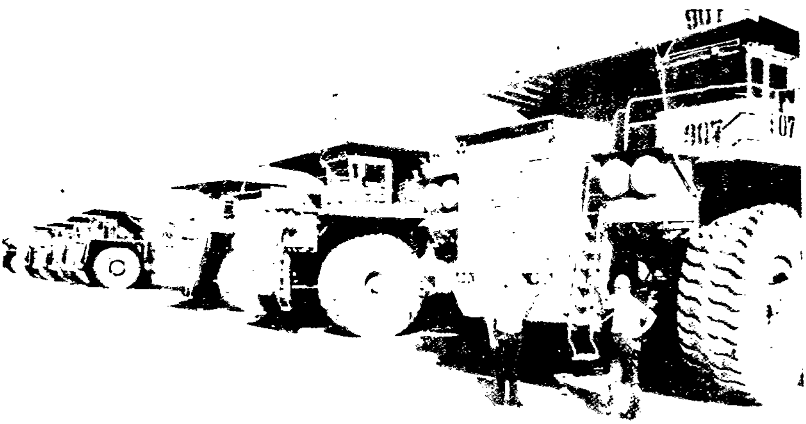
It is not the purpose of this discussion to debate the value of the mineral industry or to take sides in the balancing of Government actions with their consequences. In presenting this information, we hope to provide the Congress with greater insight into the implications of the problems of the mineral industry to the Nation.

JOBS AND JOB OPPORTUNITIES LOST

The total number of jobs lost in the mineral industry cannot be readily determined, but various reports indicate that over 18,000 workers directly employed in the mining and/or primary processing of zinc, copper, and ferroalloys have lost their jobs due to plant closings or curtailment of production during the past several years. While this number is small in comparison to national unemployment figures, these jobs can have major local or regional impacts. For example, 1,600 copper miners in Michigan's remote upper peninsula were laid off in 1976 and the already high unemployment rate in the affected area rose from 10.1 to 22.1 percent. In Ajo, an Arizona copper-mining community, retail sales declined by 40 percent after most of the 1,100 local mine and smelter workers were laid off in August 1977.

In addition to direct loss of jobs, "multiplier effects" extend unemployment; when a job is lost in mining/mineral-processing, other jobs which had provided service to the industry or its employees are also lost. In Tucson, Arizona, a construction firm which provided services to local mines laid off 1,161 employees by May 1978 as a result of mine closures and/or curtailments.

A comprehensive study of the impact of U.S. environmental, health, and safety regulations on the U.S. copper industry made by the Arthur D. Little Company for the Department of Commerce forecast that by 1987, 36 percent of the industry's potential employment, or 31,000 full-time jobs, would be lost because of these regulations.



In addition to the loss of jobs, mine and processing facilities are often idled. Shown above are some of the forty four 170-ton capacity trucks idled between September 1977 and May 1979 at the Cyprus Pima Mining Company in Arizona. These trucks cost more than $500,000 each and are part of more than $140 million in idled plant and equipment.

TRADE BALANCE ADVERSELY AFFECTED

In 1978, the United States incurred a deficit trade balance of $34 billion, continuing the trend of an increasing trade deficit. Although many factors, particularly oil imports, are responsible for the deficit, part of it can be attributed to nonfuel minerals whose own deficit in 1978 represented $9.9 billion (including steel but excluding chemicals and plastics).

Nonfuel mineral imports have contributed to the deficit in at least two ways. The most obvious factor is that such imports have been increasing faster than exports. More significant, however, is the growing valued-added impact as imports shift from lower value ores and concentrates to higher value processed minerals or metals. The change in makeup and the increase in value of nonfuel mineral imports since 1973 is shown on the next page.

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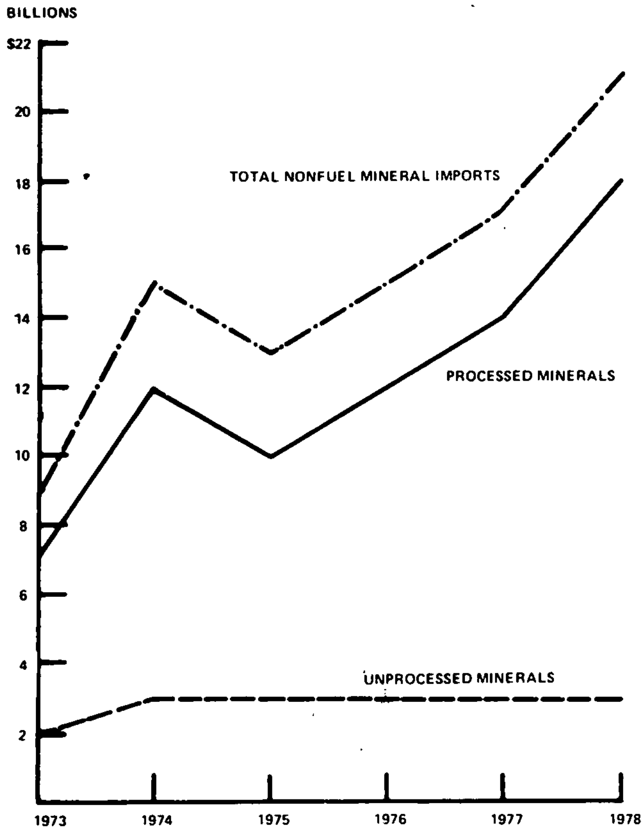
IMPORTS OF NONFUEL MINERALS (note a)



a/ DATA INCLUDES ALL NONFUEL MATERIALS OF MINERAL ORIGIN, INCLUDING NONMETALLICS. IMPORTS OF METALLIC MINERALS, INCLUDING STEEL, HAVE HISTORICALLY REPRESENTED OVER 50% OF TOTAL NONFUEL MINERAL IMPORTS. PLASTICS AND INORGANIC CHEMICALS ARE INCLUDED, HOWEVER, THEY ARE RELATIVELY INSIGNIFICANT (1978 IMPORTS TOTALED $0.5 BILLION)

SOURCE BUREAU OF MINES

Specifically, for three of the four metal industries included in our analysis, the increase in imports of processed metals in lieu of raw materials is quite pronounced, as shown in tables 8 through 11.

Table 8

Imports of Manganese Ore and Alloy

Year	Ore	Alloy (note a)	Alloys as percent of total imports
	(000 short tons manganese content)		
1968	870	183	17.4
1970	847	238	21.9
1972	793	305	27.8
1974	593	376	38.8
1976	649	478	42.4
1977(note b)	454	481	51.4

a/Includes a small amount of manganese metal.

b/Based on recent costs for manganese ore and ferromanganese, in 1977, the value added or extra cost of importing alloy rather than ore to be processed was about $112 million.

Table 9

Imports of Chromium Ore and Alloy

Year	Ore	Alloy	Alloys as percent of total imports
	(000 short tons chromium content)		
1968	341	42	11.0
1970	443	26	5.5
1972	341	92	21.2
1974	329	107	24.5
1976	365	158	30.2
1977 (note a)	368	139	26.5

a/Based on recent costs for these imports, the extra cost of metal imports over ore imports in 1977 was $78 million.

Table 10

Imports of Zinc Ore and Concentrate and Metal

Year	Ore and concentrate	Metal	Metal as percent of total imports
	(000 short tons zinc content)		
1968	543	305	36.0
1970	526	270	34.0
1972	255	523	67.2
1974	240	540	69.2
1976	97	714	88.0
1977 (note a)	123	577	82.4

a/The extra cost of metal imports over ore imports for 1977 totaled $172 million.

Table 11

Imports of Unrefined and Refined Copper

Year	Unrefined copper	Refined copper	Refined copper as percent of total imports
	(000 short tons copper content)		
1969	277	131	32.1
1970	258	132	33.8
1972	212	192	47.5
1974	264	314	54.3
1976	133	370	73.6
1977 (note a)	106	391	78.7

a/The extra cost of metal imports over ore imports for 1977 was $238 million.

In contrast to these metals, the shift away from aluminum ore (bauxite) to metal has not yet taken place. However, the United States has placed increased reliance on foreign-produced alumina (an intermediate, higher value product) to meet its increasing needs.

Imports of Bauxite, Alumina, and Aluminum Metal as Percent of Total Aluminum Imports

Year	Bauxite Amount	Bauxite Percent	Alumina Amount	Alumina Percent	Aluminum Amount	Aluminum Percent
1968	[a]3,041	67	[a]686	15	[a]793	18
1970	3,489	66	1,344	25	468	9
1972	3,231	59	1,485	27	794	14
1974	3,893	61	1,890	29	629	10
1976	3,314	56	1,880	32	749	12
1977	3,346	53	2,155	34	836	13

a/000 short tons aluminum content.

As the trend toward increasing reliance on foreign processed minerals accelerates, the significance of mineral imports in the balance of trade will continue to mount. The Bureau of Mines has projected that mineral imports, which total $21 billion today, could exceed $50 billion by the year 2000.

INCREASED CONCERN ABOUT VULNERABILITY TO SUPPLY DISRUPTIONS

As the United States meets a greater portion of its mineral needs through imports, concerns about vulnerability to supply disruptions increase. In response to this concern, the United States has a longstanding policy of maintaining a national security stockpile of critical and strategic materials. However, as import dependency increases and the United States shifts from importing ores and concentrates to processed minerals, acquiring and maintaining stockpiles could become extremely expensive.

Peacetime concern

A 1977 International Economic Studies Institue analysis of 27 important industrial raw materials concluded that supplies of bauxite/aluminum, chrome, platinum group metals, and copper over the next decade pose a potential threat to overall U.S. industrial production, employment, and inflation. Judgments involved assessments of each raw material for availability of reserves, possibility of substitution, vulnerability to producer action, ratios of imports to consumption, and the dollar cost represented.

The Institute's analysis, as well as a report by the National Commission on Supplies and Shortages, concluded that supply disruptions because of worldwide exhaustion were unlikely but that, because some minerals were concentrated in only a few places in the world, short-term supply disruptions were possible. Although these reports concluded that neither mineral embargoes nor OPEC-like cartels were likely, they found that supply interruptions due to local hostilities have been and are continuing to threaten assured supply of raw materials. For example, a bottleneck resulting from the Angolan civil war impeded the supply of cobalt, which is critical to several defense applications, from Zaire in 1976. Then in 1978, during a period of already strong demand for and insufficient supply of cobalt, tribal warfare in Zaire itself resulted in shutdown of the mines for a short period. The price of cobalt then increased from about $6 to about $20 per pound in 1978 and to $25 in 1979.

Reliance on countries with centrally planned economies can also be uncertain. For example, the United States has historically imported substantial amounts of both chromium and platinum from the Soviet Union. In late 1977, the Soviets sharply reduced sales of platinum. This fact, along with the uncertainty of the U.S. dollar and other economic concerns, followed by the announcement of South Africa's plan to reduce output, spurred the price upward, from $180 an ounce in early 1978 to $300 an ounce in early 1979. The United States experienced a similar disruption in chromium and manganese shipments from the Soviet Union in the post-World War II period.

Problems in meeting mobilization needs

Supply interruptions or cutoffs could also cause problems in supporting U.S. defense during a period of national mobilization or conflict. Because of this concern, a national stockpile of strategic and critical materials was established following World War II.

We discussed the national defense implications of increased reliance on foreign-processed minerals with officials of the Federal Preparedness Agency (FPA), which has primary responsibility for developing policy and establishing inventory goals for the strategic stockpile and for developing domestic sources of strategic and critical materials. We also talked with the Department of Defense (which advises FPA of defense needs for such materials) and the Department of Commerce (which, with the Department of the Interior, provides FPA with supply and consumption data for these materials).

The officials told us that the need for primary metal products to meet mobilization needs has been recognized and the FPA, in conjunction with various other agencies supports research projects (recycling, substitutions, new technology, etc.) to reduce import dependency. However, minimum levels of domestic primary metal capacity have not been determined.

To prevent a costly and dangerous dependence on foreign sources during an emergency, the United States has placed primary reliance on the strategic stockpile. FPA officials told us that as the United States increases its use of foreign processed minerals and domestic capacity declines, the stockpile is being increased and upgraded to assure that processed minerals, rather than ores and concentrates, will be available in the event they are needed.

While this may have provided some assurance of materials supply in the past, the continued loss of domestic metal-processing capacity may require increases in the number and quantities of items stockpiled and an upgrading of the type of stockpile materials to the extent that acquiring and maintaining the stockpile could be extremely costly. For example, if the United States lost its entire ferrochromium and ferromanganese capacities, the ores in the stockpile would logically have to be upgraded to alloys. If this was done for just these 2 of the 93 items in the stockpile, it would increase the market value of the stockpile by almost $670 million, as shown below.

Stockpile item	Inventory amount (short tons)	Market value: Ore	Market value: a/ Alloy	Difference
		(millions)	(millions)	(millions)
Chromite, metallurgical grade	1,956,382	$256.8	$442.7	$185.9
Manganese ore, metallurgical grade	3,634,140	$165.0	$646.8	481.8
Total		$421.8	$1,089.5	$667.7

a/Value of alloy that could be produced from inventory ore.

Source: GAO analysis of data contained in Stockpile Report to the Congress, Apr. 1978.

A value increase of similar magnitude could affect the stockpile requirement upon a switch from bauxite to alumina. Even for metals for which the United States has extensive ore reserves (zinc and copper), the processing shift could affect the stockpile. If domestic processing capacity is reduced, an increase in stockpile goals will be needed. In addition, items which are not now stockpiled may have to be added to the list of stockpile items because, as domestic processing gives way to imports, the United States also loses byproduct production of other metals.

The officials with whom we discussed the possibilities had not explored the cost of maintaining an upgraded stockpile, but we believe this could be an expensive alternative in light of the accelerated shift to reliance on foreign-processed minerals.

In addition to cost, relying on the stockpile to meet domestic production shortfalls has another weakness. Historically, stockpile goals and inventories have not been in harmony. Because of purchasing restrictions (FPA has interpreted the Strategic and Critical Materials Stock Piling Act as requiring that market disruptions be minimized when purchasing materials), the stockpile is not up to goal and may not be for many years. Our July 1978 report "The Strategic and Critical Materials Stockpile Will Be Deficient For Many Years" (EMD-78-82), concluded that planned procurement of materials to satisfy goals for such commodities as bauxite, cadmium, cobalt, and ferrovanadium may require more than 25 years.

FPA, by simply assuming that the current processing capacity is the minimum required and avoiding capacity constraints by upgrading the stockpile, is unable to take advantage of some opportunities for avoiding capacity reductions. For instance, the Occupational Safety and Health Act of 1970 allows the Secretary of Labor to

> "* * * make such rules and regulations allowing reasonable variations, tolerances, and exemptions to and from any or all provisions of this Act as he may find necessary and proper to avoid serious impairment of the national defense."

An OSHA official stated that, without established minimum production levels, granting relief under this provision would be difficult.

LOSS OF BYPRODUCT METALS

When domestic mineral production is cut back or eliminated, the United States also loses domestic access to byproduct metals. The consequences of such losses are similar to those for primary metals. Revenues and profits from sales of these metals are lost; the trade deficit is adversely affected as consumers use imports to replace the lost production, or prices are driven up because the supply is reduced. Further, national stockpile goals may be affected because byproduct metals often have defense applications.

The number and proportion of byproducts varies by type of metal and mine location, but nearly all ores, when processed, yield valuable byproduct metals. Copper ores, for example, can yield gold, silver, nickel, molybdenum, sulfur, arsenic, selenium, tellurium, rhenium, palladium, platinum, and cobalt. Zinc ores may contain lead, cadmium, germanium, indium, silver, and thallium.

The recent decline of U.S. zinc and copper production has had various effects on byproduct metals. For example, even though U.S. cadmium consumption declined during 1973-77, imports increased by over 42 percent, from 1,948 to 2,770 tons. The Bureau of Mines attributes this 822-ton increase to the decline of the U.S. zinc industry, which recovers cadmium as a smelter byproduct. The increase represents almost $5 million worth of imports.

Similarly, copper production cutbacks have reduced domestic silver production (two-thirds of U.S silver production is a byproduct of other mining activity, especially copper). The Bureau of Mines reported in both 1976 and 1977 that byproduct silver recovery decreased due to reduced production of base metals (e.g., copper). As a result, additional reliance is placed on imports to meet the U.S. silver demand, which in 1978 exceeded production fourfold.

Molybdenum output was also affected by copper production cutbacks. Two-thirds of molybdenum comes from primary ore, and one third is recovered as a byproduct of copper ore. The drop in byproduct molybdenum output has not led to increased imports because the United States is the major world producer. Rather, prices have increased in response to the world demand, which exceeds world production. In response to this price competition, the American Iron and Steel Institute has asked the Department of Commerce to monitor exports as a first step toward possible export regulation.

While byproduct use often is not significant in terms of tons used, some byproduct metals have critical defense applications. Molybdenum is used in alloy steels for manufacturing aircraft and space systems and in high temperature alloys used in jet engines and aerospace propulsion devices. Silver is essential for photography and has critical electronics applications. Cadmium is used in nuclear controls, special plating applications, and bearing alloys for high-speed machinery.

CONCLUSIONS

The trend toward increased reliance by U.S. manufacturers on foreign processed minerals has

--caused the loss of jobs and job opportunities in the minerals industry;

--aggravated an already high deficit trade balance; and

--increased the cost of protecting the Nation from supply disruptions.

The implications discussed in this chapter highlight the need for the United States to keep abreast of developments in its mineral industry, to be aware of the costs associated with actions detrimental to the industry, and to minimize or mitigate the effects of policy conflicts in order to optimize the industry's contribution to the Nation's well-being.

CHAPTER 6

DIFFICULTIES IN COORDINATING GOVERNMENT ACTIONS

To bolster the domestic mining and minerals-processing industry, the Congress enacted the Mining and Minerals Policy Act of 1970 (Public Law 91-631). However, the mineral industry has continued to decline and the U.S. Government has not established a mechanism to identify and resolve conflicts that arise between goals in the mineral area and those associated with environment and other national concerns.

THE MINING AND MINERALS POLICY ACT OF 1970

The Congress and the Nation have long considered the development and maintenance of a sound domestic mining and minerals industry essential to the U.S. economy. This concern has served as the basic thrust for much of the legislation and many of the Federal programs dealing with U.S. natural resources and mineral industries. However, until enactment of the Mining and Minerals Policy Act in 1970, legislation and programs were individually directed toward different aspects of mineral industry problems; nothing that could be view as a national mining and minerals policy existed.

According to a House Committee on Interior and Insular Affairs report, the Congress did not expect the act to be a cure-all for the mineral industry but hoped it might focus attention on the industry and the need for long-range planning and objectives. The Congress expected that, because of the act, questions would be answered regarding the permissible degree of dependence on foreign supplies, import and export of minerals, stockpiling for emergency situations, taxation, manpower, health and safety and environmental quality, and U.S. capability to supply its domestic needs.

The act did not suggest that other national policies should not affect the minerals industry, but the Congress did intend that the individual and collective effects of these other policies on the industry be objectively considered when tradeoffs were being made or other alternatives considered.

The act did not, however, provide any new authority or funding nor call for establishing any organizational mechanism for achieving its objectives. Although the act established policy for the entire Federal Government, it specifically directed the Secretary of the Interior to carry out the policy in accordance with other statutes authorizing such programs and to make an annual report to the Congress showing the state of domestic mining and mineral industries, trends in use and depletion or resources, and recommended legislative programs.

PROBLEMS IN IMPLEMENTING THE ACT

The expectations of the Congress have not been met, and many of its questions and concerns still exist. Effective implementation of the Mining and Minerals Policy Act of 1970 has been hindered by lack of coordinated comprehensive guidance for planning and executing programs and lack of organizational arrangements within Government to identify and balance conflicting policies or programs.

The Department of the Interior has continued to develop strategies and programs to help ensure the uninterrupted supply of minerals. These programs, which include research and development; geological investigation; and the collection, analysis, and dissemination of mineral data and participation in mineral-related policy reviews; are being carried out in accordance with Interior's historic authorities.

The Secretary of the Interior recognized in his first annual report under the act in 1972, that comprehensive guidelines were needed if the fundamental intent of the act was to be achieved. He stated, however, that the development of such guidelines was beyond the authority of the Department of the Interior under this and other statutes.

> "The broad spectrum of laws lodged in numerous agencies compounds problems in the development of constructive mineral policies. If the Nation's future national resources requirements are to be met through the wisest conservation and management of available resources, there is a positive need for integration of natural resources plans and programs, a need for consistency of treatment by the Federal Government of natural resources programs, and planning and management for the most effective use and productivity of all natural resources."

The achievement of the fundamental intent of the Mining and Minerals Policy Act is also hindered by the lack of institutional mechanisms for identifying and balancing conflicts among national policies, programs, and regulations.

The Secretary of the Interior's report also expressed concern about this organizational weakness.

> "Conflicts often arise between existing statutes in their requirements as to mineral*** development and operations. Conflicts also arise between existing statutes and appropriations measures which sometimes deny fund usage for the purposes necessary to proper administation of other laws."
>
> * * * * *
>
> "Many Federal laws directly affecting the mining, mineral, metal, and mineral reclamation industries confer authority on other agencies of the Executive Branch. The total breadth and impact of such authority is substantially greater than that conferred upon the Secretary of the Interior. Several examples illustrate this point:
>
> "The Federal Water Pollution Control Act, the Clean Air Act, the National Environmental Policy Act, the Environmental Quality Improvement Act, and many other items of legislation dealing with environmental enhancement have direct impact on the mineral industry which is among the Nation's major users of water for processing and, along with power generation (largely based on minerals), one of the Nation's major sources of emissions.
>
> "The Occupational Health and Safey Act provides for safety in many facilities of the mineral industry not covered under the specific mine safety statutes.
>
> "The Internal Revenue Code governs, among other important matters, expensing of costs involved in exploration and in research and development, allowances for depletable mineral assets, amortization and depreciation of facilities; and valuation of inventories.
>
> "The Tariff Acts, the Trade Agreement Acts, and the Anti-Dumping Acts govern questions of import regulation significant to the mineral industries.

"A wide variety of laws governing consumer protection, antitrust action, and the regulation of exchanges directly affect the mineral industry."

* * * * *

"The above authorities * * * confer a broad assortment of powers. However, the Secretary of the Interior is constrained to operate only within the bounds of the authority conferred and also within the appropriations available for specific programs."

In 1974 the Congress established the National Commission on Supplies and Shortages, consisting of representatives from the Congress, executive branch, and private industry. One objective of the Commission was to determine the institutional adjustments needed to analyze economic needs for resources on a permanent basis. In this regard, the 1976 Commission observed that:

"IF THE EXPERIENCES of recent years teach us anything, it is that Government policies developed and implemented without an understanding of how they affect specific industries and interact with other policies often create more problems than they solve. This is particularly true of policies affecting the key materials-producing industries. * * *"

* * * * *

"These industries require relatively long lead times to expand their productive capacity substantially. Once installed, this productive capacity is long-lived. The high capital-intensity of many materials production processes means that operating them at levels much below those for which they were designed drives up unit costs sharply. This combined with the fact that demand for materials is particularly sensitive to shifts in the level of aggregate demand, means that profits are likely to be volatile. Thus, these industries are especially vulnerable to abrupt policy shifts."

* * * * *

> "Understanding the impacts and interactions of proposed policies is not easy.*** Some means must be found to integrate the improved information produced by the agencies and departments into a comprehensive picture of how Government policies combine to affect basic industry, and, beyond that, the broad national interest. Means also must be found to alert high-level decisionmakers to the possible consequences of events which separately may be of little concern, but together can foreshadow major problems."

There is currently no formal mechanism for resolving conflicts between the Mining and Minerals Policy Act and other national policies, programs, or regulations, but tradeoffs are sometimes made informally. The Bureau of Mines comments on the effect of specific Government actions on the mineral industry when it is aware of them and, when asked, provides data on the sensitivity of the industry to certain actions. Current procedures, however, do not guarantee that such data be provided or, if it is provided, that it is considered in the overall interest of the United States.

CHAPTER 7

CONCLUSIONS AND MATTERS FOR THE CONGRESS

Assured access to mineral resources at prices established in competitive markets is an important concern to the Nation. Resource availability and the extent to which the United States should rely on foreign mineral resources are very complex considerations. To a large extent, traditional economic factors, such as the remoteness of projects, ore grade, facilities and equipment needed, and access to capital are important influences on trends in the domestic and international mineral industries.

Fortunately, compared with most nations, the United States is rich in mineral resources. Domestic smelters and refineries using foreign ores and concentrates to supplement domestic mine production have provided U.S. manufacturers with the majority of their mineral needs.

In recent years, however, several U.S. Government actions have reduced the profitability of domestic mineral projects, making investment in such projects less attractive than they otherwise would have been. These actions and the efforts of foreign governments to encourage development of their minerals production have contributed to the failure of investment in domestic mineral production to keep pace with growth in U.S. demand. Consequently, U.S. manufacturers are having to rely more and more on foreign processed minerals to meet their needs.

Investment decisions involve complex assessments of many variables. Investors, in their attempt to obtain the highest return on their investments, assess a project's expected development and operating costs and sales revenues. Making such assessments in the mineral industry is difficult because of the generally long payback period, cyclical nature of mineral prices, and general uncertainty about many of the cost elements involved.

Although traditional economic factors influence investment decisions, more and more U.S. and foreign governments' actions are tending to distort these factors, influencing the relative profitability of projects and thereby their locations.

In general, compared with other countries, U.S. Government actions have tended to do more to discourage and less to stimulate investment in domestic mineral projects through:

--Restricting the use of Federal lands for mineral exploration; some countries are actively encouraging or sponsoring such efforts.

--Imposing strict environmental requirements; some countries are either more lenient in their standards or enforcement or provide assistance to help defray their costs.

--Restricting the use of joint ventures to pool resources; some countries not only encourage joint ventures but actually participate in financing projects through loans, grants, loan guarantees, or direct equity purchases.

--Adding to labor costs by establishing worker health and safety requirements; some countries are either more lenient in their standards or enforcement or provide assistance to help defray their costs.

In addition, the absence of a clear Government energy policy and the existence of restrictions which delay or halt construction of power-generating facilities have created much uncertainty about the future availability of energy supplies needed for the mineral industry. Government programs, such as land reclamation requirements, are also contributing to the increasing cost of energy.

The decline of the U.S. mining and mineral-processing industry has resulted in lost jobs and job opportunities in the industry, adversely affected the U.S. balance of trade, and increased concerns about U.S. vulnerability to mineral supply disruptions.

We recognize that U.S. Government efforts in the above areas are in response to legitimate public concerns and national policies. And, we recognize the merits of congressional concerns and efforts to address these issues. However, the purpose of this report is to point out that the response to these concerns has adversely affected the competitiveness of the domestic mineral industry, particularly in view of the actions of foreign governments, and to point out the need for a mechanism for (1) objectively considering the consequences of Government actions and (2) resolving conflicts between national policies to assure tradeoffs or alternatives are made in the overall best interest of the Nation.

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We believe the attention of Congressional committees concerned with these problems should immediately focus on developing such a mechanism.

AGENCY COMMENTS

The Department of the Interior agreed with many of the basic points in our report. For example:

--There is a definite trend toward processed versus raw material imports and, as shown by estimates, this trend is likely to continue in the future.

--Changes in U.S. Government policies over the last 10 years have increased the costs of mining and processing minerals in the United States.

--Some governments are attempting to increase mining and mineral-processing capacity in their countries.

--Some improvements may be appropriate in considering the consequences of Government actions and for resolving conflicts between policies to assure that the overall national interest is served.

However, Interior expressed some concern with the lack of quantitative analysis and the apparent reliance on interviews with industry officials. Also, that no attempt was made to prioritize or quantify the various factors analyzed in the report.

We agree that quantification of the effect of each factor on the declining trends in the mineral industry would be useful; however, the amount of work necessary to compile such data was far beyond the scope of this report and, in our opinion, not necessary to conclude that the Government should become more aware of the affect of its actions on the mineral industry.

We did interview corporate officials and reviewed various corporate records and reports; however, our conclusions were also based on substantial corroboration from academicians, investment analysts, banking officials, U.S. Government officials (including those of regulatory agencies), and officials of foreign governments and corporations.

Interior stated that a major gap in our report is the omission of discussion concerning ore quality (quantity, grade, depth, and other physical characteristics). We recognized that ore quality is a factor in the relative position of the U.S. mining and mineral-processing industry and noted that the United States ranks first in ore reserves for copper, lead, molybdenum, cadmium, and silver and ranks high in many others. However, our report stressed those factors that are most significantly affected by Government actions:

--Economic access to minerals.

--Development and financing costs.

--Opportunity to pool resources.

--Labor costs.

--Energy availability and price.

Discussions with industry analysts and bankers and our comparison of proprietory data on production costs for U.S. and foreign projects indicates that these factors can make enough difference in production costs to influence the viability of projects and, thereby, influence investment in U.S. mineral production.

Interior agreed that access to Federal lands for mineral exploration and development is important and needs further policy examination, but it questioned the high priority given to the problems, particularly in the absence of any quantitative evidence that land withdrawals and restrictions on land use have had any impact on mineral exploration and development or on the level of mineral production in the United States. Data on expenditures for domestic mineral exploration is not available; however, considering that (1) several companies identified during our work have cut back on domestic exploration and (2) the amount of land with restricted access has grown considerably during the last decade, there is little doubt that a relationship exists.

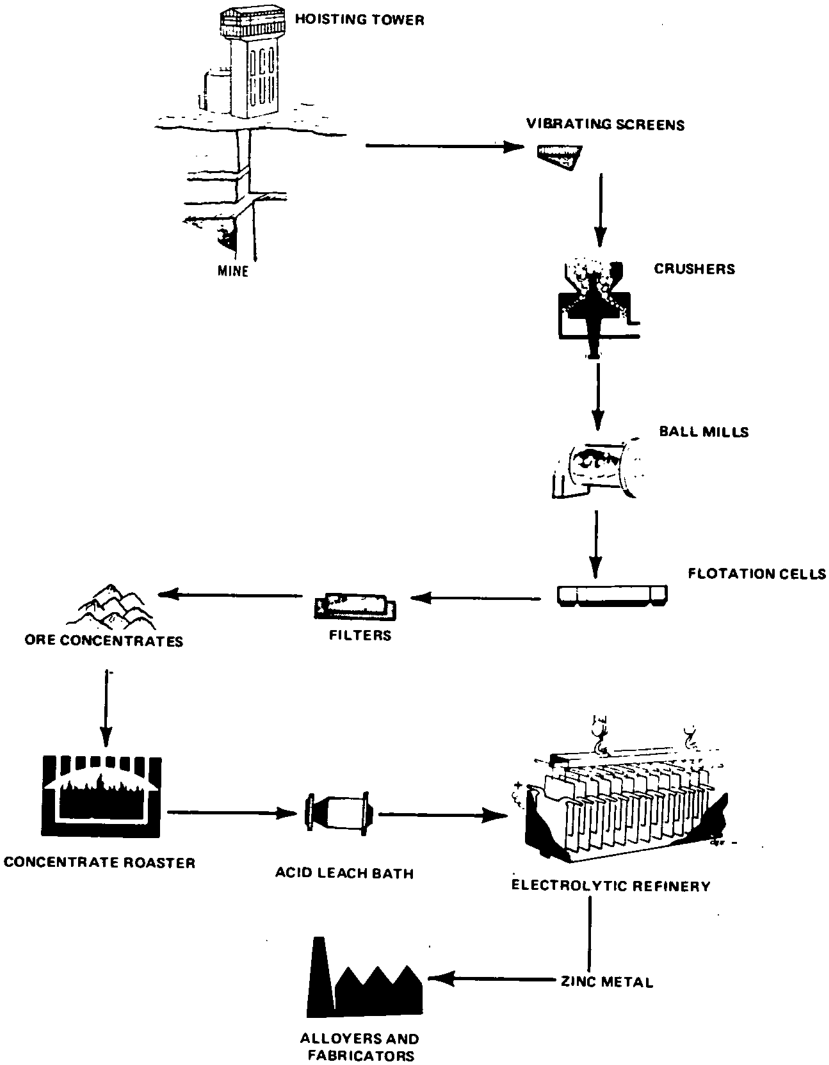
As for the impact of land restrictions and withdrawals on mineral production, because current operations are using mineral resources identified many years ago, current cutbacks in mineral exploration will not show up in reductions in mineral production for several years.

Interior asserted that the availability of Federal lands for mineral development is substantially determined by specific congressional mandates. While we agree that the Congress did provide legislative authority for restricting access to Federal lands, the Secretaries of Agriculture and the Interior exercise considerable administrative discretion in identifying areas to be withdrawn or restricted. Unfortunately, as stated in the report and according to the Department of the Interior Task Force on Availability of Federally-Owned Minerals Lands, inadequate mineral information is available for analyzing the overall mineral capabilities of Federal lands and for determining which lands should be withdrawn.

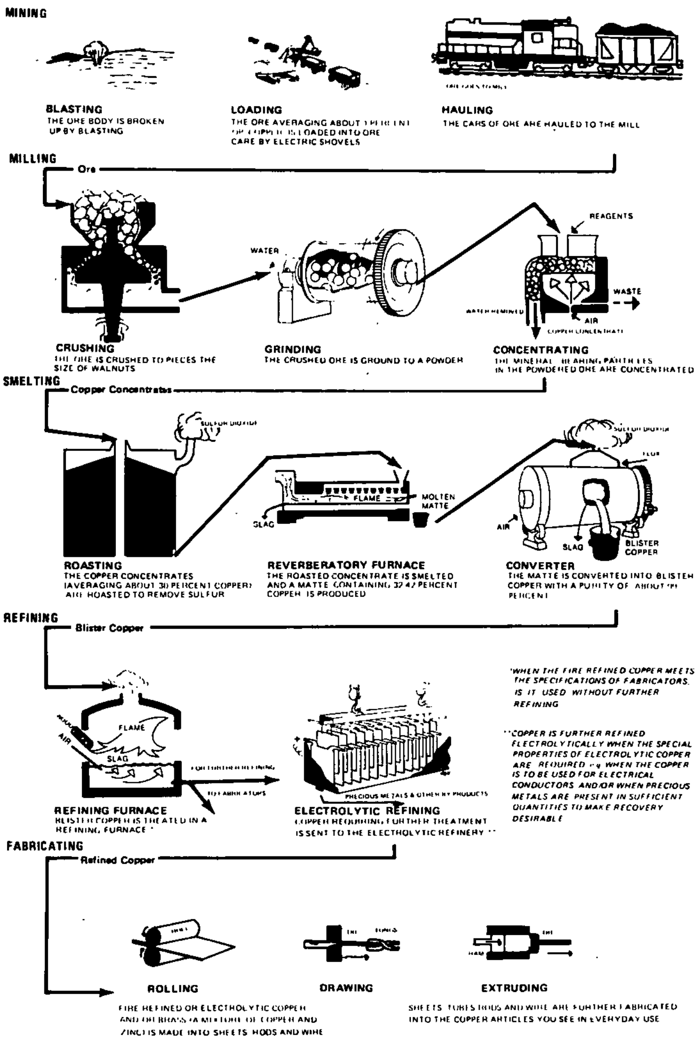
Concern was also expressed that the report indicated that the Department of the Interior is solely responsible for implementing the Mining and Minerals Policy Act of 1970. Interior stated that any Federal agency which has an impact on minerals has respnsibility for carrying out the act. Although this is true, the act gives the Department of the Interior prime responsibility for implementation. Specifically, the Congress expected that Interior would answer questions regarding the impact of Government actions concerning taxation, worker health and safety, environmental quality, and the capability of the United States to supply domestic mineral needs.

We noted, however, that Interior and other agencies whose actions have adversely affected the mineral industry have largely ignored the 1970 Mining and Minerals Policy Act. And, currently there is no mechanism for objectively considering the consequences of Government actions and for resolving conflicts between national policies to assure that tradeoffs or alternatives are made in the overall best interest of the United States.

ZINC PROCESS FLOWSHEET



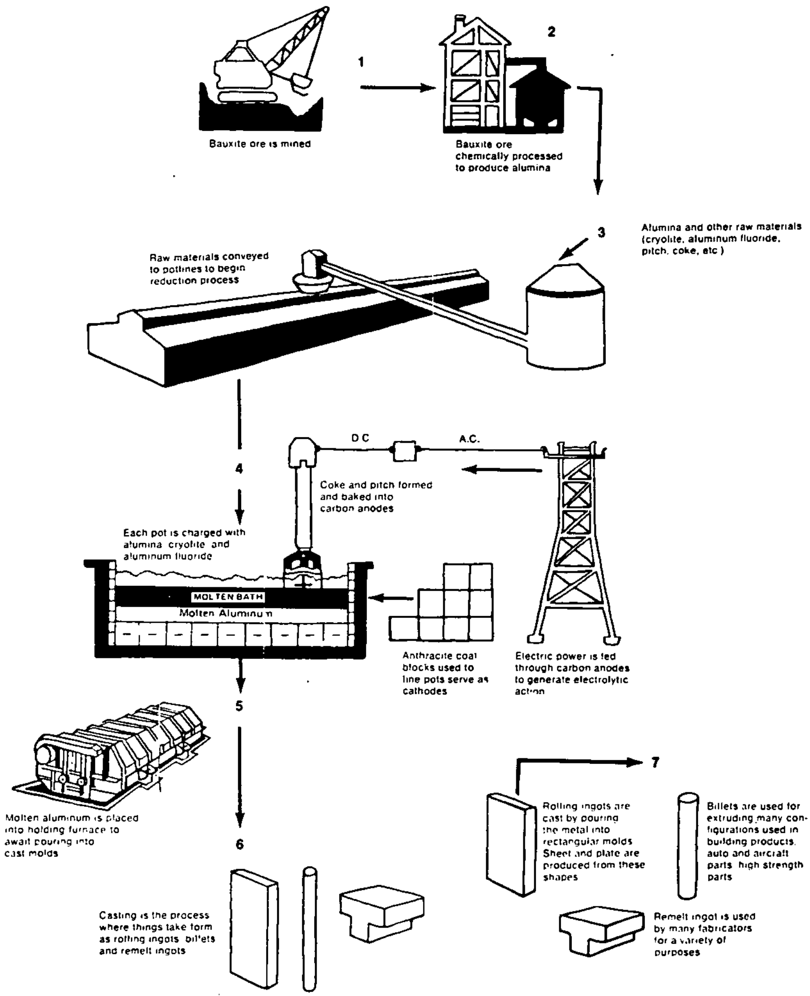
COPPER PROCESS FLOWSHEET



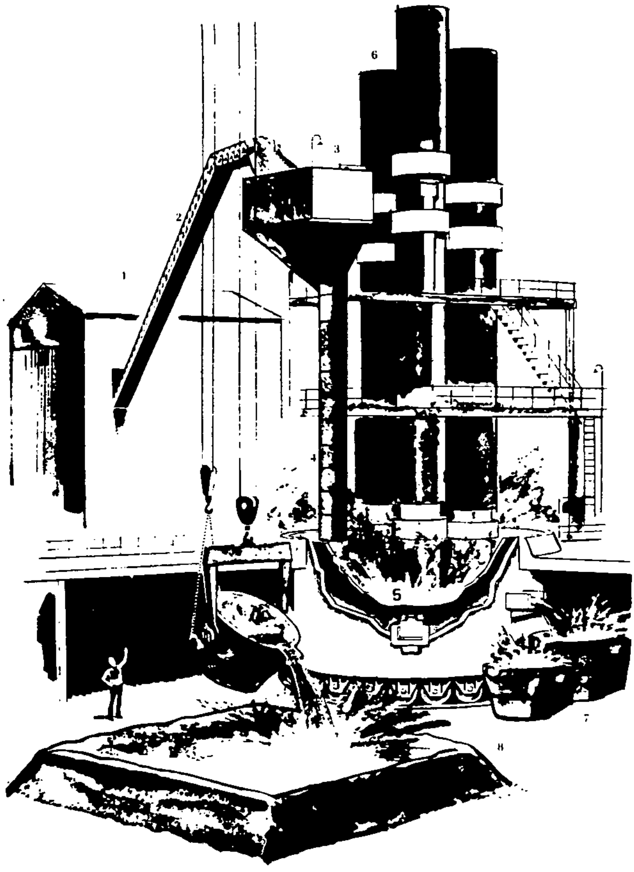
(COURTESY, KENNECOT COPPER CORP.)

APPENDIX I

THE ALUMINUM PRODUCTION PROCESS



THE MAKING OF FERROALLOYS



THE FERROALLOY MANUFACTURING PROCESS BEGINS IN THE MIX HOUSE (1) WHERE RAW MATERIALS–ORE, COKE AND OTHER PROCESS INGREDIENTS–ARE PRECISELY WEIGHED AND MIXED. A CONVEYOR (2) CARRIES THIS MIXTURE TO MIX BINS (3) WHICH STORE THE RAW MATERIALS UNTIL THE FURNACE OPERATOR RELEASES THEM THROUGH CHUTES (4) TO THE FURNACE (5). CARBON ELECTRODES (6), WHICH EXTEND INTO THE FURNACE, CARRY THE ELECTRICITY REQUIRED TO PRODUCE THE EXTREMELY HIGH TEMPERATURES (6000° F) NECESSARY TO CARRY OUT THE FERROALLOY PRODUCTION PROCESS. FINISHED FERROALLOY, IN THE MOLTEN STATE, IS TAPPED INTO A LADLE (7) AND POURED INTO MOLDS (8) FOR COOLING. AFTER SOLIDIFYING, THE FERROALLOY IS CRUSHED, SCREENED ACCORDING TO DESIRED SIZE, AND SHIPPED TO THE CUSTOMER.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

JUL 12 1979

Mr. J. Dexter Peach
Director
Energy and Minerals Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

This responds to your request for comments on the draft Comptroller General Report to Congress, "The Declining U.S. Mining and Mineral Processing Industry: An Analysis of Trends, Causes, and Implications." We appreciate the difficulty of addressing this complex subject. This GAO report describes a decline in U.S. mining and minerals processing in recent years as characterized by U.S. production and imports of four metals: zinc, ferroalloys, copper, and aluminum. We agree with the conclusion that there is a definite trend toward increasing processed versus raw material imports and that, as shown by estimates, this trend is likely to continue in the future. GAO found that, while traditional economic factors are important in determining the location of production capacity, U.S. and foreign government actions play increasing roles in minerals investment decisions.

The report singles out a number of U.S. Government policies and actions which the authors feel are contributing to a decline in domestic industry "competitiveness." Unlike the discussion of import trends which is supported in the report by factual information, the treatment of these policies is generally subjective, apparently based in substantial part on interviews with industry officials. There is no attempt made to prioritize the various policy factors nor, as the report notes, to quantify them.

We can agree that changes in U.S. Government policies over the last 10 years have increased the cost of mining and processing minerals in the U.S. It is also true that some other governments are attempting to increase mining and processing in their countries. There are also some that are discouraging investment. What is not known is, if these policies had not changed, whether investment decisions would have been different.

Most of the policy factors discussed are the responsibility of agencies other than the Interior Department. While we provide some general reactions to some of these, to provide a credible review and report, it is essential that the following agencies have the opportunity to respond to the criticisms of their programs and policies: [1]

Department of Treasury: Tax and Investment-related policies.

Department of Energy and Tennessee Valley Authority: Allegations that Federal energy policies pose major constraints to the domestic minerals industry.

Environmental Protection Agency and Occupational Safety and Health Administration: Effects of environmental health and safety laws.

General Services Administration: Adverse effects of stockpile policies.

Department of Commerce and the Office of the Special Trade Negotiator: Trade policy, quotas, and tariffs.

Council on Wage and Price Stability: Impacts of wage and price guidelines.

The GAO report expresses concern that minerals production is declining and imports are increasing. In this regard, the report would benefit from a definition of competitiveness and a discussion of its importance. There are no well defined national goals or policies which call for maximizing production and minimizing imports without consideration of other national priorities. There are, of course, national policies concerning air and water pollution, health and safety, trade relief and restrictions, and other factors cited as contributing to increased domestic costs. These policies have been established by the Congress, and the concerns expressed in the report should be related to the specific, established national goals. The Mining and Minerals Policy Act of 1970, while it does declare a continuing policy to foster and encourage a sound and stable domestic minerals industry, does not express concern about reliance on imports.[2] (This Act, contrary to the statement on page 96,[3] is directed at all Federal agencies, not just the Interior Department.)

[1]A draft (or pertinent portion thereof) of the report was provided to the Departments of Energy, Treasury, Defense, and State; EPA, OSHA, and General Services Administration and their comments and perspectives were considered in the final report.

[2]The Senate report on the Act states that "As we permit our Nation to become more and more dependent upon foreign sources for minerals * * * we tend * * * encumber our foreign policy and limit our freedom of movement within the family of nations." Therefore, concern about growing import dependency was an impetus to the legislation although it was not specifically mentioned in the Act.

[3]Page 68 in the final report.

Neither does the Act suggest that other national policies should not affect the minerals industry. There will always be trade-offs when new policies are established; they cannot be avoided. Particularly when domestic resources are limited or nonexistent, or foreign sources of ore or processed minerals are substantially less costly, the state of domestic production is just one factor that must be considered in arriving at the most acceptable domestic policy.

The report would also benefit from a clarification of how corporate decisions are made in this area. Emphasis should be given to the fact that many factors tend to be company-specific and variable. It also should indicate that there is a trend in U.S. minerals industries to invest overseas, and that this is based on a number of considerations made by individual companies.[4]

In considering investment decisions, there is a major gap in the report. Ore quality, perhaps the most significant single factor involved in the relative position of the U.S. domestic production, is completely omitted from the discussion.[5] The following is a listing of policy and economic factors of primary importance in considering the relative position of domestic production:

<u>Economic Factors</u>

- Ore Quality
- Labor Costs
- Energy Costs
- Technology
- Water Costs/Availability
- Transportation Costs
- Capital Availability

<u>Policy Factors</u>

- Tax Policies
- Environmental/Health/Safety Regulations
- Federal Land Policies
- Antitrust Policies
- Governmental Subsidies and Promotional Policies
- Nationalization and Other Foreign Government Restrictions
- Political Instability.

[4]As Government actions add costs or increase risks, the attractiveness of investment in domestic projects is reduced; this contributes to the trend toward investment in overseas mineral projects.

[5]These points are discussed in chapter 7.

While many of these are considered in the draft report, discussion of others is notably absent.[6] In addition to ore quality, there is little mention of Federal policies and other factors which might assist the domestic industry. Discussion of trade policy is particularly confusing. Quotas and tariffs designed to protect the domestic extraction industry appear to be singled out for their adverse effect on the domestic industry, apparently because of perceived impacts on the processing industry.[7]

The question of access to Federal lands for mineral exploration and development is important and needs further policy examination; but we fail to see why it is given such high priority by GAO, particularly in the absence of any quantitative evidence. We have not been able to acquire evaluations from industry showing substantial reductions over time in exploration expenditures on the public lands; nor is there evidence presented that land availability restrictions have had a significant impact on the levels of domestic production for any specific commodity. The availability of Federal lands for minerals activity is substantially determined by specific Congressional mandates for special status such as parks, wilderness, and for land use planning. It is also affected by actions of the Agriculture Department. The report should note that Federal land policies as they affect domestic production present a mixed picture. By providing free access to the public lands for most minerals under the Mining Law of 1872 and its predecessors, the Federal Government has provided a major incentive and subsidy to domestic production. The international survey fails to note that few, if any, foreign governments provide this type of free access. GAO noted this lack of return to the Treasury in its recent report on the 1872 mining law. [8]

The complexity and mixed picture of the Federal lands issue is thoroughly analyzed in the recent Office of Technology Assessment Report, "Management of Fuel and Nonfuel Minerals in Federal Land." It notes the land management difficulties inherent in the 1872 Mining Law and how this has been the source of many mineral access restrictions. The figure used on page 30[9] that 68 percent of the public lands are totally withheld from mineral entry, appears to be too high. A range of 40 percent highly restricted to 65 percent totally and partially restricted would be more accurate, although any hard numbers must be used with caution. (See the "1977 Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970," pages 89-107.)[8]

[6]Our report centers on the influence of Government actions on investment decisions, so we focused on those factors upon which such influence was strongest.
[7]We agree that this point was not clear, and it was deleted from the report.
[8]These points are discussed in chapter 7.
[9]Page 19 of the final report.

We offer the following additional comments:[10]

- Conclusions of the report with respect to the influence of government actions on development costs and access to capital fail to note that one of the objectives of the Export-Import Bank, O.P.I.C., A.I.D., Western Hemisphere trading corporations, and the depletion allowance for foreign minerals is to help domestic producers and consumers obtain access to foreign minerals for U.S. processing facilities.

- There is only a limited understanding of the impact of U.S. antitrust laws, and whether the type of cooperative industry ventures the report suggests are in the national interest.

- Energy availability limitations may not be as severe and they may not alone affect expansion and development as much as indicated in the GAO report. However, a factor affecting investment decisions is the uncertainty of future energy cost increases.

- The analysis of copper import trends may be somewhat distorted by the short term chosen (1974-1978) when there were world surpluses.

- The GAO on pages iv and 81[11] states that the U.S. nonfuel mineral trade deficit is $10.6 billion, whereas the Bureau of Mines, considering inorganic chemicals and plastics as detailed in the enclosed chart, arrives at about $8 billion. Excluding plastics, the deficit is $9 billion.

- With reference to the Mining and Minerals Policy[12] Act of 1970, discussed on pages vi, 2, and 95-100, it is important to note that the Department of the Interior is not solely responsible for implementing that Act. The Act states "...that it is the continuing policy of the <u>Federal Government</u> (underlining supplied) in the <u>national interest</u> to foster and encourage private enterprise in...." Thus, <u>any</u> Federal agency impacting upon minerals has responsibility for carrying out the Act. The Department of the Interior, through the Geological Survey and the Bureau of Mines, has long been active in helping to alleviate mineral problems

[10]The report was modified to incorporate these comments.
[11]This reference was deleted from the digest and p. 81 is now p. 58 in report.
[12]Pages iii, 2, and 68 of report.

through research and other programs. The 1979 fiscal year appropriated funds of the Geological Survey amounted to $640 million for mineral surveys, investigations, and research. The Bureau of Mines appropriation was $148 million for mine health and safety research, nonfuel mine productivity research, metallurgy programs, and mineral information systems. The Bureau of Mines was instrumental in formulating the 3-year strategic stockpile goal in 1976, which was reaffirmed by the current Administration in 1977, and the Bureau of Mines has also recommended programs under the Defense Production Act for research work on strategic and critical minerals. The Bureau and other Departmental offices participate in a number of minerals-related policy reviews.[13]

We would close by emphasizing our concern that many of the points raised in the report are subjective. It is difficult to assess the importance and priority of all these factors to the trends seen in the industry without some quantitative analysis. The report does recommend the establishment of a mechanism for objectively considering the consequences of government actions and for resolving conflicts between policies to assure that the overall national interest is best served. Some improvements may be appropriate and will be considered as part of the Nonfuel Minerals Policy Review.

We will honor your request that, because this report is subject to revision, it be appropriately safeguarded to prevent premature or unauthorized disclosure. I would note, however, that members of your study team testified in detail on the report and its conclusions before the House Subcommittee on Mines and Mining on June 12, 1979. Therefore, the study's conclusions are a matter of public record.

Some technical comments on specific pages are enclosed and we would be pleased to discuss our comments with you in more detail.

Sincerely,

Larry E. Meierotto
Assistant Secretary
Policy, Budget, and Administration

[13]These points are discussed in chapter 7.

A REPORT ON THE POTENTIAL FOR SUPPLY DISLOCATION OF SELECTED NONENERGY MATERIALS

By Lee R. Murphy

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Summary

This paper is an analysis of U.S. vulnerability to dislocations in supply of 17 nonenergy materials,[1] and includes an identification of newly emerging issues which U.S. policymakers should address. Earlier reports have primarily focussed on concerns that the actions of the Arab oil exporting states in limiting supplies, embargoing shipments, and driving up prices would lead to similar attempts at collusion among exporters of critical nonenergy materials. Also of concern at the time of the OPEC embargo was the claim by "limits to growth" theorists that the industrialized world was in transition from an era of abundant raw material supplies to one of growing stringencies.

While these concerns have largely proven groundless, there nevertheless have been important changes in global raw material markets that have affected U.S. interest. Most striking has been the recent acceleration in the erosion of the U.S. share of global metal markets. Slack market conditions since 1974 have intensified the longer term competitive problems faced by U.S. producers—namely, much tighter environmental standards and a growing foreign capacity to process raw materials.

A. Overall Conclusions

1. U.S. IMPORT DEPENDENCE

Although U.S. import dependence on critical nonenergy materials has increased since 1974, it remains modest—less than 20 percent of consumption, compared with 75 percent for Europe and 90 percent for Japan. Our dependence is concentrated primarily on developed countries, particularly Canada, Australia and South Africa, with Canada alone supplying half our needs. Lesser developed countries (LDC's) are, however, significant suppliers to the United States of bauxite, manganese, tin and natural rubber. We rely on the USSR for significant amounts of two key materials—platinum metals and chromium.

2. POTENTIAL PROBLEMS

a. Natural scarcities.—Notwithstanding occasional predictions to the contrary, the U.S. does *not* face the risk of exhaustion of world reserves of critical materials. There are ample materials available in the earth's crust to meet the world's needs for nearly every material through the end of this century.

b. Embargoes.—The chances of an Arab-style embargo of raw materials are slim. Basically, embargo actions do not make economic sense in terms of the revenue objectives of producers of critical materials. Economic interest argues for selling at a higher price, rather than denying the product altogether. An embargo is therefore likely to be undertaken only for political reasons. But a realistic scenario for an export embargo by producers that would advance their political interests is hard to identify outside the sphere of oil. A remote possibility is

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[1] The materials examined include: bauxite, alumina, and aluminium; chromium; cobalt; copper; columbium; fluorspar; iron ore; lead; manganese; nickel; phosphate rock; platinum; silver; tungsten; titanium; vanadium; and zinc.

an embargo by black African states against industrial countries having economic relations with minority regimes in Southern Africa. Such a move would affect primarily Western Europe.

c. Supply disruptions from events other than embargoes.—There is a possibility of disruption of supplies from Rhodesia as a result of internal disorders, and a more remote one in the case of South Africa. These difficulties would seriously affect U.S., European, and Japanese imports of two critical materials—platinum and chromium. In addition to these, one should add cobalt, because the bulk of the supplies come from Zaire, a country where political turmoil appears chronic. Whatever their cause, such disruptions are likely to be short term phenomina (lasting no more than a few months, with an outside possibility of a year or so). Even in cases where radical or ineffective governments take over, the new regime is likely to give first priority to maintaining production, since the mine output often provides the bulk of the country's foreign exchange earnings.

d. Exorbitant short term price increases.—Price increases well beyond those that would result from normal supply and demand forces can be forced on the world market for a short time. How long such price gouging can be sustained depends on the length of time it takes for the market to respond by starting new production, reducing consumption, or switching to substitutes. This can take from a few months to a year or so, depending on the commodity. Whatever the timing, the price gouger would soon have to restrict supplies if he wanted to maintain his price. For example, Morocco, the world's largest exporter of phosphate rock, was able to triple prices in 1973–74 when fears of shortages were widespread. As soon as demand fell in 1975, however, prices had to be reduced because of consumer resistance, competition from U.S. producers, and growing supplies from other countries. In fact, because Morocco tried to maintain its prices at too high a level for too long, its share of the global export market fell.

3. U.S. VULNERABILITY TO SUPPLY AND PRICE RELATED ACTIONS FOR SPECIFIC COMMODITIES

Seventeen major industrial materials in world trade have been assessed to determine: (1) the prospects for maintaining prices; (2) the risks of supply interruption; and (3) the impact of any prospective action on the U.S. economy and national security. Weighing these factors, one finds vulnerability in three commodities: platinum, chromium, and cobalt. With supplies concentrated in Southern Africa and the USSR (platinum and chromium) and Zaire (cobalt), a potential exists for politically related supply interruption and of price gouging through tacit cooperation among major producers.

For none of the critical materials would the economic effect of price increases approach that for oil in 1973–74. U.S. petroleum imports amounted to $45 billion in 1977, or 30 percent of total imports, compared with $1 billion, less than 1 percent, for iron ore, the highest value for an industrial raw material import outside the energy field. The U.S. oil import bill increased $16 billion in 1974 as a result of OPEC's quadrupling of oil prices causing nearly a 25 percent increase in overall imports. A similar price increase for iron ore would have raised our overall import cost by only 2 percent.

The domestic impact of higher oil prices is also much greater, in part because crude oil accounts for so large a share of the cost of petroleum products. For example, the quadrupling of crude oil prices in 1973–74 increased gasoline prices by about 40 percent and the price of less-taxed petroleum products such as fuel oil by even more. By comparison, a similar increase in iron ore prices—which is not likely within the foreseeable future—would result in a 13 percent increase in steel prices.

4. U.S. STRATEGIC CONSIDERATIONS

The degree of supply restriction entailed in price gouging or cartel-like action would have little effect on the U.S. requirements because the portion of U.S. consumption of critical materials required for defense production and military use—generally 10–20 percent in wartime and about half that much in peacetime—can be met from domestic production, stockpiling, and substitutes under any foreseeable supply restrictions.

B. Issues Requiring Further Analysis

The U.S. mining industry is facing increasing competition from foreign producers of nonferrous and ferro-alloy metals. In the past two years, U.S. exports of these metals have stagnated while imports climbed rapidly. U.S. exports of nonferrous metals, for example, rose 40 percent between the first half of 1977 and the similar 1978 period. This accelerated market encroachment by foreign producers stems from a number of causes:

United States and other devéloped country producers have had to absorb an unusually large share of the production cutbacks necessitated by the slack global demand. Government-owned mining companies (especially in LDC's) have in some instances maintained domestic employment by keeping up production even when production costs exceeded the metals' selling price. Private mining companies, in contrast, were unable to sustain such large financial losses and had to curtail output (and thus employment) to offset both the limited demand and the continuing high production elsewhere. The most notable example of such a situation is copper.

For many years, U.S. metal producers have had to cope with growing environmental restrictions which tend to be stiffer than in many other countries, especially LDC's. This problem has intensified in recent years because relatively low real metal prices, high capital costs, and an anticipated slow growth of demand have combined to inhibit new investments. In fact, in some metals, obsolete plants have been closed without bringing on replacement capacity. The result is that U.S. consumption is increasingly being met by foreign plants. Zinc is the most notable example.

At the same time, foreign producers continue to move up the processing scale and thus the United States is buying more minerals in the form of metal rather than as ores. Examples of this trend are ferrochrome and alumina.

While these circumstances have obviously had an adverse impact on metal industry profits and employment, other parts of the U.S. economy have benefited. Inflation has been less than it otherwise would have been as a result of increased foreign competition. U.S. flexibility as to foreign sources of supply has increased, reducing the chances of supply interruptions and attempts to artificially raise international mineral prices. This happens because U.S. producers who process ores depend on specific grades and sources of ores to feed their smelters or refineries. The next stage of processing, however—alumina and ferrochrome, for example—tends to be a more standard product and thus U.S. industrv can obtain these metals from a wide range of sources.

I. Introduction

The United States has been fortunate in its natural endowment of materials resources, and this has been a major factor in U.S. economic growth. In spite of the recent concerns voiced about possible exhaustion of our richest mineral reserves, the United States still has vast resources of most minerals. However, mineral deposits must be found and developed before they are economically useful, and exploration and development are usually long and expensive processes. Furthermore, while cost is a critical factor in determining whether or not a deposit is developed, political and strategic considerations are also involved. These considerations become even more important when one examines U.S. supply and wage requirements of those critical materials which we import from potentially insecure foreign sources.

The objective of this paper is therefore to identify, describe, and assess the vulnerability of the United States to future disruptions in the supply of selected nonenergy materials. The paper is limited to an analysis of 17 materials: bauxite, alumina, and aluminum; chromium; cobalt; copper; columbium; fluorspar; iron ore; lead; manganese; nickel; phosphate rock; platinum; silver; tungsten; titanium; vanadium; and lead. It should be emphasized, however, that there are over 100 nonenergy raw materials which are important to the U.S. economy.

II. Background

In assessing these materials, it is important to note that, with few exceptions, they move with relative freedom in worldwide markets. Less than $10 per ton in freight charges will cover the costs of moving most *bulk cargo* anywhere in the world; hence, relatively cheap materials such as iron ore ($12 to $25 per ton) and bauxite ($25 per ton), do move worldwide. Three or four cents per pound will cover the costs of moving materials by *liner freight*; hence, metals like copper (68¢ to 71¢ per pound); aluminum (55¢ per pound); lead and zinc (about 36¢ per pound); nickel ($2 per pound); cobalt $18 to $40 per pound); and silver $5 to $6 per troy ounce) are traded worldwide. This means that the prices of raw materials and of the primary products into which they are processed, in the United States are, and will be, largely determined by worldwide demand and supply conditions. To the extent U.S. costs of producing materials rise, or U.S. demand for imported minerals grows more rapidly than elsewhere, the United States will become more dependent on imports of raw materials and primary products, and will be less able to export the same commodities.

Moreover, because the demand for materials is derived from the consumption of finished goods and services, materials markets are cyclically sensitive. During periods of economic expansion materials demands rise, forcing prices upward in order to bring into production high-cost facilities previously shut down and to ration limited supplies, since materials productive capacity can only be increased over a long period of time. During periods of economic contraction, demands for materials decline, prices fall, and marginal facilities shut down. Thus, a dominant characteristic of material markets is a high degree of price instability accompanied by variation in employment.

A. U.S. Role in International Trade

The United States is both a major supplier and purchaser of internationally traded nonenergy materials. Total U.S. trade in these commodities last year amounted to $20 billion, from which there was a trade deficit of some $5 billion. The United States plays an important role in international raw material trade, being a leading supplier of Western Europe, Japan, and LDC's (figure 1).

While overall U.S. import dependence on certain critical materials appears high (table 1), for most of these materials, it is less than 20 percent of consumption (table 2). This contrasts sharply with the overall import dependence of Europe (75 percent) and Japan (90 percent). Further, over two-thirds of U.S. industrial raw material imports come from Canada, Australia, South Africa and other developed countries, of which half comes from Canada (figure 2).

For specific materials, the situation varies greatly. Developing countries are significant suppliers of some critical materials, most prominently bauxite, manganese, tin and natural rubber. But the problem of securing adequate supplies of critical materials does not focus simply on relations with developing countries. In fact, the United States relies on the U.S.S.R. for significant amounts of two important items—platinum metals and chromium—and the competition among the industrialized Western countries for supplies of certain materials is expected to increase and further strain international relations.

B. Raw Materials Trends and Cycles

Following the Korean war boom, commodity prices declined sharply and, while fluctuating, did not rise either absolutely or relatively until 1963. For the following 10 years, the prices of many important nonferrous metals, including copper, tin, nickel, chrome, and zinc increased more than prices for manufactured goods (figure 3). The U.S. share of world steel production has declined significantly since the 1950's figure 4).

The 1973–74 surge in minerals and metals prices reflected a convergence of a number of issues. First, the coincidence of a sharp upturn in demand in all major industrial nations, straining production capacity in many industries and causing temporary shortages. Capacity shortages worldwide meant that imports provided little relief. Second, speculative buying soared as a hedge against inflation, currency fluctuations and shortages. Third, serious supply disruptions occurred in some metals because of the effect of pollution control measures on some smelting, labor problems, political instability in some producing areas, and other production problems. Fourth, dollar depreciation resulted in particularly sharp rises in dollar quotations.

By 1975 demand had slumped as a consequence of a deep economic recession in the industrialized countries and mineral/metal prices declined significantly. While commodity prices in general recovered in 1976–77, metal and mineral prices remained depressed. With the exception of tin and lead, prices have performed poorly. Copper prices remain depressed after a modest recovery in 1976, and the market is depressed by a huge stock overhead. Zinc prices continue low, and the nickel market is hampered by oversupply and excess capacity.

There are many uncertainties involved in attempting to draw conclusions regarding future prices of nonenergy materials. For example, it is not possible to forecast with great accuracy the extent to which scientific research and technological advances can offset the increased costs of protecting the environment, or of mining and processing lower grade ores if that becomes necessary to provide adequate supply. The potential and timing of substitution is equally difficult to quantify accurately. Government programs and policies including international political and economic cooperation and agreements, all of which cannot be easily predicted, may also contribute significantly to future changes or to stability in real prices. While many methodologies for quantifying these uncertainties are under investigation none is without potential error.

Historically, the long run trend of real price for most non-energy materials has been downward. However, there have been periods ranging from a few months to several decades when the trend of real price for many materials underwent considerable change. For example, in recent times (1950 to 1973) copper, nickel. iron ore, and silver experienced an upward trend in real price. The trend of real price of the other major mineral commodities during this period was downward. The real price of most of the major materials experienced a sharp upward trend in the few years immediately following the 1973–74 oil embargo and the removal in early 1974 of U.S. government price controls. During the 7-year period, 1950–57, the real price of aluminum rose 28 percent. By 1973, 16 years later, the price for aluminum had dropped 41 percent, only to rise 53 percent in the next 4 years. Cobalt prices tripled in the first 9 months of 1978.

Keeping in mind the uncertainties involved in price forecasting, it seems highly probable that minerals and metal prices are expected to start recovering in the early 1980's as demand growth progressively reduces existing excess supply. In addition, production growth is likely to be rather slow because of the low level of investment in new capacity in recent years. This should push metal and minerals prices upward for the next decade. Copper prices are projected to recover steadily from the early 1980's onward and at the latest by the end of the decade to reach their 1971–73 levels. Tin, nickel, zinc, and aluminum/bauxite also have a favorable long-term outlook. The trend is less favorable for lead, iron ore, and manganese (figure 5).

C. Materials Vulnerability

The United States is vulnerable to dislocations in materials supply as a result of problems in three basic areas: availability, price, and competition.

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1. PROBLEMS OF AVAILABILITY

The problems related to the availability of supply can be grouped in four categories.

a. Natural scarcities.—Especially during periods of tight supplies and high prices (as was the case in 1973–74), predictions frequently are made of impending exhaustion of the world's natural resources. These forecasts, however, do not stand up to close scrutiny. For one thing, they make no allowance for the function of prices as a motive to economize natural resources, to develop substitutes, or to recycle scrap material. During the past 20 years, conservation of most raw materials has increased steadily; that is, as industrial output grows we use less raw material per unit of output.

Another weakness in scarcity forecasts is that they are derived from "proven" reserves. For most raw materials, proven reserves (that is, those which can be profitably mined at current prices and with the present technology) would last for only a generation or two at expected consumption levels. But the inventory of proven reserves is constantly increasing through the discovery of new minable deposits, price increasing which provides incentives to expand exploration and mining output, and the development of technology allowing the exploitation of previously uneconomic mines (table 3). Since 1950, for example, proven world reserves of bauxite have increased by nearly 300 percent and copper by nearly 200 percent. This continuing growth of proven reserves reflects a response to the increasing demand for particular commodities.

The best available data indicate there are ample materials available in the earth's crust to meet the world's needs for nearly every material well into the next century (table 4). Many areas of the world are only now being explored for mineral potential. Vast untapped resources are likely to exist, for example, in Arctic regions, many parts of the U.S.S.R., China, and the Amazon Basin. In addition, the mineral potential of the oceans is considerable, particularly for the nickel, copper, manganese, and cobalt contained in nodules on the ocean floor. Although the oceans' potential may not be tapped in the near term, the technology of seabed resources must be counted in longer term projections of world raw material reserves.

This optimistic longer term outlook does not mean that users can depend on unlimited supplies for all materials. Supply stringencies for mercury and silver are possible in perhaps a decade due to dwindling reserves. In these instances some users will be forced to switch to other materials to keep their product price competitive. For most applications, fortunately, there are substitutes. For example, in the case of silver, aluminum can be used to back mirrors and stainless steel can be used to produce tableware. Such substitutions would stretch out the remaining supplies for those applications where the mineral was absolutely essential.

b. Inadequate production capacity.—Supply stringencies, if they do occur, are more likely to be the result of human actions (or the lack thereof) than of natural scarcities. Unusual surges in demand (as happened in the early part of the Korean War and in 1973) are probably the most difficult to protect against. These infrequent, short-lived, but disruptive experiences are extremely painful to the economies of industrialized countries, but the material stocks needed to prevent such price run-ups would be huge and would have to be stored for decades before being called upon.

A more frequent but usually much less painful capacity problem results from the difficulties in gauging demand trends. The comparable slow growth in economic activity since 1975 has produced overcapacity and low prices for many minerals, and this, in turn, has dampened the enthusiasm for new investment. As a result, an unexpected and sustained pickup in demand could possibly lead to supply stringencies. Similar circumstances have occurred before. Again, problems stemming from such surges could be avoided but only at enormous cost, and since projecting demand trends accurately for the three-to-five years needed to put new capacity on stream is nearly impossible, the risk of investing in excess capacity is extraordinarily high. In the case of most commodities, therefore, there exists a tendency toward underinvestment during prolonged periods of slack demand.

The problems of productive capacity mentioned above are largely the result of the unpredictability of market forces. Another type of problem that affects productive capacity stems from the recent drive toward government ownership of extractive industries. While most LDC governments are every bit as interested in maximizing revenues as multinational corporations, some have proved incapable of managing their extractive industries effectively. The result has been a drop in output and in some cases serious damage to operating mines. In Zambia, for example, the lack of manpower to operate the copper mines has led to declining production. In addition, government mismanagement has made it difficult to attract the foreign financial credits needed to modernize or expand the industry.

c. Embargoes (denial of a product to particular users).—In the months following the 1973-74 OPEC price rises and the Arab oil embargo, the slogan "One, two . . . many OPEC's" was frequently heard at LDC and UN meetings. Spurred on by the example of OPEC and undaunted by the uniqueness of oil in the international economy and the central role of a coherent Arab political interest within OPEC, some developing countries sought greater control over their terms of trade with industrialized countries. What they were after was a way to transform the growing dependence of the industrialized countries on imported raw materials into sufficient leverage to raise substantially commodity prices and enhance their political influence on international affairs.

Nevertheless, embargoes of raw materials seem highly unlikely. They do not make economic sense in terms of producers' revenue objectives. The objective of increased revenue argues for selling at a high price rather than denying the product altogether. An embargo, however, may be undertaken for political reasons as in the case of the Arab oil producers. If the politically inspired embargo is to be sustained, then the producing countries must also have economic power. The Arab oil producers had both a common political desire and economic strength. This combination is not found in any other group of countries producing nonenergy materials.

As table 2 suggests, moreover, dependence on imported raw materials is not necessarily synonymous with dependence on LDC's. Australia, Canada, South Africa, and in the case of chromium and platinum the U.S.S.R., are key suppliers. In the case of those commodities for which LDC's are the major suppliers—Jamaica and Surinam for which LDC's are the major suppliers—Jamaica and Surinam for bauxite, Malaysia and Thailand for tin, Mexico for fluorspar, Brazil for columbium, and Zaire for cobalt—there has been either relatively little interest in embargoes or a shortage of political will to carry it off. Finally, when considering the portion of the critical imported war materials listed above actually required for defense production (an estimated 10 to 20 percent in wartime), the threat such dependence poses for U.S. security must be judged low.

One remote possibility is an embargo by some of the black African states against industrial countries appearing to support Rhodesia and South Africa. The United States would not be deprived of critical supplies, with the possible exception of a portion of our supplies of manganese and cobalt, but we would suffer the indirect effect of higher import prices for materials where Europe's supplies were restricted. If all black African states participated in such an embargo, it would affect Europe's and Japan's supplies of copper (from Zambia and Zaire), manganese (from Gabon), cobalt (from Zaire), bauxite (from Guinea) and iron ore (from Liberia and Mauritania).

d. Other supply interruptions.—A greater risk exists in regard to supply interruptions arising from internal warfare and political turmoil in key suppliers. Of the key suppliers identified in table 1, both internal conflict and overt warfare have proved recurrent. In some countries, domestic political turmoil has affected production for export to major consumers.

Current concern centers on the possibility of disruption of supplies from Rhodesia and South Africa as a result of internal disorders. This could seriously affect U.S., European, and Japanese imports of platinum and chromium, compounding the problems associated with our already sizable dependence on the Soviet Union for these two minerals. Further, one cannot exclude the possibility of a supply interruption for political reasons by the Soviet Union in the event that it becomes the only state capable of meeting world demand.

2. PROBLEMS OF PRICE

Defining a reasonable price for raw materials is a complex matter, and is viewed differently by consumers and producers. What is meant in the context of this report is the price that is at or close to the one that would result from competitive supply and demand forces. Because a large number of market distorting situations continually exist, it is difficult, if not impossible, to estimate the "true" price of any commodity.

What is of central concern here are efforts to increase prices artifically to a level well beyond those that would occur under free market conditions. In the case of nonenergy minerals, experience has shown that with rare exceptions producers are unable to sustain artifically high prices for any appreciable time. The belief that such a feat is possible surfaces each time market conditions tighten considerably as was the case in 1973-74. As soon as surpluses replaced scarcities in

1975, however, it became clear that oil was a unique case. Efforts by one or more countries to maintain peak prices for bananas, mercury and phosphates failed in the face of a slack market. Other producer groups, most notably the copper exporters, never tried to maintain prices since they were unable to agree to a joint action that could appreciably alter market trends.

Some LDC's nonetheless did learn from the 1973-74 experience that they had a limited potential to push up prices in a few commodities. These moves were possible because of the special circumstances associated with the commodity itself and/or because of the high degree of vertical integration that existed within the industry. Bauxite and iron ore are examples, with the former receiving most of the attention.

In 1974, Jamaica doubled the price of its bauxite by increasing taxes. Most other producers followed suit including Australia, Guinea and Guyana. Kingston has been able to sustain its price without greatly reducing production because of several reasons. Most important, its main customers (U.S. aluminum companies) are almost totally dependent on Jamaican grade ores; adjusting refineries to handle other types of ores would be very costly and time consuming. The limited competitive nature of the world aluminum industry allowed the companies to pass on most, if not all, of the higher bauxite prices even under depressed market conditions. Complaints from consumers were not that significant, because the higher ore prices added less than 10 percent to the cost of aluminum and a minute amount to those products which use aluminum. Finally, given the highly integrated nature of the industry, pre-1974 bauxite prices had been set arbitrarily and thus it is possible that these intracompany prices were below those that would have occurred under free market conditions.

Despite these factors, Kingston's ability to push up prices is limited. Too high a price would accelerate the development of alternate and abundant sources of bauxite in such places as Brazil, Venezuela, and Guinea. Such efforts could even result in the exploitation of alumina-bearing Georgia clays as a substitute for bauxite.

3. PROBLEMS OF COMPETITION

A third and relatively new problem, especially for U.S. mineral producers, is the growing competition from LDC's. The developing countries' market share of the metals trade has increased considerably over the last five years.

A combination of LDC policies aimed at maintaining production during slack demand periods, higher environmental costs for U.S. producers and the increased foreign processing of ores has increased U.S. competition in certain metals, especially chrome, copper, aluminum, zinc, and lead.

The steady change in ownership of mining facilities from private hands to government control in LDC's has brought with it new production and pricing objectives. For United States and other developed country producers, the most important repercussions of such changes have been the decision of some LDC governments to maintain mine employment during slack demand periods even when their cost of production exceeds that of their selling price. As a result of the continuing LDC production, developed country producers have had to absorb an unusually large share of the global production cutbacks. While private mining companies normally have to reduce production and employment in slack times to avoid extensive financial losses, they now, in some instances, must cut back production further to offset the excess global supplies stemming from relatively high LDC production.

Since the late 1960's environmental problems have compounded the competitive problem of developed country producers.

A factor of much longer term significance is also eroding the U.S. competitive position—the successful efforts of foreign producers to sell a more finished product. Governments have successfully encouraged this trend toward increased processing of raw materials where they are mined. For example, today most *copper* is exported in refined form. The same is true of a number of other metals including *lead*, *zinc*, and *tin*.

Although greater foreign processing has hurt the United States competitively and raised the value of imports, it has benefited consumers (through lower prices) and increased U.S. flexibility. Ores of the same metal often require different facilities. When the refining is done in the United States, domestic processors commit themselves to a particular type of ore, and thus are dependent on the country that supplies it. If the United States imports a homogenous refined product, freedom of choice among suppliers is increased. As noted earlier, the United States aluminum industry is dependent on Jamaican bauxite, and cannot switch to bauxite from other sources without costly plant modifications. Aluminum smelters, in contrast, can process alumina produced from any type of bauxite. By importing alumina the United States greatly diversifies its possible sources of supply.

D. U.S. Strategic Considerations

The degree of supply restriction entailed in price gouging or cartel-like action would not have a serious effect on U.S. defenses. The portion of U.S. consumption of critical materials required for defense production—generally 10 percent to 20 percent in the event of war and about one-half of that in peacetime—can be met under any foreseeable restrictions of this type. However, since such supply restrictions during a war would eventually influence the well-being and efficiency of the labor force, they could have important secondary effects if sustained over a long period.

Supply interruptions or cutoffs could cause problems in supporting our defense during a national emergency. Almost all imported commodities have some defense-related applications, and are covered by the U.S. national stockpile program.

Since the end of World War II, the United States has protected its defense industry against supply interruptions during an emergency by means of a stockpile of critical material. Originally, the Strategic Stockpile of some 90 materials was intended to meet our defense needs during a five-year war without seriously affecting the domestic economy.

By the late 1960's the stockpile was drawn down because it was considered that a major war between superpowers would last considerably less than five years.

Further review of stockpile policy during 1972–73 resulted in an announcement of a revised stockpile policy. The revised policy, based upon requirements to support a one year, two-front war would have further significantly reduced the aggregate value of the stockpile. In view of economic, military and political developments since 1973, a decision was made in 1976 to conduct another review of stockpile policy and procedures. The new policy developed in 1976 called for a materials stockpile:

Capable of supporting U.S. defense requirements during the first three years of a major war; and

Allowing for significant austerity measures within the national economy to sustain industrial mobilization but, at the same time, providing for a broad range of basic civilian economic needs.

The new policy which was reaffirmed by the Carter administration in 1977, requires a major restructuring of the stockpile—acquiring new materials and disposing of others. It recognizes that stockpile goals are not static and therefore requires frequent review of stockpile policy guidance (at least every four years) and the preparation of annual materials plans which will allow for changes in national security planning, economic conditions, international events and budgetary considerations.

In reaffirming the 1976 stockpile policy, the President also approved the existing stockpile goals and directed that programs of acquisition and disposal proceed. For the near term the administration plans to buy 20 materials (not yet publically enumerated) and dispose of 23 commodities but general stockpile policy legislation providing funding arrangements has not yet been approved by the 95th Congress.

Table 5 lists the current stockpile goals for 13 major, critical materials, along with recent consumption and import levels. Overall goals, defined as the estimated difference between supply and requirements to meet national security needs, are dynamic. They will be reviewed at least annually and revised whenever appropriate. As such they serve only to provide a general indication of the government's intention in the marketplace over an extended period of time. Table 7 also indicates the quantities of the enumerated materials presently in the strategic stockpile.

III. Analysis of Specific Critical Materials

A. Bauxite, Alumina, and Aluminum

Bauxite is indispensable to the production of alumina and, in turn, aluminum. Although a number of potential alternatives to bauxite currently are being investigated, it seems unlikely that an economically feasible substitute will be available for commercial production in the near future. Demand for bauxite, accordingly, is expected to remain relatively inelastic. Supplies of bauxite historically have been adequate to cope with demands of the aluminum industry.

The United States produces only about one-seventh of its bauxite needs, with the remainder imported principally from Jamaica (about 50 percent), Surinam, Guinea, and other members of the Intergovernmental Bauxite Association (IBA). Although the IBA accounts for about 65 percent of world bauxite production, its ability to exert cartel-like influence on supply and price has been restrained by: (*a*) lack of full cooperation from Australia, the largest IBA producer with about 30 percent of world output; and (*b*) the threat of additional production from such non-IBA producers as Brazil and Venezuela, which have a vast output potential.

World bauxite reserves are more than adequate to meet foreseeable world demand. These reserves—equivalent to some 370 years at 1977 rates of production—are reasonably well dispersed, half being in Guinea and Australia and much of the remainder in 10 other non-Communist countries.

In the case of alumina, imports are expected to grow considerably and probably account for most of the increase in U.S. alumina demand. Indeed, domestic alumina producers will do well to retain their present share of the market as the bauxite producing countries intensify efforts to increase the value-added of exports by supplying alumina rather than bauxite. Costs of transporting new material in the form of alumina rather than bauxite are cheaper. An increase in the presently small volume of aluminum imports also seems likely in the United States.

Although the increased U.S. reliance on imports increases the risk of supply dislocations, the degree of real danger is minimized by the fact that U.S. reliance is dispersed among a number of suppliers and most have economic, if not political, interests in continued exports. Moreover, U.S. stockpiles—both strategic and commercial—will probably adjust upwards to meet the increased risk. As of early 1978, U.S. strategic stocks of bauxite were equal to more than one year's requirement and well in excess of designated goals; the goal for alumina was unfilled. Commercial stocks of both alumina and aluminum probably are equivalent to several month's consumption.

This section is an assessment of the supply vulnerability for each of the selected mineral commodities. The analysis is based on public information supplied by the U.S. Bureau of Mines, which is included as appendix A.

B. Chromium

Because of its high resistance to heat and corrosion and its other desirable alloving properties, chromium is essential to the metals industry. Roughly 60 percent of the 400,000 tons of chromium consumed by the United States last year was used in producing stainless steel, heavy steel plating, ball bearings, machine tools, and other metallurgical end-items. Nonmetallurgical uses—chemicals (20 percent) and refractories (20 percent)—are of minor strategic significance. There are no substitutes for chromium in stainless steel; possible substitutes in other metallurgical applications do not perform as well and are usually more costly than chromium.

The United States, which does not produce chromite (chrome ore), imports all of its chromite as well as part of its ferrochromium (chrome alloy) requirements. The chromite dependence is especially critical because there are few major suppliers, and two of them (Rhodesia and South Africa) are in the politically troubled region of Southern Africa. The U.S.S.R. is one of the other major United States suppliers. Technological change, introduced in an effort to avoid use of the costly U.S.S.R.-type of high grade chromite, has resulted in an expanded reliance on South Africa—the leading world producer and source of lower grade chromite.

South Africa in recent years has widened its share of the United States and Japanese chromium markets, particularly the market for high carbon (low grade) ferrochromium. United States imports of comparatively low priced South African ferrochromium rose, in relation to domestic output, from about 45 percent in 1973 to 97 percent in 1977. United States high-carbon ferrochromium production facilities were operating at only about 50 percent of capacity during the first half of this year and similar problems were encountered by Japanese producers. Continued erosion of domestic output and idling of facilities could eventually result in almost total United States reliance on South Africa for ferrochromium used in stainless steel production. This, in turn, could pose price and supply problems.

United States stockpiles, however, are presently adequate to guard against supply interruptions. At the end of 1977, U.S. metallurgical chromium stocks—about 1.5 million tons—were equivalent to six years' normal requirements. Roughly one-fifth of these stocks were in private inventories and the remainder in strategic stockpiles.

C. Cobalt

Cobalt is one of the most critical industrial metals—virtually irreplaceable in some 60 percent of its applications (by volume of metal) in the United States. Because of unique hardening qualities and resistance to corrosion, abrasion, and heat buildup, cobalt is required in such strategic end-items as jet engines, machine tools, drill bits, well-head valves, and as a catalyst for petroleum hydrogenation. The quantity needed in each application is relatively small and forms only a fraction of final product cost. Consequently, rising cobalt prices do little to discourage consumption and, in turn, do not represent a significant inflationary factor in the national economy. U.S. consumption of cobalt in recent years has averaged about 7,500 tons (less than $90 million) annually.

The United States does not produce cobalt, although it has some reserves that could be mined economically, if cobalt prices rose to exceptionally high levels in the future. For the near term at least, the United States will remain heavily dependent on imports from a few principal suppliers, of which Zaire is the largest. Zaire's preponderant share of Free World reserves (40 percent) and output (50 percent) afford the opportunity to structure supply and prices. Although Zaire has exercised a price leadership role, it has not engaged in price-gouging tactics. Nor is there evidence of deliberate supply restraining efforts. The real danger to United States interests, however, arises from the vulnerability of Zairian cobalt supply. In addition to the possibility of disruption due to political conflicts and to breakdown of aging equipment, supply from Zaire is made tenuous by reliance on a complicated road, rail, and water transport system from point of production to port of export. Moreover, cobalt production in Zaire, as well as in other countries, is a secondary, associated product of the copper and nickel mining industries.

Several of the above factors have contributed to shortages and sharply rising prices of cobalt in recent years. The producer price for cobalt, which governs most transactions has doubled since the end of 1977 standing at $12.50 per pound in September 1978.

The large, as yet untapped, reserve of cobalt in deep-seabed nodules could provide an alternative to present heavy reliance on Zaire and other land-based suppliers of cobalt. This alternative, however, will not be available in the near term. Accordingly, from the standpoint of U.S. supply needs over the short run, U.S. strategic stockpiles are the major form of security. These stockpiles, presently equal to about two and a half year's consumption, are less than half their designated strategic goal. Moreover, the quality of U.S. stockpiles of cobalt is not fully adequate for current U.S. needs. Consumer stocks are small, normally about two months supply.

D. Copper

While the United States is virtually self-sufficient in copper and thus is not vulnerable to cartel-like action by foreign producers, the U.S. market share is decreasing. Price behavior on world markets does influence U.S. copper prices, however, and can cause serious periodic dislocations in the U.S. industry. This has been particularly apparent in recent years as imports of copper from low-cost foreign producers have kept U.S. producer prices depressed. In 1977, imports totalled 384,000 tons—about 20 percent of U.S. consumption—and by July 1978 imports reached an annual rate of 619,000 tons. Domestic production through June fell by 17.5 percent below the first half of 1977. Some marginal mines and smelters have been shut down and expansion plans have been shelved indefinitely, jeopardizing U.S. self-sufficiency as the economy continues to expand. U.S. producers applied to the government for relief and the Trade Policy Staff Committee recommended to the President that import quotas of 300.000 tons per year be imposed.

CIPEC members (Chile, Peru, Zambia, Zaire, Indonesia, Mauritania, Australia, Papua/New Guinea, and Yugoslavia) produce approximately half the copper mined in the Free World and account for 60 percent of exports. This group has little ability to act as a cartel as demonstrated during the price depression of the last four years. Efforts to cut back production and/or sales by 10 to 15 percent were unsuccessful—temporary cutbacks by African producers were occasioned more by operational and transportation problems than by adherence to the CIPEC goal. Indeed output of the CIPEC group has registered record levels since the 1975 recession despite the glut of copper on the market. CIPEC's inability to reduce sales significantly in times of weak demand reflects the dependence of many of its members on foreign exchange earnings from copper.

E. Iron Ore

Because it is the primary source of iron—the world's most widely used metal—iron ore is one of the most important mineral commodities. From the standpoint of security of supply and susceptibility to foreign price influence, the United States has no foreseeable problems. Further, domestic reserves are more than adequate to supply U.S. demand through the end of this century.

Imports come primarily from Canada (45 percent) and Venezuela (30 percent), and are expected to decline from the present one-third of U.S. consumption as U.S. ores become more competitive. Most high cost underground mines in the United States have been closed, and output now is largely concentrated in open pits where higher productivities can be realized. Expansion of open pit output can be far more expeditiously handled in the event of emergency requirements than would be possible by building additional deep pit mines.

Iron ore prices have risen along with the cost of production, although in comparison with other minerals and metals, they have been relatively low. The sharp price increase in 1973–74 reflects the quadrupling of fuel costs and inflation of other materials, equipment, and labor during the period. The high costs of financing new projects drove prices up in 1975–76, and the subsequent leveling off of prices is a reflection of dampened steel demand accompanying the world recession. There is little likelihood that foreign suppliers, whose share of U.S. market is expected to decline, will engage in disruptive supply or pricing actions. Equally, if not more remote is the likelihood of cartelization.

There are no strategic stockpiles of iron ore in the United States.

F. Lead

The United States is the largest miner and refiner of lead in the non-Communist world, followed by Australia, Canada, Peru, and Mexico. These five producers account for 65 percent of mine output and for 40 percent of refined output. Europe and Japan refine several times as much lead as they mine and depend on imports of ores and concentrates. Their main suppliers are Canada, Australia, Ireland, Peru, Morocco, and Mexico. LDC's account for only a small part of mine output—on the order of 25 percent—and for only 15 percent of refined output.

Producer price setting similar to copper and zinc is the closest the industry is likely to come to cartel-like behavior. Price setting normally does not involve production controls to support price increases, however, and such controls are considered unlikely.

Prospects for the lead industry are clouded by several basic changes in consumption now taking place. The most important of these is the growing use of maintenance-free batteries which may constitute as much as 95 percent of all battery output in the United States by 1981. Batteries now account for about 50 percent of U.S. lead consumption. The trend to maintenance-free batteries will greatly increase demand for pure lead as opposed to the antimonial lead used in standard batteries. This will cause dislocations in the secondary lead industry now geared to recovering antimonial lead from discarded standard batteries. With little new refining capacity being added by primary producers, demand for new lead will have to push prices higher before secondary producers find it profitable to invest in equipment to remove antimony from scrap in order to recover pure lead. Factors slowing demand growth, however, are the anticipated reduction in battery size and the reduction of lead in gasoline. Total phaseout of lead in gasoline would reduce lead consumption by 10 to 15 percent.

Finally, environmental and health/safety regulations, which have been recently proposed, could have a devastating impact on the U.S. lead industry.

G. Manganese

The principal use of manganese is for the production of iron and steel, and in the latter application no practical substitutes for manganese exist. The U.S. deposits of manganese are largely low-grade and noncompetitive in price with foreign supplies. Imports account for 98 percent of U.S. manganese consumption (1.3 million tons) and about half of U.S. ferromanganese consumption (1.0 million tons) annually.

Imports to date have been comparatively immune to any supply or price problems. Brazil and Gabon traditionally have been the major suppliers, although Australia and South Africa together have provided upwards of 20 percent of U.S. imports on occasion and have the potential to meet total U.S. needs. The large and reasonably well dispersed production of manganese has prevented any cohesive supply and pricing action by producers. Except for the large price increase that was common on most metals in the 1973–74 commodity boom, manganese prices have been comparatively stable during the past three years and have remained so to date in 1978.

The longer range prospect for reserves and supply is comparatively good. In addition to the 6 billion tons of manganese in land-based reserves (equal to over 200 years at current rates of world production), there are extensive deposits of manganese nodules on the deep ocean floors. Commercial exploitation of these deep-seabed nodules probably will not be economically (or politically) feasible before the end of this century. Even so, there is little threat in the interim to U.S. supply interests. Apart from stocks on hand with consumers, the U.S. has over a two years supply of manganese and a seven months supply of ferromaganese in its strategic stockpile—with inventories of both in excess of current U.S. stockpile goals.

H. Nickel

Nickel is extremely important for the corrosion resistance and high strength it imparts to metals such as stainless steel. Since substitutes exist for nickel, as well as for nickel-containing products, demand for the metal is highly price elastic. Supply is likewise price sensitive despite domination of output by a comparatively few firms. The world market in recent periods has been characterized by weak demand and low prices. In August 1978, the price of nickel was $2.07 per pound, or about 15 percent less than a year ago that time.

The United States is reliant on imports for about 70 percent of its needs, the remainder coming from scrap and, to a lesser extent, domestic production. Because of proximity to its major supplier (Canada), and access to other potential suppliers, U.S. supply is basically secure. The outlook is for continued adequacy of supply both from the standpoint of the United States and the world at large. Cumulative demand to the year 2000 by the United States and the rest of the world is estimated at 7 million and 21 million tons, respectively, while land-based reserves total a minimum of 60 million tons. Resources, excluding deep-sea nodules containing nickel, are placed at over 200 million tons.

The United States does not maintain a strategic stockpile of nickel and is unlikely to need one for the foreseeable future. Consumer stocks are equal to about two to four months' demand.

I. Phosphate Rock

The United States is the world's largest producer of phosphate rock, accounting for more than half the non-Communist world total output. U.S. reserves are adequate to continue output at the current rate for more than half a century. Other major producers include Morocco (17 percent), Tunisia (4 percent), Western Sahara (3 percent), Senegal (2 percent), and South Africa (2 percent).

The greatest potential for cartelization lies in northern Africa and the Middle East where a producers' organization composed of Morocco, Tunisia, Senegal, and Jordan was formed in early 1977. Production in these nations constitutes 26 percent of non-Communist world output and 70 percent of reserves. The ostensible purpose of the organization is to maintain uniformly high prices. To date, the effort has not been particularly successful as world production has remained high and prices have edged down since 1975. The organization's potential to disrupt the market in the future appears limited owing to the production potential of the United States.

J. Platinum

South Africa and the U.S.S.R. are the two principal producers of platinum accounting for 90 percent of world output. Canada is the only other significant producer. In 1977, South Africa produced about 65 percent of the 2.8 million ounces mined, the U.S.S.R. produced less than 30 percent, and Canada less than 10 percent.

Platinum's principal uses are as a catalyst in petroleum refining, in the chemical industry, and in pollution control devices in automobiles. In these applications some 98 percent can be removed and reused. Other important consumers are the electrical, dental, and jewelry industries. Jewelry accounts for 25 to 30 percent of total consumption, while catalytic applications account for nearly 50 percent.

The upturn in platinum prices which began in mid-1977 was caused primarily by a reduction in world supplies. South African production declined due to labor problems, the U.S.S.R. suddenly stopped selling abroad (in part because it needed the platinum to strike Olympic coins) and liquidation of stocks by speculators ended. Producer prices rose from $162 per ounce in November 1977 to $250 in September 1978 while U.S. dealer prices reached $262. Real prices, however, are about at the early 1970's level. Little change occurred in the level of industrial consumption, but consumption of platinum in jewelry declined.

Because of its dominant position as a producer, South Africa has the capability to exert almost monopolistic control over prices. Moderation has predominated in producer pricing, however, due in large part to the realities of the platinum market. The price elasticity of demand for platinum in the jewelry industry exerts a strong dampening effect on price rises. Gold is a widely accepted substitute for platinum and can be turned to easily and quickly when the price differential warrants. Since jewelry accounts for a large share of Free World platinum consumption, platinum producers are reluctant to jeopardize their stake in this market. In the case of industrial applications, demand is relatively inelastic in the short run, in large part because the cost of platinum is small relative to the cost of the consuming product. Over the long run, however, a number of adjustments can be made that would substantially reduce demand. Alternatives are available for the automobile catalytic converter program, and various substitutes can be used with some loss of efficiency in most of the other consuming industries.

Supply interruptions for periods of less than a year are not considered a threat to national security. Available scrap, dealers' stocks, and quantities obtained from recycling are probably sufficient to meet minimum needs for at least a year. Supplies would last even longer if only critical needs were met.

K. Silver

The United States ranks among the five largest silver producers in the non-Communist world. Included in the group are Canada, Peru, Mexico, and Australia. Nevertheless, domestic mine output falls far short of requirements, and the United States depends on imports for about half of its needs. Canada, Mexico, and Peru are the primary suppliers.

Other potential sources of supply include the U.S. strategic stockpile which contains about a 10-month supply at 1977 consumption rates and stocks on U.S. commodity exchanges which are of equal size. Private citizens hold tremendous stocks in the form of silverware and jewelry. As demonstrated in 1977, high silver prices call forth private holdings on the secondary market.

Photography is a major consumer of silver accounting for about 35 percent of all U.S. consumption. Electrical and electronic components and batteries account for about 25 percent. Table silver takes about 15 percent. Although silver has important strategic applications in the first two categories, such applications account for a relatively small share of total consumption.

Cartel-like action does not appear to threaten U.S. supply. Although four nations produce nearly half of world output, the other half is produced by some 50 nations with widely divergent politics and interests. Moreover, the potentially tremendous secondary sources mentioned above act as a moderating influence on price and virtually rule out the possibility of collusion among producers to withhold supplies for an extended period.

L. Zinc

The United States is now dependent on imports for more than half of its zinc requirements. Prior to 1970, the United States produced 85 percent of its needs, but in recent years more than half of domestic capacity has been closed due to obsolescence and to the prohibitive cost of meeting environmental protection standards. Nearly half of U.S. imports come from Canada.

Cartel-like action by major producers seems unlikely beyond the traditional setting of producer prices in Europe and in North America. Six countries including the United States mine two-thirds of the non-Communist world's zinc, and four of these—Canada, the United States, Australia, and Japan—account for half of Free World output. Producers in these countries would be unable to carry cartelization to the degree that it posed a threat to world supply. Action by LDC producers remains a possibility but because of the number of small producers involved, cohesion would be difficult to achieve. A further deterrent to effective cartelization is the fact that the United States possesses perhaps the largest zinc reserves in the world and within a five or six year period could double or even triple present output.

The zinc market is expected to remain weak through 1978 and into 1979 despite annual increments in consumption estimated by industry sources at around 3 percent. Large stocks still overhang the market and production is well below capacity.

M. Tungsten

Tungsten is important in uses requiring resistance to wear and heat, and has the highest melting point of any metal. About 55 percent of U.S. consumption is for tungsten carbide cutting tools, mining bits, and earthmoving equipment. The United States has significant reserves, and domestic sources currently meet half our requirements. Principal U.S. import sources during 1973–76 were Canada (23 percent), Bolivia (17 percent), Peru (12 percent), Thailand (11 percent). U.S. stockpiles of tungsten ores and concentrates are very large—a seven year supply, at current U.S. consumption rates, in excess of the strategic stockpile objective of a 6-month supply of ores and concentrates.

More than half of the world's tungsten reserves are located in Communist countries with the People's Republic of China accounting for more than two-thirds of the Communist total.

While the United States relies at present on imports for nearly one-third of its needs, it does not appear that the United States is subject to jeopardy either from embargo or rapid price action on the part of foreign tungsten producers within the foreseeable future.

N. Titanium

While use of modest amounts of titanium metal in the aerospace industry has given it a glamorous image, 90 percent of U.S. consumption is titanium pigment, used in paints, paper, plastics, and produced from domestic ore or slag imported from Canada. Australia is the dominant producer and supplier to the United States of rutile ore, the source material for titanium metal. In 1977 about 60 percent of the titanium metals was used in jet engines, airframes, and space and missile applications. The remainder was used in the chemical processing industry, power generation, in marine and ordnance applications and in steel and other alloys. Nearly 20 percent of U.S. metals needs was imported in 1977. Japan supplied about one-half and the U.S.S.R. one-third.

O. Fluorspar

The U.S. imports most of its fluorspar from Mexico for use in steel, chemicals, and aluminum production. Since economic substitutes for fluorspar are limited, arbitrary action to increase prices is possible. The U.S. stockpile currently contains nearly one year's supply of fluorspar at current U.S. consumption rates.

P. Vanadium

Vanadium is used primarily in alloyed steel. More than half of U.S. consumption is met from domestic supplies. South Africa is the principal import source and world producer. South Africa could take some short term price action, but substitution of vanadium with other alloy elements (columbium, molybdenum) could take place fairly promptly and has in fact occurred when prices rose sharply. U.S. stockpiles currently contain a one-month's supply of vanadium at current U.S. consumption rates in excess of the strategic objective.

Q. Columbium

Columbium is used almost exclusively in the form of ferro-columbium for the production of stainless steels and alloys. Market competition is provided by vanadium, molybdenum, titanium, tungsten, and tantalum. Brazil accounts for over three-quarters of world columbium production. Other producers are Canada and Nigeria. Given the limited market for columbium and the number of other metals which might substitute for it, it is unlikely that cartel-like action by producer countries would be successful.

FIGURE 1.—U.S. imports and exports of raw and processed nonfuel minerals.

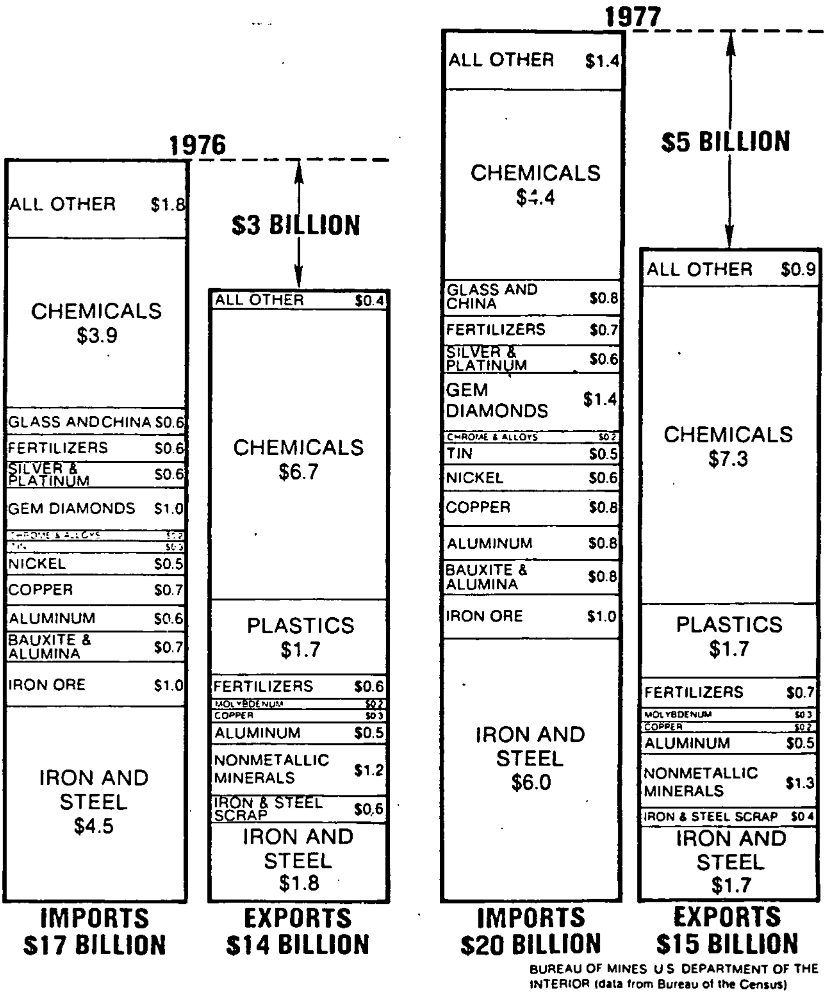
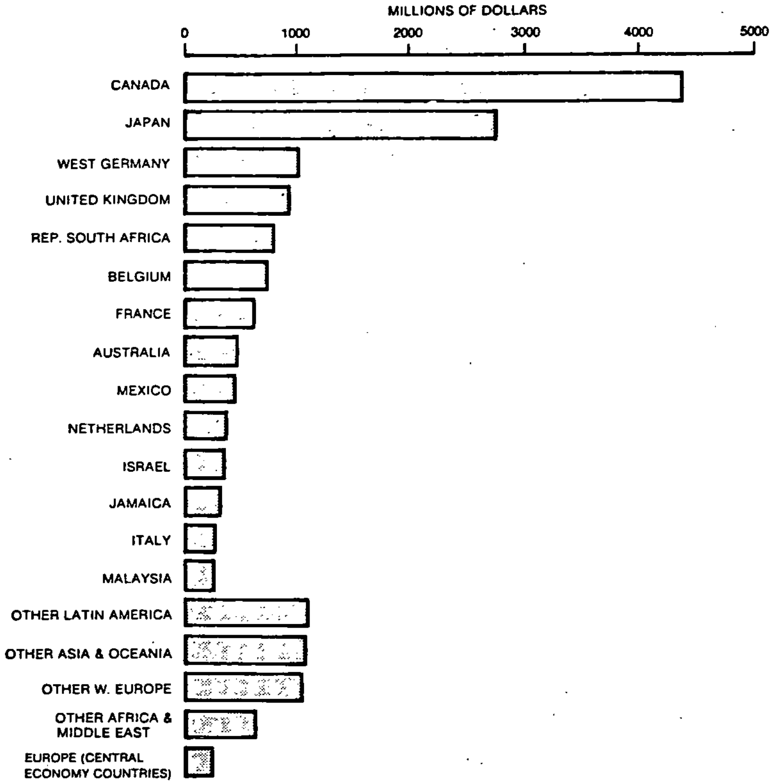


FIGURE 2.—U.S. nonfuel mineral imports by country and region, 1977.



BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR (Data from Bureau of The Census)

FIGURE 3.—World export price trends.

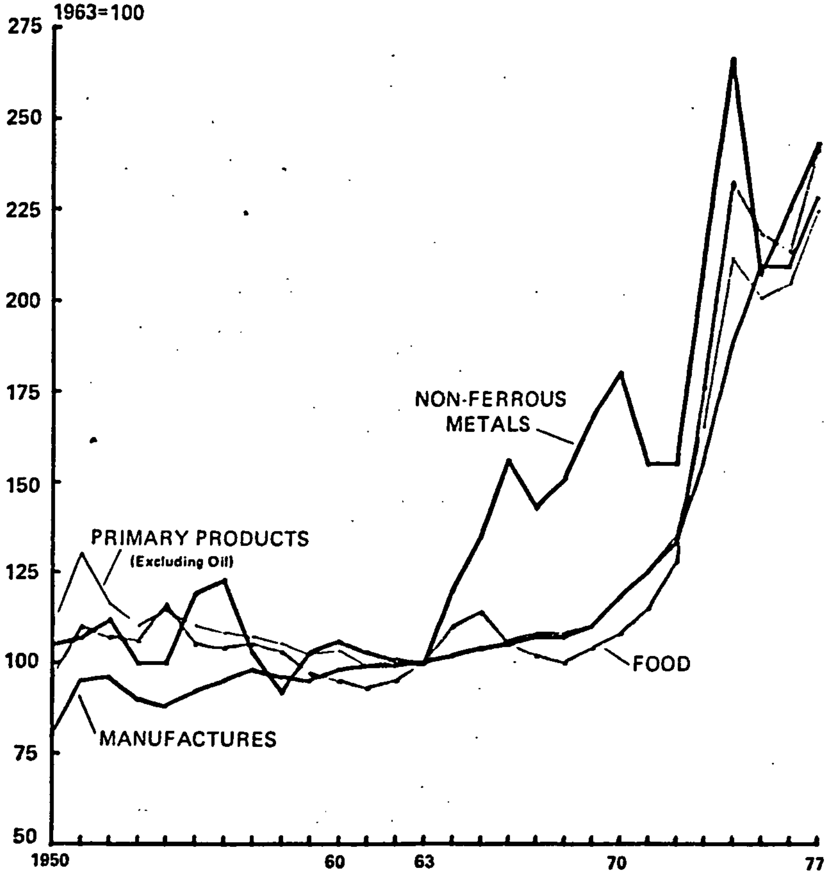
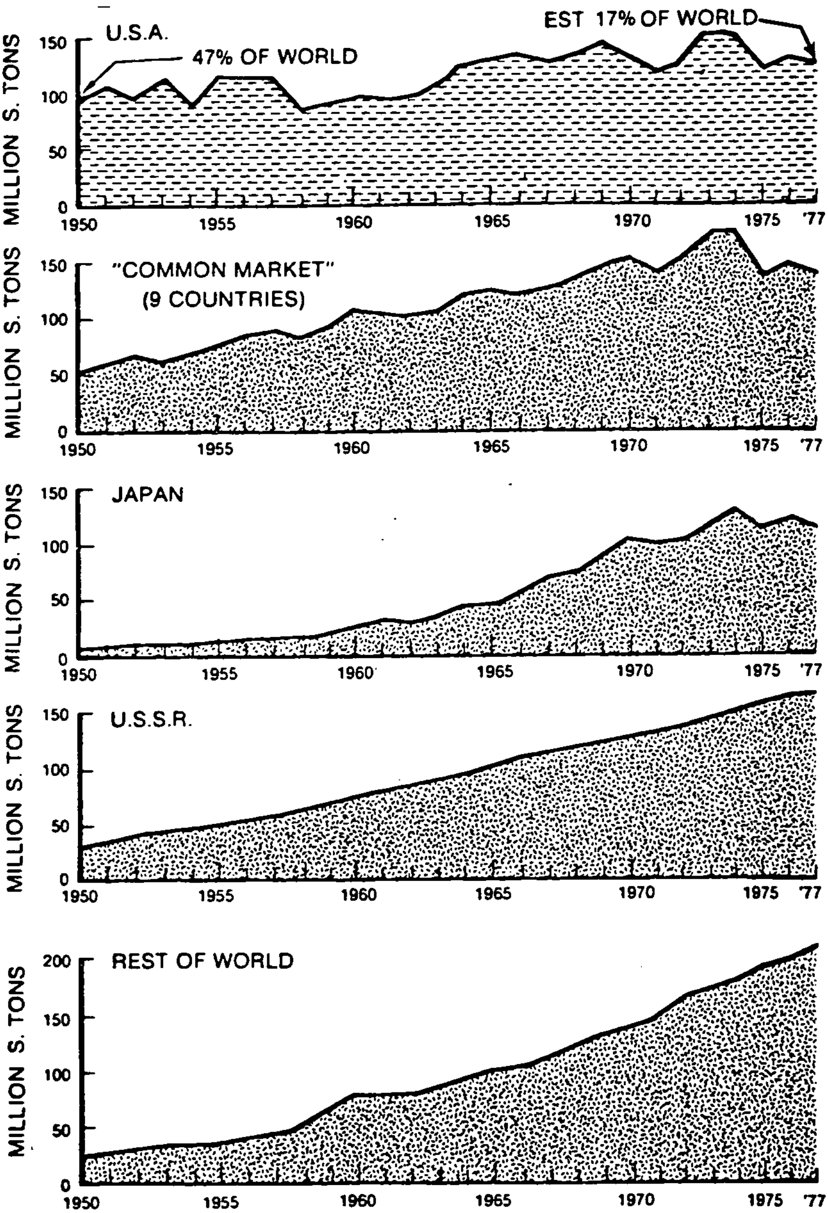
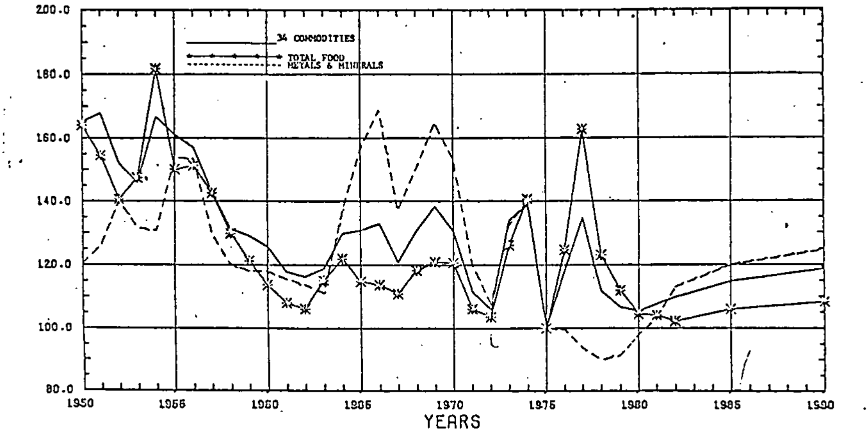


FIGURE 4.—World steel production.



BUREAU OF MINES.
U.S. DEPARTMENT OF THE INTERIOR

FIGURE 5.—Annual index of commodity prices, constant U.S. dollars (1975=100).



Source: World Bank, *Price Prospects for Primary Commodities.*

Table 1.—U.S. Net Import Reliance of Selected Minerals and Metals as a Percent of Consumption in 1977

MINERALS AND METALS	NET IMPORT RELIANCE* AS A PERCENT OF APPARENT CONSUMPTION**	MAJOR FOREIGN SOURCES (1973-1976)
COLUMBIUM	100	BRAZIL, THAILAND, NIGERIA, MALAYSIA
MICA (sheet)	100	INDIA, BRAZIL, MALAGASY REPUBLIC
STRONTIUM	100	MEXICO, SPAIN
MANGANESE	98	BRAZIL, GABON, SOUTH AFRICA
COBALT	97	ZAIRE, BELG.—LUX., NORWAY, FINLAND
TANTALUM	97	THAILAND, CANADA, AUSTRALIA, BRAZIL
PLATINUM GROUP METALS	92	SOUTH AFRICA, U S S R., U.K.
BAUXITE & ALUMINA	91	JAMAICA, AUSTRALIA, SURINAM, GUINEA
CHROMIUM	89	SOUTH AFRICA, U S S.R., TURKEY, SOUTHERN RHODESIA
TIN	86	MALAYSIA, THAILAND, BOLIVIA, INDONESIA
ASBESTOS	85	CANADA, SOUTH AFRICA
FLUORINE	80	MEXICO, SPAIN, ITALY, SOUTH AFRICA
NICKEL	70	CANADA, NORWAY, NEW CALEDONIA, DOMIN. REP.
POTASSIUM	66	CANADA, ISRAEL
GOLD	60	CANADA, SWITZERLAND, U S.S.R.
ZINC	58	CANADA, MEXICO, AUSTRALIA, PERU
ANTIMONY	52	SOUTH AFRICA, P R OF CHINA, BOLIVIA
CADMIUM	51	CANADA, AUSTRALIA, BELG.-LUX.
SELENIUM	47	CANADA, JAPAN, MEXICO, YUGOSLAVIA
MERCURY	46	SPAIN, ALGERIA, MEXICO, YUGOSLAVIA
SILVER	42	CANADA, MEXICO, PERU, U.K.
BARIUM	40	PERU, IRELAND, MEXICO
TUNGSTEN	38	CANADA, BOLIVIA, PERU, THAILAND
TITANIUM (ilmenite)	38	CANADA, AUSTRALIA
VANADIUM	37	SOUTH AFRICA, CHILE, U S S R.
GYPSUM	35	CANADA, MEXICO, JAMAICA, DOMIN REP.
IRON ORE	33	CANADA, VENEZUELA, BRAZIL, LIBERIA
IRON & STEEL SCRAP	(-11) NET EXPORTS	
COPPER	17	CANADA, CHILE, PERU, ZAMBIA
LEAD	14	CANADA, PERU, MEXICO, AUSTRALIA
IRON & STEEL PRODUCTS	13	JAPAN, EUROPE, CANADA
ALUMINUM	8	CANADA
SALT	8	CANADA, BAHAMAS, MEXICO, NETH ANTILLES
PUMICE & VOLCANIC CINDER	5	GREECE, ITALY
CEMENT	4	CANADA, SPAIN, NORWAY, BAHAMAS

*NET IMPORT RELIANCE = IMPORTS EXPORTS + ADJUSTMENTS FOR GOV'T AND INDUSTRY STOCK CHANGES

**APPARENT CONSUMPTION = U S PRIMARY + SECONDARY PRODUCTION + NET IMPORT RELIANCE

BUREAU OF MINES, U.S DEPARTMENT OF THE INTERIOR (import-export data from Bureau of the Census)

TABLE 2.—U.S. IMPORT DEPENDENCE, 1977

	Percent
Phosphate rock: Domestic production	100
Copper:	
Domestic production	85
Imports:	
Developed countries	7
Canada	5
Less developed countries	8
Iron ore:	
Domestic production	68
Imports:	
Developed countries	16
Canada	15
Less developed countries	16
Lead:	
Domestic production	75
Imports:	
Developed countries	15
Canada	7
Less developed countries	10
Zinc:	
Domestic production	42
Imports:	
Developed countries	50
Canada	22
Less developed countries	8
Nickel:	
Domestic production	23
Imports:	
Developed countries	77
Canada	49
Cobalt:	
Domestic production	5
Imports:	
Developed countries	25
Canada	6
Less developed countries	70
Manganese ore:	
Domestic production	2
Imports:	
Developed countries	28
Less developed countries	70
Platinum:	
Domestic production	8
Imports:	
Developed countries	91
Canada	4
Less developed countries	1
Chromite:	
Domestic production	11
Imports:	
Developed countries	68
Less developed countries	21
Bauxite:	
Domestic production	9
Imports: Less developed countries	91
Silver:	
Domestic production	58
Imports:	
Developed countries	26
Canada	19
Less developed countries	16

TABLE 3.—CHANGE IN WORLD PROVED RESERVES, 1950, 1970, AND 1978

	Reserves (in thousand metric tons)			Percent change	
	1950	1970	1978	1950–70	1970–78
Iron ore	19,000,000	251,000,000	259,000,000	+1,221	+3
Manganese (contained MN)	500,000	660,000	1,600,000	+32	+142
Chromite	100,000	775,000	2,700,000	+675	+248
Tungsten	1,903	1,328	1,800	−30	+36
Copper	100,000	279,000	458,000	+179	+64
Lead	40,000	86,000	123,000	+115	+43
Zinc	70,000	113,000	159,000	+61	+41
Tin	6,000	6,600	10,200	+10	+55
Bauxite	1,400,000	6,000,000	25,000,000	+329	+317
Phosphate rock	26,000,000	19,782,000	18,000,000	−24	−9

Sources: Years 1950 and 1970 from IBRD R73-258, Nov. 12, 1973. Table 3-1 year 1978 from Bureau of Mines "Mineral Commodity Summaries 1978."

TABLE 4.—WORLD MINERAL RESERVES, 1974

Commodity	Units	United States	Other North America	South America	Europe	Africa	Asia	Oceania	World total
Aluminum	Million short tons	10	270	780	300	1,270	200	1,010	3,840
Antimony	Thousand short tons	100	295	490	560	320	2,650	150	4,565
Arsenic	do	800	500	1,000	500	500	300	200	3,800
Barium	Million short tons	35	5	6	25	10	16	3	100
Beryllium	Thousand short tons	28	--	182	67	59	71	12	419
Bismuth	Million pounds	26	17	13	15	1	59	--	131
Boron	Million short tons	20	--	10	20	--	30	--	80
Bromine	--	(2)	(2)	(3)	(3)	(2)	(2)	(2)	(2)
Cadmium	Thousand short tons	180	125	55	190	40	100	140	830
Cesium	Million pounds	--	70	--	--	16	--	--	86
Chlorine	--	(3)	(2)	(3)	(3)	(2)	(2)	(2)	(2)
Chromium	Million short tons	--	--	--	13	560	4	--	577
Cobalt	Million pounds	--	1,130	--	500	2,294	--	1,480	5,404
Columbium	Billion pounds	--	2	18	2	2	--	--	24
Copper	Million short tons	90	60	130	60	60	30	20	450
Fluorine	do	3	8	2	11	9	5	(3)	38
Gallium	Million kilograms	1	7	4	9	45	3	41	110
Germanium	Thousand pounds	900	300	300	800	900	600	200	4,000
Gold	Million troy ounces	120	60	21	206	850	35	28	1,320
Hafnium	do	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Indium	Million troy ounces	10	13	4	11	3	4	4	49
Iodine	Million pounds	530	--	800	410	--	4,010	--	5,750
Iron ore	Billion short tons	4	12	20	40	3	11	10	100
Lead	Million short tons	59	25	6	25	5	27	18	165
Lithium	Thousand short tons	327	100	10	201	100	3	3	744
Magnesium	--	(2)	(2)	(3)	(2)	(2)	(2)	(2)	(2)
Manganese	Million short tons	--	2	44	755	1,005	47	160	2,013
Mercury	Thousand flask	450	370	30	3,425	30	625	--	4,930
Molybdenum	Billion pounds	6	2	2	2	(3)	1	(3)	13
Nickel	Million Short tons	(3)	10	5	6	1	6	32	60
Nitrogen	--	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Palladium	Million troy ounces	(3)	4	--	--	100	90	--	194
Platinum	do	(3)	4	(3)	--	248	45	--	297
Rare earths and yttrium	Thousand short tons	5,054	252	353	512	70	1,122	406	7,769
Rhenium	Thousand pounds	2,690	410	1,520	800	2	8	--	5,340
Rhodium	Million troy ounzes	(3)	(3)	--	--	14	3	--	17
Rubidium	Thousand pounds	--	1,300	--	--	800	--	--	2,100
Scandium	Thousand kilograms	228	163	--	48	235	--	96	770
Selenium	Million pounds	77	52	96	51	51	26	17	370
Silicon	--	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Silver	Million troy ounces	1,500	1,590	630	2,000	50	25	205	6,000
Strontium	Thousand short tons	--	1,000	20	2 420	--	60	--	3,500
Sulfur	Million long tons	230	505	30	495	20	695	25	2,000
Tantalum	Million pounds	--	7	8	11	100	18	5	149
Tellurium	do	18	12	22	12	12	7	4	87

Thallium	Thousand pounds	150	160	50	140	40	50	50	640
Thorium	Thousand short tons	140	230	70	40	40	220	40	780
Tin	Thousand long tons	42	26	1,591	911	705	6,515	330	10,120
Titanium	Million short tons	32	57	69	43	23	132	20	376
Tungsten	Million pounds	238	480	130	376	23	2,600	77	3,924
Vanadium	Thousand short tons	115		250	8,075	2,000	100	150	10,690
Zinc	Million short tons	50	43	18	64	16	46	23	260
Zirconium	Thousand short tons	6,000	1,000	1,000	3,000	2,000	2,000	7,000	22,000
Asbestos	Million short tons	9	56	5	52	22	7	9	160
Clays		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Corundum					(2)	(2)	(2)		(2)
Diatomite	Million short tons	600		70	1,330				2,000
Feldspar	do	600	110	40	100	40	90	10	990
Garnet	Thousand short tons	700		10	500	1,000	10	10	2,230
Graphite	Million short tons	(3)	1	(3)	4	1	4	(3)	10
Gypsum	do	350	520	40	900	80	100	60	2,050
Kyanite	do	30	10		25	10	25	(3)	100
Lime		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Mica:									
Scrap and flake		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Sheet	Million (pounds)	(3)		2		4	27		33
Perlite	Million (short tons)	200	5		765		20	10	1,000
Phosphate rock	do	2,500	2	80	830	12,840	340	1,120	17,712
Potash	do	200	5,000	10	5,515	20	245	10	11,000
Pumice	do	1,250	50	15	650	30	40	30	2,065
Salt		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Sand and gravel		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Soda ash		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Stone:									
Crushed		(2)	(2)	(2)	(2)	(2)	(2)	(1)	(2)
Dimension		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Talc	Million short tons	150	10	5	60	5	90	10	330
Vermiculite	do	100		5	5	75	5		190
Anthracite	do	3,500		6	3,826	30	288		7,650
Bituminous coal and lignite		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Natural gas	Trillion cubic feet	237	68	65	876	196	633	71	2,146
Peat		(2)	(2)		(2)		(2)		(2)
Petroleum	Billion barrels	[4] 41	25	24	112	68	448	2	[5] 720
Shale oil	do				30		20		50
Uranium	Thousand short tons	[6] 267	204		61	294		240	1,066
Argon		(2)	(2)	(2)	(3)	(2)	(2)	(2)	(2)
Helium	Billion cubic feet	153	1						154
Hydrogen		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Oxygen		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] Identified resources are specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category, and include reserves and subeconomic resources. The reserve is that portion of the identified resource from which a usable mineral or energy commodity can be economically and legally extracted at the time of determination.

[2] Adequate.

[3] Less than 1 unit.

[4] Includes natural gas liquids.

[5] Revised in 1975 to 665,000,000,000 barrels.

[6] 780,000 tons at $30 per pound (Federal Energy Resources Council, June 15, 1976).

TABLE 4A.—COMPARISON OF WORLD CUMULATIVE PRIMARY MINERAL DEMAND FORECASTS, 1974-2000, WITH WORLD MINERAL RESERVES,[1] 1974

Commodity	Units	Primary mineral demand 1974-2000			Mineral Reserves, 1974			Ratio of recoverable reserves to cumulative demand		
		United States	Rest of world	World	United States	Rest of world	World	United States	Rest of world	World
Aluminum	Million short tons	316	646	962	10	3,830	3,840	----------	5.9	4.0
Antimony	Thousand short tons	864	1,917	2,781	100	4,465	4,565	0.1	2.3	1.6
Arsenic	do	675	696	1,371	800	3,000	3,800	1.2	4.3	2.8
Barium	Million short tons	36	83	119	35	65	100	1.0	.8	.8
Beryllium	Thousand short tons	15	8	23	28	391	419	1.9	(2)	(2)
Bismuth	Million pounds	87	183	270	26	105	131	.3	.6	.5
Boron	Million short tons	5	11	16	20	60	80	4.0	5.5	5.0
Bromine	Billion pounds	18	16	34	(3)	(3)	(3)	(2)	(2)	(2)
Cadmium	Thousand short tons	238	506	744	180	650	830	.8	1.3	1.1
Cesium	Thousand pounds	1,940	2,131	4,071	----------	(3)	(3)	----------	(2)	(2)
Chlorine	Million short tons	596	1,088	1,684	(3)	(3)	(3)	(2)	(2)	(2)
Chromium	do	21	80	101	----------	577	577	----------	7.2	5.7
Cobalt	Million pounds	793	1,774	2,567	----------	5,404	5,404	----------	3.0	2.1
Columbium	do	367	1,018	1,385	----------	24,000	24,000	----------	(2)	(2)
Copper	Million short tons	78	275	353	90	360	450	1.2	1.3	1.3
Fluorine	do	38	96	134	3	35	38	.1	.4	.3
Gallium	Thousand kilograms	442	252	694	1,000	(3)	(3)	2.3	(2)	(2)
Germanium	Thousand pounds	1,600	4,020	5,620	900	3,100	4,000	.6	.8	.7
Gold	Million troy ounces	224	832	1,056	120	1,200	1,320	.5	1.4	1.3
Hafnium	Million short tons	1,500	1,200	2,700	(3)	(3)	(3)	(2)	(2)	(2)
Indium	Million troy ounces	30	35	65	10	39	49	.3	1.1	.8
Iodine	Million pounds	316	686	1,002	530	5,220	5,750	1.7	7.6	5.7
Iron ore	Billion short tons	3	19	22	4	96	100	1.3	5.1	4.5
Lead	Million short tons	31	105	236	59	106	165	1.9	1.0	1.2
Lithium	Thousand short tons	217	213	430	327	417	744	1.5	2.0	1.7
Magnesium	Million short tons	50	167	217	(3)	(3)	(3)	(2)	(2)	(2)
Manganese	do	46	362	403	----------	2,013	2,013	----------	5.6	4.9
Mercury	Thousand flask	1,300	5,300	6,600	450	4,480	4,930	.3	.8	.7
Molybdenum	Billion pounds	3	6	9	6	7	13	2.0	1.2	1.4
Nickel	Million short tons	7	22	29	(4)	60	60	----------	2.7	2.1
Nitrogen	do	860	2,380	3,240	(3)	(3)	(3)	(2)	(2)	(2)
Palladium	Million troy ounces	26	55	81	(4)	194	194	----------	3.5	2.4
Platinum	do	27	70	97	(4)	297	297	----------	4.2	3.1
Rare earths and yttrium	Tousand short tons	625	608	1,233	5,054	2,715	7,769	8.1	4.5	6.3
Rhenium	Thousand pounds	171	105	276	2,600	2,740	5,340	(2)	(2)	(2)
Rhodium	Million troy ounces	2	4	6	(4)	17	17	----------	4.3	2.8
Rubidium	Thousand pounds	53	48	101	----------	2,100	2,100	----------	(2)	(2)
Scandium	Thousand kilograms	260	318	578	(3)	(3)	(3)	(2)	(2)	(2)
Selenium	Million pounds	59	63	122	77	293	370	1.3	4.7	3.0
Silicon	Million short tons	22	56	78	(3)	(3)	(3)	(2)	(2)	(2)
Silver	Million troy ounces	4,500	9,000	13,500	1,500	4,500	6,000	.3	.5	.4
Strontium	Thousand short tons	700	1,050	1,750	----------	3,500	3,500	----------	3.3	2.0
Sulfur	Million long tons	426	1,570	1,996	230	1,770	2,000	.5	1.1	1.0
Tantalum	Million pounds	81	54	135	----------	149	149	----------	2.8	1.1
Tellurium	do	11	5	16	18	69	87	1.6	(2)	5.4

Thallium	Thousand pounds	42	508	550	150	490	640	3.6	1.0	1.2
Thorium	Thousand short tons	3	4	7	140	640	780	(2)	(2)	(2)
Tin	Thousand long tons	1,400	6,100	7,500	42	10,078	10,120	----------	1.7	1.3
Titanium	Million short tons	25	61	86	32	344	376	1.3	5.6	4.4
Tungsten	Million pounds	780	2,490	3,270	238	3,686	3,924	.3	1.5	1.2
Vanadium	Thousand short tons	483	946	1,429	115	10,575	10,690	.2	(2)	7.5
Zinc	Million short tons	57	182	239	50	210	260	.9	1.2	1.1
Zirconium	do	3	8	11	6	16	22	2.0	2.0	2.0
Asbestos	do	26	162	188	9	151	160	.3	.9	.9
Clays	Billion short tons	3	17	20	(3)	(3)	(3)	(2)	(2)	(2)
Corundum	Thousand short tons	26	391	417	----------	(3)	(3)	----------	(2)	(2)
Diatomite	Million short tons	26	71	97	600	1,400	2,000	(2)	(2)	(2)
Feldspar	do	35	90	125	600	390	990	(2)	4.3	7.9
Garnet	Thousand short tons	748	465	1,213	700	1,530	2,230	.9	3.3	1.8
Graphite	Million short tons	3	17	20	(4)	10	10	----------	.6	.5
Gypsum	do	680	1,860	2,540	350	1,700	2,050	.5	.9	.8
Kyanite	do	7	15	22	30	70	100	4.3	4.7	4.5
Lime	do	825	3,701	4,526	(3)	(3)	(3)	(2)	(2)	(2)
Mica:										
Scrap and flake	do	4	4	8	(3)	(3)	(3)	(2)	(2)	(2)
Sheet	Million pounds	90	358	448	(4)	33	33	----------	.1	.1
Perlite	Million short tons	25	60	85	200	800	1,000	8.0	(2)	(2)
Phosphate rock	do	1,319	5,449	6,808	2,500	15,212	17,712	1.9	2.8	2.6
Potash	do	228	839	1,067	200	10,800	11,000	.9	(2)	(2)
Pumice	do	180	483	663	1,250	815	2,065	6.9	1.7	3.1
Salt	Billion short tons	2	8	10	(3)	(3)	(3)	(2)	(2)	(2)
Sand and gravel	do	39	263	302	(3)	(3)	(3)	(2)	(2)	(2)
Soda ash	Million short tons	289	777	1,066	(3)	(3)	(3)	(2)	(2)	(2)
Stone:										
Crushed	Billion short tons	44	197	241	(3)	(3)	(3)	(2)	(2)	(2)
Dimension	Million short tons	47	1,067	1,114	(3)	(3)	(3)	(2)	(2)	(2)
Talc	do	40	187	227	150	180	330	3.8	1.0	1.5
Vermiculite	do	15	15	30	100	90	190	6.7	6.0	6.3
Anthracite	do	130	4,280	4,410	3,500	4,150	7,650	(2)	1.0	1.7
Bituminous coal and lignite	do	25,700	77,000	102,700	(3)	(3)	(3)	(2)	(2)	(2)
Natural gas	Trillion cubic feet	522	1,160	1,682	237	1,909	2,146	.5	1.6	1.3
Peat	Million short tons	40	7,320	7,360	(3)	(3)	(3)	(2)	(2)	(2)
Petroleum[5]	Billion barrels	198	520	718	41	679	720	.2	1.3	1.0
Shale oil	do	7	4	11	----------	(3)	50	----------	(2)	----------
Uranium	Thousand short tons	1,065	1,773	2,838	267	799	1,066	.3	.5	.4
Argon	Million short tons	11	11	22	(3)	(3)	(3)	(2)	(2)	(2
Helium	Billion cubic feet	(6)	(6)	(6)	153	1	154	(6)	(6)	(
Hydrogen	Trillion cubic feet	169	292	461	(3)	(3)	(3)	(2)	(2)	(6
Oxygen	Million short tons	900	1,500	2,400	(3)	(3)	(3)	(2)	(2)	(2

1 Identified resources are specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category, and include reserves and subeconomic resources. The reserve is that portion of the identified resource from which a usable mineral or energy commodity can be economically and legally extracted at the time of determination.

2 Ratio of 10 or more.

3 Adequate.

4 Less than 1 unit.

5 United States includes natural gas liquids.

6 Not available.

Source: U.S. Bureau of Mines, "Mineral Trends and Forecasts," 1976.

TABLE 5.—U.S. NATIONAL STOCKPILE LEVELS FOR SELECTED MATERIALS

Material (thousand short tons)	1976 apparent consumption	1976 net import reliance (percent)	Stockpile inventory, Nov. 30, 1977	Stockpile goal, Nov. 30, 1977
Aluminum	5,118	9	1.683	0
Bauxite and alumina	5,145	91		
Bauxite metal:				
Jamaica type			8,859	523
Surinam type			5,300	
Refractory			173	2,083
Alumina				11,532
Asbestos	726	85		
Chrysotile			10.96	
Crocidolite			2.39	
Amosite			42.42	26.3
Chromite	[1] 1,006	[2] 89		
Metallurgical			2,550	1,443
Chemical			734	250
Refractory			642	400
Chromium ferroalloys	[1] 417	[2] 89	756	429
Cobalt	9.920	98	20.453	42.708
Colombium	3,001.5	100		
Carbide powder			10.69	
Concentrate			890.43	1,565.5
Ferro			311.39	
Metal			22.43	
Copper	2,242	12	20	1,299
Fluorspar	1,416	79		
Acid			890	1,594
Metallurgical			412	1,914
Lead	1,516	15	601	865
Manganese	1,364	98		
Chemical ore			221	247
Metallurgical ore			2,440	2,052
Ferromanganese:				
High Carbon			600	429
Medium Carbon			29	99
Natural rubber	[1] 805.48	100	133.8	574.71
Nickel	218.18	70	0	204.34
Phosphate				
Platinum group metals (thousand troy ounces)	2,140	90		
Iridium			16.99	
Palladium			1,255	2,450
Platinum			452.6	1,314
Silver (million troy ounces)	170.2	50	139.5	
Tin	72.04	85	225.6	36.4
Tungsten	8.61	54		
Ore and concentrate			32.04	4.41
Metal powder			.883	1.65
Ferro			1.01	6.42
Vanadium	9.78	37		
Pentoxide			.54	2.58
Ferrovandium				10.1
Zinc	1,399	59	373	1,313

[1] Reported consumption.
[2] Overall net import reliance for chromium is 89 percent.

APPENDIX A. COMMODITY PROFILES, 1978

Individual profiles of the 17 nonenergy materials examined in this paper are included as follows:

- Bauxite, alumina, aluminum.
- Chromium.
- Cobalt.
- Columbium.
- Copper.
- Fluorspar.
- Iron ore.
- Lead.
- Manganese.
- Nickel.
- Phosphate rock.
- Platinum-group metals
- Silver.
- Titanium.
- Tungsten.
- Vanadium.
- Zinc.

Source: U.S. Bureau of Mines, 1978.

BAUXITE*[1]

[Data in thousand long dry tons, unless noted]

1. *Domestic Production and Use*: Bauxite, valued at $27.5 million, was mined by 8 companies at 12 operations in Arkansas, Alabama, and Georgia in 1977; Arkansas produced 84 percent of the quantity. Eight plants in the South Central States and one in the U.S. Virgin Islands used 93 percent of the total U.S. consumption of domestic and imported bauxite to make alumina, about 90 percent of which was reduced to aluminum metal. The remainder of the bauxite and alumina was used to make refractories, chemicals, abrasives, and other products. Gallium was recovered as a byproduct from domestic bauxite at two alumina plants.

2. Salient Statistics—United States:[2]

	1973	1974	1975	1976	1977[1]
Production: Mine	1,879	1,949	1,772	1,958	2,000
Imports of bauxite for consumption[2]	14,120	15,835	12,450	13,250	14,000
Imports of alumina[3]	3,407	3,627	3,507	3,624	4,000
Exports of bauxite	12	16	19	15	20
Exports of alumina[3]	1,048	1,022	1,029	1,158	1,000
Shipments from Government stockpile excesses	314	206	86		
Apparent consumption (bauxite and alumina)[4]	5,413	5,609	4,504	5,145	5,400
Price: Nominal (f.o.b. mine) per ton	$5–15	$5–15	$5–15	$5–15	$5–15
Stocks of bauxite: Industry, yearend	3,850	4,500	5,700	5,400	5,500
Employment: Mine	350	350	350	350	350
Net import reliance[5] as a percent of apparent consumption	92	92	91	91	91

[1] Estimate.
[2] Includes abrasive grade consumed in Canada.
[3] Thousand short tons.
[4] Aluminum equivalent of domestic bauxite production plus the aluminum equivalent of net import reliance (1,000 short tons).
[5] Net import reliance (bauxite and alumina) equals imports minus exports plus adjustment for Government and industry stock changes (all in aluminum equivalents).

3. *Recycling*: None.
4. *Import Sources (1973–76)*: Bauxite: Jamaica 48 percent, Surinam 18 percent, Guinea 13 percent, Other 21 percent. Alumina: Australia 64 percent, Jamaica 23 percent, Surinam 11 percent, Other 2 percent.
5. *Tariff*:

Item	Number	Rate of duty Jan. 1, 1978	Rate of duty Statutory
Bauxite	601.06	Free	$1 per long ton.
Bauxite, calcined	521.17	Free	$1 per long ton.
Alumina	417.12	Free	$10 per short ton.

6. *Depletion Allowance*: 22 percent (Domestic), 14 percent (Foreign).
7. *Government Programs*: The Bureau of Mines has a cooperative research program with industry on extracting alumina from domestic materials other than bauxite.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Alumina[1]	11,532			
Bauxite—metal grade:				
Jamaica type	523	8,859		
Surinam type		5,300		
Bauxite—refractory grade[2]	2,083	173		

[1] Thousand short tons.
[2] Thousand long calcined tons.

*Prepared by H. F. Kurtz.
[1] See also Aluminum.
[2] Includes U.S. Virgin Islands.

8. *Events, Trends, and Issues:* Domestic consumption of bauxite increased in 1977, but remained below the 1974 level, largely because the aluminum industry continued to operate below capacity. Imports provided all of the bauxite used at seven of the nine domestic alumina plants and over one-third of the alumina supply was imported.

Demand for aluminum in the United States is expected to increase at an average annual rate of about 8.8 percent through 1985, using 1977 as the base year. Demand for alumina should increase at nearly the same rate, but demand for bauxite in the United States is expected to increase at a lower rate because of expected increases in imports of alumina. Domestic bauxite production is not expected to change significantly.

Bauxite deposits vary widely in quality, size, and accessibility, and most of the reserves are in the less industrialized areas of the world. Eleven of the major bauxite exporting countries belong to the International Bauxite Association (IBA), which was formed in 1974 to increase revenues from and control over bauxite operations in member countries. Levies on bauxite production in most of the countries supplying the United States have become the largest element in the cost of bauxite.

Environmental problems include the disposal or use of residues (red mud) from alumina production. Land use conflicts as well as greater waste disposal problems could be important considerations in the use of some of the nonbauxitic aluminous raw materials.

9. *World Mine Production and Reserves:*

	Mine production		
	1976	1977 [1]	Reserves
United States	1,958	2,000	40,000
Australia	23,705	24,800	4,500,000
France	2,293	2,200	40,000
Greece	2,703	3,000	750,000
Guinea	10,676	11,300	[2] 8,200,000
Guyana	[1] 2,600	3,000	[2] 1,000,000
Jamaica	10,143	11,200	2,000,000
Surinam	[1] 4,500	4,500	[2] 490,000
Other market economy countries	6,596	7,100	6,700,000
Central economcy countries	11,163	11,900	950,000
World total	76,337	81,000	24,500,000

[1] Estimate.
[2] Published by International Bauxite Association from data supplied by member countries.

10. *World Resources:* Bauxite resources (reserves plus subeconomic and undiscovered deposits) are estimated at 35 to 40 billion tons. These resources (in millions of tons) are in: U.S.—300 to 325 (including bauxitic materials for refractory and chemical use); Caribbean and Central America Region—2,000 to 2,500; South America—7,000 to 8,000; Europe—2,000 to 3,000; Africa—12,000 to 14,000; Asia—4,000 to 6,000; Oceania—6,000 to 7,000. Domestic resources of bauxite are inadequate to meet long-term demand, but the U.S. and most other major aluminum-producing countries have virtually inexhaustible resources of aluminum in materials other than bauxite.

11. *Substitutes and Alternates:* Although bauxite is the only raw material used in the production of alumina on a commercial scale in the United States, research on processes to produce alumina from nonbauxitic materials has been accelerated. Possible alternative domestic raw materials for making alumina include clays, anorthosite, coal wastes, and dawsonite. Bauxite substitutes for making aluminous refractories and chemicals are clays and alumina; substitutes for abrasives made from bauxite include silicon carbide, aluminum-zirconium oxide, and diamonds.

ALUMINUM * [1]

[Data in thousand short tons of metal, unless noted]

1. *Domestic Production and Use:* In 1977, 12 companies operated 31 primary aluminum reduction plants, with 3 firms accounting for 65 percent of production capacity. Washington, Oregon, and Montana accounted for 31 percent of the total

*Prepared by J. W. Stamper.
[1] See also bauxite.

capacity; Gulf Coast States 23 percent, Northern States 26 percent, and other Southern States 20 percent. Based on estimated producer prices output of primary metal in 1977 was valued at $4.6 billion. Aluminum consumption by 25,000 firms was centered in the East Central United States. Of aluminum consuming industries in 1977, building accounted for about 25 percent; packaging 22 percent; transportation 21 percent; electrical 11 percent; consumer durables 9 percent; and other uses, 12 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production:					
Primary	4,529	4,903	3,879	4,251	4,490
Secondary (from old scrap)	265	307	334	409	430
Imports for consumption	614	629	550	749	860
Exports	561	524	440	484	420
Shipments from Government stockpile excesses	730	511	2	9	
Apparent consumption [2]	5,825	5,428	3,904	5,118	5,360
Price: Ingot, average (cents per pound)	25.3	34.1	39.8	44.6	51.6
Stocks: Aluminum industry, yearend	2,183	2,578	2,999	2,815	2,815
Employment:					
Primary reduction	23,000	24,000	20,000	22,000	23,000
Secondary smelter	4,200	4,100	4,000	4,200	4,200
Net import reliance of metal [3] as a percent of apparent consumption	18	4	[4]	9	8

[1] Estimate.
[2] Domestic primary metal production plus recovery from old aluminum scrap and net import reliance.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.
[4] Net exports.

3. *Recycling:* Aluminum recovery from scrap generated from current operations (new scrap) accounted for about 70 percent of the total recovery from purchased scrap. Discarded aluminum products (old scrap) such as cans accounted for the remainder. Aluminum recovery from old scrap of about 430,000 tons in 1977 was about 8 percent of apparent consumption.

4. *Import Sources (1973–76):* Canada 72 percent, about 30 other countries, 28 percent.

5. *Tariff:*

	Number	Rate of Duty	
		Jan. 1, 1978	Statutory
Unwrought (in coils)	618.01	1.2 cents per pound	7 cents per pound.
Unwrought (other than aluminum silicon alloys)	618.02	1.0 cent per pound	4 cents per pound.
Wrought (bars, plates, sheets, strip)	618.25	2.0 cents per pound	7 cents per pound.

6. *Depletion Allowance:* Not applicable.

7. *Government Programs:* Bureau of Mines research to develop improved methods of recovering aluminum and other metals from aluminum wastes and scrap continued. The Bureau also investigated the continuous separation and recovery of aluminum and other valuable materials from raw urban refuse. As part of this latter program the Bureau assisted in the planning of commercial-scale facilities to treat refuse in Monroe County, N.Y., and Baltimore County, Md.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Aluminum		2		

8. *Events, Trends, and Issues:* Led by strong demand in the construction sector, apparent metal consumption in 1977 continued to recover from the 1975 5-year low, increasing to about 5.4 million tons, 4.7 percent over that of 1976, but still significantly below the record 1973 demand. Aluminum use in automobiles, trucks, and busses to save weight and improve energy efficiency of these forms of transportation, also increased. The quantity of primary metal imported in 1977 was substantially larger than in the previous year and accounted for a higher proportion of total supply. Aluminum prices quoted by producers continued to increase, rising from 48 cents per pound at the beginning of 1977 to 51 cents per pound by the end of March, and to 53 cents per pound in July, where it remained at yearend. Although some discounting was reported, prices appeared to be strengthening at yearend.

A new $400 million 197,000-ton-per-year primary aluminum smelter to be built in either Berkley or Georgetown Counties, South Carolina, was announced. Alumina for the plant would be supplied from Australia and an agreement was signed with the South Carolina Public Service Authority to supply power.

In 1976 The Bonneville Power Administration (BPA) notified the six primary aluminum producers in the Pacific Northwest that by the 1980's projected electric power generating capacity in the area would be insufficient to meet expected demand and that existing contracts with aluminum producers for BPA power, which expire in the mid-1980's, would not be renewed. In 1977, ways to assure adequate power in the area in the future were being considered by BPA, various regional power authorities, and representatives of consumer and industrial power users in the area.

Using as the base year the 1977 demand, which was significantly below the long range growth trend, apparent aluminum metal consumption is projected to grow at 8.8 percent per year through 1985. A significant part of total U.S. producing capacity was closed during 1977 due to power curtailments in the Pacific Northwest caused by low water conditions and to other energy-related problems caused by the severe winter weather. Demand for aluminum appeared to be in balance with aluminum supply at yearend. However, announced expansions of domestic production capacity for primary metal of only 1.5 percent per year to 1983 foreshadow a shift toward greater reliance on imported metal supply.

Major operating problems in the aluminum metal industry, which relate to the environment, include control of fluorine emissions from the alumina reduction cells and prevention of air pollution by chlorine or chemical compounds used in recycling aluminum metal.

9. *World Plant Production and Capacity:*

	Production		Yearend capacity	
	1976	1977 [1]	1976	1977 [1]
United States	4,251	4,490	5,187	5,279
Canada	690	1,000	1,175	1,175
France	424	440	452	452
Germany, West	768	800	825	825
Japan	1,013	1,200	1,703	1,703
United Kingdom	369	400	403	403
U.S.S.R.	1,760	1,800	2,140	2,160
Other	4,497	4,600	5,185	5,418
World total	13,772	14,730	17,070	17,415

[1] Estimate.

10. *World Resources:* Long term domestic aluminum requirements cannot be met by domestic resources of bauxite, the commercial source of aluminum. Potential resources of aluminum in nonbauxitic materials in the United States are abundant and could meet domestic aluminum requirements indefinitely, however, no industrial plants have been built to treat such materials, nor have optimum processes or materials been selected. World reserves of bauxite contain over 5 billion tons of aluminum and are sufficient to meet forecast world demand through the year 2000.[1]

11. *Substitutes and Alternates:* Copper can be used in place of aluminum in many applications. Magnesium and titanium may be substituted for aluminum for many structural uses in transportation, usually at higher costs. Steel may be

[1] See also Bauxite.

used in place of aluminum in many applications where weight saving is not important. Steel, composites, and wood compete with aluminum in the building and construction market and steel, plastics, glass, and paper compete with aluminum in the container market.

CHROMIUM*

[Data in thousand short tons gross weight, unless noted]

1. *Domestic Productions and Use:* The United States continued to be one of the world's leading consumers of chromium. Chromite was consumed by five firms producing chromium ferroalloys; seven firms producing refractories; and three firms producing chromium chemicals. Most of these were in the Eastern United States. The metallurgical industry accounted for 61 percent of the total usage, the refractory industry, 19 percent; and the chemical industry, 20 percent. Consumption of chromium by end use was as follows: Construction, 21 percent; transportation, 16 percent; machinery and equipment, 16 percent; refractories, 8 percent; and all other uses, 39 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977[1]
Production: Chromite[2]				(3)	(3)
Imports for consumption: Chromite	931	1,102	1,252	1,275	1,220
Chromium ferroalloys[4]	168	170	323	259	250
Exports and reexports: Chromite	55	117	184	209	250
Chromium ferroalloys	15	8	13	14	12
Shipments from Government stockpile excesses: Chromite	285	500	418	311	540
Consumption (reported): Chromite	1,387	1,447	881	1,006	1,000
Chromium ferroalloys	511	585	336	417	460
Consumption of chromium (apparent)[5]	601	625	410	529	570
Price (yearend):					
Chromite—Turkish, per long ton, f.o.b	[6] $37	$65	$137	$137	$137
Chromite—South African, per metric ton, f.o.b	[6] $34	$50	$35	$39	$59
Consumer stocks: Chromite, yearend	597	573	952	1,009	1,060
Net import reliance[7] as a percent of apparent consumption	91	90	91	89	89

[1] Estimate.
[2] Chromite ore is typically from 22 to 38 percent chromium content.
[3] Withheld to avoid disclosing company confidential data.
[4] Chromium ferroalloys are typically from 36 to 70 percent chromium content.
[5] Calculated total demand for chromium.
[6] Delivered U.S. ports.
[7] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* In 1977, estimated chromium contained in purchased stainless steel scrap recycled amounted to 11 percent of total chromium demand.

4. *Import Sources (1973–76)*: Chromite: Republic of South Africa 30 percent, U.S.S.R. 24 percent, Philippines 18 percent. Turkey 14 percent, Other 14 percent. Ferrochromium: Republic of South Africa 34 percent, Southern Rhodesia 24 percent, Japan 16 percent, Other 26 percent.

5. *Tariff:*

	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Ore and concentrate	601.15	Free	Free.
Low-carbon ferrochromium	607.30	4 percent ad valorem	30 percent ad valorem.
High-carbon ferrochromium	607.31	0.625 cents per pound chromium.	2.5 cents per pound chromium.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* Bureau of Mines research is studying the recovery of chromium from laterites which, if successful, would extend world resources and expand the geographical supply base. Other Bureau studies being conducted concern conservation of chromium and include reclamation of refractories containing chromium, recovery of chromium values from metallurgical and tanning wastes, and conservation of chromium through surface alloying.

*Prepared by J. L. Morning.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo.
Chromite:				
Metallurgical grade	2,550	1,943		
Chemical grade	734	250		
Refractory grade	642	400		
Chromium ferroalloys	429	756		
Chromium metal	10	4		

Note: In addition to data shown, the stockpile contains the following nonstockpile-grade material: 551,758 tons of metallurgical-grade chromite and 23,764 tons of chromium ferroalloys.

8. *Events, Trends and Issues:* Paced by increased stainless steel production in 1977, chromium demand was substantially higher than in 1976. Imports of chromium-bearing materials supplied 89 percent of the chromium demand.

Prices of high-chromium (metallurgical-grade) chromite remained unchanged from those published in 1976, however, the price for high-iron South African chromite increased to $56–$61 per metric ton, southern African ports from $36–$42 per ton at yearend 1976. Ferrochromium prices, however, decreased owing to large stock holdings overhanging the market.

As an outgrowth of reimposing sanctions on Rhodesian chromium in March, 1977, interest in the California-Oregon border chromite was renewed. Chromite mining interests late in 1976 reactivated a producers' association. During 1977, plans for construction of a mill and financing were discussed and negotiations held with Japanese and domestic processors.

Petitions during 1977 to the International Trade Commission (ITC) were made by domestic producers of low-carbon and high-carbon ferrochromium for import relief. ITC at midyear 1977, determined that low-carbon ferrochromium imports were not harmful to the domestic producers. In November 1977, ITC determined that imports of high-carbon ferrochromium represent a substantial cause of threat of injury to domestic producers. ITC forwarded recommendations to the President for his decision.

Demand for primary chromium is expected to increase at an annual rate of about 3.4 percent through 1985. Along with other consuming countries, the United States will continue to rely on imports of chromium.

International relationships in the future can influence the United States supply-demand position, as they have in the past. Increasing ferrochromium imports of the last few years compete with the domestic ferrochromium industry and may restrain its growth.

Environmental considerations for cleaner air impose economic problems for some processors. Although cleaner air results from compliance with Environmental Protection Agency regulations, disposal of reclaimed dust and slag remain problems.

9. *World Chromite Mine Production and Reserves:*

	Mine production		Reserves
	1976	1977 [1]	
United States	(2)	(2)	
Philippines	471	480	2,000
Rhodesia, southern [1]	670	670	600,000
South Africa, Republic of	2,656	2,700	2,000,000
Turkey	816	800	7,000
Other market economy countries	1,622	1,600	33,000
Central economy countries	3,257	3,000	27,000
World total	9,492	9,250	2,700,000

[1] Estimate.
[2] Withheld to avoid disclosing company confidential data.

10. *World Resources*: World resources reassessed by the U.S. Geological Survey in 1977 indicate over 18 billion tons of recoverable chromite, ranging in grade from about 40 percent to 55 percent Cr_2O_3, are sufficient to meet conceivable demand for centuries. However, almost 99 percent of the world's chromite is in southern Africa, 16 billion tons in South Africa and 2 billion tons in Rhodesia.

Probably half of the remaining 1 percent is in the Soviet Union (possibly 100 million tons). North American resources are estimated at about 30 million tons, of which 8 million tons are in the United States. Most of the United States resources are in the Stillwater Complex in Montana. Renewal of substantial chromite mining in North America for domestic use would require that the present price of chromite be doubled or tripled.

11. *Substitutes and Alternates*: Some elements or materials may substitute for chromium in various end use applications, but cost consideration, performance standards, and customer appeal are major determining factors in use of chromium. Typical substitute possibilities are: Nickel, zinc, or cadmium for corrosion protection of iron and steel; aluminum and plastics for automotive decorative trim; nickel, cobalt, molybdenum, or vanadium for alloying iron and steel; titanium for chemical processing equipment; cadmium yellow pigment for protective coatings; and magnesite refractories for some refractory products.

COBALT*

[Data in short tons of metal, unless noted]

1. *Domestic Production and Use*: Domestic mine production ceased at the end of 1971. Cobalt usually is recovered as a byproduct of either copper or nickel. Most secondary cobalt is derived from recycled superalloy scrap. The single domestic refiner of cobalt, located in Louisiana, began production in 1975. About 15 processors were active in the production of cobalt products in 1977. Industrial consumers totaled about 250, with the largest in New Jersey, Pennsylvania, New York, Ohio, Indiana, Illinois, and Michigan. Major end uses were: Transportation, 25 percent; electrical, 25 percent; machinery, 17 percent; paints, 13 percent; chemicals, 10 percent; ceramics, 5 percent; and other, 5 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production:					
Mine	None	None	None	None	None
Secondary	132	135	171	165	230
Imports for consumption	9,619	8,061	3,304	8,244	8,850
Exports [1]	699	674	884	876	450
Shipments from Government stockpile excesses	4,285	4,468	3,173	3,349	
Consumption:					
Reported	9,371	9,431	6,394	8,241	9,000
Apparent	11,012	11,849	7,028	9,920	9,162
Price (range, per pound): f.o.b. New York, N.Y.; Chicago, Ill	$2.45–3.30	$3.10–3.75	$3.75–4.00	$4.00–5.40	$5.20–6.00
Stocks: Industry, yearend	4,592	4,734	3,470	4,432	3,900
Employment: Mine	None	None	None	None	None
Net import reliance [2] as a percent of apparent consumption	99	99	98	98	97

[1] Estimate.
[2] Net import reliance = imports − exports + adjustments for Government and industry stock changes.

3. *Recycling:* About 230 tons of cobalt were recycled from purchased scrap in 1977. This represented about 2.6 percent of estimated reported consumption for the year.

4. *Import Sources (1973–76):* Zaire 47 percent, Belgium-Luxembourg 24 percent, Norway 7 percent, Finland 6 percent, other 16 percent.

5. *Tariff:*

	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Ore and concentrate	601.18	Free	Free.
Unwrought metal, waste, and scrap	632.20	Free	Free.
Alloys, unwrought	632.84	9% ad valorem	45% ad valorem.
Oxide	418.60	1.2¢/lb	20¢/lb.
Linoleate	490.40	3.6¢/lb	14.5¢/lb.

*Prepared by S. F. Sibley.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* Bureau of Mines research was conducted on extraction of cobalt from laterites in Oregon, the Duluth gabbro in Minnesota, mine tailings in Missouri, and deep-sea manganese nodules.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Cobalt	42,708	20,453		

8. *Events, Trends, and Issues:* Consumer stocks reached their highest level as demand remained strong, especially for superalloys and magnetic materials. The major foreign producers increased their exports in response to relatively high demand. There was no problem in obtaining necessary supplies during the year.

Two major corporations, one domestic and one foreign, took steps toward establishment of manufacturing facilities in the United States that would produce extrafine cobalt powder for use in the cemented carbide industry. Thus, import dependence for this critical form is expected to be substantially reduced in 1978, although the basic raw material source might be foreign.

Zaire reportedly solved her export transportation problems during the year. Zambia again was a source of significant imports.

In the field of superalloys, increasing attention reportedly was paid to refining of current fabrication processes. These included hot forging, precision metalworking, hot isothermal pressing, powder metallurgy, single crystal growth, particle metallurgy, directional solidification, and cold pressing.

Two leading consortia in ocean mining planned tests in the Pacific for recovery of cobalt-bearing manganese nodules. Both operations involved 6-month test phases.

The low grade of resources and environmental restrictions were the principal impediments to development of domestic minerals. Since cobalt is a byproduct, environmental considerations are transferred to the mining and processing of copper, nickel, and iron ores from which it is derived.

Demand for cobalt is expected to increase at an annual rate of about 2.9 percent through 1985.

The producer price of cobalt remained at $5.40 per pound from December 24, 1976, to January 21, 1977, when the price was lowered to $5.20 per pound. On July 13, the price was raised to $6 per pound, where it remained until yearend.

9. *World Mine Production and Reserves:*

	Mine production		Reserves [1]	
	1976	1977 [1]	Quantity	Grade of ore (percent)
United States				
Australia	3,840	3,800	54,000	0.08–0.12
Botswana	165	200	29,000	.06
Canada	1,513	1,700	33,000	.03–.1
Finland	1,410	1,400	20,000	.2–.7
Morocco	950	1,000	14,000	1.2
New Caledonia	1,984	2,000	300,000	.1
Philippines	514	700	210,000	.03–.12
Zaire	12,125	15,000	500,000	.3–2.0
Zambia	2,430	2,700	125,000	.1–.2
Central economy countries	3,750	3,700	350,000	.01–.3
World total [2]	28,681	32,200	1,600,000	

[1] Estimate.
[2] Data may not add to totals shown because of independent rounding.

10. *World Resources:* The identified cobalt resources of the United States are more than 840,000 tons, chiefly in the Midwest and Far West. The identified cobalt resources of the world are nearly 5 million tons. In addition, the world's hypothetical and speculative resources of cobalt in manganese nodules on the sea floor and in lateritic iron-nickel deposits of tropical regions amount to millions of additional tons.

11. *Substitutes and Alternatives:* Nickel may be substituted for cobalt in several applications but only with a loss of effectiveness. Various potential substitutes include nickel, platinum, barium or strontium ferrite and iron in magnets; tungsten, molybdenum carbide, ceramics, and nickel in machinery; nickel and ceramics in jet engines; nickel in catalysts; and copper, chromium, and manganese in paints.

COLUMBIUM*

[Data in thousand pounds columbium content, unless noted]

1. *Domestic Production and Use:* There has been no domestic columbium mining industry since 1959. Metals and alloys were produced from imported concentrates, tin slags, and ferrocolumbium. Nine companies operating ten plants, processed imported concentrates and tin slags. Consumption was mainly by the iron and steel, and aerospace industries located in the Eastern United States, California, and Washington. Total estimated value, based on metal, compounds, and ferrocolumbium production was about $40 million. Tin, tantalum, tungsten, titanium, and rare-earth minerals were byproducts of columbite production and uranium was a coproduct of pyrochlore production. End uses as metals and alloys in fabricated form were: Construction, 40 percent; oil and gas industries, 20 percent; transportation, 20 percent; machinery, 13 percent; other, 7 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977
Mine production	None	None	None	None	None
Imports for consumption:					
Concentrates, tin slags, and other [2]	1,921	2,044	992	2,497	2,200
Ferrocolumbium [1]	2,120	3,276	1,872	2,221	2,600
Exports: Metal, alloys, waste and scrap [1]	48	17	27	34	30
Shipments from Government stockpile excesses	2,343	2,739	463	70	
Consumption, reported:					
Raw material	2,806	3,250	2,137	3,379	3,000
Ferrocolumbium and other [3]	4,056	4,626	3,348	3,389	4,100
Consumption, apparent	5,598	7,193	4,231	6,003	5,500
Prices:					
Columbite [4]	$1.28	$1.80	$1.85	$2.55	$3.18
Pyrochlore [5]	$1.38	$1.56	$1.56	$1.85	$2.40
Industry stocks: Processor and dealer, consumer, yearend	6,552	7,401	6,470	5,221	4,500
Employment: Processor [1]	600	800	700	700	700
Net import reliance [6] as a percent of apparent consumption	100	100	100	100	100

[1] Estimate.
[2] Metal, alloys and synthetic concentrates.
[3] Includes a small tantalum content.
[4] Average price per pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10 to 1.
[5] Average contract price per pound of contained pentoxide.
[6] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* Recycling of old (obsolete) and new (prompt industrial) scrap was not significant.

4. *Import Sources (1973–76):* Brazil 83 percent, Thailand 10 percent, Nigeria 3 percent, Malaysia 2 percent, Other 2 percent.

5. *Tariff:*

Item	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Columbium concentrate	601.21	Free	Free.
Columbium metal	628.15	5% ad valorem	25% ad valorem.
Ferrocolumbium	607.80	5% ad valorem	25% ad valorem.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

*Prepared by H. E. Stipp.

7. *Government Programs:*

STOCKPILE STATUS [1]—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Columbium:				
Carbide powder		21,372		
Concentrate	3,131,000	1,780,853		
Ferro		622,786		
Metal		44,851		

[1] Pounds of contained columbium.

Note: In addition to data shown stockpile contains 308,125 lb. of nonstockpile grade ferrocolumbium.

8. *Events, Trends, and Issues:* Prices of columbium mineral concentrates imported for domestic consumption increased about 13 percent over yearend 1976 prices. Domestic demand for columbium was expected to increase at an average annual rate of about 5.6 percent through 1985. Supply needs are expected to be met by foreign mine production and industry stocks.

There are no known uncontrollable health hazards connected with production or fabrication of columbium metals and compounds. Fumes, gases, dust, and low-level radiation generated by columbium processing plants can be controlled by modern technology.

Significant developments were the increased use of columbium in large-diameter pipeline steels, ship plate steels, heavy machinery steels, and construction steels. Alloys of columbium with tin and titanium were scheduled for use as superconductors of electricity at cryogenic temperatures in magnetic coils for an experimental fusion reactor.

9. *World Mine Production and Reserves:*

	Mine production		
	1976	1977 [1]	Reserves
United States			
Brazil	16,139	17,000	18,000,000
Canada	[1] 2,560	2,600	1,300,000
Malaysia	43	45	(2)
Mozambique	[1] 17	30	(2)
Nigeria	632	600	650,000
Zaire	48	50	910,000
Other market economy countries	[1] 209	200	900,000
Central economy countries	(2)	(2)	(2)
World total (excluding central economy countries)	[1] 19,648	20,525	[3] 22,000,000

[1] Estimate.
[2] Not available.
[3] Data may not add to totals shown because of independent rounding.

10. *World Resources:* Most of the world's identified resources of columbium lie outside the United States and occur mainly as pyrochlore in carbonatite deposits. On a worldwide basis, resources are more than adequate to supply projected needs. The United States had approximately 300 million pounds of columbium located in identified deposits, which were considered to be uneconomic at 1977 prices for columbium.

11. *Substitutes and Alternates:* Vanadium may be substituted for columbium in high-strength low-alloy steels; tantalum in stainless and high-strength steel and superalloys; molybdenum, vanadium, tungsten, tantalum, and ceramics in high-temperature applications.

COPPER*

[Data in thousand short tons of copper, unless noted]

1. *Domestic Production and Use:* In 1977 domestic mine output was 1.5 million tons of copper valued at $1,994 million, decreases of 7 percent and 12 percent, respectively, from 1976. The leading 25 mines produced 93 percent of the domestic mine output; of these, five produced 40 percent. Four companies ac-

*Prepared by Harold J. Schroeder.

counted for 58 percent of mine output. Nine companies operated 17 primary smelters and 19 companies operated 25 refineries and electrowinning plants. Principal copper-producing States were Arizona (62 percent), Utah (13 percent), New Mexico (11 percent), Montana (6 percent), Nevada (4 percent), and Michigan (3 percent). Smelters were in the principal mining States with the exception of the El Paso, Tex., and Tacoma, Wash., facilities. Nearly 40 percent of the refinery capacity was near primary smelters with most of the remainder divided between locations in Texas and the Middle Atlantic States. Most copper was consumed as refined metal—69 percent by wire mills and 29 percent by brass mills. Use of copper (primary and old scrap) is estimated to be 54 percent electrical, 15 percent construction, 13 percent industrial machinery, 11 percent transportation, 2 percent ordnance, and 5 percent miscellaneous. Significant quantities of byproducts and coproducts such as gold, silver, molybdenum, nickel, selenium, tellurium, arsenic, rhenium, lead, zinc, and sulfur were recovered.

2. *Salient Statistics.—United States:*

	1973	1974	1975	1976	1977 [1]
Production: Mine	1,718	1,597	1,413	1,606	1,490
Refined copper:					
Primary	1,868	1,655	1,443	1,539	1,600
Secondary	465	497	344	360	450
General imports:					
Unmanufactured [2]	421	609	324	535	470
Refined	203	314	147	382	365
Exports:					
Unmanufactured [2]	278	198	234	173	105
Refined	189	127	172	113	50
Shipments from Government stockpile excesses		252			
Consumption, refined (reported)	2,437	2,194	1,535	1,992	2,200
Consumption, apparent (primary and old scrap)	2,388	2,261	1,681	2,242	2,290
Price: Average (cents per pound):					
Domestic producer	59.5	77.3	64.2	69.6	66.7
London Metal Exchange	80.9	93.1	56.1	63.9	59.3
Stocks: Producer (refined), yearend	37	101	207	190	140
Employment, mine and mill	35,000	36,300	33,500	31,900	31,000
Net import reliance [3] as a percent of apparent consumption	8	20	(4)	12	17

[1] Estimate.
[2] Includes ores and concentrates, matte, blister, refined, and unalloyed scrap.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.
[4] Net exports.

3. *Recycling:* Old scrap, derived from obsolete end use items, comprised 19 percent of consumption of copper. The 420,000 tons of old scrap (recoverable copper) consumed compares with the consumption of 750,000 tons of new scrap, derived from fabricating operations. Of the total, brass mills consumed 49 percent, smelters and refiners 47 percent, and other categories 4 percent.

4. *Import Sources (1973–76):* Canada 31 percent, Chile 18 percent, Peru 16 percent, Zambia 7 percent, Other 28 percent.

5. *Tariff:*

Item	Number	Rate of duty (cents per pound)	
		Jan. 1, 1978	Statutory
Ore	602.30	0.8	4
Unwrought copper, waste and scrap	612.02–612.10	[1] .8	4

[1] Waste and scrap temporarily suspended by Public Law 94–89, effective to June 30, 1978.

6. *Depletion Allowance:* 15 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* On October 1, 1976, the Federal Preparedness Agency announced a new stockpile goal of 1,299,000 tons of refined copper. In October 1977, the Administration announced an affirmation of the copper goal established in 1976. Bureau of Mines research included investigations to improve copper recovery systems and to control smelter emissions.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authored for disposal	Sales, 11 mo
Copper	1,299	20		

8. *Events, Trends, and Issues:* The accumulation of record high levels of stocks worldwide and the apparent unwillingness of many producing countries to trim output in line with the generally weak demand that has persisted since 1974 has resulted in depressed copper prices. An improvement in demand during the first part of 1977 and anticipation of strikes in the United States copper industry in the second half of the year were the principal factors causing an uptrend in prices during the first quarter of 1977. However, strikes starting June 30 at many domestic producing units were of relatively short duration, did not materially reduce the prestrike buildup of inventories, and were followed by mine closures, production curtailments, and a serious unemployment situation.

The various market factors resulted in an advance in the price of copper on the London Metal Exchange (LME) from an average 63.3 cents per pound for January 1977 to 68.6 cents for March followed by a generally downward trend to 54.9 cents by the end of November. The average estimated price for 1977 was 59 cents compared with 64 cents for 1976. Producer prices in the United States approximated the LME pattern with price for refined cathode copper increasing in three steps, from 65 cents per pound at the start of the year to 74 cents in mid-March, then decreased in four steps between May and August to a price of 60 cents. The average for 1977 was about 67 cents compared with 70 cents in 1976.

No new production facilities were brought on stream in 1977. Several copper projects were under development or planned for early development. Other projects for which feasibility studies have been completed are being held in abeyance until market conditions are more favorable. Primary copper demand is forecast to approximate an average growth rate of 3 percent through 1985 and therefore production requirements will ultimately overtake current capacity.

Air quality standards to be imposed on copper smelters, principally directed at reducing the emission of sulfur compounds to the atmosphere, remained an area of concern among the industry, various States, and the Federal Government. New technology and large capital investments will be required to either modify existing pyrometallurgical practices or adopt new chemical-processing techniques as a solution to the problem.

9. *World Mine Production and Reserves:*

	Mine production		Reserves
	1976	1977 [1]	
United States	1,606	1,490	93,000
Australia	240	220	8,000
Canada	824	820	34,000
Chile	1,108	1,140	93,000
Papua New Guinea	194	180	10,000
Peru	221	350	35,000
Philippines	255	260	19,000
South Africa, Republic of	217	230	3,000
Zaire	490	540	28,000
Zambia	781	730	32,000
Other market economy countries	716	750	82,000
Poland	300	300	14,000
U.S.S.R.	880	910	[1] 40,000
Other central economy countries	381	400	[1] 12,000
World Total	8,213	8,320	503,000

[1] Estimate.

10. *World Resources*: Of the above reserves approximately 32 percent of the U.S. total and 36 percent of the total contained in all market economy countries are located in undeveloped deposits. These deposits can move between reserve and resource classifications depending on prevailing legal and economic conditions. Identified copper resources occur principally in western North America and South America, central Africa, southeastern and central Europe. and the

U.S.S.R. Hypothetical resources, located near known deposits, probably contain 480 million tons of copper. An additional speculative 320 million tons of copper is assigned to areas not yet prospected and 760 million tons are estimated to exist in deep sea nodule resources.

11. *Substitutes and Alternates*: Copper is vulnerable to substitution for many uses such as aluminum for electrical purposes, steel for shell casings, and plastics for plumbing.

FLUORSPAR *

[Data in thousand short tons, unless noted]

1. *Domestic Production and Use*: Domestic shipments of all grades of fluorspar from 12 operators amounted to approximately $20 million in 1977. Shipments from the Illinois-Kentucky district represented 85 percent of the total, with the balance supplied from Arizona, Montana, Nevada, Texas, and Utah. Three major companies operating nine mines and three flotation plants in Illinois and Kentucky accounted for 83 percent of the total output. Small, intermittent operations or shipments from inventory in Illinois and the Western States accounted for the remainder of the supply. Main coproducts of fluorspar mining and milling consisted of barite and zinc concentrates. Major industrial demand for fluorspar comprised steel production, 48 percent, fluorocarbons and miscellaneous fluorine compounds, 22 percent; primary aluminum, 16 percent; others, 14 percent. Supplementing domestic supplies of fluorine were 70,000 tons of fluosilicic acid, equivalent to about 108,000 tons of fluorspar, recovered from 11 phosphoric acid plants processing phosphate rock.

2. *Salient Statistics—United States*:

	1973	1974	1975	1976	1977[1]
Production: Finished (all grades)[2]	249	201	140	188	180
Fluorspar equivalent from phosphate rock	84	97	80	108	108
Imports for consumption:					
Acid-spar	706	843	699	591	650
Met-spar	506	493	351	304	350
Fluorspar equivalent from hydrofluoric acid	70	71	102	188	190
Exports: Ceramic and acid-grades	2	6	1	5	5
Sales of Government stockpile excesses	None	None	None	None	None
Apparent consumption	1,663	1,596	1,482	1,416	1,451
Reported consumption:					
Acid-spar	677	841	683	643	650
Met-spar	675	684	562	630	650
Price:[3]					
Acid-spar, per ton	$85	$90	$95–115	$95–115	$95–115
Met-spar, per ton	$65	$70	$83–88	$83–91	$83–91
Yearend stocks:					
Mine	9	14	11	15	20
Consumer	328	431	320	278	300
Employment:					
Mine[1]	600	350	300	300	300
Mill[1]	280	100	193	200	200
Net import reliance[4] as a percent of apparent consumption	80	81	85	79	80

[1] Estimate.
[2] Shipments (average grade 90 percent CaF_2).
[3] Fluorspar prices, f.o.b. Illinois, are quotations from "Engineering and Mining Journal."
[4] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* About 10 percent of fluoride values are recycled annually in the aluminum industry. There is no recycling in other consuming industries.

4. *Import Sources (1973–76):* Mexico, 73 percent; Spain, 8 percent; Italy, 4 percent; South Africa, 3 percent; Others, 12 percent.

5. *Tariff:*

Item	Number	Rate of duty (per long ton) Jan. 1, 1978	Rate of duty (per long ton) Statutory
Acid-grade (more than 97 percent CaF_2)	522.21	$2.10	$5.60
Metallurgical-grade (less than 97 percent CaF_2)	522.25	8.40	8.40

*Prepared by C. K. Quan.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* The Bureau of Mines continued its research on byproduct fluosilicic acid recovery from phosphate rock, demonstrating that over 80 percent of the fluorine can be recovered as a dilute solution of fluosilicic acid.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Acid-grade	1,594	890		
Metallurgical-grade	1,914	412		

8. *Events, Trends, and Issues:* Since 1972, imports of hydrofluoric acid, a key chemical derived from acid-grade fluorspar, have been steadily rising, from about 14,000 tons to over 85,000 tons in 1976 and 1977. Until recently, Canada was the major supplier, accounting for over 90 percent of U.S. imports. The position changed somewhat in 1975 when shipments from Mexico increased almost eightfold over the previous year; in 1976 shipments more than tripled, largely the result of the first full year of operations of a new hydrofluoric acid plant at Matamoros, Mexico. Currently, Mexico is the leading supplier of hydrofluoric acid to the United States. The total value of hydrofluoric acid imports amounted to about $41 million in 1977, almost two-thirds that of imported fluorspar.

Environmental concerns over the possible effects of fluorocarbons on stratospheric ozone continued to depress the acid-spar market, causing an over-supply situation which may prevail until the end of the 1970's. In March 1977, Oregon became the first State to ban the sale of aerosols containing fluorocarbons. In April, the Food and Drug Administration (FDA) and the Consumer Product Safety Commission (CPSC) proposed rules requiring warning labels on products containing fluorocarbon propellants. In May, FDA, the Environmental Protection Agency (EPA) and CPSC promulgated rules banning the manufacture of fluorocarbon propellants for nonessential uses by December 15, 1978, and their interstate shipments by April 15, 1979.

In view of the foregoing developments, demand for acid grade fluorspar in fluorocarbon manufacture is expected to decline slightly in the short term. However, this will be partially offset by a rising demand in the aluminum industry. Overall demand for fluorspar in all consuming sectors of the economy is expected to increase by about 3 percent annually through 1985.

H.R. 5265, providing for a temporary suspension of duty on the importation of fluorspar through June 30, 1980, was reported by the House Subcommittee on Trade, but as of November it has not been called up for a vote.

9. *World Mine Production and Reserves:*

	Production average (90 percent CaF_2)		Reserves (35 percent CaF_2 or equivalent)
	1976	1977 [1]	
United States	188	180	16,000
Canada	80	80	6,000
France	386	350	9,000
Italy	232	250	7,000
Mexico	988	1,100	39,000
South Africa, Republic of	320	350	40,000
Other Africa	177	180	21,000
Spain	444	350	11,000
Thailand	220	180	11,000
United Kingdom	265	260	22,000
Other Market Economy Countries	246	250	22,000
China, People's Republic of	400	350	6,000
Mongolia	350	350	5,000
U.S.S.R	540	550	15,000
Other central economy countries	252	280	5,000
World total	5,088	5,060	235,000

[1] Estimate.

10. *World Resources:* Identified world fluorspar resources amount to approximately 75 million tons of contained fluorine. U.S. fluorspar resources are esti-

mated at 15 million tons of contained fluorine; resources of fluorine available from phosphate rock amount to approximately 31 million tons. World resources of flourine from phosphate rock are estimated at 400 million tons.

11. *Substitutes and Alternates:* It is understood that some foreign steelmakers have been using dolomitic limestone, with good success, as a substitute flux for fluorspar.

IRON ORE *[1]

[Data in million long tons of ore,[2] unless noted]

1. *Domestic Production and Use:* Mine value of usable iron ore produced from domestic mines in 1977 was estimated at $1.4 billion. Iron ore was produced by 31 companies operating 54 mines, 40 concentration plants, and 21 pelletizing plants. The mines included 48 open pits and six underground mines. Open pits accounted for 96 percent of total output, and 98 percent of all ore was concentrated before shipment. Byproduct ore recovered from copper- and titanium-mining operations accounted for less than 1 percent of total production of iron ore. About 80 percent of all iron ore was agglomerated at or near the mine sites before shipment. Pellets made up about 80 percent of usable ore shipments. Average iron content of usable ore was 61.5 percent. Sixteen mines operated by eight companies accounted for 82 percent of total output. Domestic steel companies controlled more than 80 percent of output from U.S. mines. Minnesota produced about 62 percent of total output, Michigan 21 percent, and the remainder was produced in 15 other States. Consumption of iron ore and agglomerates was distributed as follows: Blast furnaces, 98.3 percent; steel furnaces, 1 percent; and manufacture of cement, heavy media materials and other products, 0.7 percent. Approximate consumption by region was: Maryland-Pennsylvania-New York, 31 percent; Illinois-Indiana, 27 percent; Ohio-West Virginia, 20 percent; and most of the remainder was consumed in nine other States.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977[1]
Production	87.7	84.4	78.9	80.0	57.0
Imports for consumption	43.3	48.0	46.7	44.4	37.0
Exports	2.7	2.3	2.5	2.9	2.2
Consumption, reported	146.9	138.2	114.1	125.4	118.0
Price (November) (Lake Superior ores, delivered rail of vessel at lower lake ports):					
Natural ores, basis 51.5 percent Fe, per long ton	$11.91–12.31	$15.75–16.00	$18.50–18.75	$20.26–20.51	$21.18–21.43
Pellets, per long ton unit of Fe	29.4¢	40.6¢	47.2¢	53.1¢	55.5¢
Stocks: Mine, dock, and consuming plant (yearend)	59.9	57.9	69.1	75.0	56.0
Employment: Mine and concentrating plant	19,600	19,980	19,920	20,500	21,000
Net import reliance[2] as a percent of apparent consumption	35	37	30	29	33

[1] Estimate.
[2] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* There is no significant recycling of iron ore (see Iron and Steel Scrap).

4. *Import Sources (1973–76):* Canada 47 percent, Venezuela 28 percent, Brazil 12 percent, Liberia 6 percent, Other 7 percent.

5. *Tariff:*

Item	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Iron ore	601.24	Free	Free.

*Prepared by F. L. Klinger.
[1] See also Iron and Steel, and Iron and Steel Scrap.
[2] Usable ore, including byproduct ore.

6. *Depletion Allowance:* 15 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* The Bureau of Mines continued to conduct research in 1977 on beneficiation of domestic resources of low-grade, nonmagnetic materials of the taconite type. Processes studied included high-intensity magnetic separation, flotation, and reduction roasting. Investigations were also continued on the use of solid fuels for beneficiation of taconite and induration of iron ore pellets. In cooperation with some producers and the Energy Research and Development Administration (now Department of Energy), the Bureau began a program to investigate production of low-BTU gas from coal and its use for pellet induration.

8. *Events, Trends, and Issues:* World production, trade, and consumption of iron ore declined in 1977 as a result of reduced demand for steel in the United States, Europe, and Japan. Cutbacks in ore production and rising levels of stocks were reported from several major producing countries. In the United States, the relatively low demand for ore was partially due to increased imports of steel, although a market decline in production was caused by strikes which idled most mines in the Lake Superior district from August 1, 1977 until late in the year. A major underground mine and two pelletizing plants in Pennsylvania were permanently closed; however, U.S. annual production capacity for pellets increased by 14 million tons since mid-1976 and another 16 million tons of capacity were scheduled for completion by 1981. In Minnesota, the loss of 10.7 million tons of annual capacity was averted in 1977 when a major producer received permission from the State to shift tailings disposal from Lake Superior to a nearby land site; the shift will be completed in 1980 at a cost to the producer of about $370 million.

World production capacity for iron ore, pellets, and prereduced ore continued to increase but only a few new projects were announced in 1977.

The Association of Iron Ore Exporting Countries was joined by Liberia in 1977 but Chile and Tunisia withdrew. In October, about 45 iron ore producing and/or consuming countries met in Geneva for the first Preparatory Meeting on Iron Ore convened by the U.N. Conference on Trade and Development; a program of preliminary studies of the iron ore industry was agreed upon, and a second Preparatory Meeting was planned but no date was fixed.

Shortages of natural gas in the United States were expected to result in use of coal at several pelletizing plants by 1979. The shortage of gas continued to be a barrier to construction of direct-reduction plants.

Environmental aspects of the iron ore industry mainly concern disposal of solid wastes, elimination of dust, reclamation of process water, and noise abatement. The cost of meeting environmental protection requirements is rising. More precise definition, measurement, and ecological evaluation of alleged pollutants is needed.

U.S. demand for iron-in-ore is expected to increase at an average annual rate of about 2 percent through 1985. Domestic resources are ample to supply forecast demand through 2000, but owing to advantages in price, quality, or transportation costs for some foreign ores, and investments by U.S. companies in foreign mining projects, imports of ore will continue. Dependence on imports is expected to decrease by 1981.

9. *World Mine Production and Reserves:*

	Mine production		Reserves (millions)	
	1976	1977 [1]	Iron ore (long tons)	Recoverable iron (short tons)
United States	80.0	57	17,000	4,000
Australia	91.8	92	17,500	11,800
Brazil	90.4	86	26,800	18,000
Canada	56.1	53	36,000	12,000
France	44.5	41	4,000	1,800
India	42.3	42	9,000	6,200
Liberia	18.5	16	1,400	700
Sweden	30.0	26	3,300	2,200
Venezuela	17.9	15	3,200	1,700
Other market economy countries	92.3	99	20,300	10,000
Central economy countries:				
U.S.S.R	235.2	240	108,800	31,000
China, People's Republic of	64.0	55	6,000	3,000
Other	18.0	18	1,400	200
World total	881.0	840	254,700	102,600

[1] Estimate.

10. *World Resources:* World resources of iron ore are estimated to exceed 800 billion long tons of crude ore containing more than 260 billion short tons of iron. U.S. resources are estimated at about 108 billion long tons of crude ore containing about 30 billion short tons of iron. U.S. resources are mainly low-grade taconite-type ores of the Lake Superior district that require beneficiation and agglomeration for commercial use.

11. *Substitutes and Alternates:* There is no substitute for iron ore, in the marketplace or blast furnace. In steelmaking furnaces, prereduced ore can be substituted for scrap.

LEAD*

(Data in thousand short tons of lead, unless noted)

1. *Domestic Production and Use:* MINES: The domestic mining industry was comprised of about 50 mines in 14 States with production valued at $360 million, based on the price of primary metal. Twenty-five mines produced 99 percent of the 1977 output, and the leading eight mines, all in Missouri, yielded 80 percent of the year's total mine production of ores and concentrates. Missouri supplied 83 percent, Idaho 8 percent, Colorado 4 percent, and Utah 2 percent. Major coproducts or byproducts were zinc, silver, antimony, and bismuth. SMELTERS AND REFINERIES: Refined primary lead from five plants was produced in Missouri, Idaho, and Nebraska. Important secondary smelters were in the New York, Philadelphia, Baltimore, Cleveland, Chicago, Baton Rouge, Dallas, Los Angeles, and San Francisco areas. Consumption was by about 550 firms in virtually all States. Transportation was the major end use of lead, 52 percent as batteries and 19 percent gasoline additives; followed by electrical, 9 percent; ammunition, 6 percent; paints, 7 percent; construction, 2 percent, and other 5 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977[1]
Production:					
Mine	603	664	621	610	589
Refinery (primary)[2]	688	683	638	659	590
Secondary	654	699	658	727	723
General imports:					
Ores, concentrates and bullion	110	94	88	76	62
Pigs and bars	181	120	106	148	229
Exports	126	121	71	53	73
Shipments from Government stockpile excesses	212	266	7		
Consumption, reported	1,541	1,599	1,297	1,490	1,470
Consumption, apparent	1,542	1,474	1,237	1,516	1,554
Price: Average, cents per pound:					
United States	16.2	22.5	21.5	23.1	30.6
London	19.5	26.8	18.7	20.1	27.4
Stocks: Producers and consumers, yearend[2]	142	192	208	173	150
Employment:					
Mine and mill[3]	4,900	4,800	4,600	4,700	4,700
Smelters and refineries	2,450	2,400	2,400	2,400	2,400
Net import reliance[4] as a percent of apparent consumption	29	19	11	15	14

[1] Estimate.
[2] Refined lead plus lead content of antimonial lead.
[3] Includes all lead and/or lead-zinc producing units.
[4] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes

3. *Recycling:* Recovery of lead from old scrap, at 622,000 tons was 42 percent of total consumption.

4. *Import Sources (1973–76):* Canada 30 percent, Peru 21 percent, Mexico 15 percent, Australia 14 percent, Other 20 percent.

5. *Tariff:*

Item	Number	Rate of duty (cents per pound) Jan. 1, 1978	Statutory
Ore	602.10	0.75	1.5
Bullion and metal	624.02–.03	1.0625	2.125
Dross	603.25	1.0625	2.125

*Prepared by J. M. Hague.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* The stockpile goal of 865,000 tons of lead announced October 1, 1976, was reaffirmed on October 7, 1977.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales 11 mo
Lead	865	601		

8. *Events, Trends and Issues:* U.S. mine production was down slightly because of a strike in one district and primary metal production declined about 10% because of a strike at two smelters. Secondary metal production continued at the same level as in 1976. Reported metal consumption in 1977 remained close to 1.5 million tons, supported by a heavy demand for lead in batteries due to a cold winter and increased auto production. Lead stocks held by producers declined during the year to an abnormally low level by yearend. Imports of lead metal increased in 1977, but net import reliance as a percent of apparent consumption remained about the same as in 1976.

In contrast to the price decline of most other major metals, the U.S. producer price for lead rose from 26 cents per pound early in January to 31 cents by the end of February, where it remained until October 31 when it was raised to 32 cents. The London Metal Exchange (LME) price equivalent showed more fluctuation, rising above the U.S. price for short periods in March and May, but usually remaining 2 to 3 cents below the U.S. producer price.

U.S. demand for lead is expected to increase at an annual rate of about 1.8% through 1985. Reserves are adequate to supply the domestic component of primary lead demand at competitive prices for several decades.

Regulations by the Environmental Protection Agency (EPA) limiting the amount of lead used in gasoline as an antiknock additive have reduced the consumption of lead for this purpose from the 1972 level. Although total consumption in gasoline remained equal in 1977 to that in 1976, the future trend is expected to be severely downward as the limit of 1.7 grams per gallon in 1976 is reduced to 0.5 gram per gallon by 1980. A proposal was studied by the Occupational Safety and Health Administration (OSHA) to reduce the current limit of 200 micrograms of lead per cubic meter of air in the workplace to 100 micrograms per cubic meter based on an eight hour average. Compliance with the proposed standard will require new investment in ventilation control and a more systematic program for blood lead monitoring of employees by lead producers and consumers.

U.S. lead reserves represent a decrease from previous estimates because certain inferred reserves not having near-term potential have been excluded.

9. *World Mine Production and Reserves:*

	Mine production		
	1976	1977 [1]	Reserves
United States	610	589	28,400
Australia	439	440	18,800
Canada	272	370	12,900
Mexico	220	210	4,500
Peru	187	200	3,500
Yugoslavia	148	150	3,000
Other Latin America	112	100	4,500
Other market economy countries	680	1,020	30,400
Central economy countries	1,022	1,200	30,000
World total	3,690	4,279	136,000

[1] Estimate.

10. *World Resources:* Lead resources of the world are currently estimated at above 1.5 billion short tons. Much of this resource, however, is in low-tenor or unconventional deposits that will need new technologies for exploration and

recovery. Meanwhile the prospect for the discovery of additional reserves and resources of conventional ores at a rate that exceeds consumption is highly favorable.

11. *Substitutes and Alternates:* Substitution by plastics has reduced the use of lead in building construction, electrical cable covering, and in cans and containers. Lead also competes with other metals for use in construction, packaging, and protective coatings. Nickel-cadmium and silver-zinc are alternate materials for lead in batteries.

MANGANESE*

[Data in thousand short tons, gross weight, unless noted]

1. *Domestic Production and Use:* There was no production of manganese ore, containing 35% or more manganese, in 1977. Most ore consumption was by approximately 30 firms scattered over the United States, but principally in the East. Much of this ore was converted to ferro-manganese, the chief form in which the manganese is ultimately used in the production of steel, its major use. Most of the remainder was used in the production of pig iron, dry cell batteries, and in various chemical processes. Ultimate major end use distribution: Transportation, 20%; construction, 20%; machinery, 15%.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production: Mine [2]	None	None	None	None	None
Imports for consumption:					
Manganese ore [3]	1,510	1,225	1,574	1,317	1,100
Ferromanganese [4]	390	421	397	537	700
Shipments from Government stockpile excesses:					
Manganese ore [3]	438	1,063	624	681	625
Ferromanganese [4]	68	453	55	8	
Exports:					
Manganese ore [3]	57	223	205	128	120
Ferromanganese [4]	9	7	32	7	7
Reported consumption [5]:					
Manganese ore [3]	2,140	1,880	1,819	1,601	1,400
Ferromanganese [4]	1,117	1,115	882	897	870
Apparent consumption of manganese [6]	1,554	1,492	1,133	1,364	1,280
Price (low and high): 46–48 percent Mn, metallurgical ore, per L.T.U. cont. Mn, c.i.f. U.S. ports	$0.58–0.80	$0.80–1.42	$1.38–1.45	$1.38–1.53	$1.42–1.53
Stocks: Producer and consumer, yearend:					
Manganese ore [3]	1,543	1,841	2,064	2,256	2,000
Ferromanganese [4]	258	325	396	302	350
Employment: Mine and mill	None	None	None	None	None
Net import reliance [7] as a percent of apparent consumption	98	98	98	98	98

[1] Estimate.
[2] Excludes manganiferous ore containing less than 35 percent manganese, which accounts for approximately 2 percent of apparent consumption of manganese.
[3] Manganese ore typically ranges from 35 to 54 percent manganese content.
[4] Ferromanganese typically ranges from 74 to 95 percent manganese content.
[5] The sum of manganese ore consumption and ferromanganese consumption cannot be used as total manganese consumption, because much of the ore is consumed to produce ferromanganese.
[6] Thousand short tons, manganese content (elemental manganese). Based on estimates of average content for all significant components except imports which are reported content.
[7] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* Not significant.

4. *Import Sources—United States (1973–1976):*

Manganese ore [1]—Brazil 37 percent, Gabon 31 percent, Australia 14 percent, Republic of South Africa 10 percent, Other 8 percent.

Ferromanganese [2]—France 35 percent, Republic of South Africa 32 percent, Japan 14 percent, Other 19 percent.

*Prepared by G. L. DeHuff.

[1] Manganese ore typically ranges from 35 percent to 54 percent manganese content.
[2] Ferromanganese typically ranges from 74 percent to 95 percent manganese content.

5. *Tariff:*

	Number	Rate of duty Jan. 1, 1978	Statutory
Ore and concentrate	601.27	0.12¢/lb. of contained Mn [1]	1¢/lb. of contained Mn.
Metal	632.32	1.5¢/lb. + 10% ad valorem	1.875¢/lb. + 15% ad valorem.
High carbon ferromanganese	607.37	0.3¢/lb. of contained Mn [2]	1.875¢/lb. of contained Mn.

[1] Duty suspended for additional 3 yr as provided by Public Law 94–560, effective July 1, 1976.
[2] Fee from certain countries under General System of Preferences.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).
7. *Government Programs:*

STOCKPILE STATUS—NOVEMBER 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Battery:				
Natural ore	13	206	71	3,318
Synthetic dioxide	19	3		
Chemical ore	247	221		
Metallurgical ore	2,052	2,440	143	
Ferromanganese:				
High carbon	439	600		
Medium carbon	99	29		
Silicomanganese	81	24		
Electrolytic metal	15	14		

Note: In addition to data shown, the stockpile contains 55,000 tons of natural battery ore and 1,195,000 tons of metallurgical ore of nonstockpile grade.

8. *Events, Trends, and Issues:* U.S. imports of ferromanganese, at a high level, continued to increase with some softening in price. The General Services Administration continued manganese ore shipments from Government stockpile excesses at a substantial level, mostly of ore that had been previously sold.

U.S. demand for manganese is expected to increase at an annual rate of about 1.6% through 1985. This demand will continue to be supplied primarily by imports except as it might be supplemented by sales of Government stockpile excesses. There are very extensive deposits of manganese nodules on the deep ocean floors which are currently under investigation by U.S. and foreign companies. There are potential legal problems as to ownership and mining rights as well as some mining and metallurgical problems. The third Law of the Sea session held in May 1977 arrived at no substantive conclusions, and the Congress held hearings on bills that might facilitate mining of the nodules.

Manganese is an essential element for man and animals. In excess, however, it can be harmful. Although manganese poisoning can be an industrial hazard, it is not ordinarily a hazard to the general population. Environmental effects of ocean mining are unknown, but investigative work to date suggests that they may not be significant. This work is continuing.

9. *World Mine Production and Reserves:*

	Mine production 1976	1977 [1]	Reserves
United States			
Australia	2,375	2,200	330,000
Brazil	2,400	2,100	95,000
Gabon	2,372	2,300	165,000
India	1,862	1,800	65,000
South Africa, Republic of	6,010	6,000	2,200,000
Other market economy countries	1,567	1,500	59,000
Central economy countries	10,700	10,500	3,000,000
World total [2]	27,300	26,400	6,000,000

[1] Estimate.
[2] Data may not add to totals shown because of independent rounding.

10. *World Resources*: Known land-based resources of manganese are very large and are very irregularly distributed throughout the world. There are very extensive deep-sea resources in the form of manganese oxide deposits over large areas of the ocean floors, particularly in the Pacific Ocean.

11. *Substitutes and Alternates:* There is no substitute for manganese in its major applications.

NICKEL*

[Data in short tons of metal, unless noted]

1. *Domestic Production and Use:* One firm in Oregon mined nickel ore and produced ferronickel. A second firm in Louisiana produced nickel metal from imported materials. Nickel was also produced as a byproduct of copper refining and from secondary sources. Secondary nickel was recovered from nickel-bearing alloys, stainless and alloy steel, and residues at copper smelters and refineries, foundries, and steel mills. At the foundries and steel mills, nickel was normally used in the form in which it was recovered. The principal forms of primary nickel consumed were: Pure nickel metal, ferronickel, nickel oxide, and nickel salts. Major industrial consumers totaled about 200 with the largest ones in Pennsylvania, West Virginia, Ohio, Illinois, Michigan, Maryland, and New York. Nickel was consumed in the production of stainless and alloy steels, 42 percent; nonferrous alloys, 34 percent; and electroplating, 18 percent. Ultimate major end uses were: Transportation, 23 percent; chemical industry, 15 percent; electrical equipment, 13 percent; construction and fabricated metal products, 9 percent each. The estimated value of primary nickel consumed in 1977 was $740 million.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production:					
Mine	18,272	16,618	16,987	16,469	17,000
Plant: Refined metal from domestic ore	12,937	13,220	14,273	13,043	13,000
Byproduct, copper refining [2]	958	873	9,070	20,826	25,800
Secondary	65,861	64,511	41,628	51,331	50,000
Imports for consumption	190,418	220,655	160,507	188,618	200,000
Exports (gross weight)	22,070	30,442	30,121	47,561	32,000
Consumption:					
Reported (excludes most secondary)	197,723	208,409	146,495	162,927	160,000
Apparent (includes secondary)	273,588	283,606	196,237	218,181	230,000
Price range: Metal f.o.b. Port Colborne, Ont. (per pound)	$1.53	$1.53–2.01	$2.01–2.20	$2.20–2.41	$2.20–2.41
Stocks:					
Consumer, yearend	28,759	45,291	34,936	31,596	24,000
Other, yearend	42,527	41,989	67,419	91,159	118,755
Employment:					
Mine [1]	76	70	70	70	70
Smelter [1]	265	250	250	250	250
Net import reliance [3] as a percent of apparent consumption	69	72	72	70	70

[1] Estimate.
[2] Includes nickel produced from materials imported after 1974.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* Production of secondary nickel from old and prompt industrial scrap was estimated at 50,000 tons in 1977 and accounted for 22 percent of the total nickel consumed. Of the scrap consumed, 45 percent was estimated as prompt industrial and 55 percent as old.

4. *Import Sources (1973–76):* Canada 60 percent, Norway, New Caledonia, and the Dominican Republic, 7 percent each. Other 19 percent. Norway's raw material was nickel-copper matte of Canadian origin.

*Prepared by J. D. Corrick.

5. *Tariff:*

	Number	Rate of duty Jan. 1, 1978	Statutory
Nickel ore	601.36	Free	Free.
Nickel oxide	419.72	Free	Free.
Ferronickel	607.25	Free	3¢/lb.
Unwrought nickel	620.03	Free	3¢/lb.
Waste and scrap	620.04	Free	3¢/lb.
Nickel powders	620.32	Free	3¢/lb.
Other	603.60	Free	Free.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* Research was continued on a process being developed by the Bureau of Mines for economically extracting nickel and cobalt from the Oregon-California laterites. The Bureau of Mines also conducted research on the extraction of nickel from the Duluth gabbro in Minnesota, the recovery of nickel and associated metals from the ocean nodules, the extraction of nickel and cobalt from Missouri lead ores, and the recovery of nickel and chromium from stainless steel wastes.

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Nickel	204,335			

8. *Events, Trends, and Issues:* Domestic nickel consumption during 1977 remained at approximately the same level as that of 1976. In February 1977 consumer-held stocks of nickel reached their highest level since 1975; however, by yearend these stocks were being worked down. Consumption of ferronickel and nickel oxide during 1977 was greater than during 1976 and reflected an increased demand for stainless and heat resisting steels over that experienced during 1976.

Demand for nickel is expected to increase at an annual rate of about 3 percent through 1985. Domestic mine production of nickel should remain at the level of the past 5 years and supply approximately 8 percent of the primary nickel consumed.

A 1,710-foot test shaft into the Duluth gabbro of Minnesota was completed in 1977. The exploration company began recovering a portion of what will ultimately be a 20,000-ton sample to be used in metallurgical tests. The sixth session of the Law-of-the-Sea Conference was held during 1977 and again failed to reach an accord on critical deep-seabed mining issues. Although the price of nickel was increased from $2.20 per pound to $2.41 per pound as of October 1, 1976, it never really took effect. The price increase was rescinded to its former level of $2.20 per pound on July 25, 1977.

The only really serious potential environmental problem in mining and processing nickel sulfides stems from the sulfur dioxide that is released in smelting sulfide ores. Modern plants recover a large part of the sulfur and use it to produce sulfuric acid.

9. *World Mine Production and Reserves:*

	Mine production 1976	Mine production 1977 [1]	Reserves Quantity	Reserves Grade of ore (percent)
United States	16,469	17,000	200,000	0.8–1.3
Canada	289,348	250,000	8,600,000	1.5–3
New Caledonia	117,506	112,500	15,000,000	1–3
Other market economy countries	256,014	220,000	28,000,000	.2–4.0
Cuba [1]	40,800	40,800	3,400,000	1.4
Other central economy countries	166,200	160,000	4,800,000	.4–4.0
World total	886,337	800,300	60,000,000	

[1] Estimate.

10. *World Resources:* Identified world resources in deposits averaging approximately 1 percent nickel or greater are 143 million tons of nickel. Of this, 80 percent (115 million tons) are in laterites and 20 percent (28 million tons) are in sulfide deposits. World resources from lower grade nickel deposits are very large. The United States, for example, has sulfide deposits containing more than 7 billion tons of material averaging 0.2 percent nickel; peridotites and serpentinites containing 0.2 to 0.4 percent nickel are widely distributed throughout the world. In addition, there are very extensive deep-sea resources of nickel in the form of manganese nodules covering large areas of ocean floors, particularly in the Pacflic Ocean.

11. *Substitutes and Alternates:* With few exceptions, substitutes for nickel would require increased cost or some sacrifice in the physical or chemical characteristics and hence affect the economy or performance of the product. Potential nickel substitutes include aluminum, coated steel, and plastics in the construction and transportation industries; nickel-free specialty steels in power, petrochemical, and petroleum industries; titanium and plastics in severe corrosion service applications; cobalt as an underplate for chromium in decorative plating; platinum, cobalt, and copper in some catalytic uses.

PHOSPHATE ROCK*

[Data in thousand short tons, unless noted]

1. *Domestic Production and Use:* Marketable phosphate rock was produced by 25 companies and the estimated value was $770 million. Nine companies produced 81 percent of the total U.S. production from mines in Florida. The percent distribution pattern by State was: Florida and North Carolina, 85; California, Idaho, Missouri, Montana, Utah, and Wyoming, 11; and Tennessee, 4. The principal markets for phosphate rock were fertilizers and animal feed supplements, 65 percent; industrial and food grade products, 11 percent; and 24 percent was exported.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977[1]
Production: Marketable	42,137	45,686	48,816	49,241	49,000
Imports for consumption	65	182	36	51	350
Exports	13,875	13,897	12,272	10,400	14,500
Apparent consumption	31,233	34,720	34,203	34,328	36,700
Value: Average per short ton, f.o.b. mine[2]	$5.66	$10.98	$22.99	$19.28	$15.00
Stocks yearend	8,482	6,975	9,946	15,182	14,000
Employment (mine and beneficiation plant)	4,300	4,500	5,000	5,000	5,000
Net import reliance[3] as a percent of apparent consumption	(4)	(4)	(4)	(4)	(4)

[1] Estimate.
[2] Marketable phosphate rock.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.
[4] Net exports.

3. *Recycling:* No significant quantity is recycled.

4. *Import Sources (1973–76):* Netherlands Antilles 60 percent, Mexico 14 percent, Spanish Sahara 13 percent, Israel 7 percent. Other 6 percent.

5. *Tariff:*

Item	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Phosphates, crude and apatite	480.5	Free	Free

6. *Depletion Allowance:* 14 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* Final environmental impact statements on the effects of mining phosphate rock in the Los Padres, Caribou, and Osceola National Forests were completed by Government task forces. The U.S. Geological Survey completed a hydrogeological investigation of the Osceola National Forest and Environs with the assistance of the Fish and Wildlife Service and in consultation with the Bureau of Mines, Bureau of Land Management and Forest

*Prepared by W. F. Stowasser.

Service. The Central Florida Phosphate Environmental Impact Statement is scheduled for completion in the first quarter of 1978. Evaluation of the phosphate deposits in Florida, eastern Georgia, South Carolina, North Carolina, and Tennessee for the Bureau of Mines Minerals Availability System were started during 1977.

The Bureau of Mines Metallurgy Research Center conducted programs to improve the recovery of phosphate minerals from central Florida matrix and develop beneficiation procedures to recover acceptable concentrates from mixtures of phosphate matrix and dolomitic gangue. Direct digestion of Florida matrix to produce phosphoric acid continued with achievements in simplification of process and improved filtration rates. A program to classify washer slimes followed by recovery of product from the coarse fraction and dewatering the colloidal fraction has been designed and started by the Bureau of Mines.

The Bureau of Mines is updating Information Circular 8653, Economic Significance of the Florida Phosphate Industry, for publication in 1978.

8. *Events, Trends, and Issues:* The selling prices of all grades of phosphate rock declined in both world markets and in domestic sales. More than adequate supplies were available throughout the year to meet a much improved demand compared with that of 1976. Stocks of phosphate rock in Florida and North Carolina were maintained in excess of 12 million tons, sufficient for 3 to 4 months production. The capacity of the plants in Florida and North Carolina was approximately 50 million tons per year in 1977 compared with about 44 million tons per year in 1976. The industry in Florida and North Carolina was expected to operate at about 85% of capacity. Production in Tennessee was similar to that in 1976, however, production in the Western States was curtailed by power shortages and a weakening demand for phosphates in detergents. The export market for phosphate rock markedly improved from a level of 11 million tons per year in 1976 to over 14 million tons per year in 1977.

The f.o.b. mine value of phosphate rock per short ton from Florida and North Carolina is summarized by grade for the domestic and export markets in the following tabulation for the first 6 months of 1977. The average f.o.b. mine value of Florida and North Carolina phosphate rock was $15.53 per short ton for the first 6 months of 1977.

	1960–66 BPL	1966–70 BPL	1970–72 BPL	1972–74 BPL	1974 BPL and over
Domestic	$16.27	$12.87	$15.78	$22.32	$16.54
Export	15.04	18.36	19.01	19.17	24.76

The average value reported for less than 60 BPL and 60 to 66 BPL grades in Tennessee was $7.33 per short ton and it was consumed in Tennessee electric furnaces. The average f.o.b. mine value of Western States furnace grade, less than 60 and 60 to 66 BPL, was $7.29 per short ton and the f.o.b. value of acid grade rock, 66 to 74 BPL for domestic consumption and export, was $21.47 per short ton.

A U.S. company contracted with the Office Cherifien des Phosphates (OCP), Morocco, to import Khouribga rock for its Louisiana fertilizer plant. The first shipment was made in July 1977. OCP has also contracted to begin shipments to the U.S.S.R.

Demand for phosphate rock is expected to increase at an annual rate of 2.3 percent through 1985. The industry, unless restricted by leasing policies on Federal land or by regulations that inhibit expansion on private land, should be capable of meeting both domestic and export commitments through 1985. State and Federal regulations are being met to assure that the industry maintains air and water quality standards and land reclamation programs are implemented.

9. *World Mine Production and Reserves:* [2]

	Production		Measured reserves
	1976	1977 [1]	
United States	49,241	49,000	3,800,000
Australia	274	1,000	1,000,000
Morocco	16,857	17,000	18,000,000
Senegal	1,980	2,000	130,000
South Africa, Republic of	1,807	2,000	3,000,000
Western Sahara	190		400,000
Togo	2,279	2,300	50,000
Tunisia	3,631	3,700	300,000
Other market economy countries	8,916	9,000	900,000
Central economy countries	32,573	33,100	900,000
World total	[1] 117,748	119,100	28,480,000

[1] Estimate.

10. *World Resources:* Most of the United States and world resources are widely distributed marine phosphorite deposits. Identified and undiscovered resources in the world are estimated to contain tens of billions of tons of contained phosphorus. Identified resources in Morocco and the Western Sahara are estimated to be as much as three times present reserves. Phosphate rock contains fluorine, and some deposits contain economically recoverable quantities of vanadium, uranium, and rare earths.

11. *Substitutes and Alternates:* There are no substitutes for phosphorus in agriculture. Substitutes for phosphate detergents are being developed.

PLATINUM-GROUP METALS (PLATINUM, PALLADIUM, IRIDIUM, OSMIUM, RHODIUM, RUTHENIUM)*

[Data in thousand troy ounces, unless noted]

1. *Domestic Production and Use:* Domestic primary metals were obtained as byproducts of copper refining by three firms; production was valued at $750,000. Secondary metal was refined by about 35 firms, mostly in the East and Midwest. The platinum-group metals were sold by at least 90 processors and retailers, largely in the Northeast, and were distributed among using industries as follows: Automotive, 45 percent; chemical, 15 percent; electrical, 15 percent; and other, 25 percent. The automotive, chemical, and petroleum refining industries used the platinum-group metals mainly as catalysts; other industries used the metals in a variety of ways that took advantage of their chemical inertness and refractoriness.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production:					
Mine	20	13	19	6	5
Refinery:					
New	20	13	17	7	5
Secondary	266	325	270	215	200
Imports for consumption	2,503	3,241	1,820	2,667	2,560
Exports	628	836	660	512	400
Shipments from Government stockpile excesses	.2				
Consumption (reported sales to industry)	1,831	1,981	1,310	1,603	1,650
Apparent consumption	2,150	2,640	1,725	2,140	2,330
Price (dollars per ounce): [2]					
Platinum (average)	150	181	164	162	162
Palladium (average)	78	133	93	51	60
Stocks, yearend (refiner, importer, and dealer)	1,033	1,137	849	1,086	1,000
Employment: Refinery [1]	350	350	350	350	350
Net import reliance [3] as a percent of apparent consumption	87	87	83	90	92

[1] Estimate.
[2] Producer price.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

[2] Marketable phosphate rock.
*Prepared by J. H. Jolly.

3. *Recycling:* In 1977, about 200,000 ounces of platinum-group metals were refined from scrap, an amount equivalent to 12 percent of sales to industry. The quantity of toll-refined secondary was much larger, amounting to more than 1 million ounces.

4. *Import Sources (1973–76):* Republic of South Africa 33 percent, U.S.S.R. 29 percent, United Kingdom 23 percent, Other 15 percent.

5. *Tariff:*

Item	Number	Rate of duty	
		Jan. 1, 1978	Statutory
Ore	601.39	Free	Free.
Unwrought:			
Platinum-group metals	605.02	Free	Free.
Alloys	605.03	20% ad valorem	65% ad valorem.
Semimanufactured:			
Platinum-group metals	605.07	Free	Free.
Alloys	605.08	20% ad valorem	65% ad valorem.
Scrap	605.70	Free	Free.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* The Bureau of Mines conducted research on the processing of domestic ores, on recovery from electronic scrap, on electrodeposition of thick platinum coatings, and on chemical vapor deposition of platinum.

STOCKPILE STATUS, NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Platinum	1,314	453		
Palladium	2,450	1,255		
Iridium	97.76	17		

8. *Events, Trends, and Issues:* Sales of platinum-group metals to U.S. industries rose 3 percent in 1977 to about 1.65 million ounces. Use as catalysts in automobile exhaust converters was again the largest single end use. Total demand in the U.S. is expected to increase at an annual rate of about 5 percent through 1985.

Imports, which account for essentially all of the annual U.S. requirement for primary platinum-group metals, fell 4 percent in 1977, to about 2.6 million ounces. The Republic of South Africa was the most important source, followed by the U.S.S.R., and the United Kingdom, which imports most of its source materials from South Africa.

World production of the platinum-group metals rose about 7 percent to an estimated 6.4 million ounces in 1977. Although production in South Africa increased in 1977, output was cut back in November owing to large metal inventories and weak demand for platinum in Japan, the world's largest user of the metal. Canadian and U.S. platinum-group metal outputs were lower because of reduced copper and/or nickel production.

Indications are that there will be no reductions in the use of platinum-group metals in automobile emission catalysts through 1980. Congress amended the Clean Air Act in August 1977, extending 1977 automobile emission standards through model year 1979 with more severe standards for 1980 and 1981. The 3-way catalytic converter which uses rhodium and platinum appears likely to be the prime device for achieving the 1981 standards. Sufficient rhodium may not be available for automotive use unless the 3-way converter can be developed to the point where it uses rhodium and platinum in the same ratio as produced from South African ores. Substantial progress toward the development of successful converters having the desired 1 to 18 rhodium to platinum ratio was reported in 1977.

Although the United States has sizable resources of the platinum-group metals, they are undeveloped, poorly defined, and mostly subeconomic at current prices. Exploration and evaluation of the Stillwater Complex, Montana, where most of the U.S. platinum-group resources are located continued, but no decisions toward production have been made. Although these deposits might be developed, it is unlikely that domestic production will ever satisfy domestic demand. Environmental constraints on domestic production, byproducts of copper mining, are those associated with copper production.

9. *World Mine Production and Reserves:*

	Mine production		
	1976	1977 [1]	Reserves
United States	6	5	1,000
Canada	430	400	10,000
Colombia	22	20	1,000
South Africa, Republic of	2,720	3,000	400,000
Other market economy countries	25	25	(2)
U.S.S.R.	2,800	2,950	150,000
World total	6,003	6,400	562,000

[1] Estimate.
[2] Not available.

10. *World Resources:* Present estimates of world resources of the platinum-group metals range from about 1,100 to 1,800 million troy ounces, that is, 2 to 3 times the estimated reserves, and 5 to 9 times the forecast demand for primary metal in the period 1977–2000. Total U.S. resources are estimated at about 300 million troy ounces.

11. *Substitutes and Alternates:* Potential substitutes: Gold, silver, and tungsten in electrical/electronic uses; gold in dental uses; metals, such as the rare-earth elements, iron, nickel, vanadium, and titanium, and molecular sieves in catalytic uses. Now and/or improved engines and fuels are possible alternates that could eliminate the use of emission control catalysts in automobiles.

SILVER*

[Data in million troy ounces of metal, unless noted]

1. *Domestic Production and Use:* Domestic production from more than 225 mines was from Idaho, 40 percent; Arizona, 18 percent; Colorado, 12 percent; Utah, Montana, and Missouri, 24 percent; and other 6 percent. Estimated value of production in 1977 was $172 million. About 66 percent of primary supply was a byproduct of copper, lead, and zinc mining. Seven firms supplied an estimated 63 percent of total mine production. There are 24 principal refiners of commercial grade silver, of which four are primary smelters and one a Government refiner, the U.S. Assay Office in New York City. The majority of these installations are located in the Northeastern Seaboard States. Fabricating and manufacturing firms are estimated to number over 5,000. The photographic industry is located primarily in New York State, and most other end-use manufacturing firms are mainly in Connecticut, New York, Rhode Island, and New Jersey. End-use categories of an estimated 165 million ounces of silver consumed in 1977 were: Photography, 34 percent; sterlingware and electroplated ware, 14 percent; electrical and electronic components, 24 percent; brazing alloys and solders, 9 percent; and other 19 percent.

*Prepared by Harold J. Drake.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production:					
Mine	37.5	33.8	34.9	34.3	37.4
Refinery:					
New	75.4	63.3	63.4	54.4	53.0
Secondary (old scrap)	34.6	54.1	49.6	50.2	53.0
General imports [2]	130.7	133.4	90.4	88.4	95.0
Exports [2]	11.2	18.4	32.6	14.6	17.0
Shipments from Government stocks (Treasury)	None	None	None	None	None
Consumption:					
Industrial	195.9	177.0	157.7	170.6	165.0
Coinage	.9	1.0	2.7	1.3	.1
Consumption, apparent	214.3	196.4	120.1	170.2	165.0
Price, average New York: Cents per troy ounce	255.8	471.9	441.8	435.4	460.0
Stocks, yearend: Treasury [3]	45.0	44.0	41.0	39.7	39.0
Stocks, yearend: Industry, COMEX, CBOT [4]	130.1	136.5	159.4	146.4	160.0
Employment: Mine and mill [1]	1,050	1,350	1,250	1,450	1,450
Net import reliance [5] as a percent of apparent consumption	66	55	30	50	42

[1] Estimate.
[2] Excludes coinage.
[3] Balance in Mint only.
[4] Industry: Refiner, fabricator, and dealer. COMEX: New York Commodity Exchange. CBOT: Chicago Board of Trade.
[5] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* Old scrap recycled in 1977 was estimated at 53.0 million ounces, 32 percent of total consumption.

4. *Import Sources (1973–76):* Canada 33 percent, Mexico 30 percent, Peru 13 percent, United Kingdom 9 percent, Other 15 percent.

5. *Tariff:* No duties are imposed on imports of unrefined silver or bullion.

Item	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Platinum-gold plated silver	605.45–605.47	16–25% ad valorem.	65% ad valorem.
Rolled-semimanufactured silver	605.60–605.66	12–20% ad valorem.	30–65% ad valorem.
Silver compounds	420.60	5% ad valorem	25% ad valorem.

6. *Depletion Allowance:* 15 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* Bureau of Mines research has investigated new flotation techniques for higher recovery from ore, heap-leach cyanidation and associated carbon precipitation, and carbon-in-pulp cyanidation for the treatment of slimes.

STOCKPILE STATUS, NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Silver		139.5		

8. *Events, Trends, and Issues:* U.S. mine production of silver was up about 9 percent from that of 1976. Byproduct silver recovery decreased due to reduced production of silver-containing base metal ores, primarily a result of strikes. Silver output in Idaho, which accounted for about 40 percent of U.S. production, was 31 percent above that of the preceding year, as two newly opened silver mines operated at near capacity during most of 1977.

Industrial consumption fell 3 percent from the previous year. Imports rose 7 percent and exports 16 percent. Industry and Commodity Exchange stocks rose 9 percent, whereas Treasury stocks declined 2 percent. The average monthly price of silver rose in the early part of the year and reached a daily high of 496.0 cents per troy ounce on March 21 before declining. The decline in monthly averages continued until September at which time the price began to climb and finished the year on an upward trend. The low for 1977, 432.3, occurred on June 13. The average price for the year was 460.0 cents per troy ounce, up 24.6 cents from 1976.

Demand for silver is expected to rise at an average annual rate of approximately 2 percent through 1985. U.S. demand in 1977 was about 4 times domestic mine production and about 53 percent of world production. The U.S. deficit was met by secondary recovery, existing stocks, imports, and coin melting. In the United States, there will be increased reliance on imports, secondary recovery, and withdrawal from existing stocks.

The operation of base metal smelters has been limited by reduced demand and Environmental Protection Agency imposed limitations on the emission of toxic compounds into the atmosphere. The treatment of waste generated in the processing and separation of silver from base metals has also required the addition of controls to protect ground water and stream.

9. *World Mine Production and Reserves:*

	Mine production		
	1976	1977[1]	Reserves[2]
United States	34.3	37.4	1,510
Canada	40.9	42.0	710
Mexico	42.6	45.0	850
Peru	35.6	40.0	610
Other market economy countries	87.2	90.0	420
Central economy countries[1]	64.3	64.0	2,000
World total	304.9	318.4	6,100

[1] Estimate.
[2] Includes silver recoverable as a byproduct of base-metal ores.

10. *World Resources:* Resources, about 3 times greater than reserves, will become increasingly available at higher market prices, principally from presently marginal silver deposits and undiscovered resource deposits. If the price of silver increases sharply, some low grade copper deposits which contain silver and are not presently mined, may be brought into production. However, it is recognized that some of the silver in porphyry copper deposits may not be recoverable should the copper be recovered by leaching deposits on site, rather than by conventional milling.

11. *Substitutes and Alternates:* Aluminum and rhodium substitute for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware.

TITANIUM* [1]

[Data in short tons of metal, unless noted]

1. *Domestic Production and Use:* Sponge metal was produced by three firms in plants in Ohio, Oregon, and Nevada with more than 60 percent of the production in Nevada. Ingot was made by the three sponge makers and by five other firms located in California, Michigan, North Carolina, and Pennsylvania. Twenty-one companies produced titanium mill products with 14 of them being located in the east-central region and the others in California, Oregon, and Nevada. In 1977, about 60 percent of the titanium metal was used in jet engines, airframes, and space and missile applications. The remainder was used in the chemical processing industry, power generation, in marine and ordnance applications, and in steel and other alloys.

*Prepared by L. E. Lynd.
[1] See also Ilmenite and Rutile.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production	(2)	(2)	(2)	(2)	(2)
Imports for consumption, sponge	5,172	6,963	4,190	1,778	2,700
Exports (mainly scrap)	4,142	4,730	4,326	6,144	3,500
Shipments from Government stockpile excesses	1,256	2,485	672		
Consumption of primary metal, reported [3]	20,173	26,896	17,626	13,315	16,000
Price: Per pound, yearend	$1.42	$2.25	$2.70	$2.70	$2.98
Stocks: Industry, yearend	1,941	3,822	5,669	3,617	4,000
Employment: Reduction plants	950	950	900	800	850
Net import reliance [4] as a percent of apparent consumption	(2)	(2)	(2)	(2)	(2)

[1] Estimate.
[2] Withheld to avoid disclosing individual company confidential data.
[3] See also ilmenite and rutile.
Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* New scrap recycled was 12,000 short tons in 1977, including estimated use of scrap by the steel industry, 1,200 short tons; by the aluminum industry, 450 short tons; and in miscellaneous alloying uses, 400 short tons. Virtually no old scrap was reclaimed.

4. *Import Sources (1973–76):* Japan 52 percent, U.S.S.R. 37 percent, United Kingdom 11 percent.

5. *Tariff:*

Item	Number	Rate of duty Jan. 1, 1978	Rate of duty Statutory
Unwrought, waste and scrap [1]	629.15	18% ad valorem	25% ad valorem.
Wrought	629.20	18% ad valorem	45% ad valorem.

[1] The suspension of duty on waste and scrap was extended until June 30, 1978, as provided by Public Law 94–89.

6. *Depletion Allowance:* Not applicable.

7. *Government Programs:*

STOCKPILE STATUS, NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Specification sponge	131,503	27,853		

Note: In addition to data shown, the stockpile contains 4,476 tons of nonstockpile grade material.

8. *Events, Trends, and Issues:* Production of titanium sponge increased 42 percent from that in 1976, with a slight reduction in inventories. Production for industrial use continued active. Demand for titanium sponge is expected to increase at an annual rate of about 3 percent through 1985. Industrial uses, as contrasted with aerospace uses, are increasing their share of titanium consumption, although at a slow rate.

The cause of an explosion in October 1977 which severely damaged a sponge reduction plant in Oregon was being investigated. Several months may be required to repair the damage and resume full output.

Production of titanium metal involves reaction of rutile with chlorine to manufacture the intermediate compound titanium tetrachloride, which is then reducted to titanium metal by high temperature reaction with magnesium or sodium metal. Care must be taken in both of these manufacturing steps to follow well established procedures for safe handling of these potentially hazardous materials to avoid damage to the environment.

9. *Sponge Metal Production and Capacity:*

	Production		Capacity [1]
	1976	1977 [1]	
United States	(²)	(²)	21,000
Japan	6,995	7,000	12,400
Other market economy countries [1]	2,100	2,400	4,000
Central economy countries	NA	NA	35,000
World total	[3] 9,095	[3] 9,400	72,400

[1] Estimate.
[2] Withheld to avoid disclosing individual company confidential data.
[3] Does not include central economy countries or United States.

10. *World Resources:* The source of titanium for domestic sponge production is rutile (see Rutile). The U.S.S.R. uses a high grade titaniferous slag.

11. *Substitutes and Alternates:* For aircraft and space uses there is essentially no substitute for titanium. For industrial uses high-nickel steel and to a limited extent the superalloy metals may be substituted.

TUNGSTEN*

[Data in thousand pounds tungsten content, unless noted]

1. *Domestic Production and Use:* In 1977, approximately 90 percent of the total domestic tungsten concentrate production, estimated at $62 million, came from two mines in California and Colorado. Both of these mining operations recovered metals other than tungsten. Estimated production, as measured by domestic mine shipments, increased about 19 percent during the year. Reported consumption, which increased 7 percent, was primarily in the region between New York and Chicago. End uses of tungsten were metalworking and construction machinery, 74 percent; transportation, 11 percent; lamps and lighting, 7 percent; electrical, 4 percent; other, 4 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production (mine shipments)	7,059	7,836	5,490	5,869	7,000
General imports (in concentrate)	11,047	11,786	6,908	5,802	6,300
Exports (in concentrate) [1]	90	1,187	1,316	1,729	1,700
Shipments from Government stockpile excesses	1,269	6,399	2,970	4,003	2,100
Consumption:					
Reported	15,386	16,298	14,012	16,107	15,140
Apparent	22,082	22,977	13,398	17,211	15,555
Price: Average c.i.f. U.S. ports, duty paid, per short ton unit of WO_3 [2]	$44.22	$83.93	$87.16	$107.65	$157.23
Stocks: Producer and consumer, yearend	1,671	2,094	2,489	1,152	1,678
Employment: Mine and mill	535	540	525	540	600
Net import reliance [3] as a percent of apparent consumption	66	68	55	54	38

[1] Estimate.
[2] A short ton unit (stu) of tungsten trioxide (WO_3) contains 15.86 pounds of tungsten.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* During 1977 the quantity of purchased scrap, as reported to the Bureau of Mines, represented 16 percent of reported consumption or almost 2.8 million pounds.

4. *Import Sources (1973–76):* Canada 23 percent, Bolivia 17 percent, Peru 12 percent, Thailand 11 percent, other 37 percent.

5. *Tariff:*

	Number	Rate of duty	
		Jan. 1, 1978	Statutory
Ore and concentrate	601.54	25¢/lb. W cont.	50¢/lb. W cont.
Ferrotungsten	607.65	21¢/lb. W+6% ad valorem	60¢/lb. W+25% ad valorem.

*Prepared by B. A. Kornhauser.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:* The General Services Administration continued to offer excess tungsten concentrate of stockpile grade for disposal at a rate of 6 million pounds per year. The Bureau of Mines continued to conduct research on methods to recover tungsten from brines. The Department of Commerce reviewed and conducted hearings on tungsten materials with respect to tariff reductions in the Multilateral Trade Negotiations.

STOCKPILE STATUS NOV. 30, 1977

Materials	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Tungsten:				
Ore and concentrate	8, 823	64, 072	23, 298	3, 360
Metal powder	3, 290	1, 765		
Ferro	17, 769	2, 025		
Carbide powder	12, 845	2, 033		

Note: In addition to the data shown, the stockpile contains 39,000,000 pounds of tungsten in non-stockpile-grade tungsten concentrate, also authorized for disposal.

8. *Events, Trends, and Issues*: Estimated world production and consumption of tungsten in concentrate increased about 8 percent and 10 percent, respectively, compared with 1976, as demand for tungsten carbide in cutting and wear-resisting (including hard surfacing) materials increased substantially following the U.S. trend. The average price of tungsten concentrate, excluding duty, rose during 1977 from $136 to about $152/stu.

U.S. demand for tungsten in concentrate is expected to increase at an average rate of about 6 percent through 1985. A major domestic tungsten mining company dedicated a new tungsten mine in southern Nevada which could increase U.S. production by as much as 25 percent when full-scale operations begin in 1978. Specific problems restricting full development of domestic resources include: Economic beneficiation and recovery of tungsten from low-grade ores, environmental considerations, high labor costs, and high investment costs for plant and equipment. The National Institute for Occupational Safety and Health has recommended standards for the levels of cobalt and nickel used in cemented tungsten carbides at the manufacturing facilities.

Tungsten contained in extremely low-grade domestic resources such as the Searles Lake, Calif. brines, and metal values in sludges and scrap could provide much of the supply required to meet forecast demand. Unless economic methods of recovering tungsten from these low-grade sources are developed, greater imports of tungsten concentrate will be required.

9. *World Mine Production and Reserves*:

	Mine production		
	1976	1977 [1]	Reserves [1]
United States (mine shipments)	5, 869	7, 000	[4] 275, 000
Australia	5, 379	6, 400	76, 000
Bolivia	6, 700	7, 000	88, 000
Brazil	2, 650	2, 650	92, 000
Canada (mine shipments)	3, 530	3, 650	540, 000
Korea, Republic of	5, 655	5, 940	100, 000
Portugal	2, 813	3, 200	22, 000
Thailand	4, 180	4, 800	40, 000
Other market economy countries	10, 752	11, 500	62, 000
Central economy countries	42, 315	42, 500	2, 700, 000
World total	89, 843	94, 640	4, 000, 000

[1] Estimate.
[4] Includes 100,000,000 lb of contained tungsten in numerous properties that are inactive, that have small intermittent production, or that are currently being explored and developed.

10. *World Resources:* More than 90 percent of the world's estimated tungsten resources are located outside the United States, with almost 60 percent located in southeastern China. Other areas with significant resource potential are in Canada, North Korea, South Korea, South America, Burma, Thailand, Australia, and the U.S.S.R. U.S. tungsten resources are conservatively estimated at about

three times the reserves. These potential U.S. resources include numerous identified subeconomic deposits. Searles Lake, Calif. brines, and possible byproduct production from large scale mining operations for other commodities, especially molybdenum.

11. *Substitutes and Alternates:* Titanium carbide, tantalum carbide, and columbium carbide can be substituted for tungsten in some wear-resisting applications. Also, molybdenum is being substituted for tungsten in tool steels. In many cutting tool applications, depending on factors such as material, feed speed, and depth of cut, some economical substitutes for tungsten carbide are bulk ceramics and coatings of carbides, nitrides, carbonitrides, and alumina on tungsten carbide inserts.

VANADIUM*

[Data in thousand pounds of contained vanadium, unless noted]

1. *Domestic Production and Use:* Three firms produced vanadium oxides in 1977 from domestic materials: Colorado Plateau uranium-vanadium ores, Arkansas vanadium ore, and Idaho ferrophosphorus. Production was valued at an estimated $67 million. The chief use of vanadium is as an alloying agent for steel and iron, to which it is usually added in the form of ferrovanadium or proprietary vanadium-carbon-iron products. Vanadium also is important in vanadium-aluminum master alloys prepared for additions in producing titanium-based alloys. About 285 firms throughout the United States reported industrial consumption in 1977. Major end use distribution: Transportation, 29 percent; machinery, 29 percent; construction, 16 percent; and chemicals, 6 percent.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977 [1]
Production (recovered basis) [2]	9,728	10,736	9,718	12,394	12,400
Imports for consumption:					
Ores, slags, residues	5,274	4,970	5,790	5,996	6,500
Vanadium pentoxide (anhydride)		1,066	2,408	1,224	612
Ferrovanadium	393	288	273	518	1,036
Exports:					
Oxides and vanadates	464	406	430	198	200
Ferrovanadium	1,416	1,335	1,018	1,210	605
Shipments from Government stockpile excesses	3,138	1,185	198		
Consumption (intermediate products), reported	12,786	14,400	11,002	9,440	11,000
Consumption, apparent [3]	17,098	16,906	15,716	19,558	19,739
Price (average, per pound V_2O_5)	$1.50	$2.12	$2.76	$2.90	$3.05
Stocks: Industry, yearend	8,212	7,808	9,032	8,196	8,200
Employment	(4)	(4)	(4)	(4)	(4)
Net import reliance [5] as a percent of apparent consumption	43	36	38	37	37

[1] Estimate.
[2] Previously reported on a recoverable basis.
[3] Includes processing losses from low-grade imports.
[4] Not available.
[5] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes.

3. *Recycling:* Relatively small quantities of spent catalysts containing vanadium are reprocessed. Some vanadium is recycled as a minor component of scrap iron and steel alloys, which are used primarily for their iron content.

4. *Import Sources (1973–76):* South Africa 56 percent, Chile 27 percent, U.S.S.R. 9 percent, Other 8 percent.

5. *Tariff:*

Item	Number	Rate of duty: Jan. 1, 1978	Rate of duty: Statutory
Ore and concentrate	601.6000	Free	Free.
Metal	632.5800	5% ad valorem	25% ad valorem.
Ferrovanadium	607.7000	6% ad valorem	25% ad valorem.
Vanadium carbide	422.5800	6% ad valorem	25% ad valorem.
Vanadium pentoxide (anhydride)	422.6000	16% ad valorem	40% ad valorem.
Vanadium compounds, other	422.6200	16% ad valorem	40% ad valorem.
Vanadium-bearing materials (slags, etc.)	603.6510	Free	Free.

*Prepared by G. N. Broderick.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).

7. *Government Programs:*

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Vanadium pentoxide	5,152	1,080		
Ferrovanadium	20,190			

8. *Events, Trends, and Issues:* Reported domestic consumption of vanadium, with the largest market being the steel industry, increased in 1977. Demand for vanadium in the United States is expected to increase at an annual rate of about 5 percent through 1985.

Accelerated interest in uranium production in the Colorado Plateau area has resulted in renewed interest in coproduct or byproduct vanadium production, with new operations announced or under consideration. Among these are a new uranium-vanadium processing facility expected to be onstream around 1979; reworking of two uranium-vanadium tailings piles with one to begin early in 1978 and the other in mid-1979; a uranium-vanadium milling facility to be located either in Colorado or Utah, with a target startup date set for early 1981; and a program to expand vanadium output at Moab, Utah.

Imports of cheaper foreign material will continue to meet a significant amount of primary domestic demand. Expanded operations in the Republic of South Africa and Finland along with additional U.S. capacity assure that large quantities of vanadium material will be available to meet increased world demand.

The vanadium industry has environmental problems with radon daughter exposure in underground uranium-vanadium mines, with disposal of wastes as ponded liquids and fine tailings, and with toxicity of certain vanadium materials. These are being met by modern technology.

A study to assess the applications of technological change and usage trends on the supply-demand balance of vanadium was undertaken by the National Materials Advisory Board, and a report thereon will be forthcoming in 1978. Greater diversity of applications are likely to occur as a result of the numerous research projects being sponsored by the Vanadium International Technical Committee (Vanitec), which has placed a major emphasis on the development of high performance steels having high strength and impact resistance.

9. *World Mine Production and Reserves:*

	Mine production		Reserves
	1976	1977 [1]	
United States (recovered basis)	12,394	12,400	230,000
Australia			300,000
Chile	2,398	1,900	300,000
South Africa, Republic of	21,770	22,000	4,000,000
Other Market Economy Countries	5,920	6,000	550,000
U.S.S.R	20,000	20,000	16,000,000
World total	62,482	62,300	[2] 21,400,000

[1] Estimate.
[2] Data may not add to total shown due to independent rounding.

10. *World Resources:* Total identified world resources of vanadium, which are estimated to be 62 million short tons of contained vanadium, are extensive compared with present world demand level. The major resources are contained in titaniferous magnetite and magnetite-ilmenite ores, including titaniferous iron sands; in phosphate rock or phosphatic shales; and in crude petroleum and tar sands. Most of the resources can only be recovered as a coproduct or byproduct.

11. *Substitutes and Alternates:* Steels containing various combinations of other alloying ingredients can be substituted for steels containing vanadium. Among the various metals that are interchangeable to some degree with vanadium are columbium, molybdenum, manganese, titanium, and tungsten. Platinum may be used as a substitute for vanadium compounds as a catalyst in some chemical processes. The costs of these materials influence their usage.

ZINC*

[Data in thousand short tons of metal, unless noted]

1. *Domestic Production and Use:* The value of mine production in 1977 based on the price of Prime Western metal was $318 million. The 25 leading mines accounted for 89 percent of the domestic recoverable mine production, with the leading five producing 41 percent. Major producing States were Tennessee, 20 percent, Missouri, 18 percent, New York, 16 percent, Colorado, 10 percent, and New Jersey, 7 percent. Pennsylvania, Texas, Idaho, Oklahoma, and Illinois accounted for all of the smelter production of primary slab zinc. Two primary and eleven secondary smelters produced slab zinc from scrap. About one-half of the consumption by approximately 600 firms was in Illinois, Indiana, Ohio, and Pennsylvania. Construction materials accounted for 40 percent of consumption: transportation equipment, 27 percent; electrical equipment, 12 percent; machinery and chemicals, 11 percent; and other, 10 percent. Of the zinc metal and concentrate consumed directly, galvanizing accounted for 35 percent of the total; zinc-base alloy, 33 percent; brass and bronze, 14 percent; zinc oxide, 12 percent; and other, 6 percent. Major coproducts and byproducts of zinc were lead, cadmium, silver, and copper.

2. *Salient Statistics—United States:*

	1973	1974	1975	1976	1977[1]
Production:					
Mine	479	500	469	485	463
Primary slab zinc	583	555	438	499	420
Secondary redistilled slab zinc	83	79	58	64	60
General imports:					
Ores and concentrates	200	240	145	97	100
Slab zinc	592	540	380	714	570
Exports: Slab zinc	15	19	7	4	1
Shipments from Government stockpile excesses	273	285	6	1	
Consumption (reported): Slab zinc	1,504	1,288	925	1,134	1,110
Apparent consumption (all forms)	1,582	1,404	1,416	1,399	1,251
Price: Average, cents per pound:					
United States zinc, metal, Prime Western	20.7	35.9	39.0	37.0	34.4
London, Prime Western equivalent	38.6	56.1	33.8	32.4	26.6
Stocks, yearend: Producer and consumer	140	251	182	215	160
Employment:					
Mine and mill[2]	6,700	6,700	6,700	6,700	6,600
Smelter	4,500	4,500	4,100	4,100	4,100
Net import reliance[3] as a percent of apparent consumption	64	59	61	59	58

[1] Estimate.
[2] Includes all zinc and/or lead-zinc producing units.
[3] Net import reliance equals imports minus exports plus adjustments for Government and industry stock changes

3. *Recycling:* In 1977, production of secondary slab zinc, at 60,000 tons, represented 5 percent of slab zinc consumption. In addition to zinc chemicals, about 31,000 tons of zinc dust and 15,000 tons of zinc oxide were produced from scrap zinc.

4. *Imports Sources (1973–76):* Ores and concentrates—Canada 57 percent, Mexico 15 percent, Honduras 10 percent, Other 18 percent. Metal—Canada 51 percent, Australia 6 percent, Belgium-Luxembourg 6 percent, Japan 5 percent, Other 32 percent.

5. *Tariff:*

Item	Number	Rate of duty (cents per pound) Jan. 1, 1978	Statutory
Ores and concentrates	602.20	[1] 0.67	1.67
Fume	603.50	.67	1.67
Metal	626.02	.7	1.75

[1] Duty on zinc ores, concentrates, and zinc-bearing materials suspended until June 30, 1978, as provided by Public Law 94–89.

*Prepared by V. A. Cammarota, Jr.

6. *Depletion Allowance:* 22 percent (Domestic), 14 percent (Foreign).
7. *Government Programs:*

STOCKPILE STATUS—NOV. 30, 1977

Material	Goal	Total inventory	Authorized for disposal	Sales, 11 mo
Zinc	1,313	374		

8. *Events, Trends, and Issues:* The U.S. zinc industry in 1977 was marked by production cutbacks, lower consumption, falling prices, and labor strikes. Several mine closures and strikes served to lower mine and smelter production. Producers announced cutbacks in smelter production rates to about 70 percent of capacity. Stocks of both consumers and producers fell during the year. Imports of metal declined 20 percent from the record high of 714,000 tons in 1976. Net imports of primary material supplied about three-fifths of primary consumption. Primary zinc demand in the United States is expected to increase at an annual rate of 2.6 percent through 1985.

Consumption of slab zinc declined 2 percent from that of 1976, while consumption of zinc-in-concentrate remained stable. The continued decline in the amount of zinc used in die castings by the automobile industry was an important factor in lowering consumption.

The U.S. zinc price of 37 cents per pound in January 1977 was revised downward several times during the year due to excess stocks and weak demand. The price fell in May by 3 cents, in October by 2 to 3 cents, and again in November by 0.5 to 1.5 cents. By yearend the price for Prime Western zinc was 30.5 cents per pound. The European producer price was reduced to 27.2 cents per pound. On the London Metal Exchange prices generally declined throughout the year to less than 25 cents per pound by yearend.

Construction of a 90,000-ton-per-year electrolytic zinc plant in Tennessee continued with completion expected by the end of 1978.

The Commodity Futures Trading Commission approved trading of zinc futures contracts on the Commodity Exchange Inc. of New York.

Zinc is mined by underground methods and while tailings and mine water do present disposal problems they do not seem to represent major obstacles. In many instances the mine tailings are sold as crushed rock and agricultural limestone. Sulfur dioxide emission standards promulgated by the Environmental Protection Agency would lead to increased capital and operating costs for zinc smelters, if implemented.

9. *World Mine Production and Reserves:*

	Mine production		Reserves
	1976	1977[1]	
United States	485	462	30,000
Australia	512	530	13,000
Canada	1,313	1,400	37,000
Mexico	286	280	3,500
Peru	436	530	9,500
Other market economy countries	1,815	2,000	59,000
Central economy countries	1,615	1,600	23,000
World total	6,462	6,803	175,000

[1] Estimate.

10. *World Resources:* Identified zinc resources of the world are estimated at about 2 billion short tons. Most known, readily available zinc resources are contained in such conventional-type deposits as those in stratabound carbonate formations and in massive-sulfide ore bodies. Available data on sphalerite-bearing coals in midcontinent United States suggest a resource potential of many millions of tons of zinc metal that could possibly be recovered as a byproduct of coal with limited modification of existing technology. Preliminary evaluations of

other areas imply that some of the Carboniferous-age coals on other continents may have similar zinc resources. Undiscovered (hypothetical and speculative) world zinc resources amount to another 2½ to 3 billion tons.

11. *Substitutes and Alternates:* Aluminum and magnesium are the major substitutes for zinc in die casting, although in some applications plastics are used. Plastic coatings, electroplated cadmium, and special steels can replace zinc in limited areas for corrosion protection, and aluminum alloys can be used in place of brass. Alternate materials such as aluminum, magnesium, titanium, and zirconium are significant competitors of zinc in chemicals and pigments.