MINISTRY OF ENERGY
Republic of the Philippines

INDUSTRIAL ENERGY PROFILES

- MINING
- CEMENT
- FISHING
- VEGETABLE AND COCONUT OIL
- TEXTILE

VOLUME I

USEFUL ENERGY

INHERENT LOSSES

VOLUME I

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MESSAGE

In aide of the Ministry's policy formulation exercises for energy demand management, this document comes out as a timely source of information particularly as we begin to expand our span of attention from mere provision of cost-effective energy alternatives towards ultimately the more-efficient utilization of energy fuels through improved industrial energy technology.

I, therefore, congratulate the Ministry's Planning Service for again breaking new ground in its continuing initiatives at generating reliable baseline data that constitute the necessary building blocks of sound policy legislation.

I trust that Executives as well as Energy Managers of firms engaged in these industry sectors will find in these volumes a useful and wealthy repository of energy-related industrial statistics and hopefully, be guided towards a more rational ethic of energy access.

GERONIMO Z. VELASCO
Minister of Energy

FOREWORD

Undertaken for the first time, the following volumes detail the energy consumption profiles of selected industry sectors in the economy, tracing the energy flows from the raw supply source to its embodied form in the final product. The cover design, appropriately baptized in the trade as the "spaghetti diagram", symbolizes the main output of this massive effort.

Inevitably, therefore, the document also delves into a discussion of the process technologies applicable in each particular industry and from there attempts projections of future energy options available to the industry. The main instrument used to gather data was a survey questionnaire and whenever possible the consolidated figures were cross-checked against aggregates available from secondary government sources. Thus, much of the work is to be acknowledged as submissions from the cooperating respondents themselves.

This work represents the second in a series of surveys, designed to continually upgrade the quality of baseline energy information in the country. It proceeds, albeit peripherally, to discuss financial implications of industrial energy inputs on the sector's total cost structure.

The Planning Service shares the conviction that there is no substitute for hard empirical statistics as the starting point of public policy deliberations. Only then can we begin to quantify the relevant social dividends of any given policy thrust. This 4-volume document was completed as an initial step in that direction.

PLANNING SERVICE
MINISTRY OF ENERGY

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ENERGY PROFILE OF THE MINING INDUSTRY

SUMMARY

Mining is a high-capital energy-intensive operation which employs a large number of men and machinery. Ninety-one percent (91%) of this industry's energy needs is used to run large motors, conveyors, heavy mill equipment and other mechanical drive applications. The rest of the energy consumption of the industry is used for heating, lighting, airconditioning and auxillary equipment.

Mining industry operations in the country can be separated into the mining phase and the milling phase. Both underground and open pit mining methods are utilized depending on the grade of ore recoverable. The underground method requires more energy both in bringing the mineral to the surface and in processing the rock since deeper deposits are usually harder and therefore require more energy in the milling phase (crushing and grinding operations).

The industry is dominated by copper production which accounts for half of the total value of production of the industry. In 1979, a total of 285 thousand metric tons (MMT) of copper were produced and exported in the form of copper concentrates. A large portion of gold and silver production also resulted from the production of copper since these precious metals are also found in copper rich ores and are recovered partly through the same process.

Energy Requirements

The total energy consumption of the industry for 1979 amounted to 5.1 million barrels-of-oil equivalent (MMBOE). Petroleum accounted for 77.5 percent of the total energy consumed while industry also purchased electricity which covered 18.3 percent of its energy requirements. The remaining 4.2 percent was supplied by coal. Eighty-two percent (82%) of petroleum consumption and almost all of coal consumption were used in generating electricity. The mining industry's consumption represents 8.4 percent of the total energy consumption of the entire industry sector.

Energy Losses

Roughly 72 percent of total primary energy inputs to the industry is lost to waste heat dissipated in energy conversion and utilization equipment both in and out of the plant. These losses, however, are mostly inherent to the state of technology used in the mining industry's equipment. Partial recovery of these losses may be achieved by totally or partially upgrading installed equipment in order to utilize the latest available advances in technology or by exercising better control of maintenance and utilization.

Energy Input Per Unit Weight

On account of the large range of ore grades found in nature, the amount of energy required to produce a unit weight of a particular mineral cannot be stated as a single figure. Energy consumption is closely related to the amount of ore mined and milled of which only a fraction of a percent up to several percent constitutes the desired mineral.

Given the country's average copper ore grade of 0.5 percent, the average energy required to produce copper concentrates is estimated at 16.4 BOE per MT of copper metal content. Additionally, the concentrates are subjected to further processes which extracts pure metal from the concentrate. A large amount of energy is additionally expended outside the country in these processes which include an energy-intensive smelting process.

On the other hand, gold production at an average ore grade of 6.2 grams per metric ton ore, requires 71 BOE/KG metal or

71,000 BOE/MT all of which are expended within the country.

Energy Costs

The mining industry is one of the largest foreign exchange earners in the country. Most of the industry's production is exported where copper is the dominant export item in terms of value and volume. In 1979, ₱3.3 billion of copper was exported while the cost of energy-in-copper export was valued at ₱710MM or 21.5 percent of revenue.

Total annual consumption of copper in the country is supplied by imports of the metal in various forms. The imported volume, however, is only around 2.5 percent of annual export volume. This industry, therefore mainly supplies the international market. The cost of crude oil inports used in the mining of mineral exports is roughly only 15 percent of the total value of the mining industry's exports. This low figure stems from the high value of gold and silver contained in copper concentrate exports.

Around sixty percent of the industry's energy requirements is provided by the lower-priced less-taxed petroleum product-fuel oil. The energy cost per barrel-of-oil equivalent is therefore one of the lowest among the various industries. This cost advantage is even expected to improve as the industry turns more and more to coal for powering their electric generating units.

BACKGROUND

The mining industry is characterized as both an equipment and labor intensive sector. The industry involves the excavation of the earth from which mineral products are extracted. The products are categorized into the following:

a) Precious metals like gold, silver, palladium and platinum.

b) Base metals like copper, lead, zinc, chromite, manganese, nickel, etc.

c) Non-metallic like cement, coal, gypsium, sand, gravel, etc.

There are 213 firms in the country belonging to this industry which produce a wide array of products. These can be broken into the following:

Metallic	10
Iron and Ferro-alloy Metals	22
Chemical and Fertilizer Raw Materials	97
Base Metals	18
Ceramics and Refractory Minerals	66
TOTAL	213

Although a large number of firms belong to this sector, the industry is dominated by copper and precious metals, particularly gold, in terms of value. Therefore, for the purpose of an energy study an analysis of the copper industry and the precious metals industry should give a good indication of the mining sector's energy profile.

This report covers actual survey data of energy consumption from nine mining firms of base and precious metals. Data on revenue and net income of 16 mining firms belonging to the top 1000 corporations, and related statistics from various other sources were used to cross-check the survey data.

Considering the industry's index of physical volume of production published by the Central Bank (Table 1.1 and Figure 1.1), the aggregate performance of the industry has been on the rise since 1972 except for a slight decrease in production in the years 1974 and 1976. These decreases in production are attributed to the slump in world prices of copper and gold. For the period 1972 to 1979, the average year to year

Table 1.1

INDEX OF PHYSICAL VOLUME OF PRODUCTION OF THE MINING INDUSTRY

Year	Index
1972	100.0
1973	102.6
1974	102.5
1975	113.3
1976	112.4
1977	131.3
1978	127.4
1979	133.1

Average year to year growth rate = 4.4%

SOURCE: Central Bank (CB Index)

growth rate was 4.4%. Between 1974 and 1979, the growth rate was 5.6%. The Bureau of Mines and Geosciences forecasts a 4.5% to 19.7% growth range depending on the particular commodity, based on existing and planned capacity expansions as well as recent historical performance.

Varying growth trends marked the first half of the 70's. Primary gold production was on the decline but this was cushioned by the gold by-product of copper. Copper showed an increase trend which slightly levelled off in 1974-75 due to a depressed external demand but later on picked up a stronger upward trend.

Table 1.2 shows these varying production trends among the pace setters of the industry, i.e., copper and gold. Silver, another industry pace setter in terms of sales, is produced exclusively as a by-product of copper and gold production.

Table 1.2

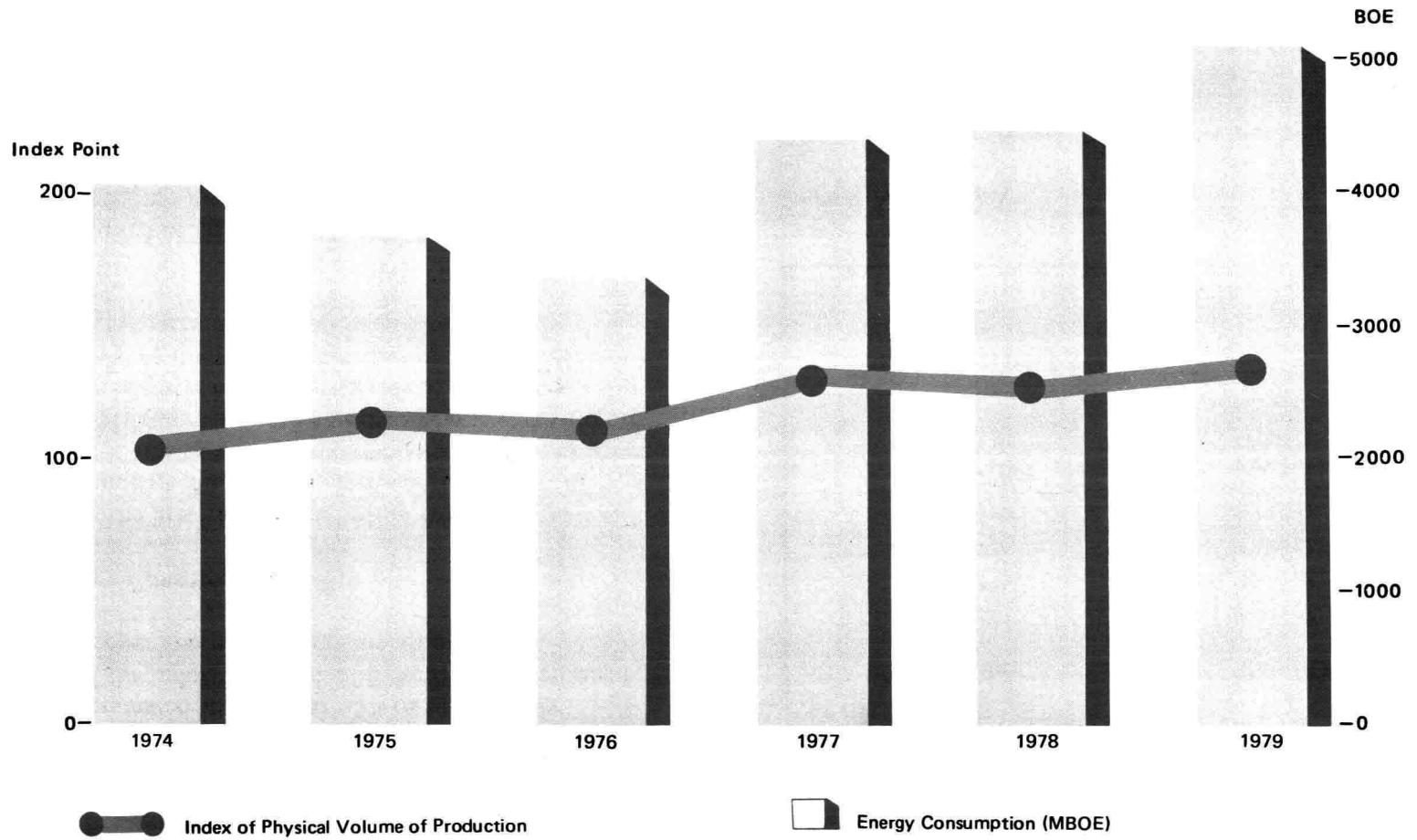
ANNUAL PRODUCTION AND VALUE OF COPPER, GOLD AND SILVER

	COPPER		GOLD		SILVER	
	Thousand MT	Value ₱MM	Thousand KG	Value ₱MM	Thousand KG	Value ₱MM
1972	213.7	1,360.43	18.87	225.17	57.47	18.08
1973	221.2	2,296.19	17.80	359.96	58.84	28.39
1974	255.5	2,793.71	16.69	554.01	53.06	52.13
1975	223.8	1,640.03	15.16	575.13	50.35	50.00
1976	237.6	1,841.54	15.58	445.91	46.05	43.99
1977	272.8	1,927.15	17.37	586.57	50.43	49.42
1978	263.4	1,877.[illegible]	18.24	807.73	50.93	49.91*
1979	285.3	3,362.70	16.65	1,129.16	55.53	54.42*

*Estimates

SOURCE: NEDA Statistics and CB Statistics

Figure 1.1
HISTORICAL PRODUCTION OUTPUT AND
ENERGY CONSUMPTION OF THE
MINING INDUSTRY



ENERGY PROFILE OF THE INDUSTRY

The mining industry is the 4th largest energy consumer among major energy-consuming industries, accounting for 8.4% of the total energy consumption of the entire industrial sector in 1979.

The nine firms surveyed account for 63% of total energy consumption of the industry. Three of these firms are engaged principally in copper and precious metals production.

Historical Energy Consumption

Table 1.3 shows the historical consumption from 1974 to 1979 of the mining industry. The figures represent direct sales of energy to mining firms by oil companies and/or electric utilities. On the whole, the figures indicate a year to year average growth rate of 5.5%. The slightly lower growth rate of energy consumption in comparison to the index of physical production growth rate of 5.6% for the same period, can be attributed to the following factors:

a) Achievement of large scale economies through the use of larger earth moving equipment as well as higher capacity milling plants.

b) Energy conservation measures undertaken to partially offset increases in fuel prices.

c) Production from richer ore bodies as well as generally more modern and efficient operations.

d) Changes in the product mix of the industry.

The large drop in consumption registered in 1975 and 1976 is to a large extent due to the phase out of iron production and the dip in copper and gold prices that reduced output.

Table 1.3

HISTORICAL ENERGY CONSUMPTION OF THE MINING INDUSTRY 1974-1979

Year	'000 BOE
1974	4061.0
1975	3647.9
1976	3374.9
1977	4330.9
1978	4405.3
1979	5078.4

Average year to year growth rate = 5.5%

SOURCE: MINISTRY OF ENERGY

Energy Applications

The energy applications of the industry can be gleaned from the applications in the copper industry. Much of the processes and equipment are generally applicable to the mining of most other major minerals. On the other hand, for the year 1979, 75% of the country's gold production was a by-product of copper production. Silver is produced exclusively as a by-product of copper and gold production. Thus the mining industry's energy profile can initially be appreciated in terms of processes involved in copper production.

Copper production can be divided into the mining/excavation phase and the milling phase. Both of these are done on site

and result in copper concentrates which are ready for shipment to smelters outside the country for metal recovery and refining. The by-products gold and silver are therefore recovered out of the country from the smelting process and refined separately. Copper concentrate shipments therefore already include high-value gold and silver production.

a) Mining Phase

Copper is most often mixed with other minerals and in the form of various ores where the amount of copper varies from 0.3% to 10% of the raw ore.

Most of the country's reserves contain 0.5% copper. Very large amounts of rock must therefore be mined and processed. For ores of this type, the open pit method is used. This involves the removal of ore from extensive deposits exposed by a large open pit, and includes the excavation of a huge amount of overburden which increases in volume as the deposits run deeper.

When the copper ore is located much deeper below the surface, underground mining becomes worthwhile only when the ore contains a considerably higher percentage of copper, say around 3 to 10%. This requires a more expensive operation which involves sinking a shaft to gain access to the deposit, and processing a relatively harder rock material.

Both methods are used in the country and for both a large amount of energy is required in drilling, blasting, loading and hauling the mined rock. Blasting, however, uses chemical explosives and this type of energy is not covered here.

Drilling equipment requires the use of pumps and compressors which may be run by on-site internal combustion engines, using gasoline or diesel oil, or electric motors.

Depending on the method of mining used, ores are hauled to milling plants via loading and hauling heavy equipment run by electric motors or internal combustion engines or via conveyors run mostly by electric motors.

b) Milling Operations

Copper of very high purity is recovered from mined rock by a three-step process. Since copper ore is usually found mixed with large amounts of material that does not contain copper, the first step involves separating the ore from worthless rock. Ore dressing, as this is called, involves size reduction by mechanically breaking the rock into its associated constituents and benefication by separating the severed components into the desired ore concentrate and the tailings. Size reduction is accomplished by large electric motor-driven mechanical crushers and grinders which progressively reduce the rock into very fine powder.

Benefication for copper ore existing in sulfide form is done through a flotation process. In this process finely ground ore is mixed with water and reagents in a flotation tank which is violently agitated with air to produce a heavy froth. The desired minerals which stick to the bubbles by virtue of the reagents used are carried to the surface. The undesired rock remains submerged and slowly drained. Removal of the reagents and water from the collected froth produces the marketable copper concentrate. Approximately 95% of the copper ore is recovered from the rock by this process.

For copper ore existing in oxide form, benefication is done by leaching the material with chemicals in order to dissolve the desired minerals. This results in a concentrate with a high copper content in the order of 90%.

Ore dressing operations produce copper concentrates containing

greater than 30% copper and up to 90% in some operations. For some ores, roasting may be required to remove undesirable volatile matter such as sulfur and arsenic. This upgrades the value of the concentrate by decreasing subsequent smelting costs.

c) External Processing

Further processes to produce the copper metal are accomplished at processing plants outside the country. These include metal recovery which involves removing other elements with which copper is chemically combined such as sulfur (for sulfides) and oxygen (for oxides) from the concentrates. For sulfides, the concentrates are fed to a smelter while for oxides, an electrolytic separation process is employed. Metal of high purity in the order of 90-95% can be obtained. The final process is refinement of the metal which removes almost all impurities resulting in 99% or better copper.

Considering the extent of energy intensive operations done within the country, the energy consumption of the copper industry is shown to be largely dependent on the volume of rock mined and milled. The same observation is applicable to most metal production such as gold and nickel.

Survey data summarized in Table 1.4 indicate that roughly 90.7% of total energy usage of the mining industry is used to run electric motors and internal combustion engines for mechanical power. This confirms the energy intensiveness of the milling operations. The industry generates in-plant electricity and to some extent steam for process heating using IFO, diesel oil and coal.

Table 1.4

CURRENT APPLICATIONS OF ENERGY IN THE MINING INDUSTRY

	Final Applications		% of Input
1.	Mechanical Power		90.7
	a. Electric Motors	81.0	
	b. Int. Comb. Engine	9.7	
2.	Process Heat		5.1
	a. Low/Med. Temp.	5.1	
	b. High Temp.	0	
3.	Transportation		2.0
	a. In-Plant	1.6	
	b. Out-of-Plant	0.4	
4.	Lighting		1.5
5.	Air-Conditioning		0.6
6.	Others		0.1
	TOTAL		100.0

Source: Survey Data

Applications of energy in selected mining firms are shown in Table 1.5. Table 1.6 contains data regarding rated capacities of energy consuming equipment of the same firms.

Table 1.5

CURRENT APPLICATIONS OF ENERGY IN SOME MINING PLANTS

FIRMS SURVEYED	A		B		C		D		E		F	
	BOE	%	BOE	%	BOE	%	BOE	%	BOE	%	BOE	%
Final Applications												
1. Mechanical Power	2,168,961	92.2	236,153	87.8	160,011	83.4	40,630	77.4	22,487	69.3	28,563	83.9
a. Electric Motors	1,917,846	81.5	231,950	86.2	160,011	83.4	22,324	42.5	21,424	66.0	19,783	58.1
b. Int. Comb. Engine	251,115	10.7	4,203	1.6	–	–	18,306	34.9	1,063	3.3	8,780	25.8
2. Process Heat	128,247	5.5	8,286	3.1	12,247	6.4	–	–	–	–	–	–
a. Low/Med. Temp.	128,247	5.5	8,286	3.1	12,247	6.4	–	–	–	–	–	–
b. High Temp.	–	–	–	–	–	–	–	–	–	–	–	–
3. Transportation	13,349	0.6*	15,688	5.9	11,536	6.0	8,378	15.9	8,058	24.8	2,795	8.2
a. In-Plant	13,120	0.6	12,550	4.7	8,652	4.5	5,789	11.0	4,480	13.8	2,519	7.4
b. Out-of-Plant	229	nil	3,138	1.2	2,884	1.5	2,589	4.9	3,578	11.0	276	0.8
4. Lighting	20,892	0.9	8,856	3.3	7,951	4.1	3,075	5.9	1,922	5.9	612	1.8
5. Airconditioning	18,767	0.8	–	–	–	–	95	0.2	–	–	–	–
6. Others	316	nil	–	–	–	–	321	0.6	–	–	2,107	6.2
TOTAL	2,350,532	100.0	268,983	100.0	191,745	100.0	52,499	100.0	32,467	100.0	34,077	100.0

* Inconsistent with data from other firms

Table 1.6

RATED CAPACITIES OF ENERGY CONSUMING EQUIPMENT AND FACILITIES IN SOME MINING FIRMS

FIRMS SURVEYED	B	C	D	E	G	H
1. Steam Generation	–	–	–	NA	–	NA
2. Electric Generation						
Total Output:	8,276 kw	–	2,000 kw	5,155 kw	4,425 kw	37.8 MW kw
Steam Turbines				NA		NA
Internal Combustion Engines			2,000 kw	5,155 kw	4,425 kw	37.8 MW kw
3. Electric Motors, Aggregate Output	45,000 hp	40,017.25 hp	30,000 hp	12,080 hp	4,299 hp	54,317 hp
4. Transport Vehicles, Total				9,938 hp	14,241 hp	45,200 hp
Land Transport		21,975.28 hp	6,000 hp	13,462	14,041 hp	45,200 hp
Marine Transport			nil	NA	200 hp	NA
5. Other Mechanical Equipment			12,00 hp	865 hp	10,706 hp	NA
6. Process Heat Equipment (Other than those using steam)	56 kw or BTU/ hr. of energy input		–	NA	–	NA