

## **APPENDIX DATA QUALITY AND METHODOLOGY FOR CALCULATING ENERGY CONSUMPTION ESTIMATES**

One of the key objectives of this report is to provide the mining research community with a benchmark for improving energy efficiency in specific mining operations. However, there is no single source of energy data collected by either the industry or the federal government to provide such a benchmark. Those sources that are available on energy use in mining include the U.S. Department of Commerce, Bureau of Census, Census of Mineral Industries which reports energy consumption for each mineral commodity produced in the U.S. However, in accordance with Federal law governing census reports, “no data are published that would disclose the data for an individual establishment or company.”<sup>1</sup> Therefore, in many cases the energy consumption by type of fuel (e.g. diesel, natural gas, electricity) are not provided for individual commodities. In addition, there are no nationally published sources of data measuring energy consumption in mining per unit of production, nor by type of mining activity, or by type of equipment used in the drilling, blasting, excavation, hauling, or processing of mineral commodities. It is these equipment- and activity-specific data that are important for establishing a benchmark for measuring energy efficiency improvements in mining operations.

To help address the need for a benchmark, this report provides estimates of energy consumption in mining and processing operations for eight selected commodities, by type of equipment used, in Btu per ton of material handled. These estimates assume a “typical” mine and are calculated using data from a combination of sources including production data from a combination of federal and industry sources as well as the SHERPA Mine and Mill cost model. The remainder of this appendix describes how estimates calculated in these report were derived.

### **A.1 Methodology to Calculate Estimated Energy Consumption by Commodity**

The following describes the methodology used to calculate energy consumption summary estimates for all of the eight selected commodities.

The “SHERPA Mine Cost Estimating Model” along with the “Mine and Mill Equipment Cost, An Estimators Guide” from Western Mine Engineering, Inc. were used to calculate the energy requirements for mining and processing the individual commodities. These calculations were based on an assumed “typical mine” and are not specific to any given year or region. The “SHERPA Mine Cost Estimating Model” along with the “Mine and Mill Equipment Cost, An Estimators Guide” were also used to identify the specific pieces of equipment used in the blasting, extraction, conveying, hauling, and processing of each commodity.

For each commodity, the number of units of equipment required at the typical mine were estimated using the SHERPA Mine Cost Estimating Model. The Model was also used to the daily number of hours that each unit is in operation. Using the Estimator Guide, the energy

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<sup>1</sup> U.S. Department of Commerce, Bureau of the Census “Census Disclosure Rules” as reported in the 1992 Census of Minerals Industries, Industry Series.

consumption in Btu per ton of material handled was calculated for each individual unit of equipment. The model was used to estimate energy consumption per day for each type of equipment. This was divided by the total number of hours each unit was used per day, per unit to estimate total energy consumption per hour at the hypothetical mine. The total energy consumed per day was divided by the daily production rate of the typical mine which resulted in energy per ton for all units of equipment. This was then divided by the number of units of equipment to calculate the energy consumption per ton of an individual unit of equipment.

This methodology was used to calculate the energy consumption estimates in the following tables:

Coal:	Tables 2-3, 2-4, 2-5, 2-6, and 2-7
Potash, Soda Ash, Borate:	Tables 3-2 and 3-3
Iron:	Tables 4-3 and 4-4
Copper:	Tables 5-2, 5-3, and 5-4
Lead and Zinc:	Tables 6-2, and 6-3
Gold and Silver:	Tables 7-2 and 7-3
Phosphate Rock	Tables 8-2 and 8-3
Limestone:	Tables 9-2 and 9-3

## **A.2 Methodology to Summarize Energy Consumption for the Eight Selected Commodities**

Figure 1-9 in the Mining Overview of this report summarize estimated energy consumption in mining stages for the eight commodities selected for this report. These estimates were developed by aggregating the data from the individual commodity chapters in proportion to their annual production shown in Table 1-2. Tables A-1 at the back of this appendix has detailed calculations used to develop further summary estimates.

1. **Activities and Equipment:** The primary activities involved in each stage of mining were identified (e.g., drilling, blasting, etc.). Within each activity, the major pieces of equipment that are used were identified. These were based primarily from the Western Mining Engineering, Inc. "SHERPA Mine Cost Software" and conversations with industry experts.
2. **Single Unit Btu per ton:** For each piece of equipment the estimated energy required to move, process, drill, etc. one ton of material was calculated. These estimates are based on the Western Mining Engineering, Inc., "SHERPA Mine Cost Software" and "Mine and Mill Cost, An Estimators Guide." They correspond to the Energy Requirements data provided in the commodity chapters of this report (e.g., Table 2-3, Estimated Energy Requirements of a 3,322 ton/day Hypothetical Eastern Underground Coal Mine.
3. **Materials Handled Thousand of Tons per year:** Material Handled (waste and ore) are provided, by commodity in Table 1-2. They represent the amount of materials handled (crude ore and waste) in the U.S. for the commodities selected and are provided by the U.S. Department

of the Interior, U.S. Geological Survey, Minerals Yearbook, Mining and Quarrying Trend, 1998. For totals not provided by USGS material handled estimates were developed based on recovery ratios (valuable constituent vs. ore) from various sources. The ratios used were underground coal = 58%; surface coal = 91%; silver = 1%; lead = 5%; potash = 21.5%. Underground coal numbers are for the Eastern and Longwall Coal Mining Energy Requirement Tables (Tables 2-3 and 2-4). Surface coal numbers are from the Interior and Western Coal Mining Energy Requirement Tables (Table 2-5 and 2-6). The material handled number for each piece of equipment is totaled for each activity.

4. Estimated Annual Energy Consumption (Btu per year) for each commodity the estimated materials handled were multiplied by the energy requirements per ton for each piece of equipment use in the mining or processing of the commodity. Results are totaled to give the estimated annual energy consumption for each piece of equipment and for each activity.

An example is provided below:

Of the commodities selected for this report, a two boom jumbo was identified as being used in the drilling of lead and of underground coal. Estimated energy consumption per ton is:

Underground Coal - 1,740 Btu/ton  
Lead - 1,560 Btu/ton

Material handled per year for these commodities (from USGS) is:

Underground Coal - 644,240 tons  
Lead - 10,616 tons

Assuming that a two boom jumbo is used in the excavation of all material handled in the production of lead and underground coal, total annual energy consumption of two boom jumbos is:

Underground Coal - 1,740 Btu/ton \* 644,240 = 1,120 million Btu  
Lead - 1,560Btu/ton \* 10,616 tons = 17 million Btu  
Total Two Boom Jumbo = 1,137 million Btu

Please note: for transportation equipment, energy consumption estimates represent in-the-mine transportation only.

### A-3. Estimating National-level Energy Consumption by Mining Activity/Equipment Type

For energy efficiency benchmarking purposes it would be useful to have valid data on the total energy used in the U.S. for individual activities within mining operations. For example, energy efficiency improvements in ball mills would improve the energy efficiency of mining operations for a number of commodities including iron, copper, lead, gold and many others. However, these data do not exist. Various methods could be used to extrapolate the estimates provided in this report to develop national-level estimates. There are numerous uncertainties, however, in developing these estimates. These uncertainties include:

- The ratio of material handled per unit of production varies greatly from commodity to commodity and greatly influences total energy consumption.
- The mineral commodities selected for this report represent key commodities for the U.S. economy and the U.S. mining industry, they represent the majority of U.S. mining production in terms of both value and tonnage. However, there are approximately 50 other mineral commodities not included in this report. Each has very different characteristics in terms of mining and processing operations that significantly influence energy consumption. These characteristics include different types of equipment used, ore grade, geology, geography, transportation requirements, and other factors.
- Mines across the U.S. vary greatly in size, depth, and age of equipment being employed – all of which impact energy consumption.

One method of roughly extrapolating total energy consumption for all mined commodities by equipment type would be to use the ratio of total material handled for the selected commodities to total material handled for all commodities mined in the U.S. (see Table 1-2). This ratio can be applied to the estimate of total energy consumed for the selected commodities to calculate total energy consumed for all commodities in the U.S. A sample calculation follows:

$$4,828,913 / 6,952,392 = 0.69 \quad (\text{ratio of total material handled for the selected commodities to total material handled for all commodities})$$

$$\begin{aligned} \text{Energy Consumed: eight selected commodities} &= 2.90 E+14 \\ \text{Extrapolated energy consumed: all commodities} &= (2.90 E+14) / 0.69 = 4.20 E+14 \end{aligned}$$

The result, 420 trillion Btu, falls short of other estimates of national level energy consumption in mining indicating that this direct form of extrapolation is not a reasonable means of estimation.

However, two of the commodities selected for this report, Coal and Stone, are both highly efficient minerals in terms of material handled per unit of production. Nearly all of the material excavated from the ground is found in the finished product. As data in Table 1-2 shows, 76 in the case of coal and 93 percent in the case of stone. If these two minerals are considered

anomalies when scaling to “all commodities”, and removed from the calculation of the ratio of material handled, then the above calculation is revised to:

$$1,607,704 / 3,731,183 = 0.43 \quad (\text{ratio of total material handled for the selected commodities less stone and coal, to total material handled for all commodities,})$$

$$\begin{aligned} \text{Energy Consumed: eight selected commodities} &= 2.90 E+14 \\ \text{Extrapolated energy consumed: all commodities} &= (2.90 E+14) / 0.43 = 6.74 E+14 \end{aligned}$$

The result, 674trillion Btu comes closer to the U.S. Department of Energy estimate of 1.125 trillion Btu for total industry energy consumption. To estimate total industry energy consumption for a given piece of equipment one could use the same methodology using the aggregated data in Table A-1 providing estimated energy consumption, by equipment type for the eight selected commodities. Using service trucks (Table A-1) as an example the calculation would be:

*total estimated energy consumption by service trucks for the eight selected commodities divided by the ratio of material handled for the selected commodities (less stone and coal) to total material handled for all commodities.*

$$3.038 E+12 / 0.43 = 7 \text{ trillion Btu/year}$$

Similar calculations could be made for groups of equipment such as the mining areas shown in Figure 1-9. However, it must be reiterated that there are a number of uncertainties such as those listed above which are not captured in this report and subsequently are not captured in these extrapolations to national level estimates. The above calculations are provided solely as an example of one way in which national level extrapolations could be performed.

Table A-1. Estimating Annual Energy Consumption for Equipment

Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Two Boom Jumbo			
Underground Coal	1,736	644,240	1,118,455,225,743
Lead	1,563	10,616	16,592,242,588
<i>Total</i>	<i>3,299</i>	<i>654,856</i>	<i>1,135,047,468,331</i>
Drills			
Underground Coal	317	644,240	204,239,649,918
Lead	802	10,616	8,512,541,850
<i>Total</i>	<i>1,119</i>	<i>654,856</i>	<i>212,752,191,768</i>
Diamond Drill			
Underground Coal	6	644,240	4,084,792,998
Lead	385	10,616	4,087,943,826
<i>Total</i>	<i>391</i>	<i>654,856</i>	<i>8,172,736,824</i>
Rotary Drill			
Surface Coal	1,946	769,179	1,496,478,298,920
Potash		0	0
Iron	2,900	364,865	1,058,068,747,497
Copper	396	986,437	390,503,980,226
Lead		0	0
Gold	1,808	222,667	402,500,939,743
<i>Total</i>	<i>7,049</i>	<i>2,343,148</i>	<i>3,347,551,966,386</i>
Percussion Drill			
Rock	928	1,675,513	1,555,314,516,000
<i>Total</i>	<i>928</i>	<i>1,675,513</i>	<i>1,555,314,516,000</i>
ANFO Loaders			
Underground Coal	1,839	644,240	1,184,641,534,038
Lead	1,280	10,616	13,590,648,210
<i>Total</i>	<i>3,119</i>	<i>654,856</i>	<i>1,198,232,182,248</i>

Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Front End Loader			
Surface Coal	5,114	769,179	3,933,451,246,889
Iron	7,560	364,865	2,758,422,443,224
Lead	1,166	10,616	12,374,243,844
Gold	711	222,667	158,242,569,600
Rock	170	1,675,513	284,304,804,000
<i>Total</i>	<i>14,720</i>	<i>3,042,840</i>	<i>7,146,795,307,556</i>
Hydraulic Shovel			
Surface Coal	3,861	769,179	2,969,580,451,969
Iron	5,532	364,865	2,018,359,182,097
Gold	2,052	222,667	456,947,644,800
Rock	5,141	1,675,513	8,614,156,831,000
<i>Total</i>	<i>16,586</i>	<i>3,032,224</i>	<i>14,059,044,109,866</i>
Long Wall Miner			
Underground Coal	592	644,240	381,103,440,216
<i>Total</i>	<i>592</i>	<i>644,240</i>	<i>381,103,440,216</i>
Continuous Miner			
Underground Coal	9,839	644,240	6,338,525,824,699
Potash	4,141	13,330	55,194,508,646
<i>Total</i>	<i>13,979</i>	<i>657,570</i>	<i>6,393,720,333,345</i>
Draglines			
Phosphate	27,509	189,598	5,215,683,360,863
<i>Total</i>	<i>27,509</i>	<i>189,598</i>	<i>5,215,683,360,863</i>
Cable Shovels			
Surface Coal	2,494	769,179	1,918,679,476,035
Copper	1,214	986,437	1,197,513,438,745
<i>Total</i>	<i>3,708</i>	<i>1,755,616</i>	<i>3,116,192,914,780</i>

Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Raise Borers			
Underground Coal	4,691	644,240	3,022,260,533,910
Lead	5,631	10,616	59,780,166,775
<i>Total</i>	<i>10,322</i>	<i>654,856</i>	<i>3,082,040,700,685</i>
Hydraulic Monitors			
Phosphate	5,279	189,598	1,000,815,511,816
<i>Total</i>	<i>5,279</i>	<i>189,598</i>	<i>1,000,815,511,816</i>
LHD			
Underground Coal	2,344	644,240	1,509,914,554,753
<i>Total</i>	<i>2,344</i>	<i>644,240</i>	<i>1,509,914,554,753</i>
Conveyor			
Underground Coal	2,665	644,240	1,716,741,119,692
Potash	910	13,330	12,123,872,483
<i>Total</i>	<i>3,574</i>	<i>880,237</i>	<i>1,728,864,992,175</i>
Rear Dump Truck			
Surface Coal	4,695	769,179	3,611,513,042,974
Iron	1,935	364,865	706,088,088,782
Copper	1,523	986,437	1,502,484,640,511
Lead	12,205	10,616	129,566,017,415
Gold	8,392	222,667	1,868,684,726,400
Rock	679	1,675,513	1,137,219,216,000
<i>Total</i>	<i>29,429</i>	<i>4,029,277</i>	<i>8,955,555,732,082</i>



Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Bulldozer			
Surface Coal	8,865	769,179	6,818,880,322,190
Iron	2,725	364,865	994,265,606,945
Copper	833	986,437	821,967,774,057
Gold	503	222,667	112,014,403,200
Rock	1,033	1,675,513	1,730,914,542,000
<i>Total</i>	<i>13,960</i>	<i>4,018,661</i>	<i>10,478,042,648,391</i> 0
Hoist			
Potash	7,241	13,330	96,527,647,160
Lead	14,080	10,616	149,474,463,666
<i>Total</i>	<i>21,321</i>	<i>23,946</i>	<i>246,002,110,826</i>
Pit Cars			
Phosphate	140	189,598	26,503,311,158
<i>Total</i>	<i>140</i>	<i>189,598</i>	<i>26,503,311,158</i>
Main Fan			
Underground Coal	11,968	644,240	7,710,046,784,416
Potash	459	13,330	6,119,852,830
Lead	14,366	10,616	152,504,351,443
<i>Total</i>	<i>26,792</i>	<i>668,186</i>	<i>7,868,670,988,688</i>

Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Service Trucks			
Underground Coal	1,839	644,240	1,184,641,534,038
Surface Coal	770	769,179	591,908,301,407
Potash	706	13,330	9,406,063,362
Iron	396	364,865	144,620,451,919
Copper	119	986,437	117,300,752,646
Lead	1,557	10,616	16,529,430,617
Gold	543	222,667	120,904,435,200
Rock	509	1,675,513	852,914,412,000
<i>Total</i>	<i>6,438</i>	<i>4,686,847</i>	<i>3,038,225,381,189</i>
Water Tankers			
Surface Coal	1,525	769,179	1,172,745,013,060
Iron	1,196	364,865	436,519,819,947
Copper	877	986,437	865,093,050,765
Gold	2,002	222,667	445,835,104,800
Rock	1,061	1,675,513	1,778,298,676,000
<i>Total</i>	<i>6,662</i>	<i>4,018,661</i>	<i>4,698,491,664,572</i>
Bulk Truck			
Surface Coal	755	769,179	580,908,657,070
Iron	396	364,865	144,620,451,919
Copper	119	986,437	117,300,752,646
Gold	543	222,667	120,904,435,200
Rock	113	1,675,513	189,536,536,000
<i>Total</i>	<i>1,927</i>	<i>4,018,661</i>	<i>1,153,270,832,835</i>

Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Pick-up trucks			
Surface Coal	440	769,179	338,466,904,467
Iron	242	364,865	88,261,011,098
Copper	73	986,437	71,587,959,335
Gold	679	222,667	151,130,544,000
Rock	679	1,675,513	1,137,673,327,000
<i>Total</i>	<i>2,112</i>	<i>4,018,661</i>	<i>1,787,119,745,901</i>
Lighting Plant			
Gold	136	222,667	30,226,108,800
Rock	15	1,675,513	25,085,718,000
<i>Total</i>	<i>151</i>	<i>1,898,180</i>	<i>55,311,826,800</i>
Roof Bolter			
Underground Coal	1,284	644,240	827,506,953,924
Lead	1,542	10,616	16,368,047,413
<i>Total</i>	<i>2,826</i>	<i>654,856</i>	<i>843,875,001,337</i>
Compressor			
Potash	955	13,330	12,725,432,780
<i>Total</i>	<i>955</i>	<i>13,330</i>	<i>12,725,432,780</i>

Equipment	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Water Pumps			
Underground Coal	72	644,240	46,197,063,672
Surface Coal	798	769,179	613,866,174,041
Potash	1,033	13,330	13,764,842,485
Iron	420	364,865	153,127,537,326
Copper	166	986,437	163,876,051,491
Lead	2,229	10,616	23,661,980,735
Gold	1,060	222,667	235,991,611,403
Phosphate	140	189,598	26,503,311,158
Rock	1,018	1,675,513	1,705,828,824,000
<i>Total</i>	<i>6,935</i>	<i>4,876,445</i>	<i>2,982,817,396,311</i>
Graders			
Surface Coal	87	769,179	67,124,030,732
Iron	213	364,865	77,680,323,623
Copper	426	986,437	420,040,195,137
Gold	165	222,667	36,745,465,600
Rock	6	1,675,513	9,476,826,800
<i>Total</i>	<i>897</i>	<i>4,018,661</i>	<i>611,066,841,892</i>
Crusher			
Underground Coal	1,759	644,240	1,133,043,772,166
<i>Total</i>	<i>1,759</i>	<i>644,240</i>	<i>1,133,043,772,166</i>

Process	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Centrifuge			
Surface Coal	585	769,179	449,958,232,460
<i>Total</i>	<i>585</i>	<i>769179</i>	<i>449,958,232,460</i>
Flotation			
Surface Coal	359	769,179	275,780,852,153
Potash	138	13,330	1,834,025,296
Copper	1,257	986,437	1,239,886,250,410
Lead	430	10,616	4,568,878,394
Phosphate	140	189,598	26,503,311,158
<i>Total</i>	<i>2,323</i>	<i>1969160</i>	<i>1,548,573,317,410</i>
Dryer			
Potash	91	13,330	1,216,248,354
<i>Total</i>	<i>91</i>	<i>13330</i>	<i>1,216,248,354</i>
Magnetic Separator			
Surface Coal	121	769,179	92,894,602,830
<i>Total</i>	<i>121</i>	<i>769179</i>	<i>92,894,602,830</i>
Screens			
Surface Coal	238	769,179	182,886,249,322
Potash	46	13,330	617,776,942
Iron	51	364,865	18,700,106,502
Phosphate	70	189,598	13,251,655,579
Rock	332	1,675,513	556,680,987,656
<i>Total</i>	<i>738</i>	<i>3012485</i>	<i>772,136,776,001</i>

Process		Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Filter	Iron	76	364,865	27,604,919,122
	Lead	140	10,616	1,490,897,160
	<i>Total</i>	<i>216</i>	<i>375481</i>	<i>29,095,816,282</i>
Cyclone	Copper	620	986,437	611,516,713,794
	<i>Total</i>	<i>620</i>	<i>986437</i>	<i>611,516,713,794</i>
Washing	Gold	1,988	222,667	442,723,593,600
	<i>Total</i>	<i>1,988</i>	<i>222667</i>	<i>442,723,593,600</i>
Electrowinning	Copper	6	986,437	5,778,110,682
	Gold	27	222,667	5,955,624,263
	<i>Total</i>	<i>33</i>	<i>1209104</i>	<i>11,733,734,944</i>
Trommel	Phosphate	87	189,598	16,406,811,669
	<i>Total</i>	<i>87</i>	<i>189598</i>	<i>16,406,811,669</i>
Grinding Mill	Surface Coal	93,220	769,179	71,703,021,559,683
	<i>Total</i>	<i>93,220</i>	<i>769179</i>	<i>71,703,021,559,683</i>
Crusher	Potash	224	13,330	2,992,357,062
	Copper	1,039	986,437	1,025,133,136,746
	<i>Total</i>	<i>1,264</i>	<i>999767</i>	<i>1,028,125,493,808</i>

Process	Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Rod Mill			
Potash	41,276	13,330	550,207,588,813
Iron	1,547	364,865	564,565,120,109
Lead	11,489	10,616	121,965,006,389
<i>Total</i>	<i>54,312</i>	<i>388811</i>	<i>1,236,737,715,311</i>
Ball Mill			
Iron	1,547	364,865	564,565,120,109
Copper	4,637	986,437	4,574,337,622,870
Lead	10,053	10,616	106,719,380,590
Gold	8,800	222,667	1,959,400,382,373
<i>Total</i>	<i>25,037</i>	<i>1584585</i>	<i>7,205,022,505,942</i>
Tertiary Crusher			
Iron	387	364,865	141,289,693,571
Rock	1,657	1,675,513	2,776,402,661,704
<i>Total</i>	<i>2,044</i>	<i>2040378</i>	<i>2,917,692,355,275</i>
Secondary Crusher			
Iron	645	364,865	235,383,880,256
<i>Total</i>	<i>645</i>	<i>364,865</i>	<i>235,383,880,256</i>
Primary Crusher			
Iron	2,580	364,865	941,238,693,936
<i>Total</i>	<i>2,580</i>	<i>364865</i>	<i>941,238,693,936</i>

Process		Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
SAG Mill	Copper	92,654	986,437	91,397,673,251,069
	Gold	14,100	222,667	3,139,606,590,397
<i>Total</i>		<i>106,754</i>	<i>1209104</i>	<i>94,537,279,841,466</i>
Compactor	Potash	23	13,330	308,888,471
<i>Total</i>		<i>23</i>	<i>13330</i>	<i>308,888,471</i>
Thickener	Iron	19	364,865	6,827,023,009
	Copper	171	986,437	168,287,473,599
<i>Total</i>		<i>189</i>	<i>1351302</i>	<i>175,114,496,608</i>
Pelletizer	Iron	38	364,865	13,950,873,105
<i>Total</i>		<i>38</i>	<i>364865</i>	<i>13,950,873,105</i>
Furnace	Copper	238	986,437	234,772,006,000
	Lead	13,269	10,616	140,863,704,000
<i>Total</i>		<i>13,507</i>	<i>997053</i>	<i>375,635,710,000</i>
Roasting	Copper	713	986,437	703,329,581,000
<i>Total</i>		<i>713</i>	<i>986437</i>	<i>703,329,581,000</i>
Smelting	Gold	3,260	222,667	725,894,420,000
<i>Total</i>		<i>3,260</i>	<i>222667</i>	<i>725,894,420,000</i>



Process		Single Unit BTU/ton	Selected Commodities Materials Handled Thousand Tons/year	Selected Commodities Btu/year
Refining	Gold	3,260	222,667	725,894,420,000
<i>Total</i>		3,260	222667	725,894,420,000
Calcining	Rock	6,120	1,675,513	10,254,834,043,041
<i>Total</i>		6,120	1675513	10,254,834,043,041
		<b>555,361</b>		<b>291,052,347,187,073</b>