THE CURRENT STATUS OF IRON MINERALS IN INDONESIA

Siti Rochani, Pramusanto, Sariman and Rezky Iriansyah Anugrah
R&D Centre for Mineral and Coal Technology
Jalan Jenderal Sudirman 623, ph. 022-6030483, fax. 022-6003373, Bandung 40211
email : rochani@tekmira.esdm.go.id, pramusanto@tekmira.esdm.go.id
sariman@tekmira.esdm.go.id, rezky@tekmira.esdm.go.id

Received : 24 October 2007, first revision : 06 February 2008, second revision : 26 May 2008, accepted : June 2008

ABSTRACT

Indonesia has great iron mineral resources, comprising primary iron ore (17 %), iron sand (8 %) and lateritic iron ore (75 %). Nowadays, Indonesia's primary iron (hematite, magnetite) has not been empowered yet, due to the scattered area of the resources location. Meanwhile, national iron sand is commonly used for cement industries and its potency has not supported national steel industries yet because of low iron content (45-48 %). However there is an opportunity to be processed by using Ausmelt process technology. At present, lateritic iron ore is being used as coal liquefaction catalyst in the form of limonite, but hydrometallurgy would be a promising solution to beneficiate lateritic iron ore for steel industries.

Keywords: primary iron ore, iron sand, lateritic iron ore. potency, resources, reserves.

1. INTRODUCTION

Indonesia has great iron mineral resources, comprising primary iron ore (17 %), iron sand (8 %) and lateritic iron ore (75 %). The recent published report or writing is not adequate to inform the latest iron minerals empowerment (reserves, location, processing) and anticipated actions of iron minerals beneficiation. Therefore, this report is proposed to give further information regarding current and future condition of iron minerals beneficiation. Based on secondary data collected, the analyze states that Indonesia should optimize the primary iron ore potency although it is scattered at amount of regions because dependences on imported iron ore must be eliminated. Having 362,564,042 tons of primary iron ore deposits, it can be predicted that exploitation will operate in 52 years.

2. METHOD

Report was taken from the amount of secondary data, such as government institutions report, magazine; private and government-owned company web site; and scientific handbook or literature. Based on the data collected, the next step is arranging and analyzing the data to convey the mindset of Indonesia current iron minerals potency and suggest the future scientific action to process iron minerals more useful.

In constructing the analyzes, we use linear correlation, chart and graphic to make all variables more close.

3. RESULTS AND DISCUSSION

3.1. Iron Minerals

Iron ore is an iron mineral substance when heated at high temperature in the presence of a reductant, it yields metallic iron (Fe). The most important iron minerals are magnetite (Fe_3O_4), hematite (Fe_2O_3), and limonite (FeOOH). Meanwhile, other iron minerals such as siderite ($FeCO_3$) and pyrite (FeS_2) are not common to process as metallic iron source. Figure 1 visualized various iron minerals.

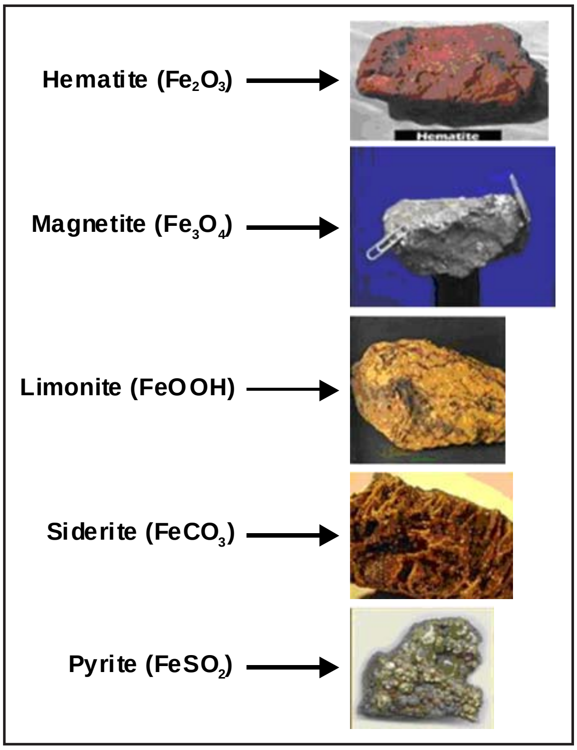

Figure 1. Various kinds of iron minerals

3.2. Iron Application

Iron is the most used of all the metals, which comprising 95% of all the metal tonnage produced worldwide. Its combination of low cost and high strength make it indispensable, especially in applications like automobiles, the hulls of large ships, and structural components for buildings.

Steel is the best known alloy of iron. Some forms of iron metals include (Pramusanto, 2006):

- Pig iron has 4.0 – 5.0% carbon and contains various amounts of contaminants such as sulfur, silicon and phosphorus. It is only significance as an intermediate steps on the production way from iron ore to cast iron and steel.

- Cast iron contains 2.0 – 4.0% carbon, 1.0 – 6.0% silicon, and small amounts of manganese. Contaminants present in pig iron that negatively affect the material properties, such as sulfur and phosphorus, have been reduced to an acceptable level. It has a melting point in the range of 1147 –1197 °C, which is lower than the two main components, and makes it the first product to be melted when carbon and iron are heated together. Its mechanical properties are vary greatly, depend upon the form if carbon takes in the alloy. 'White' cast irons contain carbon in the form of cementite, or iron carbide. This hard-brittle compound dominates the mechanical properties of white cast irons, rendering them hard, but unresisting to shock. The broken surface of a white cast iron is full of fine facets of the broken carbide, a very pale, silvery, shiny material. In grey iron, the carbon is free as fine flakes of graphite, and also, renders the material brittle due to the stress-raising nature of the sharp edged flakes of graphite. A newer variant of grey iron, referred to as ductile iron is specially treated with trace amounts of magnesium to alter the shape of graphite to sheroids, or nodules, vastly increasing the toughness and strength of the material.

- Carbon steel contains 0.4 - 1.5% of carbon, with small amounts of manganese, sulfur, phosphorus, and silicon.

- Wrought iron contains less than 0.2% carbon. It is a tough, malleable product, not as fusible as pig iron. It has a very small amount of carbon, a few tenths of a percent. If honed to an edge, it loses quickly. Wrought iron is characterized, especially in old samples, by the presence of fine 'stringers' or filaments of slag entrapped in the metal. Wrought iron does not rust quickly when used outdoors. It has largely been replaced by mild steel for "wrought iron" gates and blacksmithing. Mild steel does not have the same corrosion resistance but is cheaper and more widely available.

- Alloy steels contain varying amounts of carbon as well as other metals, such as chromium, vanadium, molybdenum, nickel, tungsten. They are used for structural purposes. Recent developments in ferrous metallurgy have produced a growing range of micro alloy steels, also termed 'HSLA' or high-strength, low alloy steels, containing tiny additions such as titanium to produce high strengths and often spectacular toughness at minimal cost.

- Iron (III) oxides are used in the production of magnetic storage media in computers. They

Table of Contents

are often mixed with other compounds, and retain their magnetic properties in solution.

3.3. Indonesia Iron Minerals, Potency, Resources and Characteristic

The amount of Indonesia iron ore resources reaches up to 76 million tons, which is relatively low compared to world iron resources and potency which are recorded as 800 billion tons and 150 billion tons, respectively. In addition, China has iron resources as much as 240 million tons. About 90 % of world iron resources comes from iron deposit, called cherty banded iron formation. The sediment physically appears as a thin to moderate layer containing iron oxides, carbonates and silicates material with chert or jasper. The deposit genesis is related to sedimentation process with under sea volcanism at the era of Pre-Cambrian. The deposit formed is found in the area of geological physiographic craton. The economical value of deposit in Banded Iron Formation is in the range of 25 - 35% Fe. Geological survey shows that Indonesia is in magmatic arc leading to the absence of Banded Iron Formation type. The Indonesian iron potency is shown in Figure 2.

Iron ore resources and deposits in Indonesia, can be grouped as iron sand, lateritic iron ore and primary iron ore (Ministry of Industry of the Republic of Indonesia, 2007). The data can be seen on Tables 1, 2, and 3.

Figure 3 shows the total amount of each type of iron minerals summarized from Tables 1, 2, and 3.

However, there are also differences in number comparing to version of iron mineral resources and reserves (Setiawan, et.al., 2004;Tambang Megazine, 2007), that can be seen in Table 4 and Table 5.

Primary iron ore is found spread out in the area of South Kalimantan, West Kalimantan, Belitung, Nanggroe Aceh Darussalam, Lampung, and Papua. Lateritic iron ore is mostly found at South Kalimantan, South-East Sulawesi, and North Maluku. Iron sand is found, spread out at South Java seashore, scattered from Sukabumi to Cianjur, Tasikmalaya, Cilacap, Purworejo and ended at Lumajang.

Figure 2. Map of iron minerals potential in Indonesia (Directorate of Mineral Resources Inventory, 2004)

Table 1. The main iron sand deposits in Indonesia

Rank	Province	Location	Ore (ton)	Metal	Fe Content (%)	Remarks
1	East Nusa Tenggara	Ende (Nangapanda)	57,134,358	8,570,153.70	15	Titanium is gangue mineral
2	D.I. Yogyakarta	Kulonprogo, Bantul	36,193,173	20,895,397.07	50.7 - 59	-
3	North Sulawesi	Bolaang Mongondow	31,400,000	18,208,860	57.99	9.85 % TiO_2
4	West Java	Sukabumi (Ciemas, Jampang Kulon)	16,463,154	8,102,028.18	57	-
5	West Java	Cianjur, (Sindangbarang, Cidaun)	7,369,151.69	4,232,103.81	57.43	12.73 TiO_2
6	Bengkulu	South Bengkulu	3,231,063	1,492,562.95	61.50	coastal sediment that contain titanium
7	Nanggroe Aceh Darussalam	Banda Aceh	2,897,114	1,593,412.70	55	sand sediment in the form of magnetite & ilmenite
8	South Sulawesi	Takalar (South Galesong)	2,865,000	1,146,000	40	coastal sediment
9	West Java	Tasikmalaya (Cipatujah, Karangnunggal)	2,357,390	1,323,203.01	57	-
10	Bengkulu	North Bengkulu (South Muko-Muko)	1,000,000	350,000	35	Fe_2O_3
	TOTAL		160,910,403.7	65,913,721.42		

Table 2. The main lateritic iron deposits in Indonesia

Rank	Province	Location	Ore (ton)	Metal	Fe Content (%)	Remarks
1	South Kalimantan	Kota Baru (Batulicin)	485,219,700	229,088,807	39 - 55	-
2	South Sulawesi	Luwu (Nuha)	371,500,000	182,035,000	49	-
3	West Irian Jaya	Raja Ampat (West Waigeo)	287,198,000	94,408,206.02	30 – 43.95	-
4	North Maluku	Central Halmahera (Mada, Patani Gebe, South Obi)	203,380,000	62,125,050	-	saprolite & limonite

Table of Contents

Table 2. Continues ...

Rank	Province	Location	Ore (ton)	Metal	Fe Content (%)	Remarks
5	Southeast Sulawesi	Kendari (Lasolo)	167,030,930	46,285,565.95	-	saprolite & limonite
6	Papua	Jayapura (West Waigeo)	19,310,000	8,457,780	30- 43.95	-
7	Papua	Jayapura (Senggi)	17,920,000	5,786,000	17.9 – 45.1	saprolite & limonite which the content of Ni, Co are 1.06 – 1.65 %, 0.05 – 0.13 respectively
8	Papua	Jayapura (East Sentani)	3,503,000	1,124,463	32.1	-
9	Lampung	East Lampung	2,415,437	421,460.88	43 max	-
10	Southeast Sulawesi	Konawe (Asera)	1,500,000	735,000	40	-
	TOTAL		1,558,977,067	630,467,333.4		

Table 3. The main primary iron ore deposits in Indonesia

Rank	Province	Location	Ore (ton)	Metal	Fe Content (%)	Remarks
1	West Kalimantan	Ketapang, Kendawangan	280,000,000	159,600,000	40- 75	iron oxide
2	West Sumatera	Pasaman	25,590,594	-	Unknown	-
3	East Kalimantan	Kutai	18,000,000	9,900,000	56	-
4	North Sulawesi	North Minahasa	17,500,000	5,250,000	30	hematite
5	Lampung	South Lampung (Sukarame)	5,625,000	3,220,312,50	55.05 – 59.47	-
6	South Kalimantan	Balangan (Awayan)	5,126,400	3,140,386.56	54 – 62.66	-
7	Lampung	South Lampung (Tanjung Bintang)	5,060,500	3,035,641	43 - 66	-
8	South Kalimantan	Tanah Laut (Palaihari)	2,478,200	1,444,970.28	40 - 70	iron oxide; Cr & Ni recorded at some places
9	South Sumatera	Musi Rawas	1,600,000	1,131,840	70.74	iron oxide
10	West Sumatera	Solok	1,583,348	938,450.36	59.27	magnetite, hematite in association with Cu
	TOTAL		362,564,042	187,661,601		

Table of Contents

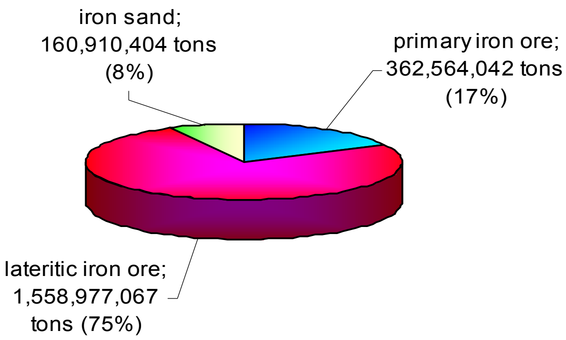

Figure 3. Iron minerals availability in Indonesia (modified from the Ministry of Industry of the Republic of Indonesia, 2007)

3.3.1. Iron Sand Characteristic

Generally, Indonesian iron sand contains high titanium oxide (TiO_2), which is undesirable to the existing iron making process. Titanium as a gangue mineral has an effect on weakening the steel strength, and corrosion problem to the furnace wall. However, titanium can be separated during smelting as titanium slag to produce steel. Nowadays, titanium minerals are identified as rutile, leukoksine, and ilmenite. Since magnetite and titanomagnetite are available in iron sand, it can be eliminated apart from silica and alumina, using their ferromagnetism characteristics.

Table 4. Iron ore potency and resources in Indonesia

Iron ore type	Location	Deposits (thousand ton)	Fe(%)
Primary iron ore (high Fe content, suitable for lump ore)	South Kalimantan	11,675,000	43.30 – 66.04
	West Kalimantan	1,000,000	55.00
	Belitung	7,400,000	62.25
	Lampung	5,243,000	42.50 – 63.50
	West Sumatera	1,600,000	-
	Sub Total	25,478,000	
Lateritic iron ore (containing Ni and Cr)	South Kalimantan	565,233,000	38.00 – 59.00
	Central Sulawesi	375,200,000	-
	Papua (Irian)	123,410,000	-
	Sub Total	1,058,600,000	
Iron sand (utilized as cement raw material, containing titanium	West Java	3.097.000	38,00 – 58,32
	Central Java	86.267.000	59,00
	Yogyakarta	30.668.000	59,00
	East Java	15.979.000	51,29 – 51,51
	Sub Total	163.311.000	
	Total	1.247.389.000	

Source: Directorate of Mineral Resources, Bandung, 2004

Table 5. Iron ore potency in Indonesia

Iron ore type	Resources (ton)		Reserves (ton)	
	ore	metal	ore	metal
Primary iron ore	76.147.311	35.432.196	-	-
Lateritic iron ore	1.151.369.714	502.317.988	215.160.000	8.193.580
Iron sand	89.632.359	45.040.808	28.417.600	15.063.748

Source: NSDM, Directorate of Mineral Resources Inventory, 2003

Table of Contents

Generally, the iron content can reach up to 58% Fe, but TiO_2 content is approximately 12%. Being processed as a raw material in iron-steel industries as research did, titanomagnetite-contained iron sand became favorable in such of industries. In addition, titanomagnetite contained iron sand would be prospective economically since it produces ferrotitanium and the high-priced titanium white powder as by product. International trading requires iron sand mineral containing ilmenite 34-40 % TiO_2 and 98 % TiO_2-contained rutile. Ilmenite and rutile are used in pigment industry. Meanwhile, titanium itself is used in military aircraft industry.

3.3.2. Lateritic Iron Ore Characteristic

Lateritic iron deposit was formed by chemical process through ultra base rock weathering process. Yet, the existing sediment has not contributed to commercial steel industries. The amount of Indonesia's lateritic iron ore potency is 1,151,369,714 tons, and resource is 215,160,000 tons (Setiawan, et.al., 2004).

Nowadays, lateritic iron ore is known as nickel mine's iron cap. This type of iron mineral has low iron content; consequently it has not been utilized yet as raw material for steel industries. Regarding iron scarce resulted from China high demand of resources, PT Krakatau Steel has to search local raw material, which is droved to collaborate with PT. Antam and PT. Sebuku Alam cooperating in lateritic iron mining. This collaboration proposes to process iron as nickel processing's by product. Lateritic nickel resources potency and reserves of PT. Antam Tbk. are approximately 240 million tons and 21.6 million tons respectively as shown in Table 6 (Annual Antam Report, 2003).

3.3.3. Primary Iron Ore Characteristic

This type of iron ore is well-known as primary iron deposit; a result of metamorphoses contact with intrusion rocks. Indonesia's primary iron ore potency is about 76 million tons. However, it has not been utilized yet, leads to import raw material dependence (Setiawan, et.al., 2004).

Table 6. Antam' s reserves & resources, December 2001

Location	Reserves		Resources	
	m wmt	Ni %	m wmt	Ni %
Saprolite :				
Pomalaa	2.21	2.34	0.87	2.37
Gebe	3.14	2.27	2.91	2.60
Halmahera-Buli	22.72	2.47	96.68	2.40
Gee	4.36	2.25	-	-
Obi	-	-	6.11	2.37
Bahubulu	-	-	19.33	2.50
Total Saprolite	32.43	2.42	125.27	2.40
Limonite:				
Pomalaa	-	-	-	-
Gebe	3.54	1.47	4.18	1.68
Halmahera-Buli	15.15	1.45	122.27	1.40
Gee	2.28	1.51	-	-
Obi	-	-	25.25	1.51
Bahubulu	-	-	58.50	1.50
Total Limonite	20.97	1.46	210.20	1.40
Gag Island (JV–BHP-B)	-	-	240.0(dmt)	1.36
Weda Bay (JV-Strand)	-	-	204.00	1.37

Antam's Nickel Tenements as per October 2002:

Antam (KP)	JV(CoW)	Total
16 152,116 ha	2 133,636 ha	18 285,752 ha

3.4. The Prospects of Indonesia Iron Minerals

3.4.1 Primary Iron Ore

Since primary iron ore contains metallic iron in significant amount, it is ready to process in steel industries which consume almost 98% of total iron ore produced.

Raw material for steel making is still imported due to some reasons:

1. Iron sand is not suitable for existing blast furnace process, but it has an opportunity to be processed by New Zealand (Ausmelt process), or by direct melting process.
2. High potential lateritic iron ore can be divided into two groups: lump ore and fines/clay ore; its utilization is still ongoing research even though its exploitation has already started.
3. Primary iron ore has been beneficiated using blast furnace process (Lampung small blast furnace), however the potential and resource are low.

Iron ore is the source of primary iron for the world's iron and steel industries. It is therefore essential for the production of steel, which in turn is essential to maintain a strong industrial base. Iron ore is mined in about 50 countries. The seven largest of these producing countries account for about three-quarters of total world production. Australia and Brazil together dominate the world's iron ore exports, each having about one-third of world total exports.

In order to increase the beneficiation of iron ore resources, formerly in the first year of its independence, Indonesian government planned to develop iron and steel industries in collaboration with foreign countries such as West Germany, Russia (Soviet Union), UNIDO. Team works had been formed comprising of government institution, research and development institutes, and universities to do research in iron ore utilization.

The utilization of iron in Indonesia can be described from the iron consumption per capita which is lower than other developing countries. Indonesia's steel consumption is about 26 kg per capita (http://members.bumn.go.id/ptkrakatausteel/news.html?news_id=16870, 2007).

Since the current Indonesia steel industries stated that the ability of steel industrial production is still depend on imported iron ore, the potency of iron minerals has to be developed. This leads to develop local raw material, forbid exported high grade iron ore, set up technology suitable for the local resources, and replace imported raw material for steel making by PT Krakatau Steel. PT. Krakatau Steel's long term business plan in supply raw material is shown at Figure 4.

According to Setiawan et.al. (2004), national crude steel capacity is 6.5 million tons per year which requires 8 million tons per year of raw materials, including steel scrap and sponge iron. The production of sponge iron has capacity of 2.3 million tons per year.

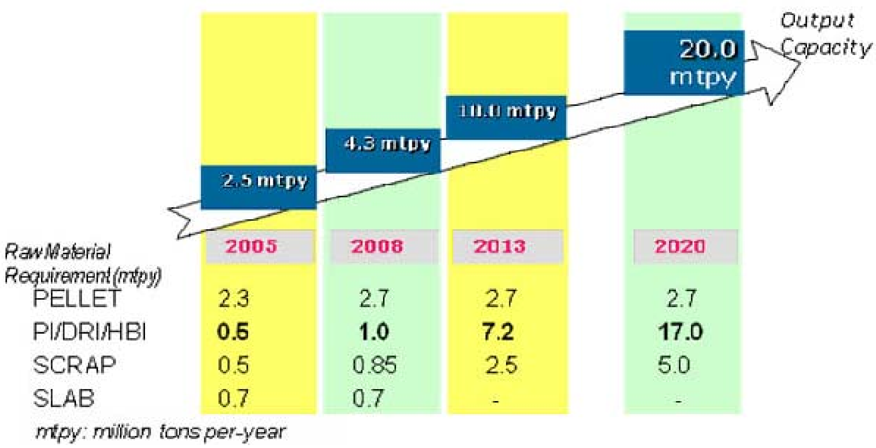

Figure 4. PT. Krakatau Steel long term business plan (material planning)

If it is assumed that steel scrap takes 10 % in steel making's raw material and steelmaking industries are running at full capacity, it can be calculated that sponge iron requirement will be 5.85 million tons per year (90% x 6.5 mill. tons/year). Thus, the sponge iron shortage for crude steel making will be 3.55 million tons per year.

To meet national crude steel capacity (6.5 mill. tons/year) and national sponge iron production capacity (2.3 mill. tons/year) that needs 4.5 million tons of primary iron ore (hematite or magnetite) (Setiawan, et.al., 2004), so the amount of primary iron ore that should be supplied to cover the sponge iron shortage will be 6.94 million tons per year. By using the data given by the Ministry of Industry, the exploitation activities can be estimated for 52 years (362,564,042 tons/6,940,000 tons per year).

Indonesia lies at rank 37 of major steel producing countries in 2005 and 2006 (http://www.worldsteel.org/?action=story pages&id=23&subId=195,2007). It gives a signal that the iron mineral resources potency has not been empowered yet. The position of each country is shown in Table 7.

The condition of world's steel supply and demand gives Indonesia an opportunity to vivid and improve national steel industries, because the major steel producing countries are also tremendous steel consuming countries, as depicted in Figures 5 and 6. (http://www.worldsteel.org/?action= storypages &id=23&subId=199, 2007).

The national steel production is seemed to be unsatisfactory because Indonesia still lacks of steel products in the market, thus affecting the supply and demand condition. This condition is shown in Figure 7 (http://www.wartaekonomi.com/indikator.asp?aid=7211 &cid=25,2007).

To forecast the future prospect of steel industries business, all preceding data and economic indicators should be considered such as inflation, average economic growth, etc.

With the inflation assumption of 6.0 - 7.5 in 2006, the economic growth 5.8 %, steel production growth 5 % and steel consumption rate 6 %, a hypothetical prediction of future national steel industries' business can be presented in Table 8 and Figure 8.

Table 7. Major steel-producing countries, 2005 and 2006

Country	2006		2005	
	rank	mmt	rank	mmt
China	1	422.7	1	355.8
Japan	2	116.2	2	112.5
United States	3	98.6	3	94.9
Russia	4	70.8	4	66.1
South Korea	5	48.5	5	47.8
Germany	6	47.2	6	44.5
India	7	44.0	7	40.9
Ukraine	8	40.9	8	38.6
Italy	9	31.6	10	29.3
Brazil	10	30.9	9	31.6
Turkey	11	23.3	11	21.0
Taiwan, China	12	20.2	13	18.9
France	13	19.9	12	19.5
Spain	14	18.4	14	17.8
Mexico	15	16.3	15	16.2
Canada	16	15.4	16	15.3
United Kingdom	17	13.9	17	13.2
Belgium	18	11.6	18	10.4
Poland	19	10.0	21	8.3
Iran	20	9.8	20	9.4
South Africa	21	9.7	19	9.5
Australia	22	7.9	22	7.8
Austria	23	7.1	23	7.0
Czech Republic	24	6.9	26	6.2
Netherlands	25	6.4	24	6.9
Romania	26	6.3	25	6.3
Egypt	27	6.0	28	5.6
Argentina	28	5.5	29	5.4
Sweden	29	5.5	27	5.7
Malaysia	30	5.5	30	5.3
Thailand	31	5.4	31	5.2
Slovakia	32	5.1	34	4.5
Finland	33	5.1	33	4.7
Venezuela	34	4.9	32	4.9
Kazakhstan	35	4.2	35	4.5
Saudi Arabia	36	4.0	36	4.2
Indonesia	37	3.8	37	3.7
Luxembourg	38	2.8	39	2.2
Greece	39	2.4	38	2.3
Byelorussia	40	2.3	40	2.0
Bulgaria	41	2.1	41	2.0
Hungary	42	2.1	42	2.0
Others		23.3		21.9
World		1,244.2		1,141.9

Source: International Iron and Steel Institute

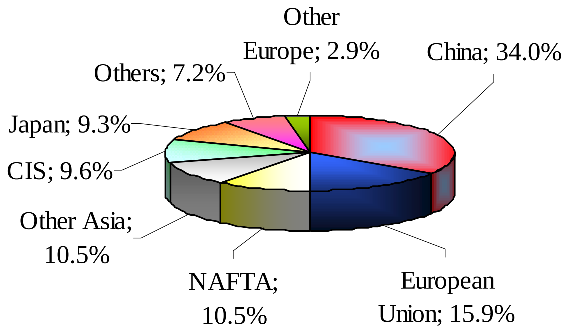

Figure 5. The composition of steel produced by major steel producer countries, 2006

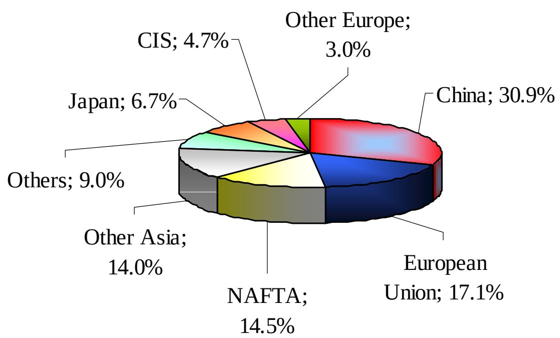

Figure 6. The composition of steel consumed by countries, 2006

Figure 7. Indonesia steel production and consumption (modified from www.wartaekonomi.com)

In addition, based on Indonesia crude steel capacity (6.5 million tons per year), the future used capacity can be predicted, taken from the steel production per year divided by national crude steel capacity. As shown in Figure 9.

Figure 9. shows that in 2020, the used capacity of national crude steel production would approximately reach the utilized capacity of national crude steel production. The assumption is based on the constant capacity of national crude steel production, and no vigorous investment or expansions on national steel industries in the next 18 years.

Developing steel industries, new factory or adding capacity in the future depends on many aspects including resources, availability of the energy, facilities, man power, and policy. Resources would relate to technology which is suitable to ore types. The waste will be an important concern since it would be constructed close to public domain. The supporting facilities play an important role, such as transportation, energy, waste, etc. In addition, iron ore business is still attractive since the risk of the business is quite low and earning before interests and taxes (EBIT) is quite high relative to the others as shown in Figure 10.

However, the national primary iron ore reserves have not been processed intensively, because the resources are available in scattered area among the land of Indonesia (Tambang Magazine, 2007).

3.4.2 Iron Sand

Recently, iron sand in Indonesia is used for cement industries. In 1999, it reached 544,000 tons and finally decreased to 245,409 tons in 2003 (Table 9). The decreasing volume is likely as an impact of copper slag substitution, i.e. Gresik copper smelter's by product which acquired their concentrates from PT. Freeport and PT. Newmont Nusa Tenggara.

Cilacap iron sand had been mined since 1971 and exported to Japan until 1978. This leads to its lower resources.

The plan to explore iron sand in Yogyakarta was begun in 1971 by PT Aneka Tambang in collaboration with Directorate of Geology. The study had been accomplished by Davy McKee to produce iron and steel, similar to technology to process iron sand in New Zealand. In 1981, a team work had been formed to study in preparing pellet from

Table of Contents

Table 8. Future prediction of Indonesia steel (ton)

Year	Production	Consumption	Steel Shortage	Sponge Iron Requirement	Steel Scrap Requirement	Primary Iron Ore Requirement
2001	2,160,000	3,250,000	1,090,000	2,392,615	265,846	4,681,204.01
2002	2,270,000	3,560,000	1,290,000	2,514,462	279,385	4,919,598.66
2003	2,040,000	3,180,000	1,140,000	2,259,692	251,077	4,421,137.12
2004	2,410,000	4,200,000	1,790,000	2,669,538	296,615	5,223,010.03
2005	3,120,000	4,300,000	1,180,000	3,456,000	384,000	6,761,739.13
2006	3,276,000	4,558,00	1,282,000	3,628,800	403,200	7,099,826.09
2007	3,439,800	4,831,480	1,391,680	3,810,240	423,360	7,454,817.39
2008	3,611,790	5,121,369	1,509,579	4,000,752	444,528	7,827,558.26
2009	3,792,380	5,428,651	1,636,271	4,200,790	466,754	8,218,936.17
2010	3,981,998	5,754,370	1,772,372	4,410,829	490,092	8,629,882.98
2011	4,181,098	6,099,632	1,918,534	4,631,371	514,597	9,061,377.13
2012	4,390,153	6,465,610	2,075,457	4,862,939	540,327	9,514,445.99
2013	4,609,661	6,853,547	2,243,886	5,106,086	567,343	9,990,168.29
2014	4,840,144	7,264,760	2,424,615	5,361,390	595,710	10,489,676.70
2015	5,082,151	7,700,645	2,618,494	5,629,460	625,496	11,014,160.54
2016	5,336,259	8,162,684	2,826,425	5,910,933	656,770	11,564,868.56
2017	5,603,072	8,652,445	3,049,373	6,206,479	689,609	12,143,111.99
2018	5,883,225	9,171,592	3,288,366	6,516,803	724,089	12,750,267.59
2019	6,177,387	9,721,887	3,544,500	6,842,644	760,294	13,387,780.97
2020	6,486,256	10,305,200	3,818,944	7,184,776	798,308	14,057,170.02
2021	6,810,569	10,923,512	4,112,944	7,544,015	838,224	14,760,028.52
2022	7,151,097	11,578,923	4,427,826	7,921,215	880,135	15,498,029.95
2023	7,508,652	12,273,658	4,765,006	8,317,276	924,142	16,272,931.44
2024	7,884,085	13,010,078	5,125,993	8,733,140	970,349	17,086,578.02
2025	8,278,289	13,790,683	5,512,394	9,169,797	1,018,866	17,940,906.92

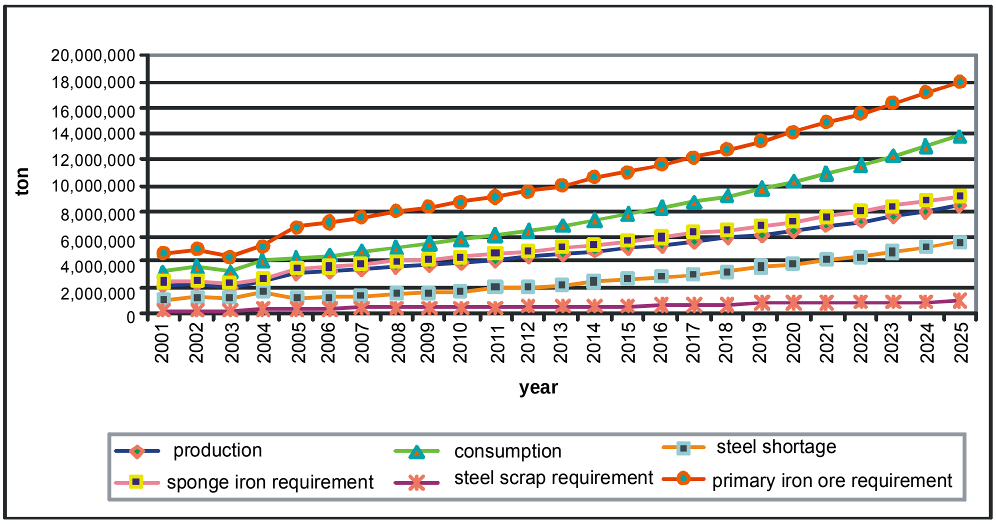

Figure 8. Prediction of future Indonesian steel industries future prediction

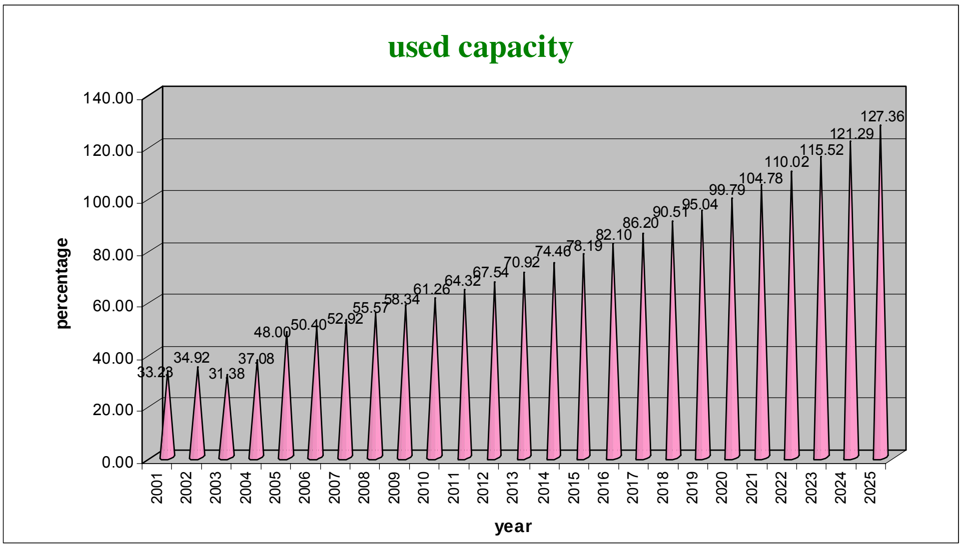

Figure 9. Prediction of national steel industries used capacity

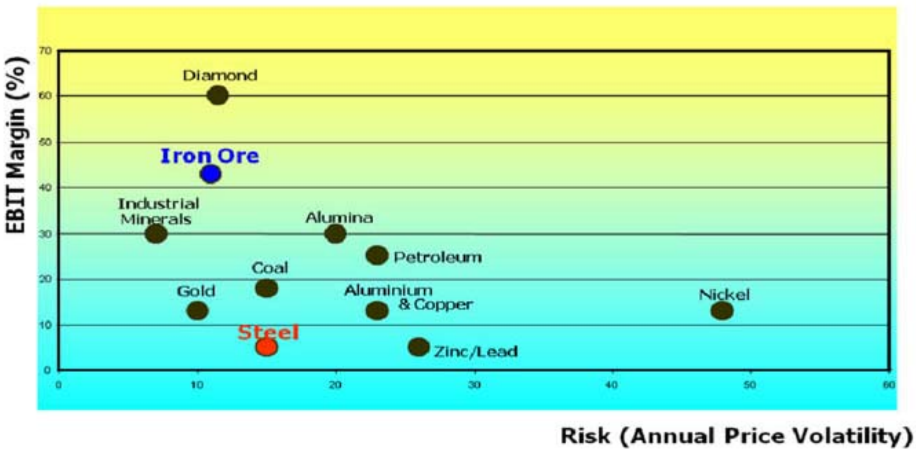

Figure 10. EBIT margin (%) vs risk (annual price votality) for some energy and mineral industries

Table 9. Sale and production of iron sand (ton)

	1999	2000	2001	2002	2003
Production Sales	584,428 496,202	489,126 403,099	469,377 439,326	378,587 340,459	245,409 108,555

iron concentrate to use as raw material for PT Krakatau Steel.

In 1991, a feasibility study of Kutoarjo iron sand had been accomplished, collaboration with Australia using Ausmelt Technology. For small scale industries, it is expected that iron minerals could be processed to yield up to 300,000 tons of pig iron per year from 600,0000 tons of iron sand concentrate.

By assuming the annual growth of cement production is 8 % (optimistic vision), and iron sand consumption is 3 %, by ignoring the effect of copper slag substitution then the projection of iron sand consumption for cement industries is shown Table 10, Figure 11 and 12.

Based on the prediction, it seemed that the iron sand utilization in cement industries is very low, so it is more profitable to be used by iron sand-

Table 10. Estimation of Cement Production and Iron Sand Consumption

Year	Cement Production	Iron Sand Consumption
2007	37,000,000	1,110,000
2008	39,960,000	1,198,800
2009	43,156,800	1,294,704
2010	46,609,344	1,398,280
2011	50,338,092	1,510,143
2012	54,365,139	1,630,954
2013	58,714,350	1,761,430
2014	63,411,498	1,902,345
2015	68,484,418	2,054,533
2016	73,963,171	2,218,895
2017	79,880,225	2,396,407
2018	86,270,643	2,588,119
2019	93,172,294	2,795,169
2020	100,626,078	3,018,782
2021	108,676,164	3,260,285
2022	117,370,257	3,521,108
2023	126,759,878	3,802,796
2024	136,900,668	4,107,020
2025	147,852,721	4,435,582

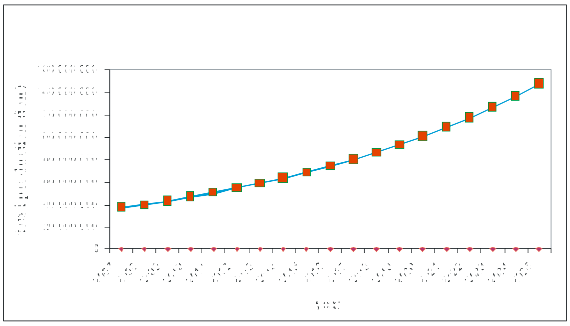

Figure 11. Projection of national cement production in Indonesia

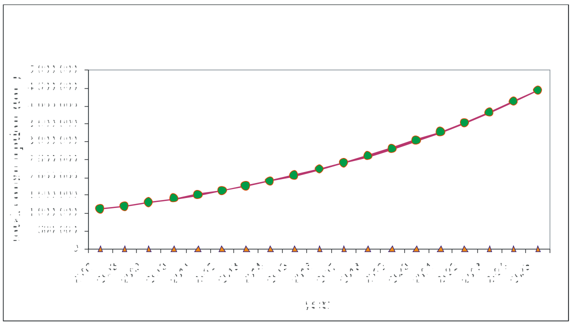

Figure 12. Projection of national iron sand consumption for cement industries in Indonesia

steel making industries. However, the iron content in iron sand is low (45 - 48 %) and needs upgrading (63 % minimum) to meet the requirement for iron-steel making industries (Setiawan, et.al., 2004). This problem can be solved by the application of direct reduction smelter process of NZ-Steel.

3.4.3. Lateritic Iron Ore

Lateritic iron ore (as limonite) is known as nickel mines over layer or overburden. This type of iron mineral has low iron content; consequently it has not been utilized yet as raw material for steel industries. However, in the future development plan, due to the escalating nickel price in the global market, both of PT. INCO and PT. Antam Tbk will implement hydrometallurgy process for the limonite ore which is lower cost in energy as well as capable to treat lower content of nickel in the ore. In addition, limonite is seemed to be high in potency since it can be used for coal liquefaction catalyst.

The limonite is mined about 10 million tons per annum as an overburden of the nickel ore. It contains 40 – 50 wt% of moisture but the content does not change even in the dry season or the rainy season (Agency for the Assessment and Application of Technology, 2002).

Soroako limonite is classified at PT. INCO as follows:

1. Medium grade limonite (MGL): nickel up to 1.6 % and iron over 30 %.
2. High grade limonite (HGL): nickel up to 1.6 % and iron over 45 %.
3. Overburden (OB): nickel up to 1.6 % and iron up to 30 %

These limonite have 1 wt% of nickel, and it was found that Soroako limonite have superior catalytic activity than other limonite found in Australia. Figure 13 gives a sketch of limonite layers on nickel deposit in Soroako, South Sulawesi, the other hand Table 11 shows the characteristics of the Soroako limonite catalyst.

Catalytic activity of iron compounds, such as pyrite, limonite, laterite, red mud, and iron sand, have been studied for a long time (Pratt, et al., 1982) and all of them have been used in many coal liquefaction process. Recent studies showed that limonite from Soroako Indonesia exhibits superior in catalytic activity and are likely candidate as a suitable catalyst (Kaneko, et.al., 2002).

However, limonite is also as a potential source of nickel and steel industries. As a consequence other iron based compounds should be taken into account, for example iron sand and red mud. It is known that, iron sand is used in cement industry. Only red mud has not been utilized properly. Unfortunately, in terms of catalytic activity red mud is the lowest compared to other iron compounds, leading to lower oil yield. Therefore it is important to develop a new method in order to improve catalytic activity of red mud. PT Antam is constructing bauxite processing plant with capacity of 300,000 tons, and about 300,000 ton red mud would be yielded as by product.

According to coal liquefaction commercialization road map, initiated by Research and Development Centre for Mineral and Coal Technology (*tek*MIRA), the limonite resources requirement can be seen at Figure 14.

The potencies of Indonesia lateritic iron ore are not merely rely on limonite availability but also on other types of lateritic iron ore such as saprolite, pyrite, and peridotite.

Research and Development Centre for Mineral and Coal Technology (*tek*MIRA) has finished their research on the possibility of improving the iron content and eliminating the impurities of Pomalaa lateritic iron ore. The final result was restricted to the impurities content (SiO_2, Al_2O_3) which were still high (above 3 %) (Aziz, et.al., 2006). Lateritic iron ore has been processed by PT. Antam Tbk in the form of saprolite and limonite as shown in Figure 15 (PT. Antam Annual Report in 2004).

It is predicted that up to 2025, the limonite requirement for coal liquefaction can not be comparable to the need of iron mineral as raw material for steel industry (Figure 16). In addition, the competitive of limonite uses in the future is suggested by the nickel production since limonite presents with saprolite.

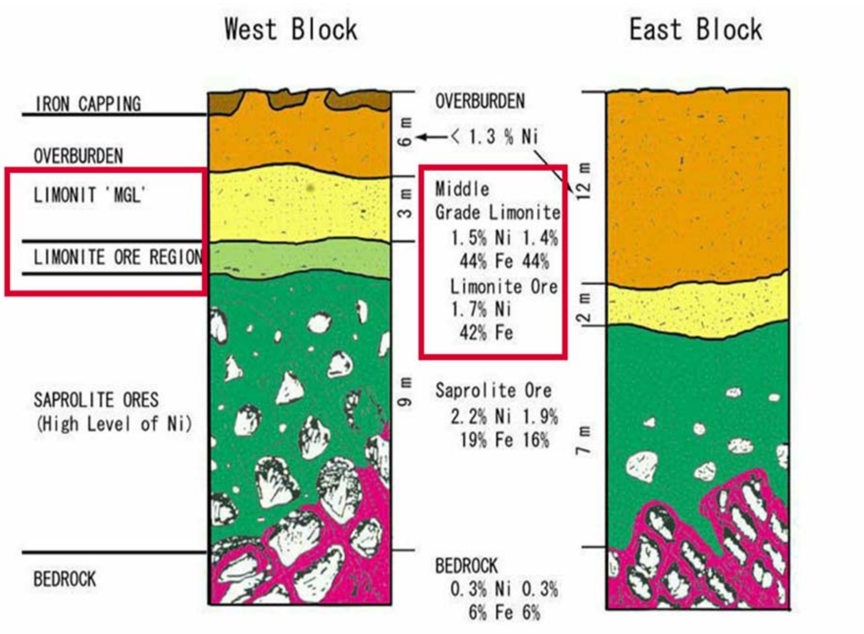

Figure 13. Limonite layers on nickel deposit in Soroako, South Sulawesi

Table of Contents

Tabel 11. Metal Composition of Soroako Limonite Catalyst

	Metal composition (wt% dry)				Activity (wt% daf)*			
Limonite	Total Fe	Si	Al	Ni	Co	Cr	Oil yield	Δ H_2
Sprpako								
HGL	45.4	0.60	7.08	0.88	0.02	1.38	47.2	4.7
MGL	45.5	0.78	5.95	1.33	0.09	1.16	49.7	4.9
OB	41.4	1.68	6.06	1.65	0.08	1.45	43.9	4.3
Yandi Yellow	55.6	2.32	1.41	<0.01	<0.01	42.8	4.8	

* Liquefaction of Banko coal: 12MPa H_2, 450°C, 2h, cart, 1 wt% daf, S/Fe=2.0

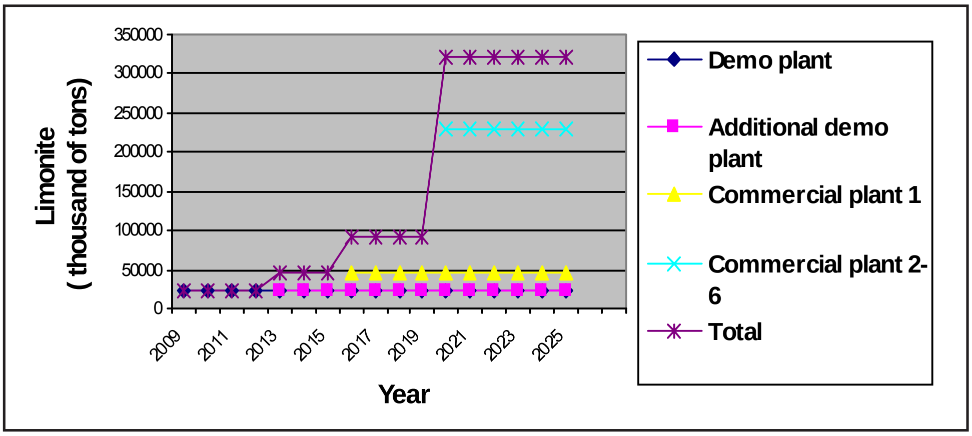

Figure 14. The projection of Indonesia limonite consumption for coal liquefaction

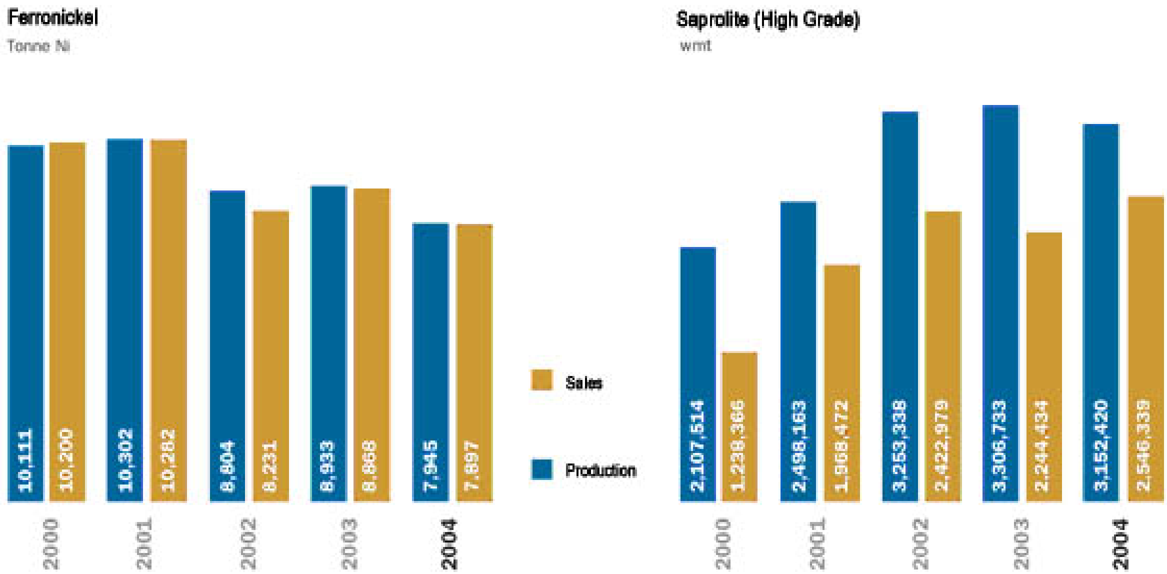

Figure 15. Sales and production of ferronickel and saprolite nickel ore, PT. Antam Tbk, 2004

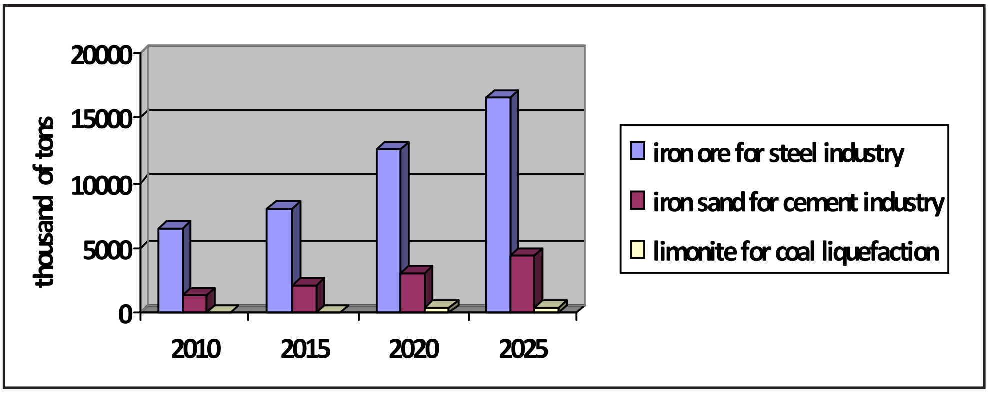

Figure 16. Prediction of iron minerals consumption

4. CONCLUSION

1. Indonesia has great iron mineral resources, comprising primary iron ore, 17 %, iron sand, 8 %, and lateritic iron ore, 75 %

2. Current condition of iron minerals beneficiations are directed to:
   a. cement industries, using iron sand as raw material.
   b. coal liquefaction project, using lateritic iron ore, especially limonite as catalyst.

   In the future, the limonite will not be used as raw material for steel industries. Nickel industries would have possibly improved limonite as nickel source which in turn, produce iron oxide as their by product (so far, iron oxide has not been researched as coal liquefaction catalyst intensively).

   Meanwhile, primary iron ore (hematite, magnetite) have not been empowered yet, due to the scattered area of the resources locations.

   In addition, there is a constraint in empowering national iron low iron content (45 – 48 %), whereas the iron content requirement for iron-steel making industries prerequisite is 63 % minimum.

3. To improve national iron mineral resources, subsequent research on adding value to national lateritic iron ore reserves is still needed to support national iron-steel industries more profitable and promising as well as coal liquefaction industry.

5. SUGGESTION

Indonesia should optimize the primary iron ore potency although it is scattered at amount of regions because dependences on imported iron ore must be eliminated. Having 362,564,042 tons of primary iron ore deposits, it can be predicted that exploitation will operate in 52 years.

Research on coal liquefaction catalyst should be done immediately related to the use of red mud (bauxite processing's by product at Tayan, West Kalimantan), and iron oxide (residue of limonite based-nickel extraction) through hydrometallurgical process. Since iron oxide residues are associated with waste, it will be disposed to the sea by nickel industries.

REFERENCES

Agency for The Assessment and Application of Technology, New Energy and Industrial Technology Development Organization, 2002. *Feasibility Study on Direct Liquefaction of Banko Coal in Indonesia*.

Anonymous, 2007. *Konsumsi Baja Nasional Bakal Naik Tahun Depan*, http://members.bumn.go.id/ptkrakatausteel/news.html?news_id=16870, accessed on September 18, 2007.

Anonymous, *Major Steel-Producing Countries* http://www.worldsteel.org/?action=storypages&id=23&subId=195, accessed on September 17, 2007.

Anonymous, *Steel Production and Consumption: Geographic Distribution, 2006*. http://www.worldsteel.org/?action= storypages&id =23&subId=199, accessed on September 17, 2007.

Anonymous, *Industri Baja: Defisit Mengancam*, http://www.wartaekonomi.com/indikator.asp?aid=7211&cid=25, 2007. accessed on September 18, 2007.

Azis, M., Pramusanto, Nuryadi, S., Yuhelda, D., Dessy, A., Soma, S., 2006. *Pengolahan Mineral Besi Laterit, Pomalaa*, Bandung: Research and Development Centre for Mineral and Coal Technology.

Kaneko T., et.al. 2002. "Highly Active Limonite Catalysts for Direct Coal Liquefaction", *Fuel 81,* 1541-1549.

Ministry of Industry of the Republic of Indonesia Directorate of Metal Industri Directorate General of Metal, Machine, Textile, and Common, 2007. *Focus Group Discussion: Pengembangan Industri Baja Hulu Berbasis Sumber Daya Mineral*.

Pramusanto, 2006. *Mewujudkan Industri Besi dan Baja dengan Mengutamakan Bahan Baku Lokal*, Orasi Pengukuhan Profesor Riset, Bandung: Puslitbang Teknologi Mineral dan Batubara, ISBN: 979-8641-59-2.

Pratt, K.,C. and Christoverson, V., 1982. Hydrogenation of a model hydrogen-donor system using activated red mud catalyst, *Fuel 61,* 460.

Setiawan, B., Bambang Pardianto, Dwi Nugroho Sunuhadi, 2004. Mineral dan Batubara: Peluang Pemanfaatan Bijih Besi di Indonesia, *Mining & Energy Vol. 2.*

Tambang Magazine, 2007. April Edition, *Merah Putih Mengerek Pasar*.