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Transport Economics of Coal Resources in South Sumatra, Indonesia

by

Bobby Hardian

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To The Super Womans,

My Mother and My Wife.

Voormijn Moeder en mijn Vrouw

Abstract

Indonesia is one of the biggest steam coal exporters in the world especially contributed by the export from Kalimantan that contributes 48% of total coal resources in Indonesia and 45% of the resources are still available in South Sumatra. However, of all the resources, only 5% are made available for export and the bottleneck is on the transportation. Existing transportation system had limitation capacity due to enormous increase for Indonesia's coal demand.Several scenarios of transport method are discussed in the hope to increase the supply capacity for domestic needs and export, with respect to South Sumatran geographical condition. If the coal must find the least-cost solution, the transportation of coal from South Sumatra, for example to China, appears to be economical; supported by the Musi River which is nearby to the seaport.

Table of Content And Appendices

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Background of the Study

Energy is very important for human life and coal has a major role to play to meet the need of our future energy, coal usually use for power plant, fuel for electricity, steel production and cement manufacturing (World Coal Institute, 2009).

Indonesia has 105 billion tons of coal resources, where 45% of the total resources are available in the South Sumatra and 48% in Kalimantan (see table 1.1.1). Until January 2009, Indonesia mined 256 Million tons of coal where 77% of the coal is exported mostly to Japan,Taiwan,Korea and European countries, the rest 23% of production is used in domestic for the power plant (Center for Data Information on Energy and Mineral Resources, 2010).

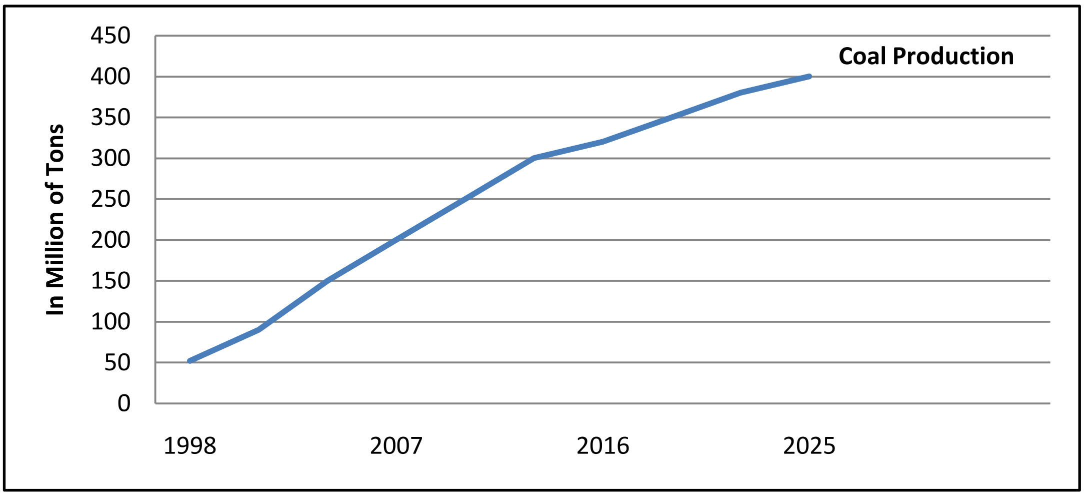
Table 1.1.1 Coal Resources In Indonesia (in Million Tons)

	Province	Resources				
		Hypothetic	Inferred	Indicated	Measured	Total
1	Banten	5.47	5.75	0	2.09	13.31
2	West Java	0	0	0	0	0
3	Central Java	0	0.82	0	0	0.82
4	East Java	0	0.08	0	0	0.08
5	Nanggroe Aceh	0	346.35	13.40	90.40	450.15
6	North Sumatra	0	7.00	0	19.97	26.97
7	Riau	12.79	467.89	6.04	1,280,82	1,767.54
8	West Sumatra	24.95	475,94	42.72	188.55	732.16
9	Bengkulu	15.15	113.09	8.11	62.30	198.65
10	Jambi	190.84	1,462.03	243.00	173.20	2,069.07
11	South Sumatra	19,909.99	10,970.04	10,321.10	5,883.94	47,085.08
12	Lampung	0	106.95	0	0	106.95
13	West Kalimantan	42.12	482.60	1.32	1.48	527.52
14	Central Kalimantan	122.72	974.70	17.33	471.89	1,586.34
15	South Kalimantan	0	5,525.16	362.59	6,377.81	12,265.56
16	East Kalimantan	14,212.67	11,068.56	4,775.42	7,684.72	37,721.37
17	South Sulawesi	0	144.94	33.09	53.09	231.12
18	Rest of Indonesia	91.53	66	0	0	157.53
	Total	**34,628.24**	**32,217.61**	**15,804.12**	**22,290.26**	**104,940.22**

Source : Center for Data Information on Energy and Mineral Resources, 2010

The acceleration of the industrial sector has increased domestic electricity consumption in Indonesia. The Indonesian government is planning to develop more powerplants to meet ends need, meaning that the coal demand for domestic necessities also needs to be improved. The Zacks investment research estimates that for the next 20 years, there will be more than 3 (three) billion tons of coal demand in Asia, and the necessity is expected to be supplied mostly from Indonesia (Sourcewatch, 2010). Yoshihiko Nakagaki, the Chairman of Japan Coal Energy Center on the APEC Clean Fossil Energy Seminar in 2009, presented the demand projection of Indonesian coal production as found in figure 1.1.1 below:

Figure 1.1.1 Consumer Expectation of Indonesia Coal Production p.a. based on Japanese Study



Source: Nakagaki, 2009

World coal market will be more stringent at least until 2020 as a result of an increasing demand from the world's two giant countries; China and India for power generation. Moreover, China's coal export restrictions by its government since 2008 through the implementation of the coal export tax by 10% in anticipation of increased demand for coal within China will further reduce China's coal exports (Miranti, 2008).

According to International Energy Agency (2007) projections, 72% of world coal consumption by 2030 will be dominated by China and India. Barlow Jonker estimates that coal import to India will reach more than 50 Million tons by 2020 and China's coal import reaches 150 to 230 Million tons in the same year.The largest export for Indonesian coal markets are Japan, South Korea, and Taiwan, while China and India posed as new buyers for Indonesia. The increasing demand from China and India in the future, will further increase the chance for Indonesia to boost export market share through both countries (Barlow Jonker, 2011).

The current bottleneck are concentrating in the low quality of internal transportation and port infrastructure. The potential of using the riverways and improvement in the railway capacity in the province of South Sumatra has become potential options.

General Manager of Indonesian Port Corporation II in Palembang mentions in Media Indonesia online news that the low productivity is not due to the incapability of mining companies to produce more coals. The case is simply caused by the fact that transportation of coals is difficult. Currently around 9,5 to 12 Million tons per year of coal is transported by the combination of both railway and truck, whereas barge usage through Musi River could bring more weight, but it is yet to develop (Media Indonesia, 2010).

1.2 The Objective of The Study and Data Collection

This research is aimed at assessing the options to transport coal in South Sumatra and finding the least-cost solution for the issue. Data-collection method applied is through the non-survey approach or secondary data obtained from the institutions in Indonesia related to the coal industry such as the data from Ministry of Energy and Mineral Resources, Indonesia Coal Mining Association, Indonesia Port Corporation II Palembang Branch *(PT Pelabuhan Indonesia II)*, Bukit Asam Mining Corporation *(PT Tambang Bukit Asam),* Indonesia Railway Corporation (*PT Kereta Api Indonesia).* Secondary data also obtained from international institutions related to the coal industry such as World Coal Institute, British Petroleum, International Energy Agency (IEA), Coal Trans Group and others. The primary data or information obtained from interviews with the experts such as General manager of Indonesia Port Corporation II and staffs, also Indonesia Railway Corporation staffs. The primary and secondary data organized in such a way that they are more readable and understandable to provide representative information in analytical work, together with the literature study from the previous coal researches such as preliminary study of coal transportation in Kalimantan provided some data to find the least-cost solution.

1.2 Research Questions

There are looming research questions demanding answers; what is the prospect and opportunity for South Sumatran coal? How is the current transport system enable to transport coal? What are the alternative scenarios of transport system that can be offered? Which scenario would give the least-cost solution? The focus of this study is to assess several coal transport options, choose the least-cost solution.

1.4 Methodology

In order to answer the question about the prospect and opportunity for South Sumatran coal, it is imperative to study the domestic coal demand for electricity generation by seeing the demand for the current domestic power plant and the new proposed power station construction by Indonesian government. For the export side, we will elaborate the study about the prospect for the main Indonesia coal consumer (Japan and Taiwan) and the opportunity to get the new consumer such as India and China. We will also use the secondary data from Indonesia Ministry of energy and Mineral and several report which produce by the institution and consultant firm which related to the coal researched such as world coal institute, IEA, British Petroleum, Barlow Jonker, Price Waterhouse Cooper and other web resources.

In order to answer the question on the current transport system and the alternatives transport scenario, the benchmarking from Kalimantan transport system and other similar system in the world will be used and then the secondary data from Indonesia Railway Corporation will also be examined. The interview with the general manager and staff of Indonesia Port Corporation II, staff of Indonesia Railway Corporation, staff of Thiess Contractors Indonesia will clarify the interpretation of the transport options. To find the least-cost solution, each of the options will be assessed by comparing the advantages and disadvantages of each option, then information about the least-cost solution from the secondary data and interview will be resumed, and analysis of benchmark will be performed from the similar business criteria from internet source, the research will be conducted on short environmental impact analysis which will be supported by the environmental and safety staff from Indonesia Port Corporation II and Indonesia Railway Corporation.

1.5 Limitation of The Study

Estimating potential coal production for any given region is a general issue, particularly over a long planning horizon, and this is the case for South Sumatra. Partly this is due to a lack of data and uncertainties regarding accuracy; but also the inherent fact that detailed physical assessments are still the only means of confirming both the quantity of coal underground and quantity that can be extracted. There is also a lack of a universal definition of reserves and resources. Generally, those quantities of coal that are known and recoverable are considered to be (proven) reserves, whereas resources are generally the total amount of coal in existence, whether or not they are technically or economically recoverable at present. Reserves provide a reasonably accurate estimate amount that can be recovered under existing operation and economic conditions. It can be inferred that over time, new mining techniques will be developed, increasing the amount of coal that is mineable. However, for the majority of sites in the study area, reserves are not identified.

Given the relatively limited amount of time available for the Research, a relevant part of the Thesis has been based on existing publications and data. This consideration slightly weakens the analysis as the rarely available information is sufficiently updated and the results obtained original. All possible has been done to update and integrate the material contacting the sources directly, making interviews and making use of web resources. Port infrastructure projects often draw the attention of public opinion. In particular their financing and their necessity are often publicly questioned and debated. The calculation for the transportation cost for each scenario are not counting the effect of time delay or other factor which may increase the cost significantly. The benchmark and assessment which use to determine the amount of transportation cost sometimes not match to the time and condition with in the different place or countries.

Data are vary interms of year, but they do not aimed at comparing the data but merely to show the trend of increase or decrease or to give idea on how much the percentage of coal in a certain situation. The study on the transportation scenario is based on the literature and secondary data which sometimes not match with the real situation. Some of the primary data such as the tariffs and route for coal transportation and the enviromental impact also gathered mostly by interviews with the individual port experts which may, at some points, bias and result different result. However, the study needs a further, in-depth study in order to obtain better results.

1.6 Structure of the Thesis

The structure of the thesis will be presented as follow. In Chapter 1, the determinant of coal and global coal market will be explained. Chapter 2 will continue with the determinant of coal and global coal outlook. Chapter 3 will proceed to the analysis of coal industry in Indonesia: prospects and opportunities. Chapter 4 will explain coal transportation method. Chapter 5 will review existing and alternative scenarios of coal transportation in South Sumatra. Chapter 6 will elucidate Final Conclusion and Recommendation.

Chapter 2 The Determinant of Coal and World Coal Outlook

2.1 Coal Process

Coal is a sedimentary rock in which about 70% of the weight in volume is an organic material. That organic material is generally derived from plants or can be traced from leaves, roots, wood, spores, pollen, resins and others. Furthermore, the organic material continue to a process of putrefaction (decomposition) that cause the physical and chemical change (Rumidi, 2006).

Several theories related to the coal physical and chemical processes; Peat Swamp theory (Peat) –*Autocthon*, isa theory that explains the formation of coal comes from the accumulation of plant remains which is then sealed by the overlying sediments in the same area. And in formation, it must have sufficient geologic time, which then altered the coal stage that began with the formation of peat which then continues with a variety of quality anthracite. The weakness of this theory is that it is not able to accommodate any transportation that a lot of mineral contents in coal. Transport Theory – *Allotocton*, is a theory that reveals the formation of coal is not derived from the degradation or decay of plant remains in a peat bog environment, but the accumulation of the collected material transport in aqueous environments such as lakes, seas, deltas, mangroves. This theory explains that there is a different process for each different types of coal. Geochemical processes and metamorphosis, after formation of source layers, then continue to several processes. The first process is digenesis, taking place in conditions of normal temperature and pressure and also involves biochemical processes. The result is, a process of coal formation will occur, and even be formed in the layer itself. The results of this initial process are peat, lignite or soft material. In this stage of biochemical processes dominate, resulting in a lack of oxygen content. Once the stage is completed, subsequent biochemical processes are dominated by physical and chemical processes that are determined by conditions of temperature and pressure. Temperature and pressure play an important role because of rising temperatures will speed up the reaction, and pressure allows the reaction to occur and produce gas elements. The process of metamorphism (temperature and pressure) is due to accumulation of material at a certain depth or due to movement of the earth continuously in time in the geologic time scale (Rumidi, 2006).

2.2 Coal Mining System and Steps

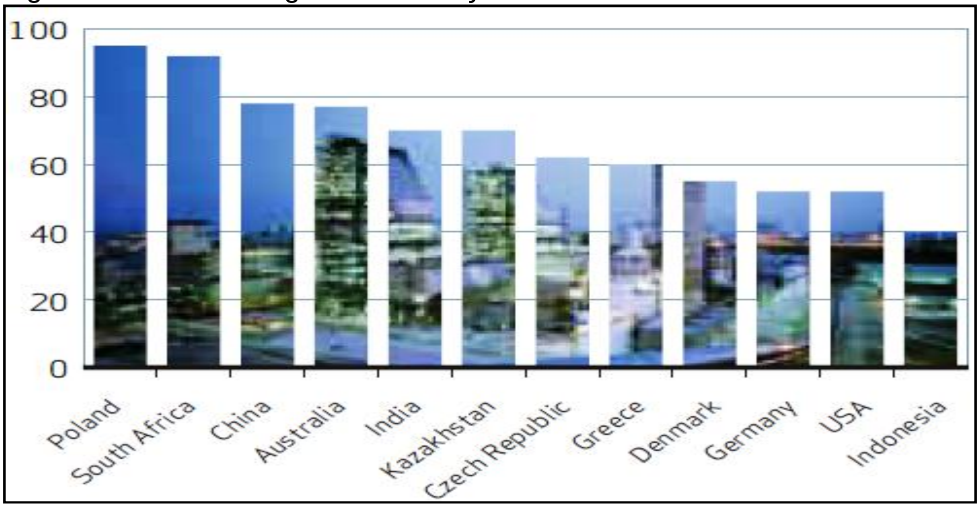
In general, there are two kinds of mining system; Open Pit Mining and Underground Mining System. The difference between them depends on the thickness of the rock or soil which covers the coal to be taken (stripping activity). The more the thickness of the cover, the more cost it will spend in stripping and it will be relatively easier to apply the underground mining system. The Geology factor such us physical factor of the rock or soil in the mining area, the coal seam position in the mining area also determines the way of coal to be take (World Coal Institute, 2009).

The Underground Mining System is divided into 2 (two) main methods. The first method is the Room and Pillar method, where the coal is taken by creating the room between the roof and the coal seam by using pillars and at the end of the mining stage, the roof and pillars which also have the coal proportion is considered to be taken. The second method in the underground system is the Long Wall method which uses more special mechanical equipment in order to take the coal seam within the wall surface. The Long Wall method will need more comprehensive geological plan before initiating mining activities. The Open Pit Mining System is economically used when the coal seam near to the surface area. If the rock or soil that covers the coal is loosen or unconsolidated, then the decision will be made for the Open Pit Mining System, when the position of the coal seam is tilted or straight, it will also decide to choose the Open Pit Mining System (Latif, 2003).

2.3 The Utilization of Coal and its Type

Coal has an important role for human life. Coal is useful as an alternative source of energy to oil and gas. Using coal as energy source had been identified for thousands of years. The Romans used the coal as the source of energy for cooking and burning the steel to create weapons, plates, spoons, and other tools. The discovery of steam engine by James Watt in1769 increased the demand for coal for the first time, especially for producing iron and steel as well as fuel for railway transport. In the 19thcentury, Thomas Alfa Edison developed steam electricity power as energy source to support the discovery of light bulb. Since 1960, coal has influenced the rapid growth in the transportation sector and up to present, coal still plays an important role to meet the needs of the world's electricity, as well asthe large scale of the steel production and cement manufacturing. Electricity becomes a very basic need in human life and can be determined as the key of all of the activities in the modern world. There are several types of coal and one of them is the Thermal coal which is used as power source in the process of electricity generation. Electricity generation from coal can be described as follow: the lump of Thermal coal is transformed into powder then it is put into a special tool to be burned and it will produce hot-temperature gas that when transferred, became a high-pressure steam. The high-pressure steam then used as the driving power for the turbine which rotates at high speed and produces electricity (World Coal Institute, 2009).

Figure 2.3.1 Percentage of Electricity Generated From Coal in Selected Countries

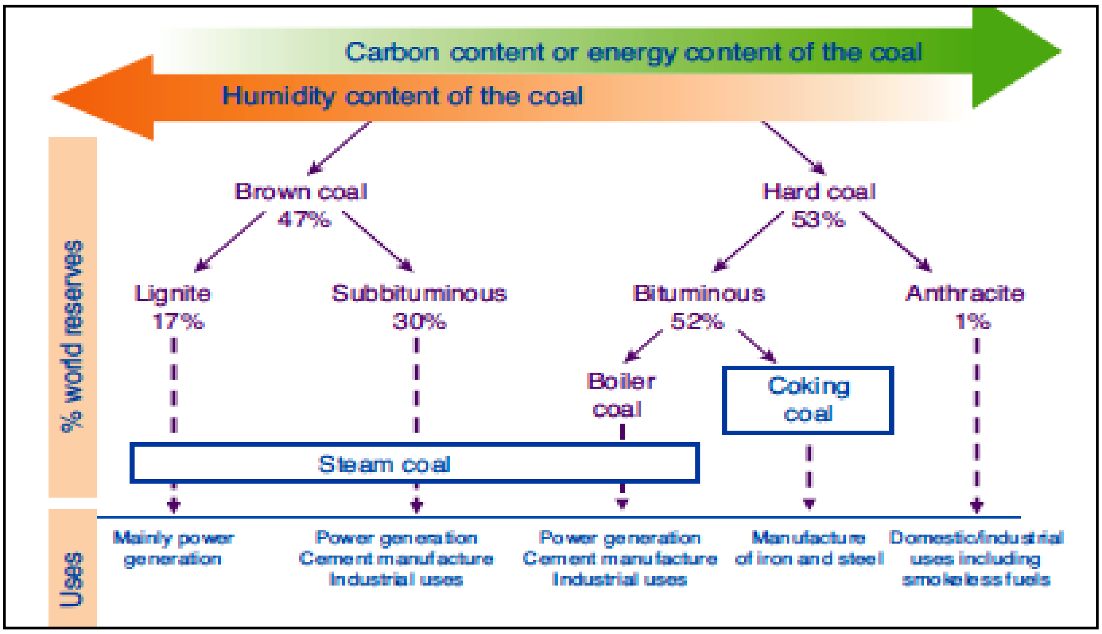


Source : World coal Institute, 2009

The easiness in obtaining the energy does not only provide benefits to economic growth of a country but also, it can improve the quality of life, health, and education in more advanced manners. It can be viewed so, as it was explained in the preceeding paragraph that coal is used as the main source for power plants, steel industry, and cement manufacture and as a liquid fuel.

The type of coal divided into the degree of its maturity (coalification), as seen in Figure 2.3.2 that coal are divided into low rank of coal (47% of world reserves) and hard coal (53% of world reserves). The low rank coal divided into two subcategories, i.e. lignite and sub bituminous. Both coals typically have low energy content. The hard coal or higher rank coal contains more carbon and higher energy content. The hard coal is divided into two subcategories which are Bituminous and Anthracite. The Bituminous is the type commonly used in power plants known as thermal coal or steam coal. The other Bituminous coal is metallurgical which is known by Coking coal and commonly used for the iron and steel manufacturing (World Coal Institute, 2009).

Figure 2.3.2 Types of Coal



Source : World Coal Institute, 2009

Other manufacturing processes using coal for energy mix are paper mills, pharmaceutical, and chemical industries. The coal byproduct also produces some chemical components used in the manufacturing process such as activated carbon, used for water purification; carbon fiber, used in construction, tennis racket and mountain bikes; silicon metal, use for lubricants, cosmetics, and others.

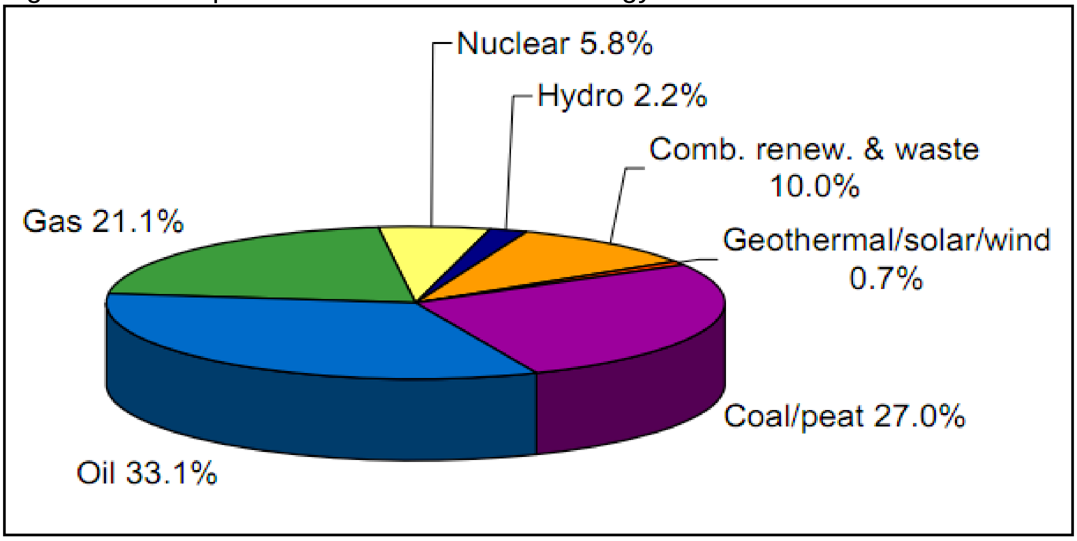
2.4 Global Coal Market

As seen in Figure 2.4.1, nearly a quarter of the world's total primary energy comes from coal energy. At present and during the next decade, coal energy is still expected to be one of the components for the mix of energy in many countries. Economic growth, selection of the energy composition and output of technology will greatly influence the demand for coal. The environmental and energy market reforms are becoming important issues to discuss. Coal market over the next decade is not only dependent to the profile of the coal demand that emerged from these developments but also about the initiatives of the coal producer to be able to prepare and respond to trends which emerge in the future (International Energy Agency, 2010).

Coal plays a better role as a primary energy source and power generation. In 2009, coal contributed 27% as primary energy supplier, the second largest energy after oil which amount to 33.1%. Meanwhile, coal-fired plants contributed the most (41%) among other sources of energy such as gas (20.1%), hydro (16%), nuclear (14.8%), and oil (5.8%). In some countries, the dominant role of coal as power generator is seen in Poland (93%), South Africa (93%), Australia (80%), China (78%), India (69%), Morocco (69%), Kazakhstan (70%), and Indonesia (71%). Along with power generation, coal is also widely used in steel industry. Approximately 13% of the production of steam coal (hard coal) is allocated to the industry and almost 70% of global steel productions depend on coal (International Energy Agency, 2010).

Asia is the largest coal market that consumes about 54% of the global coal consumption. The high consumption of coal in Asian countries led to the largest coal imports that came from Asian countries, like Japan, Korea, Taiwan, India, and China. Japan is the largest coal-importing country in the world with an import volume of 165 Million tons in 2009, followed by China,137 Million tons and 103 Million tons of Korea (Table 2.4.2).

Figure 2.4.1 Proportion of The Total World Energy



Source : International Energy agency, 2010

From the Tables 2.4.1 and 2.4.2 it is visible that the top exporter and importer countries, in which Australia is in the top of the list that exports 259 Million tons in 2009 and 52% of the total is the Coking Coal. Indonesia in the second largest exporter with an export volume of 230 Million ton in 2009 and 87% of the total is the Steam Coal. Australia becomes dominant as an exporter followed by the improvement the quality port infrastructure and internal transport; for example Koorangana Island and Dalrymple Bay are developed in order to increase export capacity with a relatively low cost of transport. Indonesia as a top exporter of Steam coal still has wide opportunity to export more and support the increase of domestic demand by improving the infrastructure and internal transport. In Chapter 5, the Researcher will expose some alternatives for the improvement in the coal transport.

Table 2.4.1 Top Coal Exporters

Countries	Total	Steam	Coking	% Steam	% Coking
Australia	259Mt	134Mt	125Mt	52%	48%
Indonesia	230Mt	200Mt	30Mt	87%	13%
Russia	116Mt	105Mt	11Mt	91%	9%
Colombia	69Mt	69Mt	-	100%	0%
South Africa	67Mt	66Mt	1Mt	99%	1%
USA	53Mt	20Mt	33Mt	38%	62%
Canada	28Mt	7Mt	21Mt	25%	75%

Source: Compiled by the Researcher from BP, IEA, World Steel Association, SSY, 2010

The top coal importer country is Japan that imports 165 Million ton, where 68% of the total is the Steam coal, followed by China and South Korea.

Table 2.4.2 Top Coal Importers

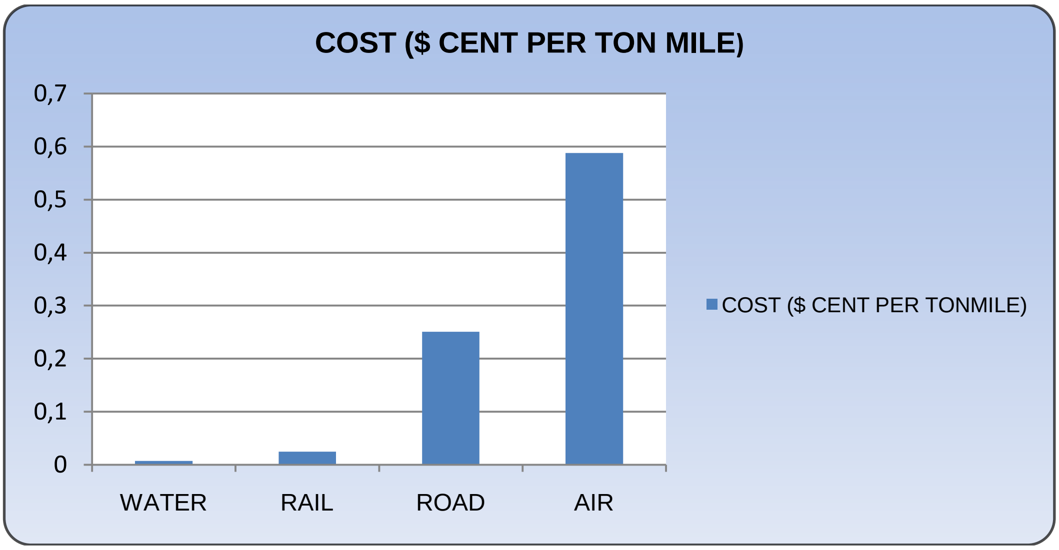
Countries	Total	Steam	Coking	% Steam	% Coking
Japan	165Mt	113Mt	52Mt	68%	32%
PR China	137Mt	102Mt	35Mt	74%	26%
South Korea	103Mt	82Mt	21Mt	80%	20%
India	67Mt	44Mt	23Mt	66%	34%
Taiwan	60Mt	57Mt	3Mt	95%	5%
Germany	38Mt	32Mt	6Mt	84%	16%
UK	38Mt	33Mt	5Mt	87%	13%

Source: Compiled by the Researcher from BP, IEA, World Steel Association, SSY, 2010.

2.5 Coal Transportation

Selection of transportation modes should be a major consideration for making transportation costs economical so as to increase the competence of product. In order to illustrate the cost of transport mode, in Figure 6 below, Ballou,1998 in his business logistic management book presents the freight cost in cent per ton mile. Based on his research, water transportation is the cheapest modes of transport while the highest cost is by air transport.

Figure 2.5.1 Freight Cost in Cent Per Ton Mile

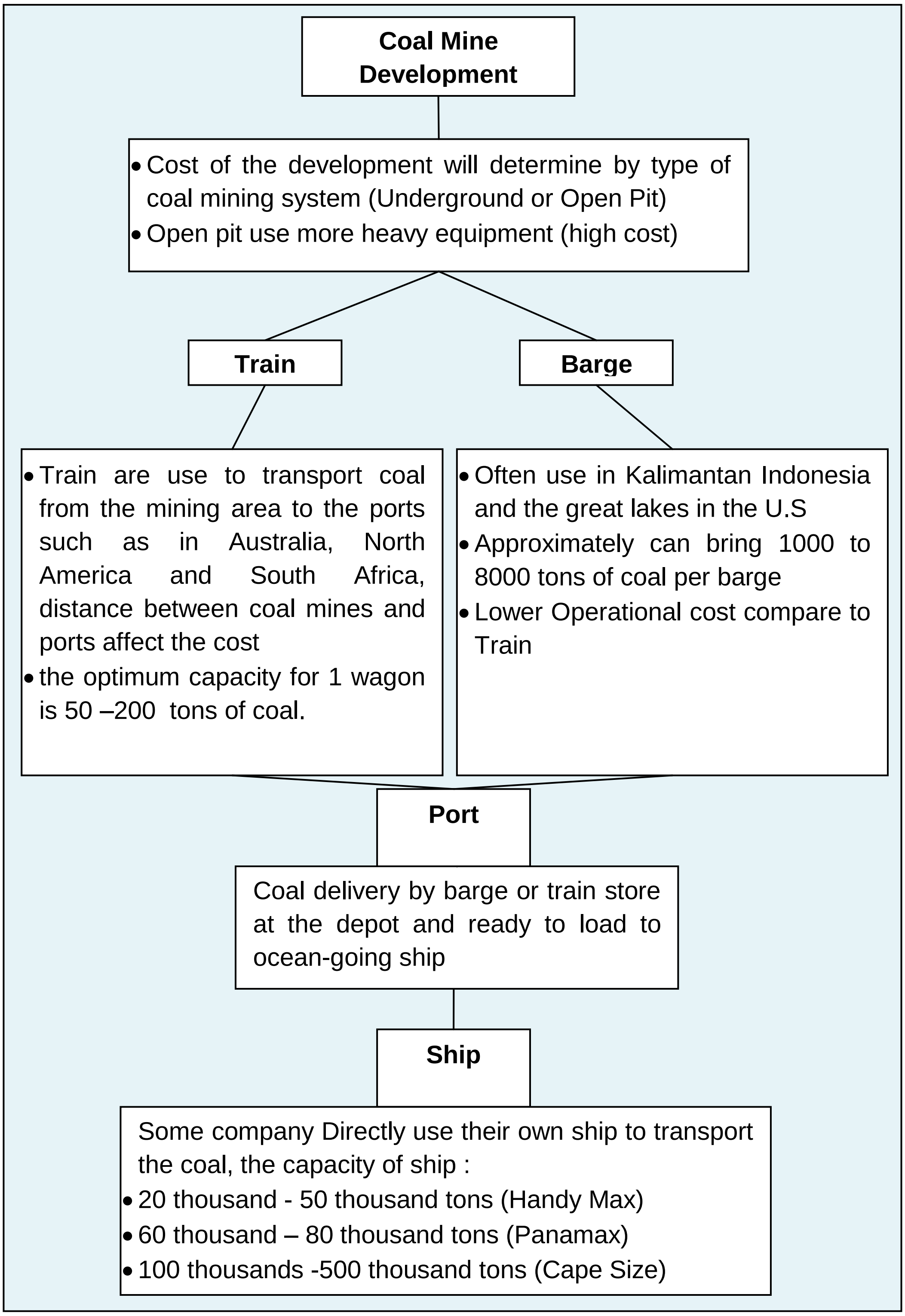


Source : Ballou, 1998

To find the way of how to transport coal will depend on its distance. For short distances, coal is generally transported by using conveyor belts or trucks. For longer distances within the domestic market, coal transported by rail or barge or the alternatives form (liquid) of coal to be transported by pipeline. In International trade, ships are commonly used to transport coal between long-distance countries. Generally the types of the vessel are Handy Max vessel (40,000 to 60,000 DWT), Panamax vessel (60,000 to 80,000 DWT) and Cape-size vessel (more than 80,000 DWT) (World Coal Institute, 2009).

The internal transportation and port infrastructure support the improvement of the coal mine development. The transportation and mining strategy become essential as one package to develop. The high capital cost to develop the infrastructure needs comprehensive supports from the government and also the cooperation between the coal producer, consumer countries, and their intermediaries (Ando, 2010). Figure 2.5.2 on the following page shows coal mine transportation development.

Figure 2.5.2 The Coal Transportation Development



Source: Elaborated by the Researcher from Ando, 2010

Chapter 3 Analysis of Coal Industry in Indonesia, Prospect and Opportunity

3.1 The Development of Coal In Indonesia

The Limitation of the world's oil-supply and the increase of oil price will require alternative energy sources that are potential to develop. Coal is one of the alternative energy that draws great attention. Compared to other countries, Indonesian coal industry is relatively new, but it shows continuing growth (International Energy Agency, 2010)

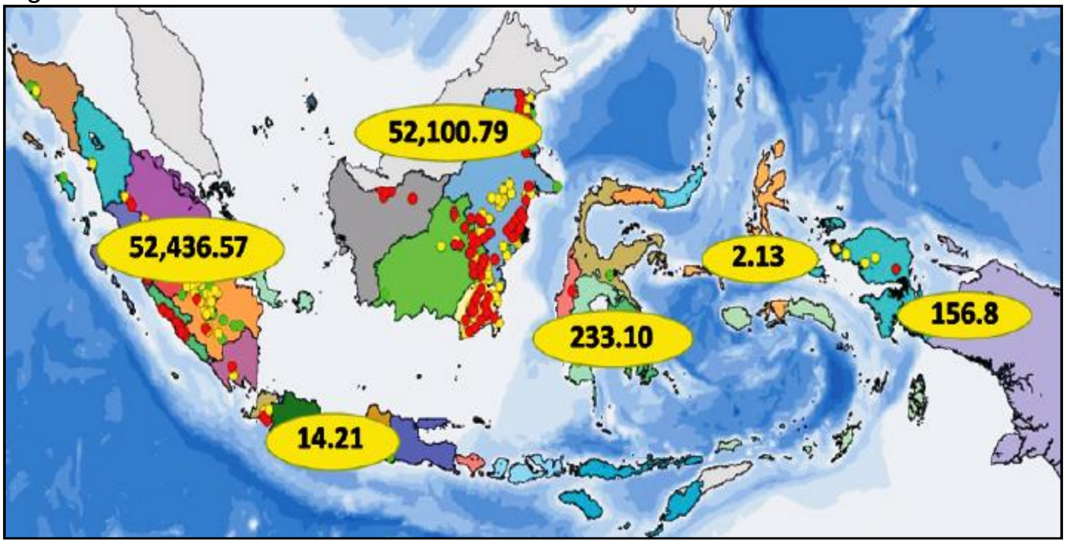
Coal consumption in recent years has increased very rapidly. In 1990, the total global coal consumption reached 3,461 Million tons, which increased in 2007 to 5522 Million tons; an increase of 59.5%, or an average of 3.5% p.a. International Energy Agency, 2010 estimates that world coal consumption will grow an average rate of 2.6% p.a. between the period of 2005-2015 and then slowed to an average of 1.7% p.a. during 2015-2030. The rising world coal consumption is inseparable from the rapidly increasing energy demand, where coal is the second biggest supplier of energy next to oil, with the contribution of 26%. This role is expected to increase by 29% in 2030. As for its contribution to electricity generation, it is also expected to increase from 41% in 2006 to 46% by 2030. The increasing role of coal as an energy supplier in the future has made the coal industry massively attractive for investors, especially in Indonesia (International Energy Agency, 2010).

The growth of Indonesian domestic coal consumption is quite spectacular, namely from 13.2 Million tons in 1997 to 45.3 Million tons in 2007; an increase of more than triple (243%). The sharply increasing amount of coal consumption was due to the increase of coal demand as an energy source, especially for power generation, both domestically and in importing countries. Not surprisingly, the number of coal mining companies in Indonesia has grown rapidly especially in recent years. Until 2003, 251 coal mining companies were listed in Indonesia (Center for Data Information on Energy and Mineral Resources, 2010).

As shown in Table 1.1.1, the total Indonesian coal resources are estimated at a rate of 104.9 billion tons and with a reserve of 21.13 billion tons, mostly in the islands of Sumatra and Kalimantan (Center for Data Information on Energy and Mineral Resources, 2010).Indonesia mined 256 Million tons of coal where 77% of the coal was exported mostly to Japan, Taiwan, Korea, and European countries. Meanwhile the rest 23% of production is used domestically for power plants (Ministry of Energy and Mineral Resources, 2010). Based on that 2009 data, it is reckoned that if the average production of Indonesian reaches coal 300 Million tons p.a. (256 Million tons of realization in 2009), it is forecasted that the total coal resources in Indonesia would last for approximately more than 400 years.

In the arena of global coal trade, Indonesia has an increasingly important role over the years both as producer and exporter. In 2007, Indonesia was in seventh position of the world's largest coal producer, contributing 4.2% and in the second position as the largest coal exporter with a total export volume of 202 Million tons.

Figure 3.1.1 Indonesia Coal Resource



Source : Ministry of Energy and Mineral Resources, 2010

3.2 Quality of Indonesian Coal

The exported coal from Indonesia is in majority range from 5.100 to 7100 kcal/kg (low to medium grade). The character of the content is identified by the low ash-yield and low sulfur. The low grade coal is mostly used domestically and it is uneconomic for export due to its high moisture content (U.S Geology Survey, 2011). However the medium grade coal has acceptance in export market due to its ultra-low sulfur content (less than 0.2%) (Ministry of Energy and Mineral Resources, 2010)and the low ash-yield makes Indonesian coal unique compared to other coals in the world.

Table 3.2.1 Quality Of Indonesian Coal By Island

	Island	Criteria	Calorie Value (Kkal/Kg)	% of Resources
1	Java	Low to Medium	<5100 - 6100	0,031
		High to Very high	>6100 - < 7100	0,005
2	Sumatra	Low to Medium	<5100 - 6100	43,85
		High to Very high	>6100 - < 7100	2,91
3	Kalimantan	Low to Medium	<5100 - 6100	41,4
		High to Very high	>6100 - < 7100	11,17
4	Sulawesi	Low to Medium	<5100 - 6100	0,36
		High to Very high	>6100 - < 7100	0,02
5	Maluku	Low to Medium	<5100 - 6100	0,003
		High to Very high	>6100 - < 7100	0
6	Papua	Low to Medium	<5100 - 6100	0,20
		High to Very high	>6100 - < 7100	0,05
	Total			100

Source : Hartoyo, 2009

Compared to other coal which produces the steam coal, Indonesian steam coal is in medium quality. The high-quality steaming coal is able to produce higher energy, lower moisture content and releases less CO_2 per unit of energy. However, Indonesian coal has proven its ability to compete. In majority, export of the steaming coal is consumed for power generation. The low sulfur content will also become attractive by its ability to be included in metallurgical processes and thus, making it possible to use the medium grade Indonesian steaming coal for the power generation. It is commonly blended with other coals to meet certain emission criteria, capitalizing on its low sulfur qualities (Cook & Daulay, 2000)

3.3 Role of Indonesia Coal Industry

Coal plays an important role for Indonesian economy. This sector contributes a substantial amount for state's revenue that increases every year. In 2004, for example, state's revenue from the coal sector reached IDR (Indonesian Rupiah) 2.57 trillion, and it was increased in 2007 to IDR 8.7 trillion. The rate reached IDR 10.2 trillion in 2008 and IDR 20 trillion in 2009 (Miranti, 2008). On the other hand, the role of coal as source of energy generation is also expanding. Currently, about 71.1% of domestic coal consumption is contributed by power plants, 17% for the cement industry and 10.1% for textile and paper industries(Ministry of Energy and Mineral Resources, 2010).

Indonesia's coal production reached 256 Million tons in 2009; an increase of more than 90% compared to that of 2003. The increasing production of 2009 was driven by an increasing coal import requests from China to 3 (three) times more or 14.5 Million tons of coal after the trimming of imports from Australia; around 34% because the rules of freight transport by ship was getting tighter (Miranti, 2008).

Indonesia and Japan has an agreement for cooperation called Economic Partnership Agreement (EPA) which includes the cooperation to enhance the demand for coal from Indonesia to Japan. Thebackground of the agreement based on the condition that China, previously a major supplier of Japan's coal demand, put restriction on its coal export due to the development of infrastructure within the country (Nakagaki, 2009).

According to Indonesian Ministry of Energy and Mineral Resources, until 2003, 251 companies were listed to carry out coal mining in Indonesia. Out of the amount, 71.7% (216 firms) are national private-companies and the rest are foreign companies. Nevertheless, about 85% of coal production is produced by nine large companies, i.e. Bumi Resources, Adaro, Kideco Jaya Agung, Berau Coal, Indominco Mandiri and Bukit Asam Mining Corporation. Based on the data in 2004, the largest coal reserves owned by Kaltim Prima Coal - Bumi Resources Group (3,472 Million tons), followed by Berau Coal (2,746 Million tons), Arutmin Indonesia – BumiResouces group (2,514 Million tons), and Adaro Indonesia (1,967 Million tons). The largest coal producer in Indonesia is Bumi Resources Group, which subordinates two major coal companies; PT Kaltim Prima Coal and PT Arutmin with a total market share of 30.3% in 2007, followed by PT. Adaro Indonesia (20.2%), Great Kideco (10.6%), Berau Coal (6.6%), IndomincoMandiri (5.8%), and Bukit Asam Mining Corporation (4.8%).

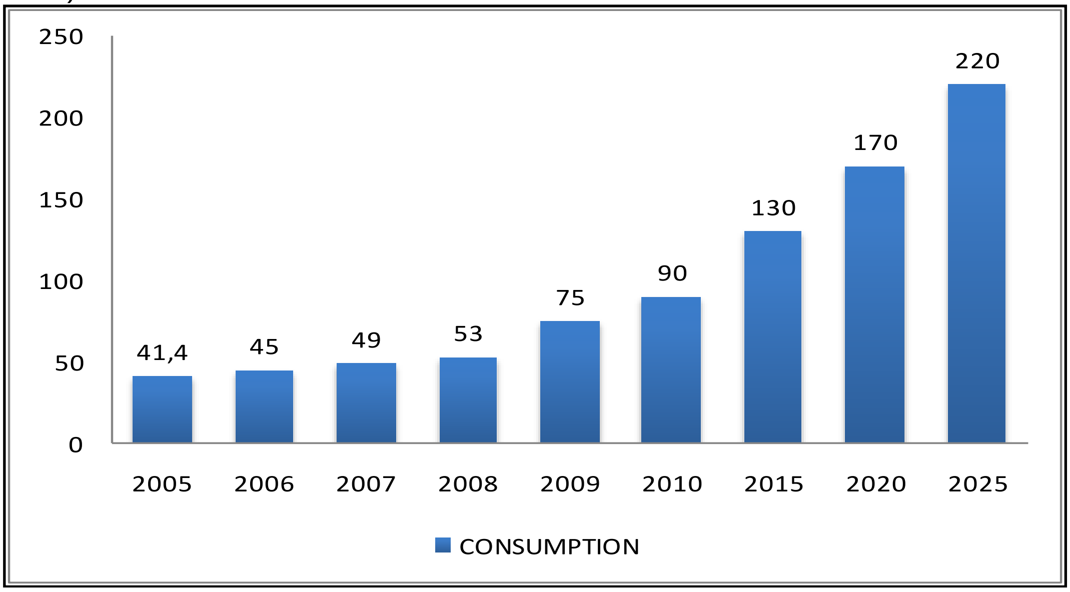
3.4 Prospect and Opportunity of Indonesia's Coal

IEA projected world energy demand will increase by 45% over the period 2006 to 2030. Coal will occupy the position as the second most important supplier of energy source after oil and shall experience an increase of demand to triple by 2030. About 97% use of coal will come from non-OECD countries (Organization for Economic Cooperation and Development) in which two-thirds are consumed by China. The increasing role of coal as energy source is in line with the increasing demand for construction of power plants in some areas that are driven by economic growth and income. China's role as a coal-exporting countries experienced a significant decline from 94 Million tons in 2003 to only 54 Million tons in 2007 due to an intense increase in China's domestic coal demand. In recent years, the Indonesian coal industry outlook expected to remain fairly well in the domestic and global markets. There are several reasons as to why this happens ;

3.4.1 Domestic Demand

The role of coal in power plants has been growing in Indonesia and around the world. It is estimated that in the future, the role of oil as source of energy will be reduced, and conversely, the role of coal and gas will even be greater. In the domestic realm, coal demand is expected to rise. When all the steam power plant projects operates, Indonesia's coal consumption in 2015 is estimated to reach 130 Million tons or more than three times increase over 2006 (Figure 3.4.1). Currently, there are at least more than 10 power plant projects in Indonesia (see Appendix 1) that will use coal as energy source; planned to be operational from 2010 to 2015 (Hartoyo, 2009)

Figure 3.4.1 Realisation and Estimation of Indonesia's Coal Domestic Used (2005-2025) in Millionof Tons



Source : Ministry of Energy and Mineral Resources, 2010

Table 3.4.1 Estimation of Indonesian Coal Domestic Consumption by Industry (2006-2025) in Million Of Tons

	Description	2006	2010	2015	2020	2025	Remark
1	Electricity	31,1	72,3	96	105	118	Electricity growth 7% p.a
2	Cement	5,7	8,4	15	23	34	Cement Industry growth 7% p.a
3	Metalugircal, Pulp and textile	1,9	4	8	11	18	-
4	Upgrade Brown coal	0	1	6	20	30	-
5	Others	6,3	4,3	5	11	20	-
	Total	**45**	**90**	**130**	**170**	**220**	**-**

Source : Ministry of Energy and Mineral Resources, 2010

3.4.2 Demand of Coal From China and India

Global coal market will be more stringent at least until 2020 as a result of an increasing coal demand for power generation from the two world's gigantic countries, China and India. Moreover, China's coal export restrictions since 2008 through the implementation of the coal export tax by 10% in anticipation of increasing demand for coal within China, will further reduce China's coal exports. Conversely at the same time, the growth in supplies from Australia and South Africa will decrease and shall encourage an increase of coal prices between a period of 2009-2010 (Miranti, 2008). According to International Energy Outlook 2007 projections, 72% of global coal consumption until 2030 will be dominated by China and India. Barlow Jonker estimates that India's coal imports will reach more than 50 Million tons in 2020 and China's coal imports shall reach 150 to 230 Million tons in the same year. Today, Indonesia's largest export markets are Japan, South Korea, and Taiwan, while China and India serve as new buyers for Indonesia. An increasing demand from China and India in the future shall increase the chance for Indonesia to boost its export market share through both countries (Barlow Jonker, 2011).

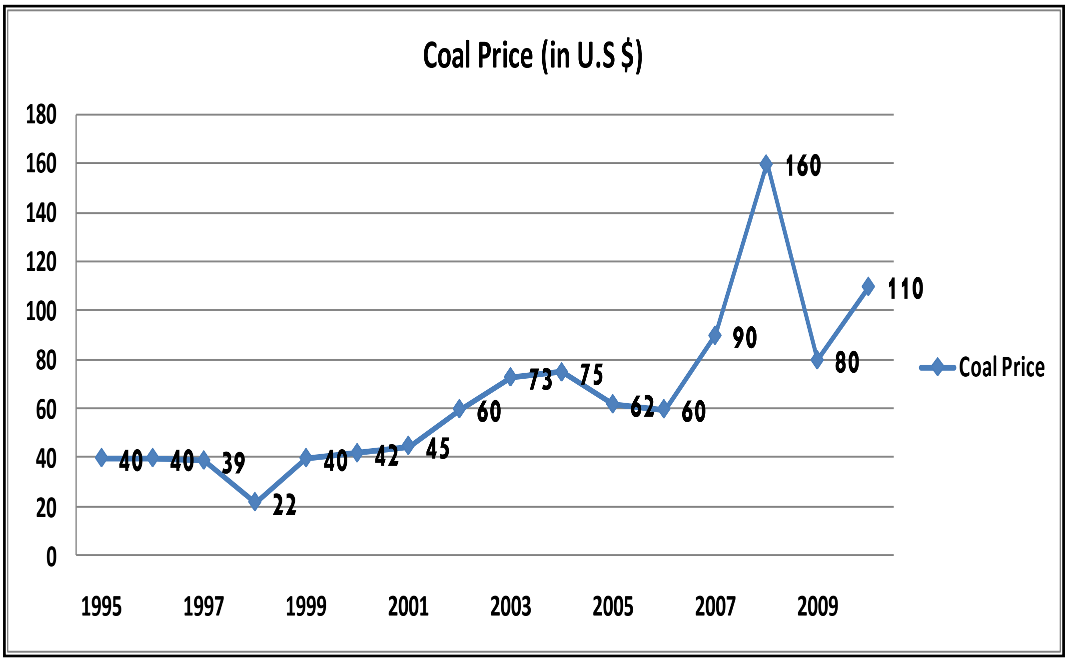
3.4.3 Lower Energy Price

The use of coal as an alternative energy is relatively cheaper than oil and LNG. Therefore, the price above US $ 80 for coal is still preferred as a source of energy than other energy sources. To produce 1 MGW/h of electricity from coal will cost US$ 12.98 (assuming a coal price of US$ 90/ton), compared to oil with a price ofUS$ 30 (assuming oil price of US$ 54/barrel), and LNG, US$ 20.47 (price assumption of US$ 6/ Mmbtu LNG) (Perdana, 2008)

3.4.4 High Demand Less Supply

Although the current price of coal is down due to the low of demand and followed by the global financial crisis in 2009, the price of coal will still be positive until several forthcoming years, driven by the relatively higher demand than supply. Besides, the nature of the coal which is un-renewable tends to be dwindling while the demand is likely to increase (Miranti, 2008).

Figure 3.4.2 Average World Steam Coal Price



Source : Bank Negara Indonesia, 2008

According to Massey Energy Report 2010, the price of steam coal is ranging from US$ 78 to 82 per ton in 2009, and US$ 90 to 130 per ton in 2010 (in December 2008 price of coal at Newcastle reached US$ 78.3 per ton after reaching its peak in August 2008 amounted to US$ 160 per ton. The Citigroup reports that in the coming few years, coal contract price for Steam Coal will reach US$ 100 to US$ 200 per metric ton and Coking Coal will reach US$ 200 per ton (Miranti, 2008).

3.4.5 High Profit Margin

Indonesian mining company profits are relatively higher than the average of the world's mining companies (Table 3.4.3 and table 3.4.4)

Table 3.4.3 Average Profit Coal Mining Company in Indonesia Versus The World

No	**Key Ratio**	**Top 40 Companies Global***		**Indonesia**	
		2003	2004	2003	2004
1	Effective Tax Rate (%)	27,9	24,7	38,2	37
2	Net Debt to Equity Ratio (%)	39,6	25,4	65,1	42,9
3	EBITDA Margin (%)	26,3	29,7	38,2	38,9
4	Net Profit Margin (%)	10,4	15,2	14,9	19,3
5	Return On Capital Employed (%)	7,6	13,7	9,1	13,3
6	Return on Equity (%)	10,5	18,9	18,6	27,3

*) Aggregate result of 40 of Largest global mining company
Source :Price Waterhouse Coopers, 2006

Table 3.4.4 Average Profit Of Coal Mining Company in Indonesia Versus Australia

No	Indicator	Country	2003	2004	Average 10 years
1	EBITDA Margin (%)	Indonesia	38,2	38,9	38,1
		Australia	28	33,7	n.a
2	Net Profit Margin (%)	Indonesia	14,9	19,3	14,5
		Australia	6,9	12,8	6,9
3	Return On Capital Employed (%)	Indonesia	9,1	13,3	7,7
		Australia	2,7	5,2	3,6
4	Return on Equity (%)	Indonesia	18,6	27,3	14,9
		Australia	7,4	14	7,2

Source : Price Waterhouse Cooper, 2006

3.4.6 Opportunity for Indonesian Coal Market

The discussion in the previous section looms a question on how the opportunities of Indonesian coal in the global coal market. Indonesia opportunity to enhance its role as coal exporter is very open ;

First, the coal resources in Indonesia is still relatively high potential, on the other side, the exploitation rates are still relatively low. The Directorate of Energy and Mineral Resources estimates the potential of Indonesian coal reached 105 billion tons, while the level of Indonesia's coal production only reached an average rate of approx. 200 Million tons p.a. The main problem of the low production is in the transportation aspect, especially in South Sumatra, where more than 40% of coal resources are available for mining.

Second, Indonesia is the largest exporter of steam coal in the world with total steam coal exports of 200 Million tons in 2009. Thus, Indonesia has an adequately large market share in the global market for thermal coal. Currently, the keymarket of Indonesian coal exports is Japan with a total of more than 46 Million tons in 2010. The cooperation with Japan through the Economic Partnership Agreement will further strengthen Indonesia's position as a supplier of Japanese coal. The more reduced the role of China, Australia, and South Africa as a supplier of coal will increase the chances of getting Indonesia to increase its market penetration in the international market.

Third, the increasing demand from China and India in recent years gives a greater opportunity for Indonesia to increase its market share in both countries, now serve as new buyers for Indonesia. Moreover, by shifting the position of China as a net importer of coal by the volume of demand (imports) are likely to increase and thus, will provide greater opportunity for Indonesia to take over the market share of Chinese exports while increasing market share of Indonesia to China.

3.5 Coal in South Sumatra and Its Challenge to Meet The High Demand of Steam Coal

3.5.1 Coal Resources

Coal resources in South Sumatra is quite large with approximately 22.24 billion tons (48% of the total coal resources in Indonesia) and scattered in seven districts namely *Kabupaten* (Regency) Banyuasin, Lahat, Musi Rawas, Ogan Komering Ulu, Muara Enim and Prabumulih. South Sumatran coal quality is generally low;ranging from lignite to sub bituminous (5000-6500Kcal/Kg). This type of coal is suitable for mining as power plant fuel. The needs of electrical energy in South Sumatrais forecasted to reach 1,500 MW by 2020, and at the same time electricity crisis could occur almost uniformly in Sumatra and Java. Potential mine mouth power plant has a promising prospect to any potential power plant to be built in South Sumatra will be marketed and absorbed by the electricity demand in Sumatra (Sumatra interconnection) and Java (Java-Sumatra interconnection) and also potential for export. This investment climate is to attract potential investors interested in coal mining in South Sumatra as well as establishing business of mining for export and domestic (Ministry of Energy and Mineral Resources, 2010).

Table 3.5.1 Coal Potention in South Sumatra

No	Criteria (Calories)	Resources (Million tons)	Alternatives (Million tons)
1	Low	11.384,89	2.653,98
2	Medium	10.376,62	-
3	High	478,89	-
	Total	22.240,40	2.653,98

Source: Ministry of Energy and Mineral ResourcesSouth Sumatra Representatives Office, 2007

South Sumatran coal resources are found in some areas such as Muara Enim, Talang Akar and Air Benakat, but the large potential coal found in Muara Enim (aging from Miocene and Pliocene). The Potential coal reserves in Muara Enim found in Lahat 2.7 billion tons, Banyuasin 3.49 billion tons, Ogan Komering Uluand Okut 0.32 billion tons and Musi Rawas with approximately 0.8 billion tons. The mines are scattered in 40 areas the prospect of which was partially owned by several companies (Aspindo, 2010). In 2009 Bukit Asam Mining Corporation has mining operations in Tanjung Enim and the surrounding area with production of 12 Million tons a year (see figure 3.5.1).

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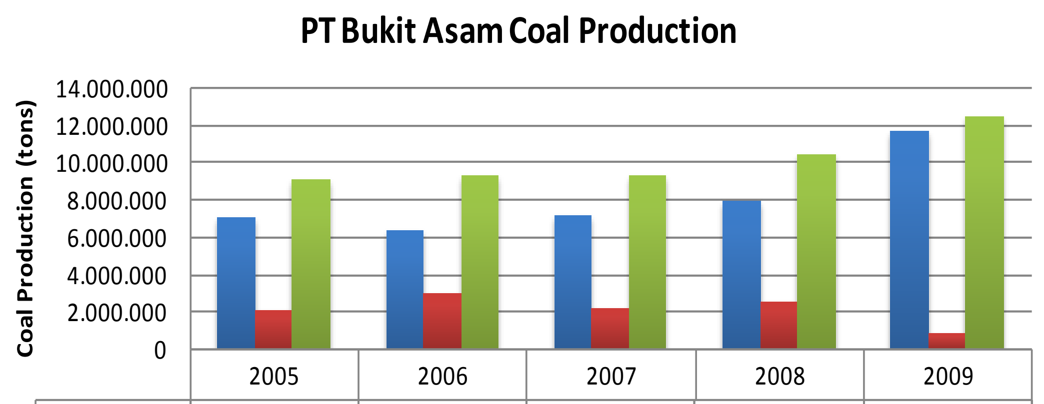
Figure 3.5.1 Bukit Asam Mining Corporation Coal Production 2005-2009



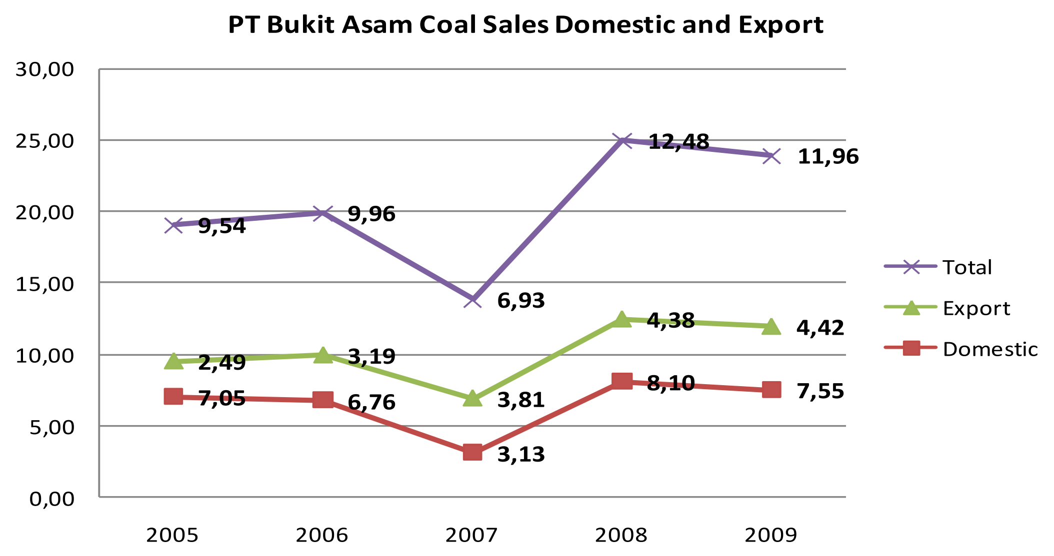
	2005	2006	2007	2008	2009
Muara Enim	7.036.776	6.320.292	7.130.273	7.933.582	11.640.568
Lahat	2.082.682	2.930.639	2.146.099	2.477.190	792.913
Total	9.119.458	9.250.931	9.276.372	10.410.772	12.433.481

Source: Aspindo, 2010

3.5.2 Challenge of South Sumatra Coal Resources

South Sumatran average coal production reached only 12 Million tons annually. If the production can be increased up to 50 Million tons with the resource 22.4 billion tons, the production of coal will be lasting more than 400 years. The bottleneck faced the coal production capacity in South Sumatra caused by inadequate and uneconomical port facilities and transport infrastructure. Currently the transportation by means of railway can convey 11.96 Million tons (as figure 3.5.2). This Study will assess the expected to increase the capacity of coal transport in South Sumatra. Several alternatives of coal transport will be examined in Chapter 5 of this Research.

Figure 3.5.2Bukit Asam Mining Corporation Coal Sales (In Million Of Tons)



Source : Aspindo, 2010

Chapter 4 Coal Transportation Method

The transport of coal from the mining site to the user uses various modes of transportation. The method used for transporting coal also depends on the distance to be journeyed. Generally, coal is used as power plantsworldwide, the distance between the area of mining and power plants, is one aspect that will determine the type of transportation used.

4.1 Overland Transportation

4.1.1 Railroad

The most widely-used method for transporting coal overland is the railroad. Railroad has developed and operated as proven successfully for a variety of weather conditions and situations and environments. The railroad in South Sumatra region was built in 1940s; now at some point where it demands new development and improvement due to the capacity and safety reason. At the present time, approximately 12 Million tons of coal is hauled over Tarahan and Kertapati railroads annually.

Construction costs for the railroad vary in different locations; depending on the labor conditions, climate, the material, and the railroad construction technology. For example, to develop the railroad in the western area to Bengkulu is substantially more expensive than Tarahan and Kertapati railroad, due to the hilly area conditions.

Different places have different construction cost due to the distance, contour and geographical conditions (Clark, 1973). Table4.1.1 below shows the construction cost of railroad in different place.

Table 4.1.1 Rail Construction Cost in Different Location

	Rail road	Location	Distance (miles)	Year Constructed /Proposed	Construction Cost/miles (US Dollars)
1	Great Slaves Railway	Roma, Alberta to Hay river, N.W.T	377	1964	199.500
2	Quebec North shore and Labrador Railway	Sept Iles, Quebec to Shefferville,Labrador	360	1954	325.200
3	Extension of Alaska Railroad	Dunbar, Alaska to Kabuk Alaska	405	1967	404.000
4	Railway to Arctic	Trout River Alberta to Prudhoe Alaska	1240	1972	1.250.000

Source : Clark, 1973

As shown in Table 4.1.1, the construction cost at the Great Slaves (Rome) is cheaper than that of Quebec North shore (Canada) due to the flat land and solid soil

(Clark, 1973). The most expensive construction cost is the Railway to Arctic due to the long distance and rail bridge construction.

The most expensive cost on the railroad construction in South Sumatra lies in the area that is mountainous and surrounded by valleys; a condition that requires bridge and additional steel material. Other expensive cost is mostly on the replacement cost to purchase the land from the locals, and in many cases the purchase process takes a long time to settle. As for the structure of the land, swamp are found in some places, and this would require little dredge and backfilled by soil.

The Unit of trainset usually consist the description as follow :

a) Number of trainset (Locomotives and Wagons)
b) Locomotives horsepower
c) Capacity of the axle
d) Long term contract between the miner and transporter
e) One mining area to several destination (Export and Domestic)
f) Number of trip per days, loading and unloading time.

The main advantages of using railroad are: high investment and utilization in the equipment, easy to manage the capacity by combination of locomotives and wagons, low labor cost, fixed scheduled give more benefit to the shipper (Glover, 1970)

4.1.2 Slurry Pipe Line

Supply of coal through the pipeline has been acknowledgedsince the20th century, but only for short distances. In recent years, the long-distance transport of coal by using pipe has been developed. The pipe used to transport coal cannot be exchangeable for other materials. Use a pipe as coal carrier requires careful planning and needs long-term contracts between miners and the pipe owners (Cox, 1983).

The Advantages ofusing pipeas ameans of transportation can be described as follow(Clark, 1973) :

a) Low operating costs, and
b) Avoid losing bits of coal during the transport process takes place.
c) Pipeline is developed to avoid the contamination from the other materials during the transport process; hence it will help to avoid noise and air pollution as well as preventing smells to attach to the coal.
d) Most of the pipe constructed underground, consequently the surface area is still available to use.
e) The construction fit for mountainous area or hilly

The velocity of pump, the concentration of the solid and the size of particle are three main factors to design a slurry pipeline (The Energy Library, 2011). The main part of the pipeline construction is pumps and pipe. Those two parts constitutes some high investment cost that needs to be considered as a decision to choose whether to use pipeline or other modes of transportation (Caldwell, 2006).

4.1.3 Road Trucking

To transport coal in big volume and long distance, road trucking is more flexible and easy to plan. The road trucking involves low initial cost but has a high operational cost compared to other modes of transport. Some side effects such as pollution and environmental impact also become disadvantages in using this mode of coal transport. The unlimited capacity of transporting coal can simply be done by adding the number of trucks and road development. A truck needs at least 1 (one) driver and 1 (one) co-driver plus the load and unloading labor which means high labor cost per unit of truck(Clark, 1973).

There are 2 (two) types of truck commonly used in mining activity: dump truck and highway truck. Dump truck is usually used in a closed mining area which has greater capacity than 300 tons. They are used to move coal from the mining point to the coal terminal within the mining area. After consolidation in the terminal, the coal is transferred to highway truck for transport to the next destination. Those trucks use public road and are subject to road usage restriction or regulation applied by the government. The width, length and height are restricting due to safety reasons. For example, in Alaska, the maximum weight for single wheels is 18,000 pounds per axle and 20,000 pounds for dual wheels. The maximum height is 8 feet and the maximum length is 70 feet (Wikipedia, 2011a). The regulation for the maximum length, width and height varies, depending on the country's regulation.

Figure 4.1.1 Dump truck (left) and highway truck (right)

Source : Wikipedia, 2011

4.1.4 Belt Conveyor

The materials used in the industry are sometimes heavy and hazardous to human. They require a transport method to transport the materials with less human effort and ensure safety for the employees. The conveyor transports solid materials such as coal, iron ore, cement, etc. Selection of the conveying equipment depends on the capacity of material handled, distance, land conditions, size, form or shape and price of the equipment.

Conveyor Belt is basically, a fairly simple equipment. This instrument consists of a belt that is resistant to transport solids materials. Belts used in belt conveyor made from various types of materials such as rubber, plastic, leather or metal, depending on the type and nature of the material to be transported. For transporting hot materials, the belt used is made of metal that are resistant to heat (Siregar, 2004).

Figure 4.1.2 Coal Belt Conveyor

Source : Sunway Machinery, 2011

Characteristics and performance of the conveyor belt (Clark, 1973) can be described as follow:

a) Operable horizontally or tilted at an angle of up to 18^{o} maximum.
b) Belt refuted by the plate roller to bring the material.
c) High capacity.
d) Versatile.
e) Sustainable operation.
f) Capacity can easily be arranged.
g) Can be directed; going up or down.
h) Easy to maintain.

The weaknesses of the conveyor belt:

a) Certain distance
b) The cost is relatively expensive.
c) Angle of inclination is limited.

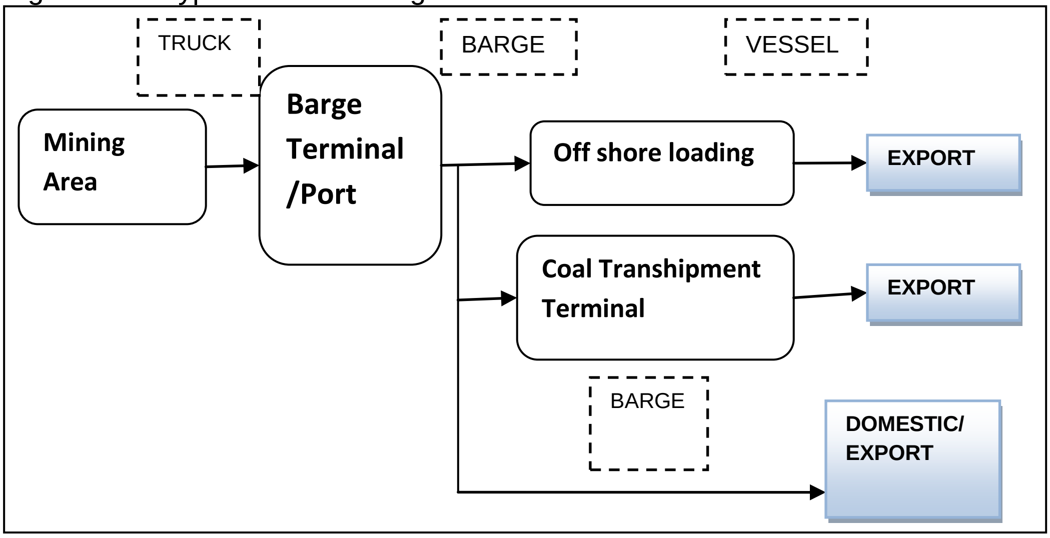
The use of conveyor in Indonesia coal mining is much popular but recently only for short distance within the mining area.

4.2 Seaborne Transportation

4.2.1 Tug and Barge

Transportation by barge was popular in Europe and America. In general, around 14 to 40 barges pulled by a 2,000 to 10,000 horsepower tug boat. The size of a large barge that can seat up to 1,800 tons of coal, approximately 40 x 1,800 = 72,000 tons of coal can be transported per trip or equivalent to 4 or 5 train set. The large amount of cargo transported by barge is an efficient and effective activity, or in other words, the achievement of Economics of Scale. Barges can be hired per ton miles basis or by distance in kilometers. But the weakness of transport by barge is always in terms of speed in delivery (The Energy Library, 2011). The figure 4.2.1 below shows the typical flow of barge in general.

Figure 4.2.1Typical Flow of Barge



Source : Mimuroto, 2002

Tug boats and barges are common combinations and suitable for use in river transport for bulk materials like coal. A larger barge for sea transport has also been developed. But in fact, the combination of tug and barge for sea transportation is difficult develop rapidly due to safety reason. The size of barges up to 30,000 Tons DWT at present has been used to export coal from the port of Palembang to China and Korea (Miranti, 2008).

Currently, barges are used to transport coal from Port of Palembang to China and Korea, and still been carried out due to several reasons (Global Security, 2011) :

a) Medium-size barge requires less workers; about 10 to 12 people.
b) Barge does not require a comprehensive port or terminal facility; it is flexible in terms of transportation door to door.
c) Flexibility in time management, by increasing the number of barges, tug boats can be re-operated for the next trip until the barge had completed loading or unloading
d) Lower capital cost than ships.

While the weakness of using barge among others, the low speed of delivery and inflexible in the face of bad weather.

4.2.2 Shipping

The shipping industry has a dynamic and special character, consisting several types; each of which has its own character as well. In general, there are two types of shipping, i.e. liner shipping and bulk shipping. Liner shipping are those pertaining to the containership activity and its special box handling. Coal transportation is a part of the dry bulk shipping that measures in tonnage of cargo. Like other services and goods, the demand for coal transport is a function of its own price (freight rates). Freight rates are usually measured in US$ per ton. The quantity of the coal transported for trading is measured in ton miles (Haralambides, 2011). The measurement in ton miles affects the distance as an important factor to determine the demand side.

The supply of transport determined by vessel productivity. Vessel productivity shows the ton miles performance of the vessel to transport cargo. Vessel productivity varies depending on the ship size, ships steaming speed (freight rate function), handling productivity at ports and the other factors (Haralambides, 2011).

The Economic of Scale in shipping is related to the condition at which the unit cost per ton reduced as the increase of the ship size with the ability to save the fuel cost by applying the slow steaming(Stopford, 2003). The relative cost for different sizes and distances are shown in Table 4.1.2 as below :

Table 4.1.2 Economic of Scale in Bulk Vessel (in Cent per Ton Mile)

Distance (miles)	**Ship Size (Deadweight)**			
	15.000	**40.500**	**65.000**	**120.300**
1.000	100	53	47	37
6.000	56	34	27	20
22.000	52	30	24	17

Source: Stopford, 2003

4.2.3 Transhipment Options

The coal transporting-related activities by means of sea transport include (The Energy Library, 2011):

a) Conveyance of coal from mining areas to coal piling station.
b) Loading to ships in the export station.
c) Ocean-going ships in various kinds and tonnage.
d) Discharge of commodity in the import station.
e) Deliverance to costumers.

Currently, the deliverance from mining areas to coal piling station such as in South Sumatra is conducted by way of railway facilities to a river port and the coal shall be proceeded for export by transporting it through small ships or barge. This series of activities have been performed for years; a series of work that might be suitable for meeting the needs of coal in the past. However, since the necessity for coal escalates in recent years, a new system of transport expected to be able to deliver maximized results is inevitable. A method called “transshipment” might be one of the solutions to fulfill the coal transport demands. Largely, 2 (two) kinds of transshipment methods are acknowledged; offshore transshipment and artificial land development. Implementation of both methods is highly reliant on the circumstances and expected objectives (The Energy Library, 2011).

The latter method, development of artificial land, would lead to high-capital cost, particularly for constructing berth and reclamation. Berth is assumed to support the anchorage and docking of freight carriers, discharge of barges, and Cape size ships loading. In general, those constructions consist of bulk berths that are related to the coast by means of an approach trestle that also supports conveyor galleries, piping for utilities, electrical systems, and trays for instrumentation cable and a path (Baram, 1977). The constructions, in relations to the cost, are generally configured as follows:

a) Berths as well as the approach trestle are built on the foundation of piles.

b) Capping beams and deck slabs concrete should be constructed in superior quality.
c) Belt conveyor support system.
d) Bollards and fenders.

The former method, offshore transshipment offers an alternative solution for coal transport compared to fixed port facility construction. This method, recently applied in Kalimantan, Venezuela, and India is also known as the Floating Transfer Station or FTS. For the implementation in Kalimantan and Venezuela, the station managed to improve the throughput of coal loading activities thanks to its flexibility for relocation, environmental-friendly nature, operational cost-effective, and last but not least, the application of this method is aimed at achieving costumer contentment because, simply, no dredging cost (d'Aniello, 2010).

Figure 4.2.2 Coal Floating Transfer Station in Venezuela

Source : d'Aniello, 2010

FTS is not the only applicable method. The Researcher wishes to expose some offshore transshipment alternatives in South Sumatra:

a) Geared Ship

A geared ship is a ship equipped with grab bucket positioned at the crane of the ship in order to facilitate the loading and unloading process. The common loading capacity is ranging from 10,000 – 16,000 tons per day (TPD), the total efficiency for cargo handling is, however, lower than other methods. Geared ships are generally handy-size and handy max ships ranging from 15,000 – 58,000 DWT. Other types of vessels such as the Panamax and Cape-size are not commonly geared with loading equipment and thus, will need extra-loading equipment for cargo loading purposes. Regarding the volumes to be catered in Tanjung Banyuasin, it will considerably inefficient to cater capacious cargoes such as coal by means of geared ships in long-term practices (Thomas, 2002).

b) Floating Cranes

Just as the crane in a berth, the floating cranes are assigned to load/unload bulk cargoes from the mother ship into barges and, to be noted, the rate of loading would depend on the grasp capability. In the case of iron ore and coal, the most commonly used and available floating cranes are that of with the capacity of 18,000 to 25,000 TPD (Indonesia Port Corporation II, 2011b). With an assumption that the average loading capacity is 23,000 TPD and secondary assumption that there are fewer interruptions during the loading processes, it will take 6-7 days to load 140,000 tons of coal from/to a Cape-size vessels, and around 3 days for 60,000 tons parcel from/to Panamax vessel. In regards to its high handling costs and rate, besides it's comparatively lower unit cost in comparison to other alternatives, the usage of floating cranes should be thoroughly examined related to the proposed utilization and cargo volume (Branch, 2007).

Figure 4.2.3 The River Floating Crane

Source : Gottwald Floating Cranes, 2011

c) Semi Submersible Trans-shipper (SST)

A Semi-submersible Trans-shipper is a non-propelled floating cargo station. It works in the following scheme. Lightering barges are hauled under the structure and cargoes are unloaded by means of conveyor belt/elevator. The SST structure is designed to meet the loading/unloading rate of 30,000 up to 36,000 TPD, but it would depend on the supply rate of barges. SST would cost approximately US$50-60 Million and thus, in regards of this high cost related to the designated cargo volume next to its incapability for buffer storage, application of SST is considered impractical

Figure 4.2.4 Semi Submersible Trans-shipper

Source: CSL Shipping, 2011

d) Floating Coal Terminal

Floating coal terminal is a kind of ship with special apparatuses and it would be stationed offshore, so large ships would be able to easily access the cargo loading/unloading structures. Common designs of floating coal terminal sets that deck cranes are set up on the side at which the unloading barges are located. It is aimed at ensuring that the operator would have a clear view towards the barges and the holds of offloading ships. Loading coal into export ship is helped by the presence of loading arms and they are installed on a bearing to make cross travelling possible, and further, will ease the loads to be carried into the export ship and grants access to the holds of offloading ships. The loading arms are movable in case the export ship maneuvers and they will be set by moving the carriage to a set position and then extra tracks for cross travel are available. A trans-shipper ship design may look like an adaptation of a Cape-size or Panamax ship. Cape-size ship is considered to be the best as choice regarding its high coal volumes. Currently, a 5-year old, 172,000 DWT Cape-size ship would cost approximately US$ 53 Million, meanwhile installation of handling system structure is estimated to cost another US$ 27 Million. Roughly calculated, a prét-a-porter trans-shipper ship would cost approximately US$ 80 Million. Apart from the calculation, a converted Cape-size ship as a trans-shipper will be able to provide a buffer storage of about 140,000 tons and its rate of handling will be around 60,000 – 72,000 TPD by the installation of loading arms in line with its desired capacity. Of all the options discussed earlier, this option is assumed operable to meet the needs for desired volume(Branch, 2007).

Transshipment stations will enable Cape-size ships to conduct loading/unloading activities. More productivity will be obtainable once larger ships used and this will lead to efficiency which will eventually maximize shippers' and buyers' revenue; the so-called Economic of Scale. Economic of Scale in Bulk Cargo such as coal is about the lower cost per ton of coal by saving the fuel through slow steaming and a developed the new technology(Wilnojst, 2009).

Chapter 5 Analysis of The Existing and Alternatives Scenario of Coal Transportation in South Sumatra

This part of the Research discusses the common, operational transport linkages allegedly applicable for the transport of coal, and it also recognizes their limitations and prospects for further development. Meanwhile several other options will be drawn with a certain range of choices that are apparently applicable as new measures for coal transport.

The required data for this scenario are taken from the parameter that was set during the preliminary study on coal transportation in Kalimantan. Then, the secondary data will be elaborated to be in line with the scenario of this study.

5.1 Existing Network (Scenario I)

Information on existing railroad is inadequate, not to mention the information on coal-related railroad. Hence, the following information was gathered from numerous sources in order to comprehend prevailing rail corridor. What will be outlined in this Research is not an entire or specific exposition of prevailing railroad operations, but it will nonetheless provide vivid image on existing coal transport.

5.1.1 Routes and Network Configuration

The prevailing railroad network in South Sumatra consists of two main routes. These routes were constructed in the early twentieth century and are connecting the distances between Palembang to Lubuk Linggau, and Prabumulih to Tarahan. Both routes are shown in Fig. 5.1.1.

As pictured in the figure, there is a T-junction connecting the two routes in the area of Prabumulih. There is also a branch line from Muara Enim to Tanjung Agung and it serves some coal mining in the area. Both the railroads are mainly single tracks and there are some passing loops in various locations. Stations for passengers are available in many sites along the two main routes.

5.1.2 Infrastructure

Corresponds to most railroad lines in Indonesia and throughout Southeast Asia and Australia, the track measurement is 1,072 mm (3' 6" and nicknamed 'Cape Gauge'), and in some areas, the tracks have been improved by means of concrete sleepers and also new rails. The route between Tanjung Enim and Tarahan is constructed and conserved to be able to sustain loads up to 18 tons, whereas the rest of the network is restrained to sustain 12 tons. Some signal instruments are placed in most of the South Sumatra railroad network, and some color-based signals are installed around Prabumulih area (Putranto, 1997).

Figure 5.1.1 Existing Coal Transport Routes Map

Note :

- Red and black line is the existing railway
- Blue Line is the musi River

Source : Indonesia Port Corporation II, 2010

5.1.3 Port Facilities

There are 2 (two) ports that are used to handle South Sumatran coal. The first port is located approximately 300 kilometres from the mining area, called as Port of Palembang.The second port is a seaport and called Port of Tarahan,situated in the southern part of Sumatra Island.

Port of Palembang has very important role in South Sumatran region.This port serves various kind of vessels such as Drybulk and ContainerVessel with maximum tonnage of 8000 Dead-Weight ton (DWT). This Port Supported by the large area along the river, is enough to be use for industrial processing activities. The development of the Port of Palembang was strongly supported by the growth of the hinterland such as agriculture, mining and industrial product. Besides coal, the commodities which have potential for significant improvement in the future is Crude Palm Oil (CPO).The facilities of the Port of palembang described as table 5.1.1 (Indonesia Port Corporation II, 2011a).

Port of Tarahan currently could handle 45.000 to 80.000 DWT Vessel.The coal terminal had 175 lenght, 16 meters depth. The Maximal tonnages coal that can be handle in a day is 5000 tons. The coal is transporting by railway to reach the Port of Tarahan for about 400 kilometres (Iqbal, 2007).

Table 5.1.1 Port of Palembang Facilities and Equipment

	Facilities	Remark	Equipment	Remark
1	Land area	722,5 Ha	Quay Container crane	1 Unit
2	Container yard	47.000 m2	Forklift	10 Unit
3	Warehouse	9.985 m2	Reach Stacker	1 Unit
4	Lenght of Berth	1.126 m	Truck's Chassis	7 Unit
5	Draft	-6,5 m LWS	Head Truck	6 Unit
6	Tug Vessel	3 Unit		
7	Pilot Boat	5 Unit		

Source : www.inaport2.co.id/palembangport

5.1.4 Railway Traffic

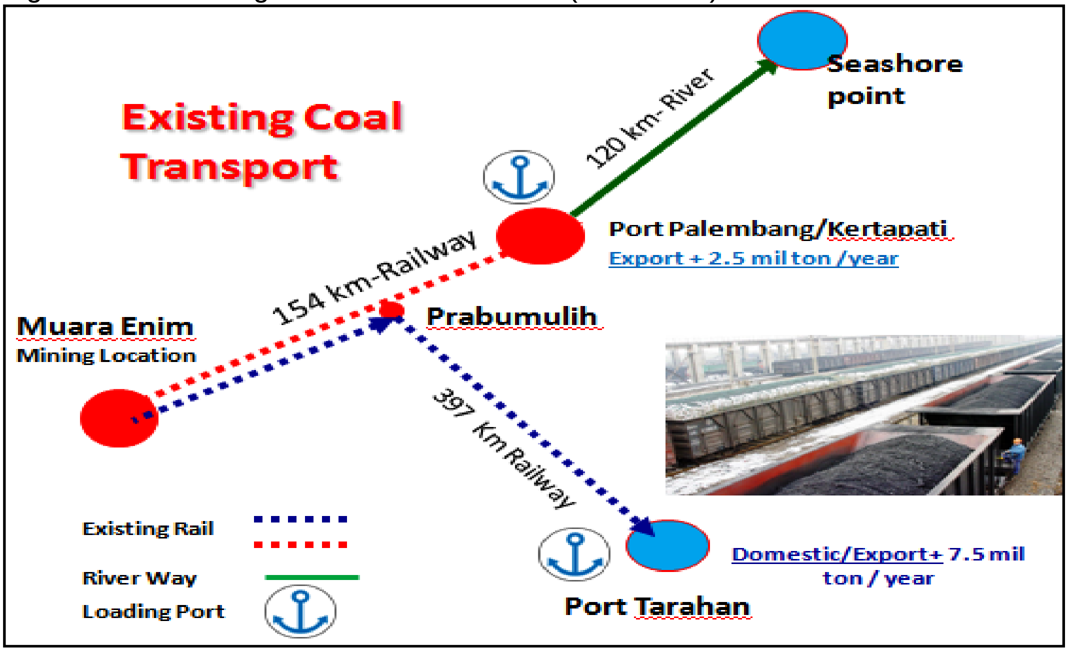
At the moment, railway transport is used to meet the needs of passengers, coal transportation, and other types of cargo' transportation (includes cement, clinker, and pulp). To serve such service, railway transport is still using diesel-traction engines.

5.1.5 Coal Train Operations

The primary movements of coal include the routes of Tanjung Enim and Muara Enim to Port of Tarahan, and Tanjung Enim and Muara Enim to Kertapati (Port of Palembang). Since axle loads of tracks become a consideration, there are two designs of coal wagon (Indonesia Railway Corporation, 2009):

a) Tanjung Enim and Muara Enim to Tarahan; wagons of 50 tons capacity.
b) Tanjung Enim and Muara Enim to Kertapati (Palembang); wagons of 30 tons capacity. The walls of wagons are designed to be lower, in order to prevent over capacity.

Figure 5.1.2 Existing Rail Scheme Network (Scenario I)



Source: Excerpted by the Researcher; data taken from PT Indonesia Railway Corporation

For serving the two routes, trains are arranged to consist of 40 wagons, locomotives exclusive. With this kind of arrangement, one set of train serving the route Tanjung Enim and Muara Enim to Tarahan may be loaded up to 2,000 tons and the set that serves Tanjung Enim and Muara Enim to Kertapati (Palembang) may be loaded up to 1,200 tons. From Tanjung Enim and Muara Enim route to Tarahan, coal trains are supported by 2 (two) locomotives. There is no information on the second route; whether the trains are supported by 2 locomotives or not. At the mining site, coal wagons are loaded by means of overhead hopperand the hopper are connected to a conveyor that serves as feeder. In Kertapati the contents of wagons are unloaded by using a Rotary Dumper Car (RDC) which overturns the wagons and directly pours the coal onto conveyor belt. Similar treatment is also performed towards wagons of 50 tons. Maintenance for the wagons is believed to be performed Balai Yasa depot in Lahat. The route of Tanjung Enim and Muara Enim to Tarahan is believed to have moved 7.5 Million tons annually and that of the route from Tanjung Enim and Muara Enim to Kertapati (Palembang Port) comprises a rate of 2.5 Million tons (Indonesia Railway Corporation, 2009).

Based on the data obtained, also supported by an assumption that trains are operational 365 days p.a., the Researcher draws the following conclusion:

a) Route Tanjung Enim and Muara Enim to Tarahan; 10 trains daily.
b) Route Tanjung Enim and Muara Enim to Kertapati (Palembang Port); 3-4 trains daily.

5.1.6 Opportunities to Increase Capacity

In order to be able to transport more masses of coal through the two main routes of railroads, there are two observable issues; the capacity of each sets of train, and the amount of coal trains daily. It is presumable that the railroads are operational at the limit of the two issues, and the two issues are directly intertwined with weight limit (axle loads) and wagon dimension limit (structure gauge).

Based on the assumption that the contemporarily used wagons reach these limits, it can be inferred (Putranto, 1997) that:

a) Engineering works to improve railroads would lead to embankment (related to weight issue), and/or;
b) Railroad clearances need improvement, and supposedly;
c) Realignment of railroad tracks would allow enlargement of loading gauge.

In the previous Chapter, the Researcher discusses that the amount of wagons in one set of train is limited by the power of locomotives, length of passing loops, wagon sidings, and loading/unloading tracks. Those limitations are viewed as current major restraints. There are many aspects to be considered if one wishes to increase the number of coal trains per day; trains schedule, infrastructure configuration, train busy traffic to be accommodated, number of fleet and crew (though the latter can be overcome relatively easier than the other aspects).

Potential rescheduling issues are believed to have been tackled, and the resolution of the issue will allow more trains to operate. Considerations on coal processing/upgrading may also act as an alternative solution to the capacity issue (for instance, removing moisture from the coal to produce briquettes), since some portion of coal weight transported are eventually found unnecessary/valueless, and thus, removing this valueless portion may lead to better effectiveness on the usage of capacity of railroad transport system. It would behoove to note that the railroad system is one aspect of logistics strings from the mine to the port. Any notion to upgrade railroad-system capacity should embrace assessments to these issues and address the issues whenever possible. With the intention of implementing upgrade of capacity, these acts will affect how immediate the capacity can be improved.

The presence of a well-prepared program for infrastructure improvement capable of addressing the aforementioned issues coupled with expenditure considerations to address them seems to be the most reasonable way to escalate the capacity and capability of the prevailing railroad network. Scheme proposition to cope with these issues is believed to have been submitted and still waiting for endorsement the Directorate General of Railway (Central Government). Specificity of such proposition is still undetermined; however, it is believed to have included rolling stock and bridge betterment. It is expected that the scheme proposition would be capable of improving capacity of the railroad to 20 Million tones p.a.(Indonesia Railway Corporation, 2009).

Increasing the handling capacity of the coal means increasing the trainset capacity. In the current situation the trainset are support by 2 (two) locomotive which bring 45 wagons.To increase the capacity it will need more fruequency or additional wagon and locomotive with the consideration of the maximum capacity of the railroad construction. We have to know whether the current fleet is sufficient to fulfill the upcoming target. If it is not fullfilled, we need to recalculated the number of wagons, trainset and the locomotive's power. Calculation for the addition would be associated with the transport targets to be achieved per year which also associated with the capacity of the path. The series of trains that can use in the same path together. The more circuits that can be accommodated by the lane, the shorter the length of each circuit. On the other hand after a long series of trainset known, the locomotives power need to be calculate. If the series wagons more long but the pull power capacity of the locomotives fixed, the maximum speed will reduced. If the speed decreases, the additional amount or number of carriages become ineffective (Putranto, 1997).

Existing pattern operations indicates that the volume of coal from Tanjung Enim to Tarahan that can be transported each year is 50 x45 x10 x 329 = 7,402,500 tons. In order to increase the capacity we need to calculate the number of train set to transport more than 7.4 Million ton.

The Railway Corporation use 10 train sets everyday where each train set brings 45 wagons and each wagon has maximum capacity around 50 tons, whereas an empty wagon has weight ±22 tons. This maximum capacity of the wagons is limited by the maximum capacity of the axle in South Sumatra, approximately 18 tons. Each wagon has 4 (four) axles, so the maximum volume for each wagon is 4 x 18 = 72 tons.

We can calculated optimal number of wagons by using formula as follow :

$$Number of wagons = \frac{Target}{Days} + \frac{1}{No. of trainset x\, 50}$$

Note :

Target	: The capacity of coal to be transported by train (tons)
Days	: Number of working days by Railway Corporation
No of trainset	:Number of trainset which operate in the railroad in a day
50	: The maximum capacity of each wagons in South Sumatra

In the existing scenario the Railway Corporation operates 10 train sets a day, with the maximum capacity of 7.5 Million tons in a year. To increase the capacity to 12 Million tons the frequency and number of working days for the train needs to be increased. To prevent the safety capacity of the rail track, the maximum number of train set can only be increased to 12 train set a day and for the working days can be increase to 329 days with the consequence, each train set only has 3 days off in a month or 1 over the 10 working days. To increase the target to 12 Million tons, the number of wagons for each train needs to be raised to 60 wagons. Suppose that a train set is to be pulled by two locomotives at one time, then the length of the circuit is (60 x 15) + (2 x 23)= 946 meters. The length of the siding of the train station is 1,100 meters. This would mean that 60 wagons with 2 locomotives are still acceptable. It can also be reckoned that the maximum number of the wagons, using the existing train station as follow [1,100 – (2 x 23)] / 15 = 70 wagons(Putranto, 1997).

To keep the speed optimal, locomotive power should also become one of the considerations. In the existing scenario, each train set brings 45 wagons by using 2 locomotives with 2,000 HP. The maximum speed in that condition is 60 km/hour in the straight and flat path. The normal time used from Tanjung Enim to Tarahan by train in that speed is 1.5 days (Indonesia Railway Corporation, 2009)

Based on the calculation of the locomotives power in the Putranto (1997) study, it is evident that to reach a speed of 60km/hour and pulling 60 wagons would require 5,500 HP. In order to obtain 5,500 HP net, at least two or three locomotives should be deployed; the available technology uses a type of locomotives called DC-DC with 2,000 HP/unit and another is locomotives AC-DC with 3,000HP/unit (Putranto, 1997).

Based on the calculation above, it can be determined that the operation scheme to reach the target 12 Million ton annually needs to meet the following criteria:

a) Use 12 train set in a day.
b) Each train set brings 60 wagons.
c) The 60 wagons pulled by 3 locomotives with 2,000 HP/unit or 2 locomotives with 3,000 horse power/ unit.
d) With 1.5 days per trip, the minimum number of train setrequired is 18 (train set per day x trip per day = 12 x 1,5)

Table 5.1.2 Wagons and Locomotives Combination

Description	Details	Total
Locomotives with 2000 Horse Power	3 unit x 18 trainset	54 unit locomotives
Locomotives with 3000 Horse Power	2 unit x 18 trainset	36 unit locomotives
Wagons	60 unit x 18 trainset	1080 unit wagons

Source : Putranto, 1997

If the number of the locomotives and wagons available to be taken into account, the number of additional locomotives and wagons can be calculated as follow:

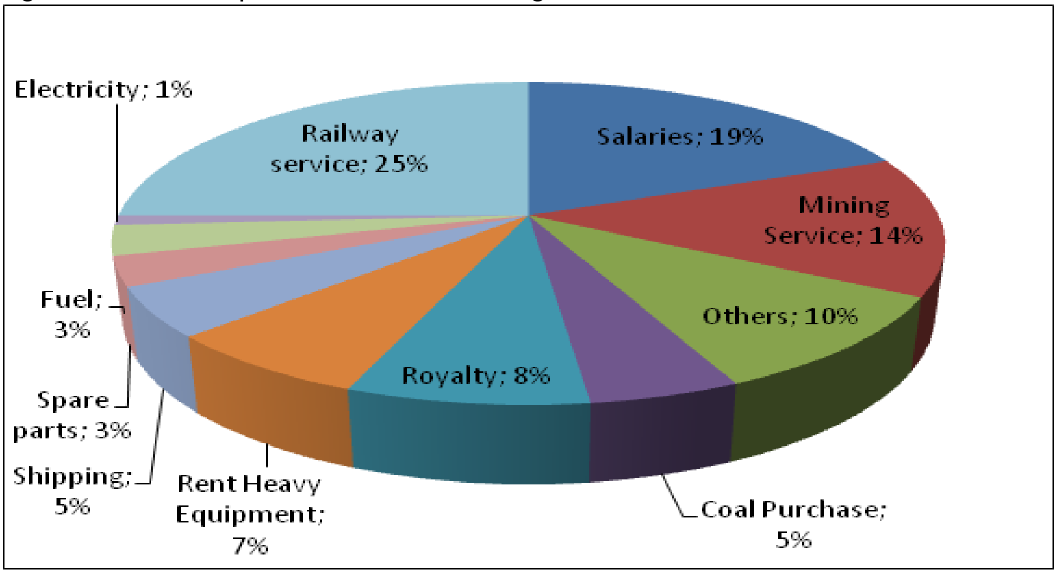
Existing Number of trainset operated by Indonesia Railway Corporation : = Train set perday x No. of Trip per day = 10 x 1,5 = 15 unit
Locomotives with 2000 Horse Power which operated in existing : = Number of locomotives per trainset x Number of trainset = 2 x 15 = 30 unit
Wagons in operation in existence: = Number of wagons per trainset x Number of trainset = 45 x 15 = 675 unit
Additional number for locomotives with 2,000 HP = [18 - (30 / 3)] x 3 = 24 unit
Additional number for locomotives with 3,000 HP = [18 - (30 / 3)] x 2 = 16 unit
Additional wagons = 1080 - 675 = 405 unit

The calculation drives to an understanding that the chance of increasing the capacity of the Railway from Tanjung Enim to Port of Tarahan is limited to 12 Million tons with the additional 24 units of 2,000 HP locomotives plus 16 units of 3,000 HP locomotives and another additional 405 units of wagons.

5.1.7 Transportation Cost Scheme on The Scenario I (Existing)

The transportation in the scenario I consist of the combination of the two routes. The first route connected the mining area to the River Port in Kertapati. As previously mentioned that the river port has limited the draft (-10,5 m LWS) which allowed the vessel with maximum tonnage of 8,000 DWT. The second routes connected the railway transportation to the Seaport in Tarahan with maximum Vessel capacity 80,000 DWT (Ministry of Energy and Mineral Resources, 2010).

Figure 5.1.3 : Composition Of Total Mining Cost



Source: Bukit Asam Mining Corporation, 2009

The total transportation cost to transfer coal under Scenario I as shown in table 5.1.6 consists of the total railway service from Muara Enim to Kertapati dan Tarahan; the loading cost at harbor; and the shipping cost. The total transportation cost from Muara Enim to Tarahan consisting 25% of railway services, 7% of harbour cost and 5% of shipping cost (shown in Figure 5.1.3). It can be inferred that the harbor/port cost (loading and unloading) at Kertapati (Port of Palembang) has the same rate with the Port of Tarahan. This is viewable from the annual report of Bukit Asam Mining Corporation in 2009. The shipping cost per ton miles by ship with 8,000 DWT (barge) via Port of Palembang is assumed as US$ 0.01 per ton miles based on the Mimuroto (2002) data study as the table 5.1.3. The loading cost and transportation cost per ton kilometres derived from the Mimuroto (2002) data study as below :

Table 5.1.3 Transportation Cost per Ton-Miles

No	Transport Modes	Costs (in US$ per Ton-miles)
1	Truck	0,07
2	Barge	0,005 – 0,01
3	Railway	0,020 – 0,023
4	Belt Conveyor	0,015

Source : Mimuroto, 2002

Table 5.1.4 Loading Cost

No	Systems	Costs (in US$ per Ton)
1	Barge	0,75
2	Railroad	0,75
3	Transhipment	1,80
4	Coal Terminal	2,25

Source : Mimuroto, 2002

Paul L Clark (1973), in his transport economic research in 1973 illustrates that the more volume of the tons handled, the more will it give chance to negotiate lower cost per tons. In his study, the illustration of 10 Million tons increase to 15 Million ton in volume lowered the transport cost by railway into 17%, whereas the handling cost decreased to 12%.

The bigger the vessel, the more it will reduce the shipping cost per ton as depicted in Table 5.1.5. changing the vessel from Panamax (80,000 DWT) to Mini Cape-Size (120,000 DWT) will save the total shipping cost per ton for about US$ 9.11 or approximately 25% saving. If it is assumed that Cape-Size Vessel (200,000 DWT) is used within the transshipment terminal as Scenario V, it is conclusive that the shipping cost per ton for the Cape-Size will be saved 40% compared to the Panamax vessel.

The Table 5.1.5 below explains the Economic of Scale of using bigger ship to transport dry bulk cargo such a coal.

Table 5.1.5 Economic of Scale Using Bigger Vessel

Estimated Maritime Unit Costs for Drybulker from the US East Coast to China ($/Ton)							
	Vessel	Fuel	Charter costs	Ports	Canal	Cargo Handling	Total
1	Panamax 80.000 DWT (75% of Utilization)	$10,99	$10,14	$4,14	$3,17	$6,71	$35,14
2	Mini Cape Size 120.000 DWT (96% of Utilization)	$7,34	$6,59	$2,78	$2,03	$7,28	$26,03
	Savings	**-$3,65**	**-$3,54**	**-$1,36**	**-$1,13**	**$0,57**	**-$9,11**

Source : Drewry Consultant, 2009

The tariffs for coal delivery from Muara Enim to Tarahan jetty and Kertapati jetty were defined by the agreement between Bukit Asam Mining Corporation with Indonesia. Railway Corporation, based on Bukit Asam Mining Corporation Interim Financial Report of 2010, in the notes to the part of financial statement (Letter No. D.02/HK/213/D6-2011, dated 21 January). The tariffs are IDR 344 (full amount)/tonne/km and IDR 472 (full amount)/tonne/km correspondingly. With these tariffs, the total coal delivery cost from Muara Enim to Port of Tarahan and Kertapati (Port of Palembang) amounted IDR 727.81 billion or US$ 84.63 Million (Exchange rate 1 US$= IDR 8,600) and IDR 91.71 billion or US$ 10.66 Million (Bukit Asam Mining Corporation, 2010).

In addition to the railway service cost, the loading and unloading cost at these ports are also defined, and the rate is IDR 49,996 or $ 5.81 per ton coal (Sani, Indra H, 2011). Considering that these costs are the result of agreement between coal mining labor association and the shipper, in the short terms, it is impossible to negotiate for the cost per kilometre-based. The only way to reduce the cost is through the shipping cost, but the constraint is in the limitation of the river draft which enable the large vessel to enter the port. The cost of shipping at port of Tarahan is lower than that of Palembang due to the size of the vessel. The maximum vessel at Port of Tarahan is 80,000 DWT while the Port of Palembang only capable of serving maximum 8,000 DWT (Bukit Asam Mining Corporation, 2009). By means of the assumption of cost per ton miles for Barge (US$ 0.01 per ton miles) as seen on Table 5.1.3 and the number of miles from Kertapati and Port of Tarahan to Tianjin (China) by the help of the data from port.com (2011), it is estimated that the total annual shipping cost of coal to Tianjin (China) at the rate of approximately US$ 71.6 Million from Kertapati and US$ 259.67 Million from Port of Tarahan.

The approximation combined with the railway service cost, port/harbour cost and shipping cost for the scenario I is US$46.73 + US$51.72 = US$98.45 per ton with the annual total capacity for about 7.5 Million tons. The details of the calculation can be seen in Appendix 2 of this Research which is summarized in the Table 5.1.6 as follow:

Table 5.1.6 Total Transportation Cost per Ton For Scenario I (Existing)

Tons p.a (Million tons)	Destination	Rail Service Cost p.a (Million $)	Port/Harbour Cost p.a (Million $)	Shipping Cost p.a (Million $)	* Total Cost/ton ($)
2	Kertapati	10.66	11.63	71.16	46.73
7,5	Tarahan Port	84.63	43.60	259.67	51.72

-* Detail Calculation is illustrated in Appendix 2

Source: Created by the Reseacher, elaborated from Mimuroto,2002; Ports.com, 2011; Drewry Consultant, 2009; Paul Clark, 1973 and Bukit Asam Mining Corporation,2010.

5.1.8 Capital Cost

Based on the additional capacity calculation as mentioned in section 5.1.6 and collaborated with the data from UPRR Enginer (2008) and Wikianswer (2011), the Researcher calculated the Total Capital cost as in the following table:

Table 5.1.7 Estimated Capital cost of Scenario I

Additional Trainset	Additional Trainset to reach 12 m.t	Estimated Cost/ unit	Total Cost
Locomotives with 3,000 HP	16	US$ 2,5 Million	US$ 40 Million
Wagons (50 tons/wagon)	405	US$ 50.000	US$ 20.3 Million
Total Cost	-	-	**US$ 60.3 Million**

Source: Calculated by the Researcher, derived from Putranto, 1997; UPRR Engineer,2008; Wikianswer, 2011.

5.2 Duplicate Railway (Double Track) Scheme (Scenario II)

New railway line along with a new alignment from Tanjung Enim to Tarahan is reported to have been proposed by Indonesia Railway Corporation. Had the report been true, it will effectually double the prevailing route serving coal transport between these two points.

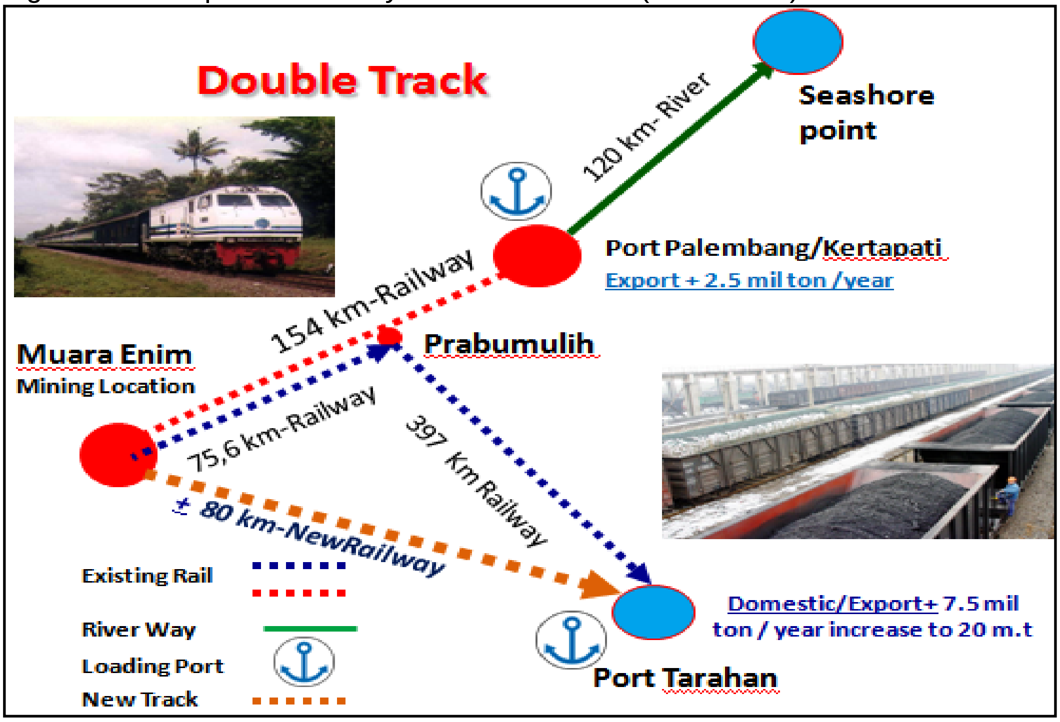
Specific scheme is still unavailable. However, there are some noted advantages and disadvantages; listed as follow:
Advantages

a) The capacity of carrying coal can be increased by constructing new tracks and better structure gauge, which will enable the achievement of better maximum axle loads. The extent of doubletrack provided can lead to larger capacity;
b) The route could cut many kilometers rather than the existing railway route, hence, it helps reducing transport costs and emissions from locomotives, and;
c) New railway avoids disturbances to current operations on the prevailing railway.

Disadvantages

a) Construction of new railway with new alignment requires purchase of land from local resident sand potential to create larger-extent environmental impact, and;
b) It is likely to be more high-priced to construct new railway rather than to upgrade existing railroads. The cost estimated for the new railway is expected to exceed that of the cost required for upgrading.

Figure 5.2.1 Duplicate Railway Scheme Network (Scenario II)



Source : Excerpted by the Researcher; data taken from PT Indonesia Railway Corporation

5.2.1 Transportation Cost Scheme on The Scenario II (Double Track)

The transport cost for Scenario II consisting the total transportation cost of scenario I, plus transportation cost for the new shortcut railtrack from Tanjung Enim directly to Port of Tarahan (for about 80 km) and continue with the shipping cost to Tianjin, China for about 3,558 miles as depicted in Figure 5.3.2 (Ports.com, 2011). Similar assumption and calculation is used as Scenario I plus the cost scheme for scenario II (double track); assumed to be developed into 12.5 Million tons additional capacity of coal. The design of the new railtrack saves the distance up to more than 200 km. The cost for the rail service and port/harbor service are assumed to be similar to the cost from Tanjung Enim to Kertapati in the Scenario I. Whereas the average total transportation cost per ton becomes US$ 46.73+US$ 51.72+US$ 45.77=US$ 144.22 (full amount) with the annual, total capacity for about 22 Million tons. The details of the calculation are listed in Appendix 3; summarized in the following Table 5.2.1:

Table 5.2.1 Estimated Total Transportation Cost per Ton for Scenario II (Double Track)

Tons p.a (Million tons)	Destination	Rail Service Cost p.a (Million $)	Port/Harbour Cost p.a (Million $)	Shipping Cost p.a (Million $)	* Total Cost/ton ($)
2	Kertapati	10.66	11.63	71.16	46.73
7,5	Port of Tarahan	84.63	43.60	259.67	51.72
12,5	Double Track to Port of Tarahan	66.65	72.67	432.79	45.77

-* Detail Calculation is illustrated in Appendix 3

Source: Created by the Reseacher, elaborated from Mimuroto,2002; Ports.com, 2011; Drewry Consultant,2009; Paul Clark, 1973 and Bukit Asam Mining Corporation,2010

5.2.2 Capital Cost

The capital cost for Scenario II consists of the new building railroad along ±80 km plus the purchase of new trainset as found in the calculation on the section 5.1.6 and 5.1.8. The cost of the new buiding railroad benchmarking as the table 4.1.1 which give the estimation cost to construct railroad in the different location. As summaries in the following table:

Table 5.2.2 Construction cost for Railroad in different location

	Rail road	Construction Cost/miles (US Dollars)	Construction Cost/Km (US Dollars) – 1 miles=1.61 Km
1	Alberta to hay river	199,500	123,964
2	Quebec to Labrador	325,200	202,070
3	Dunbar to Kabuk alaska	404.000	251,034
4	Alberta to Alaska	1,250,000	776,714
	Average Construction Cost	544,675	338,445

Source: Clark, 1973

In the last column of the table it is assumable that the average construction cost is US$ 338,445 per km in 1972. Assuming that the inflation in Indonesia is 5% each year, it is estimated that the cost will approximately be higher 200% in 2011 which is US$ 1.06 Million per Kilometres. The Railroad from Muara Enim to Port of tarahan as Figure 5.2.1 is approx. 80 km which cost around US$ 110 Million, including the assumption of 30% miscellaneous cost factor such us environment and community.The purchase of the unit of the trainset to reach 12.5 Million tons is estimated to be the same with the existing capacity plus the additional trainset from Muara Enim to Tarahan in the Scenario I (the existing railway to Port of Tarahan). The calculation of the table 5.2.3 is followed the calculation from Section 5.1.6 as summarised in the following table:

Table 5.2.3 Estimated Capital Cost for Scenario II

Additional Trainset	Additional Trainset to reach 12,5 m.t	Estimated Cost/ unit	Total Cost
Locomotives with 2000 Horse Power	36	US$ 2.5 Million	US$ 90 Million
Wagons (50 tons/wagon)	1080	US$ 50,000	US$ 54 Million
Total Cost	-	-	**US$ 144 Million**

Source: Calculated by the Researcher, derived from Putranto, 1997; UPRR Engineer,2008; Wikianswer, 2011.

The other capital cost which has need to take into account is the purchasing land from the citizen to develop the railtrack. However, the Researcher will not include these costs in the calculation.

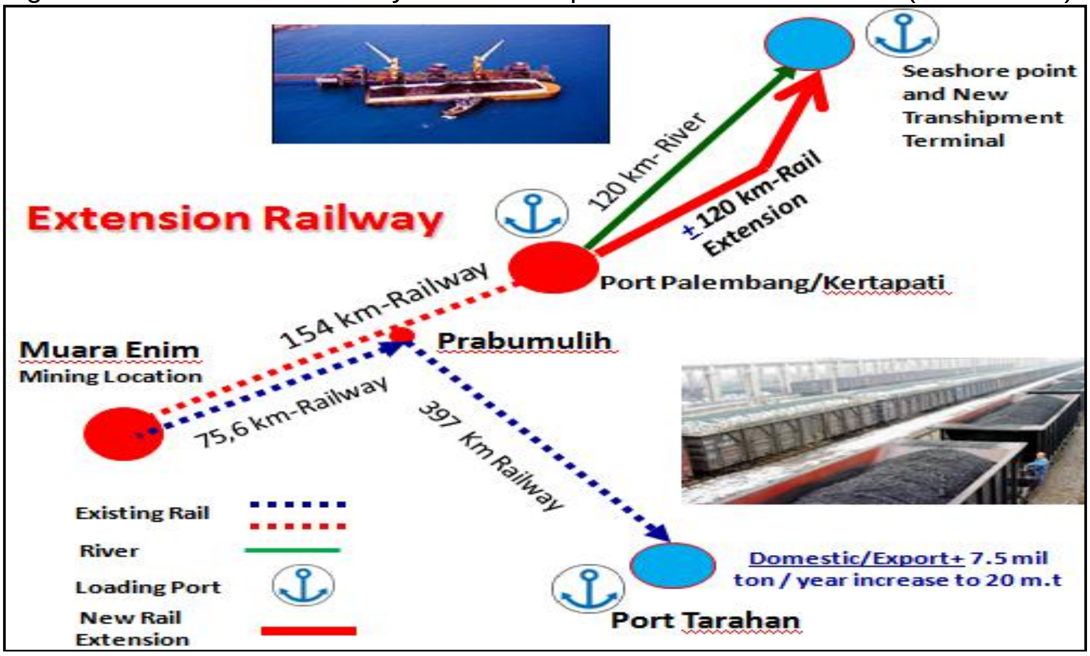
5.3 Northern Rail Corridor Scheme (Scenario III)

The 'Northern Rail Corridor', a proposal for railway improvement has been submitted, and such proposal includes an expansion of the current railroad linkage from Palembang to Tanjung Banyuasin. The implementation of this proposal will enable direct coal transport by railroad to deep water loading station, and it will not be necessary to transfer coal in Kertapati as it has a restrained capacity and capability and applicable for limited size ships.

The realization of construction project in the proposal entails the following advantages and disadvantages (Indonesia Railway Corporation, 2011a) :
Advantages:
a) Trans-shipment can directly access larger ships in Tanjung Banyuasin, and thus, preventing the needs for trans-shipment from small to large ships.
b) It is potential to reduce transit duration, anyhow, the degree of the reduction is undetermined, and financial benefit is possibly neglected.
c) Potential for faster output when the terminal at Tanjung Banyuasin is suitably sized and other capacity constraints overcome.

Disadvantages:
a. To achieve improvement on transported coal quantity, improvement of railroad capacity, especially on tracks serving from mining area to Palembang, is inevitable. This track is generally low in terms of supporting maximum axle loading compared to that of Tarahan. Besides, there might be some capacity issues.
b. Anticipation on environmental impact of the railroad betterment must be prepared, since the area to be passed by railroad tracks is sensitive, muddy area.
c. Expansion construction and design must be able to cope with issues related to constructing railroad tracks on unstable soil and as well as the maintenance issue.

Figure 5.3.1 Extension Railway and Transhipment Scheme Networks (Scenario III)



Source : Excerpted by the Researcher; data taken from PT Indonesia Railway Corporation

5.3.1 Transportation Cost Scheme for Scenario III (Extension Railway Scheme To Transhipment Terminal)

Excerpted from the cost scheme at scenario I, it is assumed that the coal is transported from Kertapati and Tarahan to Tianjin, China. The distance From Kertapati to Tianjin is approximately 3,558 Nautical Miles, coal export is performed by using 8,000 DWT Vessel (90% utilize) with a speed of 13 knots (Workboat International, 2011), where the days at sea is around 11.4 days. Meaning that in 1 (one) year a ship can only make 15 round trip which export around 105,000 tons per vessel per year (Ports.com, 2011).

Figure 5.3.2 Distance,Time And Speed From Kertapati To Tianjin,China

Source : Ports.com, 2011

Figure 5.3.3 Distance,Time And Speed From Tarahan To Tianjin,China

Source : Ports.com, 2011

Tarahan to Tianjin are separated approximately 3,847 Nautical miles (Ports.com, 2011), Coal is exported by using 80,000 DWT (70% utilize) with a speed of 14.5 knots (Workboat International, 2011), where the day at sea around 10 days. This would mean a ship that brings 56,000 tons can make 10 trips in a year, exported 560,000 tons per vessel per year. In this scenario, the prevailing river along 120 km is replaced by the new railway extension with connected to the transshipment terminal.

The difference of this scenario among the others lies in the Shipping cost that uses the bigger ship to transport the coal with more capacity which give the low cost per ton miles. The total transportation cost per ton becomes US$ 32.49 + US$ 51.72= US$ 84.21 (full amount) with the same capacity with scenario I (9.5 Million tons p.a). The details of the calculation can be found in Appendix 4, summarized in the following Table 5.3.1:

Table 5.3.1 Estimated Total Transportation Cost per Ton For Scenario III

Tons p.a (Million tons)	Destination	Rail Service Cost p.a (Million $)	Port/Harbour Cost p.a (Million $)	Shipping Cost p.a (Million $)	* Total Cost/ton ($)
2	Kertapati	10.66	11.63	42.70	32.49
7,5	Port of Tarahan	84.63	43.60	259.67	51.72

-* Detail Calculation will be illustrated in Appendix 4

Source: Created by the Reseacher, elaborated from Mimuroto,2002; Ports.com, 2011 Drewry Consultant,2009; Paul Clark, 1973; Bukit Asam Mining Corporation,2010

The mileage run by train is increased by another 120 km, compared to that of Scenario I. The advantage of this scenario can be shown in the bigger ship with the assumption the transshipment terminal had developed. Using 120,000 DWT ship give the lower total cost per ton than scenario I (existing).

5.3.2 Capital Cost

The capital cost for the Scenario III consists of the new building railroad from Port of Palembang (Kertapati) to the transshipment terminal and the new facility for the transhipment terminal. The railroad scenario followed the existing railroad with the same capacity. We assumed to use the existing facility without adding more trainset. The investment in the transshipment options has been reviewed as section 4.2.3. For the purpose of this reseached, we assume to use the floating crane vessel. If we assume to use the floating crane with the capacity 6,000 ton per day , it will need 1 (one) floating crane with capacity to reach 2 Million tons per annum. The estimated capital cost to purchase the floating crane vessel is about US$ 10 Million (Alibaba, 2006).

5.4 Railway Extension to Bengkulu Scheme (Scenario IV)

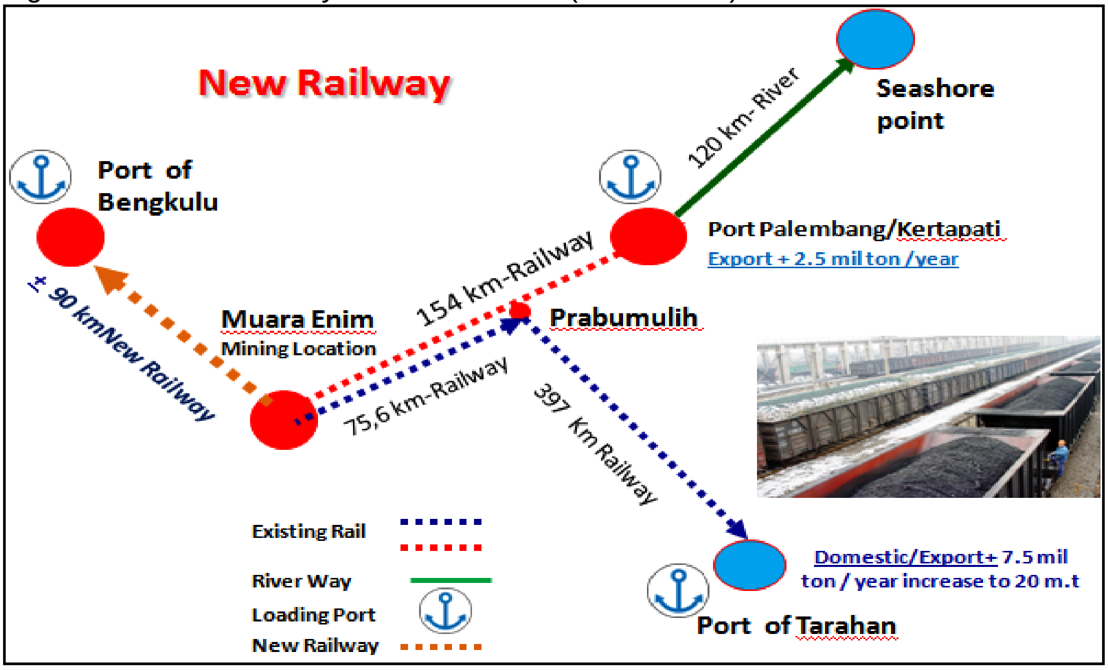
The Government has proposed projected expansion on the railway system along ±90 Km in South Sumatra. Once the proposition is implemented, it will entail that another chain of export will be opened; through the neighboring province of Bengkulu. The proposed scheme is still undisclosed but here are some outlines that can be drawn(Sani, Indra H, 2011):

a) If the projected expansion is directed towards Bengkulu, the project would have to construct railroad tracks through the Barisan Mountain. This would inevitably

be high-cost and when the project is accomplished, users of the track will be charged on a per-kilometer basis transport fare;
b) There allegedly be some environmental effects of the presence of the new tracks, and they will be discussed in section 5.6.
c) The port of Bengkulu is expected to experience hasty sedimentation
d) The port of Bengkulu which is situated on the west coast of Sumatra will provide certain advantage for potential export costumers.

Railroad transport serves as a key means of transport in coal haulage from the mining facility to an export point. Consequently, wherever possible, railroad system will be chosen when it comes to transporting large quantities of commodities through long distances. Then again, the projected scheme is relatively difficult to develop, owing the constraints to the geographical condition and if the construction is accomplished, high-cost is inevitable.

Figure 5.4.1 New Railway SchemeNetwork (Scenario IV)



Source : Excerpted by the Researcher; data taken from PT Indonesia Railway Corporation

5.4.1 Transportation Cost Scheme for Scenario IV (New Railway Scheme to Port of Bengkulu)

In order to create extra capacity for immediate coal transport, the shipper could use the available road from Muara Enim to Lubuk Linggau (Bengkulu). However, the current physical condition of the road is somewhat disabled, due to the bad road structure, enviromental and plus, safety reason for the community. If only the Government can develop highway road for about ±90 km, there will be chance to transport more coal to Port of Bengkulu. Each truck could transport at maximum 10 tons of coal, Assuming 2 (two) Million tons of coal transported in a year, there will be more than 500 truck passing the highway road in a day and it will be hard to implement due to the very expensive capital cost to develop road. The concern is also about the external effect to the community, especially smoke and noise pollution.

The Railway scheme along 90 km looks viable as one of the options to transport more tonnage of coal to Port of Bengkulu (Indonesia Railway Corporation, 2011a). The data and Information about the rail service cost per ton for this type of railway scheme are indefinite and the Researcher could not find such data. However, based on the researcher discussion with the Operational staff of Indonesia Railway Corporation, the Rail service cost is assumed 20% higher than the Existing Rail service cost (from Tanjung Enim to Port Tarahan). The hilly area makes the development of the railway infrastructure becomes very expensive both in capital and operational cost (Indonesia Railway Corporation, 2011a). Based on a further discussion with the Operational Staff of Indonesia Railway Corporation, the Researcher draws a conclusion that the new railway is viable to transport 7.5 Million tons of coal p.a. as transported from Tanjung Enim to Port of Tarahan. The port/harbor service and the shipping cost at Port of Bengkulu are assumed to have similar rate to that of Port of Palembang(Indonesia Port Corporation II, 2011b). The total transportation cost per ton becomes US$ 46.73 + US$51.72 + US$ 60.20 = US$ 158.65 (full amount) with the annual total capacity of approximately 17 Million tons. The details on cost calculation for Scenario IV can be observed in Appendix 5; summarized as the following Table 5.4.1 :

Table 5.4.1 Estimated Total Transportation Cost per Ton For Scenario IV

Tons p.a (Million tons)	Destination	Rail Service Cost p.a (Million $)	Port/Harbour Cost p.a (Million $)	Shipping Cost p.a (Million $)	* Total Cost/ton ($)
2	Kertapati	10.66	11.63	71.16	46.73
7,5	Port of Tarahan	84.63	43.60	259.67	51.72
7,5	New Rail to Port of Bengkulu	101.55	43.60	306.38	60.20

-* Detail Calculation is listed in Appendix 5

Source: Create by The Researcher, elaborated from Mimuroto,2002; Ports.com, 2011 Drewry Consultant,2009; Paul Clark, 1973; Bukit Asam Mining Corporation,2010.

5.4.2 Capital Cost

The calculation for the capital cost inScenario IV followed the scheme as inScenario II in section 5.2.2. In Scenario IV, the new railroad assume to be develope from muara enim to Port of Bengkulu. The capacity of the rail transport assumed to be the same with the existing from Muara Enim to Port of Tarahan as summarised in the Table 5.4.2 below:

Table 5.4.2 Estimated Capital Cost of Scenario IV

Additional Trainset	Additional Trainset to reach 7,5 m.t	Estimated Cost/ unit	Total Cost
Locomotives with 2000 Horse Power	30	US$ 2,5 Million	US$ 75 Million
Wagons (50 tons/wagon)	675	US$ 50.000	US$ 34 Million
Total Cost	-	-	**US$ 109 Million**

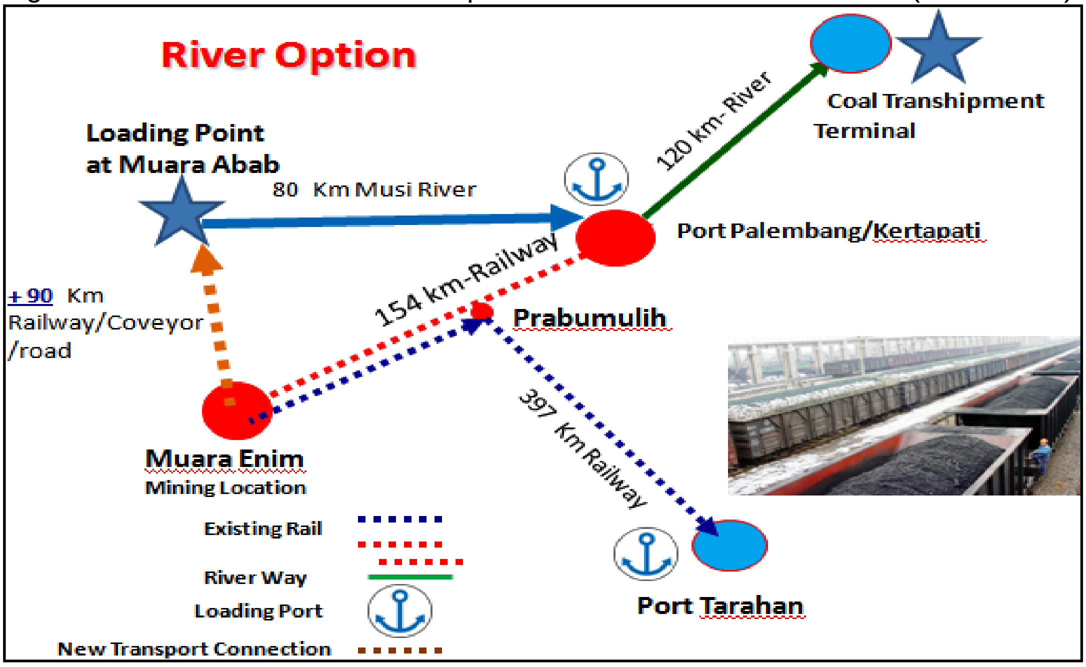
Source: Calculated by the Researcher, derived from Putranto, 1997; UPRR Engineer,2008; Wikianswer, 2011.

The development of the railroad to Port of Bengkulu will pass the forest and hilly area. However, the cost calculation for these factor are not included in the calculation.

5.5 The Musi River and Transhipment Scheme (Scenario V)

At the present time, the Musi River is used to serve the route from Kertapati to the downstream areas for transporting coal that previously delivered by railroad network. The river along with its branches especially the Calik Creek passes close to many areas of coal mining exploration. Consequently, further use of Musi River for trans-shipment possibilities further upstream is one of the possible options to support the notion to increase coal transport capacity (Media Indonesia, 2010).

Figure 5.5.1 River and Coal Transhipment Terminal Scheme Network (Scenario V)



Source: Excerpted by the Researcher; data taken from Indonesia Port Corporation II

In regards to the project, the Researcher noted some projections of advantages and disadvantages (Sani, Indra H, 2011) :

Advantages

a) Lower transport costs since water transport is commonly cheaper per ton kilometer than any modes of land transport.
b) Lower gains on energy costs and emissions.
c) Infrastructure and maintenance costs are possibly efficient than those of rail.
d) Effects to the environment ought to be less than building a new alignment.

Disadvantages

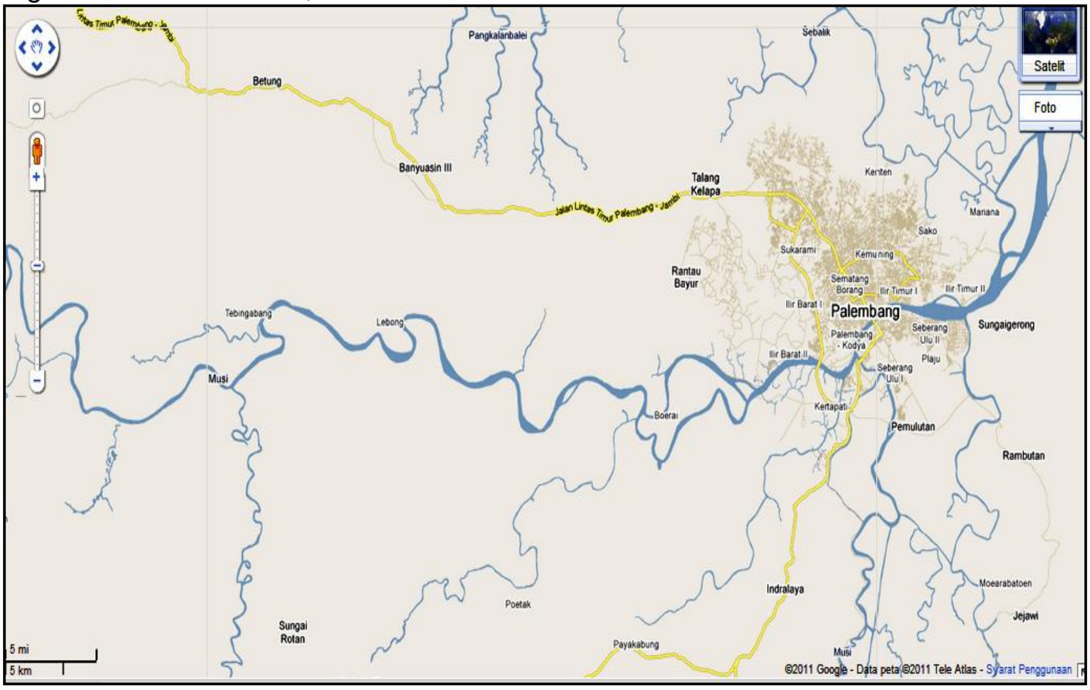
a) The factual distance the coal must be transported by river may be significant caused by the twisting alignment of rivers in South Sumatra,;
b) Air draft limits are restrained by bridges, most notably the Ampera Bridge
c) A searching action will be necessary which may be expensive and has environmental effects.

The slow speed of transport by river, worsened by the winding alignment would result in more time for transit, compared to land modes of transport. Nevertheless, since coal is non-vulnerable, the cost advantages possibly exceed this issue.

5.5.1 Overview Musi River

The river of Musi is located in South Sumatra (Figure 5.5.2), and it originates from the *Bukit Barisan* (Barisan Mountains) and runs over a distance of around 470 kilometers into the Bangka Strait. Most of the villages on the bank of the Musi River subsist from small scale agriculture and fishing activities and are largely dependent on the river (Wikipedia, 2011b). Musi River is the largest river in Sumatra with an average width of 504 meters (1350 meters wide in a circle of the longest Kemaro Island, and the shortest width of 250 meters located around the Musi Bridge)

Figure 5.5.2 Musi River, South Sumatra



Source: Google, 2011

5.5.2 Limitations to Navigation

The Researcher notes three bridges to cross the section of Musi River within the study area (Indonesia Railway Corporation, 2011a):

a) Upstream area, in the west of Sekayu, between Pengadang and Karagringin there is an old dilapidated bridge across the Musi River. The bridge was constructed before World War II.
b) There are 2 bridges in Palembang – the Ampera Bridge, built between 1962 and 1964, designed with movable center span – though it has never been moved since 1980. This bridge provides air-draft of 8.10m at HWS (11.10m at LWS); and Musi-II Bridge that was built with air-draft along the study stretch.
c) Five kilometers from the Ampera Bridge to the downstream area, situated the Musi Bridge with an air-draft limit of 7.50m at HWS (10.50m at LWS). The bridge links the Trans (North) Sumatra with the Trans (South) Sumatra highway. Separately, the national oil company, PERTAMINA constructed pipeline connections over and under the river. These lines can easily be adapted to allow for the transit of greater vessel sizes though, if there is sufficient economic justification, and thus to not exhibit limitation to navigation.

5.5.3 Inundation, Rain and Occurences Hindrance to Safe Routing

Musi River is known to be prone and subject to inundation over time. The wet season results in the raise of water levels in some months ranging from November to March, and inundation occurs along the period. Such condition is worsened by the existence of tide on the river (in Palembang even reaches 90% of the river mouth) which contributes to the fluctuation of water level. Palembang operators of barges suggested that they expect non-operational days during a common year to reach 30 days. A stern inundation is expected to occur in an every 3-to-5 year period, commonly between December to March (Indonesia Port Corporation II, 2011c). The gathered data on water level in Palembang area indicated to be similar to the explanation above and such data proved to be influential to barging operations. The height of water that was recorded in the Palembang Port was used to evaluate the effect on air flow for the bridges of Ampera and Musi. The water level measurement in relations to LWS was analyzed in order to identify occurences of air flow for ships by 6.5 m high would fall below 1 m (a value of 6.5 m is used for it is considered to be the perfect combination of highest tug and barge that are able to pass to the upstream parts of Palembang). A ship (6.5 meter-high) will have air flow clearance of 1 m, consequently, a raise of water level more than 3 m will be related to LWS; meaning there will be an air flow clearance of less than 1 m (Indonesia Port Corporation II, 2011b). For some months that are indicated, the Indonesia Port Corporation II provides data and this data infers up to 97 days p.a. at which time the airflow will be less that 1 m. Nevertheless, this does not deter routing/navigation activities every day since properly-trained and experienced crews will manage to pass below the bridge under such circumstances.

Water level increase is a momentary occurrence and thus, any analysis on its duration would prove to be influential to barging activities. The duration of air flow that is less than 1 m in each month throughout the year is in average 2 hour/influenced day and consequently, a one-day-operation will not be lost at each occurrence. The indisputable and considered-to-be-safe minimum air flow is 0.5 m. An analysis was conducted to find out the number of days on which the air flow will be less than 0.5 m. 30 days is the result of the analysis where the expected days for transiting under the bridge of Musi is not secure. For planning intentions, the above data has led to a more conservative number of days and also advice from local barge operators. The final assumption is that it is expected that there will be 35 days of non-operational day throughout a common year and hence, the number of operational days is 330 days.

5.5.4 Transportation Cost Scheme for Scenario V (Musi River and Transshipment Point)

Due to the restriction on the River draft 10.50 m at LWS, it is assumed to use the 6,000 DWT barge to transport the coal from loading point to the sea transshipment point (Indonesia Port Corporation II, 2011b). The speed of transit along the Musi River will be limited due to the tight curvature upstream, and the traffic density around Palembang. The study assumed an average transit speed of 6 (Six) knots between Loading point and Transshipment point noting much lower speeds will occur in the congested sections through Palembang and at sharp bends, and higher speeds should be achievable on straight wide sections of river. To assume a higher speed as an average is considered impractical and may not be reliably achieved.

With distance 2 x 200 Km (return trip), 24 hours per day and a speed of 6 knots the sailing time part of a roundtrip becomes (2 x 200)/(6 x 1,852 x 24) = 1,4 days. Assuming the barge operations of 6,000 tonnes capacity expected to 330 days per year, it will equal to 236 loaded trips which gives the maximum capacity 1.416.000 tons per barge per annum. If we use 20 tug and barges combination, it can reach 28,3 Million tons of coal. In this research, it is assumed that the capacity reached 28 Million tons with the demand situation and condition as explained in Chapter 3.

From the mining area to the river loading point new railway is developed along 90 kilometers with the same tariff assumption with the existing scenario from Tanjung Enim to Port of Tarahan (US$ 11,28/ton)(Indonesia Port Corporation II, 2011b). The river way transportation tariff is a combination between the delivery cost by barge and the loading cost at the loading point. We assumed the river way transportation tariff is IDR 70,000 or US$ 8.14 (US$ 1=IDR 8,600) plus IDR 50,000 or US$ 5.81 for the loading cost which has the same rate in Kalimantan River(Mimuroto, 2002).

After a benchmarking from Table 5.1.5, it is assumed that the Shipping cost for Cape-Size vessel (200,000 DWT) is lower 40% than 80,000 DWT or US$ 0.0054 per ton miles. In case of the port/harbor cost, it is assumed to use the floating crane as the equipment to transfer the coal with in the barge directly to the Cape-Size vessel. Benchmark from the Chennai Port (India), the tariff for the floating crane per ton is Indian Rupees (INR) 1.954,20 (Chennai Port, 2011)or US$ 43.32 (with exchange rate 1 US$= INR 45.1) (Coin Mill, 2011). The total transportation cost per ton become US$ 87.77 which is lower than the other scenarios. The Details of the calculation is enclosed in Appendix 6 of this research; summarized inTable 5.5.1 as follow:

Table 5.5.1 Estimated Total Transportation Cost per Ton for Scenario V

Tons p.a (Million tons)	Destination	Rail Service Cost p.a (Million $)	River way Cost p.a (Million $)	Port/ Harbour Cost p.a (Million $)	Shipping Cost p.a (Million $)	* Total Cost/ton ($)
28	Coal Transhipment Terminal	316	390,70	1212,96	537,97	87,77

-* Detail Calculation is listed in Appendix 6

Source: Create by The Researcher, elaborated from Mimuroto,2002; Ports.com, 2011 Drewry Consultant,2009; Paul Clark, 1973; Bukit Asam Mining Corporation,2010.

5.5.5 Capital Cost - Transport Facility Development

The Capital cost estimates consist of the overland transportation (railroad from Muara Enim to Muara Abab), main facilities (barge loading at Muara Abab and transhipment at Tanjung Banyuasin), vessel purchase (tug and barge), the transshipment facilities (floating crane). The construction is expected to last three years prior to the operation.

A. Capital Cost - The Overland transportation

Assuming the overland transportation will use the railway as the connection mode;the cost of building railway consists of the railroad itself, the Locomotives and Wagons. As Paul Clark (1973) stated, the construction of the railroad depend on the contour of the place to be constructed (i.e hilly, swamp area etc), size and weight of the railroad.
In the table 4.1.1 of Chapter 4, it has been explain the approximate of the construction cost of railroad in the different location. The average construction cost is US$ 338,445/km in 1972. If we assume the inflation in Indonesia 5% each year, it is estimates the cost is approximately higher 200% in 2011 which is US$ 1,06 Million per Kilometres. The Railroad from Muara Enim to Muara Abab (Barge Loading Point as Figure 5.5.1) is ±90 Kilometres which cost around US$ 125 Million, including the assumption of 30% miscellaneous cost factor such us environment and community.

The capital cost for the Overland transportation also include the cost of purchasing the locomotives and wagons which depend on the capacity to reach and the number of Trainset (locomotives and wagons that need to reach the capacity).

As reviewed in Section 5.1.6, the combination of locomotives and wagons are very important to determine the performance of the coal delivery to reach the annual capacity 12 Million tons. Based on these calculation, it is estimate to double the combination of the trainset (Locomotives and Wagons) to reach 28 Million tons as the following Table 5.5.2 :

Table 5.5.2 Estimated Trainset Combination to Reach 28 Million tons

Description	1 Trainset Combination	7 Trainset to reach 28 m.t
Locomotives with 3000 Horse Power	2	14
Wagons (50 tons/wagon)	60	420
Speed	60 km/h	60 km/h
No Hours return trip for 90 Km x 2 =180 Km	3 h	21 h
Estimated Loading/unloading time	3 h	21 h
No Of return trip in a day (24 work hours)	4	28
Tons/ trainset	3.000	21.000
Tons/ trainset/day	12.000	84.000
Tons/ trainset/year (365 days)	4.380.000	30.660.000

Source: Calculated by the Researcher, derived from Putranto, 1997 ;

From the calculation as in the above table we estimate 7 trainsets will need to transport 28 Million tons of coal, with the Total purchasing cost as the following table:

Table 5.5.3 Estimated Capital Cost to Reach 28 Million tons

Description	1 Trainset Combination	Trainset to reach 28 m.t	Estimated Cost/ unit	Total Cost
Locomotives with 3000 Horse Power	2	14	US$ 2,5 Million	US$ 35 Million
Wagons (50 tons/wagon)	60	420	US$ 50.000	US$ 21 Million
Total				US$ 56 Million

Source : Calculated by the Researcher, derived from Putranto, 1997; UPRR Engineer,2008; Wikianswer, 2011.

The total trainset combination as the above table concludes that the total capital cost for the overland transportation will be the construction cost for the railroad plus the trainset combination which are US$ 125 and US$ 56 Million respectively, the Total of the capital cost approximately US$ 181 Million.

B. Capital cost - Vessel Purchase (Barge and Tug Boat)

In deciding the barge and tug to purchase, we need to assess and select the vessel system :

B.1 Assesing the Vessel System :

This part of the Thesis studies the types and sizes of ships for coal transport that among those are self-propelled barges and towing, or tug-barge system. The analysis will deliberate ships dimensions, and routability related to existing limitations of the river. In order to ascertain the most maximized ship system, it is imperative to view all potential limitations of Musi River coal barges operations which shall include the loading and unloading conditions. In order to serve such objective, here are some aspects examined(Indonesia Port Corporation II, 2011b) :

a) Water depth availability
b) Width of the fairway
c) Angle of bends
d) Flow of the river.

The different types of vessel are described as follow :

1) Towing Tug Barge

This type of system is a shipment practice applied to serve the route from Palembang to the neighboring Southeast Asian Economies. The towing tug barge system is nonetheless inappropriate, especially at the upstream area of Musi River (approx. 250 m wide). It is possible that barges will have to be towed (pulled) at a short distance from a tug or, instead, will need a buffer tug to maintain control on the barge. Moreover, the process of exchanging towed barges requires approx. 30-40 minutes, meanwhile the pusher barge system demands shorter time(Indonesia Port Corporation II, 2011b). Related to this hindrance, the usage of towing-tug barge system is simply not feasible. This system is feasible if applied in short sea crossings.

2) Pusher Barge Systems

This system possesses greater yield than that of the towing barge system. Barges can be pushed to form single lines or multiple row. That way, the total loading volume of the conjoined barges will be ranging from 12,000 up to 18,000 tons (Indonesia Port Corporation II, 2011b). The advantage in loading volume is combined with the duration of exchanging process of pusher barges which takes approximately 30-40 seconds for connecting or disconnecting and it enables barges exchange to be about several minutes (Indonesia Port Corporation II, 2011b). This has a favourable impact on the number of trips per day that a tug can make and number of brages required.

3) Self-Propelled Barges

A self-propelled barge unit that is up to 3,000 DWT is the largest available single unit. A unit greater than 3,000 DWT can operate only when combined with a barge, that is a self-propelled unit that pushes another extra barge. In order to reach upstream site, this unit must be on shallow draft. If the water depth is 5 m, the maximum draft will reach 4.5 m. Correspondingly, a vessel with a dimension of 80 x 16 m and a draft of 4.3 m will be appropriate (Indonesia Port Corporation II, 2011b).
In this type of transport operation suggested in this Research, the crucial and frequent loading and unloading occurences infer that a self-propelled barge would become a crucial part. Every self-propelled vessel would need an engine; greater capital cost in the propelling system is needed, whereas the utilization of this system is still unpopular. More installation of machines also infer more manpower for the operation and maintainance. Consequently tug and barge systems are seemingly more economical because the propelling unit and crew are parted from the unit that carries cargo and this will allow lesser more-lavish-elements of the system (Indonesia Port Corporation II, 2011b).

B.2 Selection of the vessel types

1) The interconnected pusher barge system delivers more manuverability and it is assumed to be imperative dure to the difficult tracks of Musi River. The capability to convey numerous barges in one trip which is feasible by the improved manuverability has made this possibility a more efficient one. Tugs that are in low draft will be required to be used on the river upstream in Palembang. In Tanjung Banyuasin, or in other appropriate haven, barges might be anchored for submission by OG tugs that can tow them towards the sea throughout Indonesia and neighboring Southeast Asian Countries. The expected quantity of coal to be conveyed and durability of the activity are those would be appropriate for use in this work. Consequently the shortage of compatibility to other barge systems is not an issue. Pusher barges are expected to be matching with the berths of costumers.(Robert, 2009)
2) Since the distance travelled and frequency of loading/unloading occurences are relatively short, the capability to swiftly connect/disconnect barges possess advantages of their own. When cargo is deposited in Tanjung Banyuasin, the barges will be unloaded and the cargo will be moved to OG vessels for further conveyance to costumers.

Related to the two grounds, the most basic element of the new conveyance corridor through Musi River to Tanjung Banyuasin by means of interconnected pusher barges – demands well-organized planning.

B.3 Sizing of Vessel (pusher barge specification)

From Muara Abab, the coal are barged approximately 200 km along the Musi River. The presence of several slender routing passes and air draft constraints (related to bridges; mainly by Musi Bridge – 7.5 m air draft) pose to become significant constraints in addition to the draft restriction 5 km to the upstream direction from Palembang. Consequently shallow-draft vessels – vessels with draft not more than 3.7 to 4 m (given the margin of safety that considers potential sedimentation) are needed. Table 5.5.3 summarises the typical vessel dimensions and capacities in this range

Table 5.5.4 Typical Vessel Dimensions

Deadweight DWT)	***1,000***	***2,000***	***3,000***	***4,000***	***5,000***	***6,000***
Draft (m)	3	3,2	3,5	3,7	3,9	4,1
Lenght (m)	65	70	80	90	105	113
Width (m)	12	13	14	15,5	25	28
Displacement (m3)	1.750	3.500	5.000	6.500	8.000	10.200

Source : Inaport Corporation II, 2011b

The limitations on air draft are highly related to tugs. The peak point in tug-barge formation is the pole on the tug that carries two red towing lights (compulsory for trips to overseas destinations such as Singapore and Malaysia). The elevation of this mast is commonly lower than 8 m and hence, should not indicate any related potential air-draft problems. The anticipated height of coal stack onboard the barge would range around 4 m over the upper deck of the barge in relations to the lightweight/specific gravity of coal that can be accomodated by barges. The chosen vessel size – 6,000 DWT – is therealistic limit of vessel design for the Musi River to the upstream direction of Palembang. The air-draft limit of the second Musi Bridge (7.5 me at HWS), the river natural depth (considering the dredging proposal), width and tight bend of the river make it unattainable for larger ships lacking massive engineering works. Loaded barges are anticipated to possess elevation of around 6.5 m and similar to the tugs. The width and length plays crucial limitation to increase vessel measurement further, because doing so will hinder unlimited two-way transit at several locations (as an addition to those listed in the following), and maneuvering at some rivertwists will be more challenging. As explain in the previous paragraph, we will calculated the total fleet size requirements which are able to transport 28 Million tons per annum :

Table 5.5.5 Fleet requirement to reach 28 Million tons

Deadweight DWT	***1.000***	***2.000***	***3.000***	***4.000***	***5.000***	***6.000***
Speed (1 knot= 1,85 km/h)	6 Knots	6 Knots	6 Knots	6 Knots	6 Knots	6 Knots
Round trip Distance	400 km	400 km	400 km	400 km	400 km	400 km
Roundtrip Sailing Time (days)	1,50	1,50	1,50	1,50	1,50	1,50
No of Roundtrip per annum (330 days)	219,78	219,78	219,78	219,78	219,78	219,78
No of tons per Barge per annum	219.780	439.560	659.340	879.120	1.098.900	1.318.680
Number of Barge and tug boat Set need for 28 m.t	127	64	42	32	25	21

Source : Calculated by the Researcher, derived from Inaport corporation II, 2011b

From the calculation above it can be estimated that the number of the Barge and Tug combination which will need to purchase, it shows that the 1,000 DWT barge will need more unit of barge to reach 28 Million tons while the 6,000 DWT is required less unit. It is very difficult to determine the exact price for the Tug and barge due to many factor which influence such as the place to build, price of the material (steel and wood), labor cost etc. How ever the researcher define the range of the tug and barge based on the available data of the New building price of barge(Asia Vessel, 2011) and tug (Dredge Broker, 2011) as shown in the table below :

Table 5.5.6 Capital Cost of Barge and Tug boat

Deadweight DWT	***1,000***	***2,000***	***6,000***
Number of Barge and tug boat Set need for 28 m.t (A)	127	64	21
Range Price of Deck Barge/ unit (B) *	$350,000 - $750,000	$970,000 - $1.2 M	$1.45 M - $1.7 M
Range Price of Tug boat (2000 HP) / unit (C) **	$2.4 M – $3.04 M	$2.4 M – $3.04 M	$2.4 M – $3.04 M
Total Range Price of Deck barge (D)=AxB	$45 M - $95 M	$62M - $77 M	$31 M - $36M
Total Range Price of Tug boat (E)=AxC	$305 M – $386 M	$153 M – $195 M	$50 M – $64 M

Source: Calculated by the Researcher, derived from *Asia Vessel, 2011; Inaport Corporation II, 2011b, **Dredgebroker, 2011

In order to pull barge of 4,000 DWT at maximum speed of 10 knots, it will need tug boat powered 1,800 HP (Richard, 2009). By using these information we assume 1,000 DWT will need minimum tug boat with 500 HP, 3,000 DWT and 6,000 DWT will need tug boat with minimum 1,500 HP and 3,000 HP respectively.In this Research we assume to use the same tug boat with the the 2,000 HP. As shown in the table as above, the 6,000 DWT give more efficient interms of the capital cost to purchase tug and barge, the total cost approximately US$ 36 Million + US$ 64 Million= US$ 100 Million.

C. Capital Cost- Barge Loading Point

The cost to construct the barge loading point consist of the civil cost for berth construction, material handling can be shown as the table below(Indonesia Port Corporation II, 2011b):

Table 5.5.7 Capital cost of Barge Loading Point

Description	**Existing construction cost for the loading area for the capacity 9,5 m.t (i.e Port of Tarahan) (US$ Million)**	**Estimated Cost to build the loading point with the capacity 28 m.t (US$ Million)**
Berth area (m2)	6,000	17,600
Civil Works	6	18
Material Cost	25	73
Total Civil Works and Material	31	91
Others such as utilities etc (20% of total Civil works and material)	6	18
Total Cost	37	109

Source: Indonesia Port Corporation II, 2011b

D. Capital Cost - Transhipment Facilities

As mention in the section 4.2.3, we assume to use the floating crane vessel. With the capacity 25,000 ton per day per floating crane vessel, it will need 3 (three) Vessel to reach 28 Million tons per annum. The estimated capital cost to purchase the floating crane vessel is about US$ 20 Million (World Oil, 2010), 3 (three) floating crane vessel will be US$ 60 Million.

E. Capital Cost - Dredging Cost

To determine the dredging cost in from Muara abab to Tanjung Banyuasin will need a special study. How ever the researcher tried to determine the dredging cost by using the the existing information on the average river draft which is -3,5 LWS in average and collaborate with the known barge size and the requirement of the draft with in the river. Based on the Information from Inaport Corporation operation staff, for -1 meter LWS per 1 kilometres, the river will need around 75 cu.m material to be dredge. For the safety factor, the additional -0,5 LWS to -1 LWS will also take into the calculation.
Rate of dredging cost per m^3 (cubic meters) derived from UK Broads Authority, 2005 is £7 to £10 per cubic metre. We assume to take £10 per cubic meter or US$16 (Exchange rate £1 = USD 1,5952) (Money Converter, 2011). The calculation for the Dredging cost can be estimated as the following table :

Table 5.5.8 Capital Cost of the Dredging

Deadweight DWT	***1,000***	***2,000***	***3,000***	***4,000***	***5,000***	***6,000***
Draft (m)	3	3.2	3.5	3.7	3.9	4.1
Safety Reason (0,5 to -1 m at LWS)	0.5	0.5	0.5	1	1	1
Total Draft	3.5	3.7	4	4.7	4.9	5.1
Existing River Draft in Average (m at LWS)	3.5	3.5	3.5	3.5	3.5	3,5
Draft need to be dredge (m at LWS)	0	0.2	0.5	1.2	1.4	1.6
Dredge Volume for -1 m per 200 Km (cubic meters) – Assume 80% need to dredge ($75m^3$x200x80%)	12,000	12,000	12,000	12,000	12,000	12,000
Total Dredge Volume (cubic meters)	0	2,400	6,000	14,400	16,800	19,200
Dredging Cost per Cubic Meters (US $)	16	16	16	16	16	16
Total Dredging Cost (US$)	0	38,400	96,000	230,400	268,800	307,200

Source: Calculated by the Researcher, derived from Indonesia Port corporation II, 2011b; UK Broads Authority, 2005

F. Total Capital Cost

Summaries the previous explanation, the total capital cost for 6,000 DWT barge can be shown as the following Table 5.5.9:

Table 5.5.9 Total Capital Cost of Scenario V

Description	Capital Cost (US$ Million)
Overland Transportation	181
Purchasing: Tugs and Barges	100
Barge Loading Point	109
Transhipment Facilities	60
Dredging Cost	307
Total Cost	**757**

5.6 Review of Other Options

5.6.1 Road Truck

Coal transport by means of road/highway is viable, though it will possibly be costly than railroad or water transport, especially for long-distance transport. Two notions must be put to consideration for this Research:
a) The use of prevailing roads.
b) Construction of devoted coal hauling roads.

Both road systems have a general advantage of lower infrastructure costs, and more flexibility than the fixed-route system such as river, rail, or conveyor (Clark, 1973). When roads are less complex it will reduce the opportunity for the occurrence of infrastructure failure if compared to the options, and if such thing occurs, re-routing trucks will be more viable compared to any alternative modes of transport. The prevailing road linkage resembles the rail routes the same way as many rivers in South Sumatra. The main roads between primary mining areas and Palembang are quite straight, whereas the 2 (two) routes to Tarahan digress drastically. The quality and capacity of the roads are not distinctively acknowledged, but it is projected that average speed on public roads may be low since they are single tracks and they pass through several inhabited tenements. This would affect the labor cost (i.e. driver's hour), and also political acceptability for using public roads for the transport of coal in large quantities(Indonesia Port Corporation II, 2011b).

Use of Existing Roads
Using the prevailing road network in order to deliver coal bears the advantage of necessitating road network to convey coal has the advantage of demanding minimal infrastructure work, but with the following constraints (Indonesia Port Corporation II, 2011c):
a) The size and capacity of carrying trucks will be limited (between a range of 25-30 tons);
b) Trucking by public roads are very costly due to the long distances from mines to port.
c) The environmental effects are considerable.
d) Local residents or highway authorities it could raise objections.

The limited bearing capacity and high labor-to-payload index has made trucking by public road becomes one of the most expensive alternative in a sense of operation expenditures. However, in terms of short distance or short term movements, trucking on public road is advantageous since much lower infrastructure costs compared to other alternatives.

Construction of Dedicated Coal Hauling roads
A dedicated coal towing road shall allow larger, dedicated trucks to be deployed and practical on a public highway. This would lead to the purchase of land for the purpose of constructing roads. This would open a chance for these advantages of using public highways to be effective (Clark, 1973):
a) Larger size vehicles will be more efficient compared to those used on public roads.
b) Depending on the alignment of the coal hauling road, the distance they travel may be reduced.

c) Disputes with other road users, residents, or environmental effect can easily be reduced or managed.

Coal road demands investing in infrastructure. As a private road, the standards of construction may be different from public roads; it helps to minimize cost, and could be used over any distance. One implementation may act as a feeder route towards short to medium distances, bearing coal from some nearby mines to an accumulation point, where trans-shipment to a lower-cost mode is created for longer parts of journey to ports or costumer. As far as the Researcher is concerned, a coal road of some 200 km has been projected within the Study Area, connecting the prevailing coal production center to the coast near Tanjung Banyuasin(Indonesia Port Corporation II, 2011b).

5.6.2 Conveyor

Coal conveyor systems are generally placed for quite short distance coal transport, though some examples cover much longer distances. Dissimilarly, other modes of conveyor acknowledge constant coal movement. The cost of coal transport through conveyor compares auspiciously to road or railroad, though the subsequent weaknesses are noted (Siregar, 2004):

a) Land purchase and establishment a right of way is required.
b) Infrastructure investment would be costly.
c) Failure would lead to vulnerability.
d) Limitations on horizontal and vertical bend, and
e) Limited distance at which they are suitable, except in satisfactory conditions i.e. flat and straight.

5.6.3 Coal Slurry Pipeline

At some sites in the world, coal is transported through pipeline installation in the form of liquid slurry. This is benefiting in a sense that there are fewer moving parts, but it will be as problematic as conveyor and one more thing, it consumes much water. Once the coal arrives (Cox, 1983). The coal must immediately be dried and by means of the same pipeline, moving different types of coal at the same time is not possible. The slurry pipeline is not popular in Indonesia since railroad and river way transport are available.

5.7 *Enviromental Impact*

Environmental assessment and issues for each route have been reviewed and studied by Indonesia Port Corporation II (PT Pelindo II) and Indonesian Railway Corporation (PT KAI). The review and study explained the environmental report of the two companies along with results of interviews.

5.7.1 Use of Existing Rail Corridor (Scenario I)

The prevailing rail corridor will use existing rail and road infrastructure as indicated in Fig 5.1.2.There may be chances to improve the capacity of prevailing network to accommodate the improvement of coal transport from the mines. It would be possible that environmental impact and limitation to this option can be minimized with an assumption that the increased capacity can befall amidst increasing the frequency of train and other means as reviewed in section 5.1.6.

5.7.2 Duplicate Railway Scheme (Scenario II)

The railroad alternative suggests that new rail tracks would be built to the south from Muara Enim about 80 km (as figure 5.2.1) and then continuing in parallel with the prevailing rail track – duplicating the route – stretching between Prabumulih and Tarahan in the south. There will be several limitations and environmental impacts to be noted (Indonesia Port Corporation II, 2010):

a) Intersection with several some ‘industrial (production) forest territory’; in particular intersecting the industrial forest located eastern to Tanjung Enim. Industrial forest is the forest area which the main function to produce the forest products. The utilization of forestry area for non-forestry-related construction should be performed without changing the primary function of such forest area.
b) Transport operations (e.g. new rail construction) will require at least a license and/or revocation to forest boundaries. At the present time, the possibility of acquiring this kind of license or endorsement is yet certain, but it is apparent that the route of road between Tanjung Enim and Tarahan evades in order to prevent intersection with the forest area.
c) If the usage of industrial forest area for rail tracks is endorsed, any clearing and earthworks will be forbidden in close vicinity (100 m) from wetlands and/or rivers, creeks and other waterways under the requirements of Forestry law. It is assessed that this option is categorized as minimal to medium environmental limitations compared to other alternatives. This is conclusive based on an approach trying to prevent intersection with industrial forest area and if the intensity of the work related to rail tracks duplication shall occur on land surface adjacent to prevailing infrastructure.

5.7.3 Northern Rail Corridor Scheme (Scenario III)

This option suggests that a new rail extension will be built between the prevailing port facility in Kertapatiplus the projected transhipment terminal in Tanjung Banyuasin. Here are some possible important issues and contraints related to this design (Indonesia Port Corporation II, 2010) :

a) The demand for the rail line to cross crucial lengths of floodplain would depend on certain design of the civil engineering and infrastructure (with the possibility to impact prevailing water flow).

b) In relation to the previous point, we can determine the direct and indirect effects to wetland surroundings. The Musi Banyuasin inlet area is understood to contain complex and valuable mangrove environments with almost 17 species of mangroves and related significantly-conserved fauna (such as Sumatran Tigerand Saltwater Crocs; and up to 25 species of endemic and migrant water aviaries(Silvius, 2008)
c) The large delta system in Banyuasin and Musi River and its numerous smaller branches and creeks is thought to bear the potential to be related to the existence of world's largest breeding colony of Milky Stork. The area is also an area at which lives a population of Spot-billed Pelicans the only spot to be inhabited by such wildlife animal. The area also has the largest population of Lesser Adjutants known in Indonesia and not to mention the White-winged Wood Duck known to inhabit the swampy forest in the mangrove shrubs. Some other aviaries are also known to be natives of this area, such as the Grey Heron, the Great Egret and Black-headed Ibis (Silvius, 2008)
d) Musi Banyuasin inlet territory also serves as habitat for no less than 99pisces species and some other shrimp and prawn species. The existence of those fish and crustacean also serves the commercial and recreational purposes. Their existence is strongly related to mangrove areas that serve as their natural habitat(Silvius, 2008)
e) Mangrove is also reported to have substantial role in supporting the economy, i.e. by the collection of firewood, charcoal, Nypa leaves (utilized as roofing material), and Nypa fruits for sugar extraction. The area's significantly scenic nature also opens potential and feasible commodity for ecotourism (Silvius, 2008).
f) The projected rail route will also cross 'protective forest area' that was declared along the coast head-to-head to the foreshore. Under the Act of Forestry, a protective forest is defined as a forest with mainto protect life buffer system in order to prevent flood, erosion, seawater intrusion and maintain the soil fertility. The utilization of forestry area for non-forestry-related construction should be performed without changing the primary function of such forest area. It can be inferred that the designation of the area will require at least a license and/or revocation to forest boundaries, including the requirement to perform rehab and restore of lands that are degraded as the consequence of construction project. Projected new railway route must be carefully considered as well as civil engineering design limitation in the wetland surrounding (watercourse and other measures to preserve natural drainage patterns), doubled with the construction method at its best in controlling sedimentation and water quality, may contribute to the decrease of scale and severity of environmental impacts. Nevertheless, it is assessed that this option has medium to heavy environmental limitations compared to other alternatives, based on the prevailing values previously outlined (Indonesia Port Corporation II, 2010).

5.7.4 Railway Extension to Bengkulu Scheme- Scenario IV

This railway options projects that new rail tracks are to be built between Lubuk Linggau and the west-coast port in Bengkulu, connecting a distance of approximately 90 km through the western part of Sumatra. Here are some noted environmental glitches and limitations of this option(Indonesia Port Corporation II, 2011c):

a) The projected route possesses a certain engineering and geotechnical difficulties due to the topography of the area which includes elevated steep slopes over the

Barisan Mountain. A construction project in this area will demand extra control over sediments and extra consideration on the climatic-variation-related erosion. Higher risk of landslides in the area that possibly be caused by the construction project should also be one of the concerns.

b) The area provides very little environmental information and thus, not much that can be reviewed in terms of environmental concerns in relations to this Research. The ecological values along this projected route will distinctively be different from the lowland areas in the surroundings of Muara Enim and Musi Banyuasin floodplains. Some rainforest-type communities inhabiting the area of rail track construction will be prone to changes due to their sensitivity towards ecological changes that are caused by the construction project and furthermore, the operation of the transport infrastructure once the construction is finished. This is partly the result of the more static character of higher-elevation environments and lack of natural flexibility towards environmental changes.
c) As a result of land clearing and filing, direct and indirect impacts towards the upland habitats may occur. Related to this issue, there will be indirect operational impacts in regards to the noise disturbances to the wildlife and potential crash between trains and fauna.
d) Though the route is deviated to prevent intersection with any forest areas or parks, there is somehow a large national park area that situates right at the northwest of Lubuk Linggau. This condition may affect the construction project and once the construction is accomplished, the use of new route of railway. A review on Biological Natural Resources and its pertaining Ecosystem Act suggests that the projected new route needs to evade this national park area wherever possible. Based on some assessment, this option will be characterized as having heavy environmental limitations compared to other options, owing to the fact that sensitivity of habitats and inherent challenges of controlling erosion, not to mention landslide potential during the construction and operation of the new, projected routes.

5.7.5 Musi River and Transhipment Scheme (Scenario V)

This options possibly result in reduced environmental impacts (related to land clearing and filling for transport corridor) compared to other options. The downstream area (downstream of Palembang) are under use for maritime transport and regularly scoured (even the positioning of scoured material remains an issue to the environment – see below). The following potential environmental effects caused by this option will need further assessment in the course of future feasibility/AMDAL study(Indonesia Port Corporation II, 2011c):

a) Capital and maintenance scouring of the Musi River (and any associated canal) is required, particularly for parts between Palembang and Sekayu.
b) The positioning of this scouring material either anywhere in the River, on the banks or in a confined scouring material placement area.
c) Where such dredge material is to be utilized for land reclamation in the delta area at the entrance of the river for port and/or material transfer operations, the associated direct impacts of the reclamation on the aquatic ecology of the river and any associated indirect changes to coastal and fluvial hydrodynamics
d) Effects from the construction of related infrastructure, and further, the operation of the barges (e.g. boat-wash) on riparian mangrove and vegetation and related wildlife habitat along the river ecosystem. This is also pertaining to the recent

observation in 2005, on the endangered Hairy Nosed Otter (Lutra sumatrana) on the banks of the Musi River between Palembang and Sekayu. The rare river threadfin (Polydactylus macrophthalmus) exists in Musi River and its habitat is restricted to only three rivers on two Indonesian islands.

e) Other impacts on social or economic users of the river that might be influenced by the construction and further, the operation of related infrastructure, scouring and spoil placement and/or increased traffic of barge vessel along the river.

This Musi River option is categorized as having light and medium environmental limitations that are reliant to the preferred design and approach to transporting the coal from the mine(s) to the receiving/transfer point of the river. The degree of dredging is required to facilitate barge transport to Palembang (and then to Tanjung Banyuasin).

5.8 Selection on the Least Cost Solution Scenario

In conclusion the following options could be used for the new coal transport corridor:

1) The existing railway is best for the long distance and available for the long term transport but limited in the capacity
2) The new railway is best for long distance and available for long term transport if there is no other options except if the road are developed.
3) The new public road - only suitable for short term and short distances.
4) River and transhipment terminal seems to be the best option where available and reliable.
5) Conveyor is suitable for movements in the short distance and long term use such as ‘bridge’ to the other mode of transport.
6) Pipeline is not suitable, unless the pipeline only transport one type of coal.

From the conclusion as above we found that the river and transshipment option is the most reliable and available for the coal transport. The transportation cost, Main advantages and disadvantages and environmental impact are considered to select the least-cost option as the following table 5.8.1 in the page 67. It is very hard to determine the least cost scenario for this researched, depend on different of perception, However,the Researcher select the least cost solution as the result of the table 5.8.1 which conclude as follow:

<u>Scenario V > Scenario II > Scenario III > Scenario I> Scenario IV</u>

Table 5.8.1 Scenarios for Coal Transportation in South Sumatra						
Scheme	**Estimated Total Transportation Cost per Ton** (US $)	**Estimated Capital cost** (US$Million)	**Total Capacity** (Million Tons)	**Main Disadvantage**	**Main Advantage**	**Enviromental Impact**
Scenario I	98,45	60,3	9,5	Limited capacity (Axle capacity and Gauge Structure) to develop the railway, maximum to 12 Million tons as mentioned in section 5.1.6	Easy to increase the capacity to 12 Million tons by simply add the wagon and locomotive power.	Minimum environmental constraint (section 5.7.1)
Scenario II	144,22	144	22	New track will require purchase of land from citizen, building new track more costly than upgrading the existing (section 5.2). Railway is limited by the land structure (swamp area etc)	Coal carrying capacity could be greatly increase, save more kilometres compare to existing	Minimum to medium environmental constraint (section 5.7.2)
Scenario III	84,21	10	9,5	Capacity constraint by the maximum axle load of the old railway,potential enviromental issue due to the soft/wet land) (section 5.3)	Saving at shipping cost (Transshipment directly into larger vessel at Tanjung Banyuasin), potential reduce the transit time. (section 5.3)	Medium to Heavy environmental constraint (Section 5.7.3)

Table 5.8.1 Scenarios for Coal Transportation in South Sumatra

Scheme	Estimated Total Transportation Cost per Ton (US $)	Estimated Capital cost (US$Million)	Total Capacity (Million Tons)	Main Disadvantage	Main Advantage	Enviromental Impact
Scenario IV	158,65	109	17	High cost to build and operate per-km basis but not significantly increase the tonnage capacity (Section 5.4)	The position of Bengkulu on the west side of Sumatra is given the location for new potential export customers	Heavy enviromental constraint (section 5.7.4)
Scenario V	87,77	757	28	Airdraft limits are imposed by bridges, most notably the Ampera Bridge, dredging will be required which could be costly, high initial investment cost for vessel and transhipment terminal (section 5.5). Potential and flexible to upgrade.	Transport by water is generally cheaper per tonne kilometre than any land mode, lower energy cost per tonne transported, Infrastructure and maintenance costs may be lower than for rail	Minimal to medium environmental contraints (section 5.7.5)

Chapter 6 Conclusions and Recommendations

6.1 Conclusions

The Researcher began the Thesis with the world coal outlook and narrowed his perspective to Indonesia's coal prospects and opportunities. The increase in the demand of steam coal in China, India, and some other countries becomes a big challenge for Indonesian government to use the coal resource as wise as possible, especially for the prosperity of the citizens through the creation of job and at the same time, care for the environment. Within this Research, the Researcher has got some thoughts about the alternative modes and routes to increase the coal transportation capacities.

The objective of this study is to assess the scenarios of coal transportation in South Sumatra and find the least cost solution. There are five scenario of coal transport has been assess in this study :

6.1.1 Scenario I

The first scenario tried to expose the existing coal transportation which uses the railway mode. The existing coal transportation able to bring 9.5 Million tons of coal per annum by using 2 (two) different tracks. The first track bring 2 (two) Million tons of coal from Muara Enim to Port of Palembang (Kertapati) and the second track bring 7.5 Million tons of coal per annum to Port of Tarahan. It has been reviewed that there is an opportunity to increase the capacity of the existing coal transportation to Port of Tarahan as explain in the section 5.1.6. The additional of the trainset (locomotive and wagons) able to increase the capacity of coal transportation to 12 Million tons to Port of Tarahan. It is presumable that the railroads are operational at the limit of the two issues, and the two issues are directly intertwined with weight limit (axle loads) and wagon dimension limit (structure gauge). The total transportation cost per ton in the scenario I has been estimated about US$ 98,45. The capital cost has been estimated to be around US$ 65 Million (see Section 5.1.7).

6.1.2 Scenario II

The second scenario is constructing new rail tracks from Muara Enim to Port of Tarahan with the better structure gauge, which will enable the achievement of better maximum axle loads. The new track provided can lead to larger capacity, the route could cut many kilometers rather than the existing railway route to Port of Tarahan, hence, it helps reducing transport costs and emissions from locomotives.With the combination between existing 2 (two) rail track plus the new track, the second scenario could transport 22 Million tons of coal per annum.How ever the maximum capacity of the railway is limited by the land structure (swamp and forest area).The Total transportation cost per ton in the scenario II has been estimated about US$ 144,22. The capital cost has been estimated to be around US$ 144 Million (see Section 5.2.2).

6.1.3 Scenario III

The third scenario is constructing new rail tracks as the extension of the Railway from Muara Enim to Port of Palembang (Kertapati), the new railtrack connects to the Transshipment Terminal which can directly access the larger ships in Tanjung

Banyuasin, and thus, preventing the needs for trans-shipment from small to largerships. To achieve improvement on transported coal quantity, improvement of railroad capacity, especially on tracks serving from mining area to Palembang, is inevitable. This track is generally low in terms of supporting maximum axle loading compared to that of Tarahan. Besides, there might be some capacity issues. The Total transportation cost per ton in Scenario III has been estimated about US$ 84.21. The capital cost has been estimated to be around US$ 10 Million.

6.1.4 Scenario IV

The fourth scenario is develop the new railway track directed towards Bengkulu (eastern part of Muara Enim), the project would have to construct railroad tracks through the Barisan Mountain (hilly area). This would inevitably be high-cost. The Total transportation cost per ton in Scenario IV has been estimated about US$ 158,65. The capital cost has been estimated around US$ 109 Million (see Section 5.4.2).

6.1.5 Scenario V

In the fifth scenario, the Researcher collaborates the railway, rivers and sea transportion corridor. As the result, Musi River becomes more important as one of the ways to transport coal in big capacity, less transportation cost, less enviromental impact, flexible in anticipate the coal demand and potential for upgrade. The total transportation cost per ton in the scenario V has been estimated about US$ 87,77. The capital cost has been estimated to be around US$ 757 Million (see section 5.5.5).

6.1.6 Least-Cost Scenario

Scenario II and Scenario V seem to be the least-cost scenario as both give the lower transportation cost with bigger capacity. The capital cost of Scenario V is expensive than scenario II but the opportunity to raise and developed better transportation system has flexible limit to anticipate the demand of coal for the long term, as the other 4 (four) scenarios limited in the capacity of the rail system and only suitable for the short term planning. The development of the Scenario V may change the way of coal transport in South Sumatra.These activities will be changed to the activities related to the supply chain of the coal from the mining area to the loading point, delivery of coal by the tug and barge through Musi River, more loading and unloading activities at the port or terminal and the high utilization of the drybulk vessels. The better supply chain in the transportation will give numerous advantage for Indonesia’s economy such as opportunity for the big investmentwhich will create employment opportunity. There are also numerous advantages for the shipper or buyer such as China, because they would be able to transport coal more economically (economic of scale), which will allow them to increase their profit by reducing the shipping cost. The mining company in Indonesia also get reciprocal advantages through this economic of scale. The existing cost composition (25%) is dominated by the railway cost (as explained in section 5.1.7). By using the river scheme and bigger vessels, these composition will be much lower and it may increase the profit for Indonesian mining company in general.

6.2 Recommendations

From the results of the least-cost solution, it has been remarked that the relation between river transportation, transshipment terminal and shipping industry are really important to improve the efficiency and effectiveness of coal transportation in Indonesia, especially in South Sumatra. To make this study possible, it will need further feasibility study on each of the modes and routes of the transportation scenarios. The actual economic opportunity of the coal trading lays on the international export transportation. Indonesian coal exports in 2010 was 230 Million tons. However, the portion of the Indonesian voyage (domestic shipping) only 10% (Hudaya, 2009), meaning the 90% become a source of income of foreign shipping companies and it terribly is an irony. Assuming that an average shipping rate of export from Indonesia to China/India is about 30 US$/ton (Hudaya, 2009), it means that Indonesia will experience capital flight in terms of foreign exchange flows of more than US$ 5 billion or more than IDR 60 trillion p.a. Therefore, the application to improve the national shipping industry are set in stone and should not be put off any longer. By taking over the coal transportation, the economic opportunities that can be grabbed in terms of state revenue is quite significant. Moreover, it can also be considerable that other commodities, such as oil and gas, palmoil and other commodities should use Musi River and transshipment terminal.

Bibliography

1. Alibaba. (2006). Floating crane price. *http://www.alibaba.com/showroom/floating-crane.html* , (accessed on September 2011).

2. Ando, H. (2010). The Position of Coal on the Strategic Energy Plan. *Natural Resources Department.* Tokyo: Ministry Economy, Trade and Industry.

3. Asia Vessel. (2011). *http://asiavessel.com/sale01.php?SubCode=&page=17&Htop=&Ref=&vess_type=&vess_type2=&nation=&nation1=&year=&year1=&scrap=&cap1=&cap2=&unit=* , (accessed on September 2011).

4. Aspindo. (2010). *www.aspindo-imsa.or.id.* Jakarta: Asosiasi Jasa Pertambangan Indonesia.

5. Ballou, R. (1998). *Business Logistic Management.* United States: Prentice Hall.

6. Bank Negara Indonesia. (2008). *Economic Review.* Jakarta: Ermina M.

7. Baram, M. S. (1977). *The Economic Feasibility of Artificial Island for Clusters-Siting of offshore Energy Facilities.* New York: National Center For Analysis energy Systems. *http://www.osti.gov/bridge/purl.cover.jsp?purl=/5010637-d1Iwwr/* (accessed on July 2011).

8. Barlow Jonker. (2011). *http://www.scribd.com/doc/43392150/Indian-Thermal-Coal-Imports-Prospect.* (Accessed on July 2011).

9. Branch, A. E. (2007). Floating Terminal. Dalam A. E. Branch, *Elements of shipping* (hal. 391). London: Taylor and Francis.*http://books.google.co.id/books?id=LhtvalKd5rYC&dq=floating+cranes+for+coal&source=gbs_navlinks_s.* (accessed on July 2011)

10. British Petroleum. (2010). *Statistical Review of World Energy.* London: BP.

11. Bukit Asam Mining Corporation. (2009). *Annual Report Bukit Asam Mining Corporation 2009.* Jakarta: Bukit Asam.

12. Bukit Asam Mining Corporation. (2010). *Interim Financial Report.* Jakarta: PTBA.*http://www.idx.co.id/Portals/0/StaticData/NewsAndAnnouncement/ANNOUNCEMENTSTOCK/From_EREP/201107/FBE8A6A6-4ECC-48DD-A2F8-55C946FB7C6A.PDF* (accessed on July 2011).

13. Caldwell, J. (2006). Technology Review Slurry Pipeline. *http://technology.infomine.com/slurrypipelines/* , (accessed on July 2011).

14. Center for Data Information on Energy and Mineral Resources. (2010). *Handbook of energy and Economic Statistic of Indonesia.* Jakarta: Ministry of energy and Mineral Resources.

15. Chennai Port. (2011). *http://www.chennaiport.gov.in/pdf/cargorelcharges.pdf.* India: Chennai Government.

16. Clark, P. R. (1973). *Transportation Economics of Coal Resources of Nothern Slope Coal Fields, Alaska.* Fairbanks Alaska: University of Alaska and Mineral Industry Research Laboratory.

17. Coin Mill. (2011). *http://coinmill.com/INR_USD.html#USD=1.* (accessed on July 2011).

18. Cook, A., & Daulay, B. (2000). The Indonesian Coal Industry.

19. Cox, C. B. (1983). *Comparing the Studies of a Coal Slurry Pipeline.* Virginia: Virginia Water Resources Research Center.

20. Cslshipping. (2011). *www.cslshipping.com.* CSL.

21. d'Aniello, G. S. (2010). Offshore transshipment terminals: a Valid alternative to port infrastructure. In P. Technology, *Dry Bulk and Specialist Cargo Handling* (p. 96). Italy: Port Technology.

22. Dredge Broker. (2011). *http://www.dredgebrokers.com/Boats.html* , (accessed on September 2011).

23. Drewry Consultant. (2009). *http://www.ciasf.com/wp-content/uploads/RCAMiami_Panama_Port2_part6of6.pdf.* (accessed on July 2011).

24. FPS. (2010). Floating Crane Price. *http://www.floatingplantservices.com/plant.php?load_Plant=true&Plant_id=167&* , (accessed on September 2011).

25. Global Security. (2011). *http://www.globalsecurity.org/military/systems/ship/barge-carrier.htm* , (accessed on July 2011).

26. Glover, H. (1970). *Unit Train Transportation of Coal.* Information Circular 8444: U.S Bureau of Mines.

27. Google. (2011). Google Map. *Musi River Indonesia* .

28. Gottwald Floating Cranes. (2011). *http://www.gottwald.com/gottwald/export/gottwaldsite/galleries/Brochures/Floating_Cranes_uk.pdf* , (accessed on september 2011).

29. Haralambides, H. (2011). *Shipping Economics and Policy.* Reader.Rotterdam: Center for Maritime Economic and Logistic Erasmus University Rotterdam.

30. Hartoyo, B. (2009). Coal Supply and Demand Indonesia Toward 2025. Jakarta: Directorate of Mineral and Coal Enterprise.

31. Hudaya, G. K. (2009). The Important of coal for the Indonesia's Economy. *http://transcoalpacific.com/news_read.php?id=9* , (accessed on August 2011).

32. Illinois EPA. (1998). Lake Dredging. *http://www.epa.state.il.us/water/conservation/lake-notes/lake-dredging.pdf* , (accessed on September 2011).

33. Indonesia Port Corporation II. (2011a). *www.inaport2.co.id/palembangport* , (Accessed on July 2011).

34. Indonesia Port Corporation II. (2010). *Enviromental Impact Analysis Report on Coal Transportation in South Sumatra.* Jakarta: BMT.

35. Indonesia Port Corporation II. (2011c). Interview with Enviromental and Safety Staff of Indonesia Port Corporation II. Jakarta.

36. Indonesia Port Corporation II. (2011b). Interview with Operational Staff of Indonesia Port Corporation II by Author. Jakarta.

37. Indonesia Rail Way Corporation. (2009). *Annual Report Indonesia Rail Way Corporation.* Jakarta: Indonesia Rail Way Corporation.

38. Indonesia Railway Corporation. (2011a). Interview with Operational Staff of Indonesia Railway Corporation by Author. Jakarta.

39. International Energy Agency. (2010). *Key World Energy Statistic.* France: International Energy Agency.

40. Iqbal, S. (2007). *http://www.scribd.com/doc/36157704/Discharging-Port-Tarahan.* (accessed on July 2011).

41. Latif, M. H. (2003). *Alternative of Mining Operation.* Master Thesis, Jakarta: University of Indonesia.

42. Media Indonesia. (2010). *http://www.mediaindonesia.com/read/2010/10/10/173518/21/2/Pelindo-akan-Bangun-Pelabuhan-Khusus-Batu-Bara-.* (Accessed on 7 Oktober 2010).

43. Mimuroto, Y. (2002). *Preliminary Feasibility Study on Railway Coal Transportation in Kalimantan, Indonesia.* Tokyo: Coal Research Group, International Cooperation Department, IEEJ.

44. Ministry of Energy and Mineral Resources. (2010). *Indonesia Energy Statistic.* Jakarta: ESDM.

45. Miranti, E. (2008, December). The Prospect Indonesian Coal Industry. *Economic Review No 214* , p. 2.

46. Money Converter. (2011). *http://themoneyconverter.com/GBP/USD.aspx* , (accessed on 6 September 2011).

47. Nakagaki, Y. (2009). Future of Indonesian Energy Coal and Japanese Involvement. (p. 11). Tokyo: Japan Coal Energy Center.

48. Perdana, B. P. (2008). *Alternatives Source of Energy.* Jakarta: Bank Negara Indonesia.

49. Ports.com. (2011). *http://ports.com/sea-route/port-of-palembang,indonesia/mawei-port,china/.* (accessed on July 2011).

50. Price Waterhouse Cooper. (2006). *Indonesian Coal Industry Prospect by Ermina Miranti.* Jakarta: Bank Nasional Indonesia.

51. Putranto, E. K. (1997). Calculation of the Train facility. *Journal LIPI No 9 Tahun IV* .

52. Richard. (2009). *http://answers.yahoo.com/question/index?qid=20091022025653AAksmXA* , (accessed on September 2011).

53. Robert, H. (2009). The Articulated Tug/ Barge, the History and state of the art. *http://www.oceantugbarge.com/PDF/history.pdf* , (accessed on September 2011).

54. Rumidi, S. (2006). *Batubara dan Pemanfaatannya (Coal and its Function).* Yogyakarta: Gadjah Mada University.

55. Sani, Indra H. (2011). Interview by Author. Indonesia Port Corporation II: Jakarta.

56. Ship.org.ua. (2011). *http://en.ship.org.ua/ship/sell/950* , (accessed on September 2011).

57. Silvius, M. J. (2008). Archipelago Tourism. *http://we-tourism.blogspot.com/2008_11_01_archive.html* , (accessed on August 2011).

58. Siregar, S. F. (2004). *Transportation for The Solid Goods.* Bachelor Thesis.Medan: South Sumatra University.

59. SSY. *www.ssyonline.com.* (Accessed on July 2011).

60. Stopford, M. (2003). *Maritime Economics.* London: Routledge.

61. Sunway Machinery. (2011). *http://www.coalcrushers.org/category/coal-crusher-mining-equipment* , (accessed on July 2011).

62. The Energy Library. (2011). *http://theenergylibrary.com/node/12186* , (accessed on July 2011).

63. Thomas, L. P. (2002). Coal Geology. Dalam L. Thomas, *Coal Geology* (hal. 332). New York: John Wiley and Sons.*http://books.google.co.id/books?id=4oYWx90ybY8C&pg=PA332&lpg=PA332&dq=Geared+Ship+for+coal&source=bl&ots=2qhlYnG6k9&sig=VBK0w9-rsjAXbC1z8hbieYlOOUs&hl=id&ei=7ZlMTqvRFtHsmAWTponVBg&sa=X&oi=book_result&ct=result&resnum=3&ved=0CCkQ6AEwAg#.*(accessed on September 2009).

64. U.S Geology Survey. (2011). *http://energy.er.usgs.gov/coal_quality/coal_quality_pubs_data.html.* (accessed on July 2011).

65. UK Broads Authority. (2005). Dredging Programme Report June 2005. *http://www.broads-authority.gov.uk/broads/live/search.html* , (accessed on September 2011).

66. UPRR Engineer. (2008). *http://in.answers.yahoo.com/question/index?qid=20080820055035AA9daLS* , (accessed on September 2011).

67. Veldman, S. (2003). *Ecorys Transport Application on Transport and Regional Economics.* Rotterdam.Reader: Ecorys Transport and MEL Erasmus University Rotterdam.

68. Wikianswer. (2011). *http://wiki.answers.com/Q/How_much_does_a_railway_wagon_cost* , (accessed on September 2011).

69. Wikipedia. (2011a). Dump truck. *http://en.wikipedia.org/wiki/Dump_truck* , (accessed on July 2011).

70. Wikipedia. (2011b). Musi River (Indonesia). *http://en.wikipedia.org/wiki/Musi_River_(Indonesia)* , (accessed on August 2011).

71. Wilnojst, N. (2009). *Shipping Innovation.* Netherlands: IOS Press.

72. Workboat International. (2011). *http://www.workboatsinternational.com/8,000-dwt-new-build-mpp-geared-container-ship-mws1002.html*. (accessed on July 2011).

73. World Coal Institute. (2009). *Coal Resources- A Comprehensive Overview of Coal .* London: World Coal Institute.

74. World Oil. (2010). *http://www.worldoils.com/marketplace/equipdetails.php?id=145&1000%20Ton%20Floating%20Crane%20for%20Sale* , (accessed on September 2011).

75. World Steel Association. (2010). *http://www.worldsteel.org/.* (accessed on July 2011).

76. www.sourcewatch.com. (2011). *http://www.sourcewatch.org/index.php?title=Indonesia_and_coal.* (accessed on July 2011).

Appendices

Appendix 1 Proposed Construction Project of Power Station by Indonesia Energy Corporation (PLN)

No	Project	Capacity (Megawatts)	Projection of Operational	Location
1	PLTU Southern West Java	3 x 300-400	2011	Sukabumi, West Java
2	PLTU 1 East Java, Pacitan	2 x 300	2011	Pacitan, East Java
3	PLTU Labuan	2 x 300 - 400	2012	Pandeglang, West Java
4	PLTU Tanjung Jati Baru	1 x 600 - 700	2011	Jepara , Central Java
5	PLTU Rembang	2 x 300 - 400	2011	Rembang, Central Java
6	PLTU 1 Banten, Suralaya	1 x 600 - 700	2011	Suralaya, Cilegon
7	PLTU 3 Banten Project	3 x 300 - 400	2011	Kemiri, Tangerang
8	PLTU West North Java	3 x 300	2011	Indramayu, West Java
9	PLTU Tanjung Awar-Awar	3 x 300 - 400	2011	Tuban, East Java
10	PLTU Paiton Baru	3 x 600	2011	Probolinggo, East Java
11	PLTU Madura	2 x 100	2012	Pamekasan, Madura
12	PLTGU Bojonegara	3 x 740	2013	Cilegon, Banten
13	PLTU Indramayu	2 x 300	2012	Indramayu Betung, South Sumatra
14	PLTU Nusa Penida	2 x 100	T.B.A	Nusa Penida Island
15	PLTU Anyer	1 x 330	T.B.A	Anyer, Banten
16	PLTU Kuala Tanjung	2 x 112	T.B.A	South Sumatra
17	PLTU Banjarsari	2 x 100	T.B.A	South Sumatra
18	PLTU Banyuasin	2 x 100	T.B.A	Betung, South Sumatra
19	PLTU Baturaja	2 x 100	T.B.A	South Sumatra
20	PLTU Tanjung	2 x 55	T.B.A	South Kalimantan

No	Project	Capacity (Megawatts)	Projection of Operational	Location
21	PLTA Poso	255	T.B.A	Central Sulawesi
22	PLTU Arahan	4 x 600	2012	Muara Enim, South Sumatra
23	PLTU Central Bangko	4 x 600	2010/2011	Muara Enim, South Sumatra

Source : Annual Report PT PLN (Persero) 2006

Appendix 2 Estimation for The Total Transportation Cost on Scenario I

TONS TRANSPORTED ANNUALY (MILLION TONS)	ORIGIN-DESTINATION	RAIL COST			PORT COST		SHIPPING COST				TOTAL COST SCENARIO I (Million $)	TOTAL COST PER TON SCENARIO I
		KM	$ COST /TON	TOTAL COST (Million $)#	$ COST /TON	TOTAL COST (Million $)	MILES*	MAX DWT	$ COST /TON MILES **	TOTAL COST (Million $)		
2	COAL TERMINAL TO PORT PALEMBANG	155	5.33	10.66	5.81	11.63	3,558	8,000	0.010	71.16	93.45	46.73
7,5	COAL TERMINAL TO PORT TARAHAN	396	11.28	84.63	5.81	43.60	3,847	80,000	0.0090	259.67	387.90	51.72

Note

* -Distance of Port Palembang to Port of Tianjin =3,558 nautical miles
  -Distance of Port of Tarahan to Shanghai = 3,847

http://ports.com/sea-route/port-of-palembang,indonesia/mawei-port,china/

** - Ship 8,000 DWT cost/ton derived from IEEJ,2007
  - Ship 80,000 DWT (70% utilization) cost per ton derived from Drewry Consultant and Panama Port Authority.

http://www.ciasf.com/wp-content/uploads/RCAMiami_Panama_Port2_part6of6.pdf

- Interim Financial Report 2009 Bukit Asam Mining Corporation

Source: Create by the Researcher, elaborated from Mimuroto,2002; Ports.com, 2011 Drewry Consultant,2009; Paul Clark, 1973 and Bukit Asam Mining Corporation,2010.

Appendix 3 Estimation for The Total Transportation Cost on Scenario II

TONS TRANSPORTED PER ANNUM (p.a) (MILLION TONS))	**ORIGIN-DESTINATION**	**RAILWAY COST**			**PORT COST**		**SHIPPING COST**				**TOTAL COST p.a SCENARIO II (Million $)**	**TOTAL COST PER TON SCENARIO II**
		KM	**$ COST /TON**	**TOTAL COST p.a (mill. $) #**	**$ COST /TON**	**TOTAL COST p.a (Million $)**	**MILES***	**MAX DWT**	**$ COST /TON MILES ****	**TOTAL COST p.a (Million $)**		
2	COAL TERMINAL TO PORT PALEMBANG	155	5.33	10.66	5.81	11.63	3,558	8,000	0.01	71.16	93.45	46.73
7,5	COAL TERMINAL TO PORT TARAHAN	396	11.28	84.63	5.81	43.60	3,847	80,000	0.0090	259.67	387.91	51.72
12,5	NEW TRACK FROM COAL TERMINAL TO PORT TARAHAN	200	5.33	66.65	5.81	72.67	3,847	80,000	0.0090	432.79	572.11	45.77

Note :
* -Distance of Port Palembang to Port of Tianjin =3,558 nautical miles
-Distance of Port of Tarahan to Shanghai = 3,847
http://ports.com/sea-route/port-of-palembang,indonesia/mawei-port,china/
** - Ship 8,000 DWT cost/ton derived from IEEJ,2007
- Ship 80,000 DWT (70% utilization) cost per ton derived from Drewry Consultant and Panama Port Authority
http://www.ciasf.com/wp-content/uploads/RCAMiami_Panama_Port2_part6of6.pdf
- Interim Financial Report Bukit Asam Mining Corporation, 2010
Source: Create by the Researcher, elaborated from Mimuroto, 2002; Ports.com, 2011 Drewry Consultant,2009, Paul Clark, 1973 and Bukit Asam Mining Corporation, 2010.

Appendix 4 Estimation for The Total Transportation Cost on Scenario III

TONS TRANSPORTED PER ANNUM (p.a) (MILLION TONS))	ORIGIN-DESTINATION	RAILWAY COST			PORT COST		SHIPPING COST				TOTAL COST SCENARIO III (Million $)	ANNUAL TOTAL COST PER TON SCENARIO III ($)
		KM	$ COST /TON	TOTAL COST p.a (Million $) #	$ COST /TON	TOT. COST p.a (Million $)	MILES*	MAX DWT	$ COST /TON MILES **	TOTAL COST p.a (Million $)		
2	COAL TERMINAL TO PORT PALEMBANG	275	5.33	10.66	5.81	11.63	3,558	120,000	0.0060	42.70	64.99	32.49
7,5	COAL TERMINAL TO PORT TARAHAN	396	11.28	84.63	5.81	43.60	3,847	80,000	0.0090	259.67	387.91	51.72

Note :

* -Distance Port Palembang to Port of Tianjin =3,558 nautical miles
  -Distance Port of Tarahan to Shanghai = 3,847

http://ports.com/sea-route/port-of-palembang,indonesia/mawei-port,china/

** - Ship 120,000 DWT (96% utilization) cost per ton derived from Drewry Consultant and Panama Port Authority
  - Ship 80,000 DWT (70% utilization) cost per ton derived from Drewry Consultant and Panama Port Authority

http://www.ciasf.com/wp-content/uploads/RCAMiami_Panama_Port2_part6of6.pdf

Interim Financial Report Bukit Asam Mining Corporation 2010

Source: Create by The Researcher, elaborated from Mimuroto,2002; Ports.com, 2011 Drewry Consultant,2009; Paul Clark, 1973; Bukit Asam Mining Corporation,2010.

Appendix 5 Estimation for The Total Transportation Cost on Scenario IV

TONS TRANSPORTED PER ANNUM (p.a) (MILLION TONS))	ORIGIN-DESTINATION	RAILWAY COST			PORT COST		SHIPPING COST				TOTAL COST SCENARIO IV (Million $)	ANNUAL TOTAL COST PER TON SCENARIO IV ($)
		KM	$ COST /TON	TOTAL COST p.a (Million $) #	$ COST /TON	TOTAL COST p.a (Million $)	MILES*	MAX DWT	$ COST /TON MILES **	TOTAL COST p.a (Million $)		
2	COAL TERMINAL TO PORT PALEMBANG	155	5.33	10.66	5.81	11.63	3,558	8,000	0.01	71.16	93.45	46.73
7,5	COAL TERMINAL TO PORT TARAHAN	396	11,28	84,63	5,81	43,60	3,847	80,000	0.0090	259.67	387.90	51.72
7,5	NEW RAIL TO PORT OF BENGKULU	90	13,54	101,55	5,81	43,60	4,085	8,000	0.01	306.38	451.53	60.20

* -Distance Port Palembang to Port of Tianjin =3,558 nautical miles
  -Distance Port of Tarahan to Shanghai = 3,847
  -Distance Port of Bengkulu to Shanghai = 4,085

http://ports.com/sea-route/port-of-palembang,indonesia/mawei-port,china/

** - Ship 8000 Dwt cost/ton derived from IEEJ,2007
     - Ship 80.000 Dwt (70% utilization) cost per ton derived from Drewry Consultant and Panama Port Authority

http://www.ciasf.com/wp-content/uploads/RCAMiami_Panama_Port2_part6of6.pdf

Interim Financial Report Bukit Asam Mining Corporation 2010

Source: Create by the Researcher, elaborated from Mimuroto, 2002; Ports.com, 2011 Drewry Consultant,2009; Paul Clark, 1973; Bukit Asam Mining Corporation,2010.

Appendix 6 Estimation for The Total Transportation Cost on Scenario V

TONS TRANSPORTED p.a	ORIGIN-DESTINATION	RAILWAY COST			RIVER WAY COST			PORT COST		SHIPPING COST				TOT. COST SCEN-ARIO V (Million $)	TOT.COST PER TON SCENARIO V
		KM	$ COST /TON	TOT. COST p.a (mil. $)	KM	$ COST /TON	TOT. COST p.a (mil$)	$ COST /TON	TOT. COST p.a (mil.$)	MI-LES*	MAX DWT	$ COST /TON MILES **	TOT. COST p.a (mil.$)		
28	Loading Point to Transshipment Terminal	90	11.28	315.84	200	13.95	390.70	43.32	1,212.9	3,558	200,000	0.0054	537.97	2,457.47	87.77

Note :
* -Distance Port Palembang to Port of Tianjin =3,558 nautical miles
http://ports.com/sea-route/port-of-palembang,indonesia/mawei-port,china/
** Ship 200.000 DWT (90% utilization), cost per ton benchmark from Drewry Consultant and Panama Port Authority
http://www.ciasf.com/wp-content/uploads/RCAMiami_Panama_Port2_part6of6.pdf

Source:Create by The Researcher, elaborated from Mimuroto,2002; Ports.com,2011; Drewry Consultant,2009 and Clark, 1973.